Hunting and Fishing in the Neolithic and Eneolithic

Weapons, Techniques and Prey

Edited by Selena Vitezović
and Christoforos Arampatzis

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Introduction: Hunting and fishing in the Neolithic and Eneolithic in Europe and Anatolia

Hunting and fishing were of crucial importance for providing food and other vital resources in Pleistocene and early Holocene communities in Europe and adjacent regions.

Hunted animals can be dangerous and aggressive, or timid, very fast and/or well hidden; therefore, to catch them without putting themselves in danger or before they escape, human groups had to invent diverse techniques and weapons which enabled them to mortally wound animals from a safe distance (cf. Julien 2016). Evidence for organised hunting and specially produced hunting weapons may be found as early as the Lower Palaeolithic. Particularly fascinating are the finds from the site of Schöningen in Germany, where conditions were favourable for the preservation of organic materials and where wooden throwing spears were found in 1995, approximately 400,000 years old. They were found in association with stone tools and butchered remains of several equids, and are thought to be the oldest complete hunting weapons discovered so far that had been used by humans. According to H. Thieme, these spears strongly suggest that systematic hunting, involving foresight, planning and the use of appropriate technology, was part of the behavioural repertoire of pre-modern hominids (Thieme 1997). Fishing was also practiced as a subsistence activity very early; probably already in the Middle Palaeolithic, if not earlier. Fish remains were found on some Mousterian sites, such as Tito Bustillo and Cueva Millan (Cleyet-Merle 1990, 22–23). More secure evidence for fishing in Europe comes from the Upper Palaeolithic period; and fish remains were discovered at numerous sites across Europe since the Aurignacian (Cleyet-Merle 1990, 28–29).

Research of the hunting and fishing techniques in prehistoric societies may enable reconstruction not only of subsistence and economy, but also of technological level, social organisation and cultural attitude towards the environment. Such studies must include various perspectives and also combine diverse data available from the archaeological record. However, there are also multiple obstacles for comprehensive studies, mainly due to insufficient preservation of faunal remains, in particular fish remains, inadequate recovery of small bones, and also the fact that many of the structures used in hunting and fishing were made from perishable materials. Furthermore, identification of the exact function of some artefacts may not be straightforward.

Weapons are often an important part of the material culture; and hunting and fishing equipment may provide important evidence not only for the presence and reconstruction of the scale and complexity of these activities, but also for their role within given communities. Hunting activities may also have certain social role and significance beside a purely practical one. Hunting weapons, along with their utilitarian role, may also serve as symbols of status, identity, belonging to a group (cf. Wiessner 1983; Sinclair 1995). Symbolic value may be ascribed to certain animal species; animals' role in economy is tightly linked to the perception of animals and their role in social and cultural life (cf. Seetah 2005, 6).

There is a long history of research of projectile technology and hunting techniques in general (e.g., Knecht ed. 1997; Pétillon *et al.* ed. 2009; Iovita and Sano eds. 2016, inter al.), especially when it concerns the Palaeolithic period. Studies of lithic projectiles have a longer tradition, but analyses regarding those made from osseous raw materials are increasing in the past few decades (e.g., Delporte *et al.* 1988;

Pétillon 2006; Langley ed. 2016; Pfeifer 2016). Fishing in prehistory was the subject of the comprehensive study by Cleyet-Merle (1990), and more recent studies focused on fishing techniques and fishing gear in Europe are usually limited to specific sites or certain regions (e.g., Benecke *et al.* 2013; Ritchie 2010; Stratouli 1996; Živaljević 2017). Among them, the research of the site of Zamostje should be mentioned in particular, whit exceptional preservation of diverse structures and features, made from perishable materials (e.g., Lozovski 1999; Lozovski and Lozovskaya 2016).

With the introduction of agriculture and animal husbandry, the role and importance of hunting and fishing activities changed, nevertheless, the they did not disappear.

This volume will try to explore the extent of hunting and fishing activities, their role and importance in subsistence and also their place in social relations. Geographically, the papers will deal with the regions of southern Europe and Anatolia, and culturally and chronologically with the communities labelled as Neolithic and Eneolithic (Chalcolithic). The range of topics includes technological, typological and functional analyses of weapons used, analyses of hunting and fishing strategies and techniques, and zooarchaeological analyses of the role of hunted fauna in the economy and other aspects of lives of the past communities.

The first two papers are focused on the region of present-day Turkey. The paper by A. Siddiq and V. Özkaya offers an overview of the evidence on hunting and fishing in Anatolia during the Pre-Pottery Neolithic from both evidence from the faunal record as well as material culture. Hunting and fishing were the only means of meat diets throughout the Pre-Pottery Neolithic A and early phase of the Pre-Pottery Neolithic B, and certain temporal trends may be noted – over time, hunted large ungulates became more valuable, and the Neolithic communities gradually preferred group hunting with more effective strategies — for avoiding the dangers and securing the hunt. At the same time, authors noted gradual dependency on domestic ungulates following the PPNB. Furthermore, there is also evidence for ritual significance of hunting and certain animal species being hunted for particular rituals. Over time, many particular taxa, including cranes, vultures, aurochs and foxes, became vital for symbolism and ritual activities.

P. Crabtree and D. Campana analysed the faunal record from the Early Chalcolithic site of Çiftlik-Tepecik in Cappadocia in their paper. While Neolithic sites in the region have predominant domestic fauna, with caprinae as the most frequent species, the Early Chalcolithic levels from Tepecik include 26% wild mammals and birds. The range of wild species includes wild horses, hydruntines, aurochs, wild boars, red deer, roe deer, and smaller wild mammals, including foxes and hares.

Three papers are focused on the southern Balkans and present-day Greece. E. Elster and M. Nikolaidou provided an extensive overview of evidence for hunting, fishing and overall exploitation of wild resources, with focus on the site of Sitagroi, extensively excavated in the 1968–1970. They argue that villagers —men, women, and children—purposefully sought out wild resources for practical reasons, while such activities also reflected their perceptions of the natural world, decision making, cooperating, sharing, negotiating, learning traditions, creating material culture and surrounding it with symbolic value.

Papers by S. Papadopoulou and Ch. Arampatzis provided analyses of artefacts from the lakeside settlement of Anarghiri IXb in Western Macedonia. While S. Papadopoulou analysed lithic projectile points, Ch. Arampatzis studied hunting gear made from deer antlers. Very rich assemblage of chipped stone tools also includes projectile points made of flint and obsidian; and the assemblage is characterised by technological and typological variability, and different raw materials exploited for their production. The hunting gear produced from antler consists of items such as harpoons, harpoon heads, projectile points, fish hooks and archer thumb rings that were almost unknown in the wider area. Both these assemblages provided evidence for the involvement of the prehistoric inhabitants in hunting activities; moreover, the Anargiri IXb inhabitants had mastered, to a high degree, a lot of manufacturing techniques and they exploited intensively the wild resources of the area along with the domesticated ones.

The Early Neolithic site of Dzhulyunitsa-Smardesh in eastern Bulgaria yielded a rich assemblage of hunting and fishing gear, namely, osseous projectile points and fish hooks, and stone net-weights, analysed and presented by N. Elenski, H. Markova and D. Markov. Both hunting and fishing had an important role in the early, phase I-II of the Dzhulyunitsa settlement, but decreased in later phases.

Weapons from the Chalcolithic period in present-day Bulgaria were analysed in the paper by K. Boyadzhiev. These include bifacial chipped-stone projectile points and bone arrowheads, and the author tried to analyse their possible function (as arrowheads and spear tips), as well as their possible use as weapons for hunting or for war.

M. Mărgărit provided technological and functional analysis of harpoons from the tell-settlement of Căscioarele in Romania. The assemblage of 70 harpoons, made mainly from red deer antler, was analysed. Author reconstructed the technological scheme for their production, identified a repair/recycling procedure, and also analysed use-wear marks. The author also argued that the specific morphology of the harpoons reflected the cultural identity of the Gumelnița culture communities.

Fishing hooks from the Late Neolithic settlement from Şoimuş–La Avicola, located in the vicinity of the Mureş river, were analysed in the paper by M. Savu and C. E. Stefan. Authors applied an integrative approach by performing a combination of technological, morphometric, morphological, and fracture studies paired with statistical analyses and ethnographic comparisons. They showed that the hooks were designed and manufactured in a systematic, homogenous fashion with the main scope of securing the desired catch while withstanding stress for the longest duration possible.

S. Vitezović, D. Antonović and D. Mihailović offered an overview of the available evidence for hunting and fishing gear from the central Balkan area from the Early Neolithic Starčevo culture and Late Neolithic Vinča culture. Predominant are items made from osseous raw materials – projectile points and fish hooks in the Early Neolithic and antler harpoons and fish hooks in the Late Neolithic. Regional differences were noted; fishing and hunting techniques and artefacts were carefully adapted to local environmental conditions. Sites located in the plains, near large, wide courses of the rivers Sava and Danube and their tributaries had richer assemblages of hunting and fishing gear and even some specific artefact types in both the Early and the Late Neolithic period. In the peculiar environment in the region of the Iron Gates, where the course of the river Danube consists of gorges, small basins and whirlpools, specific method for catching large migratory fish was invented in the Mesolithic period and was practiced throughout the Neolithic, and perhaps even in later periods.

Analysis of the faunal record from the central Balkan region was offered in the paper by A. Brown and H. J. Greenfield. Evidence from several sites from different periods also revealed some of the temporal trends. While both the Early and the Middle Neolithic cultures primarily subsisted on domestic fauna, the Late Neolithic data suggests a heavier reliance on wild fauna in some regions, and less in others. Furthermore, there are some regional differences, and also differences in exploitation of certain taxa.

The paper by I. Clemente-Conte, J. Ramos-Muñoz, E. Vijande-Vila, J. J. Cantillo-Duarte, J. A. Riquelme Cantal, N. Mazzucco, D. Fernández-Sánchez, J. M. Corona Borrego, M. Soriguer-Escofet, R. Cabrera-Castro, D. Cuenca-Solana, M. Sánchez Aragón and A. Barrena-Tocino is focused on the western parts of southern Europe. Their paper represents an interdisciplinary study of terrestrial fauna and marine fauna as well as hunting and fishing implements, including functional analyses, from various periods of prehistory in the region around the Strait of Gibraltar, along both the European and the North African shore. Together with hunting, the exploitation of marine resources (fish and shellfish) was important for people's diet in this Atlantic–Mediterranean region.

The paper by P. Martin, J. Nadal, X. Oms and J. M. Vergès focuses on the role of hunting in two Neolithic sheepfold caves in the Iberian Peninsula: El Mirador cave and Cova Colomera. The Neolithic sheepfold caves, despite being clearly linked to the practice of husbandry, show that hunting continued to be important and was adapted to the environmental, occupational and economic characteristics of each group. Although the production economy was fully consolidated, hunting was still used as a source of resources. The main purpose of hunting could have been to obtain meat, but hunting could also have been used as a strategy for protecting the herds and fields. This is especially significant in El Mirador cave, where carnivores were hunted and consumed, and is also a clear example of the optimisation of resources.

* * *

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Hunting and fishing in Neolithic Anatolia

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Abstract

The PPNA people groups in Anatolia started to live sedentary life, but still were completely dependent on hunting and gathering throughout 10,200–8800 BC. The domestication of pigs, sheep, goats and cattle occurred in the PPNB (8800–7000 BC), and later farming became widespread all across the Pottery Neolithic sites in Anatolia. Yet, almost every Neolithic group was very much involved in hunting a variety of wild taxa in their local ecosystem. A majority of these species were hunted for the procurement of meat and varieties of animal sources, while others often had symbolic use. Millions of stone tools and other hunting-related artifacts including fishhooks, nets, stone sinkers and baskets also indicated that diverse hunting methods were applied throughout all Neolithic levels. Citing the zooarchaeological reports, hunting-related artifacts and particular cultural items, we attempt to present a glimpse of hunting, trapping and fishing activities and their associated socio-cultural practices in Neolithic Anatolia, spanning from 11th millennium to 6th millennium cal BC.

Keywords: Hunting; Fishing; Animal symbolism; PPN; Pottery Neolithic; Anatolia

Introduction

The Neolithic way of life spanned a long period of about 5000 years in Anatolia. During the earliest phase, the Pre-Pottery Neolithic A (PPNA) people groups began to live in permanent settlements, yet they were still hunters and gatherers in their subsistence (Arbuckle and Özkaya 2006; Baird *et al.* 2018; Emra *et al.* 2022; Hongo *et al.* 2009; Peters and Schmidt 2004). So far, the PPNA settlements in Anatolia were largely concentrated in the Upper Tigris and Middle Euphrates Basin; but the Pre-Pottery Neolithic B (PPNB) and the Pottery Neolithic (PN) was spread in many other parts by the time the Anatolian farmers introduced farming into Europe (Özdoğan 2011; Siddiq 2016). Alongside the domestication of ungulates, over time, permanent villages also helped create suitable anthropogenic environments for some local species including rats, mice, crows and house sparrows; and many animals became vital for certain rituals and symbolic activities (Kansa *et al.* 2009; Peters and Schmidt 2004; Russell 2019b; Russell and McGowan 2003; Siddiq 2019). Hence, both humans and animals were going through significant changes in their interactions, which made Neolithic hunter-animal relationships more complex and multi-dimensional, unlike previous or later prehistoric periods in Anatolia. Moreover, there were notable distinctions in subsistence strategies between the early and late Neolithic traditions. For example, the late Neolithic villagers became fulltime farmers and herders while their sedentary ancestors in the PPNA were complete hunters and gatherers. Because of the increasing demands of food for growing human populations over centuries, the late Neolithic farmers also had to engage in food production activities at a far greater rate compared to their predecessor agricultural groups in the PPNB. Yet, zooarchaeological remains indicate that hunting remained vital throughout all later Neolithic phases (Atici *et al.* 2017; Buitenhuis 2008; Çakırlar 2012; De Cupere and Duru 2003; Kansa *et al.* 2009; Özbal *et al.* 2004). However, because of great diversities in material culture and geographical distinctions, it is very difficult to concise the vast information of hunting, fishing and related techno-cultural activities at about 100 excavated Neolithic sites in Anatolia. Hence, the aim of this study was to present a glimpse of hunting and fishing in Neolithic Anatolia, with the help faunal and archaeological records of a group of sites — which revealed comparatively larger faunal assemblages and have their zooarchaeological studies published — occupied throughout the early to late Neolithic levels and spanning a time range between 10,400 BC and 5500 BC.

Background

In a few decades, over twenty PPNA (c. 10,000–8800 BC) sites in Anatolia have been brought under excavations. Most of them yielded rich assemblages of faunal remains and hunting-related artifacts (Arbuckle and Özkaya 2006; Baird *et al.* 2018; Emra *et al*. 2022; Hongo *et al.* 2009; Miyake *et al.* 2012; Özkaya 2009; Schmidt 2012; Peters and Schmidt 2004; Starkovich and Stiner 2009; Zeder and Spitzer 2016). Among them, the site of Körtiktepe (10,700–9300 cal BC) in the Upper Tigris Basin is the only securely dated Younger Dryas site in Anatolia, occupied by sedentary hunter-gathers throughout the Younger Dryas and the Early Holocene, primarily basing on wild plants, wild animals, and aquatic resource-based subsistence (Arbuckle and Özkaya 2006; Benz *et al*. 2015; Emra *et al*. 2022; Koruyucu *et al.* 2018). The site yielded so far the richest PPN assemblage in West Asia including over 2000 burials, about 500 circular architectural remains (Özkaya 2009; Özkaya and Coşkun 2011). Over a million identifiable animal bones were recorded from Körtiktepe (personal communication with V. Özkaya), composed of over 80 identified species of mammals, birds, fish, reptiles and molluscs (Arbuckle and Özkaya 2006; Emra *et al*. 2022). Another PPNA site of Hallan Çemi (10,000–9300 cal BC) also yielded a large faunal assemblage, possibly more than 100,000 identifiable specimens (Starkovich and Stiner 2009: 49). Although it was a smaller site, the faunal remains indicate a rich hunting choice at Hallan Çemi (Starkovich and Stiner 2009; Zeder and Spitzer 2016). Similarly a large number of animal bones were also recorded from the PPNA site of Hasankeyf Höyük (9600–9100 cal BC), composed only of the wild species (Miyake *et al.* 2012: 4). With a paucity of aurochs bones, wild caprines comprised about 51%, and fish comprised about 8% of the identified species at Hasankeyf (Itahashi *et al.* 2017). Another important PPNA site of Göbeklitepe (9746–7795 cal BC) yielded over 38,000 specimens of faunal remains until 2004, and also composed only of wild taxa (Peters and Schmidt 2004, 183). The faunal remains from the site of Pınarbaşı A (9800–7800 cal BC) indicated hunting of wild taxa within a diverse ecological niche; however, unlike the PPNA sites in Southeast Anatolia, aurochs comprised about 65% of total identified fauna at the site (Carruthers 2003: 133). On the other hand, among the PPN sites, Çayönü (10,200–6300 cal BC) represented all Neolithic sequences from PPNA to Pottery Neolithic. Along with three other domesticates (i.e., sheep, goat and cattle), pig was the single most dominant species in all level at Çayönü — comprising more than 30% of the identified specimens (Hongo *et al.* 2009). Yet, remains of a wide range of wild taxa including deer, gazelle, onager, bear, leopard, fox, hare, some birds and tortoise were also found at the site (Hongo *et al.* 2004).

About 20 PPNB sites have been brought under excavation in Anatolia until today. Most of the PPNB sites are also located in the Upper Tigris and the Middle Euphrates Basin. Among them, the site Cafer Höyük (8300–7500 cal BC) yielded over 8000 identifiable specimens (Helmer 2008, 175), Gritille (8450–6400 cal BC) yielded approximately 80,000 fragments of animal bones (Stein 1986, 36), Akarçay Tepe

(7950–6070 cal BC) yielded over 14,000 identifiable animal bone fragments (Saña and Tornero 2008: 159), Nevali Çori (8720–7070 cal BC) yielded over 12,000 bone fragments of mammalian species (Peters *et al.* 2005: 102), Mezraa Teleilat (8720–6480 cal BC) yielded about 35,000 bone fragments including over 9000 identifiable specimens (Ilgezdi 2008, 82), and Gürcütepe yielded over 14,000 bone fragments including over 6000 identifiable specimens (Peters *et al.* 2005, 103). All of these settlements also yielded verities of wild species including aurochs, mouflon, bezoar, wild boar, red deer, fallow deer, gazelle, hare, wolf, jackal, fox, badger, wild cat, and birds. A number of PPNB sites in Central Anatolia including Aşıklı Höyük (8450–7400 cal BC), Musular (7600–6500 cal BC), Boncuklu Höyük (8300–7600 cal BC), Can Hasan III (7400–7100 cal BC) and Suberde (8th millennium BC) also yielded rich faunal assemblages, representing a total of about 60 wild taxa (Baird *et al.* 2018; French 1968; Özbaşaran *et al.* 2012; Perkins and Daly 1968; Siddiq, 2018; Stiner *et al.* 2014). Similar to some other parts of West Asia, the Pre-Pottery Neolithic B (8800–7000 BC) in Anatolia was marked by the beginning of animal domestication. Many of the PPNB sites in Southeast Anatolia gradually showed domesticated types of pig, sheep, goat and cattle (Table 1); but a few PPNB sites such as Aşıklı Höyük, Boncuklu Höyük, and Suberde in Central Anatolia only present domestic sheep and probably goat, but not pig or cattle (Baird *et al.* 2018; Siddiq 2018: chapter 5; Stiner *et al.* 2014). Yet, PPNB people still were often dependent on the wild progenitors of these domesticates (Table 1).

The Pottery Neolithic or PN (7000–5500 BC) witness the increase of farming communities all across the Southeast, Central and West Anatolia (Figure 1). By far, over 70 Pottery Neolithic (PN) sites have been excavated in Anatolia. Among this large number of sites, particularly the sites of Çatalhöyük (7400–6000 cal BC), Tepecik-Çiftlik (7500–5800 cal BC) and Köşk Höyük (6300–5600 BC) of Central Anatolia

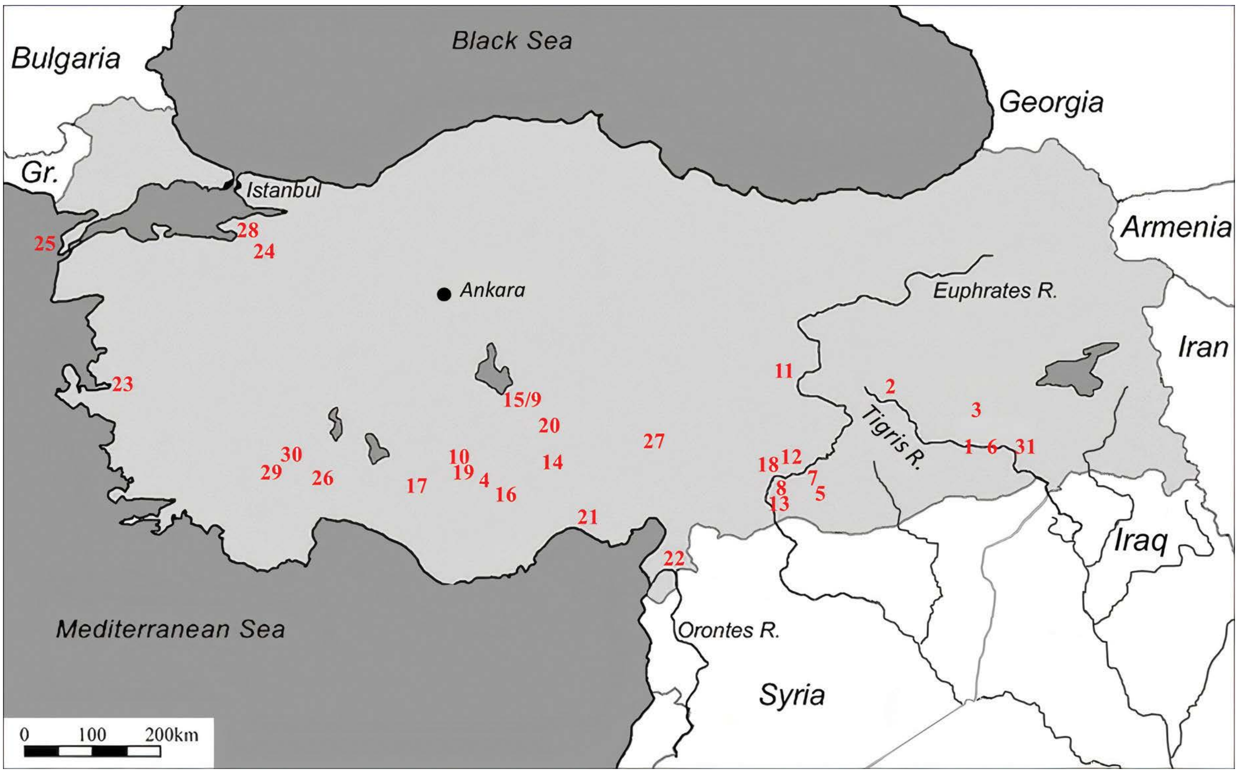

Figure 1. Map showing the location of Anatolian Neolithic sites mentioned in the text: 1. Körtiktepe; 2. Çayönü; 3. Hallan Çemi; 4. Pınarbaşı; 5. Göbeklitepe; 6. Hasankeyf Höyük; 7. Nevalı Çori; 8. Mezraa Teleilat; 9. Aşıklı Höyük; 10. Boncuklu Höyük; 11. Cafer Höyük; 12. Gritille; 13. Akarcay Tepe; 14. Köşk Höyük; 15. Musular; 16. Can Hasan III; 17. Suberde; 18. Hayaz Höyük; 19. Çatalhöyük; 20. Tepecik-Çiftlik; 21. Yumuktepe; 22. Tell Kurdu; 23. Ulucak Höyük; 24. Barcın Höyük; 25. Uğurlu Höyük; 26. Höyücek; 27. Domuztepe; 28. Ilıpınar; 29. Hacılar; 30. Kuruçay Höyük; and 31. Gusir Höyük (Photo: AB Siddiq).

(Öztan 2012; Bıçakçı *et al.* 2007; Bar-Yosef Mayer 2013; Pawłowska and Marciszak 2018; Russell 2012, 2019a, 2019b; Russell and Meece 2006; Russell and McGowan 2003; Van Neer *et al.* 2013); Tell Kurdu (6200–5700 BC) and Domuztepe (6200–5450 cal BC) of Southeast Anatolia (Kansa *et al.* 2009; Özbal *et al.* 2004); Yumuktepe (7000–5800 BC), Höyücek (6400–6000 BC) and Hacılar (*c.* 5700–5300 BC) of Southwest Anatolia (Caneva 2012; De Cupere and Duru 2003; Mellaart 1970; Minniti 2014); and Ulucak Höyük (7000–5600 cal BC), Barcın Höyük (6500–5800 cal BC), Ilıpınar (6000–5400 cal BC) and Uğurlu Höyük (*c.* 6500–5000 cal. BC) of Northwest Anatolia (Atici *et al.* 2017; Buitenhuis 2008; Çakırlar 2012; Würtenberger 2012) yielded rich faunal assemblages, comprised of 5000 to over a million bone fragments represented to over 50 wild taxa.

The climate and ecological background of Neolithic period also supported suitable conditions for an extensive number of wild taxa. During the early phase of PPNA, the return of cold by the Younger Dryas between 10,650 BC and 9500 BC might have had negative effect on small mammals, but the large mammals were abundant (Arbuckle and Özkaya 2006; Baird *et al*. 2018; Emra *et al*. 2022; Starkovich and Stiner 2009). Between 9500 BC and 6200 BC the average temperature in Anatolia was 14.5°C to 19°C, while annual precipitation was between 675 and 950mm (Roberts *et al.* 2008; Turner *et al.* 2010). Paleoclimatic evidence suggests that, this was one of the wettest periods in Anatolia lasted about 3000 years. The Early Holocene climate condition helped cover the local environment of Anatolia with extensive grasslands, pastures, meadows and rich wooded forests (Turner *et al.* 2010), supporting a great number of wild taxa. With the blessing of melting waters of the snow-covered hills, large rivers such as the Tigris, the Euphrates, the Kızılırmak, the Maritsa, smaller streams such as Çarşamba and Melendiz as well as many of their sub-streams created swamp environment in lowland regions — which hosted a great diversity of aquatic birds, fish, frogs, crabs and molluscs. Zooarchaeological records show that the coastal regions were also blessed with extensive marine resources including birds, fish and molluscs (Atici *et al.* 2017; Buitenhuis 2008; Çakırlar 2012; Minniti 2014).

Exploited wild fauna

Mammals

Aurochs (*Bos primigenius*) appeared to be the most sought after but the most dangerous animal among the hunted ungulate species in Neolithic Anatolia (Siddiq 2018: 251-254). With some exceptions, a large number of aurochs remains were recorded from most of the PPNA and PPNB sites. Aurochs comprised over 15% of the Early Holocene faunal assemblage at Körtiktepe (Arbuckle and Özkaya 2006; Emra *et al*. 2022), and about 23% at PPNA level of Çayönü (Hongo *et al.* 2004). Aurochs also comprised about 17% of the total identified mammals at Göbeklitepe (Peters and Schmidt 2004). In Central Anatolia, both the wetland-based ecological niches and open forests supported aurochs populations. Some sites including Musular and Boncuklu Höyük yielded large numbers of aurochs bones, respectively comprising about 57% and 39% of total identified species (Siddiq 2018: 208-213). In the early phases at Çatalhöyük, aurochs and cattle continued to be a major economic and symbolic focus, representing about 20% of the mammalian fauna and 60-80% of the available meat yields (Russell and Martin 2005). Aurochs bones were also high in number at late Neolithic sites including Ilipinar, Tell Kurdu, Domuztepe and Höyücek (Buitenhuis 2008; De Cupere and Duru 2003; Kansa *et al.* 2009; Özbal *et al.* 2004).

It appears that caprines were the most hunted species throughout the Late Pleistocene and Early Holocene sites in West Asia. Except for a few special activity sites, such as Musular in Central Anatolia (Özbaşaran *et al.* 2012), caprines comprised the highest ratio among the exploited ungulates in Neolithic Anatolia. At least three species of wild sheep i.e., Asiatic mouflon, Turkish mouflon and argali, were

TABLE 1. FOUR MOST HUNTED UNGULATES AND THEIR DOMESTICATION STATUS IN NEOLITHIC ANATOLIA.

Site	Location	Period	Sedentary occupation	Pig		Sheep		Goat		Cattle	
				W	D	W	D	W	D	W	D
Körtiktepe	Upper Tigris Basin	PPNA	10400 cal BC	✓	×	✓	×	✓	×	✓	×
Çayönü	Upper Tigris Basin	PPNA	c. 10,000 BC	✓	×	✓	×	✓	×	✓	×
		PPNB	c. 8500 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
		EPN	c. 6300 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Hallan Çemi	Upper Tigris Basin	PPNA	10010 cal BC	✓	×	✓	×	✓	×	✓	×
Pınarbaşı	Konya Plain	PPNA	9800 cal BC	✓	×	✓	×	✓	×	✓	×
		PPNB	8500 cal BC	✓	×	✓	×	✓	×	✓	×
Göbeklitepe	Middle Euphrates Basin	PPNA	9746 cal BC	✓	×	✓	×	?	×	✓	×
		PPNB	8800 cal BC	✓	×	✓	?	✓	?	✓	×
Hasankeyf Höyük	Upper Tigris Basin	PPNA	9600 cal BC	✓	×	✓	×	✓	×	✓	×
Nevalı Çori	Middle Euphrates Basin	PPNB	8720 cal BC	✓	?	✓	✓	✓	✓	✓	×
Mezraa Teleilat	Middle Euphrates Basin	PPNB	8720 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
		EPN	6500 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Aşıklı Höyük	Cappadocia	PPNB	8450 cal BC	✓	×	✓	✓	✓	?	✓	×
Boncuklu Höyük	Konya Plain	PPNB	8300 cal BC	✓	×	✓	✓	✓	?	✓	×
Cafer Höyük	Upper Euphrates Basin	PPNB	8300 cal BC	✓	×	✓	×	✓	×	✓	×
Gritille	Upper Euphrates Basin	PPNB	8450 cal BC	✓	?	✓	✓	✓	✓	✓	?
Akarcay Tepe	Middle Euphrates Basin	PPNB	7950 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
		EPN	6200 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Hayaz Höyük	Upper Euphrates Basin	PPNB	7520 cal BC	✓	?	✓	✓	✓	✓	✓	?
Çatalhöyük	Konya Plain	PPNB	7400 cal BC	✓	×	✓	✓	✓	×	✓	×
		EPN	7000 cal BC	✓	×	✓	✓	✓	✓	✓	✓
Ulucak Höyük	Northwest Anatolia	EPN	7000 cal BC	✓	✓	×	✓	✓	✓	✓	✓
Barcın Höyük	Northwest Anatolia	MPN	6500 cal BC	✓	×	✓	✓	✓	✓	✓	✓
Uğurlu Höyük	Northwest Anatolia	MPN	c. 6500 cal BC	✓	✓	×	✓	×	✓	×	✓
Höyücek	Southwest Anatolia	MPN	6400 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Domuztepe	Upper Euphrates Basin	LPN	6200 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Ilıpınar	West Anatolia	LPN	6000 cal BC	✓	✓	✓	✓	✓	✓	✓	✓
Hacılar	Southwest Anatolia	LPN	c. 5700 BC	✓	✓	✓	✓	✓	×	✓	×

PPNA = Pre-Pottery Neolithic A; PPNB = Pre-Pottery Neolithic B; EPN = Early Pottery Neolithic; MPN = Middle Pottery Neolithic; LPN = Late Pottery Neolithic; W = Wild; D = Domesticated.

Table 2. Ungulates hunted in Neolithic Anatolia.

Family	Species	Common Name	PPNA	PPNB	PN
Bovidae	*Bos primigenius*	Aurochs	✓	✓	✓
	Bos buffalo (?)	Buffalo	×	×	✓
	Bison bonasus (?)	European bison	×	✓	✓
	Ovis orientalis	Asiatic mouflon	✓	✓	✓
	Ovis anatolica	Turkish mouflon	×	✓	×
	Ovis ammon	Argali	×	×	✓
	Capra aegagrus	Wild goat	✓	✓	✓
	Rupicapra rupicapra	Chamois	✓	×	×
	Gazella subgutturosa	Black-tailed gazelle	✓	✓	✓
	Gazella gazella	Mountain gazelle	×	✓	×
Suidae	*Sus scrofa*	Wild boar	✓	✓	✓
	Sus scrofa attila	Carpathian boar	✓	×	×
Equidae	*Equus ferus*	Wild horse	✓	✓	✓
	Equus hemionus	Asiatic wild ass	✓	✓	✓
	Equus hydruntinus	European wild ass	✓	✓	✓
Cervidae	*Capreolus capreolus*	Roe deer	✓	✓	✓
	Dama dama	Fallow deer	✓	✓	✓
	Dama mesopotamica	Persian fallow deer	×	✓	×
	Cervus elaphus	Red deer	✓	✓	✓

PPNA – Pre-Pottery Neolithic A; PPNB – Pre-Pottery Neolithic B; PN – Pottery Neolithic

found from the Neolithic sites in Anatolia (Table 2), but wild goats were hunted less compared to wild sheep. For example, the ratio of sheep to goats was 4.6% to less than 1% at the PPNA site of Körtiktepe (Arbuckle and Özkaya 2006). Similarly only a few goat bones were reported from over 1200 identified caprine bones at Göbeklitepe (Peters and Schmidt 2004).With a majority of sheep — comprising up to 70-80% of the identified species — goats comprised only about 5-16% of the total identified fauna of some PPNB sites including Nevalı Çori, Gritille, Aşıklı Höyük and Gürcütepe (Buitenhuis 1997; Ilgezdi 2008; Stein 1986). Goats were also not regularly hunted in the PPNA site of Pınarbaşı and PPNB site of Boncuklu Höyük (Baird *et al.* 2018). However, domestic goats later appeared in Çatalhöyük, comprising about 20% of total identified species (Russell and Martin 2005). Perhaps the overall environmental condition in Neolithic Anatolia was less favourable for wild goats, since they commonly need a dry environmental condition (Siddiq 2018: 247-250).

Wild boar was also among the most hunted ungulates. In some early Neolithic sites such as Hallan Çemi (Starkovich and Stiner 2009), Çayönü (Hongo *et al.* 2004) and Boncuklu Höyük (Siddiq 2018: 213), wild boars respectively comprised about 40%, 50% and 37% of the total identified fauna. Yet, some pre-domestic PPNA and PPNB such as Körtiktepe and Aşıklı Höyük present a very low ratio of wild boar — comprising up to 3-4% of the identified specimens (Arbuckle and Özkaya 2006; Buitenhuis 1997; Emra *et al.* 2022; Siddiq 2018: 200). Although domestic pigs were raised in some PPNB and many of the Pottery Neolithic sites (e.g., Hongo *et al.* 2004; Ilgezdi 2008; Kansa *et al.* 2009), wild boar continued to provide a significant amount of meat source (Table 1). On the other hand, surprisingly domestic pigs were totally absent at some of the Late Neolithic sites including Çatalhöyük (Russell and Martin 2005) and Ulucak Höyük (Çakırlar 2012).

Among deer, at least four species i.e., red deer, fallow deer, Persian fallow deer and roe deer, were recorded in Neolithic Anatolia (Table 2). Red deer was the most hunted among them. In some Early PPNA sites such as Körtiktepe (Arbuckle and Özkaya 2006) and Hallan Çemi (Starkovich and Stiner 2009), red deer comprised up to 20-39% of the total identified species. Fallow deer comprised higher ratios in some later Neolithic sites including Ulucak Höyük (Çakırlar 2012: 8). Until 2006, about a thousand dear bones were also recorded in over 24,000 identified specimens from Çatalhöyük (Russell and Martin 2005: 43). However, since deer did not comprise more than 2-4% of the total identified fauna at most of the sites, it is arguable that except for some favourable ecological niches — as witnessed at the Early Holocene Körtiktepe and Hallan Çemi — deer were generally hunted as a supplementary meat source.

Wild horse (*Equus ferus*), Asiatic wild ass (*Equus hemionus*), and European wild ass (*Equus hydruntinus*) represent the equidae in Neolithic Anatolia (Table 2). All of these three species were hunted throughout early to late Neolithic periods. Similar to deer, equidae commonly comprised less than 2% of the total identified species at most of the sites. However, a few sites including Göbeklitepe, Pınarbaşı and Boncuklu Höyük present respectively about 8%, 5% and 11% of total identified specimens composed of equidae remains (Peters and Schmidt 2004; Siddiq 2018: 187, 216, 227).

Table 3. Carnivore mammals hunted in Neolithic Anatolia.

Family	Species	Common Name	PPNA	PPNB	PN
Mustelidae	*Martes foina*	Beech marten	✓	✓	✓
	Meles meles	Eurasian badger	✓	✓	✓
	Vormela peregusna	Marbled polecat	✓	✓	✓
	Mustela putorius	Forest polecat	×	×	✓
	Mustela nivalis	Least weasel	✓	✓	✓
	Lutra lutra	Eurasian otter	×	×	✓
Canidae	*Vulpes vulpes*	Red fox	✓	✓	✓
	Vulpes corsac	Corsac fox	✓	×	×
	Canis aureus	Golden jackal	×	×	✓
	Canis lupus	Gray wolf	✓	✓	✓
Felidae	*Panthera pardus*	Leopard	✓	✓	✓
	Lynx lynx	Eurasian lynx	✓	✓	?
	Felis silvestris	Wildcat	✓	✓	✓
	Felis chaus	Jungle cat	×	✓	?
Ursidae	*Ursus arctos*	Brown bear	✓	✓	✓
	Ursus spelaeus	Cave bear	✓	×	×

PPNA – Pre-Pottery Neolithic A; PPNB – Pre-Pottery Neolithic B; PN – Pottery Neolithic

Table 4. Small mammal species identified from Neolithic sites in Anatolia.

Family	Species	Common Name	PPNA	PPNB	PN
Leporidae	*Lepus capensis*	Desert hare	✓	✓	✓
	Lepus europaeus	European hare	✓	-	✓
Hystricidae	*Hystrix* sp.	Porcupine	✓	✓	✓
Erinaceidae	*Erinaceus concolor*	White-breasted hedgehog	✓	✓	✓
	Erinaceus europaeus	Common hedgehog	✓	✓	✓
	Hemiechinus auritus	Long-eared hedgehog	×	✓	×
Cricetidae	*Arvicola* sp.	Water voles	✓	✓	✓
	Microtus spp.	Voles	✓	✓	✓
	Mesocricetus brandti	Turkish hamster	✓	✓	✓
	Mesocricetus auratus	Syrian hamster	✓	×	×
	Cricetulus migratorius	Grey hamster	✓	×	✓
Muridae	*Apodemus* sp.	Field mice	✓	✓	✓
	Tatera indica	Antelope rat	✓	×	×
	Nesokia indica	Short-tailed bandicoot rat	✓	×	×
	Mus sp.	House mouse	✓	×	✓
	Meriones sp.	Jird	✓	✓	✓
	Murinae sp.	Old World rats	×	✓	✓
Sciuridae	*Spermophilus xanthoprymnus*	Anatolian ground squirrel	×	✓	✓
	Spermophilus citellus	European ground squirrel	✓	×	×
Gliridae	*Dryomys* sp.	Dormouse	×	✓	✓
Spalacidae	*Spalax* sp.	Blind moles	✓	✓	✓
Castoridae	*Castor fiber*	Eurasian beaver	✓	✓	✓
Soricidae	*Crocidura suaveolens*	Lesser white-toothed shrew	✓	✓	✓
	Crocidura leucodon	Bicolored shrew	✓	×	✓
	Suncus etruscus	Etruscan shrew	×	×	✓
Rhinolophidae	*Rhinolophus eurayle*	Mediterranean horseshoe bat	×	×	✓

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Among other ungulates, the black-tailed gazelle was recorded from all Neolithic levels whereas the mountain gazelle was mostly recorded at PPNB level (Table 2). It is worth mentioning that throughout the Neolithic period gazelles were distributed mainly in the Tigris and Euphrates Basin in the South-eastern Anatolia (Emra *et al.* 2022; Peters and Schmidt 2004; Sana and Tornero 2008). On the other hand, the reports of bison at Pınarbaşı (Carruthers 2003: 169) and buffalo at Neolithic level of Kuruçay Höyük (Deniz and Şentuna 1988) seemed to be very uncommon since no other Neolithic site reports even a single bison or buffalo bone.

Among the carnivore mammals the family mustelidae dominates carnivore species identified throughout the Neolithic, representing a total of six species. Among them, only beech marten and Eurasian badger were common in all Neolithic levels. The other mustelidae including polecat, weasel and otter exhibited regional and periodical variations. Among all carnivore mammals, fox was probably a significant supplementary meat source throughout all Neolithic levels (Table 3). Particularly the PPN site of Pınarbaşı in Central Anatolia, yielded a large number of juvenile red fox bones with extensive burn marks (Carruthers 2003: 159), showing that they were hunted for delicacy (Siddiq 2018: 186). Notably fox comprised respectively 21% and about 31% of the total identified species of PPN and PN occupations at Pınarbaşı (Baird *et al*. 2018: E3082; Siddiq 2018: 187). Gray wolf was also a common hunted carnivore in all levels. Besides the apparent procurement of supplementary meat, it was likely that Neolithic hunters regarded wolf hides as valuable support against harsh winter. Notably, meat obtained from wolf, fox, hedgehog, tortoise, and a variety of rodents is still being consumed as medicinal and supplementary food in different parts of Turkey, including South-eastern Anatolia (e.g., Siddiq and Şanlı 2020).

Among the felidae, leopards and wild cats were the common carnivores hunted throughout all Neolithic levels (Table 3). Although wild cat remains were common, leopard bones were very rare in most of the sites. For instances, only a single leopard bone was recorded among over 100,000 identifiable bones at PPNA site of Hallan Çemi (Starkovich and Stiner 2009); only a few leopard bones were reported from about 200,000 identifiable bones at PPNB site of Aşıklı Höyük (Siddiq 2018: 197); and only a single leopard bone was reported from over a million identified bones at Çatalhöyük (Russell and Meece 2006). Similarly, only a single leopard bone was recorded from the Late Neolithic sites of Ulucak Höyük (Çakırlar 2012: 8), Domuztepe (Kansa *et al.* 2009: 907) and Ilıpınar (Buitenhuis 2008. 307).

Brown bear represented the family ursidae in all Neolithic levels (Table 3). Large number of brown bear bones at a significant number of sites in all levels, including the PPNA site of Hallan Çemi (Starkovich and Stiner 2009). Providing the biomass comparison of the faunal remains, it was argued that people of Hallan Çemi had an overwhelming dependence on bear meat (Starkovich and Stiner 2009: 51). If considered the size and amount of meat, it is likely that bears also offered supplementary meat for other Neolithic hunters in Anatolia, providing the fact that an adult male brown bear could provide up to 300kg fresh meet (Siddiq, 2018: 311). Moreover, their valuable hides were likely to be a sought after good among the Neolithic groups in Anatolia.

Early Holocene environment condition and ecological niches were particularly favourable for rodents; and small mammals including hares, porcupines, hedgehogs, beavers, squirrels and different species of moles, voles, mice and rats were commonly present in the faunal assemblages of almost all Neolithic sites in Anatolia. Many of these species such as moles, voles, mice and rats were pests that live in the vicinity or inside (as a commensal species) of the settlements; and therefore, their presence in the faunal assemblage could be by of chances. Yet, it is likely that as supplementary meat source small mammal species such as hares, porcupines, hedgehogs and beavers were hunted and trapped by Neolithic groups of all levels (Table 4). Moreover, despite the gradual increase in domestic ungulates, small games such as hare, porcupine, badger, hedgehogs and rodents continued to have significant parts in faunal remains throughout the PPNB (e.g., Buitenhuis 1997; Carruthers 2003: 129; Peters *et al.* 2005; Saña and Tornero 2008). Particularly, hares were widely available in some sites located in open field, grassland or steppe environment. For example, hare comprised about 6% of the total identified species at PPN site of Pınarbaşı in Central Anatolia (Siddiq 2018: 187), and even at a time of increasing dominance of domestic sheep, hare still comprising 2.5% of total fauna of Phase II at Aşıklı Höyük (Buitenhuis 1997; Siddiq 2018: 200). Similarly, over 50% of about 10,000 small mammal bones from Çatalhöyük were comprised of house pests and rodents (Jenkins 2009: 118).

TABLE 5. MOST COMMON BIRDS IDENTIFIED FROM NEOLITHIC SITES IN ANATOLIA.

Species	Common Name	PPNA	PPNB	PN
TERRESTRIAL BIRDS				
Alectoris chukar	Chukar partridge	✓	✓	✓
Burhinus oedicnemus	Stone-curlew	✓	×	×
Columba livia	Rock pigeon	✓	×	×
Columba palumbus	Common wood pigeon	✓	×	×
Columbidae	Unidentified pigeons	✓	×	×
Coturnix coturnix	Common quail	×	✓	✓
Crex crex	Corn crake	✓	×	×
Galliformes	Unidentified gamebirds	✓	×	×
Otis tarda	Great bustard	✓	✓	✓
Passeriformes	Unidentified songbirds	✓	✓	✓
Perdix perdix	Gray partridge	✓	×	✓
Pterocles orientalis	Black-bellied sandgrouse	✓	×	×
Phasianidae sp.	Unidentified pheasant	×	✓	✓
Pica pica	Eurasian magpie	×	×	✓
Scolopax rusticola	Eurasian woodcock	×	×	✓
Streptopelia turtur	Turtle dove	✓	×	×
Sturnus sp.	Starling	✓	×	×
Tetrax tetrax	Little bustard	✓	×	×
Turdus sp.	Thrush	✓	×	×
AQUATIC BIRDS				
Anas acuta	Pintail	✓	×	×
Anas crecca	Green-winged teal	×	×	✓
Anas penelope	Eurasian wigeon	✓	×	×
Anas platyrhynchos	Mallard	×	×	✓
Anas querquedula	Garganey	✓	×	×
Anas sp.	Ducks, teals and mallards	✓	×	✓
Anser albifrons	Greater white-fronted goose	✓	×	✓
Anser anser	Greylag goose	✓	×	✓
Anser erythropus	Lesser white-fronted goose	×	×	✓
Anser sp.	Unidentified geese	✓	×	✓
Ardea cinerea	Grey heron	✓	×	✓
Ardea purpurea	Purple heron	✓	×	×
Ardea sp.	Herons	✓	×	✓
Aythya ferina	Common pochard	✓	×	×
Aythya fuligula	Tufted duck	✓	×	×
Aythya sp.	Diving ducks	✓	×	✓
Botaurus stellaris	Eurasian bittern	✓	×	×
Branta ruficollis	Red-breasted goose	✓	×	✓
Ciconia ciconia	White stork	×	×	✓
Ciconia sp.	Stork	✓	✓	✓
Cygnus olor	Mute swan	✓	✓	×
Cygnus sp.	Swan	×	×	✓
Egretta garzetta	Little egret	×	×	✓
Fulica atra	Eurasian coot	×	×	✓
Gallinula chloropus	Common moorhen	✓	×	×
Gallinula sp.	Swamp chicken	×	×	✓
Grus grus	Common crane	✓	✓	✓
Himantopus himantopus	Black-winged stilt	✓	×	×

Species	Common Name	PPNA	PPNB	PN
Ixobrychus minutus	Little bittern	×	×	✓
Larus ridibundus	Black-headed gull	✓	×	×
Limosa sp.	Godwit	×	×	✓
Mergellus albellus	Smew	✓	×	×
Mergus merganser	Common merganser	×	✓	×
Numenius arquata	Eurasian curlew	✓	×	×
Pelecanus sp.	Dalmatian pelican	×	✓	✓
Phalacrocorax carbo	Great cormorant	×	×	✓
Phalacrocorax pygmeus	Pygmy cormorant	×	×	✓
Philomachus pugnax	Ruff	×	×	✓
Phoenicopterus roseus	Greater flamingo	×	×	✓
Platalea leucorodia	Eurasian spoonbill	×	×	✓
Podiceps cristatus	Great crested grebe	×	×	✓
Podiceps nigricollis	Black-necked grebe	✓	×	×
Podiceps sp.	Grebes	×	×	✓
Tadorna tadorna	Common shelduck	×	×	✓
Vanellus vanellus	Peewit	✓	×	×
RAPTORS				
Accipiter nisus	Eurasian sparrowhawk	✓	×	×
Aegypius monachus	Black vulture	✓	×	×
Aquila heliacal	Eastern imperial eagle	✓	×	×
Aquila sp.	Eagle	✓	✓	✓
Asio flammeus	Short-eared owl	×	×	✓
Asio otus	Long-eared owl	×	×	✓
Athene noctua	Little owl	×	×	✓
Bubo bubo	Eurasian eagle-owl	✓	✓	×
Buteo buteo	Common buzzard	✓	×	✓
Buteo rufinus	Long-legged buzzard	✓	×	×
Circus aeruginosus	Western marsh harrier	✓	×	×
Circus cyaneus	Hen harrier	✓	×	×
Circus pygargus	Montagu's harrier	✓	×	×
Circus sp.	Harrier	✓	✓	✓
Corvus cornix	Hooded crow	×	×	✓
Corvus corone	Carrion crow	×	✓	×
Corvus frugilegus	Rook	×	✓	×
Corvus monedula	Western jackdaw	✓	×	×
Corvus sp.	Unidentified crow	✓	×	×
Falco cherrug	Saker falcon	✓	×	×
Falco peregrinus	Peregrine falcon	✓	×	×
Falconiformes	Unidentified falcons	✓	✓	×
Gypaetus barbatus	Bearded vulture	-	✓	×
Gyps fulvus	Griffon vulture	✓	✓	✓
Haliaeetus albicilla	White-tailed eagle	✓	×	✓
Milvus migrans	Black kite	✓	×	×
Milvus milvus	Red kite	✓	×	×
Pica pica	Eurasian magpie	✓	×	×
Pyrrhocorax pyrrhocorax	Chough	✓	×	×
Strigidae sp.	Unidentified owls	✓	✓	✓

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Birds

A great variety of birds were hunted and trapped in all Neolithic levels, presenting birds as the second most hunted vertebrates after ungulates (Table 5). Particularly due to the extensive work on avifauna, the Pre-Pottery Neolithic site Körtiktepe and Hallan Çemi in the Upper Tigris basin and the Pottery Neolithic site Çatalhöyük in the Konya plain presented far more identified bird species than the Neolithic sites in Anatolia (Emra *et al.* 2022; Russell 2019a, 2019b; Russell and McGowan 2012; Zeder and Spitzer 2016). Terrestrial birds such as great bustards, partridges and quail were a major meat source in all Neolithic levels. Anatolian steppe and highlands provided a more suitable habitat for the great bustards (Siddiq 2018: 411-14). Since an adult male great bustard (*Otis tarda*) could have provided about 15kg of meat, great bustards were a sought after species at particular sites including Körtiktepe, Hallan Çemi, Aşıklı Höyük, and Çatalhöyük (Emra *et al.* 2022; Russell 2019a; Siddiq 2018, 2019; Starkovich and Stiner 2009). Especially in both the Younger Dryas and the Early Holocene phases Körtiktepe the great bustard was the most commonly exploited bird, comprising about one third of the avifaunal remains at the site (Emra *et al.* 2022). Many aquatic birds including pelicans, swans, teals, mallards, ducks, geese, coots, flamingo, cranes, herons, grebes, cormorants, bitterns, egrets, spoonbills, storks, grebes, godwits, ruffs and swamp chicken were hunted mainly as sources of meat (Emra *et al.* 2022; Russell 2019a; Zeder and Spitzer 2016). Many of these species were irregular games but mainly ducks, herons and geese were common targets (Buitenhuis 2008; Russell 2019a). Like bustards, pelicans also could have provided a large amount of meat. Since they were slow due to their body weight and relatively direct flights, they were also common targets for Neolithic hunters. Presenting the fact that the Tigris and Euphrates rivers were flowing all year round as well as locating at one of the most important routes for bird migration, Southeast Anatolia also welcomed greater number of migratory birds including raptors, geese, cranes and ducks both in spring and fall. Rich assemblage of avifauna from Körtiktepe, Hallan Çemi and Göbeklitepe can support this idea (Emra *et al.* 2022; Peters and Schmidt 2004; Zeder and Spitzer 2016). Besides supplying meat, many of the aquatic birds including cranes were also hunted for symbolic purposes (Russell 2019b; Russell and McGowan 2003).

Birds of prey including crows, vultures, falcons, eagles, buzzards, harriers, and owls were also hunted throughout all Neolithic levels (Table 5). However, it has been argued that most of the raptors were hunted for symbolic purposes, supported by the presence of raptor imageries at Göbeklitepe and Çatalhöyük (Peters and Schmidt 2004; Russell 2019b).

Reptiles and amphibians

It is true that certain species of small mammals and reptiles can easily burrow into an archaeological site and die naturally; yet there is direct evidence that different types of reptiles and amphibians were hunted, trapped, consumed and exploited for funerary rituals in Neolithic Anatolia (Jenkins 2009; Özkaya and Coşkun 2011; Starkovich and Stiner 2009). Among them, spur-thighed tortoise (*Testudo graeca*) was perhaps the most exploited reptile throughout Neolithic. Some early Neolithic sites such as Hallan Çemi yielded large quantities of tortoise remains, comprising over 8% of the total identified species (Starkovich and Stiner 2009: 50). Especially about four percent of the tortoise remains at Hallan Çemi were burned, as compared to two percent burning for the entire assemblage. Cut marks were also recorded on tortoise bones at Hallan Çemi (Starkovich and Stiner 2009). Together with spur-thighed tortoise remains both from the Younger Dryas and the Early Holocene layers, the sheltopusik (*Ophisaurus apodus*) and wall lizard (*Lacertidae* sp.) were also identified in the faunal remains of the Early Holocene occupation at Körtiktepe (Emra *et al.* 2022). In particular, at least 16 of the Early Holocene burials at Körtiktepe were observed with tortoise shells deliberately placed near or covering the heads

Table 6. Reptiles and amphibians identified from Neolithic sites in Anatolia.

Species	Common Name	PPNA	PPNB	PN
Anura spp.	Unidentified frogs	×	✓	✓
Bufo viridis	Green toad	×	✓	✓
Clemmys caspica	Striped-neck terrapin	×	×	✓
Colubridae	Colubrid snakes	×	✓	×
Geoemydidae	Eurasian river turtle	✓	×	×
Lacertidae	Wall lizard	✓	×	×
Mauremys sp.	Fresh water turtle	✓	✓	×
Ophisaurus apodus	Legless lizard			
Pelophylax ridibundus	Marsh frog	✓	✓	×
Serpentes	Unidentified sakes	✓	✓	✓
Testudo gracea	Spur-thighed tortoise	✓	✓	✓
Testudo hermanni	Hermann's tortoise	×	×	✓

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of dead (Özkaya and Coşkun 2011, 94). Pond turtles, river turtles, colubrid snakes and some other snakes were also among the common reptiles reported from all Neolithic levels (Table 6).

Amphibians were also commonly found in Neolithic settlements in Anatolia. Particularly significant quantities of frog bones were recorded at the PPNA site of Pınarbaşı, comprising about 84% of the total identified microfauna of the Area A (Jenkins 2009: 105). Marsh frogs, green toads, and a significant number unidentified frog bones were also reported from other PPNB and PN sites including Aşıklı Höyük, Boncuklu Höyük and Can Hasan III (Siddiq 2018: 194, 427). Like tortoises, frogs were also apparently a vital protein supplement to the Neolithic people groups, providing the fact that isotopic data revealed about 70% of meat-diet of female individuals at PPNB site of Boncuklu Höyük was obtained from frogs and small vertebrates[1], while protein source of male individuals were mostly comprised of larger games. Therefore, similar situations could be argued for other sites such as Körtiktepe, Hasankeyf Höyük, Pınarbaşı, and Çatalhöyük, which were located in ecological niches of freshwater lakes and marshlands.

Fish

Throughout the Neolithic southeast, central and western Anatolian regions were blessed with rich habitats for fish, with the advantages of lakes, marshes and rivers. Barbells, carps, scrapers, minnows, nases, chubs, ides, loaches and catfish were the most common identified fish in Neolithic Anatolia (Table 7). These species are still common in freshwater habitats in the region. Although fish bones were reported at most of the Neolithic sites, many of them remained unidentified. Moreover, it was possible that many of the small fish bones unintentionally might have entered at the settlements embedded in

[1] Personal communication with Douglas Baird at 'Kazı Sonuçlari Toplantisi 41', Diyarbakır, 2019.

Table 7. Fish and crabs identified from Neolithic sites in Anatolia.

Species	Common Name	PPNA	PPNB	PN
Acanthobrama marmid	Tigris bream	✓	×	×
Arabibarbus grypus	Shabout	✓	×	×
Barbus barbus	Common barbell	✓	✓	✓
Barbus lacerta	Kura barbell	✓	×	×
Capoeta trutta	Longspine scraper	✓	×	×
Capoeta sp.	Barb/Scraper	×	×	✓
Chondrostoma beysehirense	Beysehir nase	×	×	✓
Chondrostoma regium	Mesopotamian nase	×	×	✓
Chondrostoma spp.	Nases	×	✓	✓
Cobitis spp.	Loaches	×	✓	✓
Cyprinus spp.	Carps	✓	✓	✓
Gobio sp.	Gudgeon	×	×	✓
Isurus sp.	Mackerel shark	×	×	✓
Leuciscus vorax	Tigris asp	✓	×	×
Leuciscus spp.	Eurasian daces	✓	✓	✓
Luciobarbus esocinus	Mangar	✓	×	×
Luciobarbus kersin	Kersin barbel	✓	×	×
Luciobarbus kottelati	Menderes barbel	✓	×	×
Luciobarbus subquincunciatus	Leopard barbel	✓	×	×
Luciobarbus xanthopterus	Yellowfin barbel	✓	×	×
Mastacembelus mastacembelus	Spiny eel	✓	×	×
Planiliza abu	Abu mullet	✓	×	×
Potamon potamios	River crab	✓	×	✓
Pseudophoxinus spp.	Minnow	×	×	✓
Seminemacheilus spp.	Stone loaches	×	×	✓
Siluriformes spp.	Catfishes	✓	×	✓
Sparus aurata	Gilt-head bream	×	×	✓
Piches spp.	Unidentified fish	✓	✓	✓

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the mud used for bricks. Yet, the bones of larger fish such as carp, nases and barbels (Siddiq 2019: 195-231) can be the direct indications of fishing in freshwater ecosystems, including the Tigris, Euphrates and Konya basin.

Figure 2. A group of freshwater fish vertebrae from the PPNA site Hasankeyf Höyük in the Upper Tigris basin (Photo: Miyake et al. *2012: Fig. 9). Not in scale.*

The PPN people groups of Körtiktepe, Hallan Çemi, Gusir Höyük and Hasankeyf Höyük exploited marshier and deltaic type environment where the Tigris and Batman Creek flooded large areas, creating alluvial fans, small lakes and scattered small wetlands in the vast semi-plain region. This overall helped Neolithic groups to access notable quantities of fish, crabs, freshwater snails and oysters (Özkaya *et al.* 2013). The faunal assemblages from both the Younger Dryas and the Early Holocene phases at Körtiktepe indicate the exploitation of a variety of fish including Mesopotamian bream, shabout, Tigris asp, kersin barbell, Mesopotamian barbell, Menderes barbell, yellowfin barbell, mangar, longspine scraper, Euphrates spiny eel and abu mullet, of all were freshwater taxa (Emra *et al.* 2022). In both phases the vast majority of the fish remains belonged to the carp family with the most commonly identified species being the mangar (*Luciobarbus esocinus*), which can reach lengths of over 3 meters and weights of in excess of 150 kilograms. A small number of especially large vertebrae from the Early Holocene layers suggests that mangar of this size were being caught at Körtiktepe (Emra *et al.* 2022). A large number of fish bones were also identified in faunal assemblages of Hasankeyf Höyük (Figure 2). In addition to the rich ichthyofaunal remains, particularly isotope analysis on human skeletons also suggested that intensive fish consumption was associated with the PPNA settlements in South-eastern Anatolia, including Körtiktepe and Hasankeyf Höyük in the Upper Tigris basin (Itahashi *et al.* 2017; Koruyucu *et al.* 2018).

Among the later Neolithic sites perhaps the most elaborate fish remains came from Çatalhöyük, yielding over 62,000 identified specimens (Van Neer *et al.* 2013: 314). A large number of fish bones also reported from the late Neolithic site of Tell Kurdu, comprising about 5% of total identified faunal assemblage (Özbal *et al.* 2004: 89). On the other hand, the rarity of fish source in some isotope studies (e.g., Pearson *et al.* 2013) may indicate that some Neolithic groups perhaps did not depend on fish for their regular diet.

Molluscs

A great variety of freshwater and marine molluscs were exploited in all levels of Neolithic Anatolia, comprising about 50 different species (Table 8). Shells, tusk shells, oysters, sea snails, freshwater snails, land snails and murex were the most common among them. Some of the molluscs such as *Conus mediterraneus*, *Columbella rustica*, *Nassarius gibbosulus*, and *Antalis* spp., and *Dentalium* sp. were brought from distant localities and used as ornamental objects and sacred burial goods (Baird *et al.* 2018; Bar-Yosef Mayer 2013; Özkaya 2009). The records of thousands freshwater snails and marine shell beads at Körtiktepe (which are the subject of detail studies) can be a potential example for this (Figure 3). However, at many sites molluscs were collected from the local environment, and mainly for consumption (Özbal *et al.* 2004: 68-69). For example, among a variety of freshwater shells particularly edible bivalves (*Unio* spp.) were preferred in all Neolithic levels (Table 8). A number of land snail species, including edible land snails and edible garden snails, were also exploited at some sites, including Çatalhöyük (Bar-Yosef Mayer 2013: 333) and Ilıpınar (Buitenhuis 2008: 307).

Figure 3. Part of the hundred thousands of freshwater and marine shells exploited and used as beads in the funerary rituals at the Younger Dryas–Early Holocene site of Körtiktepe in the Upper Tigris basin (Photo: V. Özkaya).

TABLE 8. MOST COMMON MOLLUSKS EXPLOITED IN NEOLITHIC ANATOLIA.

Type	Species	PPNA	PPNB	PN
Marine mollusks	*Ancilla* sp.	×	×	✓
	Antalis spp.	✓	✓	×
	Arcularia gibbosula	×	×	✓
	Cerastoderma edule	×	×	✓
	Cerithium vulgatum	×	×	✓
	Columbella rustica	✓	✓	✓
	Conus mediterraneus	×	✓	✓
	Cyprae	×	×	✓
	Dentalium	✓	×	✓
	Donax trunculus	×	×	✓
	Flexopecten glaber	×	×	✓
	Luria lurida	×	×	✓
	Monodonta turbinata	×	×	✓
	Murex trunculus	×	✓	✓
	Mytilus edulis	×	×	✓
	Mytilus galloprovincialis	×	×	✓
	Nassarius gibbosulus	✓	✓	×
	Neverita josephinia	×	×	✓
	Ostrea edulis	×	×	✓
	Strombus bubonius	×	×	✓
	Thais haemastoma	×	×	✓
Freshwater mollusks	*Bithynia leachi*	×	×	✓
	Bythinella spp.	×	✓	✓
	Dreissena sp.	×	-	✓
	Fagotia esperi	×	✓	✓
	Gyraulus crista	×	✓	✓
	Lymnaea stagnalis	×	✓	✓
	Melanopsis sp.	×	×	✓
	Pisidium amnicum	×	×	✓
	Planorbarius corneus	×	✓	✓
	Planorbis carinatus	×	✓	✓
	Radix auricularia	×	✓	✓
	Stagnicola palustris	×	✓	✓
	Theodoxus sp.	×	×	✓
	Unio mancus	×	×	✓
	Unio tigridis	✓	×	✓
	Unio valves	✓	×	✓
	Valvata piscinalis	×	✓	✓
	Borlumastus yildirimi	×	✓	✓
Land snails	*Cecilioides* sp.	×	✓	✓
	Helix aspersa	×	×	✓
	Helix sp.	×	×	✓
	Monacha rothii	×	✓	✓
	Oxychilus sp.	×	×	✓
	Vallonia pulchella	×	✓	✓
	Viviparus viviparus	×	✓	✓
	Xeropicta derbentina	×	✓	✓

PPNA – Pre-Pottery Neolithic A; PPNB – Pre-Pottery Neolithic B; PN – Pottery Neolithic

Tools and techniques

There were some regional variations in using raw materials. For example, while flint was the primary raw materials in the Tigris and the Euphrates Basins (e.g., Miyake *et al.* 2012; Özkaya and Coşkun 2011), obsidian was the primary source of raw materials for the manufacture of hunting tools in Central Anatolia (e.g., Bıçakçı *et al.* 2007; French 1968; Mellaart 1970; Özbaşaran *et al.* 2012; Öztan 2012). However, basic hunting techniques and the types of the tool used were more or less common throughout different levels and geographies. Besides the group hunting activities (Perkins and Daly 1968), the Neolithic people groups often chose shallow places of river basin, marshy areas and narrow passages with large concentrations of prey (Bang-Andersen 2009; Emra *et al.* 2022; Deraniyagala 1996; Carruthers 2003; Mannermaa *et al.* 2008). Regular migration routes and drinking water sources of particular ungulates were preferably chosen (Jordhoy 2008). Knowledge of annual migration, seasonal movements and hibernating places of some specific species such as bear and tortoises was also vital. Overall, direct evidence of hunting, trapping and fishing techniques are scarce. Yet, artifacts such as spears, projectile points, sling stones, fishing hooks, nets, net sinkers and baskets can provide some facts regarding possible hunting and fishing techniques.

Direct and group attack was probably the most common method to hunt large mammals such as aurochs, horses or bears. It is likely that hunters used strong, deadly and fastest weapons such as long-tipped spears, wooden spears and arrows. Especially hunting lesions embedded in a wild sheep cervical vertebra at Hasankeyf Höyük, a wild sheep scapula of Gusir Höyük, an aurochs humerus of Göbeklitepe, and an aurochs scapula of Çatalhöyük can be the significant facts regarding this (Pöllath *et al.* 2018). A one meter-long draft could also help the hunters to launch their spear at about 80km per hour, providing that the projectile point the hunter applied was still embedded inside the aurochs bone of Göbeklitepe when it was excavated (Figure 4). Similar to the Neolithic groups of northern Syria (Legge and Rowley-Conwy 1987), it was also possible that at least the Neolithic groups in Southeast Anatolia used desert

Figure 4. Projectile point embedded in an aurochs humerus at Göbeklitepe in the Middle Euphrates basin (Photo: Pöllath et al. 2018: Fig. 5).

kites for hunting a larger group of ungulates such as gazelle, asses and caprines at a time. Given possible iconographic evidence for the use of nets for hunting and trapping wild sheep at Göbeklitepe (Schmidt 2007: 92), it is possible to argue that many other Neolithic groups also captured medium sized ungulates using nets and kite like structures. Sling stones were recorded from all Neolithic levels, and although often may have had some other functions such as pot stands or heating stones (Atalay 2005: 158), it is likely that sling was preferably used for hunting small and fast-moving animals such as foxes, hares and birds (e.g., Esin 1998).

Hunting big games were often difficult, risky and needed greater group efforts. Therefore, hunting, trapping and capturing small mammals, reptiles, frogs and birds were likely to be more frequent activities to secure regular supply of meat. However, except for faunal remains and very specific assemblages such as nets and baskets, it is extremely difficult to trace trapping related material culture. Similar to baskets and nets, probably traps were also made from available materials such as animal fur, plant fibres, reed, and wood. Some local pastoral groups in Anatolia still make various traps using sheep wool, camel and goat fur, ropes and reed, for capturing rodents, aquatic birds and hares (Siddiq *et al.* 2019; Siddiq and Şanlı 2020). Many also apply smoke to capture burrow animals such as moles, voles, hares, badgers, foxes and porcupines (field observations by A. B. Siddiq). Observing the very similar types of microfaunal remains, it is arguable that similar types of trapping techniques might have been used by Neolithic hunters.

A significant number of bone-made ornamental fishhooks were used as burials goods at many sites including Körtiktepe (Özkaya and Coşkun 2011; Özkaya *et al.* 2013), Aşıklı Höyük (Esin 1998) and Çatalhöyük (Van Neer *et al.* 2013), indicating that fishhooks were one of the fishing gears in Neolithic

Figure 5. Part of a large assemblage of fishing weights and sinkers unearthed from both the Younger Dryas and the Early Holocene phases at Körtiktepe (Photo: V. Özkaya).

Anatolia. Baskets and nets were also among the primary equipment to catch fish, capture crabs and frogs, and collect snails. A wide variety of fishing techniques was evident by diverse types of artifacts from Körtiktepe. Depending on the size and types of fish, the Körtiktepe people manufactured bone-made fishhooks in different sizes and types (Özkaya *et al.* 2013: 32). The large vertebra bones of mangar — which can reach over 3 meters long and over 150 kilograms — from the Early Holocene layers at Körtiktepe confirm that the sedentary hunter-gatherer-fishers at Körtiktepe were skilled enough to catch of this size (Emra *et al.* 2022). A large number of stone fishing weights and sinkers from Körtiktepe also indicate manufacturing of different types of nets for different fishing techniques (Figure 5). Freshwater molluscs and most of the fishes in Çatalhöyük were also caught from nearby rivers and marshy areas by using fishing hooks, fine nets and baskets (Van Neer *et al.* 2013). Evidence of mackerel shark was reported at the island site of Uğurlu Höyük (Atici *et al.* 2017) — which could be an indication of additional techniques by the Neolithic groups in coastal regions including the Marmara and the Mediterranean.

Roles of dog

Domestic dogs were present in almost every Neolithic site in Anatolia. Some settlements, including Boncuklu Höyük, Çatalhöyük, Ilipinar and Ulucak Höyük yielded significant number of dog bones, often comprised up to 11% of the total NISP (Buitenhuis 2008; Çakırlar 2012; Russell and Martin 2005; Siddiq 2018: 217). Surprisingly, no cut marks have yet been observed on any dog bones, which might direct that cynophagy was not a common practice in in Neolithic Anatolia. Overall zooarchaeological observation indicates that dogs were widely used in hunting activities (Kansa *et al.* 2009; Perkins and Daly 1968; Peters and Schmidt 2004; Russell and Meece 2006). Unambiguous evidence of the hunting dogs can be found in many other parts of West Asia since the 10th to the 9th millennium BC (e.g., Guagnin *et al.* 2018). Record of dog burial was also present at Çayönü in Southeast Anatolia, where a dog was buried close to a human burial (Özdoğan 1999). Although other sites did not yield any dog burials, presence of dog bones in all Neolithic phases and some distinctive records including the dog painting at Çatalhöyük (Russell and Meece 2006) as well as posthumous treatments of dog and human remains in the Death Pit of Domuztepe (Kansa *et al.* 2009: 911) can also be the indicators for closer hunter-dog relationships in Neolithic Anatolia.

Hunting rituals

Significant number of records suggests that certain animal species were hunted for particular rituals. There are indirect indications of seasonal and ritual feasts and sacrifices throughout all Neolithic levels (e.g., Dietrich *et al.* 2012; Russell 2012). However, except for some records in special activity sites (e.g., PPNB Musular in Central Anatolia), direct evidence of hunting ritual and feast is very rare. The depictions and direct ritual/burial associations of mammals such as goat, dog, big cat, horse/ass, fox, weasel, fallow deer, red deer; birds such as vulture, crane, crow as well as many other species including fish, tortoise, snake and spiders may suggest that hunting many of these species were vital for the completions of particular rites and rituals (Kansa *et al.* 2009: 911; Miyake *et al.* 2012; Özkaya 2009; Özkaya and Coşkun 2011: 94; Öztan 2012; Pawłowska and Marciszak 2018; Peters and Schmidt 2004; Russell 2019b; Russell and McGowan 2003; Russell and Meece 2006; Siddiq 2019: 142-160).

In particular, aurochs cult at Musular (Özbaşaran *et al.* 2012), and two bull paintings at Çatalhöyük (Figure 6), can be the good examples for direct evidence of hunting rituals. Aurochs comprised about

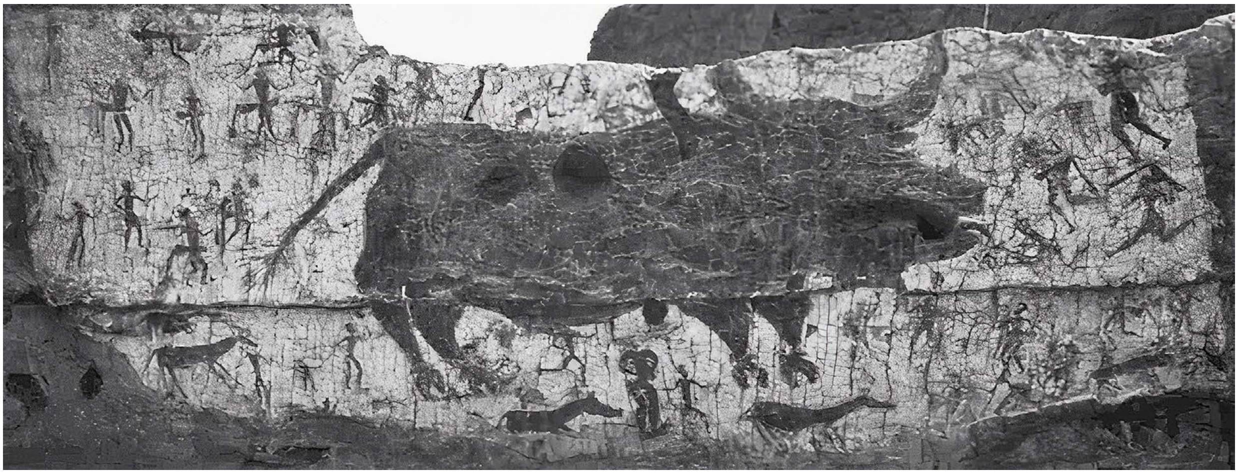

Figure 6. An extremely large bull surrounded by human groups with various weapons in their hands; this wall painting at Çatalhöyük in central Anatolia (Turkey) has often been interpreted to be associated with hunting ritual (Photo: Russell 2012: Fig. 2).

57% of total identified fauna at Musular, and the special building at the site was associated feasts and aurochs hunting ritual (Özbaşaran *et al.* 2012). In Çatalhöyük, aurochs were the ancestors of the house and the protectors of the dead (Russell and Meece 2006). Examples of plastered aurochs skulls and horn cores were also recorded at Çatalhöyük (Russell 2012). Besides, perhaps because of great taboo, aurochs were not domesticated in Central Anatolia, even after a thousand year of their domestication in Southeast Anatolia (Siddiq 2018: 440-441). Stylized cattle heads and horns as well as deer were depicted in a number of early to late Neolithic sites including Göbeklitepe (Peters and Schmidt 2004; Schmidt 2012), Köşk Höyük (Öztan 2012) and Domuztepe (Kansa *et al.* 2009: 911). Therefore, overall evidence may inspire the thought that rituals and feast were vital parts for Neolithic hunting activities in Anatolia. Yet, the factual evidence for this is still very weak.

Seasonal variation in hunting and fishing

Similar to present day, seasonal variations in hunting were inevitable in Neolithic Anatolia. The busy movements of mammal hunting probably decreased in mid-winter since there was a diversity of steppe, forests, wetlands and meadows. However, hunting birds were likely to be common throughout the late fall, winter and spring; since marshy areas were full of migratory birds including ducks, geese, loons, crakes, herons, cranes, flamingos and pelicans in these seasons (e.g., Carruthers 2003; Emra *et al*. 2022; Siddiq 2018: 170-79). Raptors such as eagles and vultures were probably flying over human habitations and nested surrounding mountains; hence, spring and summer would be the perfect seasons for hunting raptors. The dry hilly regions hosted large-scale terrestrial birds such as bustards, partridges and quails. These meat-bearing birds could be hunted anytime of the year, but like present days, they were probably hunted most during mid-spring and fall (Siddiq 2018: 170-79). Carrion birds such as crows and magpies commonly lived near the settlements, probably were actively seen and hunted throughout the year.

Egg collection was also a very important seasonal activity. A large assemblage of geese and duck eggshells in Çatalhöyük may support this idea (Sidell and Scudder 2005). Busy season of egg collection was probably between February and May since this was the breeding season for most of the birds including winter migrants (Siddiq 2018: 397-414). Commonly preferred small mammals such as fox and hare could be hunted throughout the year; but were hunted more in the spring and throughout summer because of an increase in population. Rodents such as mice and mole were breeding more in the summer and fall (Siddiq 2018: 327-335), particularly following the ripening of wild grain, and offered plenty of food for fox, owls and other large raptors.

Large games were more compatible with seasonal changes than the small animals. Wild horses and wild asses preferred grazing across the meadows, steppes, hills and open grasslands; deer preferred forest areas and semi-open woodlands; aurochs and wild boars roamed in marshlands, open oaks and dense woodland areas; and caprines such as mountain goats and wild sheep were common in the valleys, hills and mountain foothill areas (Siddiq 2018: 243-281). Although the ungulates were available throughout the year, the hunting season probably would not begin until the end of grain harvest from late spring to summer (Siddiq 2018: 168-79). Particularly deer skulls at Çatalhöyük showed that the antlers had not yet been shed off the skulls while hunting, indicating the hunt between late summer and early fall (Russell and Martin 2005). Aurochs, wild goats, wild sheep and gazelles were also probably hunted in the summer and fall, but before the arrival of winter, since the animals might feed themselves to the best and becoming their fattest, in preparation of upcoming winter (Siddiq 2018: 442-443).

Except the burrow animals, most of the carnivore mammals roamed in the grasslands, forests and the mountains during the winter (Siddiq 2018. 286-313). Most of the carnivores could be hunted any season of the year, but likely to prefer in the fall when the cubs were grown juvenile (e.g., Carruthers 2003: 159). On the other hand, hunting some winter-hibernating animals including bears and tortoises would be a secure and profitable activity in early winter (Siddiq 2018: 313, 423-424).

Although fish were available throughout the year, fishing probably did not occur during the periods of maximum flood and extremely cold winter months. Catching fish and collecting molluscs from mid spring and throughout the fall would be a preferred activity because of abundant and larger supply (e.g., Van Neer *et al.* 2013). Similar seasonal conditions were also applicable for the exploitation of other aquatic species.

Conclusion

Hunting and fishing were the only means of meat diets in Early Neolithic Anatolia for about 1500 years, throughout the Pre-Pottery Neolithic A and early phase of Pre-Pottery Neolithic B. The traditions remained major means of subsistence alongside the farming in Pottery Neolithic. However, hunting in distinct ecological niches for thousands of years might have brought heavy pressure and rapid decline in particular bovid species in the local environment. This might force the early sedentary people groups to depend more on fish, molluscs and a variety of microfauna. Over time, large ungulates became more valuable, and in order to cope with this crisis, the Neolithic people gradually preferred group hunting with more effective strategies — for avoiding the dangers and securing the hunt. This also encouraged gradual increase in frequency, totemic obligations and complexities in hunting rituals and animal sacrifice, as observed in the later Neolithic sites of Musular, Çatalhöyük and Domuztepe (Kansa *et al.* 2009; Özbaşaran *et al.* 2012; Russell 2012).

There was also gradual dependency on domestic ungulates following the PPNB. However, beyond the time and regional distinctions in Anatolia, there was no change in the overall number of species hunted in the PPNA and Pottery Neolithic. Moreover, faunal records of some late Neolithic sites showed an increase in the number of exploited wild taxa, including birds, small mammals, amphibians, fish and molluscs (Buitenhuis 2008; Jenkins 2009; Özbal *et al.* 2004; Russell 2019a; Van Neer *et al.* 2013). Perhaps advances in hunting tools and techniques as well as increasing demands with growing human population were the reasons behind this. Over time, many particular taxa including cranes, vultures, aurochs and foxes also became vital for symbolism and ritual activities (Pawłowska and Marciszak 2018; Russell 2012, 2019) — hence hunting and exploiting these species was also inseparable.

Natural forces including changes in weather, flood, snowfall, or appearance of green grasslands in the local ecosystems were absolutely not under human control. Yet, it is likely that people were waiting and had plans for these natural changes. Rather than automatically responding to natural resources, the reactions to expected and unexpected seasonal events were the products of relationships between individuals, families or clan groups, which generally occurred within the scopes of broader socio-religious and ritual traditions. This included the norms of how and where to hunt animals and go fishing; when to collect secondary animal products such as antlers and eggs; when to store dried meat for winter or when to produce hunting, trapping and fishing gears. Hunting was also valid for significant survival techniques in socio-cultural forms, including animal symbolism, rituals and seasonal feasts.

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Hunting in the Early Chalcolithic of Cappadocia, Central Turkey: Evidence from Çiftlik-Tepecik

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Abstract

Çiftlik-Tepecik is a Pre-Pottery Neolithic, later Neolithic, and Early Chalcolithic site located in the Melendiz Valley in Central Anatolia. Excavations have been carried out at the site since 2001 under the direction of Professor Erhan Biçakçi of Istanbul University. While Early Neolithic sites in the Melendiz Valley region, such as Aşikli, have produced faunal assemblages that include 80-90% domestic caprines, the Early Chalcolithic levels (6100-5800 cal BCE) from Tepecik include 26% wild mammals and birds. The range of wild species includes both wild horses (*Equus ferus*) and hydruntines (*Equus hemionus hydruntinus*), as well as aurochs, wild boar, red deer, roe deer, and smaller wild mammals including foxes and hares. This paper will explore the role of both large and small mammal hunting in the agro-pastoral economy at Tepecik based on the faunal remains that were recovered during the 2013 excavation season.

Keywords: Hunting; Early Chalcolithic; Çiftlik-Tepecik

Introduction

Çiftlik-Tepecik is a Pre-Pottery Neolithic, later Neolithic, and Early Chalcolithic site located in the Melendiz Valley in Central Anatolia. The Melndiz is a small river that runs past Tepecik, the nearby early Neolithic site is Aşikli, and terminates in the salt lake known as Gölü Tuz. Excavations have been carried out at the site since 2001 under the direction of Professor Erhan Biçakçi of Istanbul University since 2001. When we joined the Tepecik excavation project in 2014, our goal was to develop an integrated study of the unmodified faunal remains and worked bone objects from the excavation. Preliminary reports on the modified equid phalanges and other worked bone objects have recently been published (Campana and Crabtree 2019; Crabtree and Campana 2018). The goals for our study of the unmodified animal bones include reconstruction of the animal husbandry practices, hunting patterns, and diet from Tepecik from the Aceramic Neolithic through the Chalcolithic periods. We began by studying the animal bone remains that were recovered from the Early Chalcolithic contexts that have been excavated during recent field seasons. This paper will focus on the evidence for large and small mammal hunting based on the Early Chalcolithic animal bones that were excavated during the 2013 field season[1].

[1] The animal bone remains described in this paper are a small portion of the overall faunal assemblage from Çiftlik-Tepecik. While excavation at the site began in 2001, we did not join the excavation team until 2014. In addition, the analysis of the fauna recovered from Turkish excavations must be carried out on site while the excavation is in progress. As a result, we have only identified a small proportion of the animal bones that have been recovered from this excavation project.

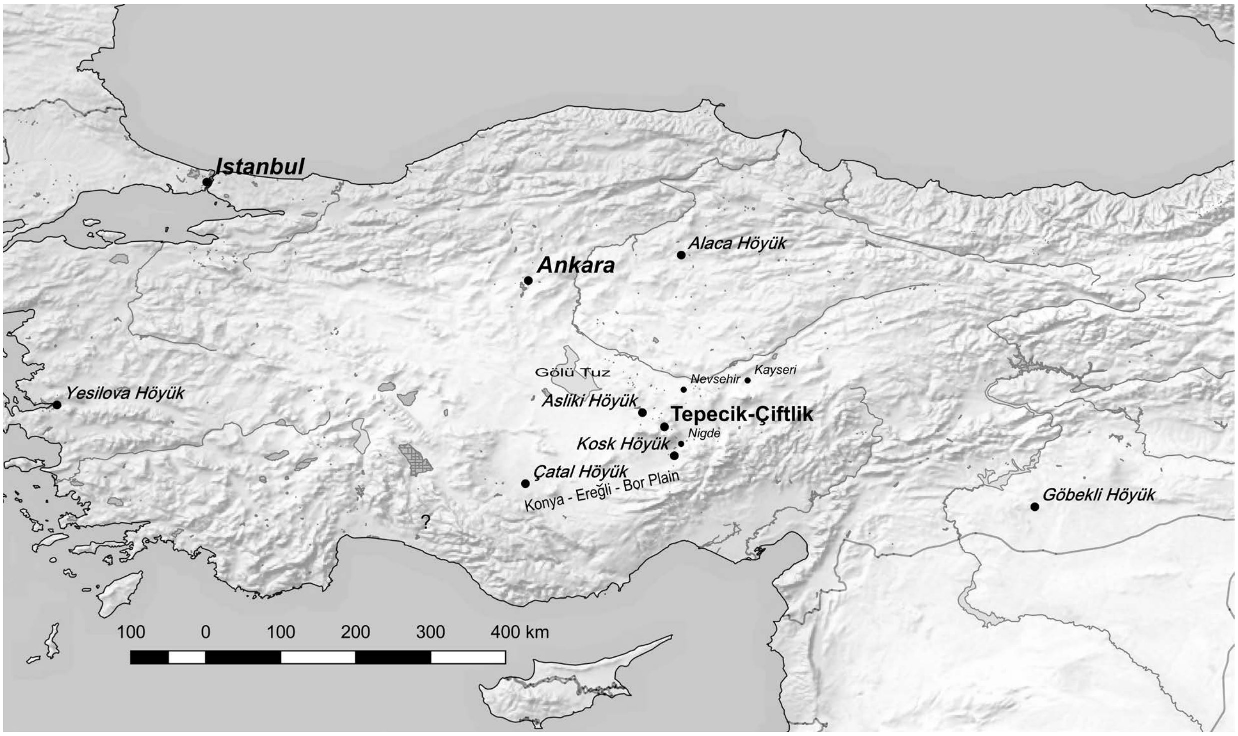

Figure 1. Location of the Tepecik site

Materials and Methods

The animal bones described in this paper were analyzed during the 2014 and 2015 excavation seasons at Tepecik. We are currently working to build a comparative collection on the site, but the bones described here were primarily identified using our collective experience, photographs, and standard identification manuals (Schmid 1972; Cohen and Serjeantson 1996; Eisenmann 1986; Boessneck *et al.* 1964; Payne 1985; Halstead *et al.* 2002; Zeder and Lapham 2010; Zeder and Pilaar 2010). Any unusual specimens that could not be identified in the field were photographed for further study.

In addition to the basic identifications (animal species and body part), the side and portion of the bone present was recorded for each bone or bone fragment, as well as taphonomic information, such as evidence for burning, staining, or weathering. Measurements were recorded following the recommendations of von den Driesch (1976). Ageing data based on epiphyseal fusion were recorded for all species. In addition, ageing data based on dental eruption and wear were recorded following Grant (1982) and Payne (1973) for cattle, sheep, goats, and pigs. The data were recorded using FAUNA, a specialized zooarchaeological database (Campana 2010).

Animal Species Identified

The mammal species identified from the 2013 excavations are shown in Table 1. The most common species recovered from the Chalcolithic contexts were domestic caprines, with sheep outnumbering goats by a ratio of approximately 3 to 1. Domestic cattle were far less common than the caprines. A small number of domestic dog remains were also identified. The striking features of this assemblage,

Table 1: Mammal and Bird Taxa identified from the 2013 Excavations at Tepecik

Taxon	NISP
Domestic Mammals	
Sheep (*Ovis aries*)	488
Goat (*Capra hircus*)	152
Sheep/Goat (*Ovis/Capra*)	2007
Cattle (*Bos taurus*)	372
Dog (*Canis familiaris*)	72
Wild Mammals	
Pig (*Sus scrofa*)	48
Red deer (C*ervus elaphus*)	189
Roe deer (*Capreolus capreolus*)	49
Wild Horse (*Equus ferus*)	10
Onager (*Equus hemionus*)	4
Equid	198
Large equid (cf. *Equus ferus*)	101
Small equid (cf. *Equus hemionus*)	106
Wild cattle (*Bos primigenius*)	2
Wild sheep (*Ovis orientalis*)	2
Brown bear (*Ursus arctos*)	10
Wolf (*Canis lupus*)	2
Red fox (*Vulpes vulpes*)	35
Badger (*Meles meles*)	2
Pine marten (*Martes martes*)	2
Brown hare (*Lepus europaeus*)	274
Hedgehog (*Erinaceus* sp.)	3
Wild Birds	
Crane (*Grus grus*)	1
Chukar partridge (*Alectoris chukar*)	2
Raptor (Falconifromes)	2
Ducks (Anatidae)	1

however, are the numbers and diversity of the wild mammal species that are present. Among the large mammals, red deer (*Cervus elaphus*), wild horse (*Equus ferus*), hydruntines (*Equus hemionus hydruntinus*), roe deer (*Capreolus capreolus*), and wild boar (*Sus scrofa*) are well represented, along with a small number of remains of brown bear (*Ursus arctos*) and the remains of possible wild sheep (*Ovis orientalis*) and wild cattle (*Bos primigenius*). In addition, two large canine remains may be the fragmentary bones of wolf (*Canis lupus*). Hares (*Lepus europaeus*) are the most common small mammals, but a range of other small mammals including foxes (*Vulpes vulpes*), badgers (*Meles meles*), and pine martens (*Martes martes*) may have been hunted for their pelts. Comments on each of the major taxa and groups of taxa follow.

Sheep (Ovis) and Goats (Capra)

The 2013 assemblage from Tepecik yielded 2649 sheep and goat bones. Most were indeterminate sheep/goat elements that lacked distinctive morphology. Of those that could be distinguished to species 488 were sheep remains and 152 were goat bones. An additional two bones were identified as possible wild sheep (*Ovis orientalis*). Caprines were the most common species in the 2013 assemblage and clearly represent the mainstays of the herding economy.

Cattle (Bos)

Cattle play a relatively small role in the Tepecik faunal economy. Most of the bones appear to be the remains of domesticated cattle, but two were identified as possible aurochs (*Bos primigenius*) on the basis of their size. Cattle require richer pasturage than sheep and goats do, and areas along the tributaries of the Melendiz River would have been particularly well suited to cattle husbandry.

Pigs (Sus scrofa)

Arbuckle *et al*. (2014) reported that pig remains are quite rare in central Anatolia, and these bones are generally comparable in size to wild boar until the 5th millennium cal BCE. The few pig remains that were recovered from the 2013 season at Tepecik are also quite large. A single lower third molar had a maximum length of 43.1 mm which places it outside the range of domestic pigs (Evin *et al.* 2014). Albarella *et al*. (2009: 130) note that the lengths of the lower third molars in wild boar from the Middle East are consistently over 40 mm. The greatest lateral lengths (GLl) of three Tepecik *Sus* astragali are 55.0, 56.8, and 51.7 mm, placing them well within the range of wild boar. Boars generally prefer wooded areas, and the slopes of the Göllüdag Mountains, a major source of obsidian, would have been forested in prehistory. Çiftlik-Tepecik probably owes its existence to its proximity to these obsidian sources. Boar hunting may have been combined with obsidian collection.

Equids: Wild Horse (Equus ferus) and Hydruntines[2] (Equus hemionus hydruntinus)

One of the striking features of the Early Chalcolithic faunal assemblage is the presence of large numbers of wild equid remains, including both wild horses (*Equus ferus*) and hydruntines (*Equus hemionus hydruntinus*). A total of 419 equid remains was recovered from the 2013 faunal assemblage. A small number of equid lower cheek teeth could be identified as wild horse (N = 10) or hydruntine (N = 4) based on dental morphology following Eisenmann (1986; see also Hite 2008). Many of the other limb bone elements were identified as small equid (probable hydruntine) and large equid (probable wild horse). Fragmentary pieces (N = 198) were simply described as equid.

Measurements on the equid limb bones showed that they fall into two distinctive size groupings. Table 2 shows the measurements taken on the distal portion of the main metacarpus. The table shows that the measurements fall into two non-overlapping groups, each with a low co-efficient of variation

[2] There has been some disagreement about the systematics of the smaller wild equids in Neolithic and Chalcolithic Turkey. Steiner *et al*. (2014) identify them as onager (*Equus hemionus*), while Arbuckle (2012) previously identified them as *Equus hydruntinus*, the European wild ass. DNA studies and analysis of the limb bones suggest that the two taxa are closely related (Orlando *et al.* 2006). I have identified them as *Equus hemionus hydruntinus* following Bennett *et al.* (2017).

Table 2: Measurements taken on the distal main metacarpus of large (probable Equus ferus) and small (probable Equus hemionus hydruntinus) equids from the 2013 excavations at Tepecik

Measurement	Mean	Min.	Max.	s.d.	c.v.	N
Large Equid Bd	47.6	45.5	50.5	1.6	2.5	12
Small Equid Bd	39.1	38.4	39.4	0.5	0.2	4
Large Equid Dd	36.8	35.8	37.8	0.7	0.4	10
Small Equid Dd	29.1	28.7	30.1	0.7	0.4	4

(c.v.). Since equids do not show a great deal of sexual dimorphism (van Asperen 2013), it is likely that the large and small equid groups do represent wild horses and hydruntines, respectively. These data suggest that the Tepecik assemblage includes roughly equal numbers of wild horses and hydruntines. Similarly, nearly equal numbers of horse and hydruntine first phalanges were also used to make the "idols" (Campana and Crabtree 2019). The "idols" are slightly modified first phalanges that have a somewhat human appearance. Wild horses and hydruntines are grazers, and Central Anatolia was home to extensive areas of steppe that would have supported these animals. Wild horse remains were also recovered from the Neolithic levels at Çatalhöyük and Aşikli (Martin 2000). The southern Cappadocia region was also well-known for horse-breeding in later historic times (Balza 2013), although recent research has shown that the Cappadocian wild horses are not ancestral to later domestic horses in the region (Guimaraes *et al.* 2020).

Red Deer (Cervus elaphus) and Roe Deer (Capreolus capreolus)

Substantial numbers of red deer bones (N = 189) and smaller numbers of roe deer remains (N = 49) were recovered from the 2013 faunal assemblage. Both species prefer forested environments, such as the ones that would have been available on the slopes of the Göllüdag. A small number of worked bone objects were also made of red deer antler.

Bear (Ursus arctos)

Only 10 fragments of brown bear were recovered from the 2013 faunal assemblage, however, additional bear bones were clearly present in the faunal material that was recovered during the 2015 excavation season. Bears are the largest carnivores present in Turkey today. They are a protected species, but the forested habitats they prefer are increasingly fragmented in modern Turkey (Can and Togan 2004). Bears do prey on cattle and sheep, and they may have posed a threat to the Tepecik livestock during the Early Chalcolithic.

Hares (Lepus europaeus) and Foxes (Vulpes vulpes)

The red fox (*Vulpes vulpes*) and the brown hare (*Lepus europaeus*) are some of the most widespread mammals in the world. The red fox is the most common small carnivore at Tepecik, and 35 fox bones were recovered from the 2013 excavations. Brown hares are exceptionally common in the 2013 faunal assemblage (N = 274), and today foxes are main predators for hares in Europe (Dimirbaş 2015). The abundance of hares is positively correlated with arable land and habitat heterogeneity (Dimirbaş 2015: 518), and this may explain their high numbers at Tepecik.

Other Carnivores

Dogs (*Canis familiaris*) were the most numerous small carnivores in the 2013 faunal sample. In addition, two possible wolf (*Canis lupus*) bones were also identified. Small numbers of bones of mustelids, including pine marten (*Martes martes*) and badger (*Meles meles*), were also recovered.

Birds

Bird bones were relatively rare in the 2013 assemblage. A small number of bones of cranes, partridges, ducks and raptors were identified. A similar range of birds was recovered from Level 4 at Aşikli (Stiner *et al*. 2014: 8405).

Discussion

At the nearby Early Neolithic site of Aşkili, Steiner *et al*. (2014) have documented a shift from a broadly-based diet to an economy based primarily on caprine herding between 9000 and 8200 cal BCE. By the end of the sequence, 85-90% of the bones are those of caprines, primarily sheep. While the economy of Chalcolithic Tepecik is also based on caprine husbandry combined with cattle herding, the Tepecik economy includes a substantial contribution from hunting a range of large and small mammals. If we divide the identified faunal remains into domestic caprines, domestic cattle, and identified wild birds and mammals, it is clear that about two-thirds (64.8%) of the bones come from domestic sheep and goats, while an additional 9.2% come from large domestic cattle. Species ratios are based on NISP, following Lyman (2008). Wild mammals and birds make up the other 26% of the assemblage, a figure that is much higher than is typically seen in neighboring Turkish Neolithic sites such as Aşikli.

The closest comparandum for the 2013 Chalcolithic assemblage from Tepecik is the Early Chalcolithic faunal collection from Koşk Höyük which is located on the eastern margins of the Konya-Ereğli-Bor Plain. The faunal assemblage Koşk Höyük includes proportions of caprines, cattle, and wild animals that are quite similar to the proportions seen at Tepecik (Arbuckle 2012). The main difference is that nearly all the wild mammals seen at Koşk are wild equids, while the Tepecik assemblage includes far more deer. The forested mountains may have provided greater access to deer and other forest species at Çiftlik-Tepecik.

The reasons for the increase in hunting seen in the Tepecik Chalcolithic when compared to the early Neolithic data from nearby Aşkili are unclear at present. The question of whether this shift is a reflection of social, economic, and/or ecological changes in the Melendiz region is a problem that requires further research. A substantial assemblage of Chalcolithic fauna was recovered from the 2015 excavation season, and the identification and analysis of these remains, when combined with other lines of archaeological and environmental evidence, may allow us to answer this important question.

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The "Call of the Wild": Hunting, fishing and foraging in the early farming villages of Northeastern Greece - environment, technologies, and culture

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Abstract

Focusing on the site of Sitagroi in northeast Greece, we evaluate the evidence for and significance of hunting, fishing, collecting, and foraging in the context of a fully agrarian neolithic village. Our thesis is that the villagers—men, women, and children—purposefully sought out wild resources for practical reasons, while such activities also reflected their perceptions of the natural world, decision making, cooperating, sharing, negotiating, learning traditions, creating material culture and surrounding it with symbolic value. Through the spectrum of available wild resources, we consider the villagers' choices of animals for food and sport, the use of by-products for tools and in various crafts, and the artistic representation of wildlife. We consider the technology of the hunt, the interconnectedness with other activities, and the functional spectrum of the by-products. Social and cultural evaluations of the "wild" are further explored in dietary/culinary preferences, the trading of commodities, the inferred intra- and inter-site interactions, and even gendered associations deduced from imagery. Beyond Sitagroi, our discussion includes other sites in the northern Aegean and comparanda from Old Europe and the New World.

Keywords: Hunting; Fishing; Foraging; Neolithic; Chalcolithic; Subsistence; Craft; Trade; Symbolism

Tastes for the wild

We borrow our title, "Call of the Wild" from Jack London's celebrated novel (1903) about a domestic dog, drawn back to his feral ancestors in that wild Alaskan Gold Rush. However, we move in a less novelistic direction, in the tracks of prehistoric settled farmers who were nevertheless drawn to the wilderness beyond.

In the context of an agrarian life, the neolithic villagers in northeast Greece —men, women, and children—purposefully sought out wild resources. Their activities involved not only practical procurement, but also cultural aspects encompassing perceptions of the natural world, decision making, cooperating and/or competing, sharing, socializing, learning traditions, creating material culture and surrounding it with symbolic value (cf. Helms 1993: 153–157; Ingold 2000; Kent 1989a; 1989b). Whereas the cultural and/or chronological distinctions between the foraging and food-producing modes of existence are emphasized in broad syntheses of the Neolithic (for example, Perlès 2001; Tringham 1971), site-specific or regional studies have recently drawn attention to the hunting and gathering activities of neolithic farmers (for example, Karathanasi 2020; Kotjabopoulou *et al.* 2003; Theodoropoulou 2011a; Veropoulidou 2011a). Here we evaluate the evidence from the site of Sitagroi, in the Drama plain of east Macedonia (Figure 1).

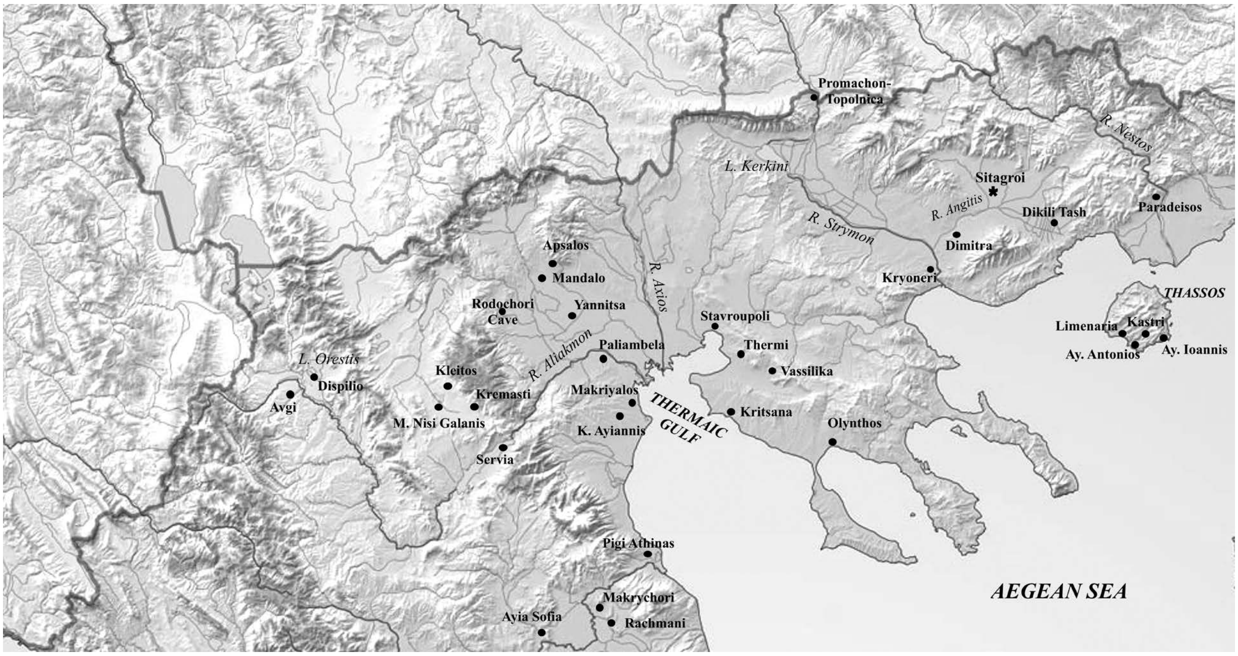


Figure 1: Map of Macedonia with Middle, Late, and Final Neolithic sites (including three within the northeastern border of Thessaly). Nearly all sites contained ornaments of marine shell.

Situated close to the Angitis river, the mound was formed over the course of some 3,000 years, divided archaeologically (Phases I to Vb), dated from Middle Neolithic through Early Bronze Age (6th to 3rd millennia BCE) (Table 1). This was a small community of a few hundred at most, and at times even less (Blouet 1986: Fig. 6.1). Excavation, 1968–1970, was conceived and carried out in the scientific spirit of New Archaeology and the data fully published (Elster and Renfrew 2003; Renfrew *et al.* 1986). By current archaeological standards, an excavation completed in 1970 must manifest a number of limitations. Thus, across the investigated area, while excavations revealed house structures and features in situ dating to the Early Bronze Age Phases Va–b (Renfrew 1986a: 184–203), only restricted and fragmentary recovery of features, floor contexts, and remains were exposed of the Phases I–III and IV. However, all of the materials recovered in those excavation units were re-contextualized as far as possible, with the goal to offer a functional assessment (Nikolaidou and Elster 2003). In most units, where only portions of the soil were water-sieved, the retrieval of small and/or fragile bones and shell was limited, thus skewing the faunal record in favor of larger species and robust elements. Whereas the terrestrial fauna, birds and fish were fully published, there is only a preliminary report on the unmodified molluscan remains. In addition, research priorities and protocols at the time had a strong quantitative and ecological-economic focus, thus less attention was paid to behavioral and cultural questions. Nowadays these limitations are (counter)balanced by rich comparative data in northern Greece, where research has progressed exponentially in recent decades (Stefani *et al.* 2014).

Table 1. The Sitagroi sequence (Renfrew *et al.* 1986, 172, table 7.1).

Phase	Duration (radiocarbon years bc)	Duration (calendar years BC)
Vb	2100–1800	2700–2200
Va	2400–2100	3100–2700
IV	2700–2400	3500–3100
III	3800–2700	4600–3500
II	4300–3800	5200–4600
I	4600–4300	5500–5200

Substantial evidence highlights some of the villager's strategies of interacting with the wild, and how these were woven into the larger fabric of life in space and time (Nikolaidou and Elster 2014; Nikolaidou *et al.* 2013). Indeed, some finds of wild origin revolutionized research at the time:

a) early, possibly local domestication of the grape in the Early Bronze Age, along with use of wild grape since the Middle Neolithic (J. M. Renfrew 2003: 13–14, figs. 1.3–1.5, table 1.19);

b) mat impressions made from reeds, and a unique cloth impression from the Middle Neolithic, presumably woven of wild flax (Adovasio and Illingworth 2003);

c) fishing for the marine mollusk *Spondylus gaederopus*, documented since the Middle Neolithic for the manufacture of ornaments which were favored for local use (Miller 2003; Nikolaidou 2003; Shackleton 2003) and likely circulated further north into the Balkans (Shackleton and Renfrew 1970; recently, Bainojci *et al.* 2013).

Radiocarbon determinations place the neolithic horizons, Phases I–III, to the mid-sixth through the mid-fourth millennia BCE (Table 1). Pottery chronology links Phase I (Middle Neolithic) east to Thrace (Paradimi) and north to Bulgaria (Veselinovo), Phase II (Late Neolithic) looks south to Thessaly (pre-Dhimini, early Dhimini), while Phase III (regional Late Neolithic II–Final Neolithic/Chalcolithic [Papadopoulos and Nerantzis 2014]) is firmly situated within a broad koine encompassing east Macedonia and Balkan cultures further north (Vinča, Maritsa, and Gumelniţa) (Renfrew 1986b: 479–482). The subsequent Phase IV dates to the late fourth millennium and, although considered the Early Bronze Age (Renfrew 1986b: 482; Sherratt 1986: 429–434, 442–448), rather represents the transition of the late Final Neolithic to the Early Bronze Age (Dietz *et al.* 2018; Papadopoulos 2007); therefore, it will be included in our discussion.

Ecology, resources, and choices

Sitagroi was favorably located at the intersection of many different eco-zones within and around the Drama plain (Figure 2, Figure 3), ranging from mountain forest to rolling hill country, fertile plains,

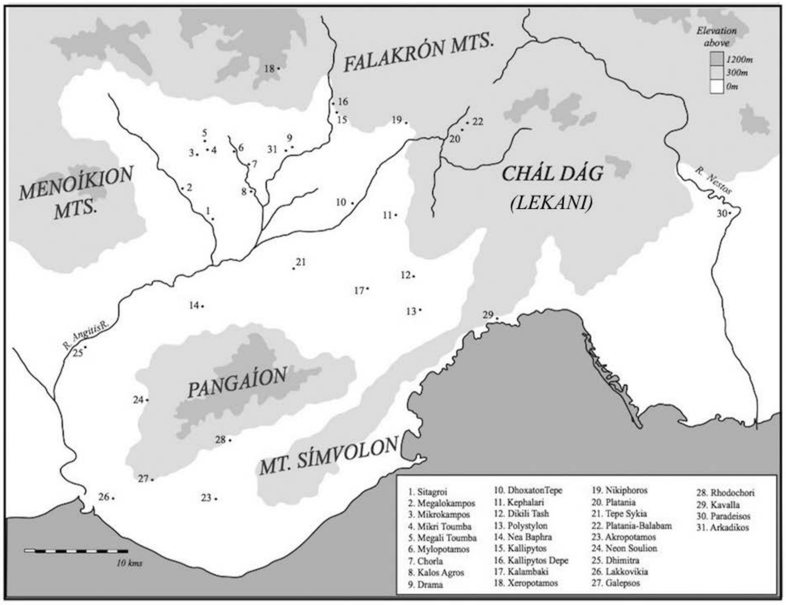


Figure 2. Map of the Drama plain, based on the Sitagroi Survey (Renfrew and Hardy 2003: fig. 13.1).

wetlands, and coast, within a radius of 25-30 km (Blouet 1986; Davidson 1986; Turner and Greig 1986). The inhabitants likely took full advantage of this situation with short walking outings, daytrips, or longer travels that may have lasted days, involving more effort and risk. The tabulated remains of wild resources point to the multitude of natural environments explored (Table 2, Table 3). The shells, bone, antler, seeds are only the preserved portion of an ecological cornucopia. The skins, furs, feathers, herbs, honey, wax have perished, as have also the favored meat, marrow, fat, offal, blood, eggs, and wild fruits.

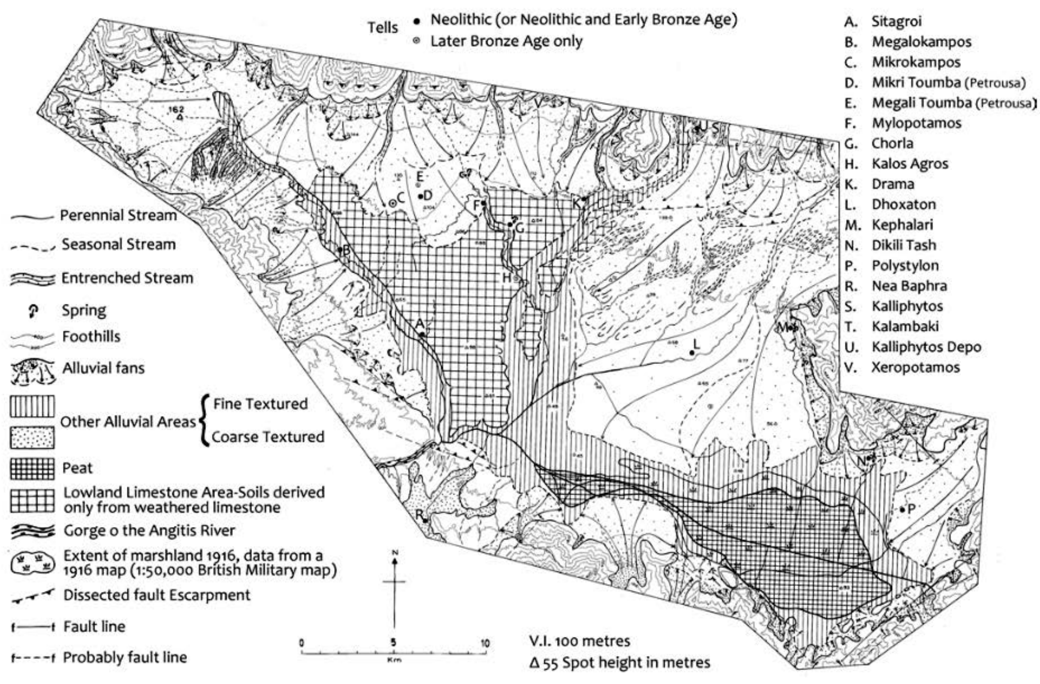


Figure 3. Geomorphological map of the Drama plain with prehistoric tells. Sitagroi: (A). (Davidson 1986: 27, fig. 3.2.).

Table 2. Identified species of wild vegetation and fauna excavated at Sitagroi, Neolithic through Early Bronze Age. Compiled after Bökönyi 1986; Miller 2003; J. Renfrew 2003; Shackleton 2003.

	Middle–Late Neolithic	Final Neolithic / Chalcolithic	Early Bronze Age
Wild Vegetation			
Acorn		x	x
Wild Almond	x	x	x
Cornelian Cherry	x	x	x
Fig	x		x
Wild Grape	x	x	x
Hazelnut			x
Pistacio	x	x	
Wild Fauna			
Terrestrial Mammals			
Aurochs	x	x	x
Badger	x	x	x
Beaver		x	x
Brown Bear	x	x	x
Wild Cat		x	x
Chamois		x	x
Fallow Deer	x	x	x
Red Deer	x	x	x
Roe Deer	x	x	x
Fox	x	x	x
Hare	x	x	x
Hedgehog			x
Marten		x	x
Mole Rat		x	x
Wild Swine	x	x	x
Wolf	x	x	x
Birds			
Bustard	x		
Gray-leg Goose		x	
White-fronted Goose		x	
Goosander		x	
Mallard	x		
Quail		x	
Griffon Vulture		x	
Reptile			
Turtle	x	x	x
Fish			
Cyprinidae	x		x
Pike		x	
Shells			
Cerastoderma	x	x	x
Columbella		x	
Cypraea		x	x
Dentalia	x	x	x
Donax	x		
Glycymeris	x	x	x
Murex	x		x
Mytilus	x	x	x
Neritea		x	
Ostrea	x		
Spondylus	x	x	x
Unio	x	x	x

Mountains. The forested mountains around the Drama plain (Figure 2) provided abundant fuel and an excellent, well-watered habitat for various animals, which show high ratios among the Sitagroi wild fauna (Bökönyi 1986: 71) The adult male red deer, *Cervus elaphus* would have been prized for its substantial supply of toothsome meat and workable skin, sinews, bones, and antlers (Bökönyi 1986: 87). Antler is stronger and more resilient than any other part of the deer, and the number of artifacts manufactured from an antler rack (Fig 4a) is greater than from any other element: the multiple tines and basal, fork, or beam segments are all potentially useful (Figure 5a, b) (Choyke 1998; Christidou 1997: 135; Vitezović 2017: 218). For farmers, no other wild animal could replace the deer's dietary and craft-related contributions (Table 4) (Elster 2003a: 37)

Wild swine was another rich source of food and by-products, including occasionally worked dentine (Elster 2003a, fig. 2.7c). Also captured for both meat and fur were the badger, the marten, the beaver (Figure 6a), and the brown bear (Figure 6b). The distribution of bear bones indicates that these carnivores were likely killed nearer to the village when attacking livestock (Bökönyi 1986: 93), and the same was probably the case with the predatory wild cat (Bökönyi 1986: 92), fox, and wolf. The latter is the natural predator of deer, thus the wolf's success with hinds or young could have allowed for human scavenging of a still viable carcass, a recognized acquisition method (cf. Binford 2014: 296).

High on the mountains the hunters sought the chamois, but apparently not for food; only two horn-cores were identified at Sitagroi (Figure 6c), and finds are also rare elsewhere. Chamois was possibly regarded a 'noble' animal, highly prized for its horn-cores (trophies?) (Bökönyi 1986: 86–87) and its soft skin. The high terrain was also home to the majestic griffon vulture, although the single bird whose remains were recovered at Sitagroi (Table 5) may have been spotted scavenging closer to the village.

Foothills. The higher, drier areas around the plain comprised woodlands and cultivable land.

Table 3. Wild fauna and principal shell species at Sitagroi, Phases I–IV, arranged by ecological niche/ zone and tabulated for dietary and by-products contribution. Inferred values are marked by "?" Compiled after Bökönyi 1986; Nikolaidou 2003; Shackleton 2003. Additional source: Veropoulidou 2011a: 30–39, fig. 2.4, table 2.2.

Species	Food Source (meat, offal, blood, fat, eggs)	Secondary Products	Modified/ Crafted
Niche: High mountains			
Chamois		horn-cores (trophies?)	
Griffon Vulture		feathers? talons?	
Niche: Mountainous, swampy forest			
Badger	x	fur?	
Beaver	x	skin?	
Brown Bear	x	fur, teeth, claws?	
Marten	x	fur?	
Red Deer	x	antlers; skin, sinews?	tools, ornaments
Wild Cat		fur, teeth?	
Wild Swine	x	skin? bone	ornaments; tools?
Niche: Forest Steppe, Culture Steppe			
Aurochs	x	skin, sinews, horns?	tools
Fallow Deer	x	antlers; skin, sinews?	?
Fox	x	fur?	
Roe Deer	x	antlers; skin, sinews?	tools
Wolf		fur, teeth?	
Niche: Hill, meadow and plain			
Fox	x	fur?	
Hare	x	fur?	
Quail	x	feathers?	
Turtle	x	shell; skin?	ornaments; tools?
Niche: River and Marsh			
Beaver	x	skin?	
Wild Swine	x	skin? bone	ornaments; tools?
Great Bustard	?	feathers?	
Gray-leg Goose	?	feathers/down?	
White-fronted Goose		feathers/down?	
Goosander	?	feathers?	
Mallard	?	feathers?	
Cyprinidae	x		
Pike	x		
Unio shell	x	valve	ornaments, containers
Niche: Estuary			
Cerastoderma	x	valve	ornaments
Ecozone: Marine waters			
Dentalia	?	shell	ornaments
Glycymeris	?	valve	ornaments
Mytilus	?	valve	ornaments, tools?
Ostrea	?	valve	implements?
Spondylus	?	valve	ornaments, tools?

In the forest steppe lived the aurochs, its young captured to aid in cattle domestication (Bökönyi 1986: 71); and the fallow deer, not well represented with worked elements until the Early Bronze Age, Phase V (Bökönyi 1986: 90, Table 5.2a; catalogue in Elster 2003a). Roe deer roamed in more open ground—an obligate drinker could be ambushed near water (Speth 2013); at Sitagroi it is mostly represented by tool material (Figure 4b) (Bökönyi 1986: 92; Elster 2003a: 34, and catalogue). The foothills were also the territory of the wolf and the fox, valuable for skin and fur; the fragmentary bones of foxes indicate consumption of the meat (Bökönyi 1986: 93). Oak groves provided valuable wood and acorns; wild cherries, almonds, figs, pistachios, and grapes were collected in the different micro-zones (Table 2).

Plain and meadows. The dry parts of the limestone plain, the meadows, and rolling hills of alluvial fans were the locale of hare, with its tender meat, soft fur, and workable bones (none at Sitagroi but see Isaakidou 2003: 235 [Makrygialos]); turtles were sought for their meat (Bökönyi 1986: 95) and their carapace (compare Trantalidou *et al.* 2005: 50, n. 12); and quail flocked.

River and wetlands. The Angitis river enters the Drama plain from an underground source in the northwest and has in fact undercut the Sitagroi mound (Higgs and Vita-Finzi 1986). Marshland and peat extended around a prehistoric lake in the southern part of the plain (Davidson 1986: fig. 3.2; Turner and Greig 1986: fig. 4.2). Mountain passes to the west and east provided access, respectively, to the major rivers Strymon and Nestos, both debouching into the Aegean (Figure 1). These aquatic locales attracted beavers, martens, wild swine, foxes and wolves, as well as waterfowl: ducks and geese. Many of these species are seen today in the protected wetlands of the region[1].

[1] https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=GR1260002 (Strymon delta); http://www.topeiros.gr/portal/parousiasi/fisi-tourismos/124-deltanestou.html (Nestos delta); http://kerkini.gr/panida/?lang=en (Lake Kerkini National Park).

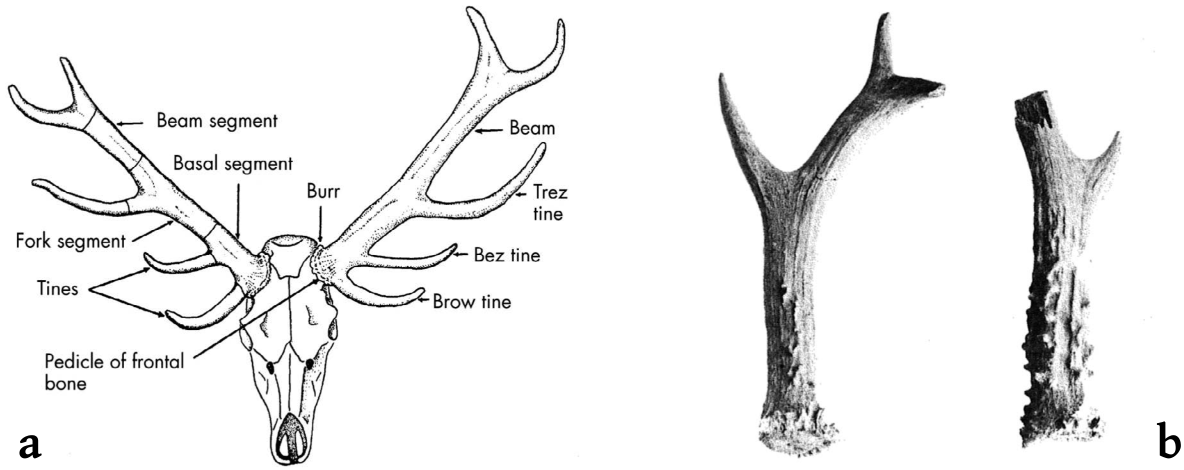


*Figure 4. Red deer (*Cervus elaphus*) antler anatomy (Elster 2003a: fig. 2.1) (a) and roe deer unmodified antlers; phase III (Bökönyi 1986: pl. IX:2) (b).*

Also available were reeds, useful for tempering clay and for basketry; and the flax (J. Renfrew 2003: table 1.19), valuable as fiber and for the medicinal and culinary value of its oily seeds (Adovasio and Illingworth 2003: 255).

The freshwater mollusc *Unio* was collected, too, although no specific quantities were reported at Sitagroi, but at Dimitra *Unio* by far outnumbers all other molluscan remains (Karali-Yannacopoulou 1997: 202). Some valves were repurposed, as seen in their worked edges (Figure 7a). Experiments (Mărgărit *et al.* 2020) show that the oblong, sharp-edged shells were handy tools for a variety of tasks: scaling fish,

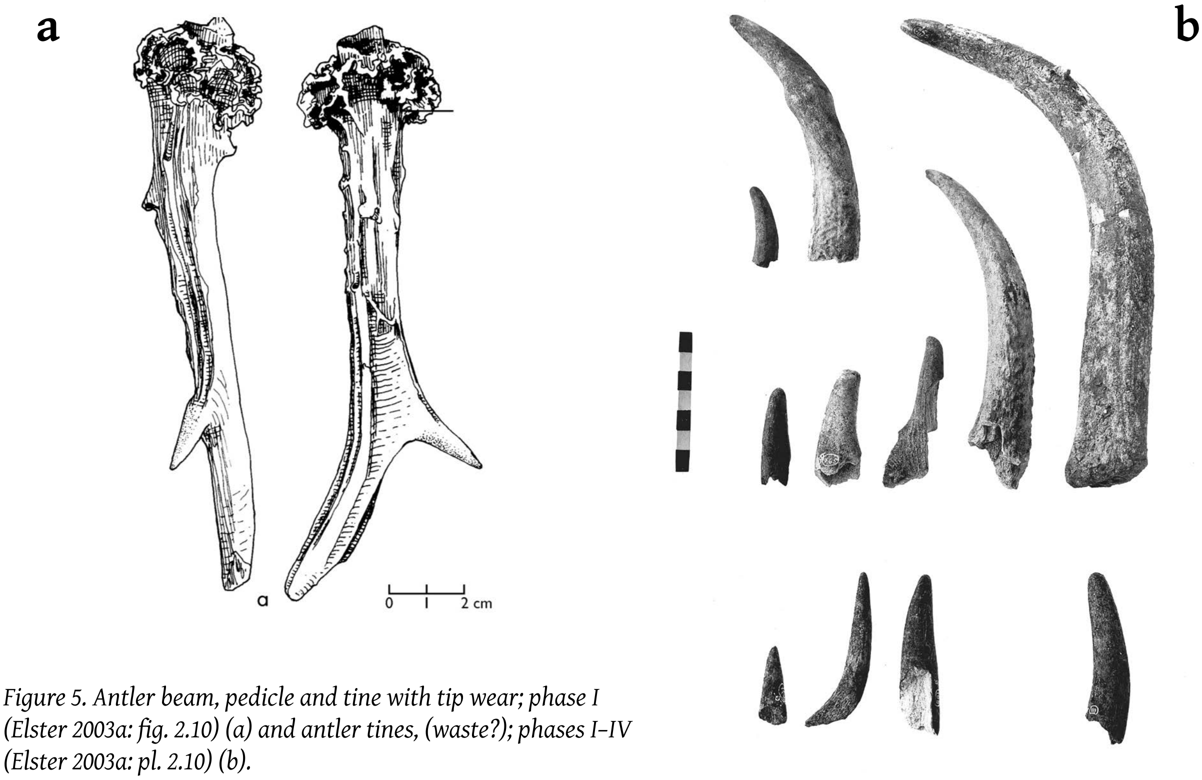
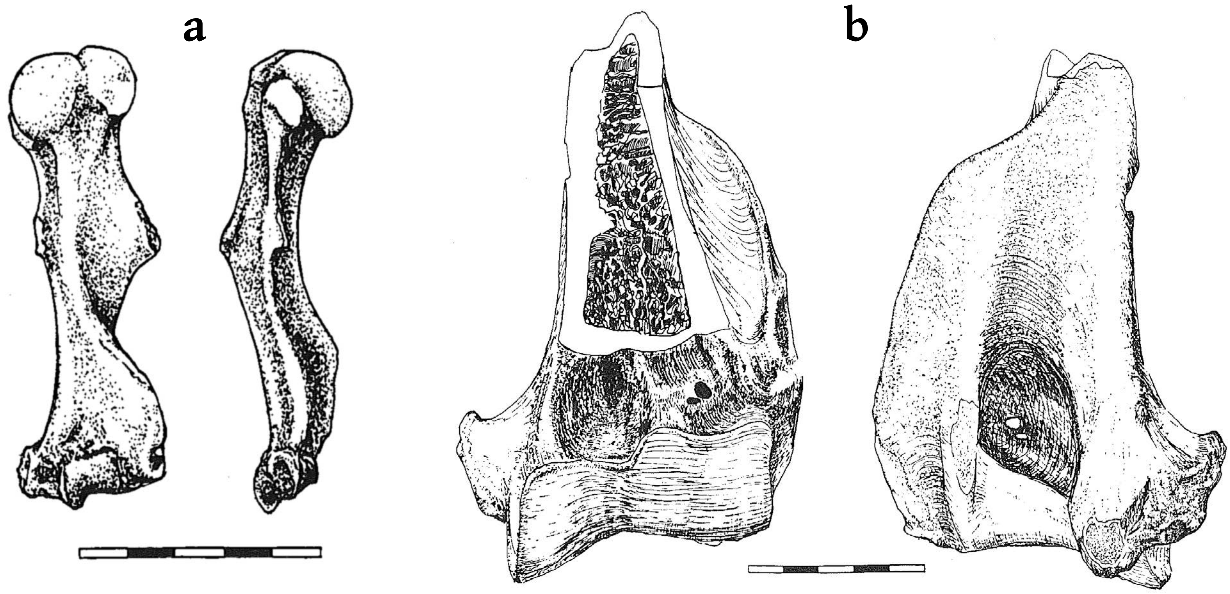


Figure 5. Antler beam, pedicle and tine with tip wear; phase I (Elster 2003a: fig. 2.10) (a) and antler tines, (waste?); phases I–IV (Elster 2003a: pl. 2.10) (b).



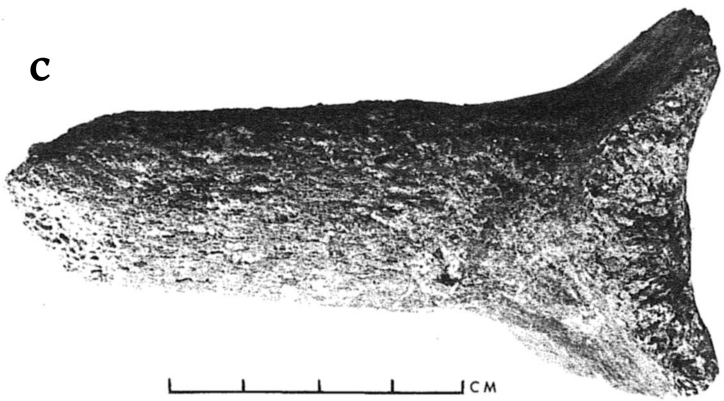


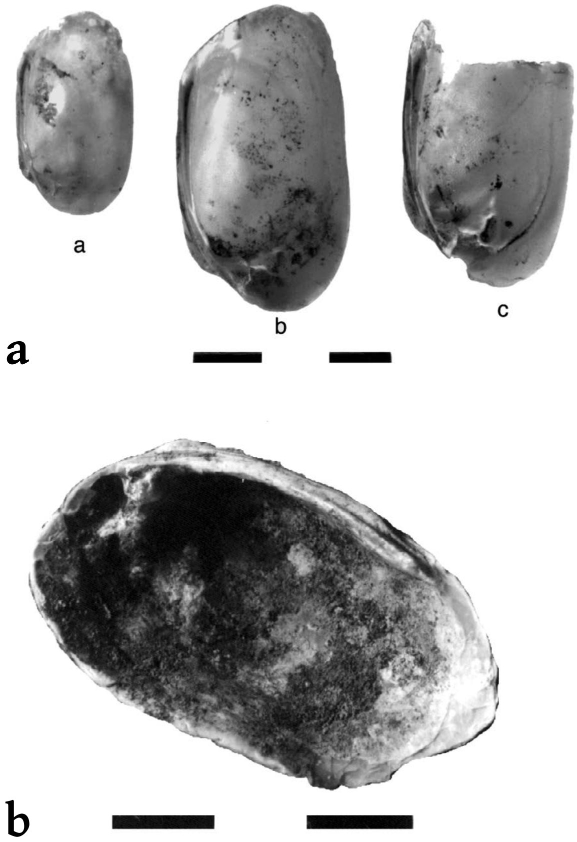
Figure 6. Unmodified elements: phase IV (a) beaver humerus (Bökönyi 1986: fig. 5.25) and (b) brown bear humerus (Bökönyi 1986: fig. 5.24); phase III (c) chamois horn-core with skull (Bökönyi 1986: pl. VIII:3b).

de-fleshing bone, cutting grasses, tooling wood and leather, scraping or polishing clay pots (compare Theodoropoulou 2020: 111). Another valve with extensive red pigmentation in the interior (Figure 7b) may have been a container for red ochre—unless the color seeped in from breaking lumps of ochre, or simply post-deposition (cf. Mărgărit *et al.* 2020: 123). Red pigment was used to embellish figurines at Sitagroi (Gimbutas 1986: catalogue nos. 19, 54, 88, 98, 101, 192, 198, 201, 202, 204); red-encrusted beads of *Unio* occur elsewhere (Ifantidis 2019: 230 [Mandalo], 231 [Kato Agiannis]). Despite the shell's easy availability at Sitagroi, only two valves show ornamental use as pendants (Nikolaidou 2003: 333, 349; compare Ifantidis 2019: 158–159 [Dispilio])—in remarkable contrast to the large number of similar ornaments made of marine shell (see below).

Fishing in local waters brought carp, pike, and tench to Sitagroi. The systematic, seasonally targeted fishing of carp, pike, tench, and catfish is documented in the Angitis/Strymon area at Dimitra and Kryoneri, and at the lakeside settlements of Dispilio and Avgi in west Macedonia (Mylona 2014: 3; Theodoropoulou 2014: 458–460, 2020: 110–111). Common among the Greek freshwater fauna, these are small- to medium-sized species that can occasionally grow larger (Mylona 1997: 527; Stratouli 1996: 17). Despite the paucity of published remains at Sitagroi (Table 5), one completely water-sieved unit (ZB) produced additional, unspecified quantities of tench (Turner and Greig 1986: 52). Of the remaining 79

TABLE 4. CHRONOLOGICAL DISTRIBUTION OF WORKED *CERVIDAE* ANTLER AT SITAGROI (ELSTER 2003A, 37, TABLE 2.5).

	Phase							
Taxon	I	II	III	IV	V	X	Grand Total	Percent
Capreolus capreolus	3	1	1	1	0	1	7	0.04
Cervus	8	8	7	4	1	0	28	0.17
Cervus elaphus L.	12	39	56	11	7	0	125	0.78
TOTAL	23	48	64	16	8	1	160	0.99
Unidentifiable	0	1	0	0	0	0	1	0. 00
GRAND TOTAL	23	49	64	16	8	1	161	1. 00
PERCENT	0.14	0. 30	0. 40	0. 10	0. 05	0. 00	1. 00	



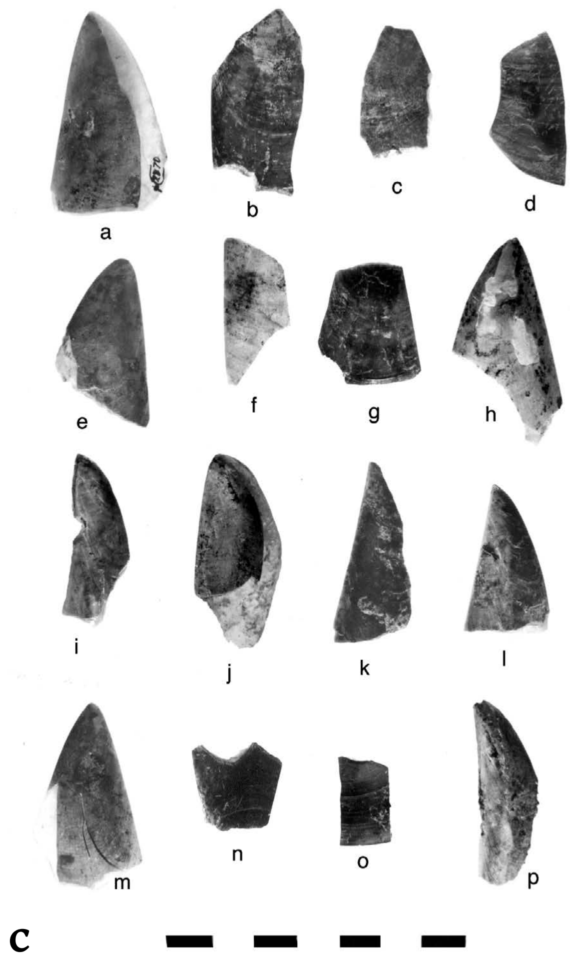


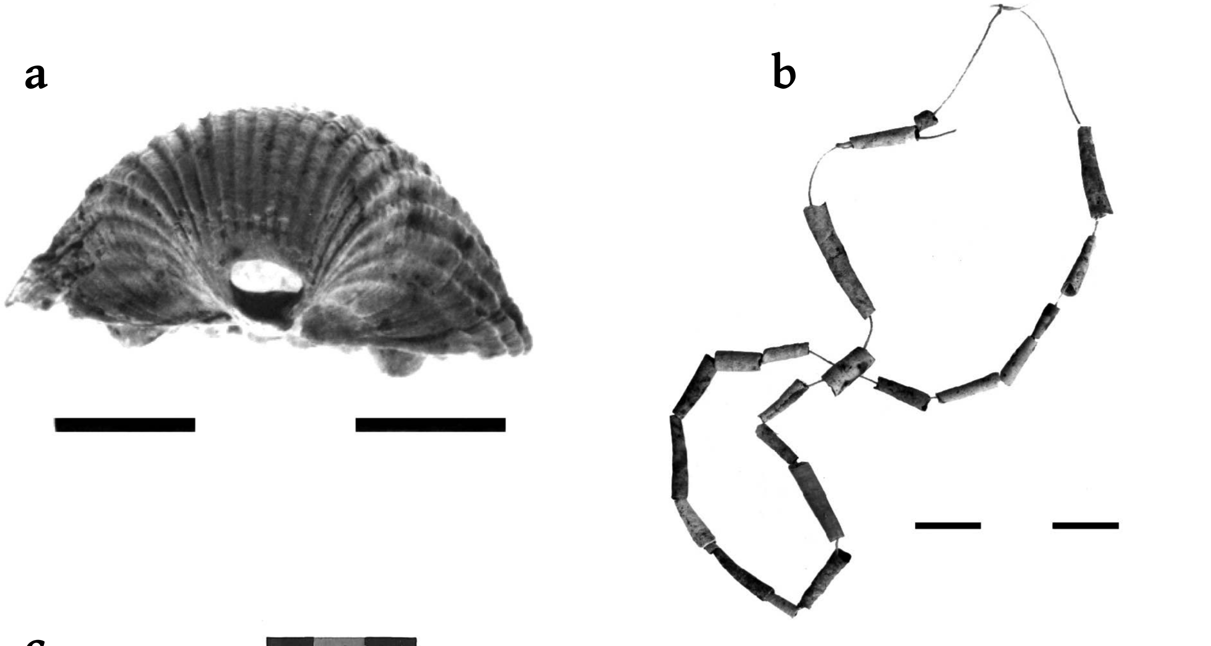
Figure 7. Repurposed shell valves: phase III (a, b), phase I–III (c); (a) Unio *with worked edges (Shackleton 2003: pl. 9.1.2), (b)* Unio *with interior red pigmentation (Shackleton 2003: pl. 9.1.1.); (c)* Mytilus *"triangles" (spoons: a, b) (Shackleton 2003: pl. 9.1.4).*

TABLE 5. DISTRIBUTION OF IDENTIFIED WILD ANIMAL REMAINS, EXCLUDING SHELLS, PHASES I–IV; IN PARENTHESIS, ESTIMATED NUMBER OF INDIVIDUALS. COMPILED AFTER BOKONYI 1986: 68–69, TABLES 5.2A, 5.2B.

	Phase I	**Phase II**	**Phase III**	**Phase IV**	**Total, Phases I–IV**
Terrestrial Mammals					
Aurochs	29 (4)	47 (7)	85 (9)	61 (7)	222 (27)
Badger	1 (1)	1 (1)	3 (2)	1 (1)	6 (5)
Beaver			7 (2)	5 (2)	12 (4)
Brown Bear		2 (1)	4 (2)	18 (4)	24 (7)
Wild Cat			3 (2)		3 (2)
Chamois			1 (1)		1 (1)
Fallow Deer	2 (1)	1 (1)	15 (3)	95 (9)	113 (14)
Red Deer	59 (6)	84 (8)	480 (38)	286 (22)	909 (74)
Roe Deer	10 (3)	8 (3)	38 (7)	41 (6)	97 (19)
Fox	1 (1)	4 (2)	6 (2)	5 (2)	16 (7)
Hare	10 (2)	18 (4)	41 (5)	1 (1)	70 (12)
Marten			1 (1)	2 (1)	3 (2)
Wild Swine	40 (5)	33 (5)	249 (21)	100 (12)	422 (43)
Wolf	1 (1)		3 (2)	5 (2)	9 (5)
Birds					
Great Bustard		1 (1)			1 (1)
Gray-leg Goose			3 (2)		3 (2)
White-fronted Goose			1 (1)		1 (1)
Goosander			3 (2)		3 (2)
Mallard	1 (1)		2 (2)		3 (3)
Quail			1 (1)		1 (1)
Griffon Vulture			1 (1)		1 (1)
Reptile, Fish					
Turtle	1 (1)	2 (1)	38 (3)	94 (5)	135 (10)
Cyprinidae		1 (1)		2 (1)	3 (2)
Pike			1 (1)		1 (1)

bones collectively grouped as fish (*Pisces*) and representing seven individuals from Phases III and IV (Bökönyi 1986: 68–69, table 5.2: a–b), it is impossible to separate fresh from saltwater species. Beyond recovery contingencies, the poor retrieval may reflect local traditions, tastes, social arrangements, now lost (cf. Theodoropoulou 2020: 111). For instance, tench was perhaps preferable to carp because it is more palatable (*The Encyclopedia Brittanica* Vol. 29: 930); or, the best fishing locales lie outside the rightful territory of Sitagroi, accessible only to other villages. Or, people at Sitagroi simply considered fish a special food, to be enjoyed mainly on visits to enterprising neighbors/kinfolk (?) down the river, while they in turn had their own specialties to offer as hosts.

The coast and sea. Mount Pangaion and low hills separated Sitagroi from the coast, about 25 km distant (Figure 2), yet the villagers were drawn to the sea (cf. Theodoropoulou 2011a: 63–64), to wade, dive and/or comb for attractive shell; the appeal was shared by the neolithic communities in northern Greece, whether near or far from the coast (Theodoropoulou 2011a: 58–60, figs. 3, 4b). Perhaps the ones further inland were supplied by neighbors closer to the coast, via the rivers, plains, and mountain passages (Figure 1). The twelve species of marine shell from Sitagroi (Table 2) are common in Macedonia (Veropoulidou 2011a); their habitats range from shallow costal water to deep sublittoral zones (Veropoulidou 2011a, 32–34, 44, table 2.4; 58, table 2.5, 527–540), and almost all are edible (Veropoulidou 2011a: 41–42, 446, table 9.12). *Cerastoderma edule*, the cockle, is plentiful in estuarine environments, and thus usually the preferred marine shell food (for example, Karali–Yannacopoulou 1997: 203; Veropoulidou 2011a: 435–437, 446, table 9.12). The few (unmodified?) reported cockles from Sitagroi (Shackleton 2003: 365) provide the



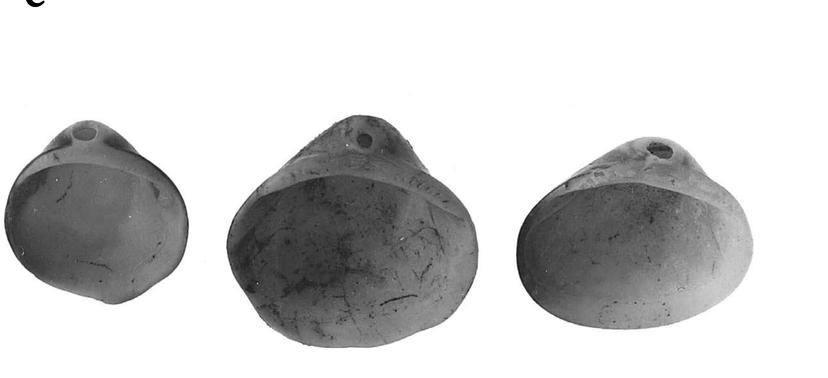


Figure 8. Simple shell ornaments: phase II (a) Pendant of Cerastoderma *(Nikolaidou 2003: pl. 9.18) and (b) Group of* Dentalia *beads reconstructed as a chain (ibid pl. 9.13); phases II-III (c)* Glycymeris *pendants (Nikolaidou 2003: pl. 9.15).*

only alimentary evidence; a few valves had been repurposed as pendants (Nikolaidou 2003: 349) (Figure 8a). All other species, by contrast, are only represented by modified/crafted pieces (Table 3), which do not preserve any telltale signs of flesh extraction or cooking (for such traces see Veropoulidou 2011a: 97 table 2.9, 445–454)—if this did happen before "recycling." Indeed, the almost exclusive presence of worked shell versus food refuse makes Sitagroi an exception among contemporary sites, even those further removed from the coast, such as Promachon or Dispilio (Theodoropoulou 2011a: 61, fig. 4b). However, judging from what people ate elsewhere (Theodoropoulou 2011a; Veropoulidou 2011a: 446 9.12; 527–540), it is possible that the Sitagroi villagers sampled on occasion the delectable common mussel, *Mytilus galloprovincialis*, and the oyster *Ostrea edulis* (represented by only one example; Shackleton 2003: pl. 9.1.6). Living in the intertidal zone, mussels can survive out of the water long enough to be safely transported over some distance (Fagan 2003: 154). Some valves served as pendants. Others provided a convenient form and sharp edge for worked "spoon" or palette-knife–like implements of indeterminate purpose (Shackleton 2003: 364–365) (Figure 7c). As these "triangles" cluster in Phase II, we surmise their use as incising tools for decorating tripod stands and other incised ceramics (Nikolaidou and Elster 2014: 310).

Other shells — *Cypraea*, *Donax*, *Neritea*, and *Murex* — came to the site sporadically, as beachcombed curios (Miller 2003: 380, table 9.3.5; Nikolaidou 2003: 348–349, pls. 9.2–9.7, 9.13–9.14, 9.24). Harder to obtain, and therefore all the more remarkable for their high frequency among ornaments (Miller 2003: 369–270, 374–375, pl. 9.2.1; Nikolaidou 2003: 333–334), were species of the deep waters (up to 40 meters) offshore: the tusk shell *Dentalia* and bittersweet clam *Glycymeris*, both buried in sandy beds, and especially the spiny oyster *Spondylus gaederopus* which must be spotted among thick marine growth and pried from the rocks (Miller 2003: 370). The village artisans appreciated the natural form of "ready-made" *Dentalium* beads (Figure 8b) and the easy-to-perforate valves of small *Glycymeris* (Figure 8c), but mostly favored the attractive and sturdier shells of large *Glycymeris* and, particularly, *Spondylus*, which they skillfully crafted into beads, annulets/bangles, and "buttons" (Figure 9, Figure 10). Although ornaments of *Glycymeris* and *Spondylus* feature prominently in Macedonia and Thessaly (Ifantidis 2019: 214–285), their alimentary use is less clear. It is plausible that, given the difficulties of *Spondylus* extraction, its succulent flesh was enjoyed, perhaps as a rare luxury food (Veropoulidou 2011a: 289). At Makrygialos, for example, a large number of fresh unworked valves was found in a large refuse pit that is connected with feasting (Pappa and Veropoulidou 2011: 110). Certainly *Spondylus* was eaten during the Bronze Age (Galik *et al.* 2013_ 167–168; Veropoulidou 2011b).

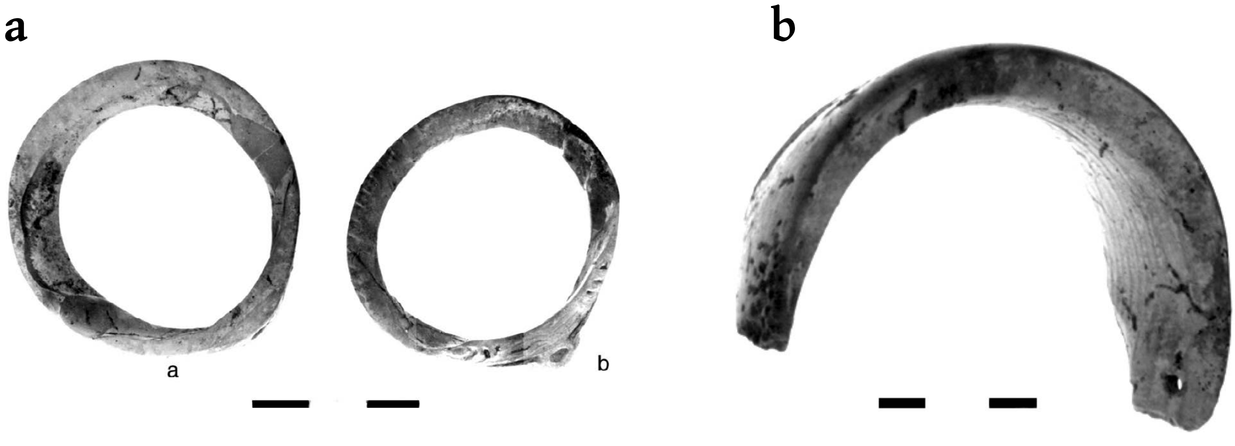


Figure 9. Shell annulets/bangles: phase III (a) Glycymeris *(Nikolaidou 2003: pl. 9.6) and (b)* Spondylus *with mending (?) perforation (Nikolaidou 2003: pl. 9.4).*

Fishing generally played a peripheral role in neolithic Greece (Papathanasiou *et al.* 2013: 24–25), and Sitagroi seems no exception. Other inland sites relied heavily on freshwater and had little interest in marine catch (Theodoropoulou 2014)—although quantities are more balanced at Kryoneri, close to both coast and river (Mylona 1997: 527).

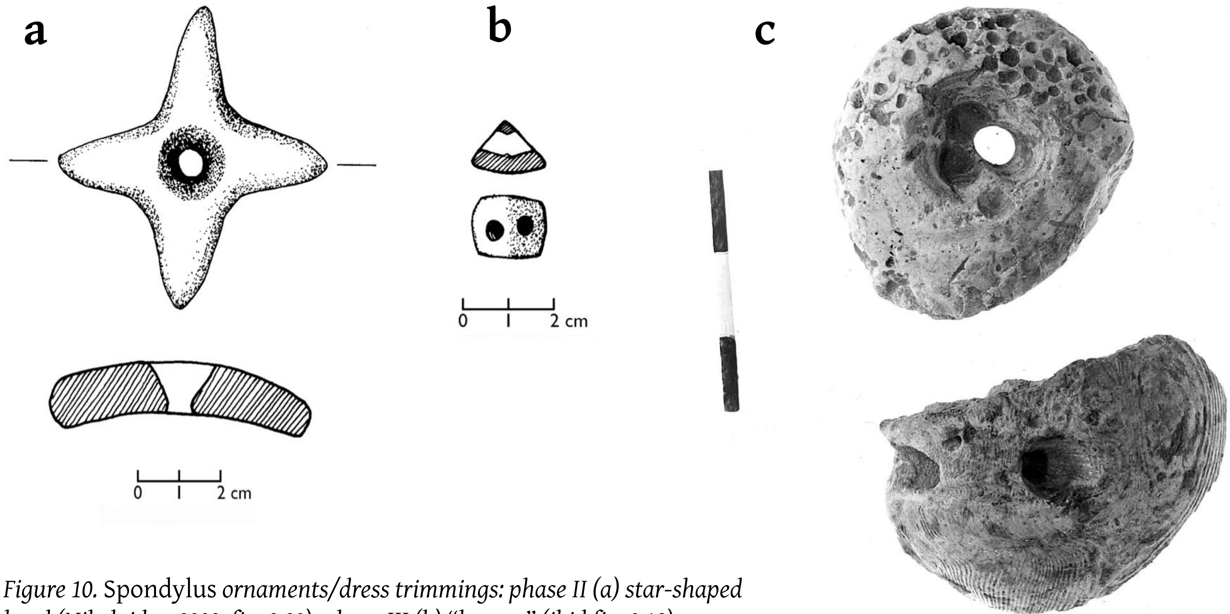


Figure 10. Spondylus *ornaments/dress trimmings: phase II (a) star-shaped bead (Nikolaidou 2003: fig. 9.20); phase III (b) "button" (ibid fig. 9.18); (c) large "buttons" or ornament preforms, phase III (top) and unphased (Nikolaidou 2003: pl. 9.24).*

Choices across time

Throughout the Sitagroi sequence, both the absolute numbers of the wild fauna and the ratio of wild to domestic taxa remain low (Bökönyi 1986: 68–69 tables 5.2a–5.2b) (Table 5), albeit with important fluctuations across time and species. The progression is rather smooth and in the single digits during most of the Neolithic (Bökönyi 1986): 8.6% in Phase I; 3.5% in Phase II, with sharp decrease of wild ungulates and corresponding increase of domesticated caprovines; 8.1% in Phase III, with steady rates of domesticates, but with tripled frequencies of the forest and swamp animals (red deer, wild swine), which signal the likely onset of wetter, colder climate and increased forestation. In parallel development, contact with the sea is evident only with *Mytilus* during Phase I (Shackleton 2003: 361, table 9.1.2), but marine shells abound during Phase II and quantities peak in Phase III (Nikolaidou 2003: 333–334, fig. 9.2, table 9.2).

In sharp contrast, the ratio of wild fauna jumps up to almost 18% during Phase IV, again dominated by the large forest animals that thrive in colder, wetter environment (Bökönyi 1986: 68–69 tables 5.2a–5.2b); indicated is the increased importance of hunting. Livestock management changes, too: the ratios of pigs increase significantly at the expense of cattle, while quantities of caprovines drop (they will increase again in Phase V with the introduction of the woolly sheep and accompanying emphasis on secondary products. By then, hunting may have lost much of its economic and/or symbolic importance; Bökönyi 1986: 70). Likewise, more wild fruits were collected in Phase IV: 18 botanical samples contained an assortment of cherries, almonds, and pistachios together with large quantities of acorns; was this "famine food", a complement to poor harvests? (J. Renfrew 2003: 13). Andrew Sherratt (1986: 441) also mentions an increase in freshwater mussels during the Early Bronze Age. Interestingly, the single direct indication of food preparation/cuisine at Sitagroi, from Phase IV, consists of "wild' foods: an unspecified but presumably small number of cockles, together with twenty-five acorns and two *Polygonum* seeds were found in a pot, apparently the ingredients of some sort of seafood soup (J. Renfrew 2003: 6), perhaps stored together briefly (cf. Veropoulidou 2011a: 68, 452). In an opposite direction, the numbers of worked shell, especially the elaborate ornaments, drop sharply in Phase IV (they further decrease in Phase V; Nikolaidou 2003: 333–334, fig. 9.2). Simpler tastes and/or scarce raw materials are implied by a small assortment of perforated items found on the floor of a Phase IV house: two *Cerastoderma*, one fragment of antler and one of turtle shell (Nikolaidou 2003: 352).

The Sitagroi patterns are common across northern Greece; hunting seems to intensify during the Late and Final Neolithic, although it remains peripheral and supplementary to animal husbandry (Karathanassi 2020: 42–43; Papathanasiou *et al.* 2013). In central and east Macedonia the ratios of wild taxa reach a maximum 12% of the total recovery (Kazantzis 2014: 448, fig. 8), with two notable exceptions: the settlement of Kryoneri (25% ratio), at the foothills of the densely forested, game-rich Mount Kerdyllion (Mylona 1997); and the cave occupation on the east bank of the Angitis (38% ratio), a likely seasonal sojourn for regional pastoralists who traded fur-rich game for fine decorated pottery and other luxury items (Trantalidou *et al.* 2005: 51–52, 61–63).

Beyond ecology and economy, Paul Halstead has proposed (1999) that the increased visibility of wild taxa in the Final Neolithic/Chalcolithic relates to a new emphasis on the individual household, in the context of emergent competitions and hierarchies which accelerated and sharpened from the Early Bronze Age onward. Contrary to the earlier open-air, possibly collective areas of cooking and eating that imply strong communal obligations, in the Final Neolithic we see cooking installations placed within the houses; and the houses themselves have clearer architectural definition. At Sitagroi, structures in parallel alignment have been traced in Phase IV and are more recognizable in Phase Va (Renfrew 1986a: figs. 8.9–8.11, 8.17). The Burnt House had a separate well-equipped kitchen, stone grinders, bone tools, and in the Central Room, a preform tool, a red deer metapodial (Renfrew 1986a: fig. 8.11; Elster 2003a, 39, fig. 2.6). By contrast, the only excavated oven from the 5th millennium (Phase III) was likely located outside of a house—although possibly associated with one—in an open-ended, semi-roofed area (Renfrew 1986a: 212–214, fig. 8.19). Many faunal elements were recovered including both domestic and wild taxa (a preponderance of the former), and a wealth of artifacts: decorated pots, tools, jewelry, figurines and more, suggesting some level of communal participation, display, and ceremony (Nikolaidou and Elster 2003: 458). Drawing on ethnographic examples, Halstead hypothesizes that although there was an obligation to share game (cf. Karathanasi 2020: 66–67; Kent 1989b), yet hunted meat was brought forth sparingly to public commensal events. When it later became acceptable to cook indoors, people felt comfortable to consume all the game they wanted, in the relative privacy of their kitchens. A strong case in point is the near-absence of wild terrestrial fauna among the exceptionally rich remains of large-scale feasting activities at Makrygialos in the early-5th-millennium; by contrast, domestic livestock was conspicuously consumed and shared at these events (Halstead 2004; Tzevelekidi *et al.* 2014). At the same time, large quantities of shells (oysters, cockles, *Spondylus*) were found in some of these deposits, suggesting that seafood consumption was deemed appropriate at feasts (Veropoulidou 2011a: 272–273). Presumably, the various "wild foods"—each captured from distinct habitats and in different ways (for example, projectile hunting versus shell "harvest" by collection or net-fishing), possessing separate qualities, and being handled by other means and/or persons—were differently evaluated and treated (cf. Isaakidou 2003: 237 Kent 1989b: 7–9, 12–15).

The ways of the hunt

Seasonality

The birds. At Sitagroi, six out of the seven identified avian species belong to migratory birds, which are also seen in the region today (Bökönyi 1986: 95, tables 5.2a–b; Katelyn Bishop, pers. comm. 11/2020[2]). There is quail, a summer migrant, and five species of ducks and geese: the graylag goose is spotted both winter and summer; the white-fronted goose, the goosander (chiefly a circumpolar boreal species), and the great bustard, all are wintering (non-breeding) visitors to or migrants over the region; the mallard is both a year-round resident and a likely migrant. Bishop (pers. comm.) notes that the site is on the Black Sea– Mediterranean flyway and that there probably was a migration path for several types of waterfowl close by. If so, the very low number of recovered bones (Table 5) seems to suggest that residents were only occasionally exploiting the presence of these birds during winter; or else, they merely "got the occasional errant individual." Yet, at least some of the additional 53 bones from unspecified birds (*Aves*) in Phases I–IV (Bökönyi 1986: 68–69, tables 5.2a–b), belonged to waterfowl. In either case, the birds offered delectable flesh and eggs, and attractive feathers (for the latter, see Manermaa and Kirkinnen 2020). Noteworthy, in comparison, is the large number of waterfowl bones at Kryoneri, very close to the Strymon delta (Mylona 1997: 528), alongside a unique representation of a bird (waterfowl?) on a painted vessel (Malamidou 2007: 306, fig. 24, right; compare Turcanu 2018: fig. 9).

A symbolic aesthetic that includes the avian, materializes in a distinct type of small, bird-headed female (?) figurine, phases II–III (Figure 11a–c), common at Sitagroi, Dikili Tash and elsewhere in east Macedonia, Achilleion in Thessaly, and in the Balkans (Gimbutas 1986: 247–249, figs. 9.41–9.48; Marangou 1997: 248; Renfrew 2003b: 480, fig. 13.1.6; Turcanu 2018); referred to by Marija Gimbutas as "bird goddesses" and linked to a "pantheon" of human and animal sculptures. These bird-human hybrids are one of the more identifiable of wild fauna in the "mythical imagery" at Sitagroi, since the local micrographic menagerie consists almost exclusively of domesticates (Gimbutas 1986: 258–259, 261; elsewhere, too, effigies of wildlife are sporadic, although quite varied [for example, Toufexis 2003]). Some of these figurines have their schematic arms perforated (Figure 11 b), possibly for the insertion of feathers (Gimbutas 1986: 249); one bird-head was the protome handle (Figure 11c) of a spoon or ladle (compare Marangou 1997: 248, no. 126; Turcanu 2018: 311–312, fig. 8.1). Perhaps, the seasonal and transitory presence of birds, their very ability to fly and reach faraway places, captured the imagination with notions of cyclical regeneration, fertility, and transcendence, expressed in art, lore, ritual/magic, and performance (cf. Manermaa and Kirkinnen 2020; Turcanu 2018: 313–318).

The seasonal rhythms can be reconstructed to some extent from the available data at Sitagroi, in light of seasonality studies elsewhere. Tatiana Theodoropoulou (2011a: 62–63) aptly remarks that the coastal and semi-coastal farmers likely hunted and foraged according to both "a climatic and a communal calendar"; carefully balancing the availability of "land/sea/freshwater but also domestic/wild resources", planning accordingly, and tuning their efforts to nature's tempo and across diverse "taskscapes" (Wolfhagen *et al.* 2020). Thus, while winter saw the occasional catch of waterfowl and/or harvest of freshwater shell to spice up the limited seasonal menu, the pace would pick up as winter expired and spring arrived. *Unio* may have been collected more systematically then, and through summer or early autumn (Wolfhagen *et al.* 2020: 103). Come February, it was time to start foraging for shed antler, easier to obtain than cut off from a hunted and captured animal. Among the abundant unmodified and worked red deer antler excavated at Sitagroi, only the specimen with pedicle attached (Figure 5a, Figure 14b) are clearly from successfully hunted game; naturally shed antlers have no such feature (Elster 2003a: 31). Mature males shed their rack in February, March, and early April, but only in

[2] sources: Cornell Lab of Ornithology's ebird and Birds of the World databases, AviBase

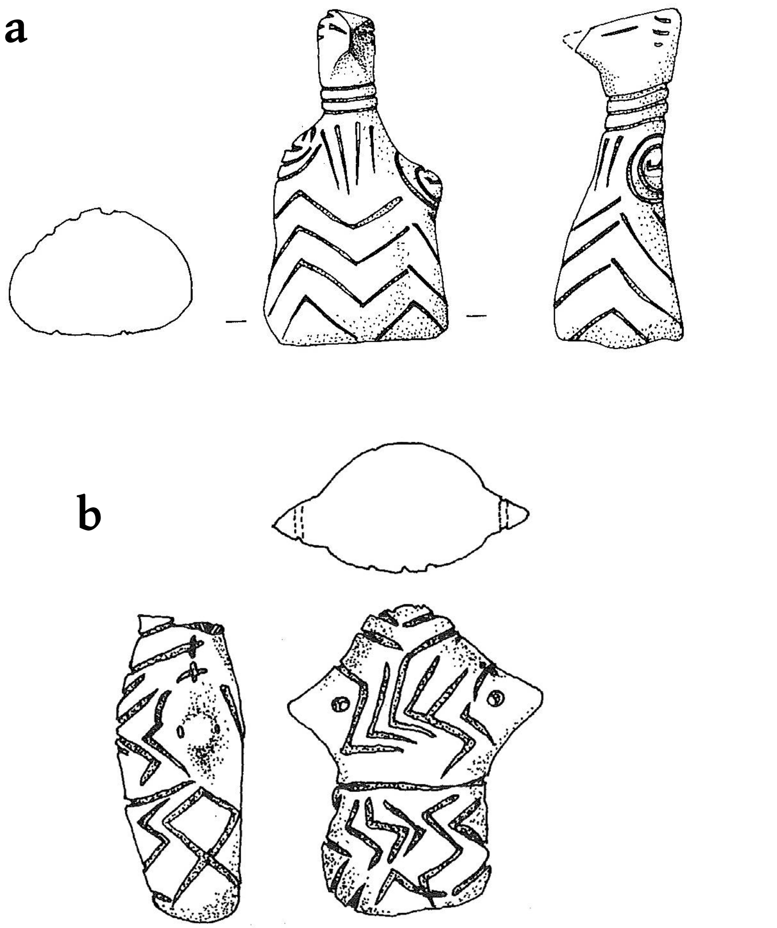


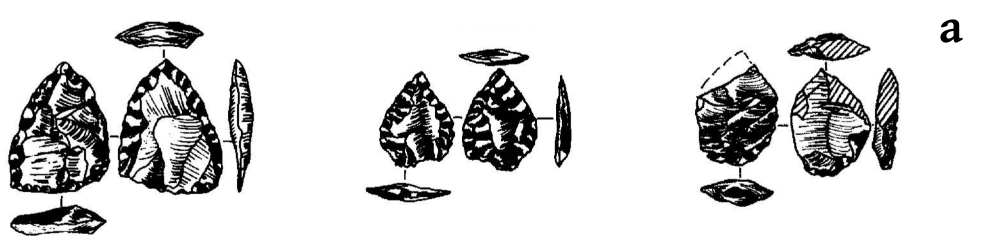
Figure 11. Avian imagery at Sitagroi: phase III (a) schematic bird-headed figurine, H. 4.4 cm. (Gimbutas 1986: fig. 9.46, pl. LIII:2); phase II (b) torso with perforations for insertion of feathers (?), H. 4.8 cm. (Gimbutas 1986: Fig. 9.2, pl. XLV:2) and (c) birdlike protome handle of a ladle (?), H. 4.5 cm (Gimbutas 1986: fig. 9.114, pl. LX:3).

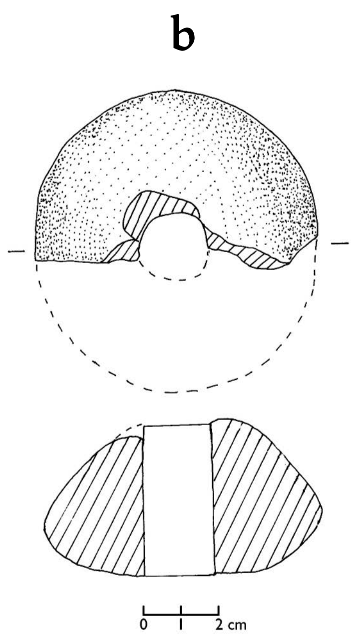
particular forest areas (Choyke 1998: 172; Vitezović 2017: 210); undoubtedly the villagers were familiar with the animal's habit and habitat. Spring also brought collectable reeds, grasses, fresh wood, and seasonal fruit (Wolfhagen *et al.* 2020: 103).

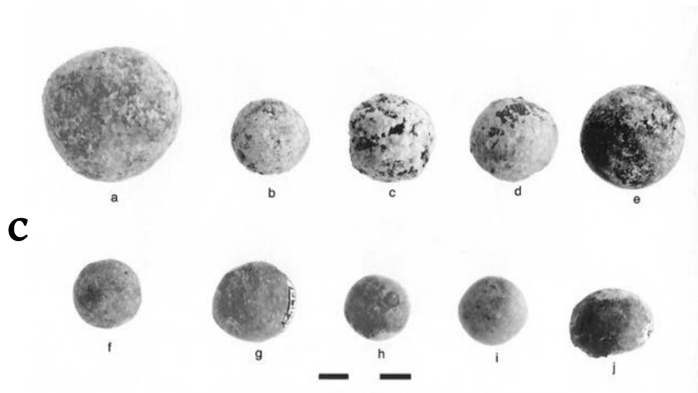
Summer offered opportunity to catch quail during its breeding season (compare Karathanassi 2020: 60). The warm months of spring and summer were also ideal for fishing/shell-fishing trips to the coast, although these continued as weather permitted (Theodoropoulou 2011a: 63; Veropoulidou 2011a: 53–54, table 2.4), and according to the timing of the shells' dangerous toxicity or their maximum of flesh and taste (Veropoulidou 2011a: 52–55). In the lacustrine environments around the Thermaic Gulf, cockles were collected, or even semi-farmed, according to seasonal/spatial rotation (Krahtopoulou and Veropoulidou 2017: 433–434). Year-round freshwater fishing, with seasonal peaks, is documented at Dimitra and Dispilio (Theodoropoulou 2014: 458–460). Fall was the time to hunt male aurochs during their rutting season (Wolfhangen *et al.* 2020: 103) or capture the females after the calves were weaned (cf. Speth 2013: 177), collect acorns and almonds, and stock up on fuel, fodder and basketry materials for the upcoming winter.

Actors, tools and techniques

At Sitagroi, only twelve stone projectile points were reported, from Phases IV (10) and V (2) (Tringham 2003: 88, 100–101, table 3.6). Three pieces from phase IV (Figure 12a) were found intact and must have been accidentally discarded—they were too good to throw away on purpose (Tringham 2003: 97, 116). If arrowheads were used in earlier times, they have left no archaeological trace in the typology (Tringham 2003: figs. 3.4, 3.6–3.9). Evidence of other potential hunting gear includes implements suitable to stun or slaughter animals: antlers (Figure 14c) with sockets to hold wood, or hammer-stones, shafted maces, hammers, and edged axes of hard rock. Ten mace heads, averaging in diameter ca. 6.5–7.0 cm, were recovered from Phase III (Elster 2003b: 190) (Figure 12b); plus stone cobbles, and isolated hammers from Phases I, II, and IV (Elster 2003b: 207, 211, 215). Other, perishable equipment may have included the bow and arrow with sharp-pointed shaft but no projectile attachment (compare Kroeber 1976: 530), or with bone and stone tips or barbs for different kinds of game; lances; a wooden thrower (or *atlatl*) outfitted with a ball of stone; or a three-cord *bola* with a round stone at the end of each cord, very efficient in capturing running game or low-flying fowl in a flock. Plain spheres of clay (Figure 12c) are part of the Phase III and V assemblages (Renfrew 2003c: 413). The Sitagroi biconoids (Figure 12d), commonly described as slingshots or sling-bullets at other sites (Renfrew 2003c: 413–414, with comparanda), are seen sporadically throughout the sequence, but ten cluster in Phase II; most exceed 4 cm in length.







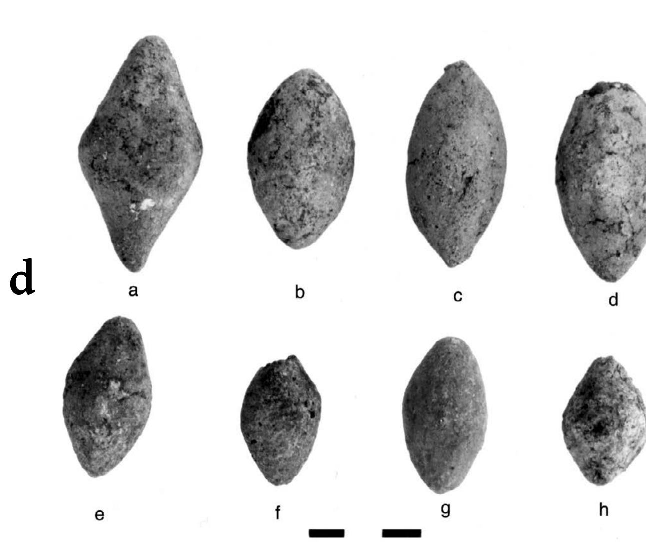


Figure 12. Hunting gear: phase IV (a) flint arrowheads (Tringham 2003: fig. 3.8: n, o, p); phase III (b) stone mace (Elster 2003b: fig. 5.33, pl. 5.41:a) and (c) clay spheres (Renfrew 2003a: pl. 10.9; phase II (d) biconoid "slingshots" (Renfrew 2003a: pl. 10.11).

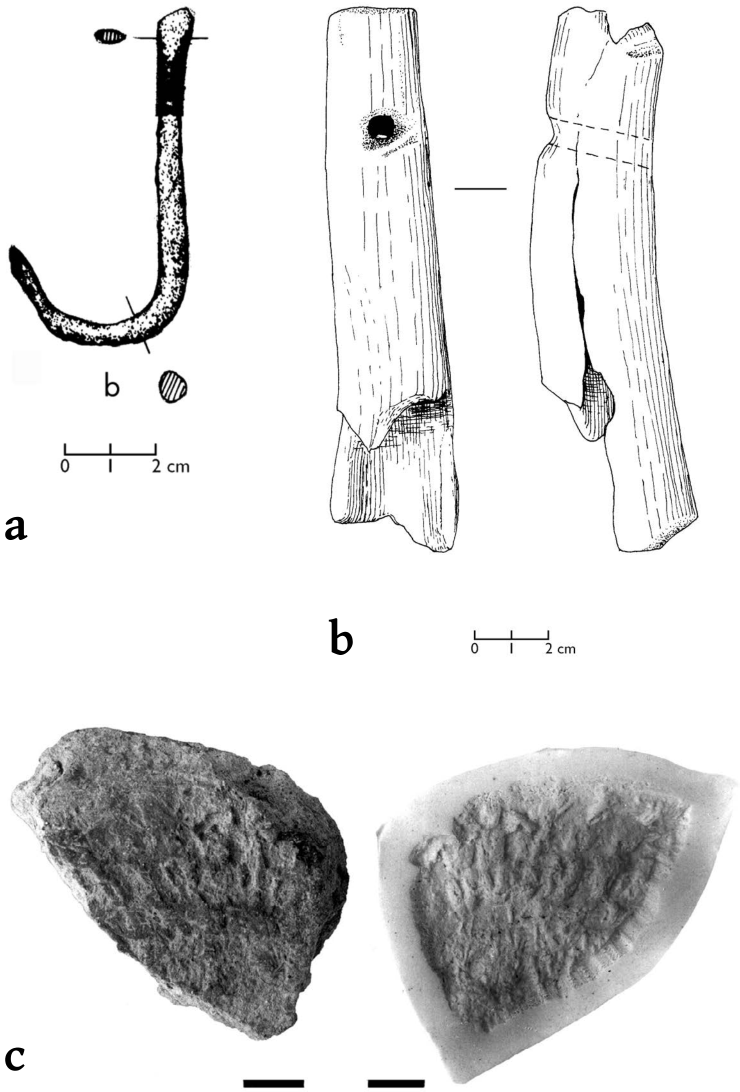
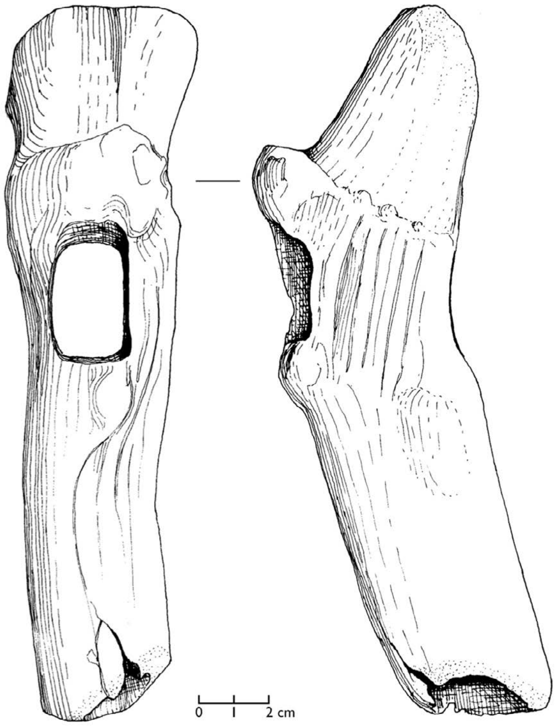


Figure 13. Fishing gear: phase IV (a) copper fishhook (Renfrew and Slater 2003: 8.2:b, pl. 8.5:c); phase II (b) antler weight/ sinker (?) (Elster 2003a: fig. 2.14, pl. 2.13a); phase III (c) impression of coiled-made basket (Adovasio and Illingworth 2003: pl. 6.14).

Lost now are the wooden points, the traps of wood (perhaps fitted with sharp blades), the nets and cords used to catch not only small animals and birds, but also large game—boar, deer or even bears (compare Karathanassi 2020: 57–62; Kroeber 1976: 525; Speth 2013: 177). Knives and scrapers of chipped stone and axes of ground stone made useful tools for butchering and processing. Whether wild or domesticated, the processing of the carcass is challenging; the aurochs, the male red deer are large animals demanding more than one hunter. Once cornered, captured, killed, skinned, dismembered—most of the carcass will have been used: hide, meat, fat, sinews, etc. Although the metapodials and phalanges are not meaty parts, they are broken to retract marrow (Binford 2014) and selected for tools, especially the metapodials. The latter are best used to form into tools when fresh (Isaakidou 2003: 234). The social organization of the hunt, following whatever customs governed this activity, be they social, symbolic, magical or religious, may account for the strong showing of red deer skeletal parts in the refuse bone of the settlement (cf. Steele and Baker 1993: 26).

A small handful of sporadic copper fishhooks (Figure 13a) from Phases III, IV, and V (Renfrew and Slater 2003: figs. 8.1:g, 8.2:b, 8.3:h) provide some evidence about angling. Theodoropoulou (2020: 111) notes that this method is not efficient for catching the small fish but better suited to the occasional carnivore cyprinid; therefore, nets would be preferable. A possible fishing weight has been recognized in an antler implement, perforated at the narrow end and hollowed out at the wider end (Elster 2003a: 48) (Figure 13b). No nets have survived, however; nor the potential fishing baskets, rods, sinkers of stone, wood or shell, or even the harpoons and spears that are used nowadays for freshwater fishing in Thessaly and Macedonia (Stratouli 1996: 11–17; Theodoropoulou 2020: 112). Shell-fishing ranged from uncomplicated to fairly involved tasks (Veropoulidou 2011a: 58, table 2.5). In the coastal shallows, the cockles would be collected with bare hands or common household utensils: digging sticks, rakes, shovels, sieves, knives, baskets. Antler picks suitable for digging (Elster 2003a: fig. 2.11a., pl. 2.8 [Phase V]), chipped stone knives, and the impression of a coiled basket/matt (Figure 13c) have been excavated at Sitagroi. To find and retrieve shells from the deeper sea floor, one had to swim, dive, or use boats, and carry equipment: nets, baskets, sticks, or



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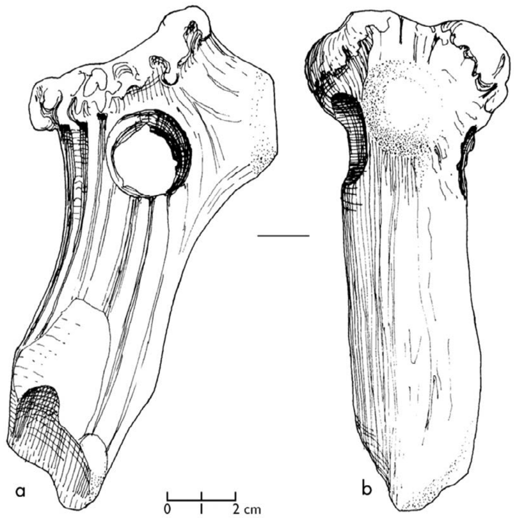

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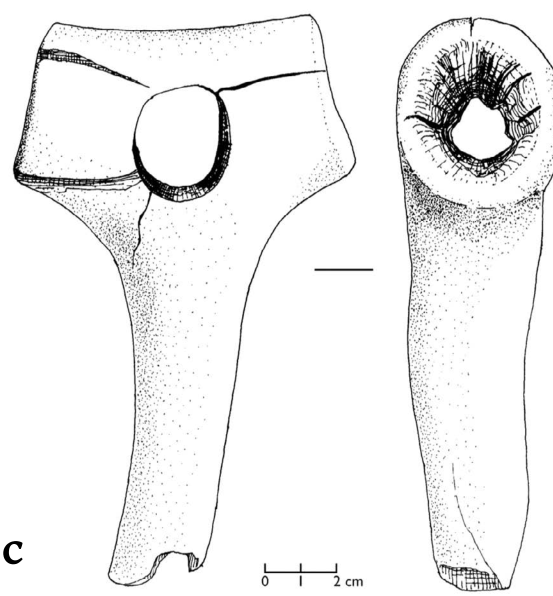


c

Figure 14. Socketed antler: phase III (a) shafted digging/hammering head of beam with rosette and pedicle and hollowed opposite end (Elster 2003a: fig. 2.15) and (b) shafted multi-purpose tool on beam with rosette and pedicle, preserving hammering surfaces at cut brow tine and opposite end (Elster 2003a: fig. 2.16); phase II (c) fork segment, with hole for insertion of tool head (Elster 2003a: fig. 2.17).

traps baited in the sand for *Dentalia* and *Glycymeris* ; and stones, knives, tongs to detach mussels, oysters, and especially the thorny *Spondylus* off the rocky beds. Alongside diving stamina, a familiarity with the underwater locales, deftness in prying the shell intact, and the ability to select the desirable specimens, were essential. Thus the laborious fishing of *Spondylus* was likely undertaken by "specialists" and/or on special occasions (Pappa and Veropoulidou 2011: 110). Symbolism, ceremony, and lore would have surrounded the expeditions and those who participated with tool and limb, and the "exotic" shells brought forth from the deep sea (Nikolaidou 2007; Theodoropoulou 2011a, 2011b).

In his compendium of the California Indians, Alfred L. Kroeber observed that their tools were simple, expedient, and multi-purpose, and the activities involved anyone and everyone in the village. The tasks were distinguished by "patience, simplicity, and ...adaptability rather than intense endeavor and accurate specialization" (Kroeber 1976: 525). In the Neolithic villages, too, the material apparatus was multifunctional and often unassuming, but the challenges of the task and the personal ability and

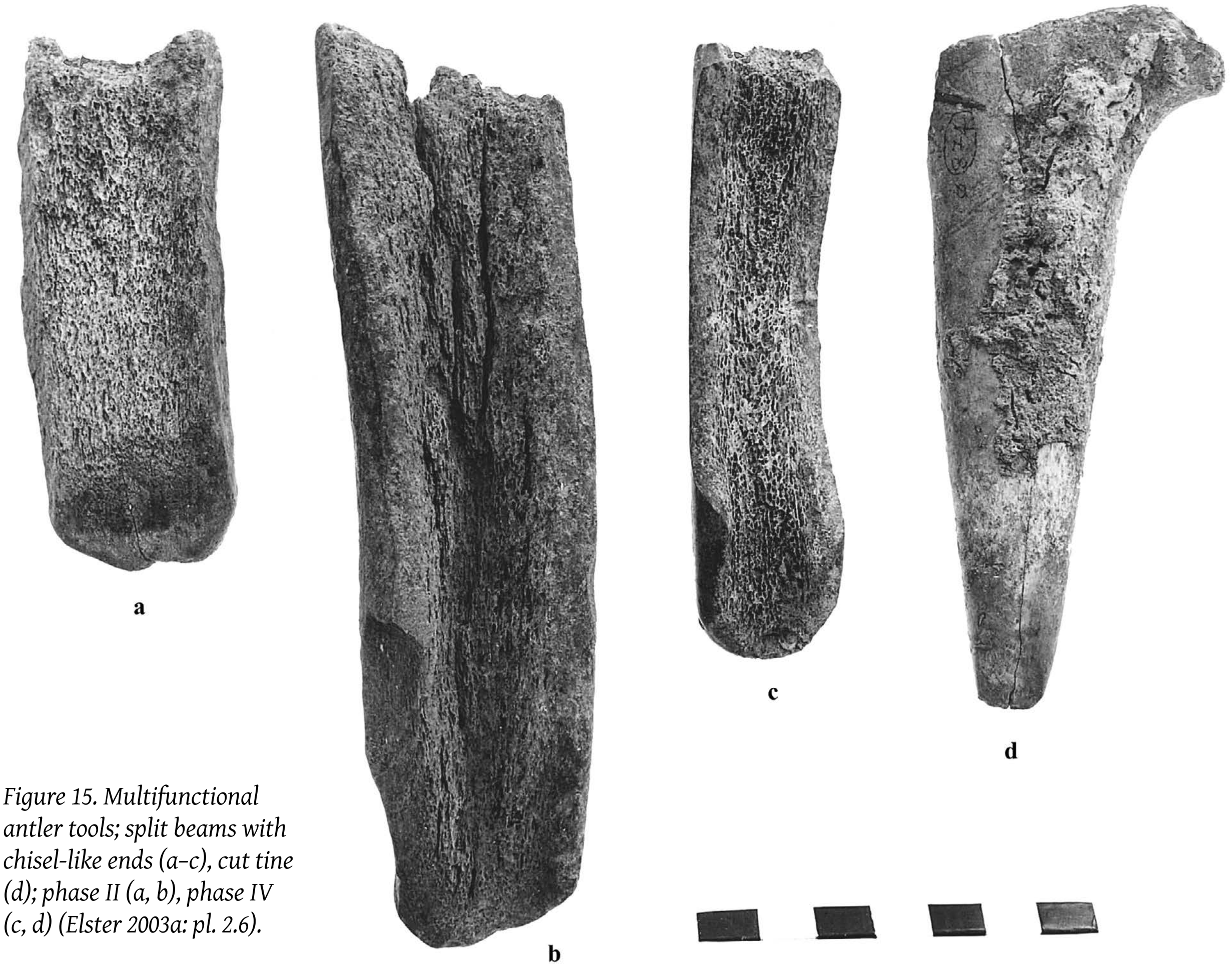


Figure 15. Multifunctional antler tools; split beams with chisel-like ends (a–c), cut tine (d); phase II (a, b), phase IV (c, d) (Elster 2003a: pl. 2.6).

achievement must have bestowed prestige on the hunter, the forager, the fisher, the diver. Patience, perseverance, perceptiveness, knowledge of animals and territory, cooperation, social know-how would be valued traits; back in the village, the talents of hospitality, generosity in sharing food, resources, and expertise, aptitude in the related crafts, storytelling skills and ritual safeguarding of the endeavors, would offer further opportunities to gain respect and distinction (Helms 1993: 13–87; Karathanassi 2020: 64–69; Kent 1986b: 11–16). The food ways of the village directed the hunters' strategies, as did also the social context of the hunt. Did people venture into the wild alone, with family, or in larger groups? Did they seek fame, alliances, brides; or provided offerings at funerals, births, and other ceremonies (Nikolaidou 2007: 193–197; Speth 2013: 176)? Was the densely populated landscape (Figure 2) competitive, the hunting areas contested by other groups (cf. Halstead 1999; Tzevelekidi *et al.* 2014: 135–136)? And was gender in play; men "hunting" large game or deep- diving while women and/or/with children harvesting, collecting, small-game trapping (Kensinger 1989; Speth 2013: 176-185)? Likewise, were men and women entitled to different "wild" foods and resources; cooking, eating, crafting with specific materials and in prescribed ways, on different occasions (Isaakidou 2003: 237, with references)? Finally, did the actual participants in the various tasks take the symbolic and social credit for the work (Kensinger 1989)? Some evidence suggests that, during the Final Neolithic in the Aegean, hunting begun to be seen in "male-gendered" terms of authority built on prowess and competition, which increasingly intensified during the ensuing Bronze Age (Hamilakis 2003). Figurines, often anatomically male, with attributes that allude to the garb of a hunter/warrior (?)— belts, "baldrics", caps—arguably embody male-centered notions of prestige built around the hunt (Alram-Stern 2016) and, by implication, around strife and aggression. However, a closer look at specific regions such as east Macedonia, reveals a counterbalancing "female" imagery which references the "wild": the bird-headed figurines discussed above are modelled in the conventions of "feminine" form and/or decoration (for example, Gimbutas 1986); other anatomically female figurines wear ornaments recognizable as shell jewelry: bangles, hair ornaments, brooches/pectorals, necklaces, and pendants (Marangou 1993: fig. 4a; Nikolaidou 2003: 356–357; Pappa and Veropoulidou 2011: 115, fig. 10). Did these ornate effigies capture women decked in their finery for special occasions—brides, hostesses, ritual specialists, or knowledgeable crafters of valuable jewelry (Nikolaidou 2007: 193, 195–196)?

Worked bone and antler

"Bone and antler tools were the 'green' artifacts of yesteryear: their manufacture recycled rubbish into recognizable and symbolic objects of utility and adornment" (Elster 2003a: 51). In the neolithic industries bone and antler were worked with stone axes, adzes, sharp cutting blades and flakes, rotary

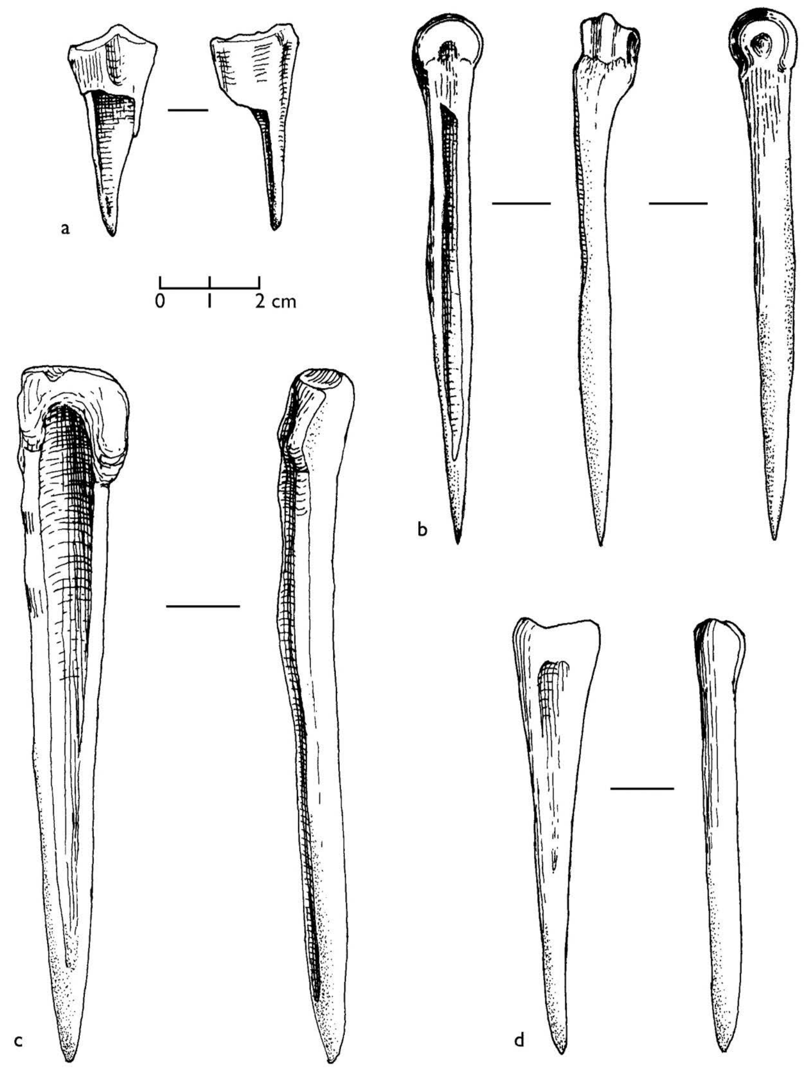


Figure 16. Pointed tools, cervid metapodials: phase II (a, b), phase IV (c, d); (a) roe deer, (c) red deer (Elster 2003a: fig.2.2).

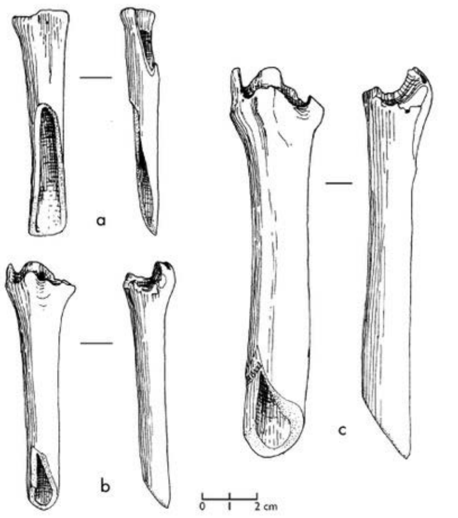


Figure 17. Sliced long bones with chisel and beveled ends: phase IV (a) caprovine metapodial and (c) red deer ; phase V (b) caprovine tibia, chisel end (Elster 2003a: fig. 2.10).

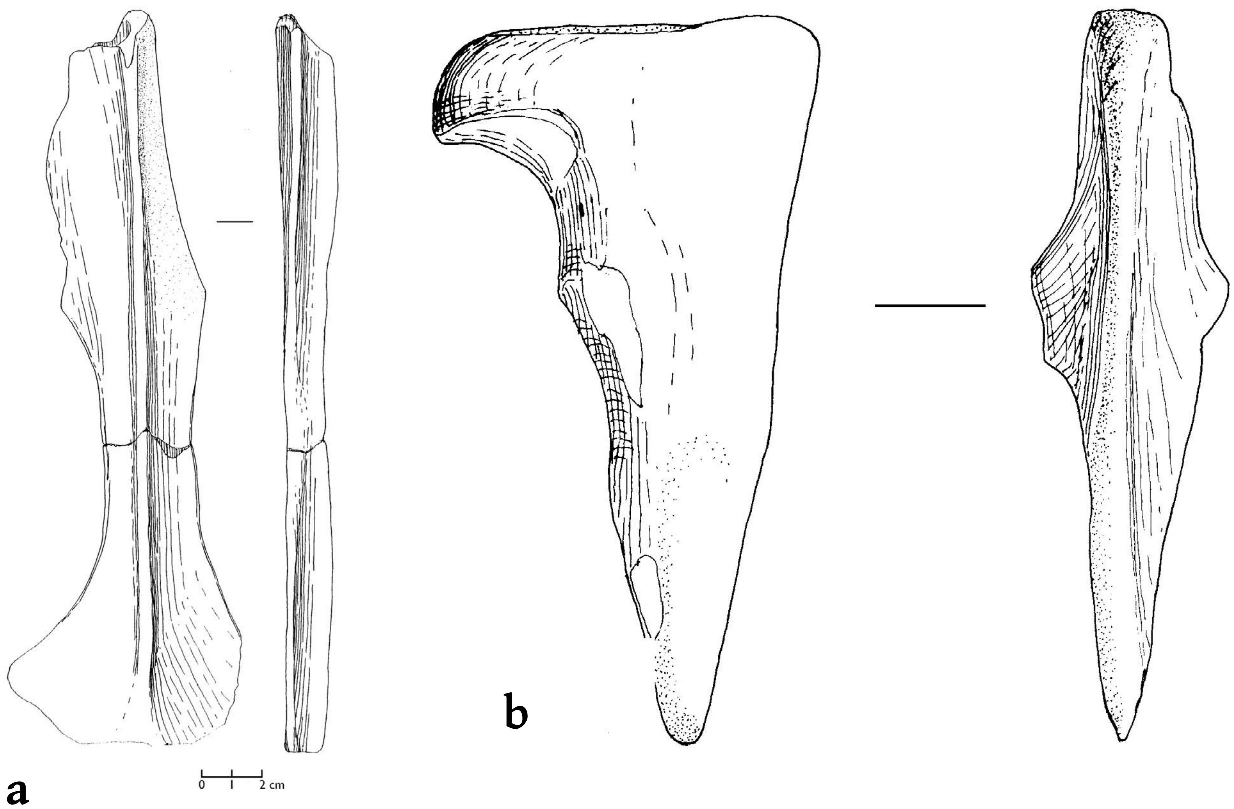
drills, and the abrasive surfaces of sandstone and other rocks. Bone was grooved, split, or broken along the grooves, shaved, polished, occasionally drilled or carved; antler was chopped, whittled, hacked, adzed, cut, carved, drilled, and finished with the thong-and-abrasive technique (Christidou 1997: 140–154 [Dimitra]; Lyneis 1988: 310–317 [Divostin]). An array of processing tools, and evidence of manufacturing wear on the bone artifacts are documented at Sitagroi (Elster 2003a, 2003b; Tringham 2003: 124); for example, a Phase II chisel-ended stone "processor" has a marginal groove that would be suitable for abrading, shaping, and/or smoothing the edges of a bone element, wood, even shell (Elster 2003b: 188, fig. 5.20).

The antler interior is composed of woven bone tissue, coarsely bundled together and surrounded by a compact surface or external layer that offers much more material for carving than do other types of bone. When the inner spongy core of a section of the rack is removed, the remaining sleeve or socket can provide a handle for holding another tool (Choyke 1998: 171–172; Vitezović 2017: 213) of stone or wood, by way of hoe or hammer; or a tine itself serves as digging/impacting tool, with a handle of different material. Variously socketed and perforated antlers (Figure 14a–c) are carefully crafted and use-worn (Elster 2003a: 46–48; fig. 2-14–2.17, pls. 2.8, 2.13–2.14, 2.22). Among other uses, antler hammers and punches (Figure 15 d) belong to a lithic toolkit (Tringham 2003: 124). For other tasks the beam (or tine) is cut longitudinally, the spongy inside removed, producing hollow split halves with one end shaped into a bevel (Figure 15 a–c). The antler halves are multifunctional: both halves tied around wood or stone forming the haft of a composite tool (Russell 1990: 538; Vitezović 2017: 219), or each half forms a scoop or spatulate shape (polishers?, flattened handles? [Elster 2003a: 46, pl. 2.12]) .

The most frequent form in the assemblage are pointed tools including antler tine fragments (Figure 5a). Deer metapodials have been identified among the numerous pointed (Figure 16), chisel and bevel-ended tools at Sitagroi (Figure 17)—although often these were made on caprovine long bones and ribs, or on unidentified taxa and elements (Elster 2003a: 39–46, figs. 2.2–2.5, 2.7, 2.10; pls. 2.1– 2.3, 2.5). Many of these artifacts must have been multiple-use tools exhibiting edge wear on ends and lateral margins. The long bones were commonly selected and carefully made into points with the epiphyses ground, perhaps for aesthetic reasons, or to operate more smoothly, possibly with textiles. Other worked elements of large deer or cattle include scapulae (Figure 18a), possibly used as pottery polishers (Russell 1990: 359) or tools for scaling fish, as is known ethnographically in Alaska (Rita Shepard 2003, personal correspondence); ulnae with polish along the longitudinal posterior edge and at the rounded point (Figure 18b); and astragali with ground medial and lateral faces (Figure 18c), likely used in the manufacture of textiles, leather, or pottery rather than in gaming (Vitezović 2015, with references). Dentine of wild animals are occasionally perforated to be hung as a pendant (Nikolaidou 2003: 349, 352 fig 9.24, and catalogue. Compare Karali-Yannacopoulos 1992: pl. 165b [wolf, from Dikili Tash]; Tóth and Choyke 2020: 371–372: fig. 5.41:1–2 [red deer, from Nebelivka]).

Some artifacts exhibit elaboration alluding to presentation, display, and adornment. A Phase III broken spoon or ladle is carved out of antler beam, extensively worked, roughed-out, thinned, but unfinished (Figure 19a); an interesting ethnographic comparandum are the spoons of elk horn with intricately carved handles that the California Indians used specifically when entertaining household guests (Kroeber

1976: 93, pl. 20). Other elaborated spoon handles at Sitagroi include one of beautifully polished bone, Phase I (Elster 2003a: fig. 2.18), and several anthropomorphic and zoomorphic clay protomes, Phase III (Gimbutas 1986: 259 fig. 9.73, 288 fig. 9.178). In the area of costume, "plaques" of highly polished boar tusk (Figure 19b) or cattle rib are flat, smoothed rectangular shapes with single or multiple perforations set along the narrower end, allowing them to be sewn on textiles or leather, or strung on a multiple cord or leather thong as necklace spacers (Elster 2003a: fig. 2.7b–d; Nikolaidou 2003: 355, fig 9.28); there are numerous parallels, including several examples from Dikili Tash (Karali-Yannacopoulos 1992: 160, pls. 164, 206d, e).



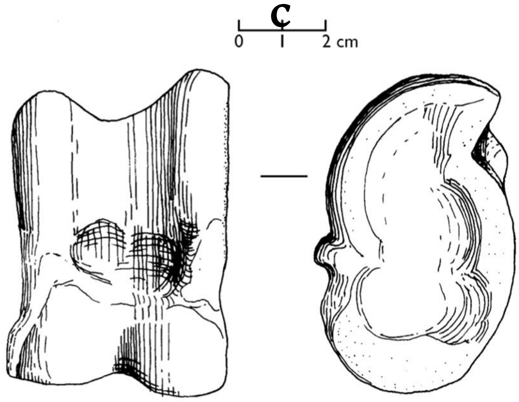


Figure 18. Miscellaneous worked elements: phase IV (a) aurochs scapula (Elster 2003a: fig. 2.19); phase III (b) cattle or red deer ulna and (c) astragalus (ibid, fig. 2.20a–b).

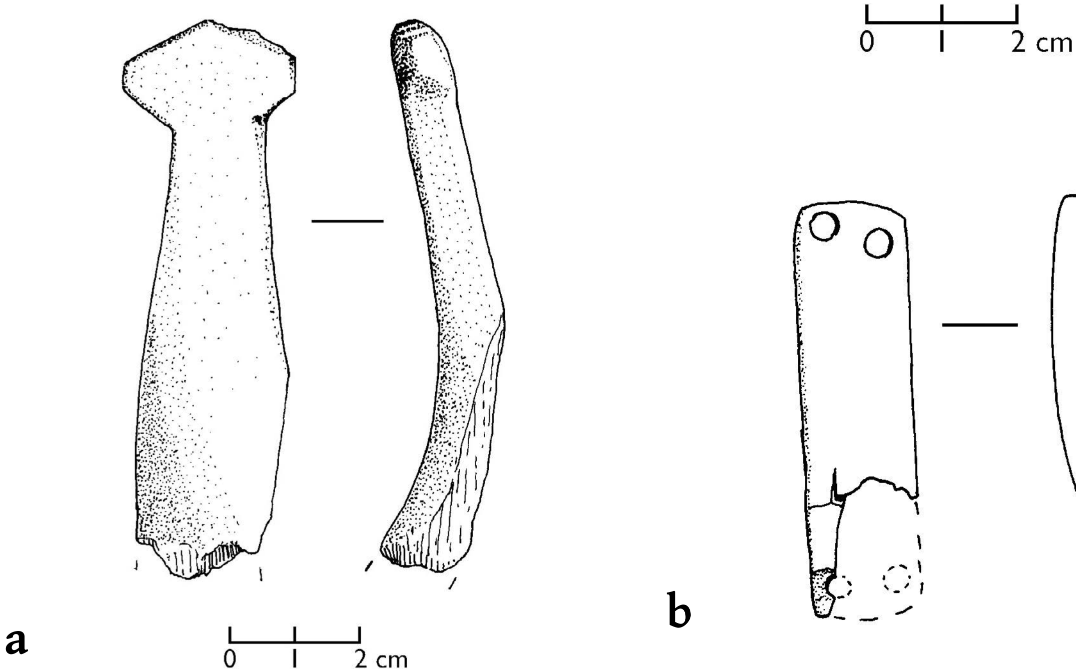


Figure 19. Elaborated artifacts: phase III (a) rough-out spoon of antler (Elster 2003a: fig. 2.12:b) and (b) bone plaque, canine of wild swine (Elster 2003a: fig. 2.7:c).

Interconnections: Tools, Technologies, and Trade

Contact and interconnection in east Macedonia was lively and comprehensive (Papadopoulos and Nerantzis 2014). The survey of the Drama plain undertaken alongside the Sitagroi excavations (Renfrew and Hardy 2003) illustrated the close similarity of signature artifacts such as pottery styles, figurines (Renfrew 2003b: 481, fig. 13.1.8), stamp cylinders and more, among the 26 identified sites—13 surveyed (Renfrew 2003b: 476, fig. 13.1). Several communities were involved in the region's specialized industries, manufacturing high quality artifacts for local use and export. Prominent among these was the black-on-red decorated pottery, which traveled widely along the Strymon/Struma valley (Malamidou 2007: 303). Four distinct production areas have been identified, one of them in the Angitis/Strymon valley including the villages of Sitagroi, Dimitra, and Kryoneri (Papadopoulos and Nerantzis 2014: 39). In addition, the Drama plain was one of the epicenters of trade in valuable shell during the fifth millennium; communities along the northern Aegean coast—from Dimini in Thessaly to Paradeisos in Thrace—collected, crafted, used, and circulated the coveted *Spondylus* and *Glycymeris*. Raw materials and/or finished products, shrouded in symbolism and prestige, radiated into the Greek mainland and north up to central Europe, where they featured prominently in burials and ceremonies (Ifantidis 2019: 520–556; Ifantidis and Nikolaidou 2011). The remarkably standardized ornament styles among the regional production centers (compare Karali-Yannacopoulos 1992 [Dikili Tash]; 1997 [Dimittra]; Malamidou 2007: 302, fig. 10 [Kryoneri]; Nikolaidou 2003 [Sitagroi]) clearly speak of a commonality — although it is impossible to know how much sharing or competition was involved. A transactional understanding, or even a neighborly arrangement is implied in Eftychia Yannouli's hypothesis that, in the Final Neolithic, the inhabitants of Dimitra traded quantities of the *Spondylus* ornaments they produced in exchange for meat supplies, which were abundant elsewhere in the Drama plain but rather scarce in their village (Yannouli 1997: 123–124).

In return for local goods, the villagers forged far-reaching trading partnerships to secure desirable lithics for chipped and polished stone tools—many of them indispensable to the hunters, fishers, butchers, cooks, and artisans. Volcanic rocks came from the Rhodope mountains some 180 km to the east (Dimitriadis and Skourtopoulou 2003), and hard stone for edge tools from outside the Drama basin (Dixon 2003: 137–138); the prized Madara flint was sourced some 300–200 km northeast in the Gumelniţa area of Bulgaria (Tringham 2003: 105). Other sought-after materials and technologies of Balkan or Thracian origin included metals and metallurgy (Renfrew and Slater 2003), and graphite cones or solutions for the graphite-painted pottery (Papadopoulos and Nerantzis 2014: 38). Alongside the durable commodities that have survived, we can also imagine a treasury of perishable goods, many harvested in the "wild": furs, feathers, culinary specialties and much more. In this account we imply any number of interconnections, perhaps best understood as entanglements: people with animals, tools, trade, exchange, travel, adventure, crafting—all ripe for further study.

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Hunting at the Neolithic lakeside settlement of Anarghiri IXb in western Macedonia, Greece. The evidence of the chipped stone projectile points

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Abstract

The Neolithic lakeside settlement of Anarghiri IXb, located at the Amindeon basin in Western Macedonia, Greece, was excavated during 2013-2016 by the Archaeological Service of Florina. The settlement lies at the shore of Lake Chimaditis and was occupied during the Late and Final Neolithic period. The excavation yielded a rich assemblage of chipped stone artefacts comprising more than 10,000 pieces. Among the various tool types, several projectile points made of flint and obsidian indicate the involvement of the prehistoric inhabitants in hunting activities. The assemblage is characterized by technological and typological variability, and different raw materials exploited for their production. This paper presents the techno-morphological characteristics of the chipped stone projectile points and explores their role in the activities of the inhabitants of Anarghiri IXb, their treatment and their social or symbolic dimensions.

Keywords: Neolithic; Greece; Western Macedonia; Anarghiri IXb; Lakeside settlement; Projectile points; Flint; Obsidian

Introduction

While hunting was an essential part of the subsistence during the Paleolithic and Mesolithic period, the sedentary Neolithic way of life depended on agriculture and animal husbandry which covered the main needs of the Neolithic communities. However, hunting was continuously practiced during the Neolithic to a smaller degree, along with other activities like fishing and gathering of wild plants and fruits. The archaeological record provides evidence for hunting activities through the remains of wild fauna, and by hunting gear found in excavations, while some rare depictions of hunting scenes also contribute to our knowledge on hunting technology (e.g. Çatal Höyük) (Mellaart 1967).

The projectile points made of various materials, such as stone and bone/antler are of the most characteristic artefacts connected to hunting. The use of bow and arrow was well-known during the Neolithic period, as it is evident by the wooden artefacts unearthed in northern and central Europe (Cattelain 2006; Junkmanns 2001; Junkmanns *et al.* 2019), as well as the Iberian Peninsula (Pique *et al.* 2015). However, the only evidence of hunting technology in Greece are the preserved active parts of the composite hunting tools, that is, the stone or bone/antler tips that were hafted on the arrow shaft (Tsangouli 2017: 3-4), and a few antler archer thumb rings found at the lakeside settlements of Dispilio (Ifantidis 2019: 123-127) and Anarghiri IXb (Arampatzis 2019: 171-178) in western Macedonia.

1. Anarghiri IXb, 2. Dispilio, 3. Avgi, 4. Megalo Nisi Galanis, 5. Kleitos, 6. Toumba Kremastis Koiladas, 7. Servia, 8. Makriyalos, 9. Stavroupoli, 10. Thermi, 11. Messimeriani Toumba, 12. Vasilika, 13. Iliotopos, 14. Pentapolis, 15. Dimitra, 16. Sitagroi, 17. Dikili Tash, 18. Proskinites, 19. Makri, 20. Rachmani, 21. Dimini, 22. Sesklo, 23. Pirgos, 24. Skoteini Cave, 25. Kitsos Cave, 26. Euripides Cave, 27. Drakaina Cave-Kaphalonia, 28. Ayios Dimitrios, 29. Lerna, 30. Franchthi Cave, 31. Kephala-Keos, 32. Ftelia-Mykonos, 33. Saliagos, 34. Melos

Figure 1. Map of the Greek Neolithic sites mentioned in the text.

Most Neolithic settlements in Greece have yielded small numbers of chipped stone projectile points, with a few exceptions in southern Greece (e.g., 249 points at Late Neolithic Saliagos, 213 points at Late-Final Neolithic Drakaina Cave in Kephalonia Island) (Evans and Renfrew 1968; Stratouli and Metaxas 2018) (Figure 1). The present paper focuses on the chipped stone hunting toolkit recovered from the excavation of the Neolithic lakeside settlement Anarghiri IXb in northern Greece. The assemblage comprises several projectile points and geometric microliths made of various raw materials, including regional and exotic ones. The tools are characterized by technological and typological diversity, while some unique artefacts point to their production by skillful knappers and their participation in long-distance interaction/exchange networks. Further discussion on the potential use and treatment of the artefacts, along with information from other assemblages (e.g., antler tools) will also contribute to the investigation of the role of hunting in the Neolithic community.

The Amindeon basin and the settlement of Anarghiri IXb

The Amindeon basin is located in western Macedonia, northern Greece, a mainly mountainous region. Of the most noticeable features of the basin are the four lakes (Petron, Chimaditis, Zazari and Vegoritis) that mark the landscape (Figure 2). The physical environment of western Macedonia favored the establishment of prehistoric settlements in the region, many of which were clustered at the lakeshores. The last 20 years field survey and rescue excavations have documented more than 54 archaeological sites dated from the Early Neolithic to the late historic periods. The search for the diachronic occupation of the area shed light on a well-defined prehistoric sequence named the 'Culture of Four Lakes'. The occupation patterns so far show a preference for the lakeside areas along with those in the form of shallow mounds and flat land. The foundation of settlements is related to factors such as proximity to water and fertile soils for agricultural exploitation. Their architecture is characterized by post-framed and subterranean circular dwellings, while some settlements are surrounded by a system of concentric ditches. Eight pile-dwellings and 19 lakeshore settlements have been recorded, most of which are located at the north shore of Chimaditis Lake (Chrysostomou 2020; Chrysostomou *et al.* 2015; Chrysostomou and Giagkoulis 2016).

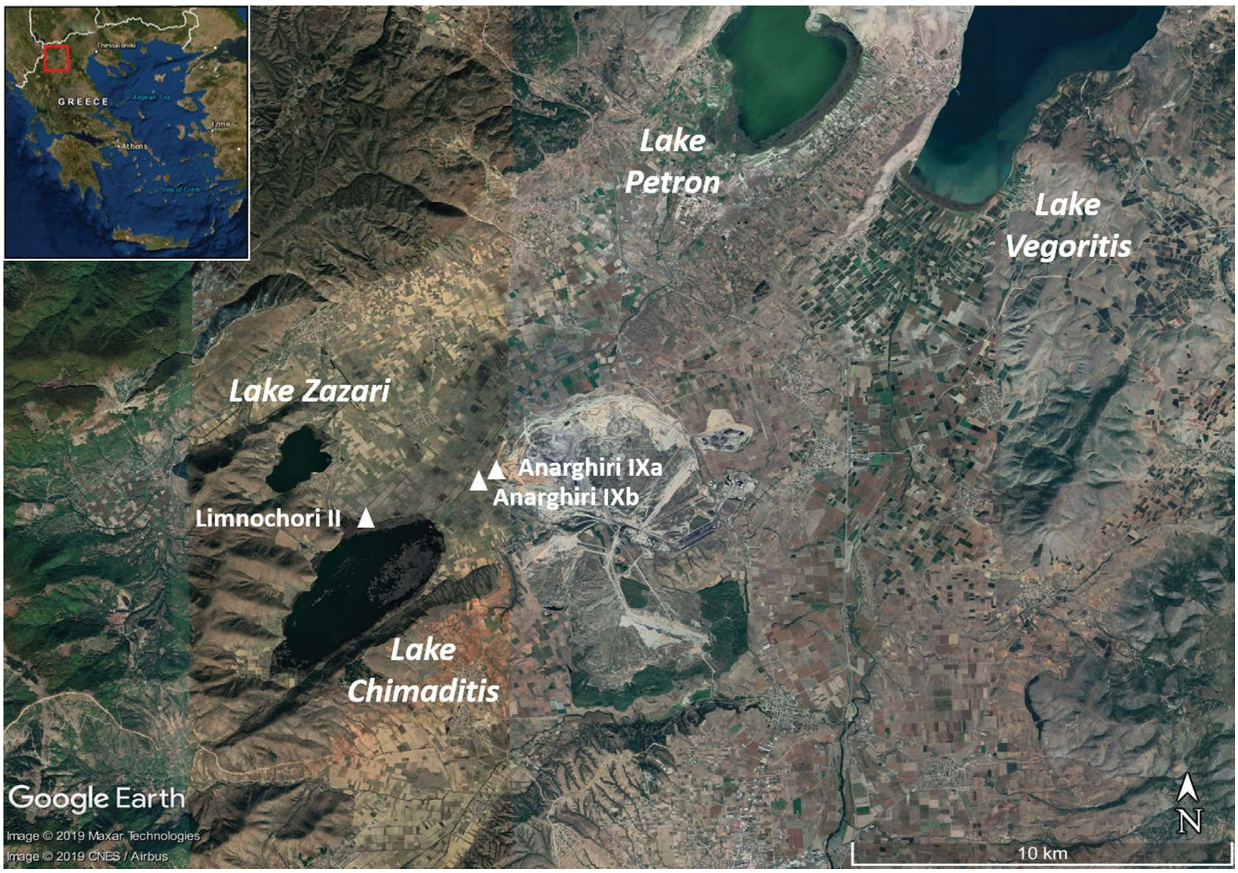


Figure 2. Map of the Amindeon basin and the location of the Anarghiri IXb settlement.

The Neolithic settlement Anarghiri IXb

The Neolithic lakeside settlement of Anarghiri IXb is located at the north-eastern marshy area of Chimaditis Lake, in the boundaries of the Amindeon Lignite mining zone of the Public Power Corporation S.A. Hellas. The prehistoric occupation covers an oval shaped area of approximately 2.8ha orientated from north-east to south-west (Chrysostomou 2020: 61; Chrysostomou *et al*. 2015: 29; Chrysostomou and Giagkoulis 2016: 8) (Figure 3). The excavation of the settlement was conducted during 2013-2016 by the Archaeological Service of Florina in the framework of the large-scale rescue excavations project and covered an area of 17,410 m^2. Due to the rescue character of the excavation the settlement's periphery was fully excavated to the natural bedrock, while the documentation at the central part was limited to the upper anthropogenic deposits. The radiocarbon dates based on 79 samples of wood and charcoal indicate an almost uninterrupted occupation from the Greek Late Neolithic (LN) I to the Greek early Final Neolithic (FN) period (5400/5300 – 4300/4200 cal. BC) (Papadopoulou 2020: 23, 25-26).

The excavation of Anarghiri IXb brought to light extensive architectural remains and destruction layers, as well as large quantities of movable finds. Of the most exceptional features are the well-preserved wooden structures found at the periphery of the settlement, corresponding to wooden trackways and fences (Giagkoulis 2019, 2020). The movable finds include large quantities of artefacts belonging to various categories of material culture, such as plain and decorated pottery, bone and antler tools, chipped stone artefacts and ground stone tools, well preserved wooden artefacts, clay figurines and stamps, ornaments of bone, stone and shell, etc. The study of the archaeological material is ongoing, while the wooden structures of the settlement's periphery, the antler and chipped stone artefacts have been part of specialized studies (Arampatzis 2019; Giagkoulis 2019; Papadopoulou 2020).

Figure 3. Aerial photo of the excavation at Anarghiri IXb (taken from north) (Chrysostomou and Giagkoulis 2016: 8, Fig. 8).

The chipped stone assemblage and the hunting toolkit

A rich chipped stone assemblage comprised more than 10,000 artefacts was collected during the excavation of the settlement. More specifically, the material derived from the excavation of 2013-2016 seasons yielded 10,953 artefacts, while 3,229 have been also recorded during the short 2017 project.

The chipped stone industry is characterized by the dominance of unretouched blades and blade tools made of various raw materials. Excellent quality flint and fine quality reddish brown radiolarite represent most of the assemblage, and probably derived from regional sources, such as the Pindus Mountains and river deposits (Dimitriadis and Skourtopoulou 2001; Tsangouli 2000: 149). Local raw materials like quartz and quartzite were less used. Moreover, the presence of imported obsidian and yellowish brown flint is documented. Obsidian is macroscopically identified as Melian, while yellowish brown flint probably originated in west Epirus or south Albania (Perlès 2001: 202; 2004: 10), but some varieties could also derive from more distant sources, such as the Rhodope mountain range and Thrace or Bulgaria (Dimitriadis and Skourtopoulou 2003: 129-132; Manolakakis 2005: 32-36). The abovementioned raw materials are represented in the chipped stone industry of both chronological periods (LN-FN). However, yellowish brown flint was mainly used during the FN period, when the percentage of obsidian and radiolarite increases in comparison to the previous period (Papadopoulou 2020: 57-64).

The tool inventory includes a diversity of types that are common at the LN-FN industries of northern Greece. Almost half of tools are represented by sickle blades/inserts, while end-scrapers also cover a significant part of the lithic industry. The remaining tool types include retouched blades, perforating tools, denticulates, splintered pieces, truncated pieces, burins, etc. (Papadopoulou 2020: 101-149).

The material under discussion refers to the types of projectile points and geometric microliths. The latter are included in the hunting toolkit since they are usually considered as projectile inserts (Perlès 2001: 205; Tsangouli 2002: 153). A number of 77 projectile points and 25 geometric microliths have been recovered from Anarghiri IXb, corresponding to 1.7% and 0.5% of the tools, respectively. More than half have been included in the recent study of the chipped stone industry of the Neolithic settlement (Papadopoulou 2020). The rest of the material derives either from the western sector excavated during 2013-2016 or refers to unstratified artefacts (surface finds, etc.).

The projectile points

The raw materials selected for the production of projectile points at the settlement of Anarghiri IXb show a variety of colors and qualities (Table 1). Gray and brown/pale brown flint of fine quality is the commonest raw material used, followed by reddish brown radiolarite. The use of yellowish brown flint is rarer, and there are few artefacts made of olive flint, obsidian and a couple of burnt or other materials.

Table 1: Raw material distribution of projectile points and geometric microliths by type.

TYPE	Gray flint	Brown/ pale brown flint	Yellowish brown flint	Olive flint	Reddish brown radiolarite	Obsidian	Other	Burnt	TOTAL
Tanged	3	4	2	1	1	1		1	13
Tanged-and-barbed	6	3		1	5	1		1	17
Leaf-shaped	4	2		1	1		1	1	10
Fusiform	1	3							4
Rhomboid	4	1			1				6
Shouldered	1		1						2
Triangular					2				2
Hollow-based			1						1
Spearhead			1						1
Various	8	5	2		2	1			18
Semi-manufactured	1		1		1				3
Geometric microliths	8	6	4		4	1		2	25
TOTAL	36	24	12	3	17	4	1	5	102

Table 2. Dimensions of projectile points and geometric microliths by type (maximum, minimum and mean values in cm).

TYPE	Max. Length	Min. Length	Mean	Max. Width	Min. Width	Mean	Max. Thick.	Min. Thick.	Mean
Tanged	6.2	2.1	3.5	2.8	1.2	1.8	0.6	0.3	0.45
Tanged-and-barbed	6	2	3.8	3.4	1.1	2.2	0.9	0.3	0.5
Leaf-shaped	6.6	3.5	4.7	2.6	1.5	2	0.7	0.4	0.5
Fusiform	4.8	3.2	4.2	1.9	1.3	1.6	0.7	0.4	0.5
Rhomboid	4.8	2.9	3.6	2.2	1.7	1.9	0.6	0.4	0.48
Shouldered	4.3	3.7	4	1.7	1.5	1.6	0.6	0.3	0.45
Triangular	3	2.1	2.5	2.1	1.4	1.7	0.8	0.3	0.5
Hollow-based	2.5			1.2			0.4		
Spearhead	8.1			2			0.8		
Various	4.6	1.8	2.8	3.5	1.3	1.9	0.8	0.2	0.5
Semi-manufactured	3.9	2.1	3.1	2.2	1.3	1.8	0.5	0.3	0.4
Geometric microliths	3.2	1.2	1.8	2.3	0.7	1.5	0.6	0.1	0.3

Most projectile points are complete (n: 46) or almost complete (n: 18), but in some cases the point is fragmented (n: 13). Their dimensions vary according to the type and the blank used (Table 2). Most of the points are shaped on long and wide blades (n: 34), but large flakes have also been used (n: 8). Blank identification was not possible for the rest of the assemblage due to covering retouch or breakage.

Classification of the projectile points is based on their techno-morphological characteristics. However, the great variety in morphology does not allow a strict categorization in all cases. Of the most common types are the tanged and tanged-and-barbed projectiles. *Tanged points* (n: 13) show a variety of shapes (Figure 4). The body is usually triangular with straight or slightly curved sides. The tang is in most cases fully developed, but there are also sorter tangs, while in one case a V-shaped tang is formed by short and abrupt retouch (Figure 4b). The shoulders are curved or have an oblique outline. Almost half of the tanged points have bifacial covering retouch, which in most cases is parallel or sub-parallel with oblique removals. This is mainly recorded at symmetrical and thin points of skilled manufacture and fine quality flint, as well as obsidian. Some points are covered with irregular bifacial retouch or have asymmetrical shoulders. There are also tanged points with plain faces that are formed by short lateral

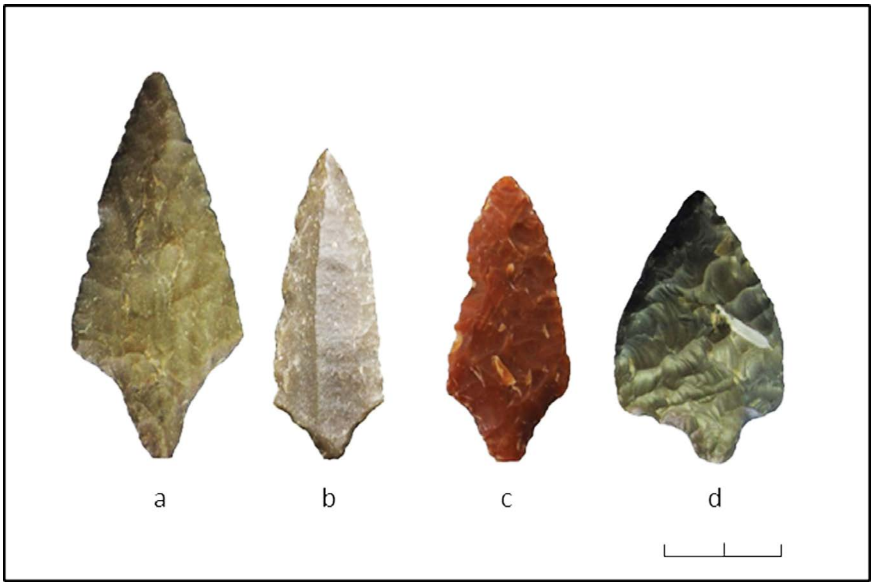


Figure 4. Tanged points: 4a. Grayish brown flint (FN), 4b. Gray flint (unstratified), 4c. Reddish brown radiolarite (FN), 4d. Olive flint (FN).

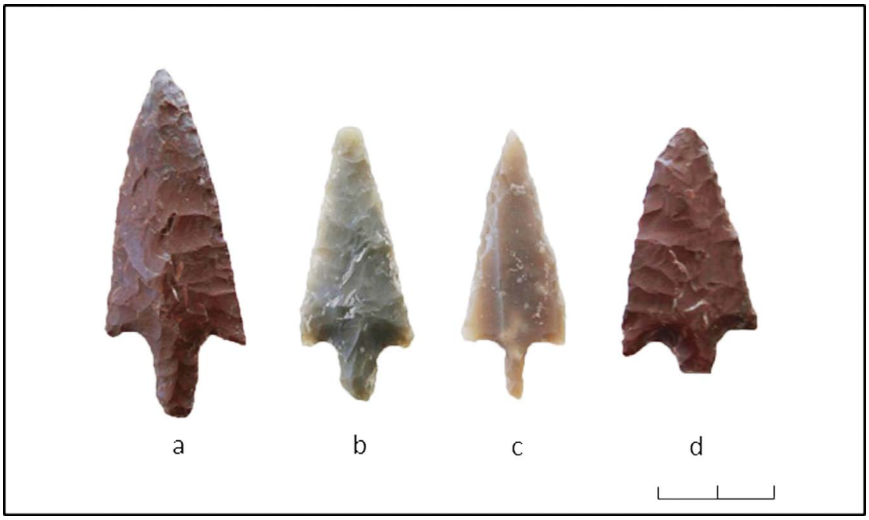


Figure 5. Tanged-and-barbed points: 5a, d. Reddish brown radiolarite (FN), 5b, c. Gray flint (FN).

or bilateral retouch on blade blanks. Few cases include an intentional break, which shapes one of the body edges.

Tanged-and-barbed points (n: 17) are subdivided into two groups. The first one includes points with fully developed tang and barbs (Figure 5). They are elongated with triangular body and bifacial notches that shape the barbs, which sometimes are asymmetrical. Almost all cases but one bear bifacial covering retouch, which is either parallel/sub-parallel or irregular. There are also two artefacts with short tang and longer barbs of convex outline, covered with parallel and oblique bifacial retouch (Figure 6a). The second group includes tanged points with very small, almost rudimentary formed barbs, usually shaped with small notches (Figure 6b). Most of them are elongated with triangular body. The majority has plain faces and retouch is usually partial with short and abrupt removals. A couple of cases include bifacial covering retouch or invasive retouch limited to the tip of the point.

Points with an almost *leaf-shaped* outline are also usual (n: 10) including some intermediary types of tanged points. Six points have an elongated leaf-shaped body and its prolongation at the proximal end forms a wide tang. The points are thin, symmetrical in most cases and covered with bifacial pressure retouch, which is parallel/sub-parallel or irregular (Figure 7a-e). There are also projectiles where the body is leaf-shaped but the base forms a small, short and narrow tang (Figure 7f-g). This shaping might have resulted from secondary modification, to recycle the tool or repair a broken part. The points are covered with parallel/sub-parallel bifacial retouch and pressure technique must have been applied. Moreover, a couple of leaf-shaped points involve blades with almost straight or convex base and bilateral or invasive retouch. Another variant includes points that could be classified as *fusiform* (n: 4). The points are elongated with elliptical outline and a V-shaped base and tip (Figure 7h-j). They are symmetrical and worked with invasive or short and invasive retouch, and there is one case with covering retouch only at its dorsal face.

A small number of *rhomboid points* (n: 6) appear as either elongated or as a short and wide variant (Figure 8a). These points have fine bifacial covering retouch with sub-parallel or irregular removals. There is also a rhomboid point with plain faces, formed by convergent intentional blows and marginal retouch for the shaping of the tip. Additionally, there are two complete *shouldered points* with plain faces shaped on a blade blank (Figure 8b). Their body is elongated and formed by continuous bilateral short and long semi-abrupt retouch. The base is located at the bulbar part of the blank and a shoulder is shaped at its

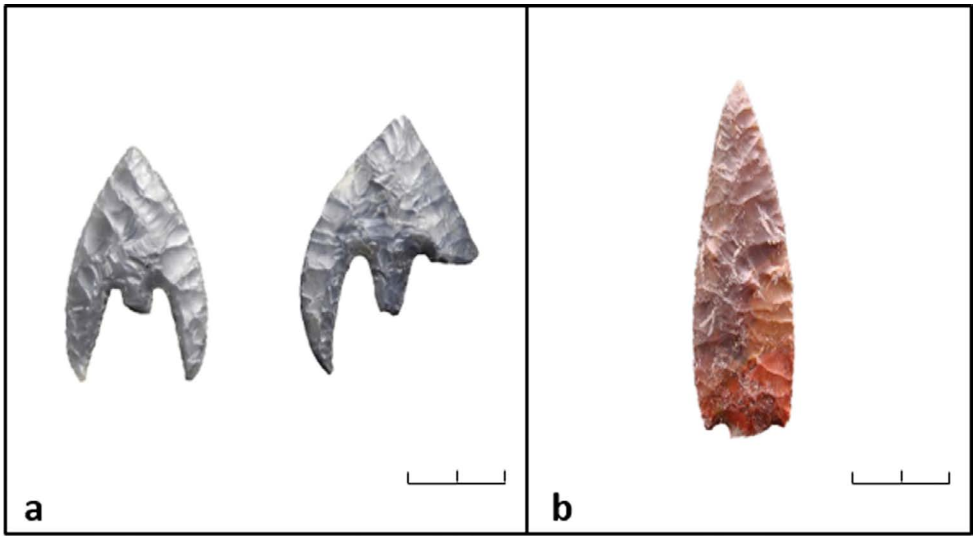
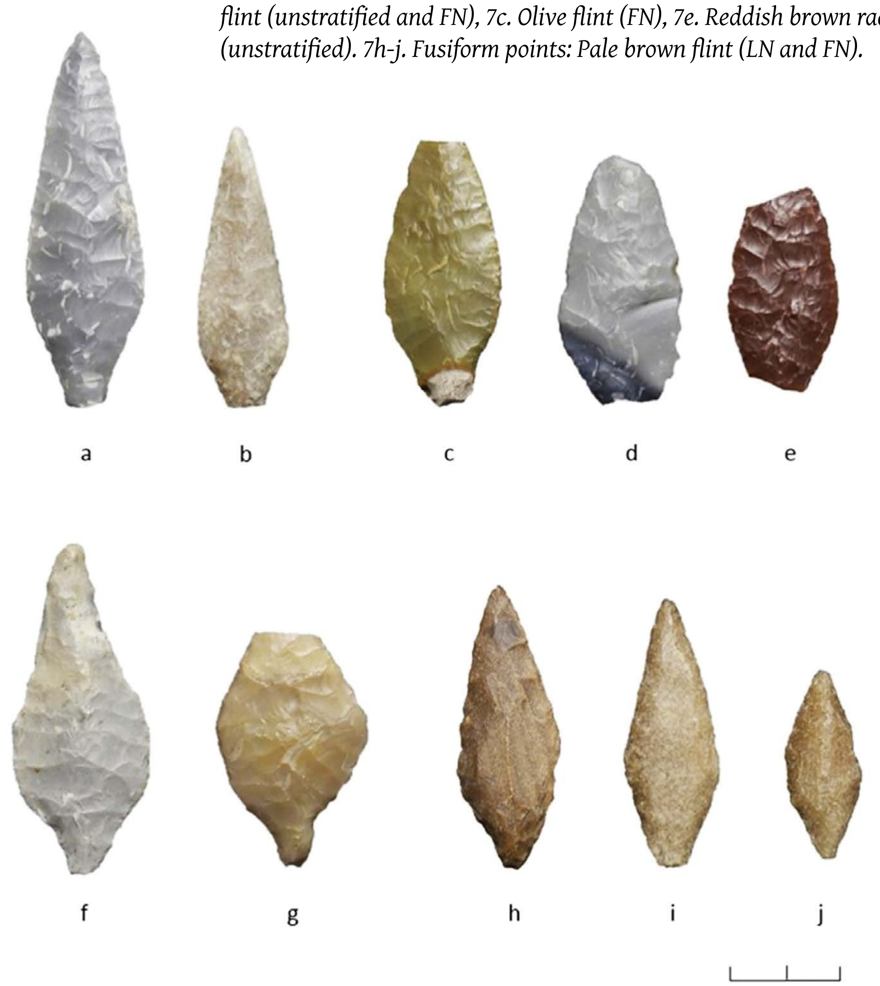


Figure 6. Tanged-and-barbed points: 6a. Gray flint (unstratified), 6b. Reddish brown radiolarite (unstratified).

Figure 7a-g. Leaf-shaped points: 7a, d, f. Gray flint (LN), 7b, g. Pale brown flint (unstratified and FN), 7c. Olive flint (FN), 7e. Reddish brown radiolarite (unstratified). 7h-j. Fusiform points: Pale brown flint (LN and FN).



right or left proximal part, with short and abrupt removals. In one case, the tip and the tang are formed by invasive retouch.

Two characteristic *triangular points* of reddish brown radiolarite are small and symmetrical (Figure 8c). The lateral edges are slightly convex and the base is straight. The face of the points has invasive retouch at the dorsal part and the ventral part has long and low bilateral removals. Moreover, there is a single *hollow-based* point made of yellowish brown flint shaped on a blade blank (Figure 9b). It is elongated and its shape is triangular. The faces of the point have invasive retouch and its base is formed by a notch with short and abrupt bifacial removals.

One projectile point is markedly larger than the other points (8.1cm length) and could be classified as a *spearhead* (Figure 9a). It is of excellent quality yellowish brown flint and has been collected from the FN deposits. It is complete, elongated and covered with bifacial retouch of parallel/sub-parallel removals. At both faces, the central area of the spearhead forms a low arris, right at the part where the removals meet. The tang has a triangular outline with a slightly convex end.

Apart from the above projectiles, there are some artefacts that cannot be attributed to the previous types, as well as some indeterminate fragments with bifacial covering retouch, which are classified as *various* (n:18). The category mainly involves points on blade blanks with plain faces, either asymmetrical, formed by an intentional break, or triangular with marginal short retouch for the shaping of the tip. There are also short and thick flakes with a straight or slightly convex base and bilateral short retouch ending to a pointed tip. Among the points with covering bifacial retouch is an elongated artefact of reddish brown radiolarite resembling the "limaces" (slugs) of Franchthi (Perlès 2004: 212) and another artefact almost rectangular in shape, with only one short barb.

Finally, three *semi-manufactured* projectile points include blade blanks used for the production of tanged or tanged-and-barbed points. In all cases the face of the blank is plain and has not been modified yet. Covering bifacial retouch is used to shape the tang and barbs.

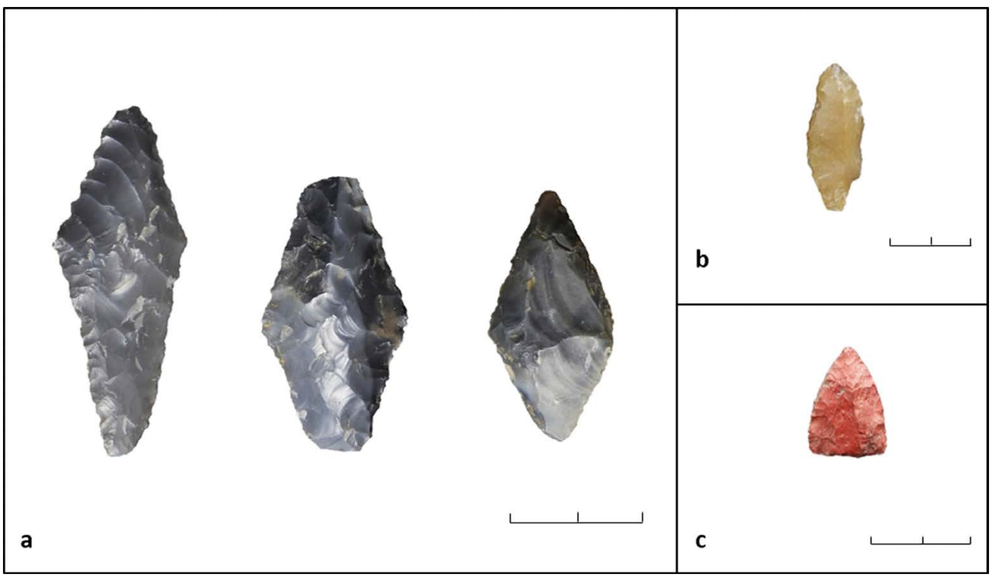


Figure 8a. Rhomboid points of gray flint (unstratified), 8b. Shouldered point of yellowish brown flint (FN), 8c. Triangular point of reddish brown radiolarite (FN).

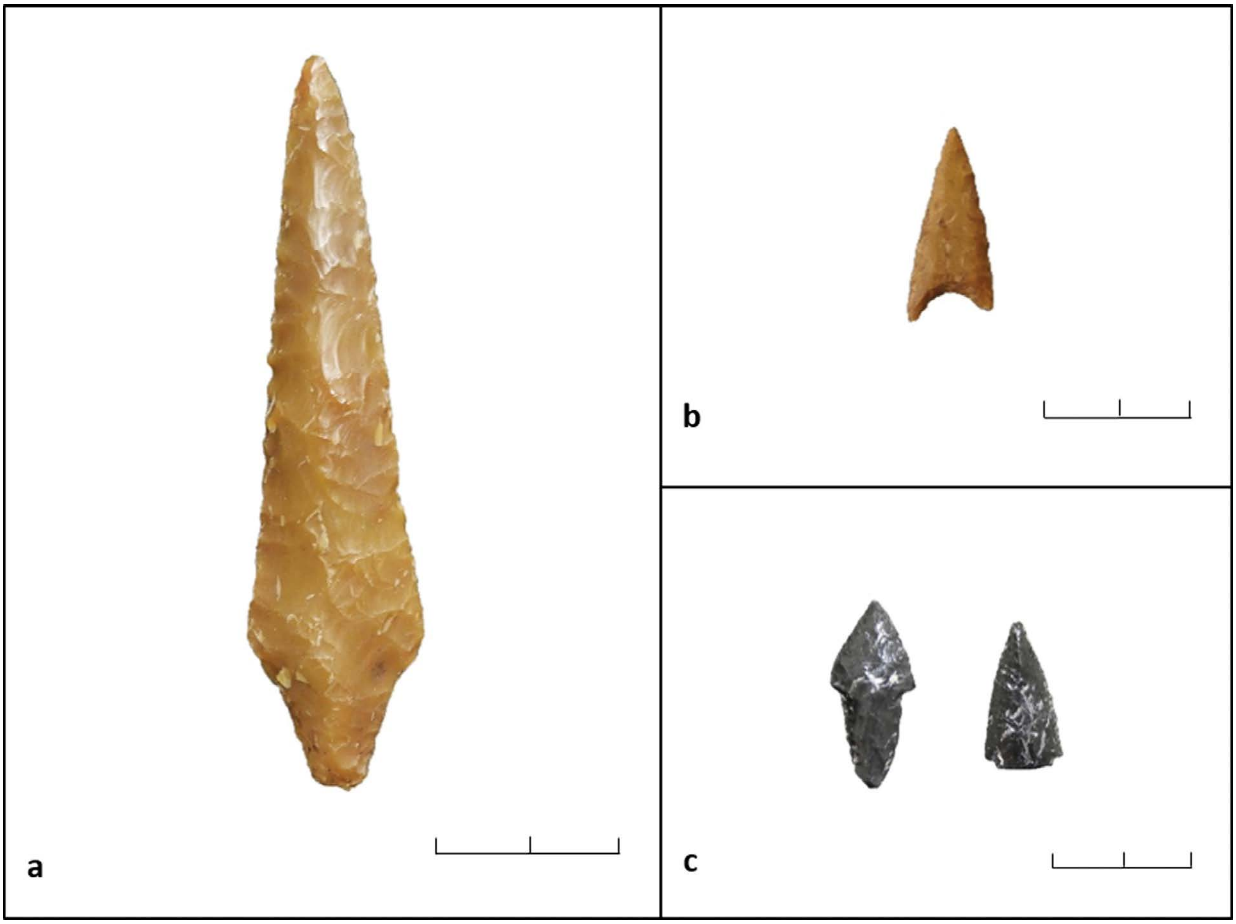


Figure 9a. Spearhead of yellowish brown flint (FN), 9b. Hollow-based point of yellowish brown flint (EBA?), 9c. Tanged and tanged-and-barbed obsidian points (FN).

The Geometric microliths

Geometric microliths cover a small part of the chipped stone industry (n: 25). They are mostly made of gray and pale brown flint, yellowish brown flint and reddish brown radiolarite. It seems that there are no specific preferences for raw materials, but the morphology of the blank could have played an important role. They are shaped on blades and rarely on microblade fragments of triangular or trapezoidal section. The blades have symmetrical profiles and the mesial part of the blank is used.

Most geometric microliths shape a trapeze with double truncation at the distal and proximal end (Figure 10). Few artefacts have an almost square shape or indeterminate form. The truncated part of the tool is shaped with short or long, continuous and abrupt retouch with parallel or sub-parallel removals. In some cases there is a combination of direct and inverse retouch, or the one end is truncated and the other is formed by an intentional oblique break. Some artefacts have also a backed edge at one lateral part probably to enable hafting, while there are few tools bearing lateral retouch and sickle gloss. In the latter case it is possible that the tool was used as a sickle insert at some point.

Figure 10. Geometric microliths from the FN layers.

Remarks on production techniques

The variability in techno-morphological characteristics of the projectile points from Anarghiri IXb allows some observations regarding production techniques. The tools show evidence of both simple and skillful knapping. Simple points have triangular or elliptical outline and are shaped with short, marginal or lateral continuous removals. Usually, the base of the point is located at the bulbar part of the blank. Few cases involve blade blanks with plain faces and small notches to shape the tang and barbs. There are also asymmetrical points on blade fragments which often display intentional fracturing at the base or one edge. These points are made of both fine and lower quality flint as well as radiolarite. The limited peripheral working and modification on various blanks (blades and flakes) does not point to a skilled manufacture or special time and labor investment for their production.

Half of the projectiles from Anarghiri IXb are carefully designed and indicate a more elaborate technique for their manufacture. They are usually thin and symmetrical with parallel and sub-parallel bifacial covering or invasive retouch pointing to skilled production. The projectiles include various types, such as leaf-shaped, tanged, tanged-and-barbed, triangular and rhomboid points. The production of the points required the selection of suitable blanks of certain dimensions, in order to proceed with their modification. It seems that the use of fine quality materials also enabled further working performed by pressure technique. The raw materials used in most cases are of excellent quality flint, radiolarite and obsidian. Olive flint has been exclusively used to produce points with bifacial covering retouch, as well as most of radiolarite artefacts. Excellent quality gray and pale brown flint is also used, and most rhomboids are made of fine quality dark gray flint. Some similarities in techno-morphological characteristics and raw materials in the region could demonstrate their production by skilled craftsmen who shared common technical traditions. Similar tanged and tanged-and-barbed projectile points covered with bifacial retouch and made of excellent quality flint (gray, pale brown, olive) or reddish brown radiolarite are mainly reported at the sites of western and central Macedonia, like Dispilio (Tsangouli 2002, 2017) and Avgi (Andreasen 2011, 2020: Fig. 37), Toumba Kremastis Koiladas (Hondroyianni-Metoki 2009: Vol. II, 585, Fig. 179), Makriyalos and Stavroupoli (Besios 2010: 53; Skourtopoulou 1999, 2004). It should be noted that the presence of semi-manufactured artefacts at the settlement of Anarghiri IXb points to an on-site production, at least in most cases.

Some projectiles of exceptional knapping quality and manufacture could be also considered as products of skillful, probably specialized knappers. The obsidian points from Anarghiri IXb are unique examples in northern Greece (Figure 9c), except for a possible preform from LN Stavroupoli (central Macedonia) (Skourtopoulou 2004: 389). Not only the exotic material used, but also the highly skilled manufacture with parallel removals by pressure technique indicate that the artefacts were either introduced ready-made into the settlement or they were knapped on-site by skilled craftsmen, since obsidian was worked at the settlement to a small degree. Similar obsidian projectiles bearing bifacial covering retouch are more common at the Neolithic settlements of Thessaly (e.g., Dimini) (Moundrea-Agrafioti 1981), southern Greece and the Aegean islands (e.g., Franchthi Cave, Kitsos Cave, Saliagos, Ftelia, etc.) (Evans and Renfrew 1968; Galanidou 2009; Perlès 1981, 2004). Another interesting case is the spearhead of excellent quality yellowish brown flint. Its high technical standard as well as the raw material used for its production could hardly support its manufacture by locals, pointing to specialists probably from distant areas. The yellowish brown spearhead is unique for northern Greece and there are few cases of large points made of this raw material in Greece, which are triangular or have serrated sides and various tang shapes (e.g., Dimini, Euripides Cave) (Lolos 1999: 319, Fig 18; Moundrea-Agrafioti 1981: PL.10: 14). The abovementioned cases demonstrate the participation of the community in wider and long-distance networks, a suggestion also reinforced by a number of imported chipped stone artefacts made of obsidian and yellowish brown flint (Papadopoulou 2020: 271-279).

Projectile points in the chronological context of northern Greece

Projectile points are underrepresented in the tool assemblages of the Neolithic settlements of northern Greece (Table 3). According to the limited published information, the Anarghiri IXb material is one of the most numerous, but high numbers are also reported at Neolithic Avgi (Andreasen, *pers. communication*), Dispilio (Tsangouli 2017: 11) and Stavroupoli (Skourtopoulou 2004). However, one should keep in mind that since the artefacts were used outside the settlement's area, a number of points could have been lost during an unsuccessful hunt (Tsangouli 2017: 11).

The projectile points from Anarghiri IXb consist of characteristic types of the Late and Final Neolithic period, some of which are found at contemporary settlements of northern Greece. However, the dating of the Anarghiri IXb projectile points is not possible for the total of the assemblage (Table 4). Almost 55% derives from the FN layers and 18% from the LN, while a significant part of the points comes from unstratified deposits. All geometric microliths -except for one- belong to the FN contexts. The partially excavated LN deposits and the numerous unstratified artefacts do not provide a clear picture of possible changes between the two chronological periods.

According to the stratified material, most projectile types are represented during both the Late and Final Neolithic. However, some types, such as the shouldered and triangular points, the spearhead and the elongated "limace" derive only from the FN layers, as well as most of the geometric microliths. Regarding raw materials, all points made of obsidian, yellowish brown flint, olive flint and reddish brown radiolarite belong to the FN, a period when the use of these materials increases at the settlement. Technologically, the fine bifacial covering retouch with parallel, sub-parallel or irregular removals performed by pressure technique is represented during both chronological periods, but at the LN assemblage is mainly documented at the leaf-shaped points.

Some types of projectile points are related to certain chronological periods. For instance, the hollow-based points appear in Greece during the Early Bronze Age (EBA) (Karimali 2010: 162-163; Karimali and Karabatsoli 2010: 346). In Northern Greece, points with a concave base and bifacial invasive or

TABLE 3. DISTRIBUTION OF PROJECTILE POINTS AND GEOMETRIC MICROLITHS AT MN-FN SETTLEMENTS OF NORTHERN GREECE.

Settlement	Chronology	Projectile points	Geometric microliths	Raw material	Reference
Western Macedonia					
Megalo Nisi Galanis	MN-FN	Triangular points with bifacial covering retouch (FN)	?	Jasper or radiolarite	Fotiadis *et al*. 2019: Fig. 19
Toumba Kremastis Koiladas	LN	Tanged with bifacial covering retouch (1), tanged-and-barbed (1), triangular (4)	?	Flint/ chert	Hondroyianni-Metoki 2009: 382
Servia	MN-FN	Triangular points with bifacial retouch (6), tanged (1), transverse (2)	-	Chert	Watson 1983
Dispilio	MN-FN	Tanged, tanged-and-barbed with bifacial covering retouch by pressure technique (n:36, LN-FN layers)	Trapeze on blade fragments	Flint, radiolarite	Tsangouli 2002: 153, 2017: 11
Avgi	MN-LN	Tanged with short bilateral retouch (2), tanged-and-barbed with covering (30) or invasive (2) retouch, tanged-and-barbed/ asymetrical with covering rertouch (1), hollow-based with bifacial covering retouch (2), atypical (1), other (3)	3 trapeze	Flint/chert	Andreasen, *personal communication*
Central Macedonia					
Makriyalos	LN	Tanged, tanged-and-barbed with bifacial covering retouch by pressure technique, 'atypical' triangular points	?	High quality flint	Besios 2010: 53; Skourtopoulou 1999
Stavroupoli	MN-LN	Tanged, tanged-and-barbed, triangular or elliptical, shouldered, hollow-based, asymmetrical with simple breaks. Marginal, bilateral and less bifacial covering retouch (n:30)	-	Quartz, jasper (siliceous limonite), radiolarite, flint and an obsidian preform	Skourtopoulou 2004
Thermi B	MN-LN	Triangular, leaf-shaped, tanged and shouldered points on flakes and blades (n:19)	1 triangle	Jasper	Skourtopoulou 1990: 260, PL. 1, 2a, Skourtopoulou 1993: 89 95, Fig. 44, Table 45
Vasilika III-IV	LN	1 transverse point	3 trapeze	Jasper	Kyriakidou 1991: 72, 74
Iliotopos	LN	Triangular with invasive bifacial retouch (1) and tanged with marginal retouch (2) on flakes	-	Jasper, flint	Lychna 2010: 85-86
Kalindoia	LN	A tanged point with marginal retouch on a flake	-	Jasper	Lychna 2010: 84
Eastern Macedonia &Thrace					
Dikili Tash I	LN	-	2 triangles, 1 trapeze	?	Sefériadès 1992: 73-74
Sitagroi II-III	LN-FN	-	1 triangle, 1 trapeze	Flint	Kakavakis 2011: 152-153
Dimitra	MN-LN	A mesial fragment with bifacial covering retouch (leaf-shaped?)	2 trapeze	?	Kourtessi-Philippakis 1997: 216
Proskinites	MN-LN	Triangular and tanged points on flakes with marginal and bilateral retouch (n:11)	-	Flint	Papadopoulou 2007: 56
Makri	MN-LN	Few triangular pressure points, mostly atypical	?	Flint	Skourtopoulou 1998

Table 4. Stratigraphic distribution of projectile points and geometric microliths by type.

TYPE	LN Layers	FN Layers	Indeterminate
Tanged	1	8	4
Tanged-and-barbed	2	9	6
Leaf-shaped	3	3	4
Fusiform	2	2	
Rhomboid	1	2	3
Shouldered		2	
Triangular		2	
Hollow-based			1 (EBA?)
Spearhead		1	
Various	4	11	3
Semi-manufactured	1	1	1
Geometric microliths	1	24	
TOTAL	15	66	21

covering retouch derive from the Bronze Age levels of Megalo Nisi Galanis (Fotiadis *et al.* 2019: 31, Fig. 19c), Messimeriani Toumba (Skourtopoulou 2002: 275, Fig. 1:4), Dikili Tash (Sériadès 1992: PL. 117) and Pentapoli (Kourtessi-Philippakis 2010: Fig. 2:17), but are also well-known from the lithic industries of southern Greece (e.g., Lerna) (Hartenberger and Runnels 2001; Runnels 1985). The hollow-based point from Anarghiri IXb found at disturbed excavation layers could be considered as a contamination from later periods. However, it should be noted that this type of projectile has been recorded at the MN-LN settlements of Avgi and Stavroupoli (Andreasen 2011; Skourtopoulou 2004: 377, 383). Similarly, the triangular bifaces are characteristic of the FN period, like those from Megalo Nisi Galanis (Fotiadis *et al.* 2019: 31, Fig. 19:a-b) and Servia (Watson 1983: 122, Fig. 2:1), but are more common in Thessaly (e.g., Dimini, Sesklo, Rachmani, Pyrgos) (Moundrea-Agrafioti 1981: 150-152; Tsountas 1908: PL. 42: 14-18; Wace and Thompson 1912: 51, Fig. 27q) and Southern Greece (e.g., Franchthi Cave, Kitsos Cave, Ag. Dimitrios, Kephala, etc.) (Coleman 1977: PL. 68: 86; 172; Moundrea-Agrafioti 2008: 246; Perlès 1981: 170, 2004: 196-197).

The most characteristic types of the Late and Final Neolithic period are the tanged and tanged-and-barbed points, which appear in Greece at the beginning of the LN period (Karimali and Karabatsoli 2010: 346; Moundrea-Agrafioti 2008: 244; Perlès 2004: 195-196). Tanged and tanged-and-barbed points either with plain faces or bearing bifacial invasive and/or covering retouch are common in northern Greece, including various shapes for the tang and the barbs. However, the two points with longer barbs and convex outline from Anarghiri IXb are unique cases, although unstratified. A similar projectile has been found at the LN settlement of Limnochori, nearby Anarghiri IXb (Chrysostomou, *pers. communication*).

Rhomboid points are rare in northern Greece. At Anarghiri IXb the one point with plain faces is assigned to the LN period, while two others with bifacial covering retouch derive from the FN deposits and the rest are unstratified. Similar artefacts derive from the FN layers of Ag. Dimitrios in Peloponnese (Moundrea-Agrafioti 2008: 244) and Kitsos Cave (Perlès 1981: 175-186, Fig. 120). Neither leaf-shaped points with bifacial covering retouch are common at the lithic industries of northern Greece. A mesial fragment possibly from a leaf-shaped point is documented in Dimitra (Kourtessi-Philippakis 1997: PL. 61: 21) and another artefact was found in Thermi B (Skourtopoulou 1990: PL. 1), while some tanged points with elliptical outline are recorded at Makriyalos (Besios 2010: 53) and Dispilio (Kita 2020: 166, Fig. 80-81). The range of the Anarghiri IXb leaf-shaped points is noteworthy and all variants are represented during both chronological periods (LN-FN). Similar points are reported from central and southern Greece, like for instance, an obsidian projectile from LN Dimini that is described as intermediary type of a biface and a tanged point (Moundrea-Agrafioti 1981: PL.10: 5, 10), while at Kitsos Cave a flint point is classified as fusiform (Perlès 1981: 176, PL.VIII: 15). Similarly, fusiform points are documented in southern Greece (e.g., Skoteini Cave) (Perlès 1994: 51), but in most cases the artefacts are more elongated and totally covered with bifacial retouch, in contrast to the Anarghiri IXb material.

The use of blades and mainly flakes for the production of simple points is rather common at most settlements of northern Greece. Plain faces with short marginal and bilateral retouch, asymmetrical shoulders or intentional breaks, but also "atypical" triangular points with short bilateral retouch and straight or convex base are usually associated with local raw materials, sometimes of lower quality. For instance, a great part of the points in Stavroupoli has been formed on quartz flakes with basic shaping (Skourtopoulou 2004: 377).

Finally, geometric microliths can be found in all chronological phases (Perlès 2004: 189-190). It is one of the rarest tool types at most Neolithic settlements of northern Greece (Dispilio, Avgi, Thermi B, Vasilika, Sitagroi, Dimitra, Dikili Tash) and they usually shape a trapeze and less a triangle.

The use of projectile points

Projectile points are simple or more sophisticated manufactured elements that were hafted on a spear or arrow and are usually considered as weapons for hunting activities or warfare (Runnels 1985: 381; Tsangouli 2002: 153). However, other uses have been also suggested, including cutting, scraping, boring and engraving (Andrefsky 1998: 191-192). At the MN-LN settlement of Stavroupoli the use of some points for cutting activities has been proposed due to the retouched rounded tip of the artefacts (Skourtopoulou 2004: 369-370). Another suggested use is fishing, like in the case of the Neolithic lakeside settlement of Dispilio, but also at the LN Saliagos for tuna fishing (Almatzi 2002: 139; Evans and Renfrew 1968: 79). Similar activities are connected to geometric microliths, which were used as projectile inserts, but also for harvesting, engraving, etc. (Andrefsky 1998: 194-195; Perlès 2001: 205, 2004: 188-189; Tsangouli 2002: 153).

Due to the lack of microwear analysis, the discussion on the use of projectile points and geometric microliths at the settlement of Anarghiri IXb is limited to some macroscopic observations. Almost half of the points show breaks at their base, tang and tip, which could be related to their use or resulted from accidental breakage. Macroscopically, only 21 points bear traces on their tip that could be possibly connected to impact fracture (burin-like fractures and small flake removals). Moreover, the attempt to repair a broken part of the tool in order to get re-used is recorded. Some artefacts show secondary modification that could also change the shape or the size of the body and its tang (Figure 7f-g).

The diversity of the artefacts could potentially demonstrate different uses. The tools were most probably used for hunting activities, while the variability in morphology and dimensions might be determined by the pray. Their use as weapons for warfare should not be excluded (Runnels 2009: 179), but the archaeological record has not provided sufficient evidence so far to support organized conflicts among groups during the Neolithic period in Greece (Tsangouli 2017: 14). The information from the examination of human skeletal remains -although fragmentary- does not point to generalized warfare but to sporadic non-lethal confrontations (Papathanasiou 2012).

On the other hand, cutting activities can be connected to a few projectiles shaped with intentional fracture and presence of sickle gloss. However, in these cases a strategy of tool recycling is suggested. Some projectile points come from the modification of sickles. Eight artefacts bear sickle gloss interrupted by removals that followed to form the point. It seems that the tool was first used for cutting plants (or similar materials) and later was re-shaped as a point. All cases involve points on blades or flakes with plain faces and basic shaping. Similarly, few geometric microliths bear sickle gloss, indicating that they were used as sickle inserts at some point.

At the same time, some projectile points were later modified into different tool types. A leaf-shaped point with covering bifacial retouch was turned into a sickle insert with denticulations and gloss at one cutting edge (Figure 7d). Another leaf-shaped point with covering retouch was turned into a perforating tool (Figure 7f). The body is elongated with additional abrupt retouch at both edges, while the tip is rounded with traces of abrasion indicating its secondary use as a borer. It could be argued that some points show more complex biographies, since they were repaired, reshaped or recycled and turned into different tool types. It is interesting to note that most cases involve points of fine quality raw materials with bifacial covering retouch and elaborate manufacture. An effort to prolong the use life of the tools could be suggested, either for practical reasons (e.g., raw material economy) or due to the special ties of the owners to the artefacts (personal value).

The economy of the settlement and the role of hunting at Anarghiri IXb

Although the study of the archaeobotanical and zooarchaeological material from Anarghiri IXb has not been conducted yet, some remarks on the economy of the Neolithic settlement and the role of hunting could be made, based on indirect information deriving from the stone, bone/antler and wooden artefacts.

The dynamic landscape of Anarghiri IXb enabled the exploitation of a variety of natural resources by the occupants of the settlement. The fertile arable land facilitated crop production and cultivation of cereals, pulses, etc. A significant number of sickle blades/inserts that cover almost half of the Neolithic chipped stone toolkit during both the LN and FN, but also the numerous grinding tools for food processing, demonstrate that agriculture was an important activity for the economy of Anarghiri IXb. Gathering wild nuts and fruits could have also been part of the diet, an activity practiced at many Neolithic settlements of northern Greece (Valamoti 2014). At the same time, the settlement's economy was also based on domesticated animals. Coastal halophytic and open vegetation, as well as proximity to water could facilitate animal herding and grazing (Gassner *et al.* 2019; Gkouma and Karkanas 2018). Numerous animal bones have been collected from the excavation of the settlement attesting animal husbandry (Arampatzis, *pers. communication*). The consumption of animals' meat was obviously important in the diet of prehistoric people. Additionally, animals' skin was also worked and used, as it is evident by several scrapers made of stone and antler (Arampatzis 2019; Papadopoulou 2020).

Apart from agriculture and animal herding, fishing and hunting likely contributed to the diet of the inhabitants. The settlement's proximity to the lake offered easy access to aquatic resources. Fishing at Chimaditis Lake could have been practiced all year round and freshwater fishes and molluscs collected as a supplement to the diet. Specialized studies of the ichthyological and malacological material from the neighboring lakeside settlement of Dispilio indicate the systematic exploitation of the lake's resources, including fishing and gathering of freshwater molluscs (Theodoropoulou 2008, 2014; Veropoulidou 2009). The fishing gear found at Anarghiri IXb attests to the activities practiced by the prehistoric inhabitants. For instance, some clay weights were probably used for fishing, as well as the bone and antler harpoons, fishhooks, etc. (Arampatzis 2019: 165-171, 179). The use of wooden tools or other organic equipment that have not been preserved (e.g., nets, baskets) could be also suggested (Almatzi 2002). Among the exceptional finds, the remains of wooden boats recovered from the excavation of Anarghiri IXb demonstrate the dynamic relationship of the inhabitants with the lake and their possible use -among others- for fishing activities in deep water (Chrysostomou *et al.* 2019: 42, Fig. 1).

At the same time, hunting was also an activity practiced by the prehistoric inhabitants of the settlement. According to the palaeoenvironmental studies in western Macedonia (Bottema 1974; Gassner *et al.* 2019; Marinova and Ntinou 2018; Ntinou 2014) dense deciduous oak forests and conifers at lower and higher altitudes provided a hospitable environment for wild fauna. Due to the lack of specialized studies on fauna remains from Anarghiri IXb, there is no direct information regarding the wild animals that were hunted. However, research at contemporary settlements in the region of western Macedonia points to a restricted wild fauna (2-10%) during the LN and FN periods. At the settlements of Dispilio, Avgi, Kleitos and Megalo Nisi Galanis the usual wild taxa included wild boar, red deer, roe deer, wild cattle, hares and wild pigs, but also carnivores (bear, fox, etc.) and birds (Greenfield and Fowler 2005; Samartzidou 2014; Tzevelekidi 2020; Ziota 2014). In the case of Anarghiri IXb, the intensive antler exploitation mainly of red deer, but also of roe deer and fallow deer, is attested by the numerous antler tools unearthed from the excavation (n:488). Apart from the shed antler collected after they fell off the animals during specific months of the year, there is evidence indicating that antler derived also from hunting and killing of animals (Arampatzis 2019: 210). Similarly, the pendants made of teeth from wild mammals recovered from the neighboring settlement Anarghiri IXa could point to their hunting during the Neolithic period (Arabatzis 2016).

Indirect information on the hunting activities derives also from the hunting toolkit used by the prehistoric inhabitants. The use of bow and arrow is evident from the chipped stone projectile tips, but also by the antler artefacts used for hunting, like archer thumb rings, projectile points, etc. (Arampatzis 2019: 171-178, 180-185, 216; *see also this volume*). Wooden tools could have also been used for hunting, like a wooden point found at Anarghiri IXb that was possibly used for bird hunting (Chrysostomou *et al.* 2019: 43, Fig. 2:e).

During the Neolithic wild fauna was a less significant component in the diet of prehistoric people. Hunting and killing wild animals were practiced not only for meat consumption (as a complementary diet source or as a risk-buffering strategy), but also for obtaining raw materials used for the production of bone and antler tools, pendants, or for using their skin and fur, which could have been exchanged (Halstead and O'Shea 1989; Nikolaidou and Elster 2014; Zvelebil 1992). Apart from its economic role, hunting has been also conceived as a social and symbolic practice. Hunting by a group of people of a settlement or even neighboring communities could be an activity that connected the participating individuals, reinforcing the collective identity among the members. Exercising hunting would require the involvement of skilled persons, with knowledge of hunting technology, animal habitats and prey behavior. Social relations and bonding could strengthen the social identity of the hunters, but also individuals could practice hunting to negotiate gender roles (e.g., male identity) and gain social status among the members of the community that could result in inter-site differentiation (Hamilakis 2003; Kent 1989).

The social and symbolic role of hunting has been supported in the case of the LN-FN Drakaina Cave in Kephalonia Island, where the numerous arrowheads found were interpreted as part of symbolic and communal events. It is suggested that the gatherings that took place in the cave were related to the negotiation of male identity through hunting, including the preparation/manufacture of projectile points and their disposal after their use (Stratouli and Metaxas 2009, 2018). A similar pattern has been proposed in the case of the LN-FN Skoteini Cave, but also to LN-FN Euripides Cave where the arrowheads found were regarded by the excavators to participate in rituals or other symbolic actions (Lolos 2000: 20; Sampson 1993: 265). The symbolic nature of projectile points has already been supported for some unique artefacts of highly skilled production for the LN period, as well as the large triangular spearheads of the FN circulating in southern Balkans and the Aegean, the utilitarian function of which is questioned (Carter and Ydo 1996: 164-165; Démoulé and Perlès 1993: 394-395, 402; Moundrea-Agrafioti 1996: 104; Perlès 1992: 143, 2004: 148-149). Furthermore, the negotiation of identity among the members of the community could be expressed through the symbolic connotations of hunting. A rare pendant in the shape of a tanged arrowhead made of soft stone (steatite) was found at the MN-LN Dispilio (Ifantidis 2019: 140-142, 362, Fig. 4: 32). The imitation of a hunting weapon used for personal adornment could reflect the individual's personality and identity.

Turning back to Anarghiri IXb, the lack -so far- of information regarding the habitation's spatial organization does not allow the attribution of the material into specific contexts, and any attempt for interpretation would be speculative. However, it could be argued that hunting was practiced by individuals or a group of inhabitants that were familiar with the surrounding environment and hunting techniques. They used a variety of hunting tools, including simply manufactured, as well as skillfully worked weapons. Some projectile points were objects of long-distance circulation, mainly documented during the FN period at Anarghiri IXb. Besides the obsidian points -which, however, could have been manufactured on-site by specialists- the large spearhead made of yellowish brown flint was probably imported ready-made into the settlement. Such rare artefacts made of exotic materials and manufactured by skilled producers were circulating in a wide area probably along with other valuable objects. They could have been part of goods exchange or gifts among individuals in the framework of social interactions. The potential association of these exceptional weapons with certain individuals could express respect and recognition gained through their performance in hunting, highlighting their role within the community.

Concluding remarks

The projectile points and geometric microliths recovered from Anarghiri IXb provide interesting information on the chipped stone hunting toolkit of the Late and the early Final Neolithic period in northern Greece. The typological and technological characteristics of the assemblage are consistent with similar types from the LN-FN periods in Greece. Some projectiles stand out by their high quality, probably produced by skilled knappers, in contrast to expediently manufactured artefacts. A few points made of exotic materials attest to interregional communication and long-distance circulation of valuable objects. As regards the function of the projectile points, it is suggested that they have been used for hunting activities, while their variability could be also related to their potential differentiated use. Future microscopic examination could shed light on the use(s) of the projectile points and geometric microliths from Anarghiri IXb, but also demonstrate patterns of modification and recycling.

The chipped stone hunting assemblage, along with the antler and wooden hunting gear indicate that hunting was part of the activities practiced by the Anarghiri IXb community. Apart from agriculture and animal husbandry, the exploitation of the rich natural resources of the region could have offered complementary sources for the diet, as well as raw materials for the production of antler/bone tools. Future work on the faunal remains will demonstrate the range of hunted wild fauna and the degree to which the settlement invested in exploitation of the wild. Besides its economic character, hunting could have constituted a social practice that connected the participants, offering shared experiences and probably opportunities to negotiate their social identity among the members of the community.

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“Pick up your bows. We go hunting”. Deer antler hunting gear from the Neolithic lakeside settlement Anargiri IXb, Western Macedonia, Greece

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Abstract

This paper addresses the antler hunting gear from the Neolithic lakeside settlement of Anargiri IXb which is located in the Four Lakes region in Western Macedonia, Greece. Recent research showed that the inhabitants of the settlement exploited intensively red deer antler during the 5th mil BC and that this raw material was used for the manufacture of tools, weapons, hunting and fishing equipment and ornaments. The hunting gear consists of items such as harpoons, harpoon heads. projectile points, fish hooks and archer thumb rings that were almost unknown in the wider area. Moreover, this gear reveals that the Anargiri IXb inhabitants had mastered to a high degree a lot of manufacturing techniques and that they exploited intensively the wild resources of the area along with the domesticated ones.

Keywords: Projectile points; Thumb rings; Harpoon heads; Neolithic; Lakeside settlement; Anargiri IXb; Macedonia; Greece

The Four Lakes region and the settlement of Anargiri IXb

In the last two decades, the Archaeological Service of Florina conducted numerous systematic surveys and excavations in the Amindeon basin, which is characterized by the presence of four lakes (Zazari, Chimaditida, Petron and Vegoritida) and shed new light into our knowledge concerning the prehistory of the area. The excavations in the expansion areas of the Coal Mining Zone of the Public Power Corporation (ΔΕΗ Α.Ε.) outside of the modern town of Amindeon have revealed a vast number of settlements that were built in the banks of the lakes Zazari and Chimaditida (Figure 1,2).

One of them is the settlement Anargiri IXb, which was located in the marshy area of Lake Chimaditida, very close to the modern village Anargiri (Chrystostomou *et al.* 2015; Chrysostomou and GiagkoulIs 2016) (Figure 2). The investigation, the biggest one in a former neolithic lakeside settlement in the Balkans, lasted four years (2013-2016) and it was funded by the Power Public Corporation S.A. Hellas (Δ.Ε.Η.) since the settlement was situated in the boundaries of its coal mining zone. The excavation revealed wooden structures that can be characterized as trackways (Giagkoulis 2019, 2020), thousands of clay figurines, spindle whorls, wooden artifacts, ground stone tools, chipped stone tools (Papadopoulou 2018, 2020) and bone and antler artifacts (Arabatzis 2016; Arampatzis 2018, 2019).

Figure 1. Map with the excavated sites in the area of the Four Lakes region in the Amindeon basin (Chrysostomou et al. *2015: fig. 3).*

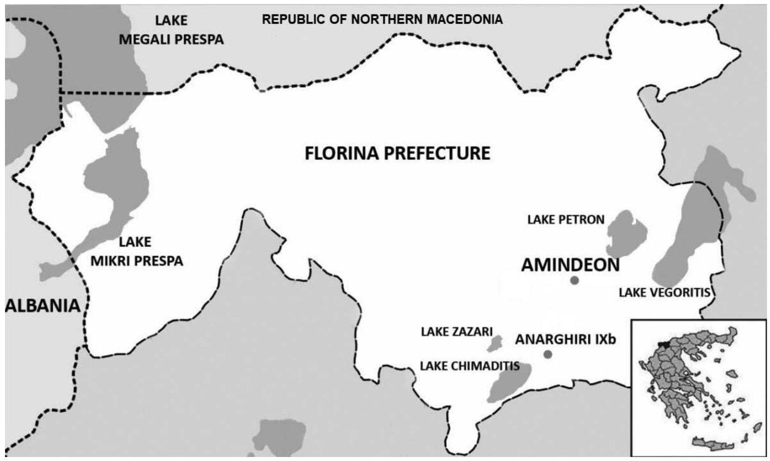

Figure 2. The location of Anarghiri IXb settlement and the adjacent area (Arampatzis 2019: fig. 7.1).

According to the C14 dates that were calculated by the Laboratory for the Analysis of Radiocarbon with AMS of the University of Bern and the study of the stratigraphy, the settlement had five main habitation phases and it was inhabited without any obvious interruptions from almost the mid- 6th mil BC to the end of the 5th mil BC covering the Greek Late Neolithic I (5400/5300-4900/4800 BC), Late Neolithic II (4900-/4800-4500 BC) and part of the Final Neolithic period(4500-3300 BC) until almost 4000 BC. Moreover, they are some indications that the settlement was inhabited shortly during the Early Bronze Age as there has been identified one layer with mixed Final Neolithic and Greek Early Bronze Age material (3300/3100-2200 BC) (Arampatzis 2019; Giagkoulis 2019; Papadopoulou 2020).

The assemblage

A big assemblage of antler artifacts was unearthed during the extensive excavation of the settlement. The 488 antler artifacts that were found, comprise the biggest so far published assemblage of worked antler material in Greece. The antler hunting and fishing gear is small in quantity (n: 31) and comprises 6.35 % of the total assemblage. Nevertheless, it is characterized by diversity since it consists of five distinct categories: harpoons, harpoon heads, projectile points, thumb rings and fish hooks.

Table 1. Chronological distribution of Fishing gear.

	Late Neolithic	Final Neolithic	FN/EBA	Total
Fishhooks	1	0	0	1
Harpoons	0	2	0	2
Projectile points	0	7	1	8
Archer thumb rings	4	5	0	9
Harpoon heads	0	11	0	11

The harpoon heads comprise the biggest category followed by the thumb rings and the projectile points. The remaining categories are not so well represented here and consist only of a few items. Most of the items are coming from the Final Neolithic phase. The harpoon heads and the harpoons are attested only in the Final Neolithic phase while the projectile points are attested mainly in the Final Neolithic phase and only an item belongs to the FN/EBA layer. The thumb rings are attested in both in Late and Final Neolithic layers and that there are no fish hooks in the Final Neolithic phase as the only one belongs to the deep layers of the Late Neolithic phase (table 1).

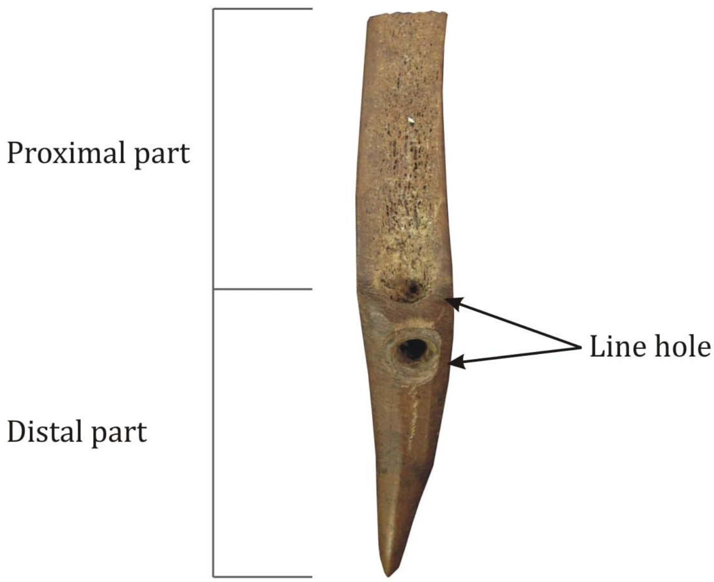

Figure 3. Morphology of the harpoon head.

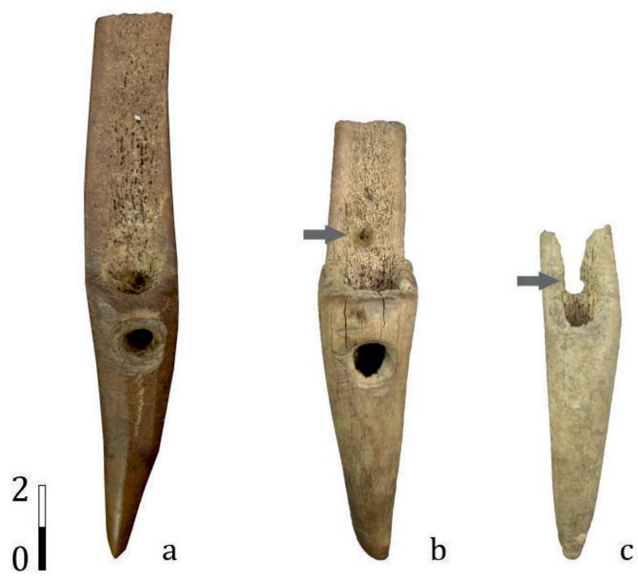

Figure 4. Harpoon heads. a.Semi finished item (Type A),b.Semi finished item (Type B), c. Completely manufactured but half preserved (Type C) (arrows indicate the holes in the proximal parts).

Their function distinction is not so clear as most of them (except the fish hooks) could have been also used in armed conflicts (interpersonal or between groups of different settlements) although so far there is no evidence of such kind of conflicts from the excavated settlements of the area.

Harpoon heads

The eleven collected harpoon heads comprise the biggest antler harpoon assemblage found so far in Greece. All of them belong to the Final Neolithic habitation layers. This small number indicates that perhaps the majority of the harpoons were made on non-preserved materials such as wood.

They are shaped on tine segments (their length, regardless of the preservation status or the manufacture status, ranges from 3.55 cm to 12.3 cm) and they have two distinct parts: the distal part, which has a line hole (diameter 0.52 cm to 1.1 cm) on it and a pointed end and the proximal part which is the part that is attached to the wooden shaft of the harpoon (Figure 3). They are shaped on tine segments and all belong to the same morphological type that presents some small variations. The harpoon heads present different manufacture and preservation status. Three items are finished and the rest of them are semi-finished. All finished

Figure 5. Harpoon heads. a.Manufacture traces on a semi finished item, b.Grinding traces in the lateral side of the proximal part.

Figure 6. Distal part of a harpoon head with grinding traces and polish on the tip.

items are half preserved while the semi-finished items lack their proximal part.

There have been distinguished three variations of the harpoon head according to the position of the line hole (type A, B and C) (Figure 4). The manufacturing sequence was the following: at first, the manufacturer selected the appropriate tine and later extracted the desired part out of it through percussion and/or sawing. The next step was the shaping of the base in the proximal part of the tine segment through percussion that was applied almost in the middle of the blank (Figure 5a). The next step involved the use of sawing and grinding techniques in the proximal part which obtained a flat inner surface and a plano-convex cross section. In one case the grinding was applied not only in the inner surface of the proximal part but also in its lateral sides (Figure 5b). The active end in the distal part was shaped mainly through shaving and griding (Figure 6).

In the type A and B harpoon heads, the line hole was opened in the anterior part of the tine segment at the end of the distal part through boring. In type A and B harpoon heads the rope was inserted from the main line hole and exited from a nearby hole at the beginning of the proximal part that also served as a mounting socket as the tip of the wooden shaft was inserted in that hole (Figure 4, 7). In type B there was also an attempt for drilling a second line hole in the proximal part of the harpoon head near to the line hole of the distal part (Figure 7b) probably in order to secure the strap between the harpoon head and the wooden shaft. In type C the main line hole was drilled in the proximal part and not in the distal part (Figure 4). In all types the rope must have been tied in the wooden shaft so that the antler harpoon head wouldn't get lost after an unsuccessful throw or in order to pull the harpoon head and the fish out of the water.

It seems that most of the items are semi-finished and were not used in the hunting activities. In seven items the tip is unmodified (Figure 8) and it retains its natural form and only in one case it was shaped through grinding and polishing. The

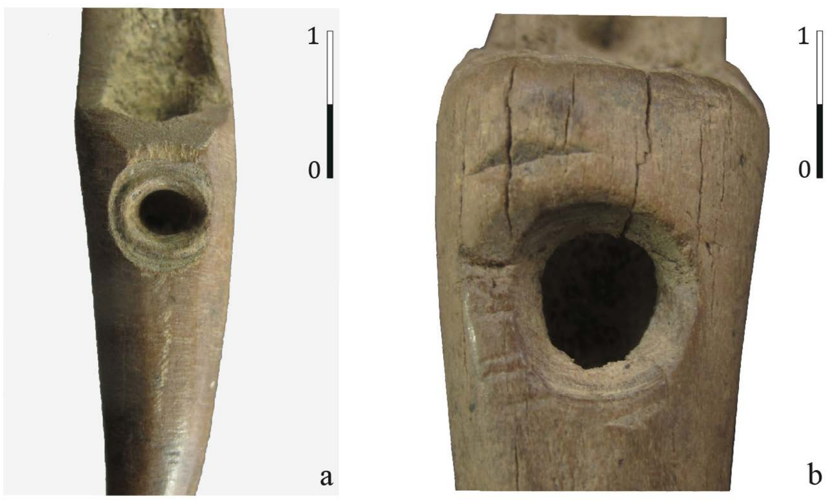

Figure 7. Harpoon head line holes. a.Unfinished, b.Completely manufactured.

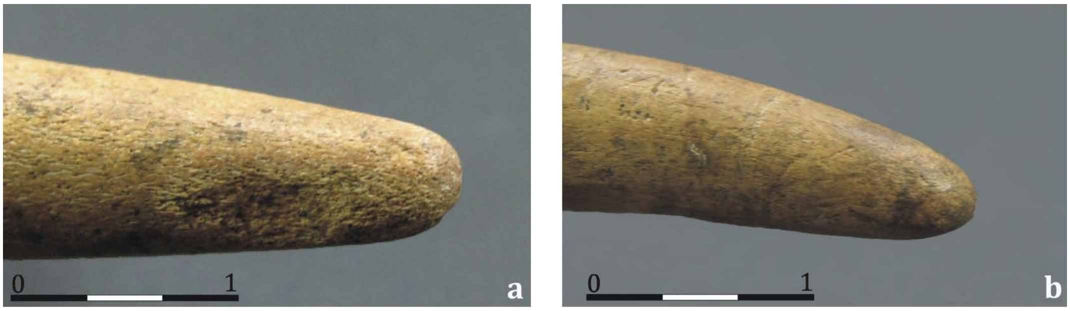

Figure 8. Unmodified and unused harpoon head tips.

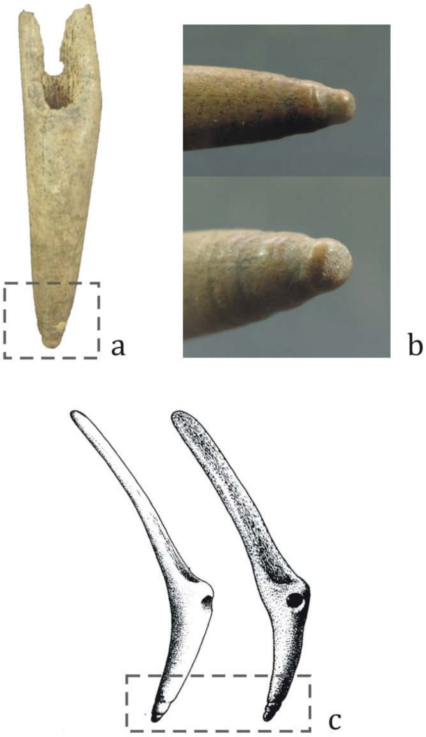

Figure 9. a, b. Use wear traces on the tip of the harpoon heads, c. Harpoon head from Divostin with similar traces on its tip (modified after Lyneis 1988: fig.10.2.a).

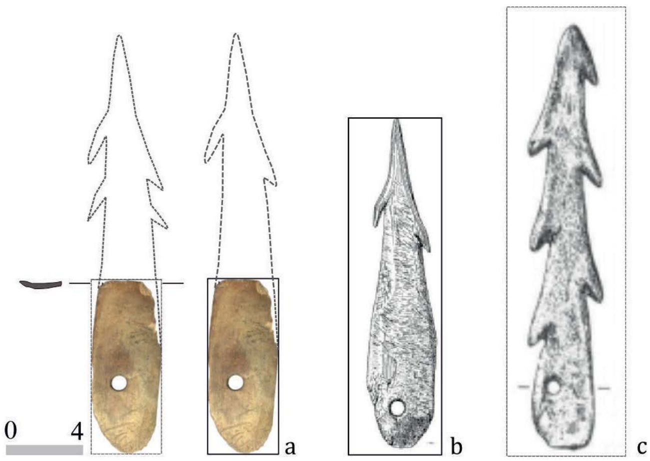

Figure 10. a. Possible reconstructions of the antler harpoon, b, c. Similar barbed harpoons from Egolzwil 3 and Montilier/Platzbünden (Wyss 1994; Ramseyer 1995).

line hole is completed only in three items while in the rest of them is semi-finished or the shaping stopped almost in the beginning of the process. In one case, the tip presents the same use wear traces (blunt ruffled tip) with a harpoon head found in Divostin (Bačkalov 1979: t.XXXVI, fig.2; Lyneis 1988: fig.10.2.a) (Figure 9). This kind of tip indicates that the harpoon head was used long enough in order to get blunted and perhaps the next step was to recycle it as it happened in other harpoon heads that were transformed to pendants after they became useless to the hunter due to their inactive point (Arampatzis 2020: 292-293).

Figure 11. Type HR2 harpoon.

Figure 12. Close view of the HR2 harpoon barb.

Harpoons

The assemblage contains only two harpoons and each one represents a different morphological type (HR1 and HR2). Both of them belong to the Final Neolithic habitation phase. The HR1 type is a unique find in the region of Western Macedonia. It is partially preserved (length: 9.3 cm) and it was shaped on a beam segment (Figure 10). The fragment belongs to the basal part of a possible barbed harpoon and preserves the line hole that was used for its retrieval after the throw. Similar harpoons have been found in Swiss Neolithic lakeside settlement of the 5th mil BC (Egolzwil 3-Wyss 1994) as well as of the 4th and 3rd mil BC (Montilier and Auvernier- Ramseyer 1988).

The type HR2 (Figure 11) is represented by one item whose morphology is totally unknown in Neolithic Greece. It was shaped on a beam segment and it seems to be the distal part of a barbed harpoon that also preserves a small part of the shaft (proximal part) (preserved length: 6.5 cm). For its manufacture the artisan used the sawing and grinding techniques. As it seems, it had only one barb (length: 3.3cm) and it was shaped through sawing and grinding. It has a well preserved point which bears use wear traces (bluntness and small pits (Figure 12). The curved proximal part is rather thin and has a plano-convex cross section.

Archer thumb rings

The hunting equipment includes nine items that were used in archery hunting and until recently were almost unknown from the Neolithic settlements in Greece. So far, archer thumb rings have been found only in lakeside settlements; in the Neolithic settlement of Dispilio (Ifantidis 2018) and in Anargiri IXb (Arampatzis 2019). It seems that it is a local tradition that appears in Northwestern Greece in the Late Neolithic and it continues in the Final Neolithic period. The assemblages of these sites are unique in the area and they are the oldest manifestations of the use of the antler thumb ring archery in Europe.

The thumb rings were shaped on beam and tine segments. At first the manufacturer extracted the desired part through sawing and then through grinding levelled one of the sides. The final form of the ring along with its hole shaping was the result of a lot of techniques like sawing, bow drilling, grinding and polishing. In some cases, the spongy tissue of the antler is still visible under the polishing traces.

The Anargiri IXb antler thumb rings differ from the modern traditional bone thumb rings or from the Dispilio thumb rings. Their thumb hole is mainly oval and they consist of the following elements: a) the front lip or thumb cover which is the part that protects the thumb, b) the string rest, which is the angled or curved part between the two lips where the bow string rests before the release of the arrow and c) the back lip (Figure 13). According to modern traditional archers, the front lip is placed in the inner part of the thumb facing towards, to the target and the string is placed in the string rest between the ring and the thumb (Figure 14).

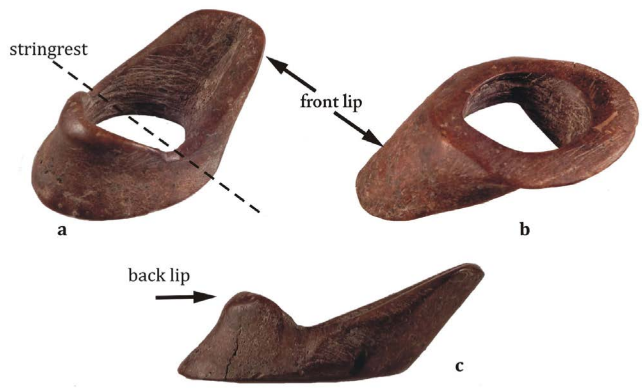

Figure 13. Different views of a thumb ring and its major parts.

Figure 14. Close view of a traditional thumb ring (Photograph by Martin Groeber. Used under kind permission).

Two different thumb ring types have been identified. Their categorization was based on the morphology of the front and back lip. The type I rings were found both in Late Neolithic and Final Neolithic habitation layers while the type II rings belong only to the Final Neolithic habitation layers. It seems that the type I was used mostly in the Late Neolithic and later it was substituted by the type II which is closer to the type that is used even nowadays by traditional archers. The type I thumb rings are oval shaped with a wide but narrow front lip that is not so extruded. The back lip has usually a round or plano-convex cross section (Figures 15a, 16). The type II thumb ring has a long protruding front lip which covers if not whole but the biggest part of the thumb and the back lip has big thick walls that enclose big part of the thumb as well (Figures 15b, 17, 18).

The five rings of the type I thumb rings are completely manufactured items. Four items belong to the Late Neolithic phase and one in the Final Neolithic phase and there seems to be a size difference between the rings of these periods.

Two Late Neolithic rings are totally preserved and the other two are half preserved. The two totally preserved have almost the same dimensions (outer LD and SD diameter: 4.25 cm x 3.7 cm and 4.8 cm x 4.0 cm respectively) (Figure 16). All four items have oval shaped thumb holes. The two fully preserved thumb holes are relatively small (inner LD and SD diameter: 3.0 x 2.3 and 2.6 x 2.1 cm respectively) compared to the ones of the Type II thumb rings. The height of the front lip is 1.5 cm and 2.1 cm respectively. In all rings the inner walls of the back lip and in two cases the inner walls of the thumb holes have high polish due to the contact with the thumb of the archer.

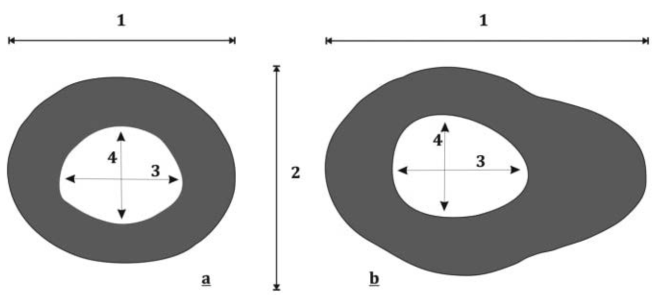

Figure 15. Metrical analysis of the thumb rings. a. Type I, b. Type II (1. Outer long diameter, 2. Outer short diameter, 3. Inner long diameter, 4. Inner short diameter.).

The Final Neolithic thumb ring I (Figure 19) is half preserved as it lacks its distal part with the front lip and it is quite bigger than the LN rings (preserved

Figure 16. Type I thumb ring.

Figure 17. Type II thumb rings.

Figure 18. Type II thumb ring.

dimensions: 6.0 cm x 3.9 cm). The string rest angle is quite acute and the back lip is rather thick (max. thickness: 2.6 cm). Given these dimensions it is quite probable that the archer's hand was rather big.

The four completely manufactured type II thumb rings belong to the Final Neolithic habitation phase. Three of them are totally preserved (Figure 17) while the fourth one preserves only part of the string rest and the back lip. These are not completely identical as there have been identified some variations in either the form of the thumb cover (front lip) or in the shape of the back lip. The thumb cover

Figure 19. Type II thumb ring

Figure 20. Type II thumb ring. Manufacture and use wear traces.

Figure 21. Type II thumb ring. Manufacture and use wear traces.

could be oblong or could have a wide base and a narrow curved ending. The outer diameter of the rings ranges from 5.2 cm to 6.4 cm. In two cases the thumb hole has an oval cross section (inner LD and SD diameter: 2.6 cm x 2.1cm and 3.2cm x 2.7 respectively) and in one case the thumb hole has almost round cross section (2.4cm x 2.2 cm). In one case in the outer surface of the thumb ring there are still visible grinding manufacture traces. The contact of the thumb and the ring resulted in the appearance of high polish in the thumb hole walls but also in the front and back lip of the rings (Figure 20, 21).

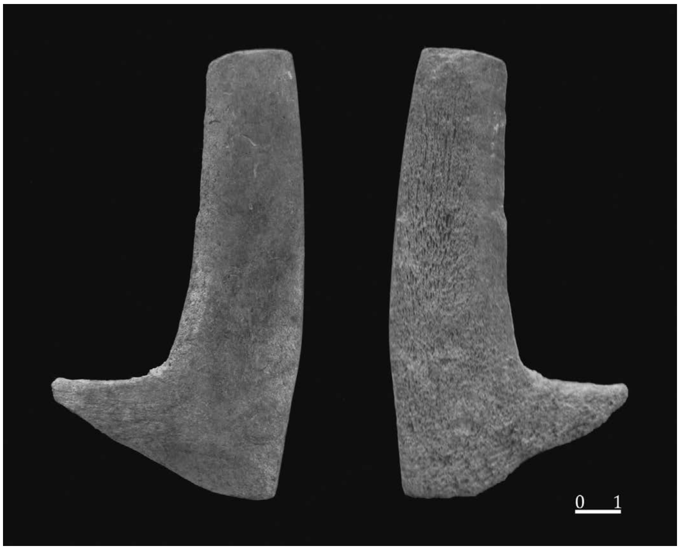

Figure 22. Unfinished fish hook.

Fish hooks

The fishing equipment contains only one fish hook preform (Figure 22) that belongs to the Final Neolithic habitation layers. So far it is the only osseous fish hook recovered in the settlement. This image is in contrast with the situation in the settlement of Dispilio where more than forty bone fish hooks have been unearthed (Stratouli 2008: 15) but none of them resembles typologically the Anargiri IXb antler fish hook.

The fish hook is shaped on a beam segment that was cut out though the groove and splinter technique and then it was fashioned through abrasion. It is a one-piece fish hook (length: 10.3 cm, width: 5.5 cm) with an almost straight, wide and thin shank (rectangular cross section) that has a rectangular flat head. The small unshaped point (length: 2.45 cm) is almost vertical to the shank and it is rather short compared to the shank. There are not any notches in the lateral sides of the shanks base nor any

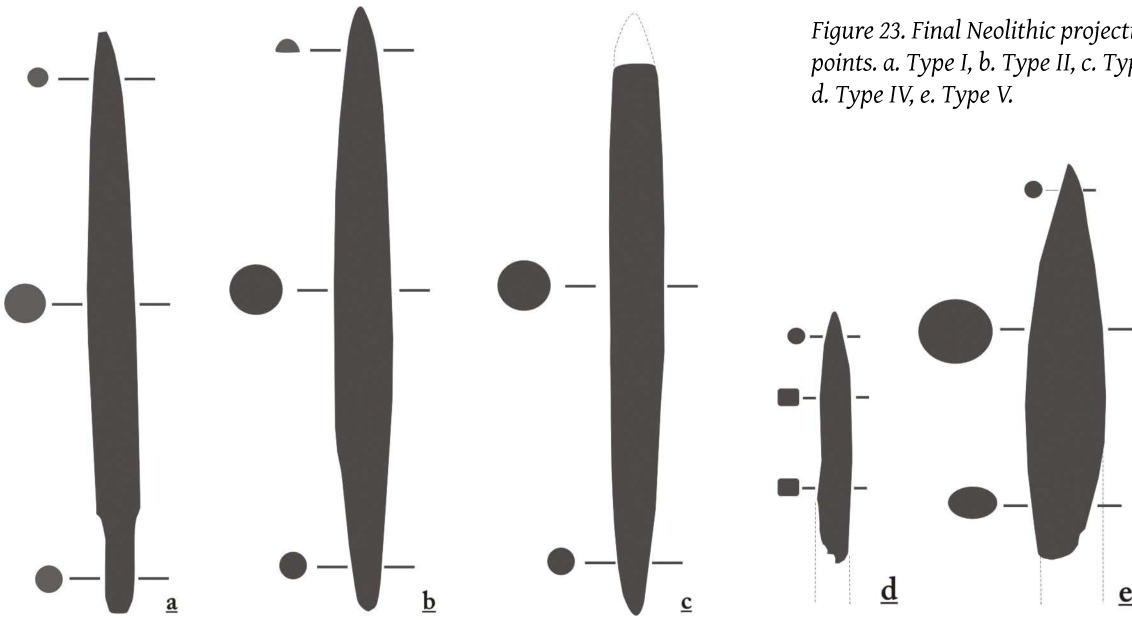

Figure 23. Final Neolithic projectile points. a. Type I, b. Type II, c. Type III, d. Type IV, e. Type V.

suspension hole drilling attempts on it so it is not possible to identify the way the hook was going to be attached to the fishing rope.

Figure 24. a. Type I projectile point, b. Detail of the distal part, c. Detail of the tang.

Projectile points

The assemblage contains eight projectile points which could be used as spear points. Seven of them belong to the Final Neolithic layers and one to the FN/EBA disturbed layer. All of them seem to have shaped on red deer antler and mostly on beam segments except from the FN/EBA projectile point that was shaped on tine. The points that belong to the Final Neolithic phase are divided into five distinct categories based on their overall morphology (Figure 23).

The type I consists of one point which is completed and totally preserved (length: 12.2 cm) (Figures 23a, 24a,b). It is shaped on the compact part of a beam segment. It has a small distinct tang with a round cross section that was inserted into the wooden part of the spear or arrow (Figure 24c). The mesial and the distal part also have round cross sections. The sides of the distal end are sub-parallel and only converge near to the tip, which seems to have been resharpened judging from the asymmetrical outline. A similar bone projectile point has been found in the nearby Neolithic settlement Anargiri IXa (Arabatzis 2016: fig.11a).

The three type II points (Figure 23b, 25) were also shaped on the compact part that was extracted from a beam segment. The difference between this type and the previous one is that in type II the transition from the mesial to the proximal part is smoother. As in type I, the blank was probably scraped all over its length and in some cases it was grinded as one projectile point with plano-convex cross section in the mesial and proximal part retains oblique and transversal traces of heavy grinding that was applied.

Two projectile points are completed, totally preserved and quite lengthy (average length: 10.0 cm). These three points have different cross sections in their three main parts. The proximal part could have oval or round cross section, the mesial part could have round or plano-convex cross section and the distal part could have round or plano-convex cross section. In both points the maximum width is close to the proximal part. The sides of this type seem to converge straight from the point of maximum

Figure 25. a. Type II projectile point, b. Type III projectile point.

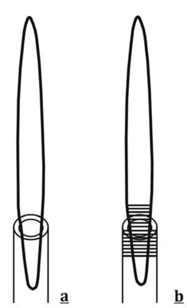

Figure 26. Projectile point hafting methods. a. Fixing the point into the wooden shaft, b. Fixing and fastening the point into the wooden shaft (modified after Knecht 2000: fig.12).

Figure 27. a. Proximal part of the Type II projectile point, b. Proximal part of the type III projectile point.

Figure 28. a. Projectile point from the FN/EBA layers, b. Possible hafting method (after Petillon 2009: fig. 1a).

width to the tip. It seems that these points were fixed into a wooden shaft without any extra ligature (Figures 26a, 27a). In one case the tip of the point was heated but it is unknown if it was heated during the manufacture process or just before its use in order to increase the prey's pain after the impact. This type of projectile point is almost totally unknown in Neolithic Greece as only one similar antler projectile point has been found in the nearby Neolithic settlement Anargiri IXa (Arabatzis 2016: fig.11b).

The type III consists of one item (length: 9.5cm) (Figure 23c) that is not totally preserved as it lacks its distal part that probably was about to be reshaped. The proximal part bears marks that are vertical to the longitudinal axis of point that indicate the method that was used for its hafting (Figure 26b, 27b). It seems that after its insertion to the wooden shaft, the point was fastened on it with fibres that left their marks in its proximal part.

The fourth type and fifth type consist also of one item. These two rather small points (5.6cm and 6.65 cm respectively) are completed and half preserved. The type IV has a mesial part with a rectangular cross section that was shaped through heavy transversal grinding that is converging into an active end with a round cross section (Figure 23d). The type V point has an oval cross section mesial part and its tip has a round cross section (Figure 23e). Since the proximal part in both of them is not preserved, it is not possible to identify their hafting method.

The projectile point of the FN/EBA layers (Figure 28a) belongs to the sixth type that differs totally from the previous ones. This morphological type is already known from the Upper Magdalenian period in Europe (ca.13.500-12.000 BC) (Pétillon 2009). This big spearhead (length 14.5cm) was shaped on a tine that was attached to a wooden pointed shaft. The biggest part of the tine was scraped and removed and only its distal part was left in order to serve as the penetrating end. The tine was attached to a wooden shaft and was probably fastened with fibres or with a rope in order to be steady. This form is rare in the wider Balkan area as so far there haven't been found any similar items. Bone points with almost similar morphology have been reported from the Arbon Bleiche 3 settlement in Switzerland (Deschler-Erb *et al.* 2002: Abb.70)

Discussion - Conclusions

The hunting and fishing equipment of the settlement give us information about the activities outside of the settlement and in the area of the lakes that surrounded it. The search of bone artifacts in the zooarchaeological material , the number of osseous artifacts from wild animals (Arampatzis 2016, 2018, 2020) and the antler artifacts of the settlement (Arampatzis 2019, 2020) indicate that hunting must have played a significant role in the settlements' economy as in other Neolithic settlements of the area (Megalo Nisi Galanis: Fowler and Greenfield 2005; Dispilio: Samartzidou 2014; Avgi: Tzevelekidi 2014) or in other settlements in Northern Greece (Promachonas: Kazantzis 2015; Sitagroi: Nikolaidou and Elster 2014). Although the ichtyoarchaeological material of the settlement has not been studied yet, it is possible that a part of the settlement's economy was based on the fish resources of the four lakes just like in the nearby settlement of Dispilio (Almatzi 2002; Theodoropoulou 2008, 2014). The antler hunting gear is not the only artefactual indication concerning the hunting activities of the settlement. This assemblage must be seen as part of a repertoire that includes the lithic hunting gear (Papadopoulou, this volume), the wooden projectile point and the wooden log boat (Chrysostomou *et al.* 2019) that were both found in the settlement and probably were used in the hunting and fishing activities of settlements inhabitants.

The choice of antler as raw material for the manufacture of this gear could be based on technological choices rather than cultural ones. As it has been demonstrated (Currey *et al.* 2009; Guthrie 1983) the mechanical properties of the antler (high resilience and high absorbment of shock) make it an excellent raw material choice for the manufacture of projectile points, harpoons or harpoon heads. Antler could be obtained from a successful hunt or it could be collected after its fall. Since this gear is not shaped on basal segments that could indicate their acquisition mode, it is impossible to determine how the raw material ended up in the settlement before its shaping. The preliminary study of the zooarchaeological material and of the antler artifacts (Arampatzis 2019) showed the high presence of antler in all habitation phases and especially during the Final Neolithic phase.

All of the items were carefully manufactured. Their form shows that the artisans were very skilful and that they spent a lot of time and energy on their shaping. Many of them are semifinished (8 out of 11 harpoon heads) and probably they were shaped by the settlements inhabitants and were not imported as it has been suggested for the majority of the antler artifacts of the settlement based on the number of the blanks and the waste of antler working (Arampatzis 2019).

The assemblage consists of items that are rare or unknown from other Neolithic settlements in Greece. So far none of the excavated Neolithic settlements of Central and Southern Greece presents antler hunting gear. The only similarity in Northern Greece can be traced to the presence of the archer thumb rings in the settlement of Dispilio but the Anargiri and Dispilio thumb rings differ typologically so it is difficult so far to speak about common forms that are used in the same period in the region. The presence of a similar harpoon head in Divostin is another example that strengthens the idea for the existence of wide exchange networks between settlements of Northern and Southern Balkans in the 5th mil BC (Kapuran *et al.* 2018: 81).

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Going into the wild: Hunting and fishing at the Early Neolithic site of Dzhulyunitsa-Smardesh

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Abstract

Excavations at the Early Neolithic settlement of Dzhulyunitsa-Smardesh started in 2001. Study of the earliest layers of the site is crucial for understanding the beginning of the Neolithic period in Bulgaria and Southeastern Europe. One of the main questions concerns subsistence strategies of the earliest farming communities. This article is focused on the development of hunting and fishing implements. For example, the variety and quantity of fishing gear during the earliest phases are larger than at the end of the Early Neolithic. On the other hand, we try to define the relationship between the artifacts and the hunted animal species recorded in the bone assemblages of the settlement. The results show that hunting and fishing played a significant role in the economies of Early Neolithic societies inhabiting the area.

Keywords: Hunting; Fishing; Weaponry; Subsistence; Wildlife exploitation; Early Neolithic; Northern Bulgaria

Introduction

The Early Neolithic settlement is situated on the first non-flooded terrace between two rivers in the locality *Smardesh*, three km north of the village of Dzhulyunitsa (Figure 1). This place was probably chosen due to the existence of seven natural springs at the foot of the terrace whose waters flow into the Yantra River. The previously meandering water courses of these rivers have been artificially regulated and corrected (Elenski 2006: 96-97; Krauß *et al.* 2014: 52-53). The excavation of the Neolithic settlement began in 2001 by Nedko Elenski from the Regional museum of History from Veliko Tarnovo. Twenty three trenches were excavated initially and since 2012 they are concentrated in the central sector (300 m^2) and the excavations are still ongoing. Significant results for the stratigraphy of the settlement are based on the excavations in trenches no. XII, XIII, XXII and XVIII which are located in the western part of the terrace. A depth of 2.30 m has been reached in them (Elenski 2006: 97-98, 115; Elenski 2011: 35-37; Elenski, Leshtakov 2006: 36-37). The studied material allows us to distinguish four main phases in the development of the settlement (Dzhulyunitsa I, II, III and IV), which cover the entire Early Neolithic period in Northern Bulgaria (ca. 6400?/6050-5550 BC) (Elenski 2006: 114-115; Krauß *et al.* 2014).

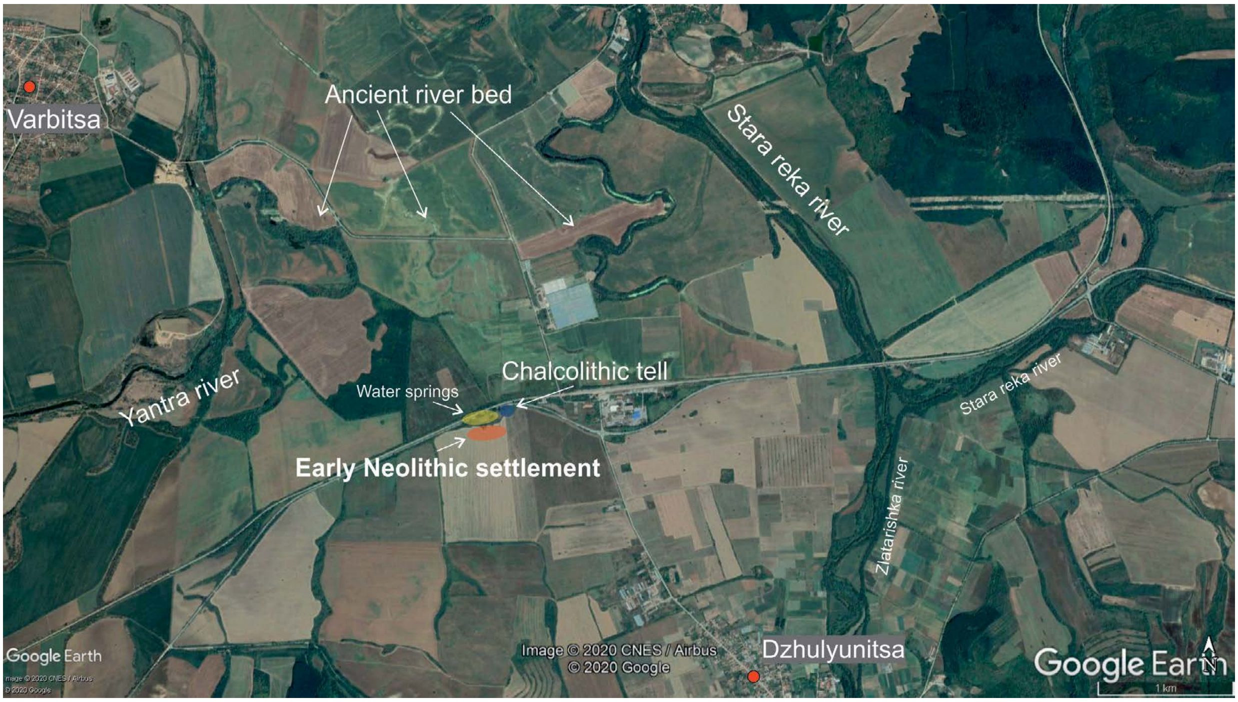

Figure 1. Map of the Early Neolithic site of Dzhulyunitsa, the Chalcolithic tell and the area.

Paleoecology

An important aspect of the Neolithic way of life and economy is the interaction with the surrounding natural resources. Archaeobotanical and archaeozoological research provide information about paleoecology and the relationship of humans with the environment. Archaeobotanical data from several Neolithic sites in the Danube valley allow for a reconstruction of the paleoecology in the area of Dzhulyunitsa (Marinova *et al.* 2013: 467-478). There, patchy oak forests in an open landscape shaped the region, perhaps in the form of wooded steppe or more open remains of the Late Glacial steppe vegetation. Riparian forests and wetland areas were also attractive as a local source of both wood and fruit. It appears that more or less the same taxa were consistently in use throughout the Late Mesolithic and Early Neolithic in the Danube valley (De Groene *et al.* 2018: 45; Marinova *et al.* 2013: 475; Marinova, Krauss 2014: 190).

This type of environment offers very good living conditions for a diverse range of animal species. About 900 specimens have been studied from the stratigraphic sequence of Dzhulyunitsa-Smardesh excavated in 2010, which covers the entire Neolithic sequence. A total of 1264 specimens from the horizontal exposures were associated with the earliest Neolithic phases of the site. Sheep, goat and domestic cattle are present in Dzhulyunitsa I. Sheep and goats are dominant, comprising approximately 50 % of the horizontal exposures and approximately 65 % of the material from the stratigraphic sequence. The domestic status of the sheep and goat during the first phase is clear because Dzhulyunitsa falls well out of the natural distribution area of their wild progenitors (Krauss *et al.* 2014: 69-70). The percentage of studied bones of cattle reaches 30-35% of all identified mammals, and aurochs (*Bos primigenius*) are also present in small numbers. Wild boar (*Sus scrofa*) is represented by very few specimens in both sieved and hand-collected assemblages. Bones of domestic pig were not detected among the earliest assemblages at Dzhulyunitsa (Krauss *et al.* 2014: 71). Some preliminary observations were made on the materials from the later Dzhulyunitsa layers (De Groene *et al.* 2018). The dominant animal species remain the same, however, there is a marked difference in the proportion of domestic and wild animals. Although sheep and goats used to dominate over cattle during the earlier phases in the economy, they are equalized in layer IV. The deer have a leading part among the hunted prey, whereas the pig remains are very poorly represented. There is a gradual decline of the wild animals' proportion from Dzhulyunitsa II onwards, such remains are underrepresented in layer IV (18 minimum number of individuals or 3.2 %) (De Groene *et al.* 2018: 40, Tab. 2).

The scarcity of fish bones (around 30) is due to the excavation method (hand-collecting only) but their presence only in phases I and II seems significant. Most of the remains are small unidentified fragments of rays and ribs. However, seven vertebras of *Silurus glanis* (three individuals), *Cyprinus carpio* (three individuals) and *Cyprinidae* family (one individual) were identified. The estimate size of the fishes is as follow: *Silurus glanis* – 90-100 cm, 90-100 cm and 180 cm; *Cyprinus carpio* – 65-70 cm, 70-80 cm and 100 cm; *Cyprinidae* – 50 cm. According to the archaeozoological data, the age-at-death range was quite wide (De Groene *et al.* 2018: 41-42). The Dzhulyunitsa I population probably used the domestic animals for milk, wool and fertilizer, whereas the main meat products were most likely supplied by game. In the later phase, the high percentage of bone remains from young individuals indicates their role as a major meat source and while the small number of older specimens show that they were still kept for other reasons.

Hunting and fishing implements

Projectile points

Projectile points are among the first items related to prehistoric hunting and warfare. Complete weapons are found quite rarely during archaeological excavations because they were mostly made of perishable materials (wood). The only remaining evidence of their use is the tip, usually made of flint or animal bone. These projectiles were shot with a bow or crossbow, thrown with a spearthrower or hurled by hand against targets (Letourneux and Pétillon 2008: 2850). Bone and flint examples are known from a number of Copper Age settlements and necropolises in Bulgaria (Boyadzhiev 2014: 94-118). However, until recently such bone objects have not been reported from Neolithic Bulgarian sites, probably remaining unrecognized or misinterpreted due to the lack of extensive studies on Neolithic worked bone assemblages. The projectiles are distinguished by their slender and straight form, as well as by the specific shaping of their edges for use in component weapons. The use-wear traces such as polish, shine, striations, lines, common on awls or other tools used in processing organic materials, are completely missing on projectile points (Vitezović 2018: 43).

The striations from use and the morphology of Dzhulyunitsa objects prove their function. On the surface of the tips of all the arrowheads are damage marks in the form of crushing as well as fractures, probably resulting from contact with a target. Experimental studies have been conducted on the shooting of projectiles that prove different type of fractures (Pétillon 2005). When the tip strikes, moderate changes occur in the bone, which take 2-4 mm from the projectile length. Damage to the proximal part is also possible as a result of the hard surface impact that detaches the projectile from the wooden shaft (Pétillon 2005: 247-248).

We identified three small projectiles (arrowheads) derived from archaeological phase IV at Dzhulyunitsa and one spearhead from layer II. All the finds are made of animal bone (Fig. 2: Dzh 001, Dzh 002, Dzh 003). There are two subtypes of arrowheads according to the shape of the objects' proximal ends (also called the "tang") and the method of attachment to the shaft. The projectiles of the first subtype have

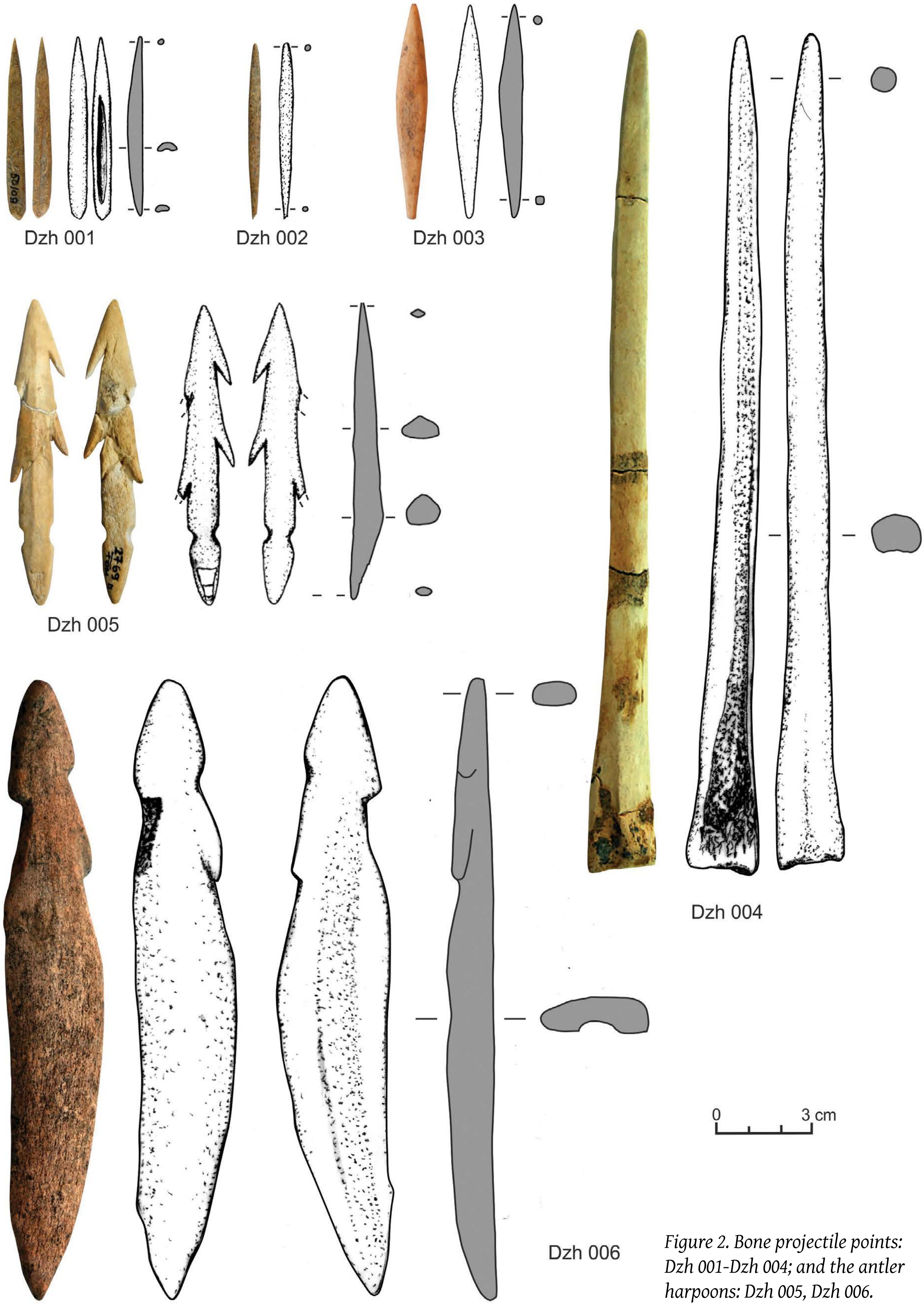

Figure 2. Bone projectile points: Dzh 001-Dzh 004; and the antler harpoons: Dzh 005, Dzh 006.

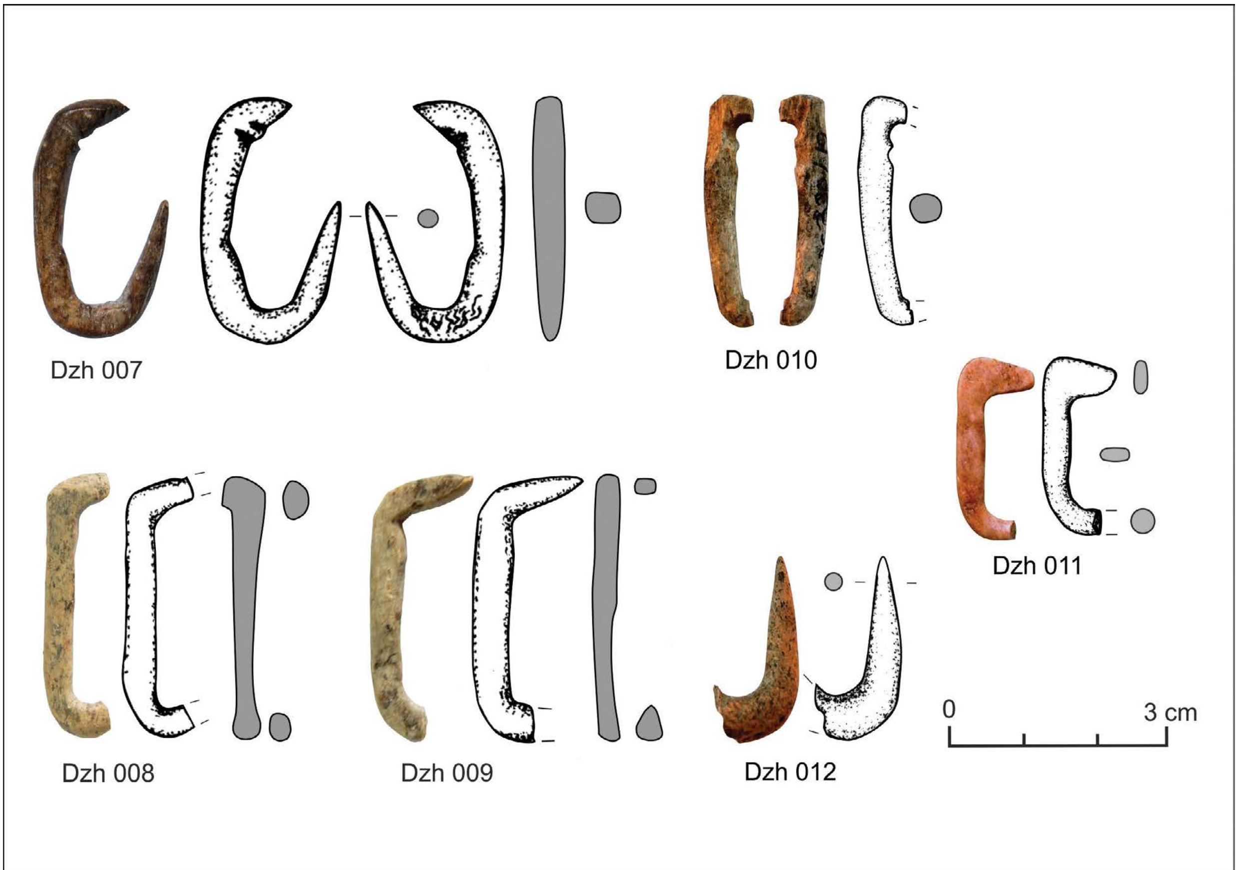

Figure 3. Bone fishhooks.

a stronger, massive distal tip, slightly blunted and damaged by flaking-facets. The "tang" is sharper and more slender than the distal end and is designed to be set into a socket of the wooden shaft (Fig. 2: Dzh 002, Dzh 003). The second way of attaching the projectile is by lateral hafting, probably tightly bound with a string or animal sinews. The proximal part of these projectiles has a different shape (wide and flat) through the remains of the medullary cavity that also aids this kind of attachment (Fig. 2: Dzh 001).

The object Dzh 001 was made from a small ruminant (ovicaprine sized) metapodial bone. The epiphysis was removed from the bone and the proximal end of the object was slightly beveled for easier insertion into the wooden shaft. This type of projectile is laterally attached by binding, probably in conjunction with wood resin adhesive. There are similar projectiles with flat proximal ends from the Neolithic period at Starčevo-Grad in Serbia (Vitezović 2018: 42, Fig. 3: no. 284; Vitezović 2012: 239, fig. 5: Stč 026). The raw material for finds Dzh 002 and Dzh 003 is derived from large ruminant long bones (*Bovidae/ Cervidae*). The *débitage* phases are difficult to reconstruct due to the high degree of processing of the objects, but probably the bone was separated by longitudinal splitting along an incised groove or by direct fracturing. Shaping seems to have taken place by scraping with flint tools and subsequently by abrasion. Traces of these techniques on the surface of the arrowheads are visible to the naked eye (Fig. 5: Dzh 003).

The double-pointed or "spindle-shaped" projectiles (Fig. 2: Dzh 002, Dzh 003) correspond to the other method of attachment – by insertion into a socket of the wooden shaft. In this case the "tang" is slightly longer and thinner than the distal end, as they are separated by a strong (Dzh 003) or a less pronounced (Dzh 002) mesial part which functioned to control the tang penetration. The same type of arrowheads

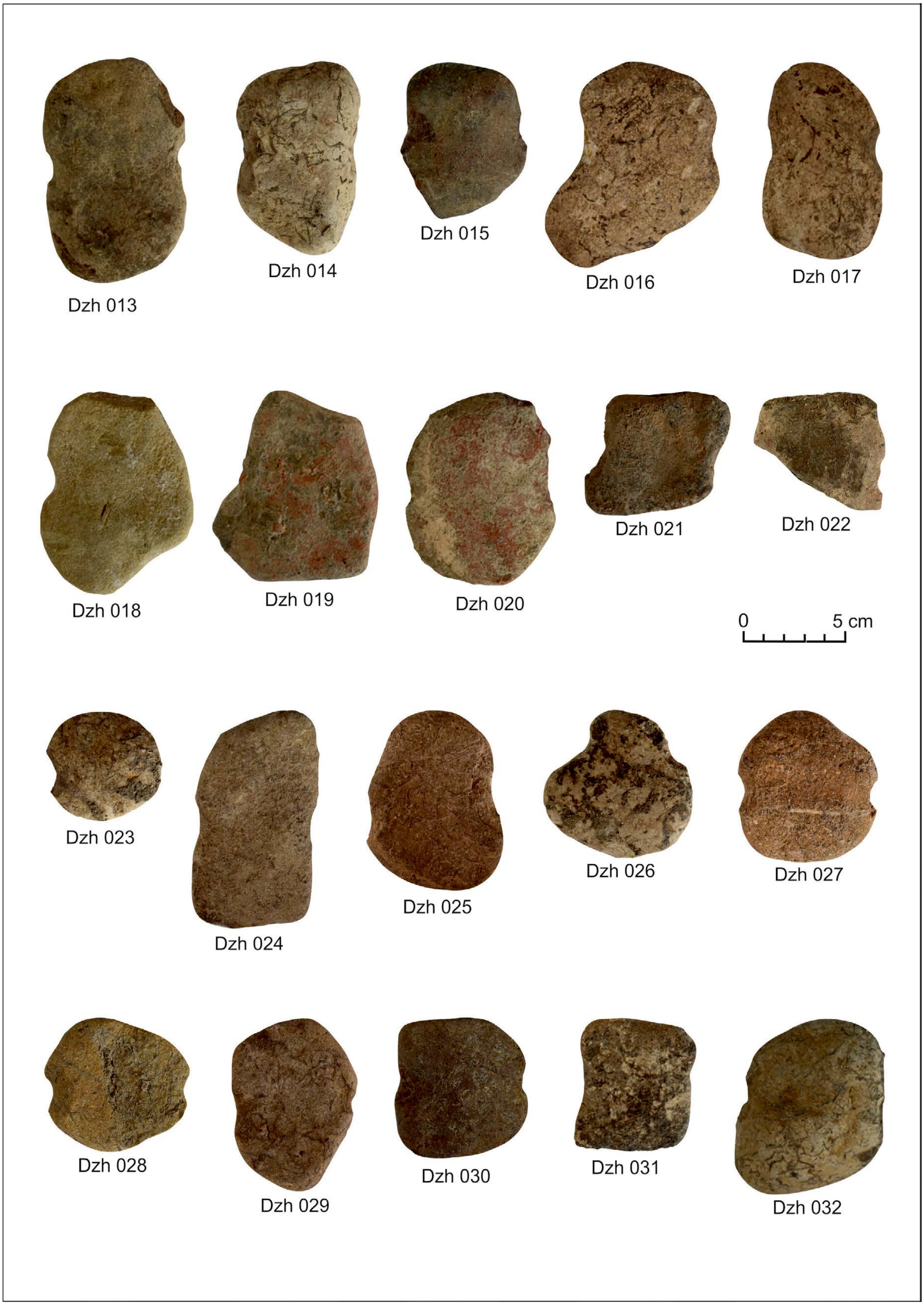

Figure 4. Stone weights.

was discovered among the worked bones from phase A at the Neolithic tell Samovodene, northwest of Dzhulyunitsa (Markova 2021). This kind of bone projectile is known from the Natufian culture (Klein *et al.* 2017: 99, Fig. 3: 11, 12; Le Dosseur 2008: 65, Fig. 5:2,5), the Mesolithic of the Balkans in Ostrovul Banului in Romania (Mărgărit *et al.* 2017: 66, Fig. 9), The Cave of the Cyclops in Greece (Moundrea-Agrafioti 2011: 29, Figure 1.2, 30, Figure 1.13, 31, Figure 1.14, 35) and also widespread in the first half of the Neolithic period in Donja Branjevina, Starčevo-Grad in Serbia (Vitezović 2018: 42, Fig. 3; 44, Fig. 6, 7; Vitezović 2012: 236, fig. 1, 237, fig. 2, 238, fig. 3, 4) and Nea Nikomedia, Prodromos in Greece (Stratouli 1998: 88-90; Taf. 6: 2; 7: 5). The same form of artifacts which are not identified as projectiles are known in archaeological studies about the Early Neolithic in tell Karanovo (Hiller and Nikolov 1997: Taf. 78: 19-21 and 28-29) and Ovcharovo-Gorata (Bulgaria) (Zidarov 2014: 254; Abb. 188: 3), the settlements from the Early Neolithic Körös culture (Makkay 1990: 33; Abb. 8, 35; Tóth 2012, 174; Fig. 2: b), Hacilar in Turkey (Mellaart 1970: 446, Figs 184: 12-15).

A large projectile (25 cm long, 1.2 cm wide and 1.0 cm thick) was registered in the worked bone assemblage at Dzhulyunitsa II (Fig. 2: Dzh 004). There is no doubt that it was attached into a much larger and thicker wooden shaft and it was not possible to throw it with a bow: this object actually is a spearhead. It was made by longitudinally splitting metapodial bone of a large ruminant (*Bovidae/ Cervidae*). In spite of the numerous hard residues on the object, it is possible to observe longitudinal, relatively deep and coarse traces in the area of the proximal and mesial part – resulting from the flint scraping during manufacture of the projectile. The "tang" is slightly beveled for ease of lateral attachment. Unfortunately, it is not possible to identify striations on the distal part of the spearhead. Morphologically, these large projectiles represent a kind of massive point, but they differ from the arrowheads in their relatively longer size and wider distal part. Some of the bone spearheads have transverse short and parallel deep cuts that probably facilitate binding to the wooden shaft. A partial

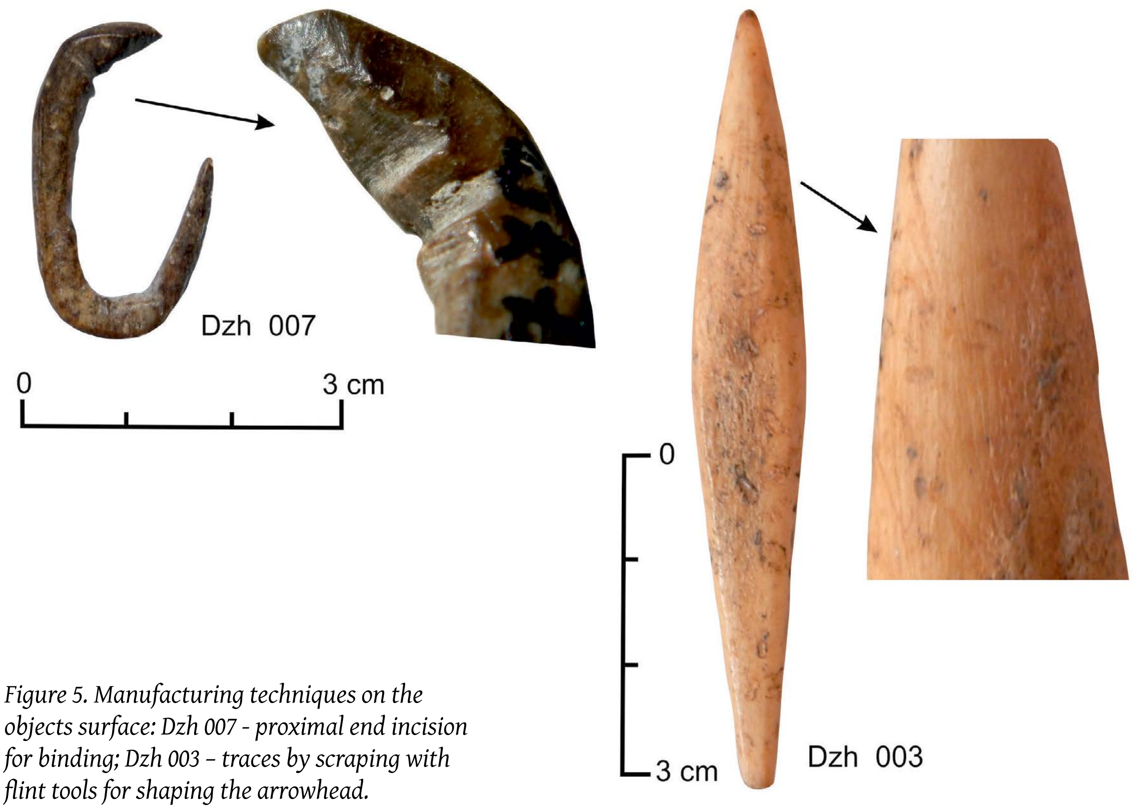

Figure 5. Manufacturing techniques on the objects surface: Dzh 007 - proximal end incision for binding; Dzh 003 – traces by scraping with flint tools for shaping the arrowhead.

bone spearhead was discovered in the earliest stage of the Neolithic period at the Belyakovets-Plochite settlement, located about 30 km west of Dzhulyunitsa-Smardesh (Elenski 2008: 71, fig. 47:1). This find represents the earliest appearance of this kind of weapon made of animal bone in Central Northern Bulgaria. The same large projectiles from the Mesolithic period in Kula were made from long bone and antler cortex of red deer (Vitezović 2011: 7). Neolithic bone spearheads are known in the Balkans from the Starčevo culture sites (Vitezović 2012: 239, fig. 6: Stč 117).

Bone projectile points continue to be widespread throughout Central Northern Bulgaria in the Late Neolithic which indicates continuity with Early Neolithic hunting weaponry (Markova 2019a: 24, fig. 4:1; Markova 2019b: 117, Fig. 7: XO 072; Markova 2020: 30).

Harpoons

These specific barbed points were first used by humans about 90,000 years ago in Africa (Yellen 1998). However, discussions about their exact function in prehistoric times continue (see Weniger 1992; 2000; Pétillon 2008; Estévez, Vila 2013; Christensen *et al.* 2016; Cristiani and Borić 2020). Based on J.-M. Pétillon's definition of the operating mode of harpoons (2008: 77) and the limited distribution of the barbed points, we suppose that their main function during late prehistory is related to fishing (Markov 2020: 21-25). Yet, the possibility that they were used to hunt mammals in aquatic environments should not be excluded.

Two harpoon heads made of red deer antler were discovered during the excavation of Dzhulyunitsa and both finds are from the earliest phase (Fig. 2: Dzh 005, Dzh 006). Harpoon Dzh 006 is an unfinished specimen which is 18.6 cm long and 2.2 cm wide. The rectangular blank was extracted from the compact tissue of the antler beam by grooving. Consequently, the first three or four barbs were formed and arranged asymmetrically on both sides of the trunk. The next technological operation was smoothing of the entire surface and edges by abrasion and/or scraping. Probably at the same time the distal and proximal ends were formed, laterally sharpened by abrasion again. The production of barbs consists of three stages: 1) the outer contour of each barb was formed by successive longitudinal incisions with a burin or similar tool; 2) the excess part was removed by transverse cutting at the base of the previous (upper) barb; 3) finally, the inner contour of the barb was formed by incising with a flint tool between the barb and trunk. Only stages 1) and 2) were performed on the Dzh 006 specimen. Why was the harpoon head left unfinished? Supposedly, this was an unsuccessful attempt to make a harpoon point. The blank itself is not of a suitable shape, since its longitudinal axis is slightly curved.

The other harpoon Dzh 005 is completely preserved but the barbs on its left side are broken (Figure 6). The point is 9.4 cm long and has a maximum thickness of 0.9 cm, while the restored maximum width is probably about 2 cm, i.e., it is half the length of the previous one. The entire surface is well smoothed. One of the specific features of this point is the edge along the longitudinal axis of the trunk. Thus, the cross section of the mesial part has a specific shape, similar to a pentagon. The barbs are straight and sharp and the distance between them is about 2.5 cm. They were carefully elaborated using a flint tool. Another specific feature is its proximal part. It consists of two lateral slots (gorges) which served to attach the rope and a sharpened proximal end. The longitudinal section of object Dzh 005 is also very peculiar – the thickness of the point gradually increases from its distal end to the beginning of the proximal part, and then drastically decreases to the proximal end of the tip. Thus, the beveled (wedge-shaped) proximal part is particularly suited for easy insertion into the wooden shaft (or probably foreshaft), i.e. pin-hafting (cf. Weniger 1992: 261-262). On the other hand, this shape is adapted to stop unnecessary penetration of the antler point into the wooden shaft when the harpoon strikes the prey. On the upper

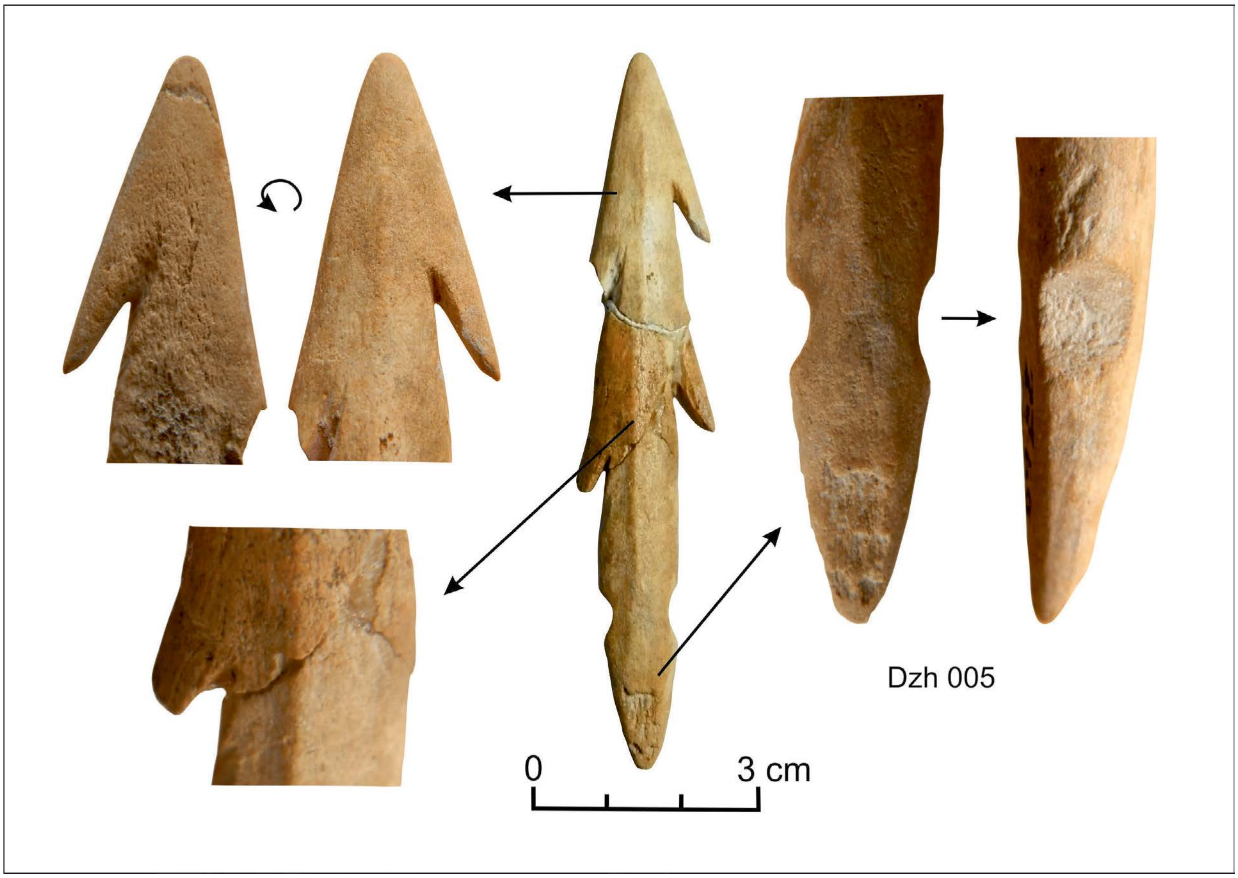

Figure 6. Manufacturing techniques and use-wear on the harpoon Dzh 005.

surface of the proximal end several damages are identified and most likely they were caused by removal of the wooden shaft during fishing. The suitable shape of the proximal part as well as the traces on it, are evidence that this point was removably attached to the shaft. Other traces of use are not observed.

As we mentioned above, the Dzhulyunitsa harpoons were discovered in a layer dating to the end of the 7th millennium BC. Only one more harpoon from the earliest Neolithic phase has been discovered in Bulgaria. It originates from a settlement located near the bank of the Lower Danube River, close to the village of Major Uzunovo (Northwestern Bulgaria) (Ganetsovski 2015: 9, fig. 12: 2). Only the distal-mesial part was preserved but this specimen was probably of a size similar to that of the unfinished Dzh 006 harpoon. There are two main similarities between the three specimens – they all are bilaterally asymmetrical barbed points and have a very well smoothed surface.

The Dzh 005 harpoon has no parallels within the published Neolithic and Chalcolithic harpoons from the Balkans (Beldiman and Sztancs 2009; Comşa 1986; Georigev and Angelov 1952; Mărgărit *et al.* 2010; Mărgărit, Popovici 2011; Markov 2020; Vasić 1936). What sets it apart are the lateral gorges of the proximal part. This type of attachment system seems to be characteristic for earlier periods. The closest parallel, geographically, is the antler barbed point found in the Mesolithic layer I of Kula, Serbia (Vitezović 2011). However, this specimen is almost twice as large and more roughly processed – maybe it is more similar to the unfinished Dzh 006 and Major Uzunovo examples. In terms of size, the Dzh 005 harpoon falls within the group of the Alpine Mesolithic barbed points with lateral gorges (Bandi 1980: 28, taf. I: 1, 5, 7, 8, 10 and 30, taf. II: 5, 6 and references; Cristiani 2009 and references; Cristiani and Borić 2020). They are all bilateral points with a maximum length of about 8-14 cm (according to the presented images). Even some of them have the same specific feature – a pentagon-like cross section (Bandi 1980: 30, taf. II: 5, 9, 8). At the same time, Dzh 005 is different from two other traditions which are common for the Mesolithic in Europe and some parts of the Balkans – the production of unilateral harpoons (Bačkalov 1979: t. XI; Karavanić *et al.* 2013: 50, fig. 18: 8; Turk 2004: 16, fig. 2.2) or barbed points with perforation for binding (Bandi 1980: 28, taf. I: 6; Mons 1995; Cristiani and Borić 2016; Borić *et al.* 2019).

The lack of parallels in the later assemblages and a number of similarities with earlier specimens actually reveals "the Western Mesolithic" roots of the harpoon manufacturing tradition in Dzhulyunitsa. However, the more precise production (finely smoothed surface, straight linear contours etc.) marks the difference between the studied Early Neolithic harpoons and the aforementioned Mesolithic points. This is proof that they were made by craftsmen who had great experience in processing of hard animal materials and a better range of manufacturing craft tools (flint and/or bone). Therefore, we assume two possibilities: 1. these craftsmen were part of the early farmers groups but possessed higher level skills, a range of tools and mastered the Mesolithic tradition through contact with other groups, or 2. the craftsmen were part of the Mesolithic groups and had mastered a better technological approach and the better tools of production from the early farmers after joining their settlement.

We may assume that the harpoon Dzh 005 is a developed form of the Mesolithic tradition of making barbed points with lateral gorges on the proximal end. At first glance, the mentioned similarities and differences outline the path of this Mesolithic tradition from the Alpine region along the Danube (through Kula) to Northern Bulgaria. But it is possible that this tradition may have entered the life of the early farmers earlier (and somewhere else) – during their migration towards the valley of the Yantra River. Unfortunately, the data about these Early Neolithic archaeological finds is still too scarce at present and it is not possible to trace their development.

Fishing hooks

In the Early Neolithic Dzhulyunitsa II, six bone fishing hooks were found (Figure 3). Each is characterized by the L-shaped end of the proximal part, which serves to attach the line. Fishing hooks are made of long bone but due to the high degree of processing (scraping and smoothing) and the lack of semi-finished products, we can't completely restore the *chaîne opératoire* used at the settlement. Probably, production began with the extraction of a piece of bone from a large ungulate animal such as *Bos* sp. or *Cervus elaphus*. There are several methods to outline the fishhook internal margin that cannot be identified on the finished products. Generally, the methods include different combinations of perforations and incisions (Fig. 3: Dzh 009, Dzh 010). The fishhook-form was achieved by intensive scraping and/or abrasion that removed the traces of previous technological processes. Thus, the cross section became oval and only in the mesial part is it rectangular or square. The distal part of four hooks is missing and one object is a distal fragment. According to experimental data, it is possible that most of the fractures were caused by extra loading during fishing (cf. Olson *et al.* 2008). Only object Dzh 007 is complete. In the proximal part two oblique incisions were identified which facilitated binding (Fig. 5: Dzh 007). The distal end is relatively long (1.7 cm), with fine striations at the very tip.

The Dzhulyunitsa fishing hooks are analogous to a number of other objects found in Neolithic settlements throughout the Balkans: Nea Nikomedia (Stratouli 1998: tafel 26: 1-2, 4-5); Tumba Madžari (Republic of North Macedonia) (Kanzurova and Zdravkovski 2011: 144, fig. 9: a); Cuina Turcului (Romania) (Stratouli 1998: 155, abb. 11: 1-7); Lepenski Vir III (Serbia) (Srejović 1969: fig. VIII; Stratouli 1998, 155, abb. 11: 8-10); Aşağı Pınar 6-7 (Turkey) (Özdoğan 2013: 260, fig. 143). The wide spread of this type in the beginning of the 6th millennium BC demonstrates that these objects are common in the Balkan Early Neolithic complex. Judging by the shape of the proximal part, it is most likely that this type of fishhook originates from, or at least is influenced by, the region of Northwestern Anatolia. Hooks with the same binding system were found at several sites – Pendik (Özdoğan 2013: 218, fig. 26) and Hoça Çeşme (Özdoğan 2013: 241, fig. 89) in Turkey. The numerous similar finds located in such a large area are indicative of the successful use of this form of fishing hook in regions with similar geographical conditions and ichthyofauna (Stratouli 1998: 158).

Stone weights

The stone weights with one or two lateral notches for rope attachment are usually associated with fishing nets (known as "waisted" or notched weights, notched pebbles). Of course, they can also be used for other everyday activities due to the ease of adaptation of most types of weights to various uses. Several notched stone weights covered with a "creamy" engobe are found in Dzhulyunitsa (Dzhanfezova *et al.* 2015: 69, fig. 4). We do not discuss them in this paper because they were used as loom weights. However, we believe that the use of notched pebbles as net weights is their primary function. This is confirmed by a number of parallels with sites located in the Middle East, the Aegean and Central Europe. Such weights have been known since the Late Upper Paleolithic in the area of the Sea of Galilee (Israel) and have been identified as fishing gear for nets or for line and hook (Rosenberg *et al.* 2016: 458-459 and references). Arguments in support of this hypothesis have also been suggested in the study of stone weights from the Neolithic site of Servia in Greece. According to Jill Carington Smith, these weights were not used for weaving because the finely textured twine would wear through relatively quickly against the weights' crude notching. On the other hand, weaving was well developed with the help of clay weaving equipment, and these finds were most likely used as fishing net-sinkers (Carington Smith 2000: 162-163). At the Neolithic settlement Saliagos (Greece) the notched weights were used to catch tuna fish, as no other suitable fishing gear was found (Renfrew *et al.* 1968: 120-121). Their use in fishing of large specimens is proposed for the Neolithic sites in Serbia as well (Antonović 2006: 24). Similar weights were found in archeological contexts at later prehistoric fishing settlements and there are clear evidences that they were attached to nets (Huber and Rehazek 2016).

Through the 2019 excavation campaign at Dzhulyunitsa, two fragmented and eighteen completed waisted weights without engobe were discovered at the site (Figure 4), and several finds were already published (Elenski 2006: 114, fig. 14; Krauss *et al.* 2014: 58, fig. 8: 10). Most of them originate from phase II – 15 (Fig. 4: Dzh 016 - Dzh 030), whereas only three objects are from phase I (Fig. 4: Dzh 013, Dzh 014, Dzh 015) and two from the earlier stage of phase IV (Fig. 4: Dzh 031, Dzh 032). Almost all the objects were found in open spaces and only three belong to specific archaeological features (a dwelling and pits). One of the latter (Dzh 014) was discovered in dwelling 1, together with harpoon Dzh 005. The weights are made of flat pebbles and most of them are oval or rectangular in shape but always follow the natural outline of the pebbles. There are no traces of further manufacturing on the stones' surfaces, except for the lateral notches. On the edges of the long sides were created two opposed notches and only in four cases on the short sides. However, 25 % of the weights have only one notch. In about 65% of the finds, the axis that connects the notches passes through the absolute center of the stone weight or has a minimal deviation of up to 2 mm. The depth of the notches is commonly between 3 and 5 mm. The weight varies from 51.2 to 226.5 grams (mean 120.6 g). Half of the weights are in the range between 70 g and 115 g. The average length is 83 mm (varies from 55 to 113 mm). Naturally, there is a strong correlation between the weight and length: $r = 0.800$; $p = 0.00$. The maximum width is within the 53-86 mm range (average 67 mm). The maximum thickness is 10-23 mm. Stone notched weights are common for Neolithic sites in Bulgaria but they are not published in detail – Balgarchevo (Grebska-Kulov and Kulov 2011: 16); Promachon-Topolnica (Koukouli-Chryssanthaki *et al.* 2007: 72, fig. 49: 3);

Yabalkovo (Hadzhipetkov 2014: 368); Yassa tepe (Detev 1976: 124, fig. 57). The overall dimensions of the Dzhulyunitsa stone weights are very similar to the Servia weights, which are generally dated slightly later (Carington Smith 2000: 161-162, fig. 4.18). Based on these two well-documented assemblages, we can assume that there was some kind of standardization in the production of this type of weights in the 6th millennium BC on the Balkan Peninsula. Therefore, we suggest that the notched weights had the same function in the different settlements. At present, it seems that they were used mainly in fishing but further specialized studies are needed to confirm this.

Discussion and conclusions

The hunting and fishing implements from the site of Dzhulyunitsa-Smardesh demonstrate great technological know-how: they were made from carefully selected raw materials with investment of a large amount of time and labor, especially for the fishing implements and the projectiles. On other hand, it seems that a very experienced person was involved in their production. Generally, the osseous raw materials, from which the bigger part of the collection consists, are appropriate to make such weapons. These are red deer antlers and the large ruminant long bones which are very hard, resilient and shockproof. The technology and morphology of the Dzhulyunitsa collection also reveal a very well organized *chaîne operatoiré* and standardization for all types of items, demonstrating a long-standing tradition of hunting and fishing among the Early Neolithic population of the settlement.

These kinds of devices are well represented in the Early Neolithic strata – indicative of the greater importance of the exploitation of wild animal resources in the settlement economy. As mentioned above, the scarcity of fish bones is most probably affected by the hand-collecting method. Their presence only in layers I and II completely corresponds to fishing gear which was also found only in the same layers. The quantity and the variability of the fishing implements represent clear evidence that fishing was a well-developed and common activity. The harpoons from Dzhulyunitsa I are different in dimension and probably that depended on the size of the prey (cf. Estevéz *et al.* 2013; Christensen *et al.* 2016; Elliott and Little 2018: 291-292). The harpoons are suitable for fishing in shallow waters during the spring river floods. In this case the fish swims closer to the water surface and it is much easier to spear. This time of year coincides with the present-day spawning period of fish species in the Yantra River. The spawning time seems to be the most suitable moment for fishing with harpoon because "most species seek shallow waters near riverbanks as well as residual waters for spawning, where they become more visible and easily fall victim to human predation" (Bartosiewicz and Bonsall 2004: 267). We assume that the big *Cyprinus carpio* species were caught this way. It is also possible that harpoons and fishing nets were used together for hunting of big fishes (Stratouli 1996: 18). Perhaps the studied bone hooks were used as baited fishhooks. It is impossible to determine at present whether the hunted fish species were predatory or not – further and specialized research is expected to find a solution to this problem (cf. Gyria *et al.* 2013).

Fishing with harpoons and fishhooks is more orientated to single large fish as catfish, carp, pike – a practice also known as quality fishing. In contrary, fishing with nets is connected to mass harvest of small specimens – i.e. quantity fishing. It is possible that the small fishes provided more animal protein and were more easily available than the larger specimen (Bartosiewicz and Bonsall 2004: 216). There are two ways to catch large amounts of small fishes – by using fishing nets or fish traps. Unfortunately, both were made of perishable materials and archaeologically it is only the stone waisted weights (probably a part of a fish net) that are found. So, interestingly, stone weights were probably the most commonly used fishing gear. We suggest that their primary function is related to the fishing nets which are the most effective device compared to the other two. Moreover, fishing nets were either used alone or were combined with harpoons. The stone weights were also needed when practicing the hook-and-line technique. The variety of items which were involved in fishing and the presence of fish bones testify that the Early Neolithic Dzhulyunitsa inhabitants were very experienced and knowledgeable about the river resources and how to exploit all of them.

Hunting is only represented by the bone projectile points. It is well documented that bone arrowheads were successfully used for hunting of both large and small prey. Bipoint bone arrowhead was found stuck in the sacrum of red deer (Winiger 1992: 77). Arrowheads made from organic materials are very suitable for hunting birds or small mammals, as well as for hunting in aquatic areas (for discussion see Ellis 1997, 47-50). We suggest that the spearhead was used as part of a throwing spear for hunting of large mammals such as red deer, aurochs, wild boar. However, the sharp distal end is appropriate for a thrusting spear. If we assume that hunting nets were used with weights, then the role of stone waisted weights increases. Despite this, the number of notched pebbles is negligible. Naturally, the use of unprocessed stones is also possible and even more likely. To conclude the discussion about the hunting implements, we have to emphasize the absence of the lithic projectile points. According to ethnographic studies, the use of stone projectile points depends on a number of factors. The brittleness is their main disadvantage and leads to extra time and labor for tool production and maintenance (Ellis 1997). From this point of view, the bone points are a better choice because they are more resilient and can be easily repaired. Actually, the scarcity of lithic projectile points seems to be a common phenomenon for the Early Neolithic archaeological assemblages from the region. Five microliths from Kovačevo possess stigmata of use as projectile points (Gurova 2017: 275). Only three stone arrowheads were identified within the Starčevo culture area (Vitezović 2018: 39 and references). Selena Vitezović suggests that lithic raw materials were rarely used because of the hunting techniques and the cultural attitude towards certain raw materials (Vitezović 2018: 46).

Analyzing the stratigraphic position of the artifacts, it is clear that hunting and fishing were more frequently practiced during phases Dzhulyunitsa I and II. In these layers there is a greater quality, variety and quantity of implements. In contrast, only three bone arrowheads were found in Dzhulyunitsa IV. This distribution corresponds very well with the archaeozoological data where the percentage of wild mammals decreases from layer I to IV (De Groene *et al.* 2018: 40, Tab. 2). The presence of fish bones solely in the earliest two layers also supports our proposition.

This study, despite its preliminary character (also because the excavations of Dzhulyunitsa are still in progress), suggests that both hunting and fishing played an important role in the life of Dzhulyunitsa I-II societies and transformed into a minor activity later, in phase IV. One of the possible explanations for this change is the chronological gap between the layers II and IV (for absolute dates see *Kraus et al. 2014*). Maybe the preference for wild resources in the earlier phases is due to the presence of still existing Mesolithic traditions. However, only future research at this site and other Early Neolithic hunting and fishing assemblages will help us resolve this problem.

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Distribution and use of projectile points during the Chalcolithic period in Bulgaria

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Abstract

During the Neolithic (6th millennium BC) the evidence of hunting tools and weapons in the Eastern Balkans and modern-day Bulgarian lands, in particular, is surprisingly scarce, almost completely absent. The situation changed at the beginning of the Chalcolithic (early 5th millennium BC) with the appearance of bifacial chipped-stone projectile points and bone arrowheads. In the second half of the Chalcolithic, their number, distribution and typological variety significantly increased.

The paper aims at presenting important aspects and problems regarding both the distribution of these projectiles and their function. General typology of both osseous and chipped-stone projectiles is proposed. Some chronological and cultural specifics are attested. At the same time, the variety of materials used, shapes and dimensions suggest certain specialization and differences in their particular use (for hunting different game and for warfare). This hypothesis is further discussed in the background of spatial distribution and finding context, as well as archaeozoological data.

Keywords: Projectile points; Arrows; Spears; Hunting; Warfare; Chalcolithic; 5th millennium BC

Introduction

Projectiles are the first specialized weapons created by humans. Spears first appeared in the Lower Palaeolithic, and in the Upper Palaeolithic there is evidence that bows and arrows were used as well (Guilaine and Zammit 2005: 54). Chipped-stone spearheads and arrowheads are already known in the Palaeolithic of the Balkans, and in some Mesolithic sites in the Iron Gates area at the Danube River bone projectile points were found (Bonsall 2008: 263–264; Roksandić *et al.* 2006: 342, 346). The use of projectile weapons is attested in the Neolithic in the Near East, including hunting scenes from Çatal Hüyük (Mellaart 1967: fig. 54–55, 57; Hamblin 2006: 25–27).

Surprisingly, so far the evidence of such weapons in the Neolithic of the Balkans (late 7th and 6th millennium BC) is scanty, and in Bulgaria and some neighbouring regions is almost completely absent. The situation changed during the 5th millennium BC (the Chalcolithic period according to Bulgarian periodization) when both chipped-stone and osseous arrow- and spearheads spread out.

Were projectiles absent in the 6th millennium BC? Why did they "appear" and spread in the 5th millennium? Are there chronological or cultural differences, or functional choices behind the variety of projectile points used in terms of materials, shape and dimensions? The paper analyses the finds from Bulgaria, searching for answers to these questions.

Bows and arrows

Bows

So far, the only evidence for the Chalcolithic bows in the Eastern Balkans comes from the Varna I cemetery. These are golden "cylinders" found in four of the graves – No 1, 4, 35 and 43 (Ivanov and Avramova 1997: 26, 31, 43). They were probably used for the decoration of bows, as the position of the golden fittings in grave 43 suggests (Figure 1). The latter were found in symmetrical pairs (the bigger in the middle, the smaller at the ends) forming a slight arch along the body of the buried man. According to the original documentation, the two smallest (most distant) ones were found close to the shoulder and the knee, respectively (personal observations). This position suggests that they decorated a quite short (about 1.20 m), simple symmetrical bow, probably similar to the Mesolithic and Neolithic bows found in bogs in Western Europe (Guilaine and Zammit 2005: 63–64; Rausing 1967: 35–39).

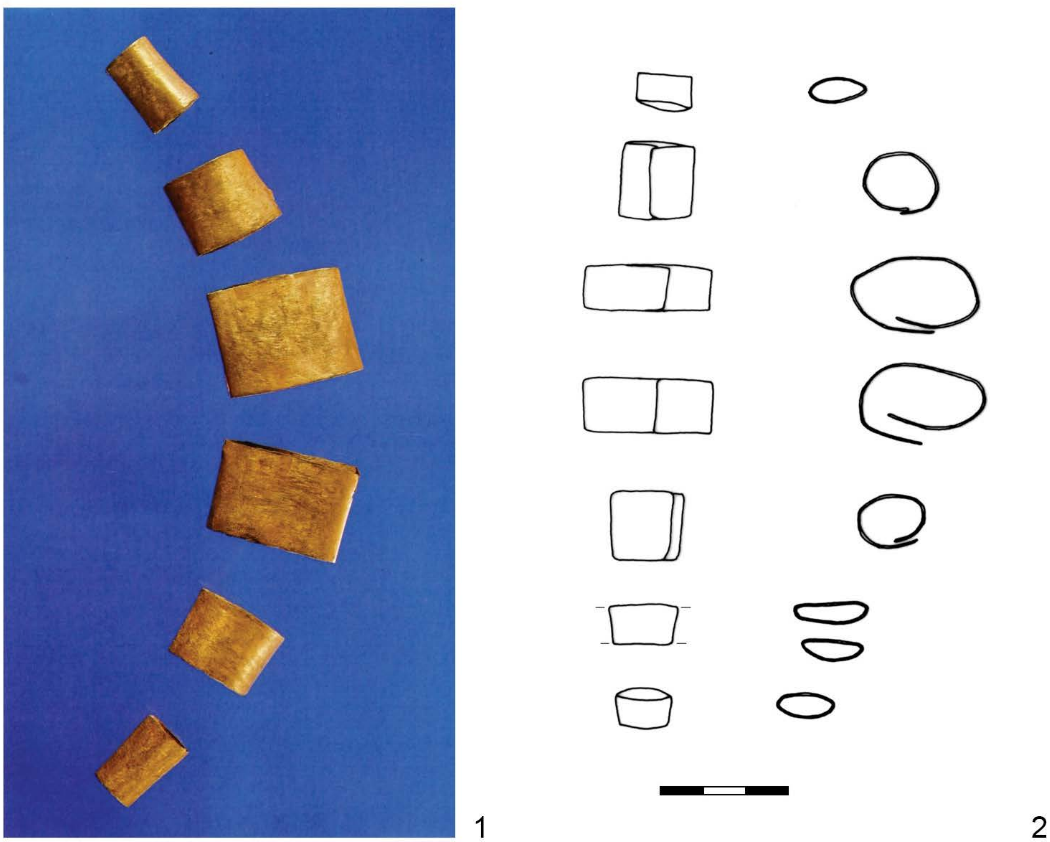

Figure 1. Gold decorations of bows from the Varna I cemetery: 1 – grave No 43 (The first civilization 1982: 144: 306); 2 – grave No 4 (drawing K. Boyadzhiev).

It is important to note that no arrowheads were found in these four graves, but spearheads were present in two of them (see below).

Arrows

So far, there is no evidence of wooden arrow-shafts in the Neolithic and Chalcolithic in Bulgaria. The use of bows and arrows is attested by arrowheads made of chipped-stone and bone.

Bone arrowheads

In Bulgarian archaeological literature, bone artefacts with different morphological and metrical features are interpreted as arrowheads. They may be generally divided into two large groups: objects with both ends thinned out and sharpened (double points) and artefacts with one sharp and one butt end (the latter being the epiphysis of the bone). At the same time, items from both groups are identified as awls by some researchers. Small symmetrical double points are interpreted as fishing gorges or "pins or fasteners" as well (Campana 1989: 83–92 with references).

The author analysed different possible data for distinguishing between arrowheads and tools: the morphological specifics of the artefacts, use-wear traces (especially breakages), the finding context of some of them, historical and ethnographic data, experiments conducted (Boyadzhiev 2014, 94-97; the detailed analysis is outside the scope of this paper).

The analyses show that we may regard most of the double-pointed osseous artefacts as arrowheads: mainly the items with a marked tang but probably also the symmetrical ones. One of the points is thinned and sharpened in order to be inserted in the shaft, while the opposite may be sharp or blunt. Ethnographic observations show that blunt bone arrowheads are used for hunting birds or small animals with valued fur. In such cases, the impact is enough to bring down the animal while the weapon does not cut the fur (Ellis 1997: 47-50; Luik 2006: 142).

About 340 osseous double points from the Chalcolithic period may be interpreted as arrowheads and are further analysed here. Recent excavations have provided information of concentration of such weapons in a couple of sites, but it remains unpublished yet.

The double-pointed artefacts are usually made of massive bones. In a few cases, the use of antler is suggested. However, most specimens were not analysed by an archaeozoologist.

Manufacturing traces are often visible macroscopically. Use-wear analysis has not been performed, but specific breakages are observed on about 1/4 of the artefacts. They usually affect the tang but sometimes the tip, too. Experiments show that such breakages may be a result of arrows hitting bones or a hard surface (Knecht 1997: 204; Pétillon 2005: 24; Tyzzer 1936: 268, 278).

The dimensions of the osseous double points are similar. About 2/3 of the finds are between 40 and 65 mm long and usually about 2-3 g heavy (the biggest ones reaching 14 cm and 11 g).

The author has defined five types according to differences in the longitudinal shape of the objects:

- Type I: It is characterized by a well-defined tang (Figure 2, 3, 4: 1–16; 6).

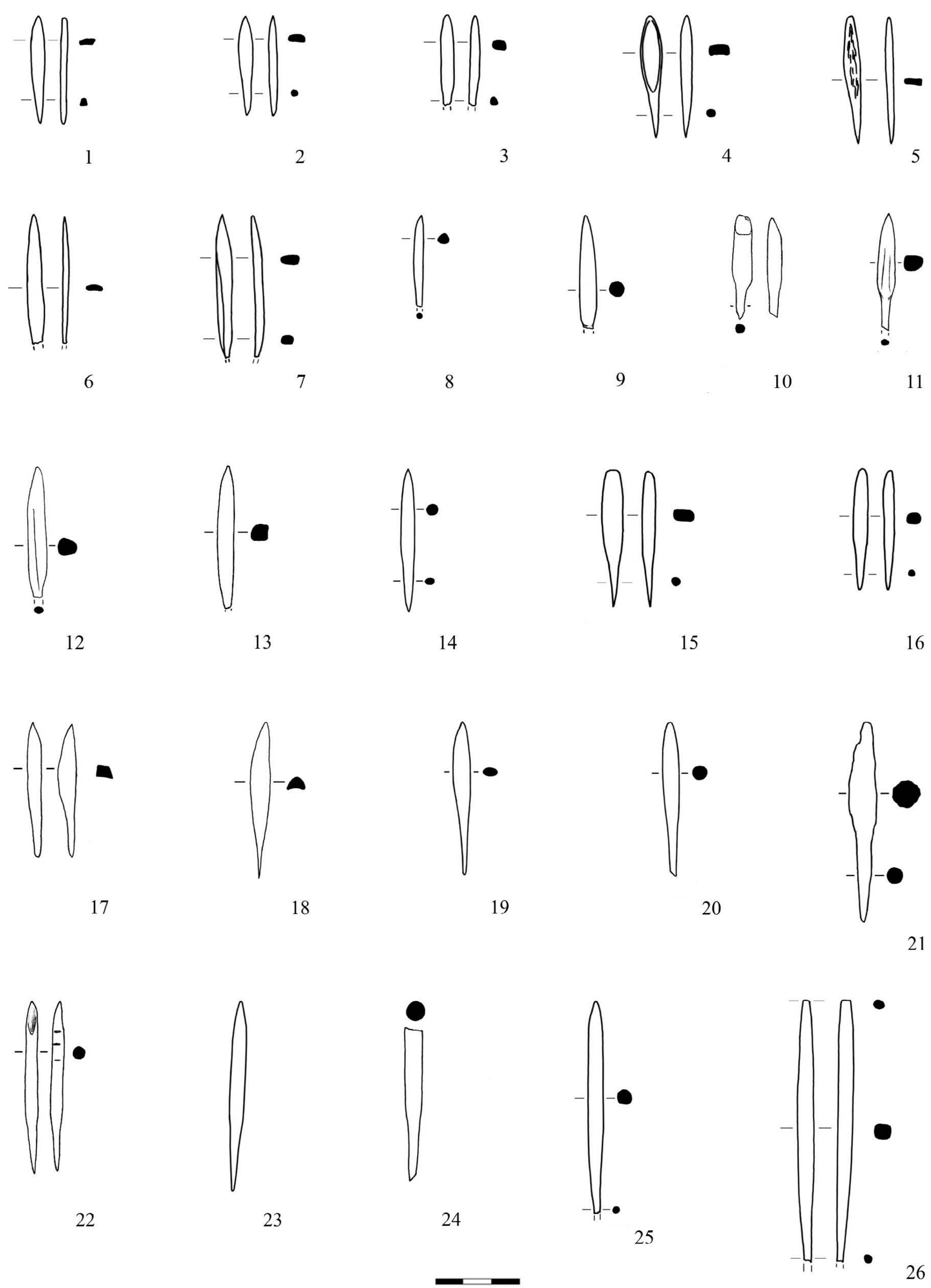

Figure 2. Bone arrowheads, type I. From Tell Nevski (1-7, 25-26), Tell Golyamo Delchevo (8-14), Tell Salmanovo (15, 16), Tell Vinitsa (17, 18), Madara (19-21 – Popov 1913: 100 – fig. 78; Popov 1934: 60 – fig. 29: A, B), Tell Ruse (22, 23 – Georgiev and Angelov 1957: 68 – fig. 29: 8), Miladinovtsi (24). Drawings K. Boyadzhiev, if not specified.

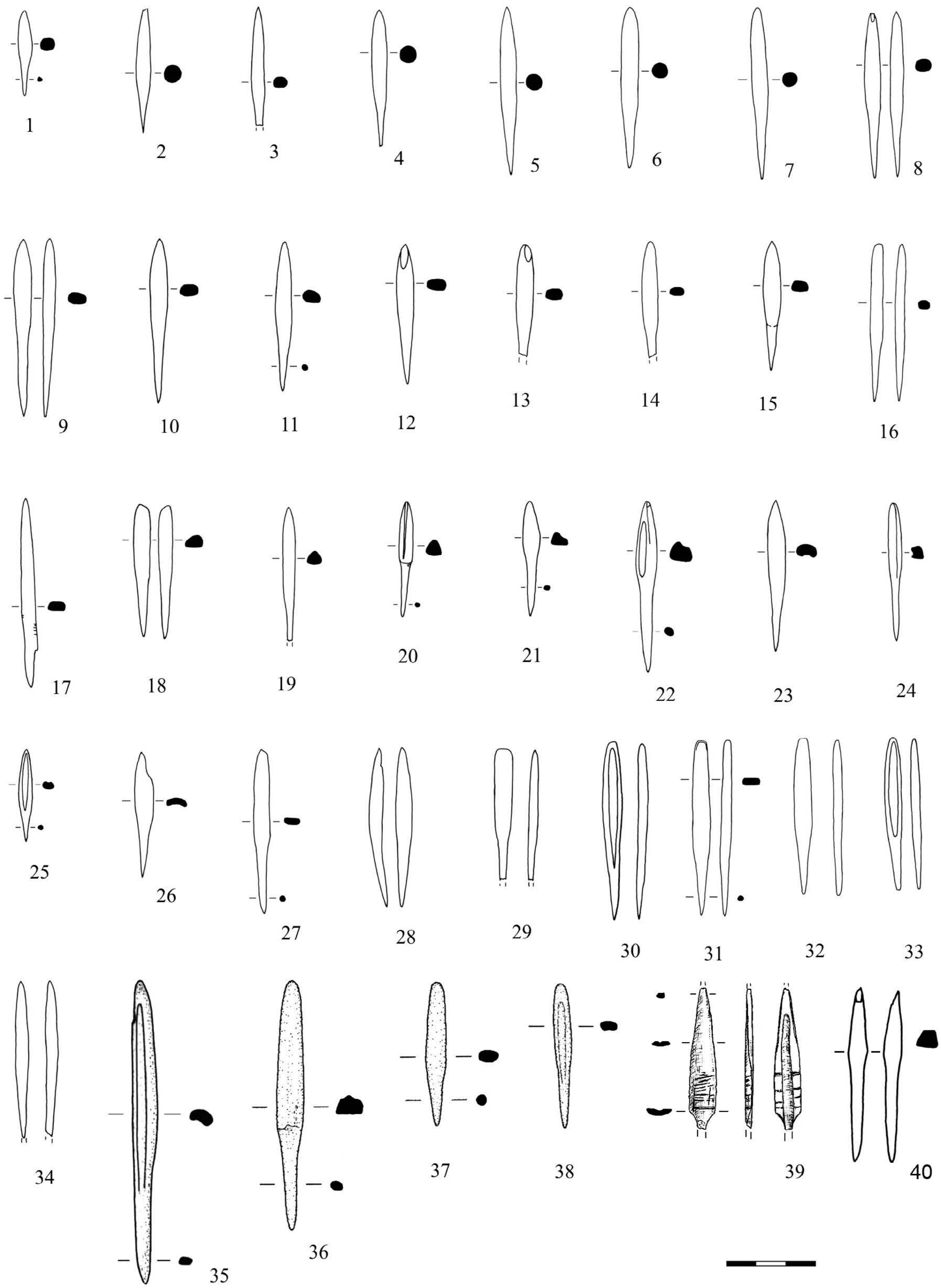

Figure 3. Bone arrowheads, type I.

From Tell Azmashka (1-34; 30-33 – collective find), Tell Karanovo (35-38 – Lang 2005b, Tafel 190: 10-12, 25), Tell Yunatsite (39), Devetashka cave (40). Drawings K. Boyadzhiev, if not specified.

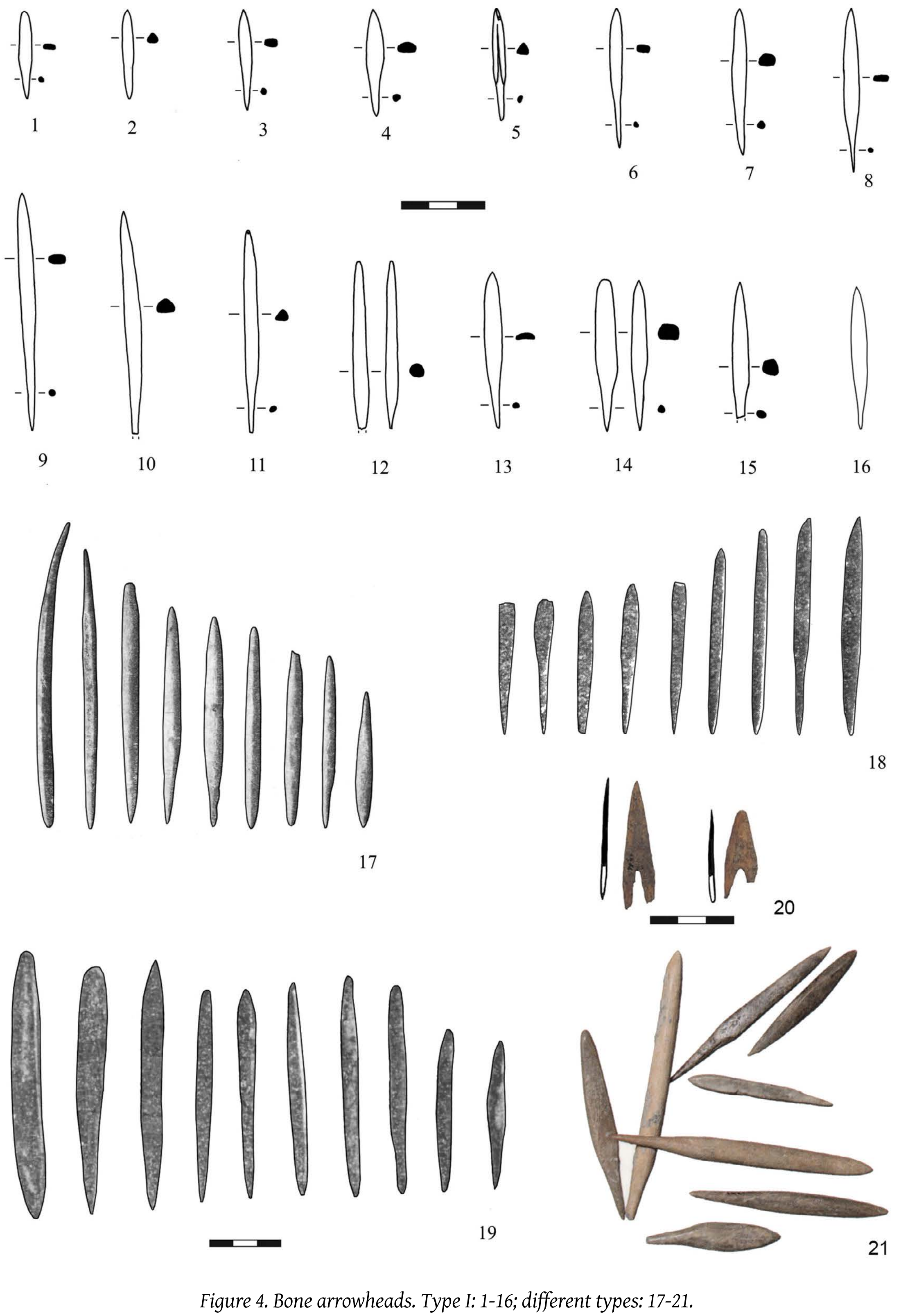

Figure 4. Bone arrowheads. Type I: 1-16; different types: 17-21.

From Tell Smyadovo (1-15), Tell Zavet (16 – Mikov 1961: 278 – fig. 11: e), Tell Kodzhadermen (17 – collective find; Popov 1916-18: 97 – fig. 88), Tell Sava (18 – Mirchev and Zlatarski 1960: 23 – fig. 44), Tell Ruse (19 – Georgiev and Angelov 1952: 135 – fig. 106), Mayor Uzunovo – Early Neolithic (20 – Ganetsovski 2015: 9, 10 – fig. 12: 1), Tell Targovishte-Garata (21 – Bachvarov and Leshtakov 2011: 15). Drawings K. Boyadzhiev, if not specified.

- Type II: There is no tang, but the whole body thins out in the back part to facilitate inserting into the shaft (asymmetrical double points) (Figure 5: 1–20; 7: 1–28).

- Type III: Symmetrical double points. Both ends are identically shaped which makes the identification of front and back parts difficult (Figure 5: 21–30; 7: 29–36).

- Type IV: Approximately rhomboid shape. The front part is shorter than the tang (Figure 5: 31–33).

- Type V: The type is presented by one item, partially broken. It differs significantly from the other bone arrowheads. The body is triangular and flat, with two side notches, probably for binding to the shaft (Figure 5: 34).

Seven subtypes are differentiated according to the shape of the cross-section. Four variants are defined according to the shape of the tip: piercing, rounded, flat – blunt, and cutting edge.

Type I is the most numerous one, including almost 2/3 of the finds analysed. It is the only type in which all subtypes and variants are attested. The piercing tips dominate in all types, but rounded ones are present in types I and II, too.

No certain chronological tendencies or spatial differences are visible in the distribution of types, subtypes and variants. Probably the morphological differences reflect some functional specifics (use of different arrowheads for different purposes) rather than local phenomena.

The finding context of the bone arrowheads provides some clues regarding their use. Almost all of them were found in settlements. Three collective finds are known. Two of them come from Tell Kodzhadermen (Late Chalcolithic), including 23 and 9 double points (Popov 1909: 534–535; Popov 1916–1918: 96, 97 – fig. 88). The second one (Figure 4: 17) includes artefacts with similar shape (mainly type I) but different dimensions. It probably represents a set of arrows with a different purpose related to the game hunted or specifics of the hunting techniques.

The third collective find comes from Tell Azmashka and includes four almost identical points – type I, with rounded tip (Figure 3: 30–33).

Among the few finds from cemeteries, one is intriguing. This is a double point from the Golyamo Delchevo cemetery, found in a woman's chest (Todorova *et al.* 1975: 62, 236 – t. 124: 1). It is possible that the arrowhead was not part of the grave goods but the weapon that caused the death of the woman and remained stuck in her body.

Copper arrowheads

Symmetrical or slightly asymmetrical double-pointed copper artefacts, similar to types II and III bone arrowheads, are known from the Bulgarian Chalcolithic (Chernyh 1978: 113–115, t. 15–17). Unlike bone artefacts, the tang of the copper ones was necessary for inserting into any kind of handle and is no sure argument in determining their function. The discovery of some copper double points inserted in short bone handles shows that they were used as awls. Other similar objects might have had the same function.

Two double points with a tang, very close to type I bone arrowheads, are worth noting: from Telish-Luga (Late Chalcolithic, Figure 15: 6; Merkyte *et al.* 2005: 107, 108 – Fig. VI: 14) and Tell Yunatsite (Late

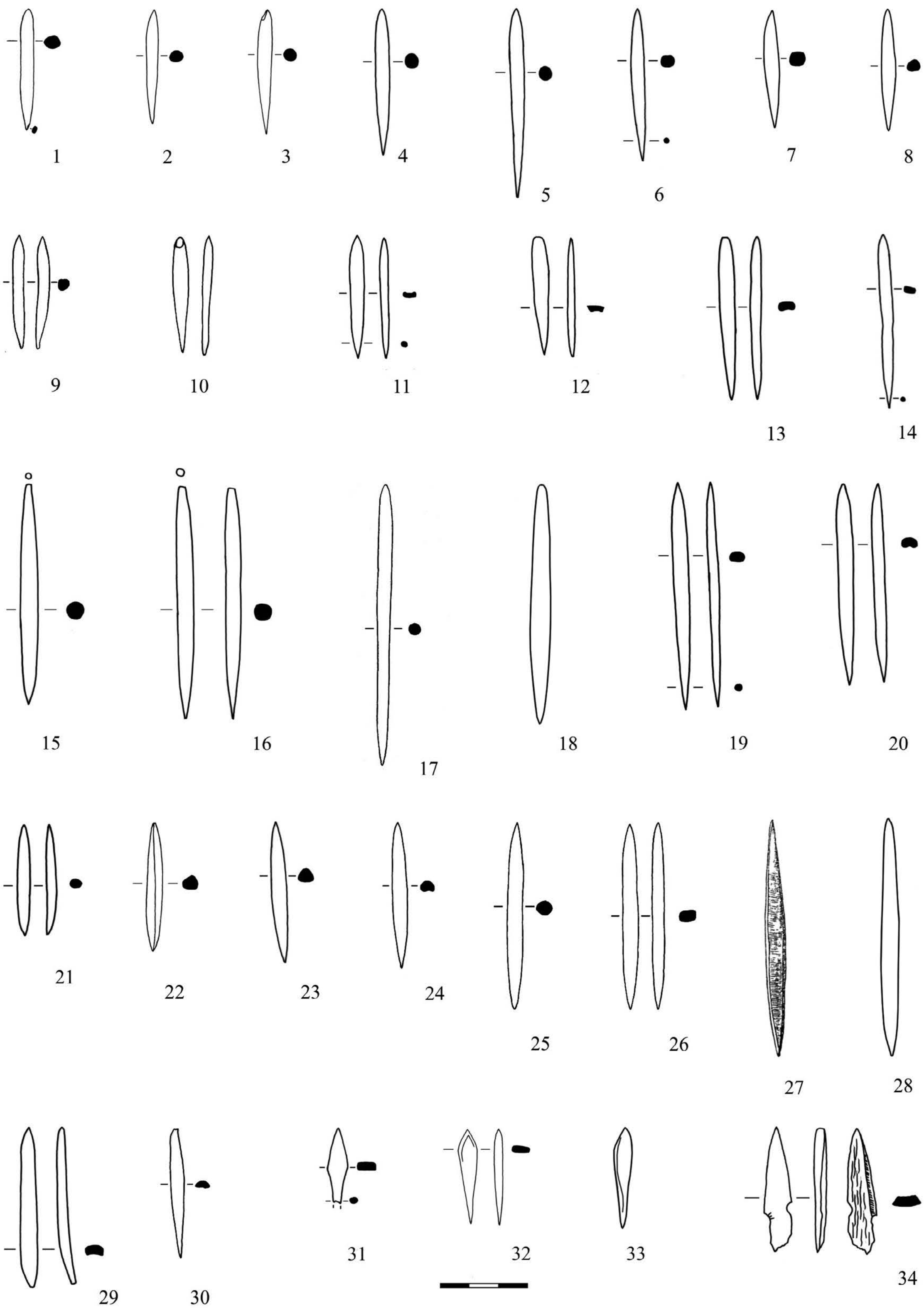

Figure 5. Bone arrowheads. Type II: 1-20; type III: 21-30; type IV: 31-33; type V: 34.

From Tell Golyamo Delchevo (1, 9, 25, 26), Tell Azmashka (2, 3, 7, 8, 10, 24, 30, 32, 33), Tell Smyadovo (4-6, 14, 23, 31), Tell Nevski (11, 12, 13, 15, 16, 19, 20, 21, 29), Tell Ruse (17, 27), Emenska cave (18, 28), Tell Karnobat (22), Tell Targovishte (34). Drawings K. Boyadzhiev.

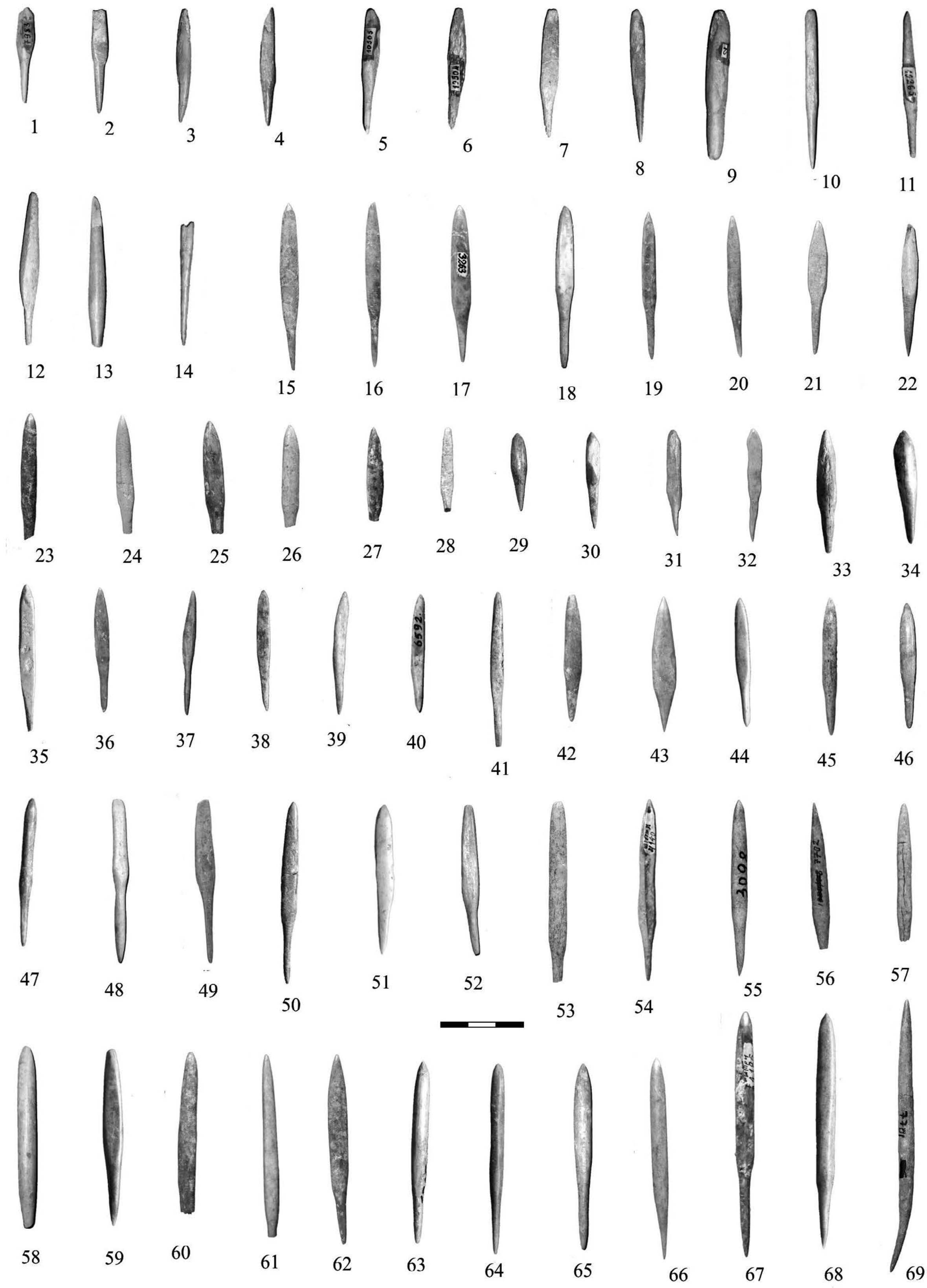

Figure 6. Bone arrowheads, type I.
From Tell Azmashka (1-14) and Tell Smyadovo (15-69). Photos K. Boyadzhiev.

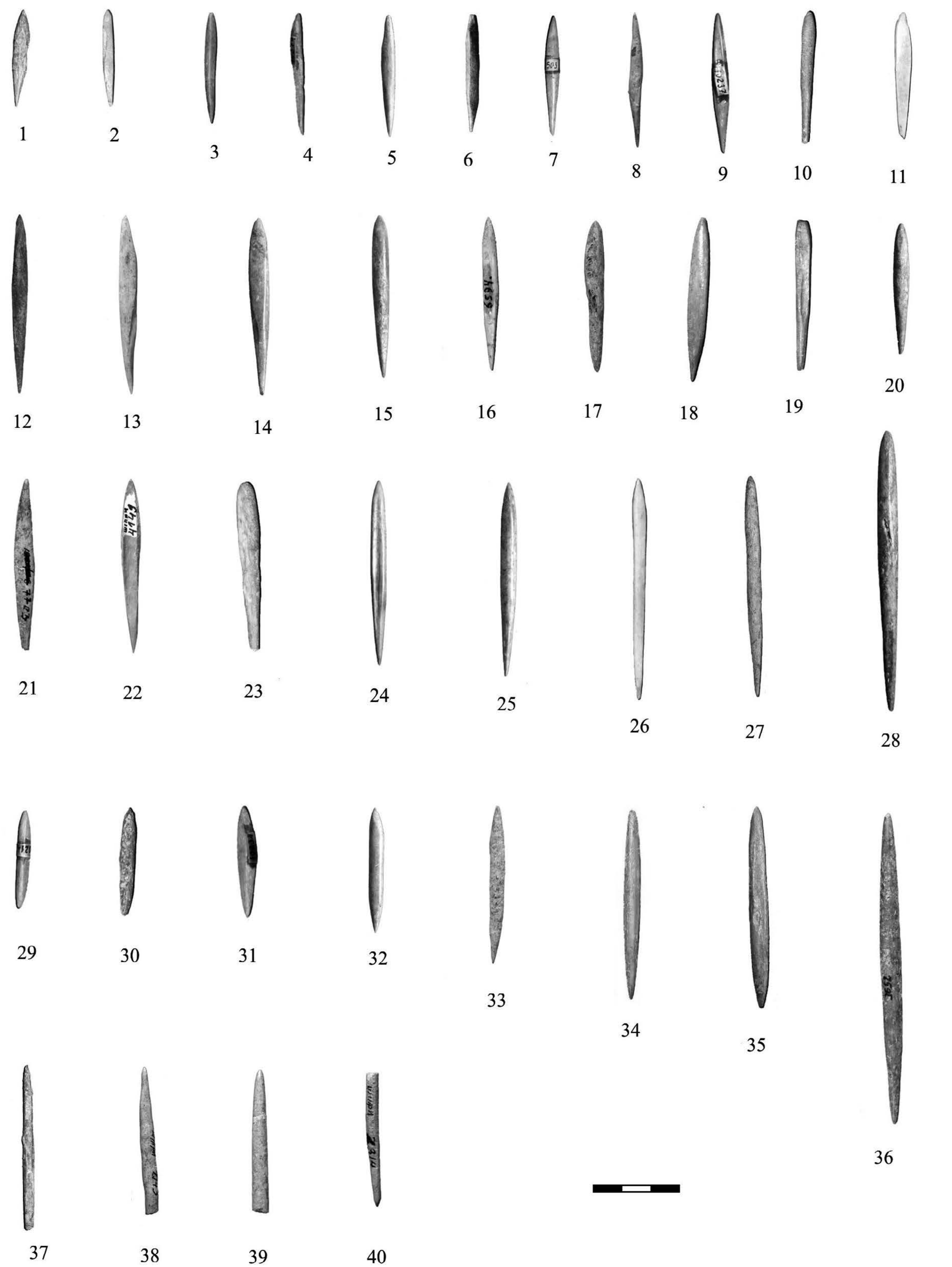

Figure 7. Bone arrowheads. Type II: 1-28; type III: 29-36, unidentifiable fragments: 37-40.

From Tell Azmashka (1, 2, 4, 7, 9, 10, 18, 19, 23, 26, 29-31, 34, 37) and Tell Smyadovo (3, 5, 6, 8, 11-17, 20-22, 24, 25, 27, 28, 32, 33, 35, 36, 38-40). Photos K. Boyadzhiev.

Chalcolithic, Figure 15: 5). The first one has a sharp point, while the second one ends in a cutting edge. While a cutting edge was attested on some bone points as well, its use as a tool is not completely excluded (but different from an awl or needle). The interpretation of these artefacts as weapons is tempting, but not sure. The use of copper arrowheads in this very early period of metallurgy is questionable, because the risk of losing the rare material objects was great, while bone and flint points were functional as well.

Flint arrowheads

Flint arrow- and spearheads are a distinct group of artefacts, which differ from the other chipped-stone objects both by morphological specifics and in terms of manufacture. Their shape is usually close to an isosceles triangle. The lateral edges are sharp and cutting, and join into the piercing point. In most cases, the base is thin, ending in sharp edge facilitating insertion into the shaft. Most of the projectile heads are bifaces, but points made on blades or flakes are also found.

The distinction between arrowheads and spearheads in the absence of their shafts is problematic. The dimensions of the point depend on the specifics of each particular weapon and may vary a lot for both arrows and spears. Both different criteria for this discrimination (length, weight, etc.) and different values of the criteria used have been proposed in the archaeological literature (Beckhoff 1966: 36; Ivanova 2008: 65; Korfmann 1972: 37; Lichardus and Lichardus-Itten 1993: 23; Rausing 1967: 164).

The main criterion to distinguish between flint arrowheads and spearheads in the current study is the length of the artefacts. The analysis of the metrical features of all available Chalcolithic finds (210) shows that among the length values there are certain intervals with a concentration of artefacts and an intermediate interval almost lacking objects: between 51 and 57 mm. The length of 51 mm is considered a border (although approximate) between arrowheads and spearheads. The weight of the projectile points and a border value of 10 g is used in addition.

The classification of the flint arrowheads from the Bulgarian Chalcolithic (105 analysed finds) is based on the shape of their horizontal longitudinal section. The author differentiates two groups according to the symmetry of the artefacts:

- Group A: Symmetrical points. The items are usually bifacially retouched.

- Group B: Asymmetrical points. These are the so-called geometric microliths. Their shape is of asymmetrical trapeze or, rarer, asymmetrical triangle. These artefacts are also discernible for their small size (between 15 and 33 mm long) and manufacture (on bladelets).

Eleven types are defined among the group A arrowheads based on the shape of lateral edges and base:

- Type I (Figure 8: 1–17): The lateral edges and the base are straight or almost straight. The overall shape is of an isosceles triangle.

- Type II (Figure 8: 18–22): Straight lateral edges, concave base.

- Type III (Figure 8: 23–28): Straight lateral edges, convex base.

- Type IV (Figure 8: 29–36): Convex lateral edges and convex base. The transition between them is smooth, with no angles.

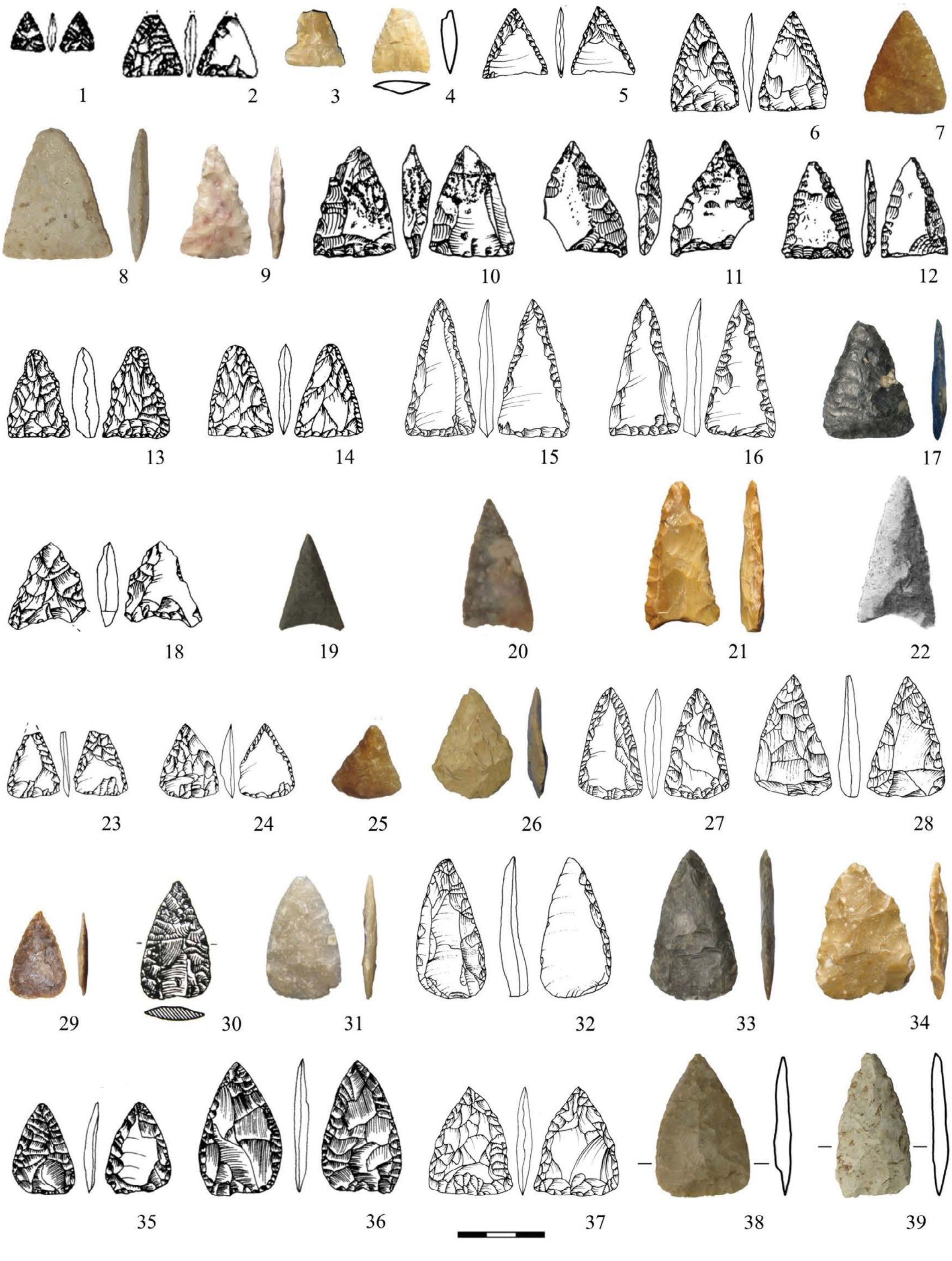

Figure 8. Chipped-stone arrowheads, group A. Type I: 1-17; type II: 18-22; type III: 23-28; type IV: 29-36; type V: 37-39.

From Perperikon (1, 2 – Gurova 2005: 93, 101 – fig. 3: 2, 3), Devetashka cave (3, 4, 8, 28, 38, 39), Gradeshnitsa (5, 6 – Sirakova and Zlateva-Uzunova 2012: 37, table V: 8, 11), Tell Krivodol (7, 25 – Nikolov 1984: 47), Tell Kodzhadermen (9, 34), Rebarkovo (10-12 – Georgieva 1994, 22 – fig. 14: 7-9), Adata (13, 14, 18 – Zlateva-Uzunova and Kurchatov 2005, 3 – Pl. I: 2; 5 – Pl. II: 2), Mezdra (15, 16, 27 – Zlateva-Uzunova 2014: fig. 2: 4, 6, 7), Tell Durankulak (17, 26, 33), Borovan (19, 23, 24), Tell Golyamo Delchevo (20), Tell Smyadovo (21, 31), Zaminets (22 – Nikolov 1975: fig. 12), Tell Yunatsite (29, 35, 36 – Sirakov and Tsonev 2001: 357 – fig. 9: 2, 3), Tell Drama-Merdzhumekya (30 – Lichardus et al. *2000a: Tafel 6: 10), Tell Nevski (32 – drawing S. Taneva), Dolna Dryanka (37 – Zlateva-Uzunova 2012. 60 – table IV: 7). Photos K. Boyadzhiev, if not specified.*

- Type V (Figure 8: 37–39): The lateral edges are convex, and the curve of the arch is closer to the concave base.

- Type VI (Figure 9: 1–4): The lateral edges are convex, and the curve of the arch is closer to the base. The base is also convex, with angles between it and the lateral edges.

- Type VII (Figure 9: 7, 8): The lateral edges are convex, and the curve of the arch is closer to the point. The edges are almost parallel in their proximal part. The base is straight.

- Type VIII (Figure 9: 5, 6): Convex lateral edges, concave base.

- Type IX (Figure 9: 9–12): The lateral edges are straight. There is an arch-shaped notch in the middle of the base.

- Type X (Figure 9: 13–15): There are side notches on the lateral edges, placed closer to the straight base.

- Type XI (Figure 9: 16): The lateral edges form an obtuse angle. The overall shape is almost rhomboid.

The artefacts with straight lateral edges without notches (types I, II and III) predominate the flint arrowheads from group A – almost 60%. Type I is the most numerous. The arrowheads with convex lateral edges (types IV-VIII) follow those with straight ones. Just four finds represent types X and XI.

The group B points are much less in number (15 known so far) and typological variety. According to their shape and position towards the shaft, respectively the way they "work", two types are differentiated:

- Type I (piercing points): The shape is asymmetrical trapezoid or almost triangular (Figure 9: 18–25). The short cathetus was inserted into the shaft.

- Type II (cutting points): The shape is of a symmetrical trapeze. The short base of the trapeze was inserted into the shaft, and the long base was the functional part of the artefact. Thus, such points served for cutting, not piercing. Only two finds are known from the Chalcolithic (Figure 9: 26 and a find from Tell Yunatsite).

Most of the flint arrowheads analysed come from settlements, but precise data on their context is usually lacking. In Gradeshnitsa three similar points were found in one building – may be part of an arrow-set.

Fifteen arrowheads were discovered in Chalcolithic cemeteries, all of them in the Hamangia (Early and Middle Chalcolithic) and Varna (Late Chalcolithic) cultures' area. Fourteen of them are geometric microliths: nine from Durankulak (Todorova *et al.* 2002: 110) and five from Varna II cemetery (Ivanov 1978: 85). All but one were found in male graves. Grave 644 from Durankulak is defined as female (Todorova *et al.* 2002: 110). All five arrowheads from Varna II come from one grave, and three points come from grave 994 from Durankulak. In both cases, they were found together close to the pelvis and may be related to arrow-sets worn in quivers.

One flint arrowhead was also discovered in the cemetery of Tell Provadia-Solnitsata (grave 27). Information about the artefact's morphometrics is missing, but the finding context is intriguing. It was stuck into a vertebra and, according to the researchers, was the probable cause of death (Nikolov *et al.* 2014: 91).

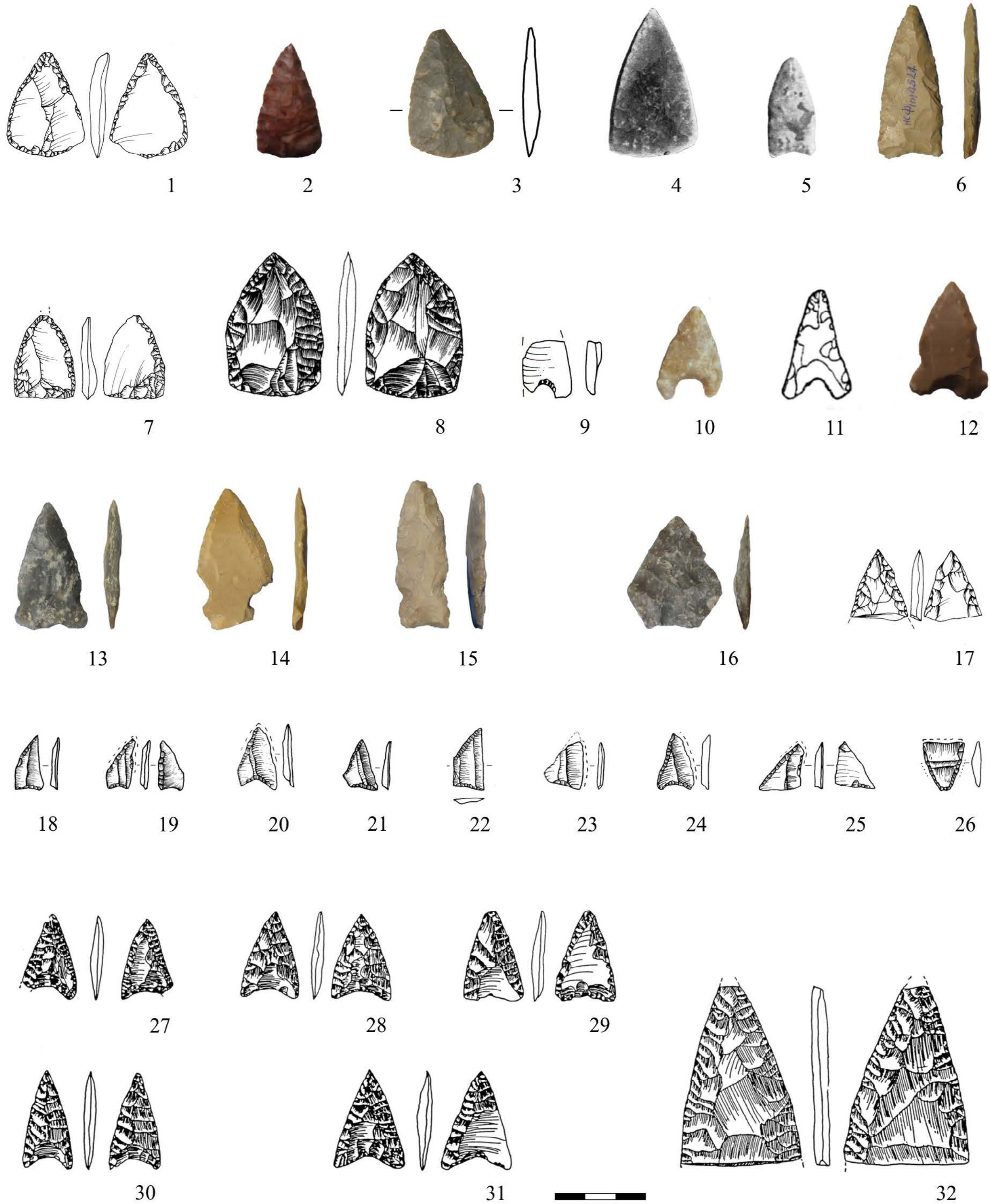

Figure 9. Chipped-stone arrowheads. Group A, type VI: 1-4; type VII: 7-8; type VIII: 5-6; type IX: 9-12; type X: 13-15; type XI: 16; unidentified fragment: 17; Group B, type I: Viel point – 18-22; atypical Viel point – 23-25; type II – 26. Arrowheads (27-31) and spearhead (32) from the so-called Transitional period.

From Mezdra (1, 7 – Zlateva-Uzunova 2014, fig. 2: 5, 8), Tell Durankulak (2, 6, 12-16), Devetashka cave (3), Polichki cave (4, 5), Tell Yunatsite (8 – Sirakov and Tsonev 2001: 357 – fig. 9: 1), Dervishov odzhak (9 – Gatsov 1997: 149 – fig. 1: 9; 154), Tell Krivodol (10 – Nikolov 1984: 47), Tell Golyamo Delchevo (11 – Todorova et al. *1975: 211 – table 99: 24), Borovan (17 – Zlateva-Uzunova and Miteva 2009: 248, 256 – table III: 11), Durankulak cemetery (18-26 – Sirakov 2002: 244, fig. 14, 15), Hotnitsa-Vodopada (27-32 – Sirakov and Tsonev 1995: 247 – Pl. I).*

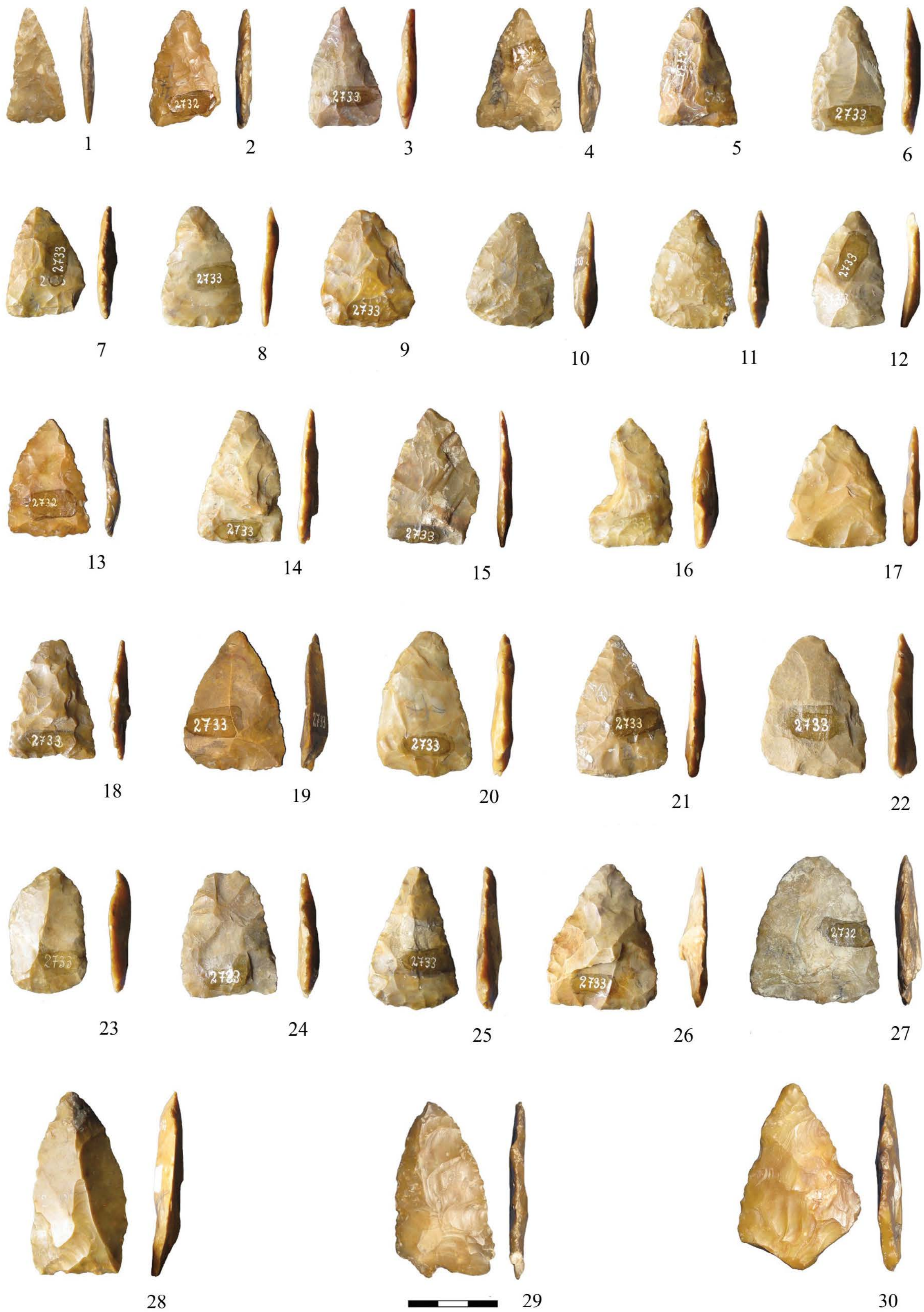

Figure 10. Chipped-stone projectile points from the Madara "workshop": arrowheads – 1-27 and spearheads (?) – 28-30. Photos K. Boyadzhiev.

The collection of flint projectile points from Madara is worth noting. It includes about forty artefacts in different manufacturing stages (Figure 10). Obviously, this was a workshop specialized in their production (Popov 1934).

Spears

The spears can be used both by throwing at a distance (throwing spear or javelin) or for thrusting, hold in hand (pike). However, there are no shafts of spears preserved from the Neolithic and Chalcolithic in the Balkans, which could give more information on the dimensions and specific function of these weapons. Evidence of spear-throwers is also missing. The only source of information about their existence and use are the heads made of flint, bone or antler (?) and copper.

Flint spearheads

Based on the analyses mentioned, the author defines symmetrical flint points longer than 51 mm and heavier than 10 g as spearheads. They are classified according to the same principles as the symmetrical flint arrowheads. Thirteen types are differentiated:

- Type I (Figure 11: 1–4): The lateral edges and the base are straight or almost straight. The overall shape is of an isosceles triangle.

- Type II (Figure 11: 6–9): Straight lateral edges, concave base.

- Type III (Figure 11: 5): Straight lateral edges, convex base.

- Type IV (Figure 12): Convex lateral edges and convex base. The transition between them is smooth, with no angles.

- Type V (Figure 13: 1–10): The lateral edges are convex, and the curve of the arch is closer to the straight base.

- Type VI (Figure 13: 11–15): The lateral edges are convex, and the curve of the arch is in the mid-part or closer to the point. The edges are almost parallel in their proximal part. The base is straight.

- Type VII (Figure 13: 16): The shape is similar to type IV. The specific feature defining the type is two small symmetrical “barbs” on the edges, close to the base.

- Type VIII (Figure 13: 17–20): Straight lateral edges and an arch-shaped notch in the middle of the base.

- Type IX (Figure 11: 11–18): Side notches on the lateral edges, placed closer to the straight base. In one case, there are two pairs of notches (Figure 11: 16).

- Type X (Figure 11: 19–21): Side notches on the lateral edges, placed closer to the convex base.

- Type XI (Figure 11: 10): Side notches on the lateral edges, placed closer to the concave base.

- Type XII (Figure 14: 1–3): Wide notches in the proximal part of the spearhead form kind of a tang, which is wider in the base. The lateral edges are straight in the distal part.

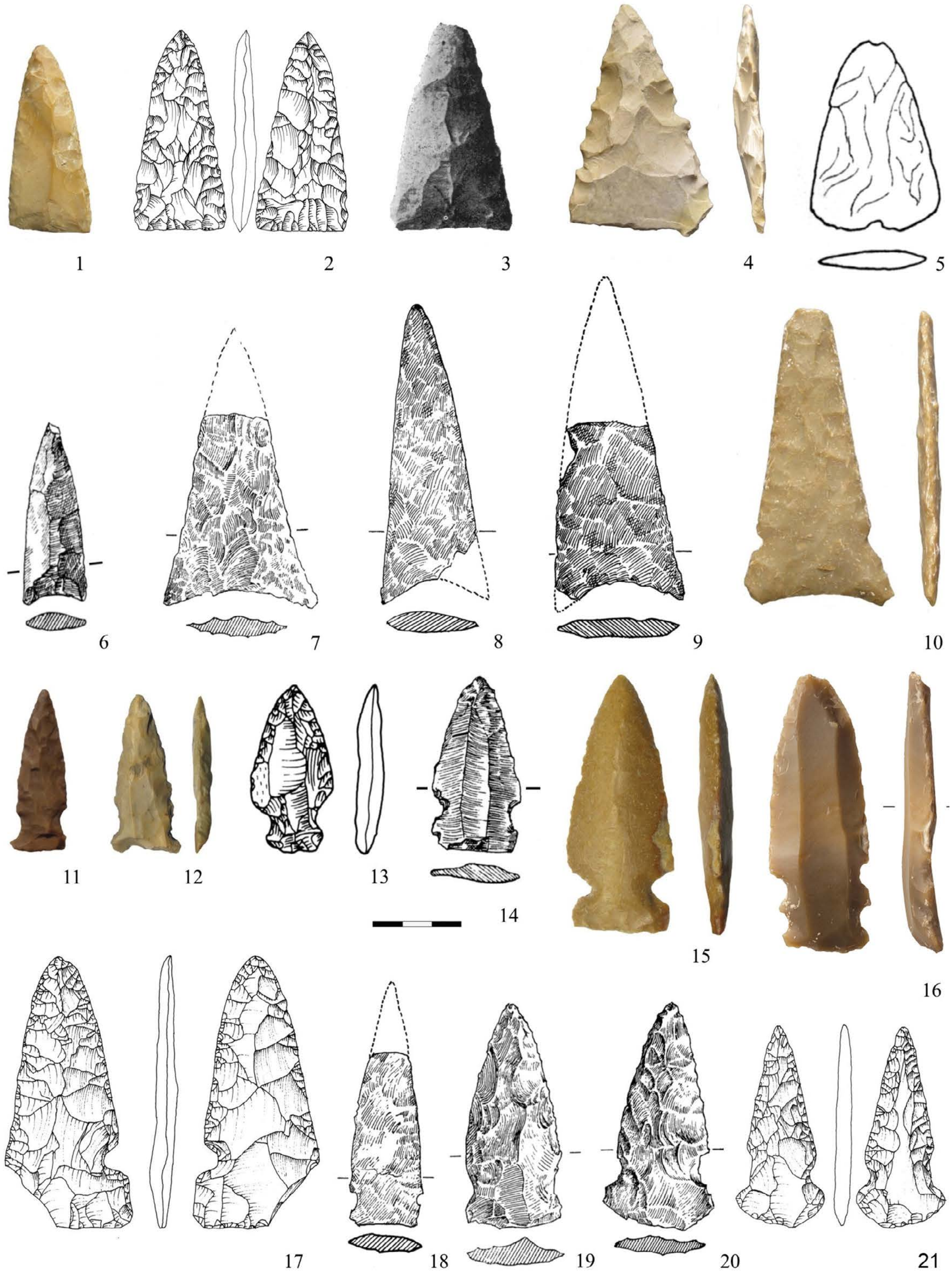

Figure 11. Chipped-stone spearheads. Type I: 1-4; type II: 6-9; type III: 5; type IX: 11-18; type X: 19-21; type XI: 10.

From Tell Polyanitsa (1), Mezdra (2 – Zlateva-Uzunova 2014: fig. 2: 12), Zaminets (3 – Nikolov 1975: fig. 12), Tell Smyadovo (4, 10), Tell Golyamo Delchevo (5 – Todorova et al. *1975: 211 – table 99: 22), Tell Ruse (6-9, 18-20 – Georgiev and Angelov 1957: 63 – fig. 24; 14 – Georgiev and Angelov 1952: 126 – fig. 94: 1), Tell Durankulak (11-13, 15, 16; 13 – Todorova 1986: 155 – fig.78: 3; 16 – Vaysov and Slavchev 2017: 83 – fig. 2), Tell Nevski (17 – drawing S. Taneva), Tell Zavet (21 – drawing S. Taneva). Photos K. Boyadzhiev, if not specified.*

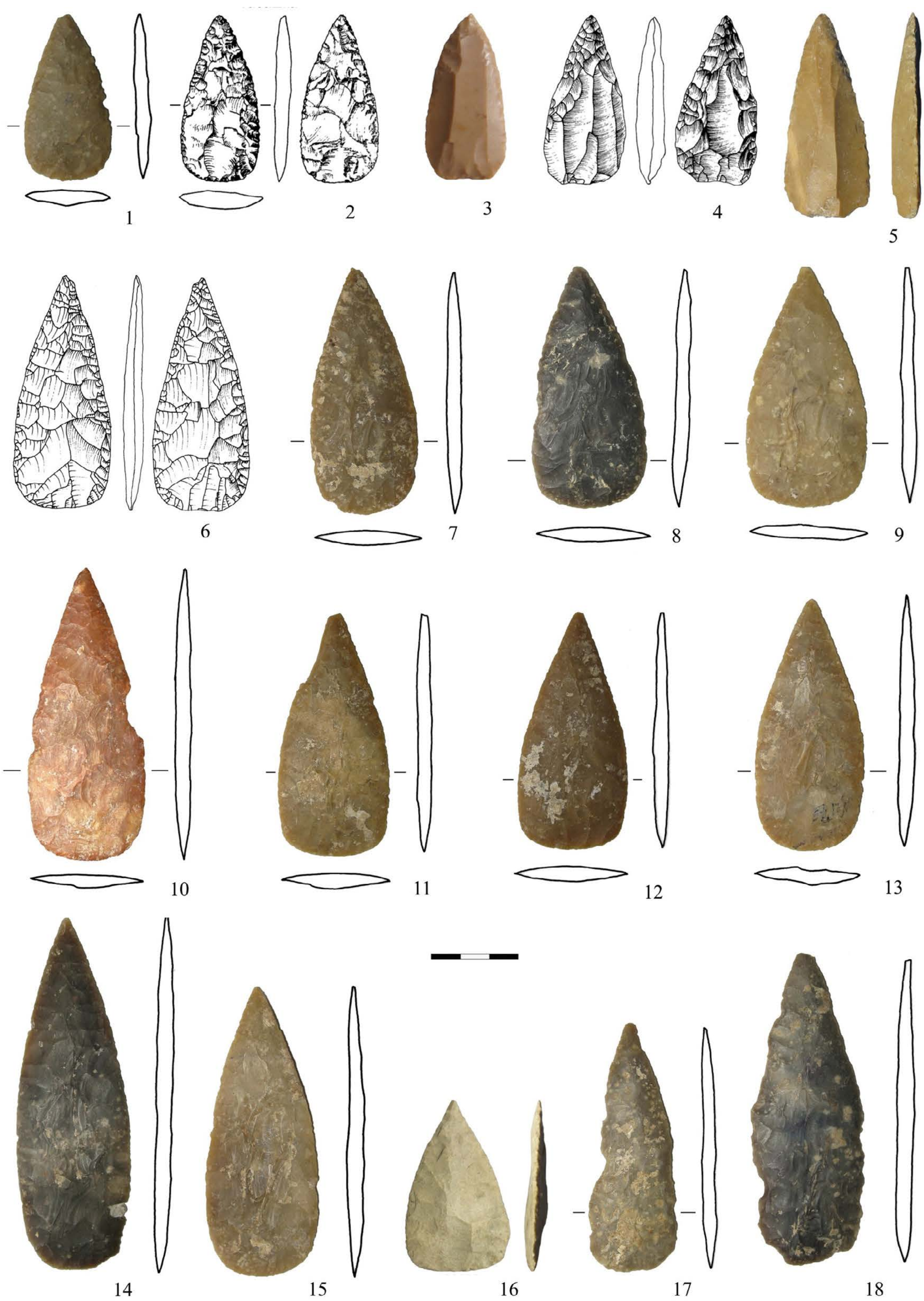

Figure 12. Chipped-stone spearheads, type IV.

From Devetashka cave (1, 6 – drawing S. Taneva, 17), Tabashka cave (2 – Dzhambazov 1963: 228, 229 – fig. 29: г), Durankulak (3-5; 4 – Sirakov 2002: 244 – Fig. 14: 6), Leshnitsa (7-9, 18), Hlevene (10), Smochan (11-13), Goznitsa (14-15), Tell Starozagorski Mineralni Bani (16). Photos K. Boyadzhiev, if not specified.

- Type XIII (Figure 14: 7): Tanged spearhead. The distal part is triangular, with straight edges. The tang is almost rectangular. The type is presented by just one artefact (from Tell Durankulak), and its function (as spearhead or arrowhead) is unsure. It weighs 11 g and is 5.9 cm long, but about 1/3 of it is the tang.

Most of the types of spearheads are identical with arrowheads types. However, some differences are visible. The "simplest" types (with straight edges and no notches: I-III), which are most numerous among the arrowheads (almost 60%) cover just about 13% of the spearheads. The types with convex lateral edges are best represented among the spearheads: almost 60%. The leader is type IV, which includes 30% of all spearheads analysed. Another difference is the high percentage (about 20%) of points with side-notches (types IX-XII). These points were typical for spears (probably for better attachment of the heavier point to the shaft) and were used on arrows as an exception.

The artefacts in most of the types are not uniform in dimensions. The largest variety is attested in type IV, where the length of the spearheads varies from 5.2 to 12.7 cm, and the weight – from 10 to 34 g. However, the artefacts in collective finds are usually similar in size.

About 85% of the flint spearheads are bifaces. Most of the points made on blades come from Tell Durankulak.

The analysis of the finding context shows an almost complete lack of flint spearheads in cemeteries. Two artefacts were found in the Varna I cemetery, in graves 43 (adult male) and 97 (cenotaph) (Figure 13: 16; Ivanov and Avramova 1997: 44), and one in grave 597 (adult male) at Durankulak (Figure 12: 4; Todorova *et al.* 2002, 108). The points from Varna I were found in the northeast corner of the grave, together with a copper spearhead. The position suggests that they were attached to long wooden shafts. The position in the grave from Durankulak is different – close to the pelvis, similar to that of the flint arrowheads from the cemetery. It either had a short shaft, or, for unknown reasons, only the point was placed in the grave.

A concentration of stray collective finds in the Lovech region is noticeable – in the town itself and the villages of Leshnitsa, Smochan (Petrov 1950), Goznitsa and Hlevene (Mikov 1933: 39, 47). In some of them about a hundred of spear- and arrowheads, blades and scrapers were attested, unfortunately without precise information (Petrov 1950, 213). The author's observations on the available artefacts reveal that the projectile points are very similar to finds from Devetashka and Tabashka caves, in the same region (compare Figure 12: 7–15, 18 and Figure 12: 1, 2, 6, 17; Dzhambazov 1963: 228, 229 – Figure 29: g; Mikov and Dzhambazov 1960: 58 – Figure 41: n), and may be dated in the Chalcolithic, as well. This also suggests the presence of a local production centre.

Copper spearheads

Four copper artefacts from the Late Chalcolithic are defined in the literature as spearheads. Three of them share similar morphological and metrical features (Figure 15: 1–3). The front part is widened (leaf-shaped or rhomboid), ending in a piercing point; the tang is long and thin; the total length is between 26 and 33 cm. Two of them were found in the Varna I cemetery, graves No 43 and 97 (Dimitrov 2007: 122; Ivanov and Avramova 1997: 44, 46), and the third one is part of a stray find from the city of Varna, known as "Second grave 43" (Dimitrov 2007: 141). Their function as weapons is confirmed both by the specific morpho-metrical features and the finding context of the Varna I artefacts. They were placed in the northeast part of the graves, parallel to their axis, together with a flint spearhead. The position suggests they had long wooden shafts, up to 2.5 m at the most (according to the length of the grave-pit).

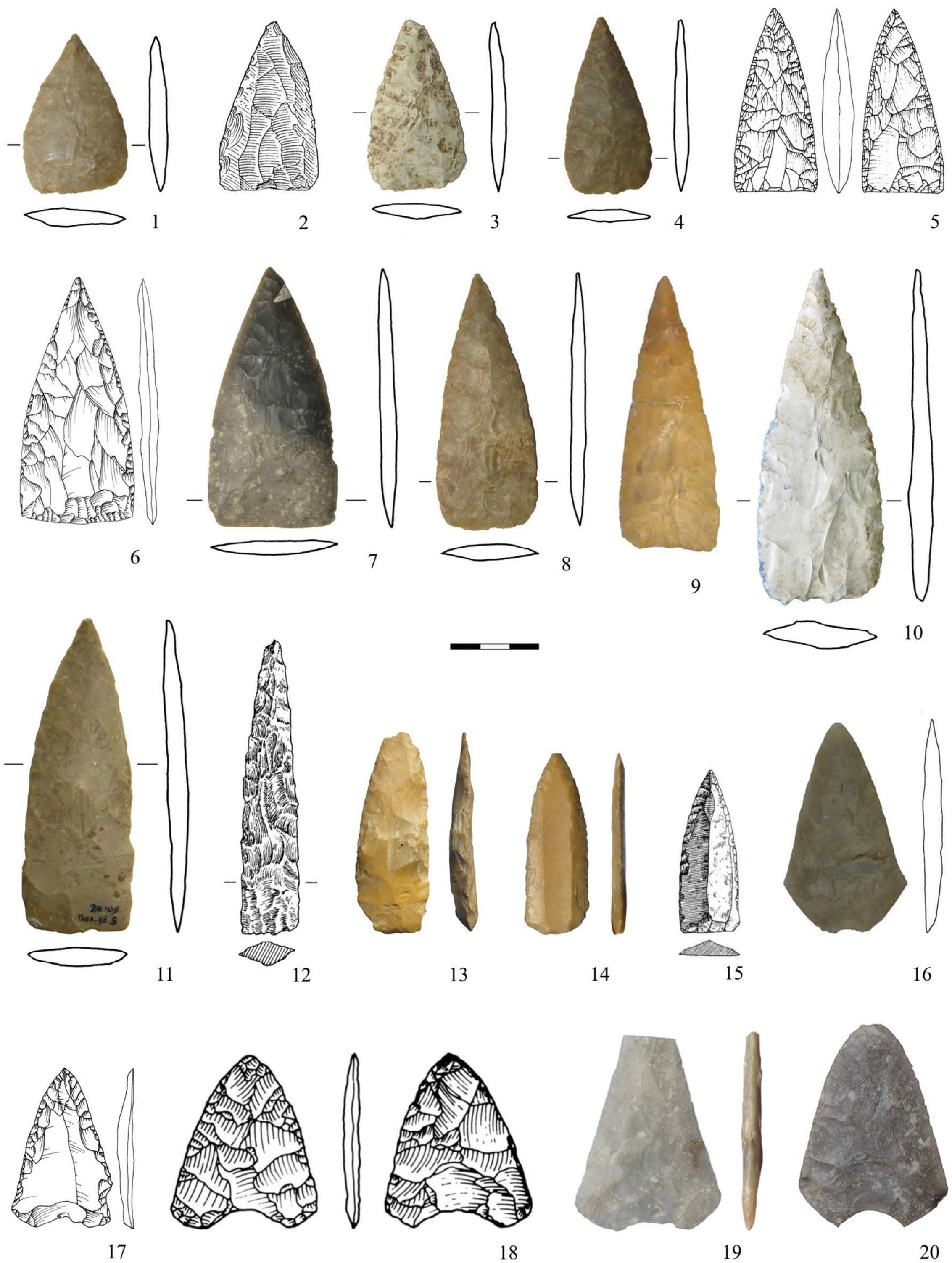

Figure 13. Chipped-stone spearheads. Type V: 1-10; type VI: 11-15; type VII: 16; type VIII: 17-20.

From Devetashka cave (1, 3, 10, 11), Tell Deve-bargan (2 – Popov P. 1926: 75 – fig. 128: A), Leshnitsa (4, 7, 8), Tell Zavet (5 – drawing S. Taneva), Mezdra (6, 17 – Zlateva-Uzunova 2014: fig. 2: 1, 2), Tell Karanovo (9), Tell Ruse (12 – Georgiev and Angelov 1957: 63 – fig. 24: 4), Tell Polyanitsa (13), Tell Kodzhadermen (15 – Popov 1916-18: 80 – fig. 62), Varna I cemetery (16), Tell Durankulak (14, 19; 18 – Todorova 1986: 155 – fig. 78: 4), Tell Targovishte-Garata (20 – Bachvarov and Leshtakov 2011: 15 – not to scale). Photos K. Boyadzhiev, if not specified.

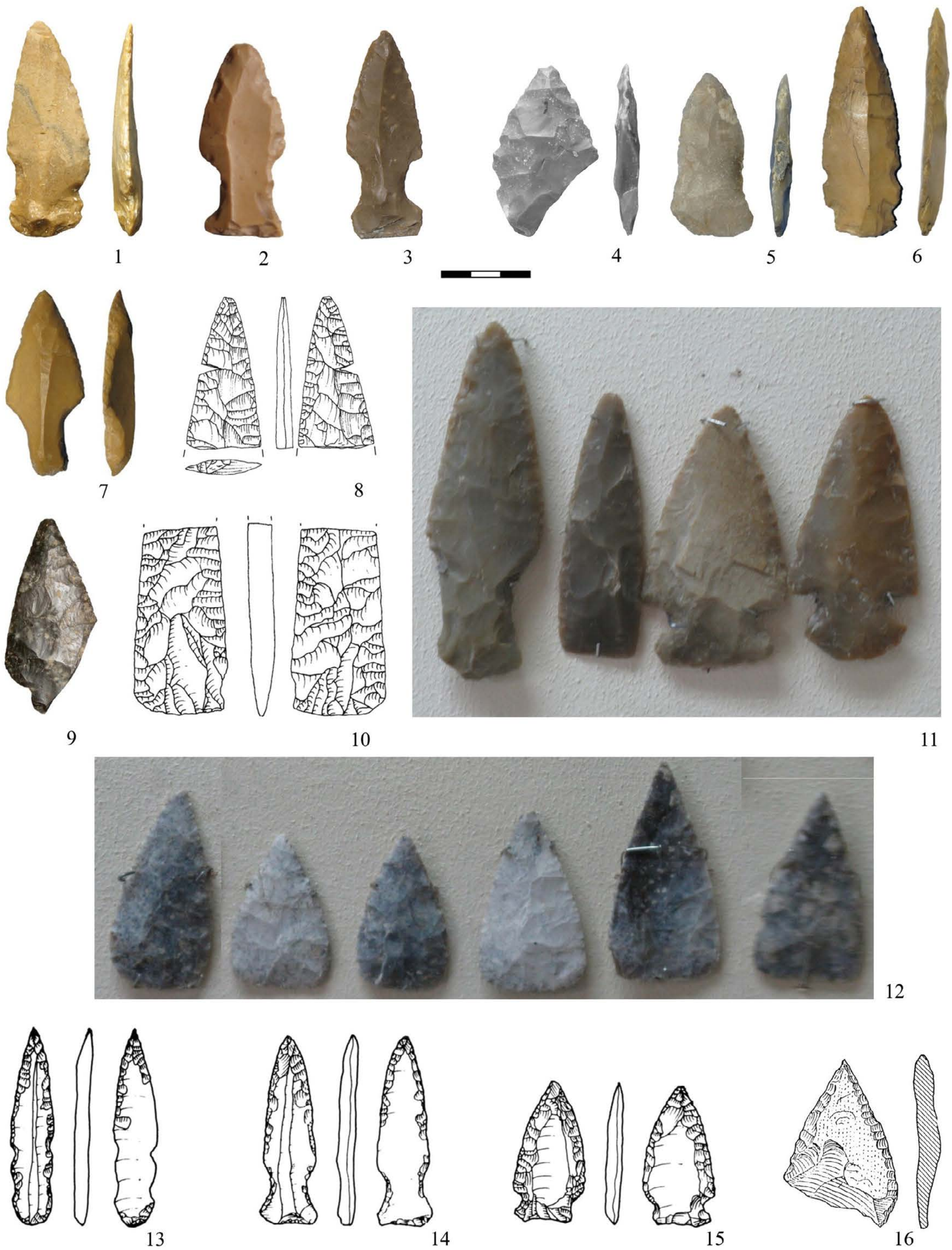

Figure 14. Chipped-stone spearheads. Type XII: 1-3; type XIII: 7; fragmented spearheads: 4, 8-10; collective find of spearheads from Stan, Shumen region: 12; projectile points (not to scale): 13-16.

From Tell Smyadovo (1), Tell Durankulak (2, 5-7; 13-15 – Todorova 1986: 138 – fig. 54), Tell Targovishte-Garata (3 – Bachvarov and Leshtakov 2011: 15 – not to scale), Tell Kodzhadermen (4), Tell Hotnitsa (8 – Chohadzhiev and Chohadzhiev 2009: 85 – fig. 3: 1), Tell Starozagorski Mineralni Bani (9), Tell Azmashka (10 – Gatsov 2009: 45, Fig. 27: 3), Tell Smyadovo and Tell Vinitsa (11 – in the exhibition of the Regional Museum of History – Shumen), Tell Karanovo (16 – Vutiropulos 1991: 76, Tafel XIII: 1). Photos K. Boyadzhiev, if not specified.

Based on the weight, shape and valuable material of these weapons, they may be considered as pikes rather than javelins (Dimitrov 2007: 122).

The fourth artefact was found in the Peklyuk settlement, western Bulgaria (Krivodol culture; Petkov 1963: 82). It differs significantly from the other three and is closer to the bone arrowheads of type I (Figure 15: 4). The tip is not sharp but rounded, which distinguishes it from the double-pointed copper "awls". It does not seem too practical for a spear either. The function of the find is uncertain.

Bone spearheads

Finds of bone or antler "spearheads" are mentioned in the publications of a number of Chalcolithic sites in Bulgaria. Mostly, these are artefacts with a sharp point and a butt end, which is the epiphysis of the bone (sometimes smoothed). This shape of the proximal part hampers the secure fixing of the point to a shaft, but offers good support to grip and push with a hand. The tip is sharp and usually well-preserved. In my opinion, the use of such artefacts as spearheads is too questionable.

This function is more probable for objects with thinned proximal part. Finds of similar points with partially preserved shafts from Neolithic sites in the Swiss lakes (Ramseyer 1985: 197, 208 – Figure 10: 3, 209 – Figure 11) offer possible evidence for such interpretation. However, there are just a few published

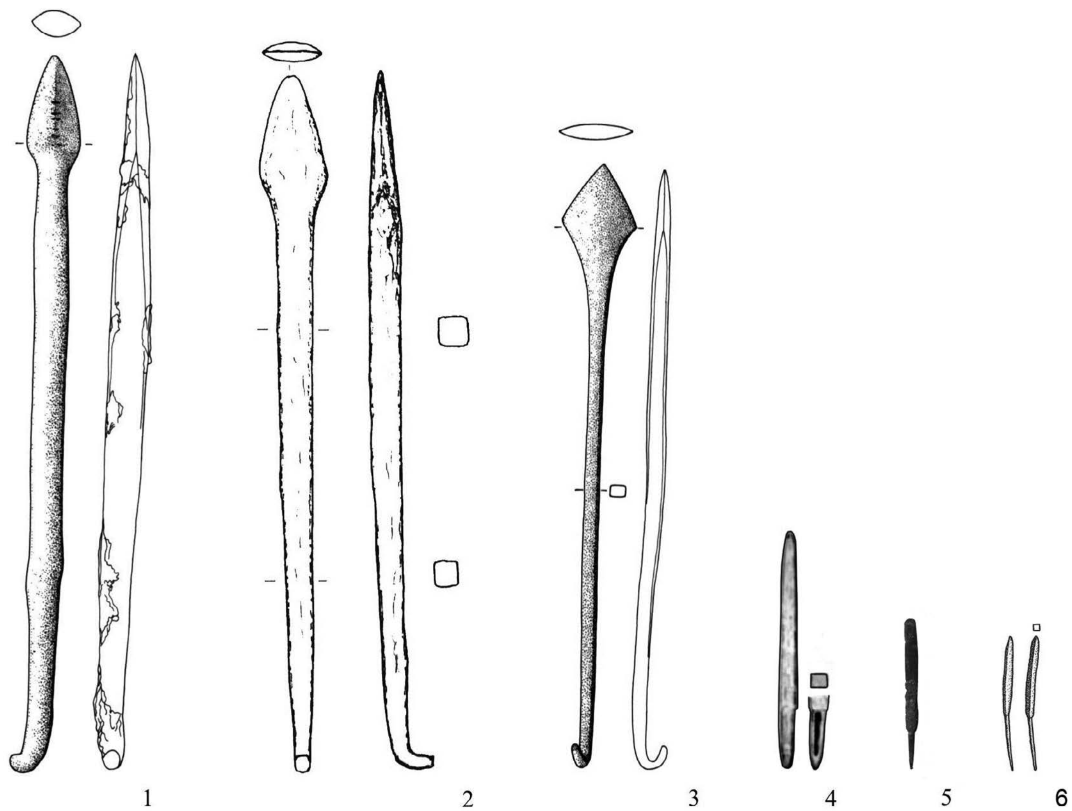

Figure 15. Copper spearheads: 1-4; copper arrowheads (?): 5, 6.

From the Varna I cemetery (1, 3 – Todorova 1981, Tafel 18: 201, 202), the so-called "Second grave 43" in Varna (2 – Dimitrov 2007), Peklyuk (4 – Petkov 1963: 181 – fig. 3p), Tell Yunatsite (5 – photo K. Boyadzhiev), Telish-Luga (6 – Merkyte et al. 2005: 108 – Fig. VI: 14).

artefacts of this kind from the Chalcolithic in Bulgaria such as the ones from Tell Zavet (Mikov 1961: 278 – Figure 11: c) and Tell Deve-bargan (Popov 1926: 83 – Figure 141). This impedes further conclusions on their use and distribution.

Development and distribution of projectile points in the Chalcolithic in Bulgaria

The evidence of the use of bows, arrows, and spears during the Neolithic in present-day Bulgaria is extremely scanty. The Early Neolithic record includes just a couple of osseous points from the settlement at Mayor Uzunovo, Vidin region (northwestern Bulgaria) (Figure 4: 20; Ganetsovski 2015: 9, 10 – Figure 12: 1). Their shape differs significantly from the Chalcolithic double points and from Neolithic projectiles from neighbouring regions. However, the specific shape suggests their use as arrowheads. Bone arrowheads are also known from Mesolithic sites in the Iron Gates region on the Danube River (Bonsall 2008: 263-264; Chapman 1999: 106; Roksandić *et al.* 2006: 342, 346) and from some Early Neolithic sites from the Starčevo culture (Vitezović 2012) to the west. It is possible that this was a local phenomenon with Mesolithic routes.

In the Late Neolithic (second half of the 6th millennium BC) flint arrowheads from group B (geometric microliths) appeared as well. The finds are not numerous, but attested in different cultural regions (Gurova 2010: 172 – Fig. 2: 6, 8; 179; Todorova *et al.* 2002).

The absence of projectile points in the Neolithic is surprising since these weapons existed in the Near East – the "homeland" of the first Neolithic communities in the Balkans. Hunting was indeed slightly presented in the Early Neolithic, but its role increased in the Late Neolithic (Karastoyanova 2018: 14 – fig. 6; 19). Surely, people needed weapons for it and the use of slings, especially for hunting large game, does not seem plausible[1]. The lack of evidence of projectiles in the Neolithic may be due not to their real absence but the use of entirely wooden or other archaeologically "invisible" points. Both ethnographic observations and experiments have attested the efficiency of wooden projectile points (Pétrequin and Pétrequin 1990: 489-492; Semenov 1968: 287).

The situation gradually changed in the Chalcolithic. Flint bifacial arrowheads and double-pointed bone arrowheads both appeared in the Early Chalcolithic (first half of the 5th millennium BC), and their spread sharply increased in the Late Chalcolithic. Over 90 % of the finds are dated to the later period. The earliest flint spearheads from Bulgaria belong to the Middle Chalcolithic (mid-5th millennium BC). Most of them date to the Late Chalcolithic when copper spearheads (and arrowheads?) appeared as well.

Some authors suggest that flint arrowheads appeared in modern-day Bulgaria as a result of influence from the Aegean (Vutiropulos 1991: 106). Others propose that the spearheads in Cucuteni-Tripolie, Kodzadermen-Gumelnitsa-Karanovo VI (KGK VI), Varna and Krivodol-Salcutsa-Bubani hum Ia (KSB) cultures spread from the northeast, as an influence by the steppe cultures Sredni Stog II, Novodanilovka and Hvalinsk (Lichardus and Lichardus-Itten 1993).

The available data do not support these hypotheses. Both significant morphological differences between the arrowheads from the Aegean and Bulgaria and the lack of finds from the intermediate territories (eastern Macedonia, southwestern Bulgaria and Aegean Thrace) confute the first idea. There are arguments against the second hypothesis as well. First, the Sredni Stog II, Novodanilovka and Hvalinsk cultures are synchronous with the end of the Chalcolithic in Bulgaria. Second, besides the similarities

[1] According to M. Özdoğan (2002, 442-443) slings replaced bows and arrows in the second phase of the Pottery Neolithic in the Near East.

between the spear points from the northern and western Black Sea coast, certain morphological differences are visible.

The data available so far suggest the local origin of the flint arrowheads in the northern part of the Balkans, and the flint spearheads probably represent a further development of this technology and of projectile weapons. The collective finds from Madara and Lovech region are evidence of local "workshops" in northern Bulgaria.

In the Late Chalcolithic, both distribution and variety of projectile weapons increased significantly. Some regional and cultural specifics are visible. First, they encompass the spread of osseous and chipped-stone points. Bone double points are extremely rare finds in western Bulgaria and the Black Sea coast (Krivodol and Varna cultures; Figure 16), as well as in Greece (see Arabatzis 2016: 12). The vast majority of these artefacts is concentrated in the area of the KGK VI culture, and especially in northeastern Bulgaria and southeastern Romania.

Second, regional specifics in the distribution of different types of flint arrow- and spearheads are observed. In the 5th millennium BC, the geometric microliths are attested only along the Black Sea coast, mainly in the Early and Middle Chalcolithic Hamangia culture (with a single exception known from Tell Yunatsite). The symmetrical points (group A) are attested in all cultural regions. Type I predominates,

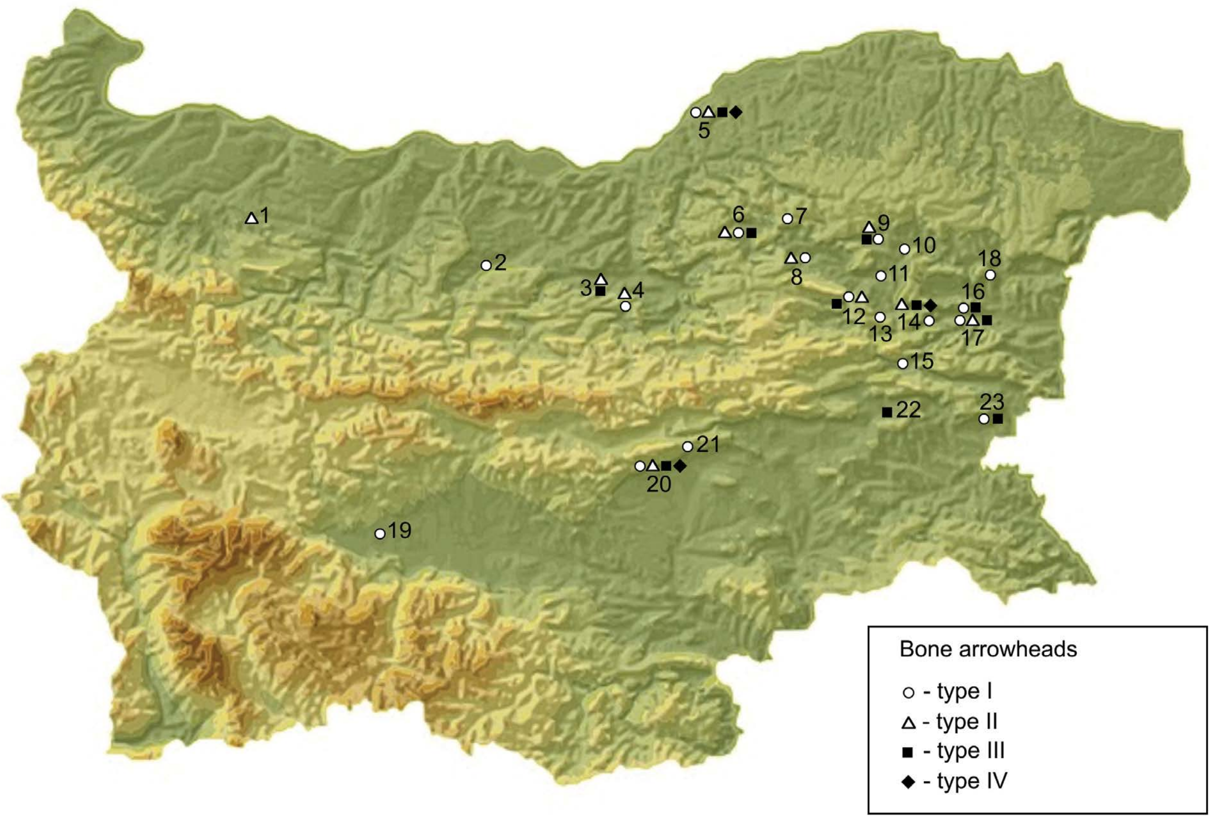

Figure 16. Distribution map of the osseous arrowheads. 1 – Borovan-Ezeroto, 2 – Devetashka cave, 3 – Emenska cave, 4 – Hotnitsa, 5 – Ruse, 6 – Nevski, 7 – Miladinovtsi, 8 – Targovishte, 9 – Kodzhadermen, 10 – Madara, 11 – Salmanovo, 12 – Vinitsa, 13 – Sushina, 14 – Smyadovo, 15 – Zavet, 16 – Sava, 17 – Golyamo Delchevo, 18 – Provadiya-Solnitsata, 19 – Yunastite, 20 – Tell Azmashka, 21 – Karanovo, 22 – Karnobat, 23 – Tell Kozareva.

followed by the types with convex lateral edges (IV-VI). The greatest number and typological variety are recorded in the Late Chalcolithic in northeastern Bulgaria (Figure 17).

The flint spearheads are also most numerous in northeastern Bulgaria (over 45 % of the finds), and the greatest typological variety is observed there (Figure 18). This variety is also large in the Black Sea coast area, but most of the types are presented by singular or very few finds. In northwestern Bulgaria and Thrace types IV and V largely prevail while those with side-notches are lacking. The latter ones are specific for northeastern Bulgaria and the Black Sea coast (KGK VI and Varna cultures).

Types VII and XIII are attested only in the Varna culture. The first type is recorded only in the Varna I cemetery and might be a specific local production. The latter one (presented by one find from Tell Durankulak – Figure 14: 7) suggests influence from the North Pontic steppes (parallels in Klochko 2001: 32 – fig. 6: 9-11; Lichardus and Lichardus-Itten 1993: 48). The arrowhead of type XI, found in the same building level (IV) of the same tell confirms such an influence (Figure 9: 16).

In the sites from the so-called "Transitional period" or "post-Chalcolithic" (early 4th millennium BC) the variety of projectile points decreased to a large extent. Osseous points are not recorded, and just one fragment of a flint spearhead is known (Figure 9: 32; Sirakov, Tsonev 1995: 258 – Figure 2: 7). Flint arrowheads became standard in shapes (mainly type II) and dimensions (Figure 9: 27–31).

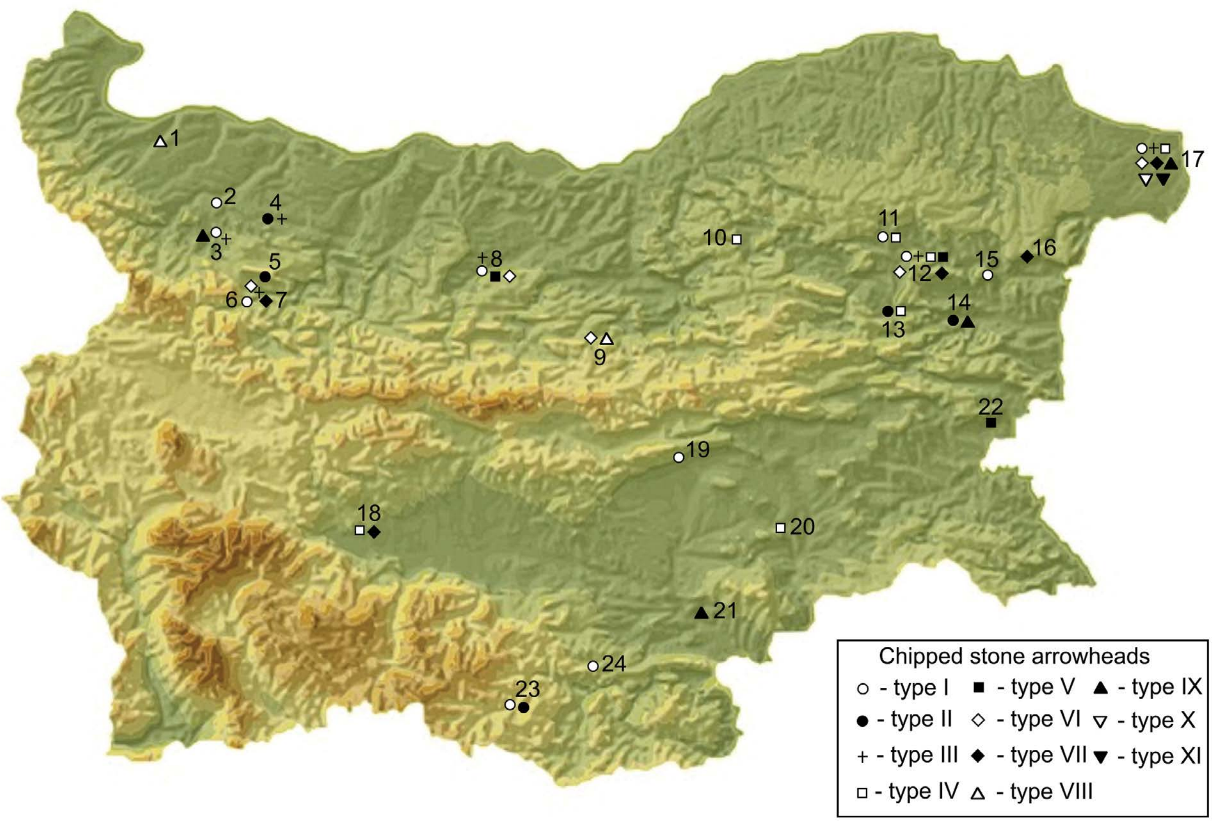

Figure 17. Distribution map of the chipped-stone arrowheads from group A. 1 – Bagachina, 2 – Gradeshnitsa, 3 – Krivodol, 4 – Borovan, 5 – Zaminets, 6 – Rebarkovo, 7 – Mezdra, 8 – Devetashka cave, 9 – Polichki cave, 10 – Nevski, 11 – Kodzhadermen, 12 – Madara, 13 – Smyadovo, 14 – Golyamo Delchevo, 15 – Provadiya-Solnitsata, 16 – Levski, 17 – Durankulak, 18 – Yunatsite, 19 – Karanovo, 20 – Drama-Merdzhumekya, 21 – Dervishov odzhak, 22 – Tell Kozareva, 23 – Adata, 24 – Perperikon.

Notes on the use of arrowheads and spearheads

The spread of arrow- and spearheads in the Chalcolithic and their gradual growth in number show their elaboration and increasing importance. At the same time, the variety of materials used, shapes and dimensions suggest certain specialization and differences in their particular use. Some ethnographic data show differentiation in the use of organic and chipped-stone projectile points depending on the specifics of each material. Organic points (bone, antler or wooden ones) are more durable and more likely to be repaired if broken. Chipped-stone points offer wide cutting edges, which inflict larger wounds and cause intense bleeding (Ellis 1997: 57; Knecht 1997: 206). Thus, some traditional societies prefer organic arrowheads in "everyday" hunt, usually for hunting small animals, and use flint points when larger deadly wounds should be inflicted, i.e., against large game or in battle. Blunt bone or wooden points are designed for hunting small animals with valued fur or birds. Spears are used mainly for hunting large game or in warfare.

It is tempting to suggest that similar differentiation of projectiles existed in the 5th millennium BC in the Balkans. However, we should consider the specifics of the available data. It is important to note the general lack of bone points in western Bulgaria, which presumes different cultural choices. Theoretically, in this region entirely wooden arrows may have been used instead, as the flint projectiles are not too numerous to be regarded as substitute of the osseous ones. Different approaches to their

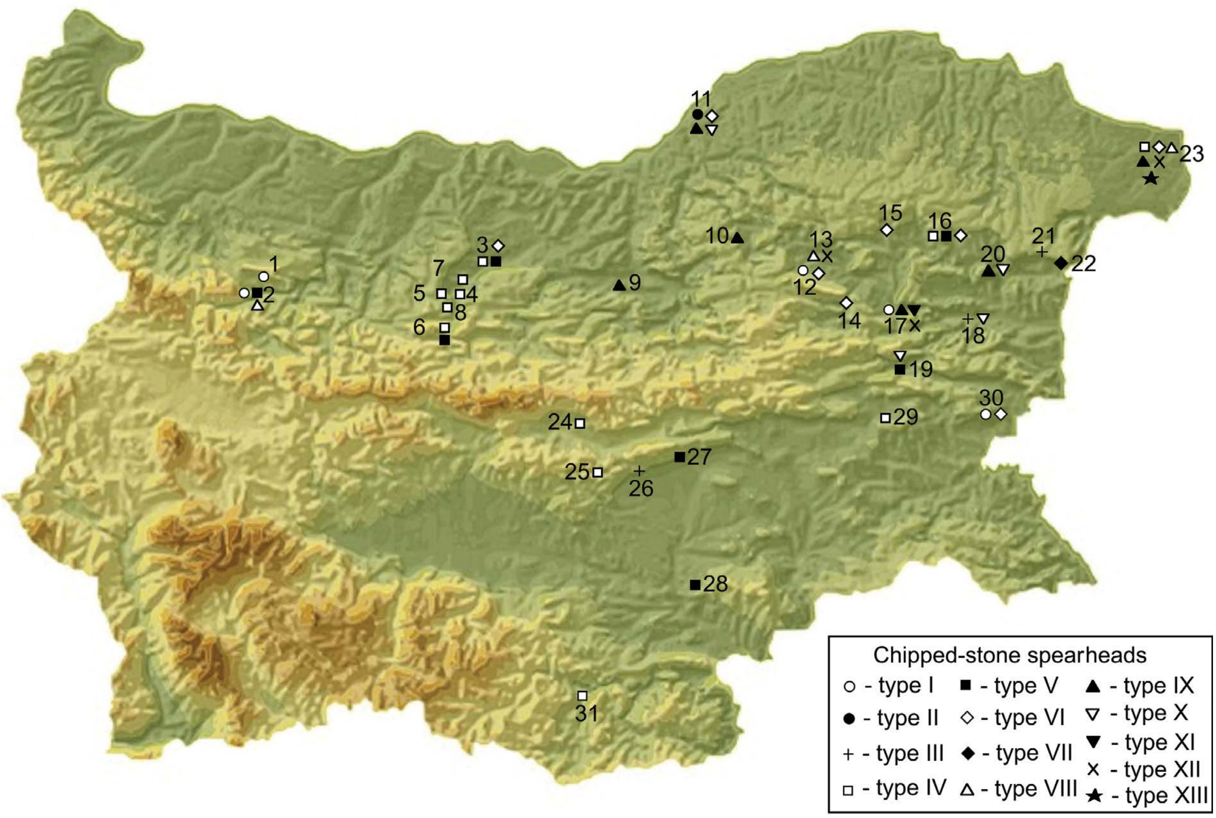

Figure 18. Distribution map of the chipped-stone spearheads. 1 – Zaminets, 2 – Mezdra, 3 – Devetashka cave, 4 – Tabashka cave, 5 – Goznitsa, 6 – Leshnitsa, 7 – Smochan, 8 – Hlevene, 9 – Hotnitsa, 10 – Nevski, 11 – Ruse, 12 – Polyanitsa, 13 – Targovishte, 14 – Vinitsa, 15 – Kodzhadermen, 16 – Stan, 17 – Smyadovo, 18 – Golyamo Delchevo, 19 – Zavet, 20 – Provadiya-Solnitsata, 21 – Levski, 22 – Varna, 23 – Durankulak, 24 – Enina, 25 – Starozagorski Mineralni Bani, 26 – Tell Azmashka, 27 – Karanovo, 28 – Deve-bargan, 29 – Karnobat, 30 – Tell Kozareva, 31 – Varhari.

storage and discard or deposition are also possible, and we should have in mind the smaller number of largely excavated settlements in western Bulgaria compared to the east and the lack of cemeteries known.

On the other hand, bone arrowheads may have also been used against people, which is plausibly the case with the artefact found in the chest of a woman from the Golyamo Delchevo cemetery. Similar cases are attested in the Mesolithic in the Iron Gates (Bonsall 2008: 263–264; Roksandić *et al.* 2006: 342, 346).

Another challenging question is whether the typological variety of flint arrow- and spearheads attested in northeastern Bulgaria reflects some functional differences or different traditions, or even artisans' preferences. There is ethnographic evidence of differentiation between flint-tipped arrows used in hunting and in warfare. However, this differentiation is often related to the hafting (tight or loose, so that the point may remain stuck in the body) or visual details, but not to the morphological specifics of the points. According to A. Christenson's (1997: 39) observations on native North Americans, different types of points (with or without notches in this case) do not reflect universal functional difference. A study on flint points found embedded in human skeletons in the Neolithic of France shows the use of points with different shapes and dimensions (Dias-Meirincho 2008).

At this point, the archaeological record for the Chalcolithic in Bulgaria does not provide information for functional differentiation among the flint projectile points types. However, there is evidence that both flint and osseous points were used against people. As already mentioned, one flint arrowhead was found embedded in human vertebrae in the cemetery of Tell Provadia-Solnitsata, and a bone double point was attested in a woman's chest in the cemetery of Tell Golyamo Delchevo. The high concentration of bone and flint projectile points discovered together with human remains around the Late Chalcolithic fortification wall of Tell Provadia-Solnitsata also suggests that both kinds were used in warfare. Brief journal information mentions more than 500 points (Milcheva 2019: 50). It is important to note that the site is just in the contact zone between the KGK VI and Varna cultures. At Tell Ruse, a concentration of flint spearheads, usually with broken tips, was attested in three Late Chalcolithic levels together with skeletal remains (some of them with violent traumas) and burnt building debris (Georgiev and Angelov 1957: 59, tab. 1). These data fit well into a broader scope of evidence of armed conflicts during the Middle and Late Chalcolithic in northeastern Bulgaria (Boyadzhiev 2016).

The analysis of the role of hunting in the Chalcolithic may provide indirect evidence of the use of projectile points. There is an increase of wild animals from the Early to Late Neolithic, which coincides with the appearance of flint arrowheads (geometric microliths) in the later period. However, no significant difference in the domestic/wild animals ratio is attested either between Late Neolithic and Chalcolithic in general or between Early, Middle and Late Chalcolithic (Vasilev 1982: 303–304; Karastoyanova 2018: 14, 16, 19). The situation is rather site-specific and in some tell-sites the percentage of wild game is high throughout the 5th millennium BC, while in others it is much lower and in few cases even slightly decreases in the Late Chalcolithic (Karastoyanova 2018: 14 – fig. 6). There is no visible tendency in changing the game hunted, as well. Red deer, roe deer, wild boar and hare predominate (Karastoyanova 2018: 16 – fig. 8). The zoological record does not provide secure evidence of a direct connection between the increased use of projectile points and hunting in the Chalcolithic, and especially in the Late Chalcolithic. Thus, the vast spread of arrow- and spearheads in the second half of the 5th millennium BC may reflect the need for combat weapons as well.

Conclusions

Projectile points are almost completely absent in the archaeological record from the Neolithic in modern-day Bulgaria. Their number, distribution and variety largely increased in the Chalcolithic, and especially in the second half of the 5th millennium BC. Although they are usually not numerous, projectile points are found in most of the excavated Late Chalcolithic settlements.

The analysis suggests a local development, with arrowheads preceding the appearance of spearheads. At this point, just a few chronological tendencies related to their morpho-metrical specifics are attested. During the Late Neolithic, only flint geometric microliths are recorded, and they gradually disappeared in the Chalcolithic. In the so-called "Transitional period" or "post-Chalcolithic", after the collapse of the Late Chalcolithic cultures, the typological variety decreased and mainly type II flint arrowheads were used.

During the Middle and Late Chalcolithic, a great variety of projectile points is observed. The analysis allows us to outline some cultural specifics in their distribution. Osseous arrowheads and some types of flint points are typical of KGK VI culture and especially for the region of northeastern Bulgaria.

Hypothetically, the variety of materials and shapes may reflect not only cultural choices but also some differences in the use of the weapons – for hunting different game and/or for warfare. However, the available material do not provide sure evidence for this. Some finds suggest that both chipped-stone and osseous projectile points were used in armed conflicts, too. Analysis of other data for warfare and the zoological record allow speculating that the large increase of arrow- and spearheads in the second half of the 5th millennium BC reflects the need for combat weapons.

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Harpoons from the tell-settlement of Căscioarele-Ostrovel (Romania): A technological and functional analysis

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Abstract

Tell-settlement from Căscioarele-Ostrovel is located in the south of Romania, here being identified three main cultural levels (c. 5200-3900 cal BC): the first chronologically framed Boian culture and the other two contemporary with the Gumelnița culture. For our study, both Gumelnița levels are of interest. In the Gumelnița settlements, located along the Danube or along other important rivers, the harpoon was an artefact which was continuously present illustrating the relationship of these communities with the aquatic resources in order to obtain their food. The analysed assemblage consists of 70 harpoons, most being fragmented. These were made exclusively from *Cervus elaphus* antler. In the case of some of the items, we identified a repair/recycling procedure, without however being a systematic preoccupation in this regard by the members of the community. This study aims to reconstruct the technological scheme for transforming the red deer antler to obtain the finished pieces, as well as identification of use-wear marks what could give us information on how these harpoons were used.

Keywords: Gumelnița culture; Antler; Harpoons; Technical transformation scheme; Repair/Recycling procedure; Use-wear marks; Functional hypotheses

Introduction

The Eneolithic tell-settlement from Căscioarele-Ostrovel (Călărași county) was located on an island of Cătălui Lake. It was situated in a bay guarded by three parts of the high slopes of the Danube terrace, its size being 57x103 m (Marinescu-Bîlcu 2001). The first archaeological researches were carried out in 1925, by Gh. Ștefan (1925), who identified the existence of two cultural levels, which the author placed at the end of the Neolithic and in the period of transition to the Bronze Age. The archaeological investigations were continued by a team led by Vl. Dumitrescu and were conducted between 1962 and 1968 (Dumitrescu 1965, 1986). The mentioned archaeologist has published the existence of three main levels: layer I - between 4.20-5 m - attributed to the Spanțov phase of the Boian culture; layer II - between 2.60-3 m - attributed to the Gumelnița culture, phase A2; layer III - between 0.40-0.70 cm - assigned to the Gumelnița culture, phase B1.

The tell-settlement from Căscioarele-Ostrovel had an area of about 3400 sqm used, in the late phase of the Gumelnița culture. 16 dwellings and an annex were inventoried. S. Marinescu-Bîlcu (2001, 2002) argues that, considering the orientation of the houses, not all the constructions were contemporary, an opinion supported also by other specialists (Ilie 2016). Interestingly, from the data published by Vl. Dumitrescu (1965), some dwellings seem to have specialized functions, responding to the needs of the community within the settlement such as dwelling no. 2, which seems to have been the place of a flint processing workshop, while 100 weights of clay were discovered in house no. 4, which could come from several looms.

House no. 8 seemed also to have a specialized function: it contained osteological remains among with red deer antlers (some of them turned into artifacts). According to Alexandra Bolomey's conclusions (Marinescu-Bîlcu 2002) here must have been the "abattoir" of the settlement. The large number of vessels - over 20 could serve for the chopping and sharing of meat products. Vl. Dumitrescu (1965) assumed another function for this house, the one for the antler processing workshop, because red deer antlers in various processing stages were identified here, out of which four finished pieces are mentioned. According to our analysis, from this house come 7 finished harpoons in various stages of fragmentation, next to a preform what is in the first stages of processing. Other types of antler tools are also present: bevelled tools - 7 pieces processed from all the elements of the branch (from the basal area of the shed antlers to the tines); pointed tools (including arrowheads) - 10 items; preforms - 5 items; blanks - 1 item. It is difficult to determine whether in this case we could speak of a place for processing the antler or it is about a specific toolkit for each family within the community of Căscioarele.

For this tell-settlement, a series of radiocarbon dates were published and they are summarized in Table 1.

TABLE 1. AMS ^{14}C RADIOCARBON DATES RELATED TO CULTURAL LEVELS FROM CĂSCIOARELE-OSTROVEL SITE

Cultural level	**14C date (BP)**	**2 σ calibrated (cal. BC)**	**References**
Boian	6100±**35**	5207-4909	Lazăr *et al.* 2013
	5780±**65**	4786-4488	Bréhard, Bălășescu 2012
Gumelnița	5500±**40**	4450-4264	Lazăr *et al.* 2018
	5450±**35**	4353-4246	Lazăr *et al.* 2018

Gh. Ștefan (1925) mentioned the discovery of 24 whole and fragmented harpoons. He said that the bone was also used to make small items but we did not identify this raw material. Moreover, being discovered and a preform, he provided information on the technological stages of processing harpoons. Instead, Vl. Dumitrescu does not seem to have shown interest in these types of pieces, so he said that "many" harpoons were discovered (1965: 227). The assemblage from our study consists of 18 pieces assigned to the Gumelnița A2 level and 52 pieces attributed to the Gumelnița B1 level what are in various stages of processing. According to the archaeological data, they come from the excavations carried out by Vl. Dumitrescu. We tried to link the harpoons to one of the three archaeological levels, the only reference being the altimetric data inscribed on the pieces. Thus, the pieces were classified in one of the two levels Gumelnița, obviously, with the necessary reserves. We have not identified any items that can be attributed to the Boian level.

In the Gumelniţa settlements, located along the Danube or along other important rivers, the harpoon was an artefact what was continuously present illustrating the relationship of these communities with the aquatic resources. Archaeozoological data indicate fishing as an important source of subsistence activities in the Gumelniţa tell-settlements. For the site of Căscioarele we do not have a clear picture on the weight of fishing in the community food, because no detailed data have been published. However, the presence of fish remains was reported, for example in house no. 8, with 17 bones (Bolomey 1964). On the other hand, in other tell-settlements, such as the one from Hârșova, ichthyological studies were carried out that highlighted the presence of the remains from 19 species of fish, the dimensions of the fished specimens being generally large and very large (Bălășescu *et al.* 2005: 213-214).

Harpoons found in the Gumelnița sites from the north of the Danube were inventoried in a paper published by E. Comșa (1986). For the tell-settlement of Gumelniţa, there is mentioned a unilateral harpoon with two barbs and 7 bilateral harpoons, having varied morphologies of barbs (Dumitrescu 1924, 1925). We can also mention the two preforms of harpoons from Cuneşti (Călăraşi county) (Mărgărit *et al.* 2013), six harpoons from Vărăşti (Călăraşi county) (Comşa 1986), two harpoons from Măriuța (Mărgărit *et al.* 2014) or the harpoon from Tangâru (Berciu 1935). Gumelnița culture also includes harpoons from the settlements at Pietrele (Toderaș *et al.* 2009; Benecke *et al.* 2013), Luncaviţa (Micu and Maillé 2006) or the 22 harpoons, of what two can be considered preforms coming from the settlement of Bordușani-Popină (Mărgărit *et al.* 2010). In the tell-settlement of Hârşova we identified 19 finished harpoons, to which is added a piece that is being processed (Mărgărit and Popovici 2011).

Raw material

All specimens from the tell-settlement of Căscioarele-Ostrovel were made from red deer antlers. Obviously, we cannot neglect the importance of the cultural factor in the selection of raw material (Choyke and Daróczi-Szabó 2010; Margaris 2014) but most often, at least for prehistory, there is no a binary distinction between the cultural and the technological option. At the technological level, we can invoke the mechanical properties of the antler – an optimal elasticity/hardness ratio, which better absorbs shocks, thus making it resistant to impact. Then, the pieces made of hard animal materials can be more easily repaired after fracturing and, finally, anatomical constraints of material: in this case, a larger blank was needed as a preform of the future harpoon and antler could provide such debitage blanks (Averbouh 2000; Currey 2002; Christensen 2004; Guthrie 1983; Grégor 1985).

Cervid antler can be obtained by gathering or as a by-product from hunting. At Căscioarele, B1 level, the hunting is attested by the high number of wild mammals remains (Bolomey 1964), what reach 84.1% (Bălășescu *et al.* 2005: 220), from the faunal assemblage. Red deer was the main hunted mammal (Bălășescu *et al.* 2005. Fig. 102). A. Bolomey (1964, 1968) notes that deer remains make up more than 1/2 of the total osteological material, mentioning 1193 fragments from Gumelnița B1 level. The situation seems radically different in the Gumelnița A2 level. The predominance of domestic animals is attested, the red deer being present with only 84 fragments (Bolomey 1968). This different ratio between the two archaeological levels related to raw quantities of faunal remains is also reflected at the technological level, because the number of harpoons (the type of artifact analysed in this study) is much higher in the B1 level.

Counting the antler basal areas (the only ones that can give us information on the type of antler used), the situation is as follows: 32 shed antlers in B1 level (Figure 1a) and 16 shed antlers in A2 level. More interesting are the statistics related to the antlers from hunted red deer. Starting from the archaeozoological studies, we would have expected that such antlers would be much less numerous in the A2 level. Or, out of 14 antlers from hunted animals: 8 come from the B1 level and 6 come from the

Figure 1. a. shed antlers (Gumelnița B1 level); b. antlers from a hunted animal (Gumelnița A2 level); c. blank in volume; d. flat blank; e. sawing with abrasive fiber; f, g. percussion marks.

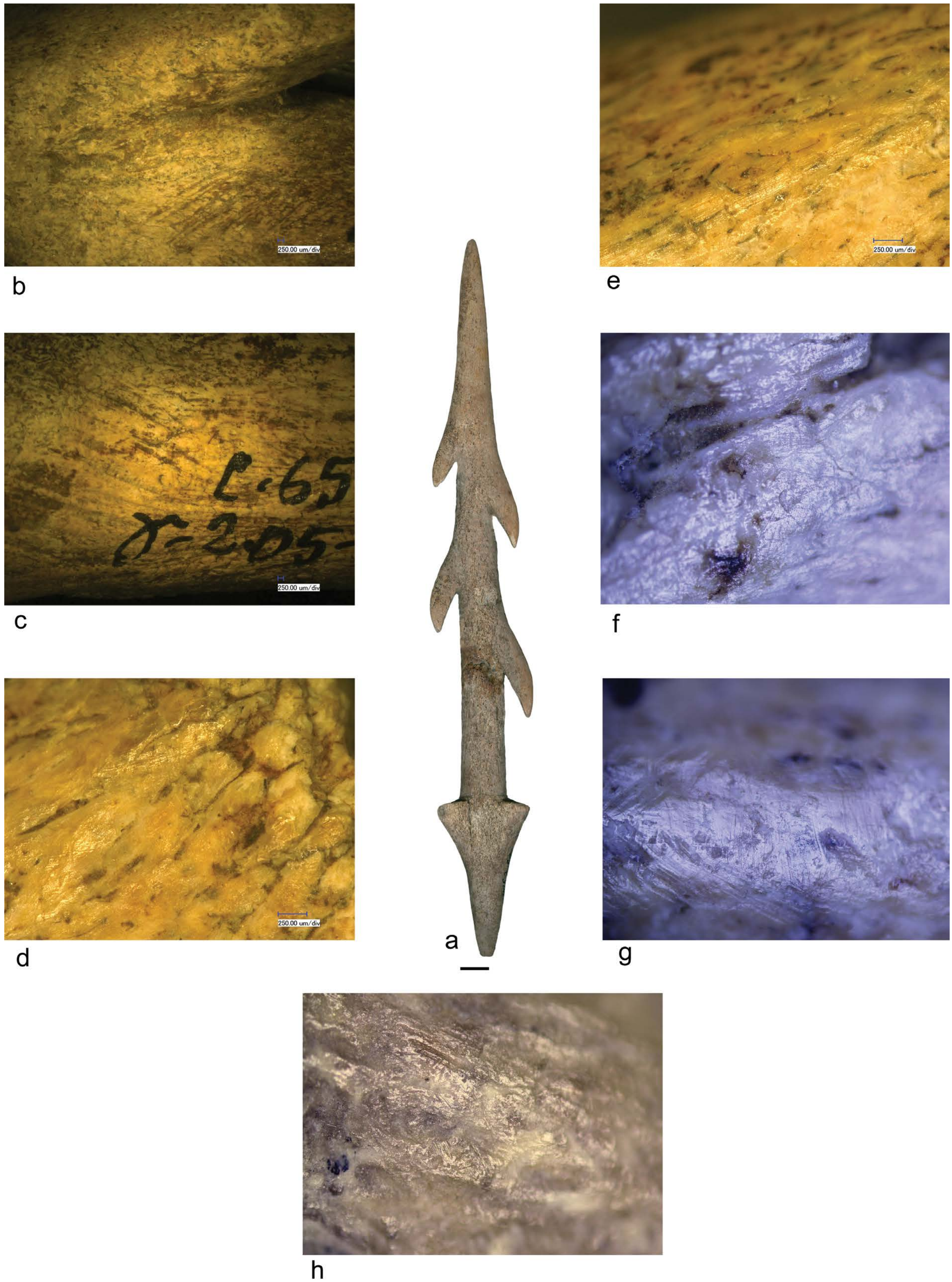

Figure 2. a. harpoon with convex barbs (Gumelnița A2 level); b. sawing marks; c. scraping marks; d, f. use-wear at proximal end; e, h. use-wear at distal end; g. use-wear at barbs level.

A2 level. Furthermore, all items from A2 level are hammers (Figure 1b) while these hammers are absent in the B1 level. We wonder if we can't see in the disappearance of these hammers a change in material procurement strategy? At the archaeological level, however, it is quite difficult to prove it and we can only make assumptions.

According to experts, shed antler is more suitable for manufacturing; as it is at its maximum growth, the area of cross-sections with compact tissue (used for processing) being much wider (Averbouh 2000; Goutas 2004). In the studied assemblage, we identified 48 shed antlers, out of the total of 62 basal areas. The predominance of the shed antlers as a raw material illustrates a good knowledge of the mechanical properties of the antler. The antler grows from April until July (when it reaches maximum calcification) and falls at the end of the winter (in March for adult specimens) (Provenzano 2001). It is attacked by rodents, carnivores, even red deer, then by invertebrates, shortly after it falls (Averbouh 2000, 2005; van Gijn 2007). At Căscioarele settlement, the presence of shed antlers implies that expeditions with the aim of gathering the antlers were organized close to the settlement a short time after the deer lost its antlers. Two arguments support this hypothesis: on the one side, the zooarchaeological studies (Bolomey 1968; Bălășescu *et al.* 2005) which highlighted the presence of red deer (*Cervus elaphus*) among the fauna present in the surroundings of the sites, and on the other the fact that the antlers waste recovered from the settlement presents a very good state of preservation.

The archaeological assemblage is a special one for specialists, because it contains antlers in different stages of processing, including waste and blanks, whose external surface has not been technologically transformed. This allowed us an examination of the surfaces, to distinguish those alterations of a taphonomic nature. The physico-chemical actions produced by the alternation of temperature and humidity (hot/cold; wet/dry), what would have been intense and successive if the antlers had been on the ground for a long time - affect the fibrous structure of the deer antler, leading to progressive damage: cracks, fissures, even holes, which will lead to gradual exfoliation, until dissolution (Morel and Müller 1997). Also, following long contact with the ground, the antlers would have suffered the action of other natural agents: the roots - recognizable by the grooves in the external layer of the antler or invertebrates - which dig real tunnels even in depth (Morel 1986). They could also be eaten by different mammals, which would have produced on the surface multiple depressions, very close to each other or overlapping, which would have given the imprint of those teeth. There are no exfoliation marks, cracks or grooves on the surface of the analysed antlers and this is the raison why we assume the organisation of gathering expeditions, a little while after the red deer lost its antlers. We have already highlighted the particular resistance of antler weapons and tools, so renewal of the set of objects was done quite rarely and that expeditions were not very frequent.

Archaeological assemblage

Morphological criteria of establishing the various types of harpoons are quite numerous, but no functional variety could be deduced from this typology. In these conditions, we have established the typological categories, depending on the morphology of the barbs: convex, straight and sharp.

Gumelnița A2 level

Six harpoons with convex barbs were inventoried. All items were made on the beam. Only one specimen is entirety preserved (Figure 2a). The barbs, in number of four, are asymmetrically arranged two by two,

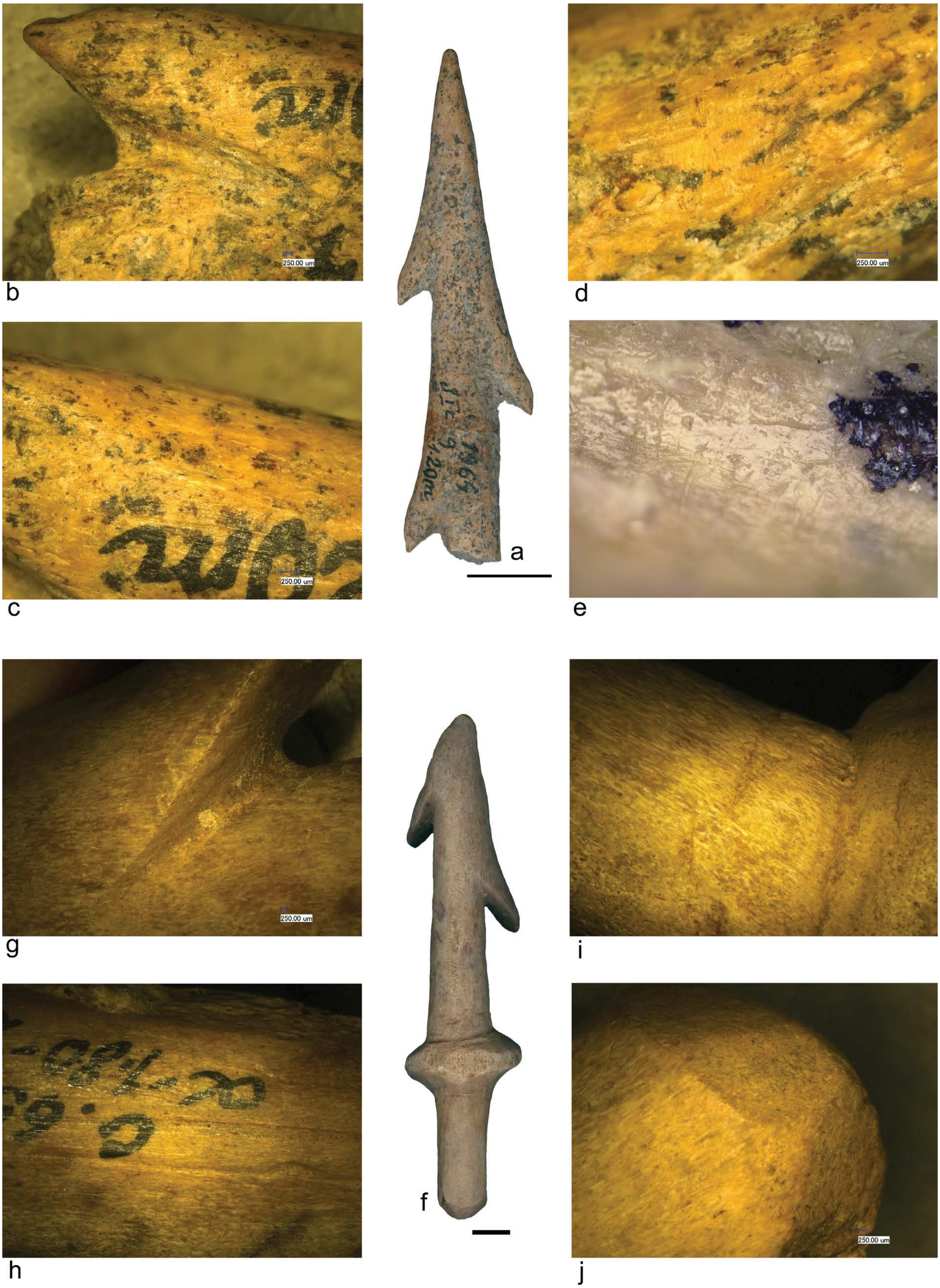

Figure 3. a, f. harpoons with convex barbs (Gumelnița A2 level); b, g, i. sawing marks; c, h. scraping marks; d. abrasion marks; e. use-wear at barbs level; j. surface modification by cutting.

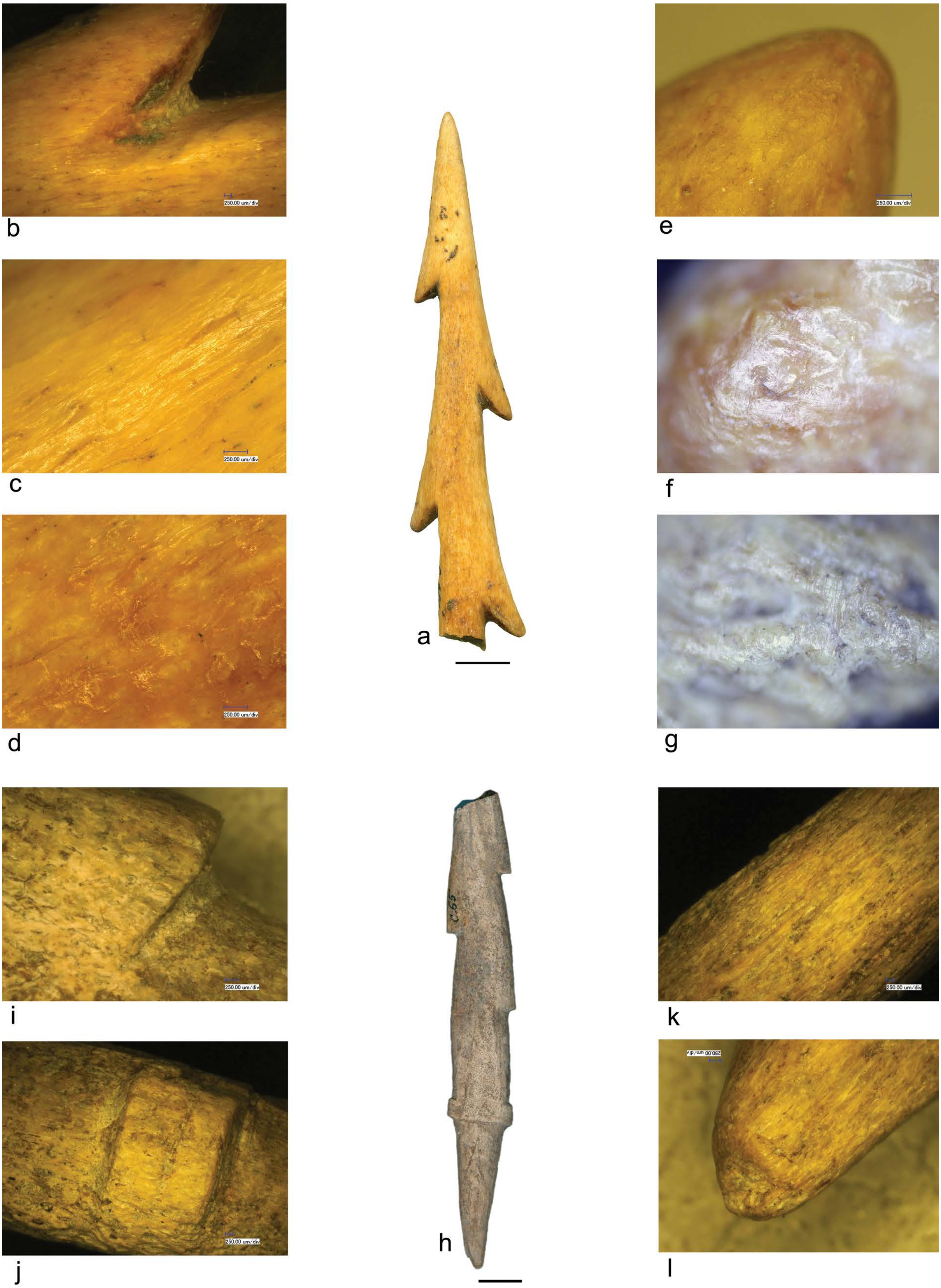

Figure 4. a, h. harpoons with straight barbs; b, i, j. sawing marks; c, k. scraping marks; d. abrasion marks; e, g. use-wear at distal end; f. use-wear at barbs level; l. detail of proximal end.

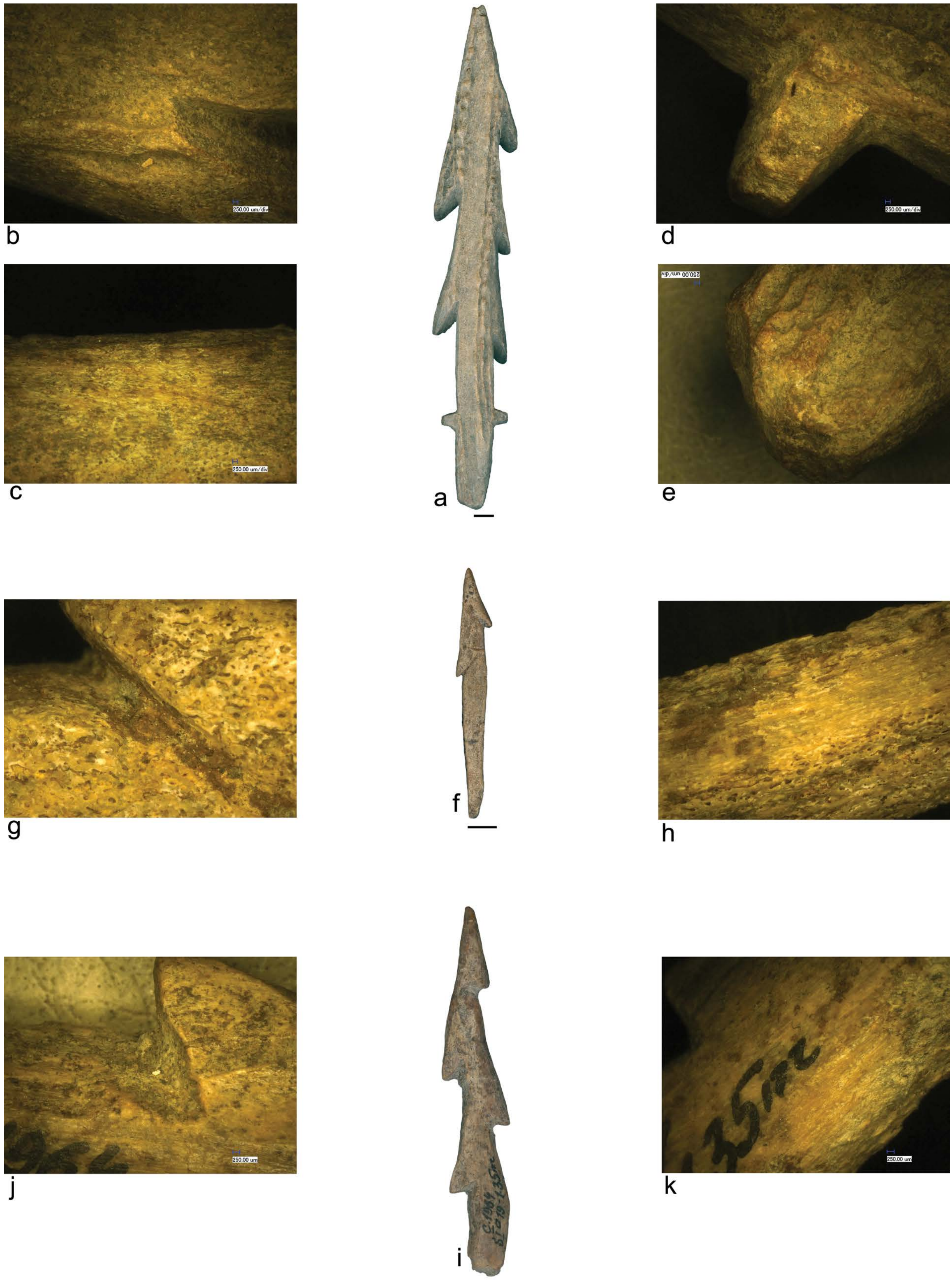

Figure 5. a, f, i. preforms (Gumelnița A2 level); b, d, g, j. sawing marks; c, h, k. scraping marks; e. surface modification by cutting.

far from the trunk. The tip was created in the extension of the last barb, having a conical morphology. The proximal part is delimited by two protuberances with triangular morphology and the extremity is conical.

The barbs are bilaterally, asymmetrically and far from the trunk for the other harpoons. They have variable degrees of fracture (Figure 3a, f). At three specimens, the tip is in the extension of the last barb, having a conical morphology and is fractured, in the case of the other specimens. The glove system is characterized by the presence of triangular (two items) or trapezoidal (two items) protuberances, being fractured at one item. The proximal extremity has a conical morphology.

Five harpoons have straight barbs (Figure 4a, h), bilaterally, asymmetrically arranged and close to the trunk. As a blank, the antler beam was also used in this case. The tip is in the extension of the barbs, having a conical morphology (three items) or is fractured (two items). At the proximal level, the protuberances are rectangular (one item), while the extremity is conical (one item). In four cases, the proximal part is fractured.

A harpoon made on the beam has all the barbs broken, so we were unable to frame it typologically. The barbs were bilaterally, asymmetrically disposed. The tip is in the extension of the barbs, having a conical morphology, while the protuberances have a triangular morphology, and the extremity is conical.

Another three items are, in our opinion, preforms because they did not know a finishing stage and they do not show any use-wear. The first specimen (Figure 5a) has well-individualized, bilateral, asymmetrical barbs, with a biconvex morphology. The protuberances have a trapezoidal morphology. The extremities are not regularized. Another piece (Figure 5f) has two biconvex barbs, while the tip is short, arranged in the extension of the last barb. At the proximal level, the glove system has not been finalized. The last specimen (Figure 5i) has four barbs, the final morphology of which appears to have been biconvex. The tip is short, extending the last barb. At the proximal level, a glove system was not cut. The area is too short, it may not have agreed to the arrangement and therefore the finishing process has been abandoned.

Gumelnița B1 level

Twenty-one harpoons have barbs with convex morphologies. Fifteen specimens were made on beam (Figure 6a, h) and six specimens on tine. The barbs are bilaterally, asymmetrically and far from the trunk. The tip was made in the extension of the barbs, having a sharp morphology. The glove system is delimited by two protuberances with triangular (four items) or trapezoidal morphology (five items), while the proximal end has a conical morphology (seven items). One of the specimens presents at the proximal level an atypical glove system for this assemblage, consisting of a groove made by cutting around the entire circumference, on which a line could be attached (Figure 7a). It is not excluded that the piece had previously broken at the glove system and had been repaired in this shape. Another interesting specimen (Figure 7f) retains only a protuberance with trapezoidal morphology. The other protuberance probably broke and the surface was abraded. Only one barb is preserved. Symmetrically, it can be seen the place of a barb probably broken, the fracture being shaped. It is a very interesting case of restoration, a phenomenon also visible at other harpoons from the analysed site. Another 10 items are fractured at the level of the proximal end.

Two harpoons (Figure 7g) have sharp barbs. The pieces were made on the beam, the barbs being in the same plane as the trunk. The only intact barb at the first specimen has a trapezoidal morphology, being separated from the trunk. At the proximal level protuberances were made, of which only one

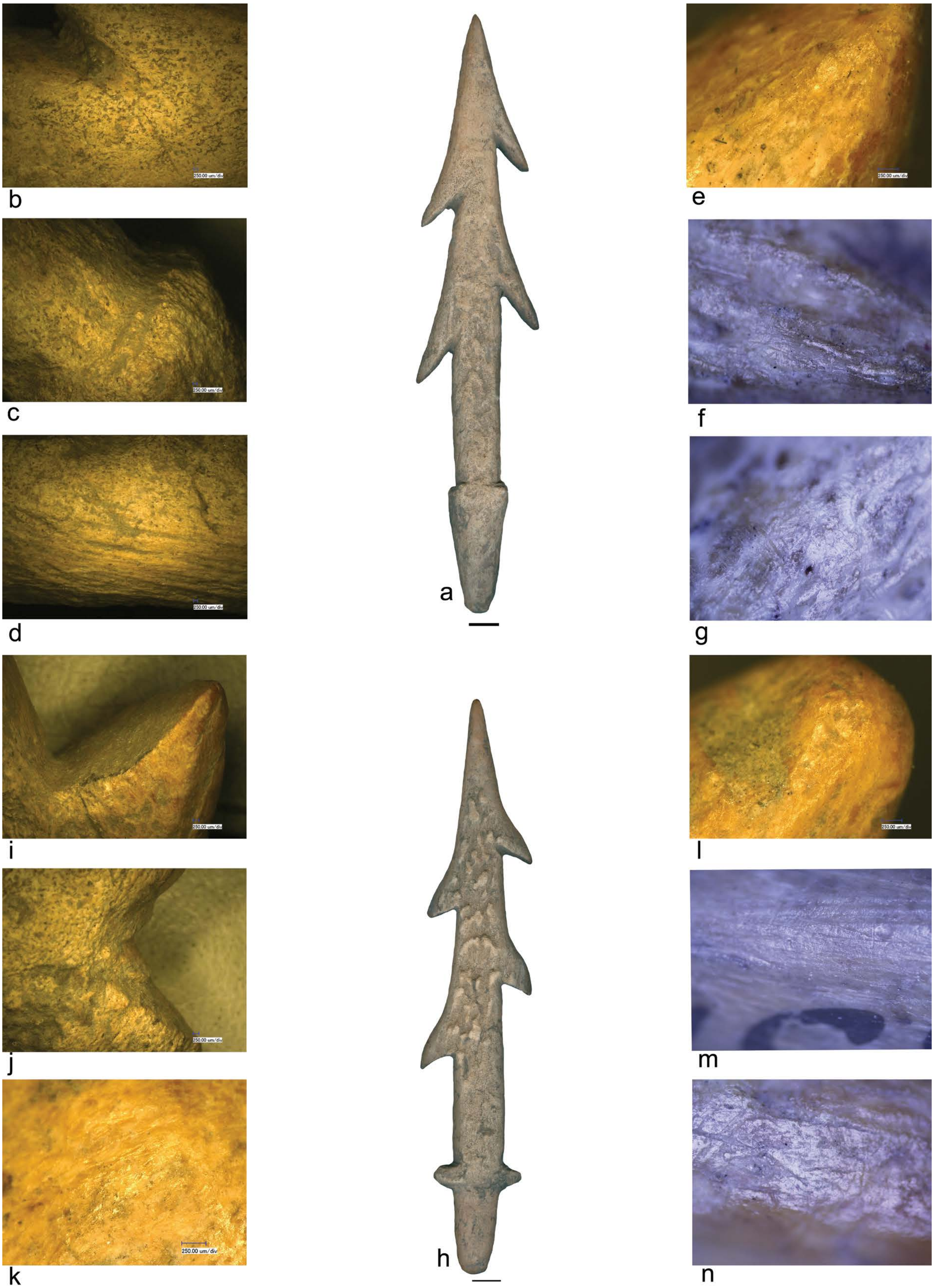

Figure 6. a, h. harpoons with convex barbs (Gumelnița B1 level); b-c, i-j. sawing marks; d. scraping marks; e-f, l-m. use-wear at distal end; g, n. use-wear at barbs level; k. use-wear at proximal end.

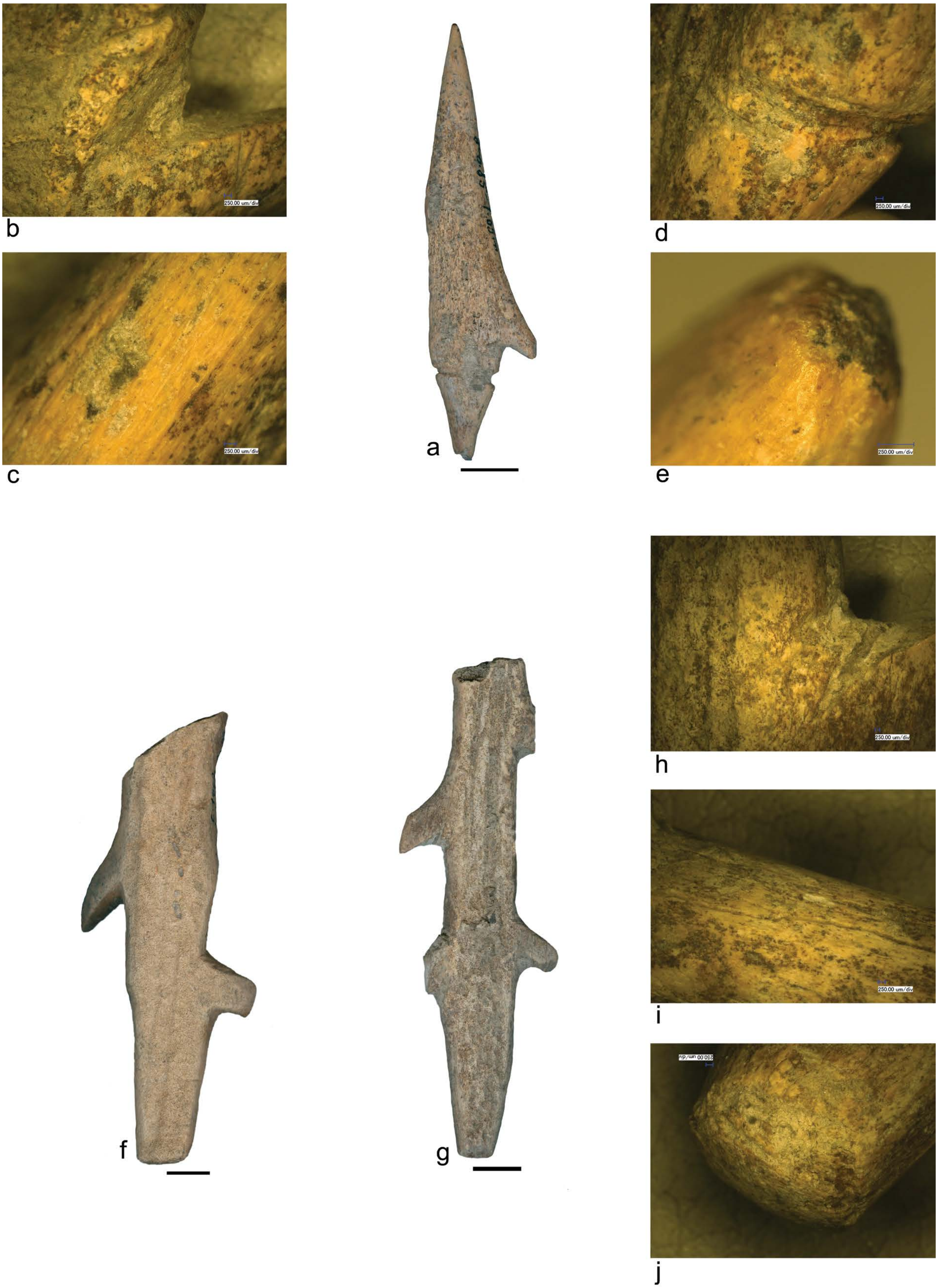

Figure 7. a, f. harpoons with convex barbs (Gumelnița B1 level); b, h. sawing marks; c, i. scraping marks; d. incision; e. detail of distal end; g. harpoon with sharp barbs (Gumelnița B1 level); j. detail of proximal end.

is intact. This is not perpendicular to the trunk, as is usually the case with these protuberances and is not at the same level as the second protuberance. We believe that it is about two barbs that, as a result of the fracture of the piece, have been transformed into protuberances. Then, the proximal end was arranged acquiring a cylindrical morphology. For the second specimen, the protuberances are triangular, continuing with a proximal conical extremity.

Proximal or distal fragments also come from the same level. Six proximal items have triangular protuberances and seven items have trapezoidal morphology, continuing with a proximal part with conical morphology. The assemblage consists of five other pieces whose barbs and protuberances are fractured, so we cannot describe them.

Six pieces can still be considered under processing (Figure 8a, d). They are made on the beam, the barbs being in the same plane as the trunk. Barbs have irregular morphology, but a convex morphology is assumed in the finishing stage. The pieces are raw cut, without a sharp extremity. They were clearly not finished.

Another preform (Figure 8g) was probably abandoned due to the too large curvature of the blank. Its importance is exceptional because we see the way of cutting the six bilateral, asymmetrical barbs and the protuberances (one of them was initiated) (Figure 8h). We could thus establish that the profile of the future harpoon was not fully carved, the cuts alternately progressively deepening, until the final shape, after which the trunk was regularized by scraping (Figure 8i). In the case of another preform (Figure 9a) we have even an early stage of detachment of the barbs. The blank was obtained from the compact tissue, by percussion in longitudinal debitage. The cutting of the barbs was initiated alternately, on both sides (Figure 9b, c). It is important to demonstrate how the process of preparing the preforms begins. The same incipient processing stage appears at another preform (Figure 9d). Four asymmetrical bilateral barbs (Figure 9e, f) were drawn, and the tip also began to form (Figure 9g). The proximal extremity began to be thinned, by percussion (Figure 9h). At another specimen (Figure 9i), a large part of the blank, obtained by longitudinal percussion, is preserved. It is possible to see how the detachment of the barbs was started by oblique cutting (Figure 9j), which is getting deeper and deeper. At the proximal level, the surface was thinned in percussion - resulting in longitudinal cuts (Figure 9k). A proximal fragment also appears to come from a preform; only a protuberance with a triangular morphology is preserved.

Processing techniques

The study of finished specimens but especially of the items undergoing technological processing, have enabled to reconstruct technological transformation sequence for harpoon processing. All the items were made on flattened blanks, with an approximately rectangular outline obtained using a bipartition method of debitage. Beams or eye tines were used as obtaining a blank with a significant width to allow cutting of barbs. According to the data we have available for the assemblage from Căscioarele-Ostrovel, the transversal segmentation was performed either by sawing with abrasive fibre (Figure 1c, e) or by percussion (Figure 1d, f). Longitudinally, indirect percussion was used as a processing technique (Figure 1d, g).

The manufacturing of a harpoon, after the debitage from the antler, involves several important operations: cutting out the particular elements (barbs, protuberances, point etc.) and delineating of the final shape, through finishing. We did not identify differences between the two archaeological levels, regarding the succession of the technological stages in the transformation schemes. Thus, the preforms in the first processing stage show that first, the future barbs and protuberances were roughly

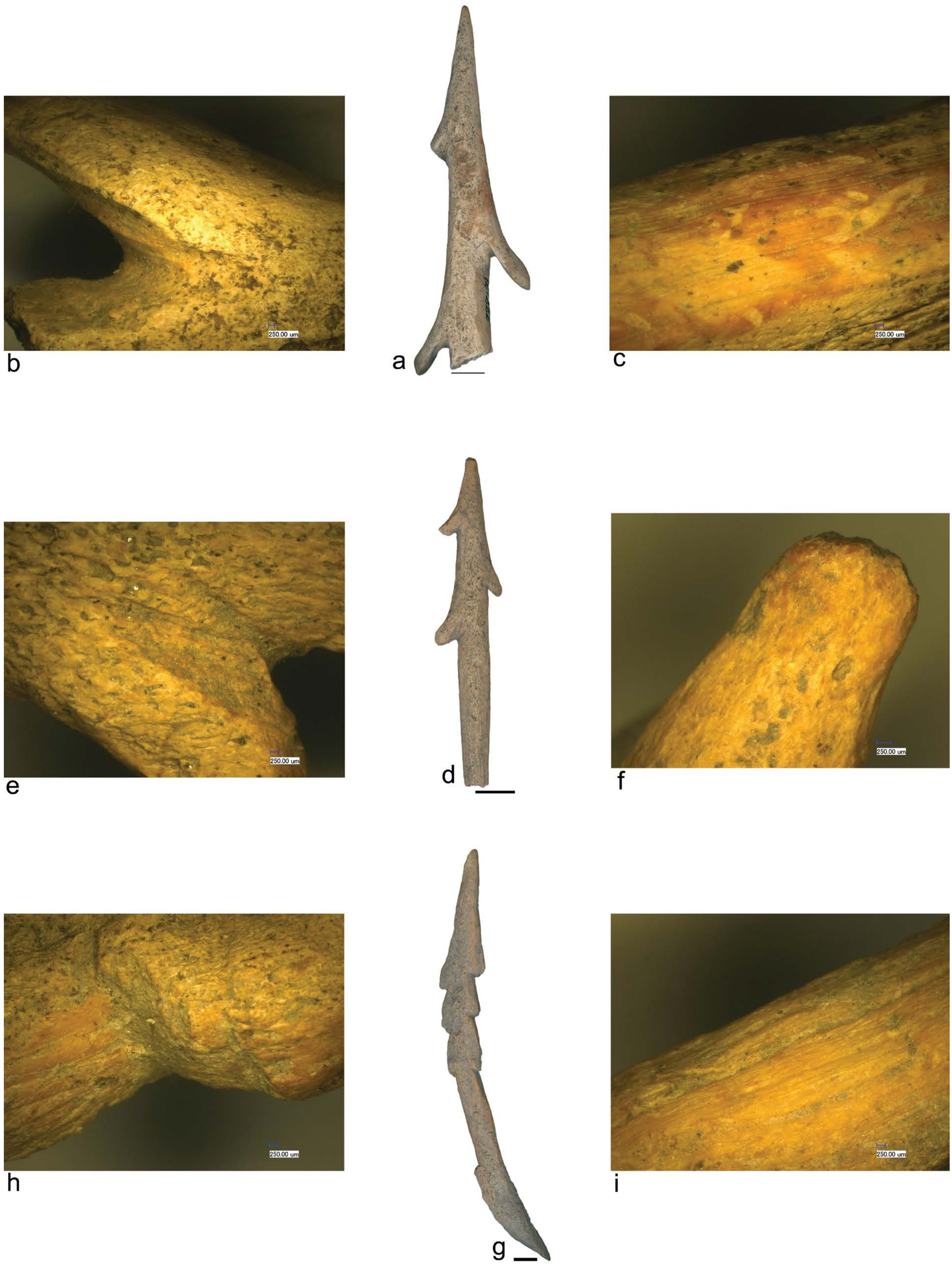

Figure 8. a, d, g. preforms (Gumelnița B1 level); b, e, h. sawing marks; c, i. scraping marks; f. detail of distal end.

cut and then the thinning (Figure 8g; 9a, d, i), the regularization and the shaping followed after this action. The superior side of these preforms preserves the typical antler structure, no shaping action is attested, in order to remove the pearling. First action is made by progressively deepened grooves, alternatively from both faces, the technique being that of sawing. We consider that we are dealing with sawing, because we were able to identify a succession of straight grooves, developed subsequently to an oscillating movement, the starting points of which are not superposed but divergent (Figure 2b; 3b, g; 5b, j; 6b, i; 7b; 8b, e; 9e, j; 10b). The grooves show a V-section, with continuous and straight striations visible on the inner side, identical on both groove walls. The main element determining the morphology of the barbs is the direction of the incisions made to cut them out. When the barbs are located far from the body (Figure 7g, h), their purpose is to create a space between the barbs and the trunk, through the elimination of a small waste, which is approximately rectangular in shape. This is why the sawing is applied from three points: the proximal edge of the first barb, the area in between the barbs and the distal edge of the following barb. The second procedure, much more suitable for the barbs situated close to the trunk (Figure 4b, i; 5g; 9b, c), consists of two incisions made by sawing, creating the distal edge of a barb and the proximal edge of another, both of them deepened, until they meet.

The proximal end presents several variants of the hafting system. The most frequent are the protuberances, made by using the same procedure of cutting by sawing (Figure 3i; 4j; 5d; 6j) as that of the barbs. The second variant consists of a groove made by cutting around the entire circumference (Figure 7d). For another specimen (Figure 6a) no protuberances are present, whereas the proximal end, with a conical morphology, is thicker than the rest of the trunk. The last variant has no specific arrangement for adding a thread, the proximal end forming a continuum with the trunk (Figure 5f; 8d), the shaping being done by longitudinal scraping.

As regards surface modification procedures, scraping was the most frequently used technique. For the analysed specimens, the distal extremity (pointed end) was thinned by scraping applied around the entire circumference (Figure 3c, h; 4c; 5c, k; 7c, i; 8c, f, i; 9g; 10d), starting from the last barb. This action destroyed the marks of the previous actions. The trunk was also shaped by longitudinal scraping. Scraping can give the final shape of the object, being, sometimes, the only phase of shaping. The next technique, present with these procedures, is removal by pecking (small overlapped flakes), suitable for the proximal extremity (Figure 3j; 9h, k). There are specimens that have also involved a finishing stage, characterized by the application of abrasion (Figure 2e; 3d; 4d), especially on the superior side towards the distal extremity.

Maintenance and recycling

The study of a weapon aims at integrating it in an economic cycle, from the perspective of its manufacturing, use and maintenance. Related to the maintenance of harpoons from Căscioarele-Ostrovel, we identified two variants: repairing, if the tool can be reconditioned, preserving its original shape and function and recycling, if its original shape and function cannot be preserved. With regard to the number of broken and abandoned harpoons, we have not identified a systematic preoccupation for reconditioning fractured pieces. We assume that this situation was also determined by the fact that this raw material was readily available on site. The assemblage of manufactured antlers from Căscioarele illustrates a stock of blanks and preforms what would have replaced the broken/lost items. Therefore, the production exceeded the immediate needs. In addition, if there was no harvesting period for the shed antlers and new blanks were needed, they could be obtained from the hunted animals, as already mentioned. Therefore, most likely the repairs were probably *ad-hoc*, perhaps because the harpoon had a special meaning for the owner and not because there was no easy access to raw materials.

Thus, for two items at the proximal level there is only one protuberance (Figure 7f, g). Interestingly, it is not perpendicular to the trunk, as is usually the case with these protuberances and has an atypical morphology. We propose that the harpoons were fractured proximally and one of the barbs was transformed into a protuberance.

There are cases where fractured harpoons have been transformed into another find. Thus, for a piece from level A2 (Figure 10a) - we think that was a harpoon that has been broken and has been reworked into bevelled tool. The only preserved barb appears to have been convex (Figure 10b). The hafting system consists of a protuberance surrounding 2/3 of the diameter of the piece (Figure 10c). The active part was created through longitudinal scraping (Figure 10d). At the distal level, probably after fracturing the original end, an active bevelled extremity was created by bifacial abrasion (Figure 10e). In the case of a second fractured harpoon (Figure 10f), the scraping was applied bilaterally, which regularized the area of the fractured barbs. At the proximal level, it seems that a hafting system has been started but the action was not completed. The third specimen (Figure 10g) is a harpoon fragment, which has begun to be repaired, but the process has not been finished. The sides began to be regularized by scraping, to flatten the surface, at the level of the barbs and protuberances broken. At the distal level, two abraded, flattened surfaces formed. This repair activity is also found in other Gumelniţa settlements, such as Bordușani-Popină (Mărgărit *et al.* 2010) or Hârșova (Mărgărit and Popovici 2011).

These reshaping actions, compared to the mechanical strength of the experimental harpoons (Pétillon and Letourneux 2006), could attest that they correspond to numerous fishing/hunting expeditions. From the perspective of the mechanical characteristics, the cervid antler is the best adapted for the fabrication of the different artifacts specific of prehistoric equipment (Billamboz 1977; Michels and Zurbruchen 1991; Averbouh 2000; Riedel *et al.* 2004; Vercoutère *et al.* 2007). It absorbs the shock or the impact, due to the important proportion of organic matter of its structure (Grégor 1985). R. D. Guthrie (1983: 279), who made hunting weapons from three types of raw material (bone, antler, lithic), concluded that antler is the most suitable: it can be easily worked, shaped or straightened when wet, it is resistant to breakage, can be easily re-sharpened, and in most cases is readily available. From these observations, it is clear that harpoons were used for a long period of time, and in the case of fracture it could be easily repaired.

Functional hypotheses

Under the generic name of harpoon are combined all the objects having in common a detachable hafting system provided with a line and a trunk with barbs, in order to hook up the prey. As regards the analysed assemblage, we have identified three areas where various marks and a deformation of the initial outlines seem to show how these harpoons were used. The first of them is located at the level of the proximal extremity and it presents compressions (Figure 2d; 6k), with small cavities resulted from raw material losses, covered by polish, which proves prolonged usage. Microscopic study has revealed series of micro-striations arranged in different directions, which seem to have resulted from repeated irregular friction, hence the assumption of a movable hafting system (Figure 2f). Moreover, when the items are fractured, the predominant fractures have a sawtooth appearance, following the bending. These functional modifications at the proximal level seem to attest to the insertion of the harpoons into shaft. The ethnographic examples prove that these different morphologies of the proximal part do not necessarily have to do with a fixed or mobile hafting and that, sometimes, these variations mean nothing else but the search for optimal solutions to a problem, such as finding a shape as adapted as possible to the way of use (Scheinsohn 2010). Moreover, none of these weapons, despite their morphological variability, presents any other typical element allowing us to foresee their individualisation; we can imagine a management of the hunting weapons rather on the scale of the whole group.

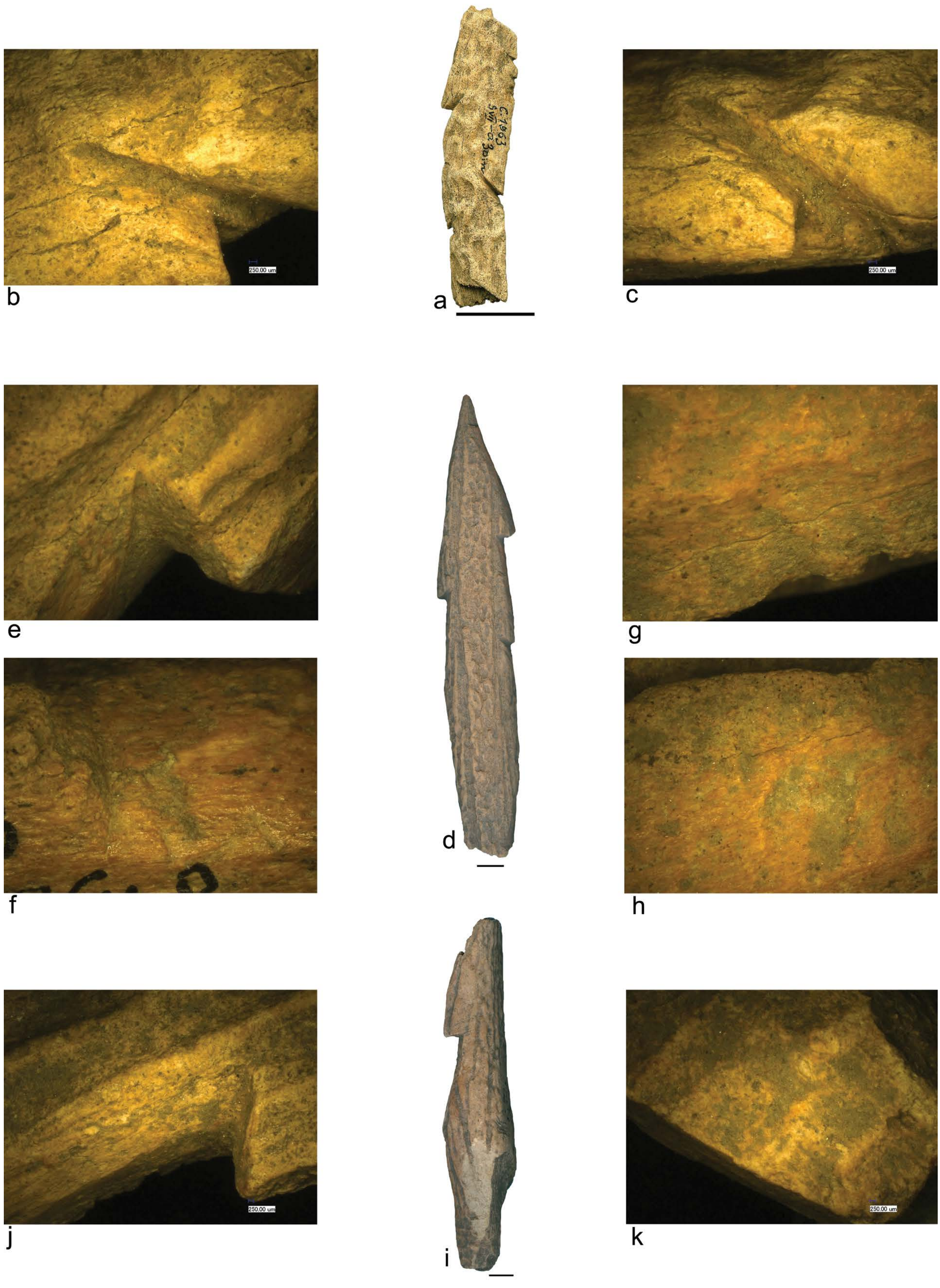

Figure 9. a, d, i. preforms (Gumelnița B1 level); b-c, e-f, j. sawing marks; g. scraping marks; h, k. surface modification by cutting.

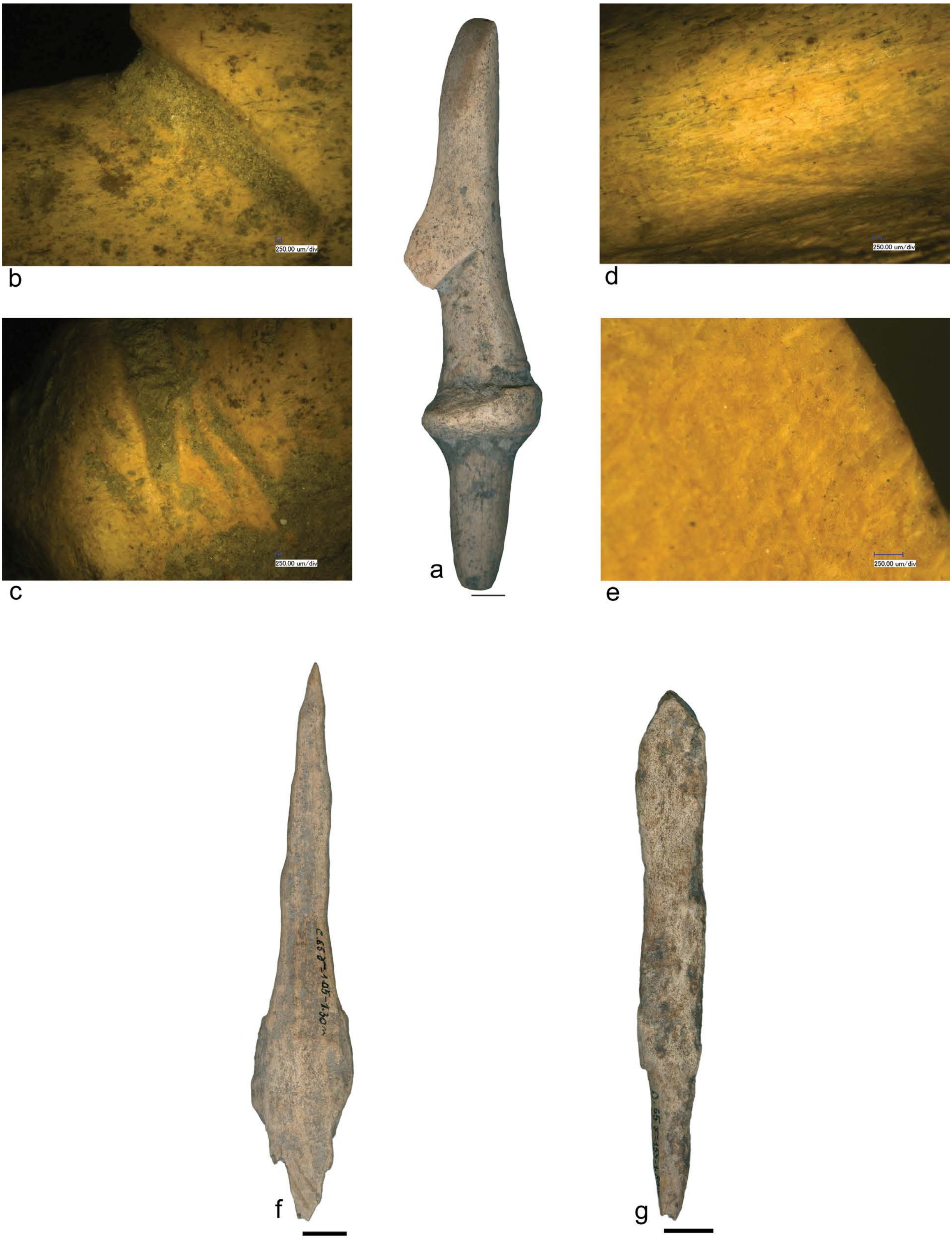

Figure 10. a, f, g. recycled harpoons (Gumelnița A2 level); b, c. sawing marks; d. scraping marks; e. detail of distal end.

The distal end is, in most of the cases, fractured *en languette* – an oblique fracture, but the sawtooth fracture is also present. The predominance of the first type of fracture allowed, for example, the transformation of a harpoon into a bevelled tool (see above). These two types are seen by experts as being of functional nature, belonging to flexion fractures (Legrand 2000; Pétillon 2006, 2008). The general morphology of the pointed end, in case it is not fractured, has a worn aspect (Figure 4e; 6e, l) with macroscopic polish. At most of the items, the micro-striations caused by use-wear are located transversally (Figure 2h; 4g; 6f, m) in relation to the axis of the equipment. We consider that the compacted aspect of the distal end, associated with the micro-striations appeared as a result of the impact with the prey and then of the friction with an organic tissue.

Finally, the last use-wear area is located at the level of the barbs and is characterized by a different way of changing the surface, which tends to flatten, by the gradual disappearance of technological marks. Few micro-striations are present, arranged obliquely (Figure 2g; 3e; 4f; 6g, n).

The advantage of this type of weapon – the harpoon – is the fact that it gets hooked up well in the body of the prey thanks to the barbs. At the same time, the prey can be retrieved, using the handle attached to it. In today's indigenous societies, the harpoon is used to hunt (e.g., Inuit), to capture whales and dolphins (Polynesia) (Wallin 1996), seals and sea lions (Kodiak Archipelago) (Margaris 2014), to catch water birds and even mammals while crossing a water (Julien 1982; Goodchild 1984; Van Stone 1993), or even tree-climbing animals – monkeys (the Agta people from the Philippines) (Bion-Griffin 1997). Most likely, in the settlements of the Gumelnița culture, large species of fish were caught with these harpoons, in the colder periods or during the breeding period (Radu 2007-2008). It could be argued that such a comparison (Neolithic-indigenous societies) may be exaggerated, given the differences in space and time. Yet, the situation is completely different, if we start from the premise that the harpoon has accompanied the entire evolution of modern man, being "invented" by the first *Homo sapiens sapiens* (Yellen *et al.* 1995; Langley (ed) 2016), moreover, being used in different ecological environments (Arctic areas, Australia, South and North America, Pacific).

Harpoons are artifacts which provide multiple information not only at the level of the technological schemes, but also at the social level, because as some authors suggest (Tostevin 2007; Langley 2019), that the projectile weaponry are highly visible to persons who are both intimately familiar with the individual carrying the implement. Moreover, they are considered as functioning of the social and symbolic 'glue' that hold together social groups (Conard 2008) because we imagine a cooperation within the community in order to obtain food which increases the chances of survival of to all community members. At the same time, they seem to reflect cultural identity, because the design or style of weapons is considered to be identifiable to regionally distinct communities (Langley 2019). Analysis of harpoons present in other Gumelnița settlements (e.g., tell settlements from Bordușani-Popină, Hârșova, Pietrele - see Introduction section) seem to reflect this cultural identity defined by the predominance of harpoons with bilaterally barbs and a proximal part with conical morphology delimited by two protuberances. Harpoons with a different morphology of the proximal part appear sporadically. Equally, we can glimpse an individual identity defined by the fact that, keeping this general design, a diverse range of items was manufactured, there are practically no two identical harpoons.

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Indirect evidence for fishing on the middle course of Mureş River in the Late Neolithic: A multi-analytical approach to evaluating osseous hooks

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Abstract

This paper introduces a group of 19 osseous fishing hooks in different stages of completion and integrity, discovered in the Late Neolithic settlement from Şoimuş–*La Avicola (Ferma 2)*, Romania. These artifacts currently represent the sole evidence for fishing at the site, despite its vicinity to the watercourse of Mureş River. To analyze the fishing hooks, we applied an integrative approach by performing a combination of technological, morphometric, morphological, and fracture studies paired with statistical analyses and ethnographic comparisons. Our results demonstrate that the hooks were designed and manufactured in a systematic, homogenous fashion with the main scope of securing the desired catch while withstanding stress for the longest duration possible. Besides the hook assemblage changing the local picture in regards to the fishing practice, the methodology proposed here could be relevant for future inter-site analysis.

Keywords: Mureş River; Prehistoric fishing; Osseous fishing hooks; Hook design; Osseous technologies; Fracture patterns.

Introduction

Hooks and lines are regarded as the simplest and easiest to operate fishing devices (Eyo and Akpati 1995; Thomas *et al.* 2007; von Brandt 2005) that can be handled by merely one individual with minimum resources. Angling represents, however, a labor-intensive activity, requiring a specific approach in securing the desired fish by learning their feeding and spawning behaviors and using the appropriate tools and baits. To be efficient, a fishing hook needs to be designed in such a manner to hold the bait, to lure the target fish, and to secure it. Hooks contributed to the adaptation and dispersal of modern humans (Fujita *et al.* 2016), the oldest known examples being largely produced of organic materials, such as wood, bone, antler, dentine, or shell (Rau 1884; Mortillet 1890; Cleyet-Merle 1990).

The contribution of fishing to the economy of Late Neolithic (ca. 5400-4500 cal. BC) societies of Southeastern Europe has been until recently regarded as minimal, with an apparent lack of aquatic remains (Bartosiewicz and Bonsall 2004; Choyke and Bartosiewicz 1994) and a relatively low number of fishing tools, even at sites closely connected with large watercourses (Vasić 1936; Banner 1960; Zalai-Gaál 1983). Notable discussions were initiated lately around the production and use of osseous fishing hooks, contributing to the reconstruction of this activity during the Late Neolithic (Choyke and Bartosiewicz 1994; Bartosiewicz and Bonsall 2004; Cristiani *et al.* 2016; Vitezović 2018; Vitezović 2019; Vitezović and Antonović 2020).

In this context, we present here the findings regarding a group of 19 osseous hooks from a Late Neolithic site, located in Transylvania, Romania. In the total absence of fish remains at the site, our research has focused solely on the osseous hooks. For this, we used an interdisciplinary approach focused on technological and functional studies. Our main aims were to understand the design behind each hook part and how it might affect the overall item, as well as to evaluate possible differences within the assemblage.

Site and Chronology

Şoimuş is a village at the junction of the Transylvania and Banat historical provinces in Hunedoara County, on the middle sector of the first terrace of River Mureş. The terrace, of Pleistocene age, lays 4–5 m above the river's level and is part of a complex of terraces to the south and southeast of village Şoimuş, with the Mureş River being the main watercourse (Bărbat 2015: 19–21). Unfortunately,

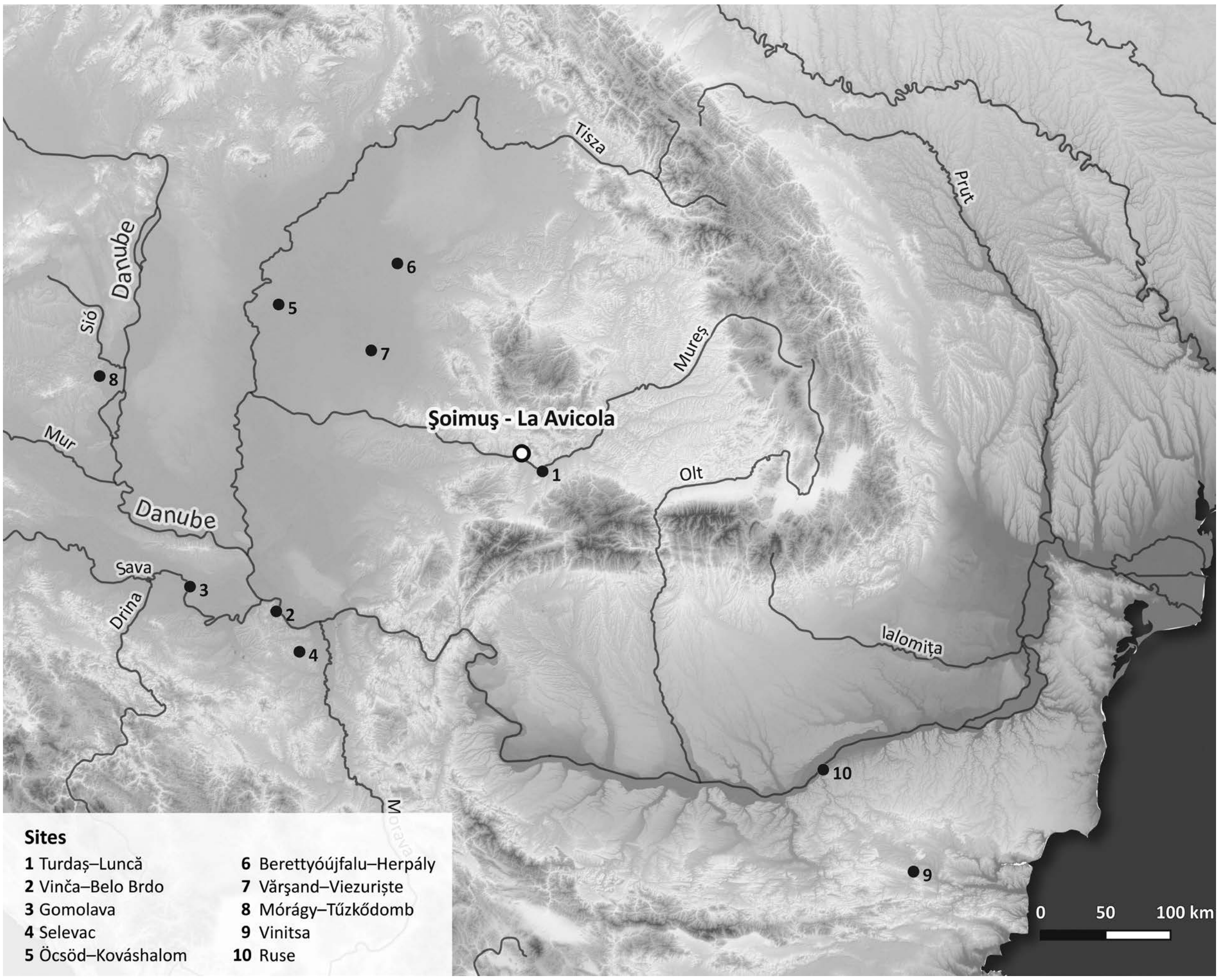

Figure 1. Map showing the position of Şoimuş–La Avicola and the main other archaeological sites mentioned in the text.

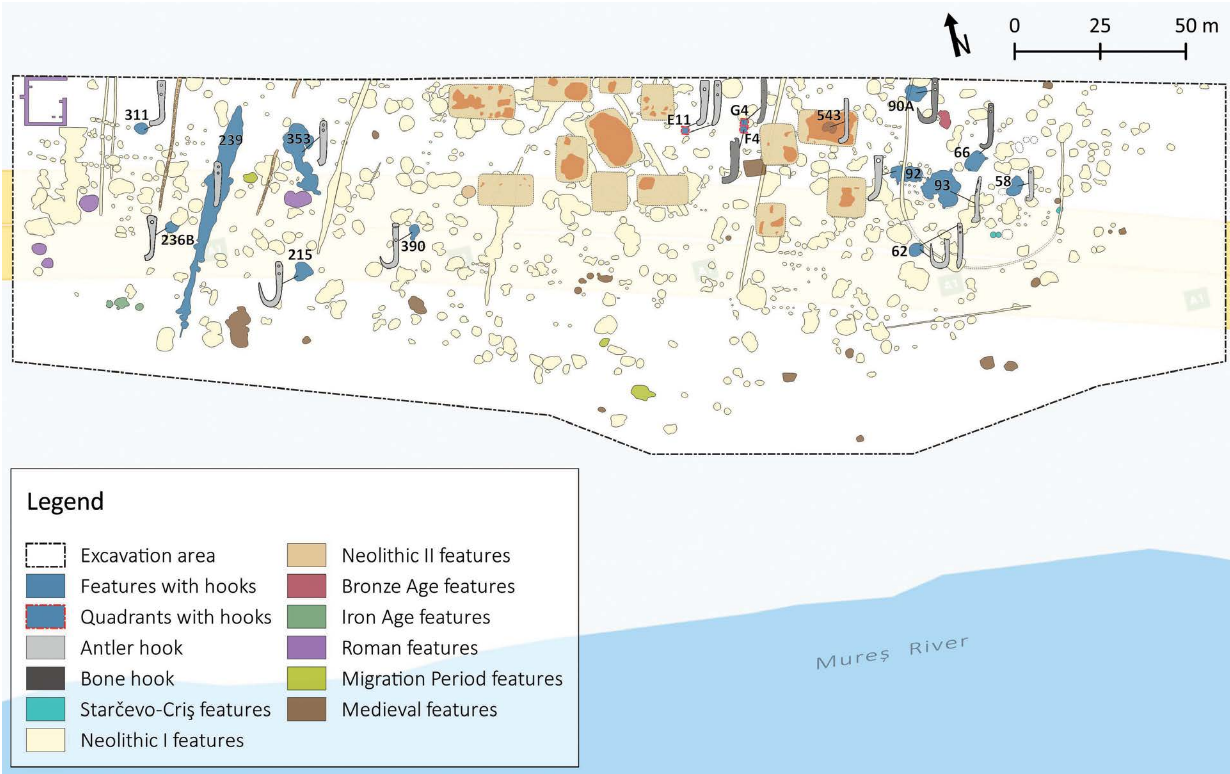

Figure 2. Planum showing the horizontal distribution of the hooks at Şoimuş–La Avicola analyzed in this paper. Numbers indicate the local feature IDs. Yellow band underneath the excavation area marks the track of the current A1 motorway.

environmental studies in the region are generally lacking. However, it appears that during the Holocene, Mureş River's watercourse became steady and the horizontal bed changes became less significant (Andó 1995: 10). The positioning of several prehistoric settlements on the middle course of the Mureş River confirms this relative steadiness of the riverbed at that time (Czajlik *et al.* 2014: 461). Archaeological information in the vicinity of Şoimuş was signaled since the 19th century (Mailand 1891), with few minor field investigations until 2011, when construction works were initiated for the A1 Motorway, crossing between villages Şoimuş and Bălata. Our study focuses on Şoimuş 1, area A, placed in the point known as *La Avicola (Ferma 2)*, where a joint team of archaeologists from the *Vasile Pârvan Institute of Archaeology* (Bucharest), the *Roman and Dacian Civilization Museum* (Deva), and the *Romanian National History Museum* (Bucharest) conducted preventive archaeological research between August and October 2011 (Ştefan 2017 and references therewith). Throughout this paper, we will use the terms Şoimuş and Şoimuş–*La Avicola,* interchangeably, in reference to the find place. During these researches ca. 700 features were unearthed, with the majority ascribed to the Neolithic period (Ştefan 2017: 7), for which two main inhabitance phases could be delimited based on the different architectural styles. The first phase (i. e. Neolithic I, Figure 2) is characterized by pithouses, while the second one (Neolithic II) corresponds to a level of surface dwellings. The two habitation levels were separated by a layer of ashy-brown soil, interpreted as a leveling phase. Both Neolithic inhabitance phases were initially attributed to the Turdaş ceramic style (Ştefan *et al.* 2015: 183), based on the archaeological finds.

Only two AMS radiocarbon dates were measured so far, on samples taken from human bones (Ştefan 2017: 8). The resulted dates (6233±39BP and 6020±41BP) place the features between 5307 and 5057 cal. BC for the older date and between 5024 and 4796 cal. BC for the younger one (both with 95.4 % probability). Further, this would correspond with the conventional Vinča B, and Vinča B2-C intervals

(Whittle *et al.* 2016: Figure 37). However, we think more data is necessary for strong inference in this sense, preferably with samples other than human bones for cross-comparison. Thus, provisionally, the Neolithic settlement could be ascribed to the Vinča B–C phases, with some of the later pits assigned to the Turdaş ceramic style (Ştefan 2017).

Materials

The assemblage of osseous artifacts analyzed is comprised of 19 fishing hooks (labeled in this study with IDs OH-01 through OH-19), identified in different contexts, from the Late Neolithic levels at Şoimuş-*La Avicola.* The majority of hooks (n=15) were manufactured from red deer *(Cervus elaphus)* antler, with only a few specimens (n=4) made of long bone from undetermined large mammals, to which we add a preform, not available to us for analysis (Mărgărit *et al.* 2016: 369). Although mainly preserved in a fragmentary state, it is possible to classify the hooks as *J*-shaped, with barbless points and equipped at the proximal extremity with 1 or 2 perforations, as well as a combination of a knob and a perforation. Their sizes within the assemblage are comparable, with an average length of 6.98 cm, as are the shapes, although there are distinguishable differences that will be analyzed later on.

Fourteen of the osseous hooks were found in 13 archaeological features, the remaining five hooks being either stray (n=1) or identified in the strata (n=4). The latter items were plotted on the map with the help of an artificial 2x2 m grid, traced for documentation purposes (Figure 2).

The features containing osseous hooks were classified into pits (n=7), pithouses (n=6), and ditches (n=1) (Table 2), all attributed to the Neolithic I phase. The density of hooks inside the features is generally of one item per feature, except for feature C 62, containing two such items. The precise contextual information of the osseous hooks inside the features was mostly not documented, except for one specimen (OH-01), found in what seems to have been the refuse pit of an oven within pithouse C 66.

Methods

The study of the specimens consisted of macro- and microscopic investigations meant to acquire data regarding the variations in size, form, physical characteristics of the raw material, manufacturing technology, and degree of preservation as well as fracture patterns.

Morphology and size

For the size and form parts of the study, we considered modern hooks as reference (Edappazham *et al.* 2008; Thomas *et al.* 2007) due to their highly specialized and standardized shapes, but also archaeological (Allen 1996; 1995; Choyke and Bartosiewicz 1994; Olson *et al.* 2008) and ethnographic (von Brandt 2005; Gerritsen 2001; Rau 1884; Stewart 1982) examples as more sensible working analogies. Based on this information, we differentiate between four hook parts: point, bow/bend, shank, and head/suspension region (Figure 4a, b, c, d). To evaluate the efficiency of particular shapes, we have established, wherever possible, the cross-section for each of these hook parts in every specimen (see Figure 3), as well as the morphology of the perforations.

TABLE 1. CONTEXTUAL INFORMATION AND MEASURED PARAMETERS OF ALL ANALYZED ŞOIMUS – *LA AVICOLA* SPECIMENS.

Hook ID	Integrity	Material	OHL (cm)	ShL (cm)	ShT (cm)	ShW (cm)	BW (cm)	BS (cm)	BT (cm)	Gap (cm)	Bite (cm)	GA (°)	PL (cm)	PT (cm)	Spr. (cm)	SpL (cm)	SpT (cm)	SpW (cm)	KL (cm)	KT (cm)	Weight (g)
OH-01	fragmentary	bone	7,70	5,00	0,60	0,90	0,70	1,90	0,60	-	-	-	-	-	-	1,50	0,55	0,90	-	-	7,00
OH-02	fragmentary	antler	7,60	4,80	0,50	1,50	0,80	-	0,60	-	-	-	-	-	-	0,80	0,50	1,30	-	-	7,20
OH-03	entire	bone	6,98	4,60	0,70	1,00	0,65	2,90	0,70	2,20	1,90	35	2,00	0,16	3,00	1,30	0,60	1,10	-	-	9,00
OH-04	fragmentary	antler	-	4,80	0,50	0,60	-	-	-	-	-	-	-	-	-	1,40	0,50	0,50	-	-	4,80
OH-05	fragmentary	antler	8,80	4,55	0,70	0,80	0,80	-	0,85	-	-	-	-	-	-	2,55	0,70	1,50	-	-	11,10
OH-06	fragmentary reconstructed	antler	6,50	3,00	0,70	0,90	0,86	2,80	0,80	2,44	2,60	47	3,40	0,20	3,30	1,50	0,70	1,01	-	-	7,40
OH-07	fragmentary	antler	5,40	2,60	0,60	0,70	0,57	-	0,70	-	-	-	-	-	-	1,70	0,65	1,00	-	-	4,60
OH-08	fragmentary	antler	7,20	4,60	0,50	1,20	0,85	-	0,62	-	-	-	-	-	-	0,80	0,60	1,45	-	-	6,50
OH-09	fragmentary	antler	6,50	4,20	0,60	1,20	0,68	-	0,70	-	-	-	-	-	-	1,10	0,70	1,27	-	-	6,10
OH-10	fragmentary	antler	-	3,30	0,60	1,06	-	-	-	-	-	-	-	-	-	1,90	0,70	1,13	-	-	6,80
OH-11	fragmentary	antler	-	4,50	0,80	1,18	1,05	-	1,00	-	-	-	-	-	-	1,90	0,70	1,24	-	-	10,30
OH-12	fragmentary	antler	7,90	6,10	0,60	1,20	0,80	-	0,50	-	-	-	-	-	-	0,70	0,60	1,20	-	-	8,20
OH-13	fragmentary	antler	4,90	3,00	0,60	0,70	0,90	2,90	0,65	2,15	3,13	38	4,05	0,20	2,94	–	0,55	0,78	-	-	5,60
OH-14	fragmentary	antler	6,70	4,30	0,90	1,00	0,70	-	0,80	-	-	-	-	-	-	1,30	0,80	1,15	-	-	9,60
OH-15	fragmentary	antler	-	4,60	0,70	1,20	-	-	-	-	-	-	-	-	-	1,70	0,60	1,20	-	-	8,00
OH-16	entire	antler	6,80	2,40	0,70	0,85	0,80	2,50	0,68	2,03	1,11	38	1,87	0,20	2,10	2,80	0,70	1,10	0,61	0,60	6,80
OH-17	fragmentary	bone	-	4,60	0,70	1,10	0,74	-	0,65	-	-	-	-	-	-	2,50	0,60	1,10	-	-	8,70
OH-18	fragmentary	antler	7,70	5,66	0,70	1,00	0,82	-	0,80	-	-	-	-	-	-	0,54	0,75	1,05	-	-	8,30
OH-19	fragmentary	bone	-	4,46	0,75	1,20	0,90	-	-	-	-	-	-	-	-	0,50	0,70	1,20	-	-	8,80
mean			6,98	4,27	0,66	1,02	0,79	2,60	0,71	2,21	2,19	40	2,83	0,19	2,84	1,47	0,64	1,11	-	-	7,62
median			6,98	4,55	0,70	1,00	0,80	2,80	0,70	2,18	2,25	38	2,70	0,20	2,97	1,45	0,65	1,13	-	-	7,40
s.d			3,44	0,98	0,10	0,23	0,31	1,19	0,32	0,93	0,98	17	1,26	0,08	1,21	0,75	0,08	0,23	-	-	1,75
min			4,90	2,40	0,50	0,60	0,57	1,90	0,50	2,03	1,11	35	1,87	0,16	2,10	0,50	0,50	0,50	-	-	4,60
max			8,80	6,10	0,90	1,50	1,05	2,90	1,00	2,44	3,13	47	4,05	0,20	3,30	2,80	0,80	1,50	-	-	11,10

OHL = overall hook length, ShL = shank length, ShT = shank thickness, ShW = shank width, BW = bow width, BS = bow spread, BT = bow thickness, GA = gripping angle, PL = point length, PT = point thickness, Spr. = hook spread, SpL = suspension length, SpT = suspension thickness, SpW = suspension width, KL = knob length, KT = knob thickness, mean = mean of the values for all observations in each variable, median = median of the values for all observations in each variable, s.d. = standard deviation, min = minimum value in the range, max = maximum value in the range.

TABLE 2. SUMMARY TABLE OF THE FEATURES FROM AREA A AT ŞOIMUŞ – *LA AVICOLA*, CONTAINING OSSEOUS HOOKS.

feature name	# of hooks	hook ID	pit	pithouse	ditch	length (m)	width (m)	inner depth (m)	shape	ash	daub	stone	charcoal	burnt clay	pottery	shells	antler tools	unworked antler	bone tools	animal bones	human bones	flint tools	obsidian tools	sand stone tools	clay weights	grinding tools	anthrop. figurines	other/*details*
C 58	1	OH-12		•		6.00	5.40	1.40	irregular		•		•		•	•			•	•		•	•	•	•		•	
C 62	2	OH-04 OH-13		•		3,64	3.10	1,58	oval	•	•		•		•		•		•	•	•	•	•	•	•			
C 66	1	OH-01		•		4.70	3.20	1,14	rectangular	•	•				•				•	•					•			
C 90A	1	OH-03	•			4.20	2.10	1,25	irregular						•				•	•								
C 92	1	OH-02		•		6.70	3.20	1,42	irregular	•	•	•	•		•		•		•	•		•	•		•			
C 93	1	OH-05		•		9.00	8.40	1.80	irregular		•		•		•	•	•	•	•	•		•	•		•		•	hearth fragments
C 215	1	OH-06	•			4.30	4.25	1.00	irregular		•	•			•	•	•	•	•	•		•	•				•	ceramic strainer
C 236B	1	OH-08	•			4.00	3.60	0,93	irregular		•				•		•	•		•							•	
C 239	1	OH-15			•	54.0	4.10	2.20	irregular		•				•	•	•			•	•	•	•		•	•	•	miniature vessels
C 311	1	OH-07	•			2.90	2.70	0.90	circular	•	•		•				•			•								
C 353	1	OH-11	•			6.25	17.5	1.60	irregular		•			•	•		•			•		•	•	•	•	•	•	stainer; stone disk
C 390	1	OH-16	•			3.70	2.20	3.20	irregular		•				•		•		•	•		•	•				•	
C 543	1	OH-18	•			2.90	2.70	0.70	irregular		•				•		•		•	•		•	•					
quadr. E11	2	OH-09 OH-10				2.00	2.00	-	square	– N/A –																		*artificial grid*
quadr. F4	1	OH-19				2.00	2.00	-	square	– N/A –																		*artificial grid quadrant*
quadr. G4	1	OH-17				2.00	2.00	-	square	– N/A –																		*artificial grid quadrant*
stray	1	OH-14								– N/A –																		

The measurement system used was developed for a larger assemblage of osseous hooks, as part of a dissertation dedicated to fishing tools from the Lower Danube region (Savu forthcoming). It includes 20 parameters (Figure 4) and is designed to acquire size information for entire specimens, the rate of which is very low at Şoimuş. Therefore, the number of actually measured parameters differed depending on the degree of preservation for each item. The measurements were carried out with a vernier caliper in the broadest region of each hook part, with values noted to the second decimal, in centimeters. Where the perforations could be measured (Figure 4:19), the values indicate the size of the actual orifice, and not of the rotary traces created during drilling. This decision aimed at getting an account of the maximum thickness the cordage must have had. As most specimens in our sample are fragmented in the bow region, the corresponding parameters were measured also for those fragmented specimens that preserved at least 50 % of this part.

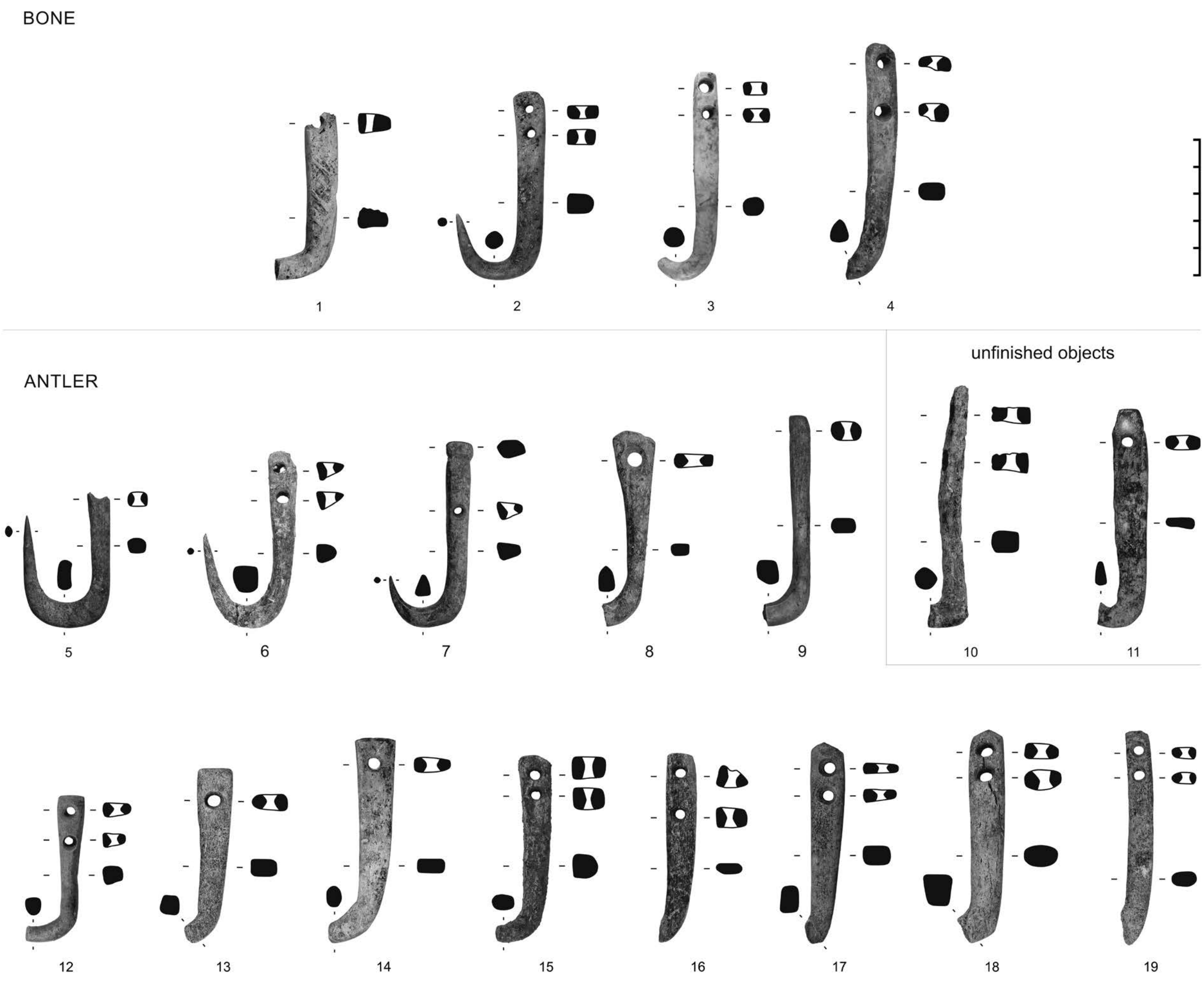

Figure 3. The sample of osseous hooks from Şoimuş-La Avicola and their cross sections in different regions. 1 = OH-19, 2 = OH-03, 3 = OH-01, 4 = OH-17, 5 = OH-13, 6 = OH-06, 7 = OH-16, 8 = OH-08, 9 = OH-18, 10 = OH-05, 11 = OH-12, 12 = OH-07, 13 = OH-09, 14 = OH-02, 15 = OH-14, 16 = OH-10, 17 = OH-15, 18 = OH-11, 19 = OH-04. Scale units in cm. Photographs by M. Savu

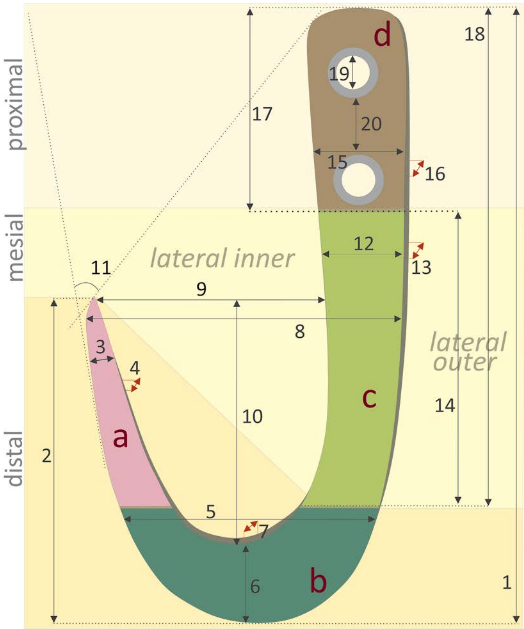

Figure 4. Hook parts: a = point, b = bow, c = shank, d = head; Parameters: 1 = overall hook length (OHL), 2 = point length (PL), 3 = point width (PW), 4 = point thickness (PT), 5 = bow spread (BS), 6 = bow width (BW), 7 = bow thickness (BT), 8 = hook spread, 9 = gape/gap, 10 = bite, 11 = gripping angle (GA), 12 = shank width (ShW), 13 = shank thickness (ShT), 14 = shank length (ShL), 15 = suspension width (SpW), 16 = suspension thickness (SpT), 17 = suspension length (SpL), 18 = overall shank length (OShL), 19 = perforation diameter (PØ), 20 = distance between perforations (PtoP); sketch based on the shape of OH-06 (modified after Averbouh et al. *1995 and Olson 2008)*

Statistical analysis

Although there are some stylistically noticeable differences within the assemblage of hooks from Şoimuş, we were curious to see if they represented enough to distinguish between different types. Furthermore, we wanted to explore if certain observations we made - such as the relation between different hook parts and their dimensions and shapes – can be validated and shown in a more reliable manner rather than by simple visual inspection. For this reason, we subjected the measured parameters to a series of statistical tests. To determine if the data have been drawn from a normally distributed population, we ran the Shapiro-Wilk normality test for each parameter.

As a means of assessing if variances are homogenous across groups, we tested the measured parameters against the categorical variables of material and feature type, using Levene's Test and Fligner-Killeen Test.

To summarize complex multidimensional realities, enabling effective comparisons by including more information in a single variable, we created indices for the bow, shank, and suspension regions, following the formula: $I = \frac{x}{y} \times 1000$, where I = the value of the index, x = thickness in the designated region, y = width in the designated region (summarized in Table 3).

Additionally, Pearson's *r* correlation coefficient was calculated for different combinations of parameters and indices, to establish how strong (if any) the linear association is between them. This test was thought of as a manner of checking if the sizes of different hook parts in the assemblage evolve proportionally to one another.

When the level of fragmentation or completion impeded the computation of tests, the specimens were excluded from the respective analysis. For all tests, an alpha of 0.05 was regarded as a level of significance. All computations and graphs were executed using *R* and the Integrated Development Environment (IDE) *RStudio* (R Core Team 2020; RStudio Team 2020).

Table 3. The composite indices for the shank (ShI), suspension (SpI) and bow (BI) regions.

		%		
	ID hooks	SpI	ShI	BI
		SpT/SpW × 100	ShT/ShW × 100	BT/BW × 100
	OH-01	61,11	66,67	85,71
	OH-02	38,46	33,33	75
	OH-03	54,55	70,00	107,69
	OH-04	100,00	83,33	-
	OH-05	46,67	87,50	106,25
	OH-06	69,31	77,78	93,02
	OH-07	65,00	85,71	122,81
	OH-08	41,38	41,67	72,94
	OH-09	55,12	50,00	102,94
	OH-10	61,95	56,60	-
	OH-11	56,45	67,80	95,24
	OH-12	50,00	50,00	62,5
	OH-14	69,57	90,00	114,29
	OH-15	50,00	58,33	-
	OH-16	63,64	82,35	85
	OH-17	54,55	63,64	87,84
	OH-18	71,43	70,00	97,56
N=		17	17	14

Manufacturing and use-wear traces

An overview of the manufacturing process of the osseous hooks in the assemblage at Şoimuş was offered by Mărgărit and colleagues (2016: 368–370). Here we will attempt to illustrate in more detail some of the particularities we encountered during our research. For this specific stage of analysis, the specimens were examined using a Hirox digital microscope RH-2000 equipped with an MXB-2016Z Low Range High-Resolution Zoom Lens attached to a camera unit at magnification 20–160x. All observations were made based on well-known approaches and nomenclature dedicated to the investigation of osseous materials (Le Dosseur 2004; Christidou 2008; Buc *et al.* 2014; Averbouh 2000; Averbouh 2016; Choyke and O'Connor 2013).

Fracturing

To establish if there are certain breaking patterns, which would speak for the function and use of the specimens, we attempted to evaluate the nature of their fractures. We also observed the fractures' trajectories and corroborated this information with the aspects related to hook design. This evaluation was carried out following the principles and terminology in the macro-fracture analysis of brittle solids (Odell 1981; Bradfield 2016 and references therewith), with which osseous materials share some traits regarding response to impact or fatigue.

Results

Morphology and size

Hooks can be classified into numerous categories based on their general shapes. The two main categories, applying also to prehistoric specimens, are the round bend or *J*-shaped hooks and the rotating/circle hooks (Thomas *et al.* 2007). In this sense, the direction of the point in relation to the shank is parallel for the *J*-shaped hooks, while for the rotating hooks, the point is turning inward in relation to the shank at nearly 90° angle (Thomas *et al.* 2007: 5).

The shape of a fishing hook is given by the elements composing it. Besides its main parts, there are other conventionally recognized parameters influencing the function and efficiency of a fishing hook: the gap, bite/throat, and spread.

At Şoimuş, but also at other Late Neolithic settlements from the Balkan region, *J*-shaped hooks were the main type used in line fishing, their overall hook length (OHL) ranging between 4.90 and 8.80 cm (Table 1).

The point (Pt) is probably the most important hook part, as its purpose is to penetrate the flesh and secure the capture. Its design influences the capture, not only by the point's direction relative to the shank, but also by the hook's length, profile, sharpness, or offset. The point can be re-sharpened (von Brandt 2005), for as long as the material allows it, an action which can be done directly at the fishing site.

Most specimens of the fishing hooks from Şoimuş–*La Avicola,* are missing their point, with the exception of 4 items. The length (PL) ranges between 1.87 and 4.05 cm, the 2 shorter points (OH-03, OH-16) displaying extensive polish and roundness at the tip (Figure 12G; 18F), resulted from usage and possibly re-sharpening. Partly ablated striations and a very slight rounding at the tip, as well as facets formed during abrasion, are visible on the point of specimen OH-13 (Figure 13I). The sharpness of the point is similar in all items, measuring between 0.16 and 0.20 cm in thickness and, except for OH-13, all cross-sections are circular in this part. One item has the tip chipped (OH-06) with patination on the edges of the break (Figure 14F). The gripping angles (GA) are between 35° and 47° (Table 1), with the smallest angle in OH-03, having a shorter point.

The bow (B), known also as bend, is the region connecting the point and the shank. In modern, industrial hooks and ethnographic wooden examples (Stewart 1982), this part is formed by bending. Either round or angular, the bow can take various shapes and in the hook's structure represents the region withstanding most stress. Additionally, it has the greatest influence in determining the spread of a hook. Wide bows target predatory species, they help to embed the hook deeply in the fish's jaw and reduce the risk of being spit out. By contrast, narrower bows are used more for nibbling fish. The bow determines, thus a size selection in fish, being closely related to the fish mouth widths, but almost always smaller than that, to ensure a successful catch (Allen 1996).

As in the case of points, there are only four complete hook bows at Şoimuş, fracturing occurring most frequently in this region. Their general shape is rounded on both inner and outer sides, taking the form of the letter "U", with a slightly rounded rectangular shape in the 2 entire hooks (OH-03, OH-16) and in some of the fragmented ones, preserved enough to establish the shape (OH-13, OH-02, OH-07, OH-09, OH-11, OH-14, OH-18, OH-19; Figure 3). The bow cross-sections take different shapes, most common being the rectangular one (n=5), followed by circular (n=3), triangular (n=3), flat-elliptic (n=2) and flat-rectangular (n=2). The bow spreads vary between 1.90 and 2.90 cm (n=9), with an average width of 0.79 cm (n=16) and an average thickness of 0.71 cm (n=15) (Table 1).

TABLE 4. SUMMARY OF PERFORATION TYPES AND VALUES.

	Perforation (P)							
ID hooks	N entire	N fragm.	N unfinished	Ø (cm)	bifacial	drilled (rotation)	shape	dist. P to P (cm)
OH-01	2	–	–	0.40	•	•	circular	0,40
				0.30	•	•	circular	
OH-02	1	–	–	0.40	•	•	circular	–
OH-03	2	–	–	0,26	•	•	circular	0,40
				0,28	•	•	circular	
OH-04	2	–	–	0.30	•	•	circular	0,40
				0.30	•	•	elliptic	
OH-05	2	–	–	0,43	•	•	circular	1,20
				0,41	•	•	irregular	
OH-06	2	–	–	0.40	•	•	circular	0,60
				0.40	•	•	circular	
OH-07	2	–	–	0,27	•	•	circular	0,70
				0,26	•	•	circular	
OH-08	1	–	–	0.50	•	•	circular	–
OH-09	1	–	–	0,41	•	•	elliptic	–
OH-10	2	–	–	0,31	•	•	circular	1,00
				0,34	•	•	circular	
OH-11	2	–	–	0.30	•	•	elliptic	0,30
				0,31	•	•	elliptic	
OH-12	1	–	–	0,35	•	•	circular	–
		–	2	0.50		•	circular	
		–		0,25		•	circular	
OH-13		2	–	0.40	•	•	indet.	–
			1	0,35		•	circular	
OH-14	2	–	–	0.30	•	•	circular	0,30
				0.30		•	circular	
OH-15	2	–		0.40		•	circular	0,60
				0,35		•	circular	
			2	0.40		•	circular	–
				0.50		•	circular	–
OH-16	1	–	–	0,34	•	•	circular	–
OH-17	2	–	–	0.30	•	•	circular	1,15
				0.30	•	•	circular	
OH-18	1	–	–	0.30	•	•	circular	–
OH-19	–	1	–	0.40	•	•	circular	–

The shank (Sh) continues the hook bow toward the proximal extremity. It can have a straight trajectory, parallel to the point, as it can be incurved or bulged at various angles. *J*-hooks, where the shank goes to parallel with the point's axis, need to be pulled sharply to secure the catch. To compensate for the fact that some fish can release themselves by biting the line after swallowing the hook, the shank's length can be increased. For the hooks in our assemblage, we considered the shank that part between the end of the bow and the lower/single perforation in the suspension region.

The hook shanks (Sh) at Şoimuş are straight, with lengths (ShL) between 2.40 and 6.10 cm (Table 1), and a general robust aspect. Throughout the length, 9 specimens have a rather uniform width, while other 9 become broader toward the proximal end. The shank width (ShW) varies between 0.60 - 1.50 cm and the thickness (ShT) between 0.50 – 0.90 cm. The cross-sections are flat-rectangular (n=8), rectangular (n=5), flat-elliptic (n=3), triangular (n=2) and circular (n=1) (see Figure 3).

The head, located at the most proximal end of the fishing hook, serves for fastening the line. It can be a continuation of the shank with no modification of the stylistic features, or it can appear as a separated part, which wildly varies in shape. In this study we will refer to this region mainly as *suspension* (Sp), owing to its primary function of suspending the hook. The suspension system can take the form of striations, notches, knobs, perforations, or a combination of them.

The edge of the suspension region (Sp) at the most proximal end for the hooks at Şoimuş is either straight (n=8), triangular or slanting on one side (n=6), or rounded (n=2). Two items (OH-08 and OH-18), have a small concavity from previous perforations, now ablated (Figure 15B, C; 17F). The suspension region continues the shank, which in certain cases, as shown previously, is broader in this region, the widths varying here between 0.5 and 1.5 cm (Table 1). The fastening system involves 1 (n=6) or 2 (n=11) perforations (Table 4) and, in one case (OH-16), a combination between a knob and a perforation (Figure 3:7; 18A). The perforations are circular and elliptical, with diameters of the orifice of 0.26 to 0.50 cm. In the case where the hook was designed with 2 perforations or, as in the case of OH-16 with a knob and a perforation, the distance between them varied between 0.30 and 1.20 cm, the highest value being registered by the unfinished item OH-05 (Table 4). Two items have the shanks and suspension regions rotated with the broadest side towards the point. The perforations are also drilled perpendicularly to the point, in the cases of these 2 hooks (Figure 3:9, 10).

TABLE 5. THE CORRELATION COEFFICIENT (PEARSON'S R) BETWEEN DIFFERENT MEASURED PARAMETERS.

Parameter	r	p-value	N =
		significance ≤ 0.05	
ShL - ShI	-0,4402	0,0592	19
ShW-ShT	-0,0786	0,7642	17
SpW-SpT	0,2988	0,2439	17
ShT-SpT	0,7289	0,0009	17
ShW-SpW	0,6058	0,0099	17
ShI - SpI	0,6297	0,0067	17
BW-BT	0,4610	0.0970	14
ShW-BW	0,3604	0,2055	14
ShT-BT	0,6906	0,0062	14
ShI - BI	0,7135	0,0041	14
BW-SpW	0,1407	0,6169	15
BT-SpT	0,6844	0,0049	15
BI-SpI	0,5167	0,0584	14

The cross-sections in the suspension region are flat-rectangular (n=8), flat-elliptic (n=8), and triangular (n=3) (Figure 3). The knob in the case of item OH-16 has a robust, rather rectangular shape with a length (KL) of 0.61 cm and a similar thickness (KT) of 0.60 cm. The cross-section of the knob is slightly triangular, a shape more pronounced in the other parts of this specimen (Figure 3:7). A perforation is placed additionally, lower down the shank.

The gap measures how far the point is from the shank. Narrower gaps increase the chances of securing the prey and those hooks with wide gaps are efficient when it is necessary to release the capture fast and continue fishing. The bite/throat, in turn, represents the depth between the gap and the inner part of the bow. The spread, as shown, is influenced by the bow spread and the angle the point makes with the shank, essentially representing the maximum width of the hook. As for other parameters, the gap (0.50–1.00 cm), bite (1.11–3.13 cm) and spread (2.10–3.30 cm) could only be measured for the 4 specimens with intact bows.

Statistical Results

The results of the Shapiro-Wilk test indicated the data are normally distributed. All the results of Levene's Test and Fligner-Killeen Test revealed there are no significant differences between the hooks made of antler and those made of bone, and no distinguishable difference between the hooks found in pits, pithouses, ditches, or in the strata, with all p-values staying above the critical alpha. All results of Pearson's *r* computations are summarized in Table 5.

Direct plotting of shank length (ShL) against shank index (ShI), shows a decreasing relationship between them (Table 5). Nonetheless, we caution that the relationship is rather weak, with the p-value slightly over the critical alpha. Moreover, no clear group separation is formed based on the values of the ShL and ShI, as shown by the scatterplot in Figure 5. A partial grouping forms for items with ShI between 75 and 90 % and another one for those hooks with a ShI of 50 to 70 %, a few items exceeding these limits. Although, not a strong separation, this result indicates that about 80 % of the data fall in the two partial groups, based on the values of the width and thickness of the shank.

Taking separately the values of the shank width (ShW) and shank thickness (ShT) (Table 5), we observe that the two have no linear relationship, their dimensions evolving separately from each other (Figure 8). A similar result is shown when testing the suspension width (SpW) and thickness (SpT), where only a very faint partial correlation exists, whit a p-value over the significance level (Table 5). A similar trend is visible between the bow width (BW) and bow thickness (BT) where we note a partial positive relationship.

By directly plotting the SpW against SpT marking the different suspension system for each item (Figure 10), we wanted to determine if there is a differentiation of width or thickness for items having either 1 or 2 perforations, 1 knob and 1 perforation, or 2 probable perforations (for the cases of OH-08 and OH-18, where fragmented and ablated perforations were documented at the proximal end). Although at simple visual inspection several specimens (n=10) seem to display a gradual increase of the width along the shank and suspension, this is not confirmed by the results of our tests. Moreover, when attempting to compare the perforation diameters according to their placement in hooks with 1 or 2 perforations, we once more obtained an inconclusive result (Figure 9). The graphs show a faint separation between the values of single perforations by contrast to those of upper and lower perforations, but we believe that this is related to the low amount of data and possible measurement error, as the differences lie sometimes in the second decimal, being thus too small.

Although no correlation was established between the widths and thicknesses of the different hook parts, the relationships seem to be stronger across hook parts, particularly in what the thickness values are considered. The BW appears to have no linear relationship with the SpW and only a weak positive relationship with the ShW. However, considering the width values, we note a stronger partial, positive relationship between the ShW and SpW (Table 5), denoting that they increase proportionally. Plotting the indices of both shank and suspension, which take into account also the thickness in both regions, we observed an ascending linear pattern (Figure 7).

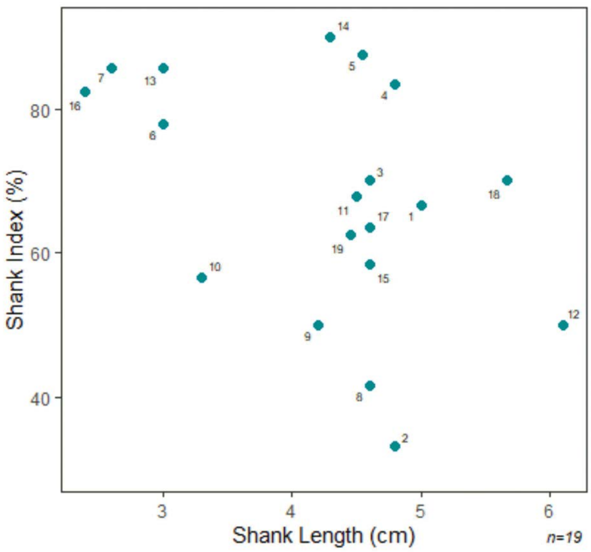

Figure 5. Scatterplot of the shank length (ShL) compared with the shank index (ShI) for all specimens in the analyzed sample. Point labels within the graph indicate the hook IDs.

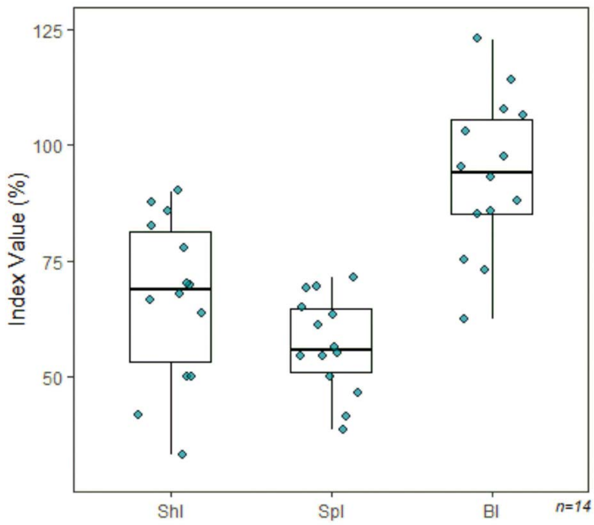

Figure 6. Box plots of values of shank index (ShI), suspension index (SpI), bow index (BI). Due to fragmentation impeding the calculation of the indices, five specimens were excluded.

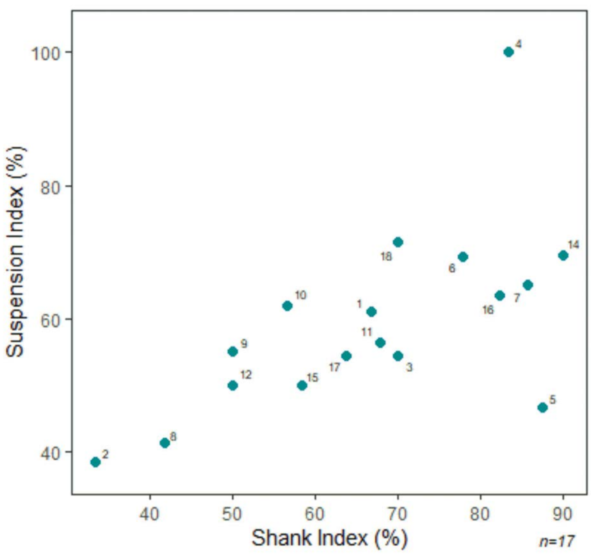

Figure 7. The relationship between the shank index (ShI) and suspension index (SpI).

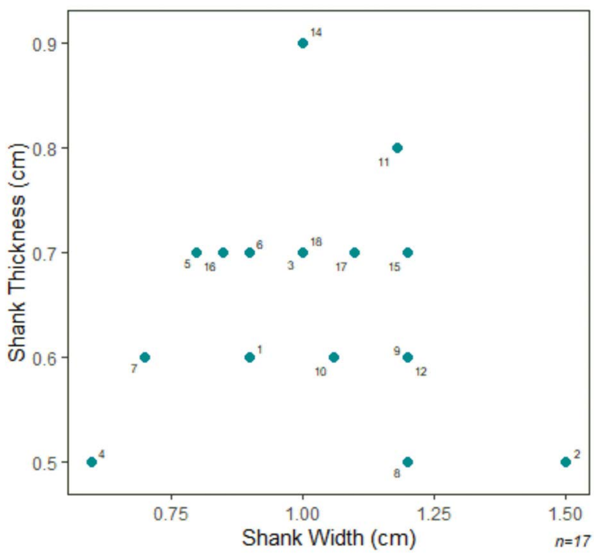

Figure 8. The relationship between the shank width (ShW) and shank thickness (SpT).

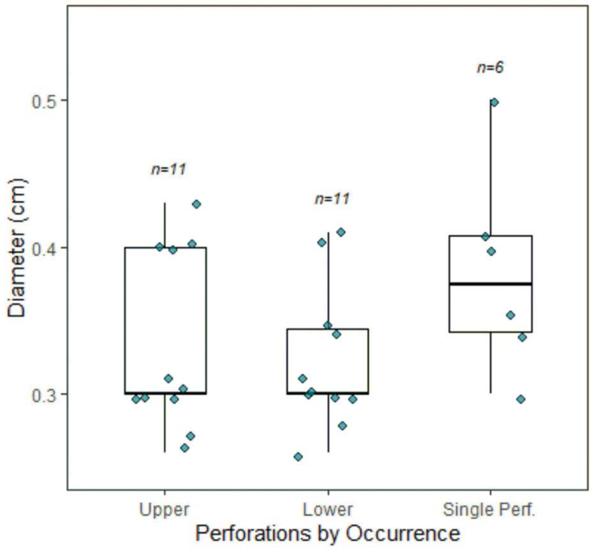

Figure 9. Box plots illustrating the perforation values classified according to their occurrence on the hook's suspension.

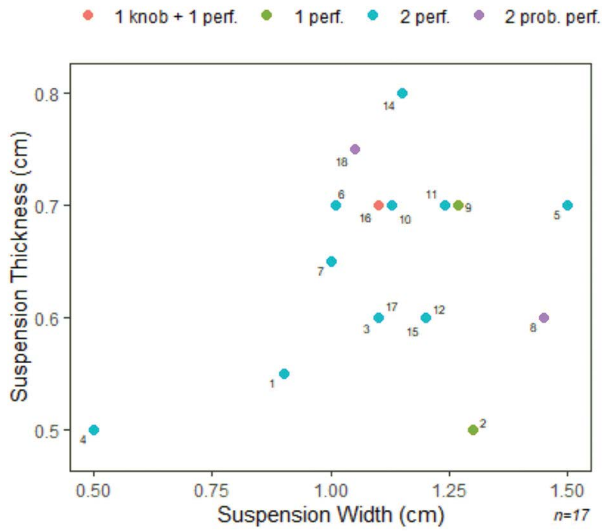

Figure 10. The relationship between the suspension width (SpW) and suspension thickness (SpT) showing the variations in hooks with different combinations of perforations. Two perforations were assumed (i. e. noted with 2 prob. perf.*) in those cases where a fragmented, ablated second perforation was observed at the proximal end.*

As mentioned, these relationships become stronger for thickness in the hook regions considered here: bow, shank, suspension. The strongest positive relationship is between ShT-SpT, followed by ShT-BT, and ultimately BT-SpT (Table 5). These results show that across the length of a hook (with the exception of the point, excluded here due to low data), there is a positive relationship between the thicknesses of each part, signifying that when the thickness increases in one region, it will accordingly increase also in the other 2 parts. The thickness values for Sh, Sp, B seem to support this assumption (Table 1). However, the width does not necessarily follow the same pattern, particularly regarding the bow. This is demonstrated by the graph comparing the indices of the Sh, Sp, and B (Figure 6), where the BI has higher values than the other 2 variables, owing to the fact that, in some cases, the thickness of the bow is higher than its width, which rarely happens for the shank and suspension.

Manufacturing and use-wear traces

The general picture regarding the species exploitation at Şoimuş provided by Mărgărit and colleagues (2016: 367) showed a prevalence of bone (88.35 %) as raw material, followed by deer antler (10.43 %). However, in the hook assemblage, we note a higher incidence of antler items (79 %) over those made of bone (21 %). Whether the antler was acquired through hunting or collecting could only in a few cases be determined, according to the same study (Mărgărit *et al.* 2016: 365), with only two items confirming the exploitation of shed roe deer antler.

The presence of a bone hook preform in the assemblage at Şoimuş contributed significantly to the reconstruction of the *chaîne opératoire* for the bone items. Unfortunately, the respective specimen (Mărgărit *et al.* 2016: Figure 16:2; see also Figure 11 in this study) was not available for the current report and, since we could not study it ourselves, we will refer mainly to the work of Mărgărit and collaborators (2016) when drawing parallels with the hooks analyzed here. The blank extraction was achieved by splitting the bone through percussion and segmenting the resulted piece to the desired size, by sawing. Abrasion was then used to flatten and smooth out the surface, removing debitage stigmata.

Drilling constituted an essential step in planning and extracting the rough shape of the future fishing hook. The bone preform (Mărgărit *et al.* 2016: 370, Figure 16:2) shows one completed bi-facial perforation in the region of the bow and an attempted, unifacial perforation near it. Three grooves spring from the perforations, delineating the shank and point of the future hook (Figure 11). Similar extraction methods have been documented before (Choyke *et al.* 1994; Gates St-Pierre 2010; Moore 2010). The preliminary perforation may have been intended as a manner of enlarging the bow region. The next stage in the process involved applying longitudinal scraping to shape the hook (Figure 12D) and sharpen its point. Bifacial perforations were then drilled and, lastly, abrasion was applied (Figure 12B, F), not always removing the cancellous tissue entirely (Figure 12C).

Among the antler specimens, there are 2 items (OH-05, OH-12) that can be qualified as unfinished, with a possible third one, having the cancellous tissue on the ventral side only partially smoothened (OH-10). A preliminary perforation placed close to the lateral-inner side of the bow region was documented for one of these unfinished antler specimens from Şoimuş (Figure 16G), pointing to a similar rough-out extraction for antler hooks as in the case of bone specimens. The prior blank preparation involved applying longitudinal percussion for the extraction of the desired cortical tissue from a beam segment, and transversal percussion to reduce it to size (Mărgărit *et al.* 2016: 370). Yet item OH-06 displays irregular indentations at the proximal extremity consistent with a prepared fracture with flexion, preceded by sawing (Figure 14B). Therefore, it can be estimated that at times this was the preferred segmentation method. This seems to be supported by OH-02, presenting skid marks from sawing in the same region.

The shaping of the hook from the extracted rough-out involved gouging the surface around the circumference of the hook, as demonstrated in OH-05 (Figure 13B, C) or scraping longitudinally, as indicated by the indents left on the inner side of the shank of OH-15 (Figure 17B). The shaping of the knob in specimen OH-16 was done through gouging and sawing a channel underneath the knob (Figure 18B), while on the shank longitudinal scraping was applied, as was the case of other hooks (Figure 18G; 14D).

Item OH-05, having the suspension region roughly shaped with the pearling still present, has the perforations already drilled through bifacial rotation (Figure 13A, D). It is not clear at which point the drilling was carried out, but with certainty before the final shaping of the hook. Another specimen, OH-08, having a particularly wide perforation, determined the expansion of suspension width. This meant a readjustment of the initial shape planning, which left behind one

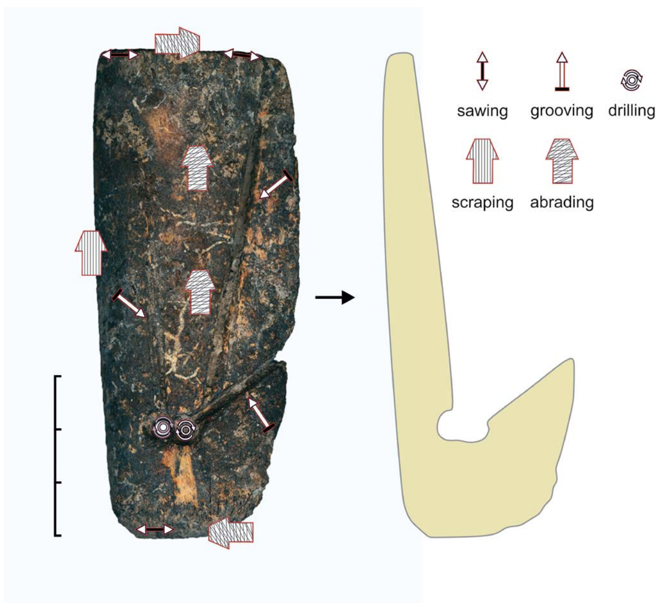

Figure 11. Bone preform of a fishing hook (left) and the sketch of a possible extracted rough-out (right) (modified and appended after Mărgărit et al. 2016). Technical symbols (modified after Averbouh 2000) indicate the procedures used in order to trace the outline of the hook. Scale units in cm.

groove from the initial extraction process, a groove which was then intersected by the perforation as detailed in Figure 15D, G. Based on these two examples, it can be assumed that, at least in some cases, the perforations were drilled as early as immediately after extracting the rough-out.

As illustrated, drilling was an important stage in the manufacturing process, as at least one perforation is present in all the specimens. In all cases, the drilling was applied from both sides of the object until the material was pierced through and the required diameter was achieved (Table 4). The inner shape of the walls is bi-conical (see cross-section in the suspension region, Figure 3) and often shows rotary technological traces (Figure 13G; 15D; 17F) in the form of concentric striations (Olsen 1979: 345; David 2004: Fig. 13; Gurova *et al.* 2013; Cristiani and Borić 2016). These striations are visible also on the outer edges, which vary in size, depending on the shape and size of the drill (Figure 12C; 13D; 16B, E), which defines also how conical the inner walls would become (Olsen 1979: 345). Experimental studies (Gurova *et al.* 2013) have shown that mechanical drillers will achieve a more conical inner wall by contrast to handmade drilling. The supposition of using a mechanical driller for the hooks from Şoimuş is supported by the occurrence in four specimens of 'parasite', unfinished perforations with U-shaped profiles (Figure 13G; 16F, G; 17C, D). It has been suggested (Cristiani and Borić 2016: 179) that these occurrences are the result of the mechanical driller not getting a grip on the surface being perforated, which causes a skid, leaving a shallow preliminary perforation. This seems like a justified presumption since in three of these cases the skid marks accompany finished perforations.

After shaping the hook, the antler specimens were finished as in the case of the bone hooks, through abrasion, applied on the dorsal (Figure 14C) and lateral surface of the shank (Figure 15F), on the bow (Figure 14G), as well as on the proximal (Figure 15B, C; 17F; 18B) and distal (Figure 13H, I) extremities. A distinct abrasion pattern, having a hatching aspect, resulted from repositioning the item during the process (Figure 18D).

Several antler specimens (n=5) show also a particular grouping of striations, transversally arranged on the inner side of the bow. These striations are straight, narrow, closely spaced, and smooth (Figure 12E; 15E; 18C; 17H). They are mostly parallel to each other, but they can be also crossed in zig-zag patterns (Figure 18). In all the cases they migrate on the lateral sides of the bow too and sometimes on the shank (Figure 17G, I) or towards the point (Figure 14E). They cannot be separated into bands and their pattern suggests an abrading process, possibly with a tool with mixed graining which determined alternating shallow and deeper striae.

Similar traces were noted in bone instruments used experimentally in smoothening pottery (Maigrot 2010) and working rush (Buc 2011: 18). Since for the hooks these two activities would be unlikely, we argue that the traces may have been produced by moving back and forth a handheld stone file or an abrading fiber to regularize the otherwise inaccessible region of the bow. The theory of using handheld stone tools for osseous hooks was explored in other studies (Charpentier *et al.* 1997; Cavulli *et al.* 2009; Bergsvik *et al.* 2015), indicating also that the disposition of striae need not be limited to a transversal arrangement (Le Dosseur 2004: Fig. 20; Vinayak 2016: 368). We propose, further, that the employment of such a file was not restricted to the concave side of the bow, and that also the inner sides of the shank and the point have been regularized using this kind of technique, as the presence of the point would not allow grinding these regions on a large slab. Slight polish was noted around the circumference of some of the finished perforations (Figure 12C; 15G; 17C), one item presenting also a small compressed area on the right side (Figure 17B). Invasive polish was documented also around the circumference of the point in two cases (Figure 12G; 18F). Incidentally, these are also the specimens with shorter points, seemingly as a result of usage and re-sharpening.

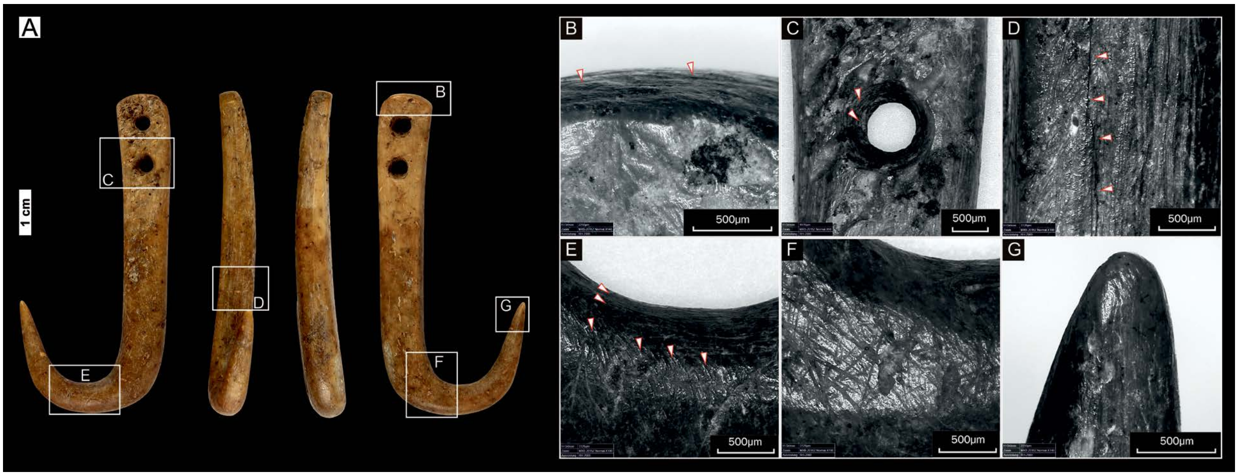

Figure 12. A) Bone specimen OH-03, views of the ventral, lateral inner, lateral outer and dorsal sides. Close-up images showing: B) proximal end finished through abrasion and invaded by macroscopic polish; arrows indicate the faint striation traces (140x); C) detail of the drilling with visible polish on the outer edges of the perforation (60x); note also the traces of cancellous tissue incompletely eliminated; arrows indicate the different concentric rotary traces; D) longitudinal scraping traces located on the lateral inner side of the specimen (100x); note also the longitudinal crack pointed by arrows; E) closely spaced parallel striations located on the ventral and lateral inner sides of the bow (100x); arrows indicate the orientation of the striae; F) intersected shallow striations located on the ventral side of the bow (100x); G) detail of the point with invasive polish and roundness at the distal extremity (140x).

Figure 13. A) Antler preform OH-05, views of the dorsal, lateral inner, lateral outer and ventral sides. E) Antler specimen OH-13, views of the ventral, lateral inner, lateral outer and dorsal sides. Magnified images showing: concentric rotary traces from the drilling process of the lower perforation D) (60x) and details of chiseling on the lateral outer side B) and lateral inner side C) of the bow (60x); arrows indicate the formed facets. F) detail of the fragmented perforation with middle rib indicating a bi-facial drilling process (60x); note also the presence of partly smoothened cancellous tissue, H) determining light surface delamination also on the lateral inner side of the point (100x); G) detail of the completed, then fragmented perforation and of the preliminary perforations (60x); I) close-up of the faceted point, showing partly ablated longitudinal striations and the rounding of the tip (100x).

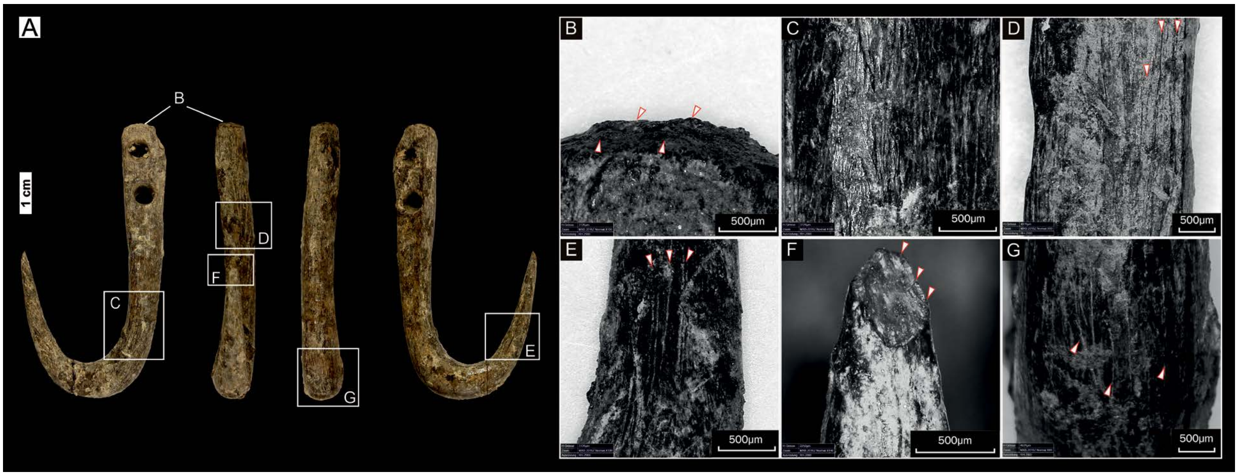

Figure 14. A) Antler specimen OH-06, views of the dorsal, lateral inner, lateral outer and ventral sides. Magnified close-ups showing: B) sawing marks at the proximal extremity with leftover irregular indentations suggesting a prepared fracture with flexion (100x); C) longitudinal abrasion striae overlapping scraping traces (60x); D) longitudinal scraping traces with adhesive depositional wear (100x); E) longitudinal abrasion striae on the inner side of the point (100x); F) detail of the feather terminating bending fracture of the point, note the roundness and patination on the edges (140x); G) longitudinal fine striae on the lateral outer side of the bow (60x).

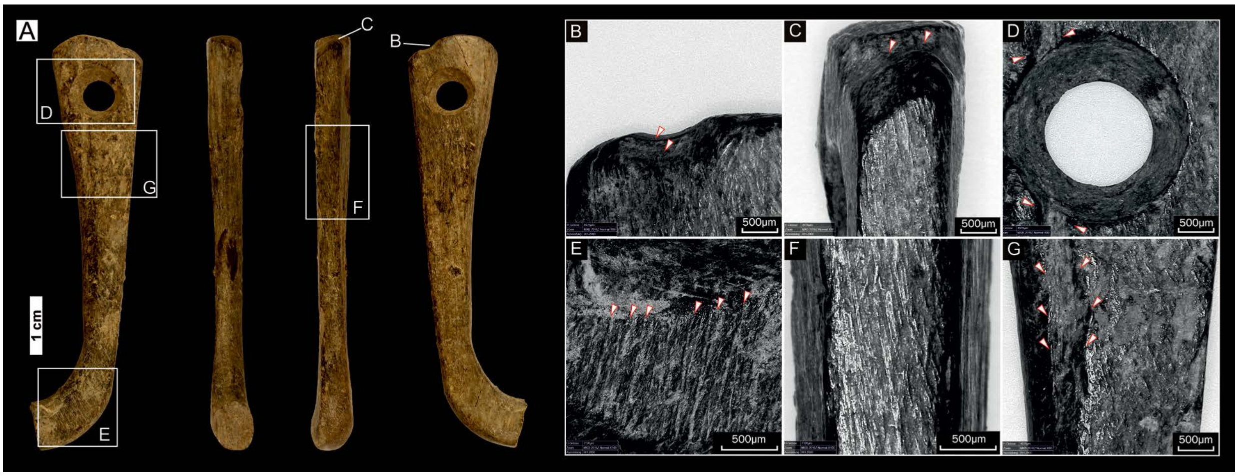

Figure 15. A) Antler specimen OH-08, views of the dorsal, lateral inner, lateral outer and ventral sides. Magnified images showing: B) and C) details of a fragmented perforation at the proximal extremity (60x); fragmentation traces were ablated and the region was smoothened almost entirely; arrows indicate the rotary traces of the perforation and the central rib indicating a bi-facial drilling process; D) the perforation intersecting the initial groove delineating the preliminary shape of the hook (60x); arrows indicate the groove channel as well as the rib left by the drilling process at the edge of the groove channel, making it ulterior to the grooving process; more details of the groove are visible and pointed by arrows in image G) (60x); E) closely spaced parallel striations located on the ventral side of the bow; arrows indicate the orientation of the striae (60x); F) abrasion traces on the lateral outer side of the shank (100x).

Fracturing

Although antler and mammalian long bones can essentially be regarded as thick-walled tubes with similar microstructure and chemical compositions (Chen *et al.* 2009), there are many particularities separating the two materials into very different categories. To start, each of the materials plays a very specific function in nature, withstanding each a certain kind and level of stress, which requires them to have a particular overall architecture (Currey *et al.* 2009; Landete-Castillejos 2012; Landete-Castillejos *et al.* 2019). A comparison between the two materials shows that hydrated antler has the highest fracture toughness when emerging cracks have a transversal orientation, while the lowest is that of dry, long bone in longitudinal orientation (Chen *et al.* 2008). The elasticity of bone is gradually lost as it dries, while the mineral content, namely the calcium hydroxylapatite, increases (Bradfield 2016).

Of all the 19 specimens studied, only 10.5 % (n=2) are preserved without signs of breakage, the remaining 89.5 % (n=17) registering fractures in at least one region. The majority of the breaks are of ancient date, with only two determined as recent and another two indeterminate. A total number of 26 complete breaks and cracks were documented, of which the majority are snap fractures, amounting to 50 % of the total, followed by embryonic bending fractures or cracks (19 %), feather termination fractures, and step termination fractures in equal ratios (12 %), while the remaining 7 % are indeterminate breaks.

The region with the highest incidence of rupture is the bow region, as also shown by other studies (Allen 1996; Olson *et al.* 2008), with 84 % (n=16) of the total amount of hooks from Şoimuş undergoing at least one kind of fracture in this region, granted that the assemblage is rather small. The breaks in the bow region can be determined as bending fractures, 11 of them falling in the category of snap bending fractures (Figure 17), 1 in that of feather terminating fractures (Figure 13C), and 2 in that of step terminating fractures (Table 6). Their propagation is longitudinal, as the planning of the hooks involved aligning the blank in the direction of the antler or bone growth to achieve the desired length. This is demonstrated by a few specimens (OH-01, OH-05, OH-13) where the concavity of the bone and antler bone channel has not been reduced and the orientation of the natural curvature is visible in the bow region (Figure 3:3; 13A, E). Under load, material fatigue installs, embryonic fractures, or cracks then form and propagate longitudinally until complete detachment. Cracks in a transverse orientation tend to deflect from the original path upon encountering osteons, resulting in surface delamination, while in longitudinal orientation cracks propagate linearly along the osteons (Figure 12D). In several cases, cracks accompany other fractures (Table 6) and, in two specimens (OH-12, OH-19), they most likely determined interlamellar separation (Figure 16A, B, D). As OH-12 is likely an unfinished hook, as is OH-05, it can be expected that failures in the material, as well as poor handling, can lead to fragmentation even when the item is not in use.

In the studied hook assemblage, the transversal cracks are present in only 4 specimens, out of which 3 are located in the suspension region. In all these 3 cases they are likely to be caused by the perforations, which significantly weakened the hook structure in the area, by leaving too little bone as support on the lateral sides (Figure 3:1, 5; 13F, G; 16B). Potentially this was the case also for specimens OH-08 (Figure 15B, C) and OH-18 (Figure 17F), which present ablated former perforations at the proximal extremity. One other transversal fracture is located at the tip of the point, where the region is very thin and frail (Figure 14F).

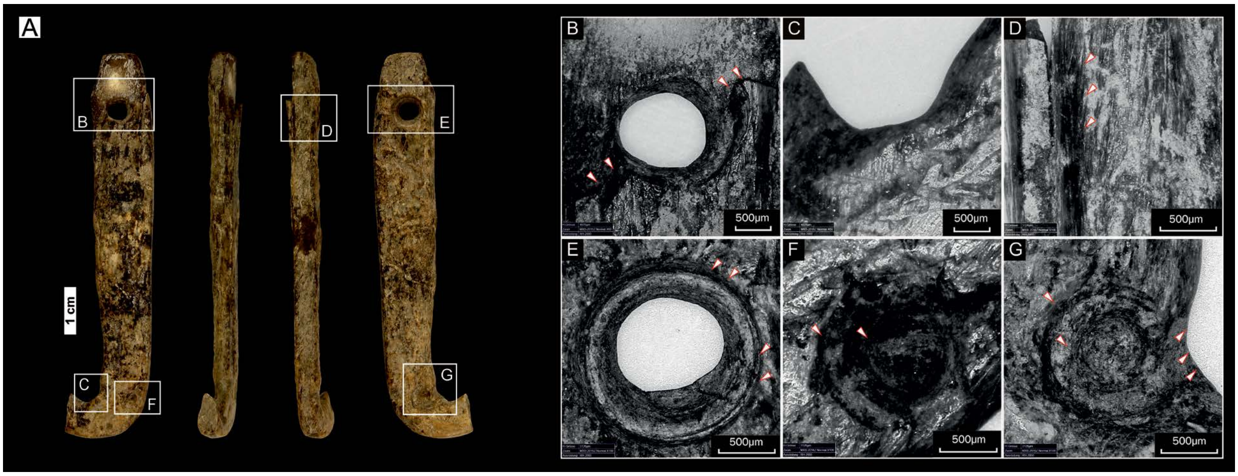

Figure 16. A) Antler preform OH-12, views of the dorsal, lateral inner, lateral outer and ventral sides. Close-up images: B) detail of the exfoliation in the cortical bone at the proximal extremity, around the perforations with detachment of a fragment of the dorsal cortical bone (60x); arrows indicate the interlamellar separation; this aspect is visible also from the lateral view in image D) (100x); C) detail of the bow region with the narrow opening, indicating only a slight enlargement of the perforation drilled to extract the rough-out hook (60x); possible remains of the perforation are visible in image G), marked by the arrows pointing to the inner edge of the bow; no abrasion traces are present in the region; E) view from the ventral side of the completed perforation shank (100x); arrows indicated the accentuated rotary traces; F) preliminary perforation on the outer edge of the bow located on the dorsal side shank (100x) and on the inner edge of the bow on the ventral side G) shank (100x); note the same accentuated rotary stigmata.

Direct evidence for fishing

More than 50 fish species have been recorded along the entire Mureş River (Nalbant 1995), out of which only two are endemic – loach (*Sabanejewia aurata*) and gudgeon (*Gobio gobio muresia*) – other four being exotic. It can be expected that the fish population in the river has suffered changes through time, due to anthropic interventions or environmental factors. Fish remains are altogether missing from Şoimuş, presumably due to several reasons connected to taphonomic factors and recovering techniques. But, as is it likely for the catch site to coincide with the consumption site at Şoimuş, considering the proximity with the watercourse, the total lack of fish remains is rather intriguing. Yet, this is not a singular case, as the presence of fish bones is very reduced in the region, several sites registering rather low amounts of fish bones, despite the close connection to waterscapes and the presence of fishing tools (Kalicz *et al.* 1987; Raczky 1987; Vitezović 2019).

Data provided by hand-collected zooarchaeological assemblages at other prehistoric sites in the neighboring regions (Bartosiewicz *et al.* 2008; Bartosiewicz and Bonsall 2004) regularly contain remains of various Sturgeon species (*Acipenser sp.*), large carp (*Cyprinus carpio*), catfish (*Silurus glanis*), pike (*Exos lucius*) and sometimes pikeperch (*Stizostedion lucioperca*), owing to the size they can reach. All these species either live currently in the Mureş River, although not in all the sectors, as fish are bound to their respective aquatic habitats (Bartosiewicz and Bonsall 2004), or they migrate seasonally here.

Figure 17. A) Antler specimen OH-15, views of the ventral, lateral inner, lateral outer and dorsal sides. E) Antler specimen OH-18, views of the ventral, lateral inner, lateral outer and dorsal sides. Microscopic images detail: B) indents created during the scraping of the shank, indicated by arrows (100x); C), D) skid/preliminary perforations visible also macroscopically on the dorsal side next to the completed perforations (60x); arrows indicate the edges of the preliminary perforations; note also the rotary stigmata in both cases; F) a fragmented perforation at the proximal extremity (40x); fragmentation traces were afterward ablated and the region was smoothened almost entirely; arrows indicated the edge of the perforation and the central rib indicating a bifacial drilling; closely spaced abrasion traces located on the ventral side of the shank G) (60x), ventral H) (100x), and lateral I) (60x) sides of the bow; arrows indicate the orientation of the striae.

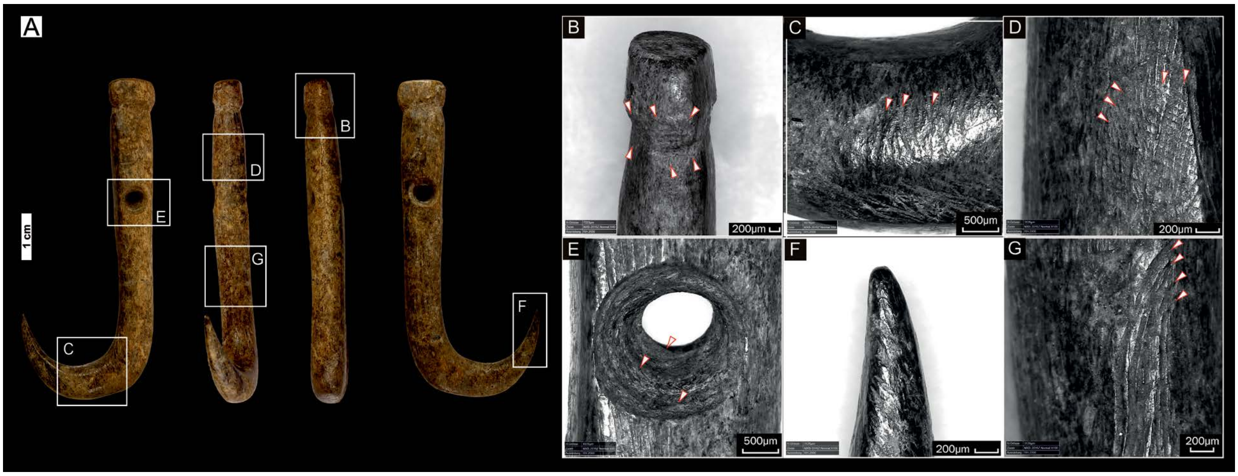

Figure 18. A) Antler specimen OH-16, views of the ventral, lateral inner, lateral outer and dorsal sides. Close-up images showing: B) sawing and gouging stigmata from creating the knob (40x); C) parallel and intersecting closely spaced striae located on the ventral side of the bow (60x); arrows indicate the orientation of some of the striae; D) abrasion stigmata with repositioning of the specimen (100x); E) details of the drilling traces (60x); arrows indicate the rotary striae; F) invasive usage polish covering the distal extremity (100x); G) longitudinal scraping stigmata located on the inner lateral side of the shank (100x).

TABLE 6. SUMMARY OF FRACTURE TYPES AND THEIR POSITIONS.

Hook ID	Fracture region	Ancient/ Recent	Fracture type
OH-01	bow	ancient	snap
OH-02	bow	ancient	snap
OH-03	-	-	-
OH-04	bow	ancient	feather term.
		ancient	step term.
OH-05	bow	ancient	feather term.
OH-06	point	ancient	feather term.
	bow	indet.	snap
OH-07	bow	ancient	snap
OH-08	bow	ancient	embryonic
		ancient	snap
	suspension	ancient	embryonic
OH-09	bow	ancient	snap
OH-10	bow	ancient	snap
OH-11	shank	ancient	embryonic
	suspension	ancient	embryonic
	bow	ancient	snap
OH-12	suspension	recent	step term.
	bow	ancient	snap
OH-13	suspension	indet.	indet.
OH-14	bow	ancient	snap
OH-15	bow	ancient	snap
	shank	ancient	embryonic
OH-16	-	-	-
OH-17	bow	ancient	snap
OH-18	bow	ancient	snap
OH-19	suspension	recent	indet.
	bow	ancient	step term.

Analogies

Despite clear direct and indirect proofs for fishing in Transylvania, Tisza, and Lower Danube Regions during the Late Neolithic, osseous J-shaped hooks occur at a rather low rate, making up for a handful of published items. Zalai-Gaál (1983) and Choyke and Bartosiewicz (1994) offered brief overviews of fishing hooks from the Tisza, Vinča, and Lengyel cultural milieus, giving an insight into the local and temporal developments in terms of hook morphology. From different sites in the Tisza milieu, very few bone and, exceptionally, boar tusk specimens are known (Raczky 1987; Choyke and Bartosiewicz 1994; Choyke and Daróczi-Szabó 2010). Three bone hooks were recorded in the Tisza levels at the site Vărşand–*Viezurişte* (Popescu 1956: 57/6,8,9) all fragmented in the bow region and having notches on the shank toward the head of the hook, likely as a suspension mechanism. The same system was noted for the boar tusk item found at Öcsöd–Kováshalom (Raczky 1987: 25/13; Choyke and Bartosiewicz 1994: Figure 1:3), as well as for a bone specimen from the Neolithic levels at Berettyóújfalu–Herpály, accompanied by a bone hook equipped with a knob (Kalicz *et al.* 1987: Fig. 39). Notches with a similar aspect were recorded also for a hook coming from the Vinča cultural space, more exactly from the site at Selevac (Tringham *et al.* 1980: Fig. 29; Russell 1990: Fig. 14:3a). Fishing hooks are rather infrequent also in the mentioned Vinča milieu, with the notable exceptions of the sites at Gomolava (Vitezović 2016; Vitezović 2019) and Vinča–Belo

Brdo itself (Vasić 1936) where an assemblage of bone lure hooks was also documented (Cristiani *et al.* 2016). The collections at Gomolava and Vinča – Bello Brdo are comparable to those at Şoimuş–*La Avicola* in terms of amounts and materials utilized. However, the shapes present significant differences, such as the suspension mechanism typically taking the form of a knob (Vasić 1936; Babović 1984). Besides this element, Vinča osseous hooks are sometimes equipped with barbs that can be placed on either side of the point (Choyke and Bartosiewicz 1994: Fig. 3:2). It cannot be excluded that at least some hooks from Şoimuş–*La Avicola,* or other sites mentioned here, also had barbs initially, which are not discernable due to the frequent rate of fragmentation in the bow region.

Perhaps the closest parallel to the fishing hooks at Şoimuş is found in the hook collection from the site at Turdaş–*La Luncă*, located in the vicinity of Şoimuş, on the opposite bank of Mureş River. Five hooks (Figure 19:5, 6, 8-10) and a possible preform (Figure 19:7) were published by Roska (1941: LXXIII/1-3, 10-13), most of them made of antler with 2 items unspecified. Two of the hooks, fragmented in the bow region, have sizes and shapes equivalent to those at Şoimuş, presenting one (Figure 19:5) and two perforations (Figure 19:6). Three other specimens are much larger (see Figure 19:6-8) and have no perforations, one item being comparable to those in the Vinča milieu (Figure 19:8). Another stylistically similar item, albeit also fragmented in the bow region, was recovered from the Lengyel site at Mórágy-Tüzködomb (Zalai-Gaál 2003: Fig. 2:2). Of a rather small size, the item has one perforation and a slightly triangular head similar to hooks at both Turdaş (Figure 19:5) and Şoimuş (Figure 3:8, 17, 18).

One more comparable item, although much younger, comes from the Eneolithic site at Vinitsa (Raduncheva 1976: 50/2), in northeast Bulgaria. The hook, fragmentary as well, is made of bone, has a length of ca. 6.8 cm, two perforations, and a rounded head (Figure 19:4), as seen in hook OH-03 (Figure 3:2). Double perforations are rare in this region too and even more outstanding are the hooks with three perforations from the Eneolithic site at Ruse (Tringham 1971: Fig. 26L; Chernakov 2009: Fig. 29). It can be imagined that a different kind of suspension was used in that respective case, and likely a different fishing technique altogether.

Discussion and conclusions

The selectivity of prey when fishing with a hook and line device depends on the size of the hook, thickness, and strength of the line, and the bait used. The line used in fishing with hook and line needs to have just the right thickness and strength to be able to secure the prey, but at the same time be as little noticeable as possible, depending on the fish and fish habitat exploited (Salls 1989: 183; von Brandt 2005: 95). The reasoning behind shaping the hook parts can be seen as a combination of stylistic and practical requirements. For instance, the diameter of perforation had to be wide enough to have the cordage passing through. However, this diameter cannot be increased endlessly, as this would increase the width of the suspension as well, which would make the hook heavier, more visible, and likely unusable. Evidence of cordage at Şoimuş exists indirectly through the presence, for instance, of loom weights, but the nature of the line used is escaping us. Considering the function of the second perforation in hooks, it has been suggested that fishhooks need to be weighted (Rau 1884: 49; Stewart 1982: 30–31), and there are examples of items interpreted as hooks sinkers (Karmanski 2005: 48). Alternately the hook can have a buoy attached to make it float in a certain manner (Velušček 2004: 41). We could assume that the second perforation was used to attach either of the two, which would speak for a particular technique. Whether or not there was indeed an intended difference between the diameters of items with 1 and 2 perforations, resulting from a distinct way of suspending the hooks and of using them altogether, is rather difficult to establish at this point with the amount of data available.

We have observed that the thickness of the hooks tends to stay constant across their parts, which can be regarded as a result of longitudinal scraping and abrasion against a slab, which determines them to have uniform dorsal and ventral surfaces. We could imagine that shaping the shank, at least on the inner lateral side must have been more rigorous and not always as precise, leading to uneven widths, which by coincidence are higher in the suspension region. But we consider this aspect to be closely related to the planning of the hook's shape, which involved allowing enough broadness for the perforation. It could be expected that in at least some cases the drilling in the suspension region preceded the shaping of the shank, in which situation, an already existing large perforation would impose a wider suspension region.

A similar practical reason can be considered for the bow region for which the width does not increase as much as in other regions. This appears not to happen even in those cases where the thickness tends to be higher, resulting in bows that are more thick than wide. Besides, the bows tend to have more robust cross-sections, the circular and rectangular ones predominating (Figure 3), while for the shank and suspension we see more a tendency toward flat-rectangular and flat-elliptic cross-sections. The bow region being the most likely to withstand fracture was discussed previously (Allen 1996; Olson *et al.* 2008), pointing to the necessity to reinforce this region up to a point which does not affect the proper functionality of the hook. In the mentioned study Allen (1996) suggested that one method of reducing the stress on the bow involves thickening this region. When the thickness is restricted to a certain size, one way of achieving this is by decreasing the bow width.

The hooks' spatial distribution (see Figure 2) could be interpreted as forming two concentration areas, one in the north-eastern part of the research perimeter, and the other in the central-western region.

We could not distinguish any significant dispersal pattern of hooks bearing one or two perforations, the items in quadrant E11, for instance, representing both categories, within the area of 4 m^2. However, wenote that the bone specimens all cluster in the north-eastern part, although, arguably, their number is fairly low (4 items).

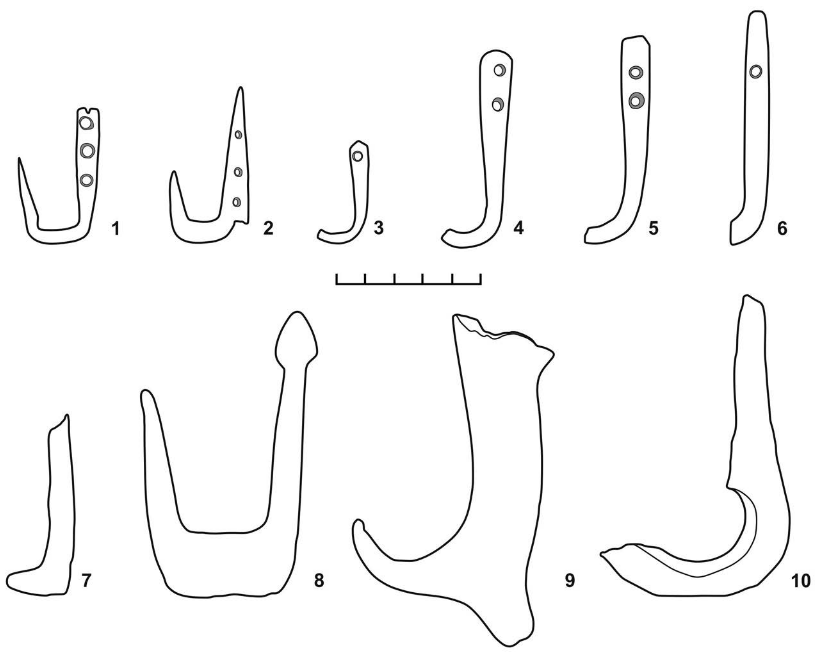

Figure 19. Drawings of osseous hooks from 1, 2 Ruse (modified after Chernakov 2009, fig. 29 (1) and Tringham 1971, fig. 26/l (2); mirrored) 3 Mórágy-Tűzkődomb (modified after Zalai-Gaál 2003, fig. 2/2; mirrored), 4 Vinitsa (modified after Raduncheva 1976, fig. 50/2; mirrored), 5-10 Turdaş-La Luncă (modified after Roska 1941, plate LXXIII/1-3, 10-13). Scale units in cm.

The most frequent items occurring alongside hooks in the features are summarized in Table 2. The occurrence of fishing hooks in 2 of the 8 features containing human remains is without doubt notable. In the case of pithouse C 62, 2 fragmented antler hooks were found (OH-04, OH-13; Figure 2) alongside a human cranium, showing traces of a possible healed trauma. Worth mentioning is also the presence of fragmented hooks inside pithouses (Table 2), while the 2 entire specimens are found exclusively in pits (not counting OH-06, broken and restored, for which the fragmentation in the bow region is of unknown date).

Equipment designed for hunting or fishing is intended to be used off settlement and likely to be lost there or to suffer fragmentation beyond repairment, leading ultimately to abandonment. The presence of such a large number of hooks, even if largely in a fragmentary state, within the settlement has possibly to do with the location of the site directly next to the watercourse. We might imagine that the hooks were brought back from the fishing spot together with the catch, potentially still embedded in the flesh, the attempt of removing them possibly leading to fragmentation. Similarly, it is safe to assume that what is left to study in terms of retrieved objects is an incomplete picture of the original toolkit.

Due to the high rate of fragmentation and the small sample we cannot identify different types unless based on the number of perforations. The assemblage has overall a homogenous aspect, suggesting a planned, systematic production process, involving specific raw materials, selected for their morphology and physical properties, specific proportions between the different parts, and a rather uniform overall length. All these aspects speak for a skilled behavior, not just in what production is concerned but most likely in the fishing process as well and it can be argued that such tools, due to their size, which filters out the smaller fish species, were possibly used in an organized, collaborative manner.

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Hunting and fishing equipment in the Neolithic period in the central Balkans

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Abstract

The Neolithic in the central Balkans and adjacent areas is characterised by the Early and Middle Neolithic Starčevo culture, part of the Starčevo–Körös–Criş cultural complex, and the Late Neolithic Vinča culture. Their subsistence was based on agriculture and animal herding, although hunting and fishing also had a certain role. Currently available faunal data show that there are considerable regional differences, probably linked to geographical and ecological conditions, in the ratio of wild fauna and represented species.

In this paper, we will present an overview of the current evidence for the hunting and fishing equipment made from diverse raw materials (bone, antler, chipped stone, ground stone, etc.), and analyse their role and possible hunting and fishing techniques used. Osseous raw materials were widely used for production of projectile points, harpoons and fish hooks, often very carefully made, with a large labour and skill investment. On the other hand, chipped stone artefacts that can be associated with hunting or fishing are rare. Ground and polished stone objects include weights for fishing, and some are associated with specific fishing techniques applied in the Early Neolithic in the Iron Gates, on whirlpools of the Danube. Also, some of the ceramic artefacts can be associated with fishing, such as weights, and hunting, such as possible sling bullets.

Keywords: Hunting; Fishing; Hunting and fishing equipment; Projectile points; Fish hooks; Fishing weights; Central Balkans; Neolithic

Introduction

One of the most important hallmarks of the Neolithic period, in fact, the very definition of it, is subsistence based on agriculture and animal husbandry. That also implies a decrease in hunting and fishing activities; nevertheless, hunting and fishing as a supplementary source of animal protein, source of raw materials such as fur, etc., or simply an activity of social and/or symbolic significance, did not completely disappear.

In the central Balkans and adjacent areas, the Neolithic is characterised by the Early and Middle Neolithic Starčevo culture, part of the Starčevo–Körös–Criş cultural complex, and the Late Neolithic

Vinča culture. Their subsistence was based on agriculture and animal herding. Hunting and fishing were not entirely abandoned, however, the evidence available for scale, significance or techniques that were used is somewhat limited. Faunal analyses are available for selected sites only, and some of the analysed assemblages have sample bias, since the faunal remains were mainly hand collected, even selectively collected at some of the excavations carried out in the first half or mid-20th century. Artefacts that may be related to hunting and fishing activities were usually presented along with other artefacts and seldom analysed separately; furthermore, the interpretation of some of them is sometimes ambiguous and it is possible that some were not interpreted or published in an adequate manner.

In this paper, we will present an overview of the currently available data on fishing and hunting implements from both the Early and the Late Neolithic period from Serbia, based on our analyses and published data.[1] Artefacts that may be interpreted as being used in hunting and fishing include fish hooks, projectile points and harpoons made from bone or antler, stone mallets, chipped stone arrowheads, stone and clay fishing weights, and stone and clay sling bullets. Throughout the Neolithic period we may note great diversity in typology and morphology of these items, as well as great differences in frequency and regional distribution. Faunal data show some regional differences as well, thus reflecting some local traditions and preferences, and also, at least to a certain extent, regional differences in subsistence and economy – some of them correlated with geographical and ecological conditions.

Hunting and fishing equipment in the Early Neolithic Starčevo culture

Archaeological background

The Early/Middle Neolithic Starčevo culture is a part of the Starčevo–Körös–Criş cultural complex. It was widespread in present-day Serbia and adjacent areas – eastern parts of Croatia, Bosnia and Herzegovina, and northern parts of Montenegro (Garašanin 1979; Srejović ed. 1989) in the period between 6200–5500 calBC (Whittle *et al.* 2002).

As mentioned above, the faunal record from Starčevo culture sites is somewhat uneven in quality and sample bias is present. Certain regional differences may be observed, but the domestic animals prevail at the majority of analysed sites. In the region of Vojvodina, part of the Pannonian plain, faunal analyses from the sites of Starčevo–Grad, Donja Branjevina and Ludaš–Budžak show the predominance of domestic animals (Figure 1). At Starčevo, situated on the banks of the Danube in the southern Banat region, domestic animals comprised about 65% of the fauna. The most frequent was cattle (*Bos taurus*) (cca 66%), followed by sheep and goats (*Ovis aries / Capra hircus*) (30%), domestic pigs (*Sus scrofa domestica*) and dogs (*Canis familiaris*). Among wild species, red deer (*Cervus elaphus*) and wild pigs (*Sus scrofa*) were the most frequent, followed by aurochs (*Bos primigenius*) and small percentages of *Equus przewalski*, badgers, otters, small carnivores, rodents, fish and birds (Clason 1982). At Ludaš, domestic animals comprised about 80%; caprinae being the most frequent (68%), followed by cattle (10%). Limited amounts of remains of red deer, aurochs and roe deer (*Capreolus capreolus*) were found, as well as fish and birds (Bökönyi 1974: 436). Caprinae were also the most frequent at Donja Branjevina (approximately 50% of domestic fauna), followed by cattle and limited amount of pigs. Wild species included aurochs, red deer, roe deer, as well as small percentages of otters and small carnivores. Faunal remains also included birds (*Otis tarda* and unidentified species), fish (*Silurus glanis, Esox lucius, Cyprinidae*), and tortoise (*Emys orbicularis*) (Blažić 2005: 74-76).

[1] See references for individual sites and finds further in the text.

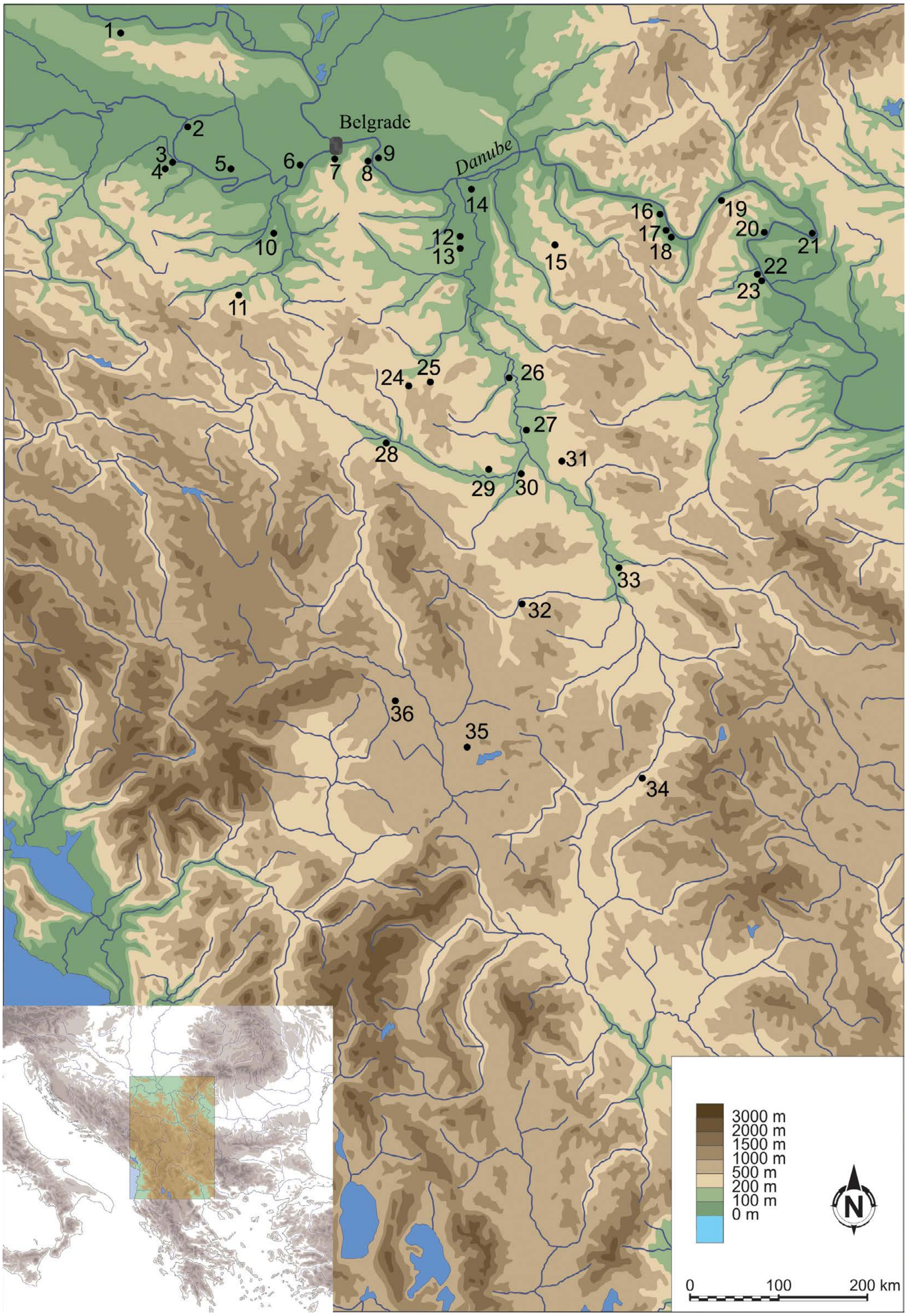

Figure 1. Map showing the sites mentioned in the text: 1. Golokut, Vizić, 2. Gomolava, 3. Benska Bara, Šabac, 4. Popovića Brdo, Zablaće, 5. Baštine, Obrež, 6. Kormadin, Jakovo, 7. Žarkovo, 8. Belo Brdo, Vinča, 9. Starčevo, 10. Mali Borak, Kolubara, 11. Petnica, 12. Selevac, 13. Zmajevac, 14. Orašje, Dubravica, 15. Belovode, 16. Padina, 17. Lepenski Vir, 18. Vlasac, 19. Hajdučka Vodenica, 20. Velesnica, 21. Zbradila, Korbovo, 22. Ušće Kameničkog potoka, 23. Knjepište, 24. Grivac, 25. Divostin, 26. Međureč, 27. Drenovac, 28. Divlje Polje, Ratina, 29. Blagotin, 30. Ornice, Makrešane, 31. Crnokalačka Bara, 32. Pločnik, 33. Bubanj, 34. Pavlovac, 35. Rudnik, Srbica, 36. Predionica.

In central Serbia, at the site of BatAševo, near the modern town of Mladenovac, the faunal assemblage was also predominantly composed of domestic animals, 93% in total. The most frequent species were sheep, goats and cattle, followed by pigs and dogs. Wild species included red deer, roe deer, wild boar and hare (*Lepus europeus*) (Marković *et al.* 2018: 31; Vitezović *et al.* 2020). At the site of Divostin, situated near the town of Kragujevac, domestic fauna was also predominant with over 90%, with cattle as the most common species (47%), followed by caprinae. Remains of domestic and wild pigs, red deer, aurochs and dogs were noted as well (Bökönyi 1988).

Only the region of the Iron Gates in eastern Serbia showed a somewhat different picture, with a greater ratio and diversity of wild species; presumably, the geographical setting is correlated with a different economic basis. The preliminary results of the faunal remains from the site of Ušće Kameničkog Potoka showed the predominance of wild fauna, mainly wild pigs and red deer; goats, cattle, fish and birds were also present (unpublished preliminary results by S. Bökönyi are cited in Stanković 1986a). At the site of Knjepište, domestic fauna comprised about 82%, with a predominance of cattle and caprinae and small quantities of pigs and dogs. The wild fauna included a variety of species – red deer with approximately 22% was the most frequent, followed by aurochs, red deer, roe deer, wild pigs, chamois (*Rupicapra rupicapra*), brown bear (*Ursus arctos*), fox (*Vulpes vulpes*), hare, tortoise (*Emys orbicularis*), birds and fish (*Cyprinidae, Silurus glanis* and other) (Bökönyi 1992).

Hunting and fishing equipment from osseous raw materials

Hunting and fishing equipment produced from osseous raw materials includes fish hooks, made from bones, and projectile points (Figure 2, 3), made from bones or, rarely, antler (Vitezović 2012a, 2018).

Fish hooks were only seldom found, and just three items are known from two sites – Starčevo–Grad and Donja Branjevina (Vitezović 2018). They were manufactured from segments of diaphyses of larger long bones by cutting and scraping with a chipped stone tool. They are more or less U-shaped or L-shaped, with straight shanks and sharp tips. Basal parts differ, one example from Donja Branjevina has a groove, probably for attaching strings, while the other has a flat, slightly widened base. Manufacturing traces are usually well visible; besides traces of scraping with chipped stone tools, they were finalised by burnishing with sandstone. Morphologically similar hooks were known from other Neolithic sites in Europe (e.g., Stratouli 1996; see also Cleyet-Merle 1990; Averbouh and Cleyet-Merle 1995, and references therein).

Projectile points were somewhat more frequent; Starčevo and Donja Branjevina yielded the largest collection (57 and 22 items, respectively) (Figure 2, 3), while few or single finds were noted at the sites of Ludaš–Budžak, Golokut–Vizić, Obrež–Baštine, Velesnica, Knjepište, Grivac, Divostin, Međureč, Zmajevac, Drenovac, Bubanj and Pavlovac (Vitezović 2011; 2012a; 2018, table 1).

Projectile points were made from bones and antlers (Figure 2, 3); among the projectiles made from bones, three subtypes may be distinguished. Large long bones of large mammals were selected for all of them, presumably because of their physical and mechanical properties – thickness of the cortical bone, resilience, etc. (see Christensen 2004 for more details).

Subtype A are projectiles made from long bone splinters, with a more or less concave (semi-circular) cross-section in the basal part, and a strong, massive point of full, solid circular or oval cross-section in the distal part. Subtype B projectiles are roughly lozenge-shaped, with a more or less emphasised widening, and with a full, solid cross-section. They have a massive, heavy point at one end, and the basal part ends either with an unused blunt point, or a small circular surface (Figure 2a, 2c). They

Figure 2. Bone projectile points from Donja Branjevina (photo S. Vitezović).

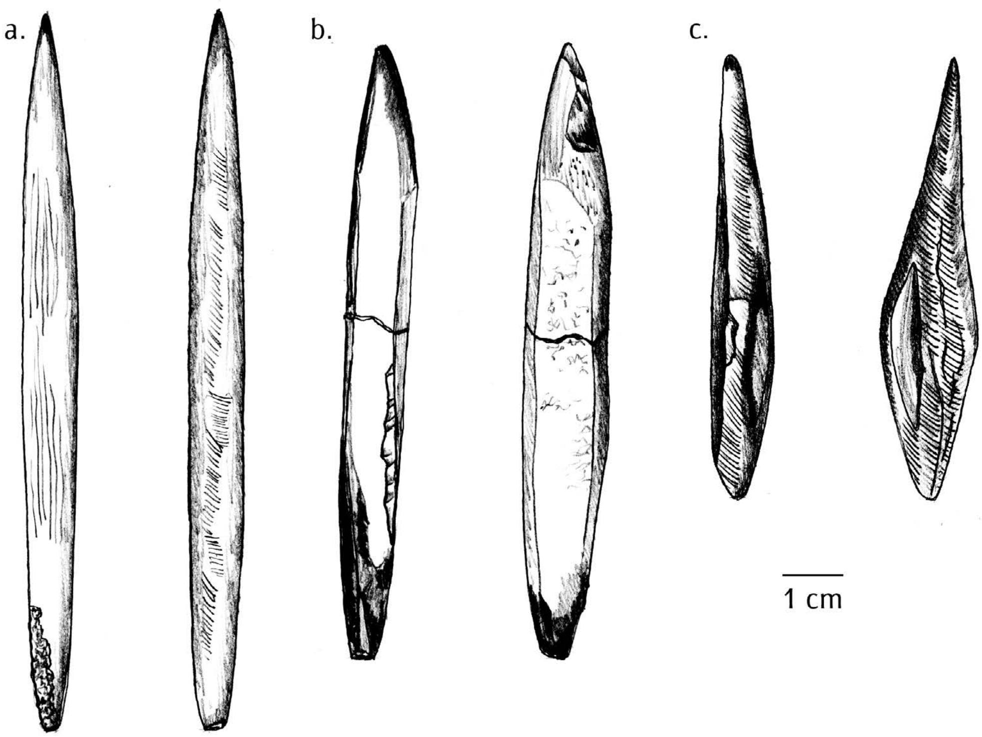

Figure 3. Bone projectile points from Starčevo (drawing Ž. Utvar).

are particularly frequent at the sites of Starčevo and Donja Branjevina, and several specimens from Starčevo have a particularly emphasised widening in the basal portion (Vitezović 2012a) (Figure 3c). These subtypes have analogies in the Palaeolithic and the Mesolithic assemblages, including Mesolithic sites in the Iron gates region (Beldiman 2007).

Subtype C are manufactured from large ungulate (predominantly *Bos*) metapodials, by using the same manufacturing technique as for the production of spatula–spoons, or by recycling broken spoons into projectiles (for more details on the production of the spatula–spoons and these projectiles, see Vitezović 2012a, 2016a, 2016b). Projectiles of this subtype are particularly characteristic for the Early Neolithic in the Balkan area and are encountered at other Starčevo–Körös–Criş culture sites as well (Makkay 1990; Beldiman 2007).

Among these, one projectile-shaped artefact from Donja Branjevina stands out. It has a zoomorphic head, and it was most likely a modified (repaired) spatula–spoon, judging from the polish from manipulation at its mesial part. It is not certain whether it was used as a projectile point at all, since the tip is broken (Vitezović 2018: fig. 9).

Antlers were also a convenient raw material for the production of projectiles, because of their resilience (see Guthrie 1983; Christensen 2004). However, possible projectile points from the Early Neolithic made of antlers are rare, and all of them are fragmented. They were produced from antler tines, and usually have traces of manufacture, but no traces of use, except for breakage. One fragmented projectile point from roe deer antler tine comes from Zmajevac, while one produced from a red deer antler segment was discovered at Drenovac (Vitezović 2011, 2018).

These projectile points are found complete and fragmented; fragmented pieces include both distal and proximal segments, suggesting that some of the broken projectiles were recovered from the shafts and some from prey. Fragmented projectile points from Zmajevac and from Međureč are interesting in that respect – in both cases, the preserved part is the distal portion (the tip) and these projectiles were exposed to high temperatures (they are completely whitish – see Lyman 2001 for alterations on bone materials caused by fire), and were probably recovered from prey (Vitezović 2011, 2018).

The criteria for discerning possible projectile points from simple pointed tools are based on their morphology and use-wear traces (following criteria outlined by Arndt and Newcomer 1986; Bradfield and Lombard 2011; Pétillon *et al.* 2016). Projectile points are stronger and more massive. Their tips are thicker and stronger than those of awls or needles, and their cross-sections are full, circular or oval in their entire length or, rarely, in the mesial and distal portion, unlike awls or needles, who usually have semi-circular cross-section lengthwise. The average weight of projectiles from Donja Branjevina is about 15-20 gr (in comparison, awls made from split caprinae metapodials are usually up to 3 grams). Manufacturing traces, such as traces of scraping and polishing (cf. Newcomer 1974; Semenov 1976; Legrand 2007) are clearly visible, while use-wear traces, such as polished surfaces or striations, common on awls or other tools used in processing organic materials (cf. Semenov 1976; Legrand 2007), are completely missing. Instead, traces of smaller damages from impact may be noted on the tip, which can be described as chipping or crushing (cf. Arndt and Newcomer 1986; Bradfield and Lombard 2011; Pétillon *et al.* 2016). In the case of spoons recycled into projectile points, we may note that the use-wear traces are restricted to mesial and proximal parts, while the distal part has traces of scraping or burnishing (it should be noted that, contrarily, use-wear traces are not reliable criteria if the projectile points are recycled into tools, hence, such items may remain unrecognised within the assemblages).

Hunting and fishing equipment from lithic raw materials

Hunting and fishing tools made of stone comprehend mallets, fishing weights, pebble axes (blunt axes) and sling projectiles. Majority of them were discovered at the sites in the Iron Gates area, and they show strong resemblance with the Late Mesolithic ones discovered in the region (Antonović 2006).

Mallets are massive tools made of large pieces of stone of elongated shape, with the length of up to 50 cm (Figure 4d). Some scholars believe that they were primarily used in a cult function, on the basis of decorations carved into some of them, hence, they are occasionally also called sceptres (Srejović and Babović 1983). It is assumed that their primary use was in fishing, to kill larger fish (beluga, sturgeon, catfish), as indicated by use-wear traces which occur in the form of shallow circular recesses with a rough surface on one end of the tool. For the making of mallets, rough rocks were primarily used, resistant to constant impact, which was the basic function of this type of items. Fine-grained metamorphic sandstones were used, as well as small-grained poorly silicified limestone, granite, diorite and various types of schist metamorphic rocks.

The largest number of items of this kind was found at Lepenski Vir (Antonović 2006). A smaller number was discovered on the floors of houses of the Late Mesolithic settlement, while a considerably larger quantity was in the Neolithic context, along with the ceramics of the Starčevo culture (Antonović 2006). Several examples were also discovered at Hajdučka Vodenica (Radovanović 1996) and Padina (Antonović 2003a, 2004; Jovanović 1969), but at the Mesolithic site of Vlasac as well (Srejović and Letica 1978).

Also in the Iron Gates region, tools of larger dimensions, labelled as pebble axes (blunt axes), have been discovered, made of pebbles, shaped through minimal anthropogenic modification into axes or hammers. Those were magmatic rock pebbles, of an elongated shape, which had a cutting edge made by polishing on one end, or else a finely rounded top, resembling a severely blunted cutting edge. A rib-shaped protrusion made in the middle of the tool probably had the function of fastening the tool to a

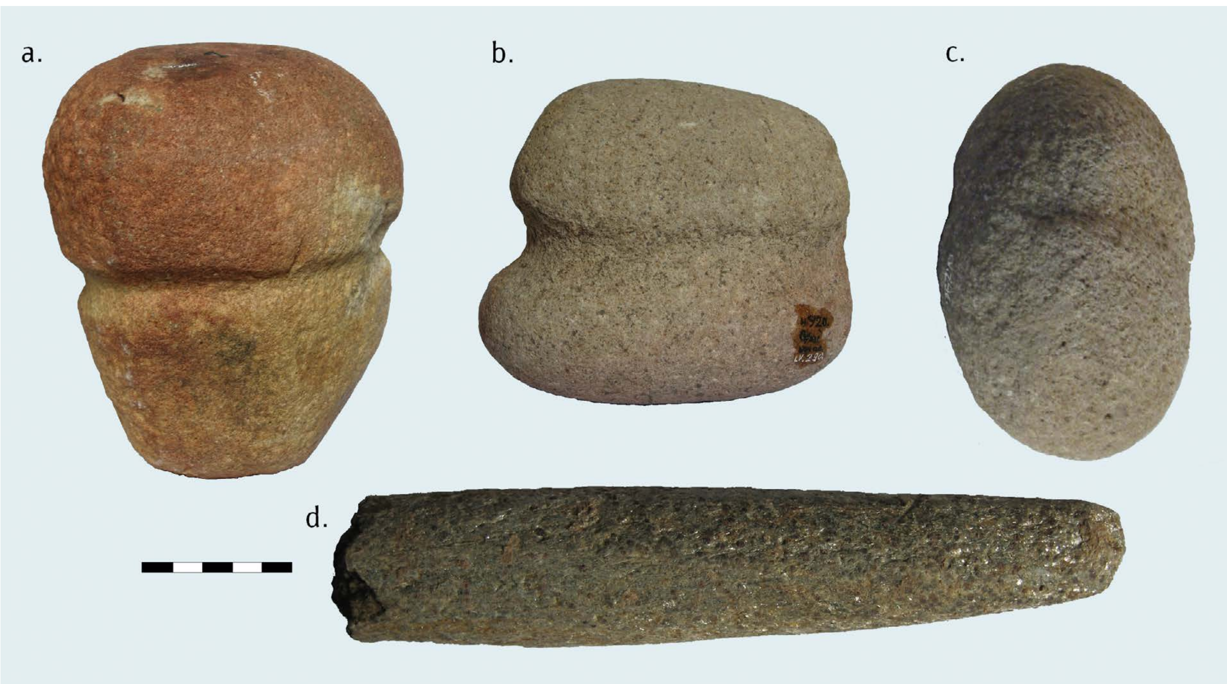

Figure 4. Lithic fishing gear: a-c) fishing weights and d) mallet (scepter), from Lepenski Vir (photo D. Antonović).

handle. Tools of this type can be found in the Mesolithic of the Iron Gates (Srejović 1969; Srejović and Letica 1978), but they are also found within Early Neolithic layers at the site of Velesnica, with regular grooves for fastening the tool onto a handle (Antonović 2003b). These tools could have been used as axes, if they had a cutting edge on one end, or as hammers, if the cutting edge was made blunt through polishing.

From lithic raw materials also the weights were produced – large fishing weights were used for fishing nets or sturgeon lines, and smaller ones for fishing with hooks (Figure 4a-c). Large weights were made of pebbles, whose natural shape was slightly modified with minimal processing through fine chipping or, very rarely, burnishing. As a rule, they have one transversal groove in the middle, along the entire circumference, in the widest part of the tool. There are also rare occurrences of weights with two grooves, crossed at a right angle. The weights were mostly made from sandstone and magmatic pebbles, and the heaviness of the stone was more important than its hardness and toughness. Use-wear traces indicate that they were secondarily used as mallets (hammers) and anvils.

The primary use of these tools, according to ethnographic analogies (Petrović 1941), would most probably have been in catching large fish from the Danube. All the way until the end of the 19th century, organised fishing of large fish species from the Danube was being practiced in the Iron Gates, mostly beluga, sturgeon, catfish, etc., for which an implement with a simple construction was used – a sturgeon line (Figure 5). By using this implement, fish wouldn't have been caught by swallowing the hook, instead, their stomach, sides, tail or another body part would get caught onto the hooks. The most important elements of this implement were large stone weights, sufficiently heavy so that the fast waters of the Danube couldn't move them. Gourds, attached to these stones, would float on the surface of the water, and a line would be stretched in-between the lines holding the gourds with sharp hooks on it (without baits), onto which large fish would get caught (Figure 5). This way, once caught, the fish couldn't swim any more, and the fishermen would pull it into the boat and subsequently kill it, by bludgeoning it with mallets. In the past, fishing with sturgeon lines was a speciality linked exclusively to the lower Danube

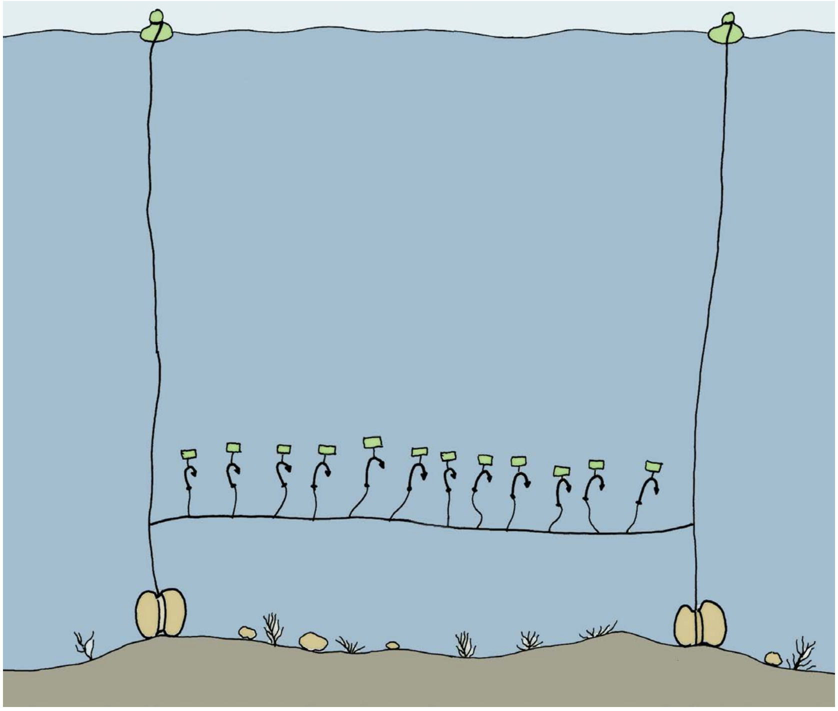

Figure 5. Reconstrcution of a sturgeon line used in organised fishing of beluga at Danube in the 19th century (after Petrović 1941, drawing by D. Antonović).

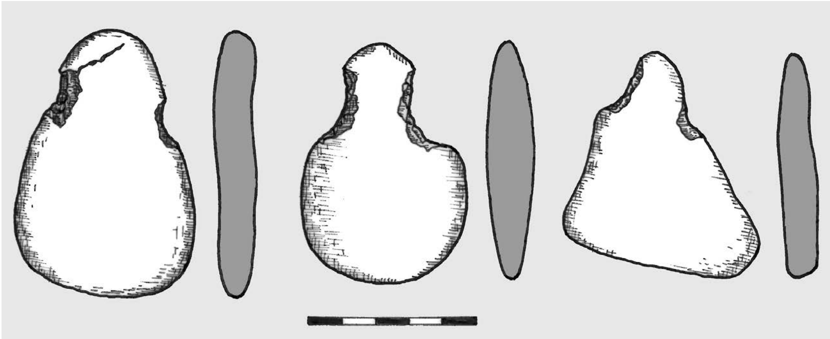

Figure 6. Small fishing weights from Velesnica (photo D. Antonović).

valley. It can only be assumed that the weights from Lepenski Vir had a similar function (for more on fishing practices in the Mesolithic period, see Živaljević 2017).

These weights, same as the mallets, represent Mesolithic traditions, and their use continued throughout the entire Early Neolithic in the Iron Gates. Weights have been found on all Early Holocene settlements in this region: Lepenski Vir (Antonović 2006), Padina (Antonović 2004), Ajmana (Stalio 1986) and Velesnica (Antonović 2003b).

Small pebbles, 50–100 mm long, with recessions for fixing a rope on lateral sides, have been interpreted by some authors as fishermen weights (Antonović 2003b), although some believe that those were amulets (Vasić 1986) (Figure 6). They have been found within the Starčevo culture settlements situated on banks of larger rivers – beside Velesnica (Antonović 2003b), Knjepište and Ušće Kameničkog Potoka (Stanković 1986a, 1986b) in the Iron gates, they were also noted at the sites of Drenovac and Ornice near Makrešane (Stanković 1988a).

Similar items, labelled as "notched cobbles", are also known from the Neolithic sites in Greece, and recent traceological studies have shown that they were most likely used in fishing (Stroulia *et al.* 2022).

Possible sling bullets are smaller pebbles, usually 50–73 mm in diameter, made of hard compact rocks (quartz sandstone, magmatic rocks), shaped through fine chipping and abrading into almost regular spherical shapes. These items appear rarely; they were noted within Mesolithic layers at Vlasac (Srejović and Letica 1978: 100) and Padina (Antonović 2003a), and from Lepenski Vir three examples of this type are known, one of which was discovered in a layer with the Starčevo culture pottery.

It is very interesting to note that chipped stone artefacts which may have been used in hunting (arrowheads) are virtually non-existant. The only findings include four specimens: from the sites of Popovića Brdo near Zablaće, Orašje near Dubravica (Šarić 2014: 127), Blagotin and Rudnik near Srbica (Šarić 2005: 16; 2014). The projectile from Rudnik is a pentagonal, double-sided projectile. Projectiles from Popovića Brdo and Orašje represent a very simple type, made with convergent retouch on broad flake with thinning on the proximal area for easier hafting (Šarić 2014: 165), hence, there is no doubt that those had been made to serve as tips for spearheads/arrowheads; however, given their completeness, it is not certain if they had been used for those purposes. The best indicator of them being used as spearheads/arrowheads in hunting would be the presence of damage on the tip and impact fractures so in this case we can safely conclude they probably hadn't been used as such. Still, a functional analysis has to be conducted in order to reach further conclusions. The projectile from Blagotin, in the form of a transversal arrowhead, is particularly interesting given that it typologically represents a relic of the earlier Mesolithic tradition.

The scarcity of these findings, as well as a lack of uniformity, opens numerous questions, especially whether they really represent evidence for hunting in any way. Perhaps it was not only hunting that was carried out far from the settlement, but the preparation for hunting as well, or these chipped stone projectiles represent an exception in every way, while other types of artefacts (such as bone projectiles) were used for hunting.

Hunting and fishing equipment from clay

Some artefacts produced from clay recovered from Starčevo culture sites may be associated with hunting and fishing activities, although the interpretation of their function is often ambiguous. These include possible weights for fishing nets and sling bullets. Clay weights are relatively abundant findings at all the Starčevo culture sites (e.g., MacPherron *et al.* 1988: 326, fig. 11.4/i-k; Vuković *et al* 2016: 190-191, pl. VIII). They display a large variety in shapes, dimensions and weights – they may be flat discs, globular, elliptical, larger or smaller, with or without decorations, etc. This great diversity certainly points to a variety of possible usages; however, there are still no comprehensive studies focused on distinguishing loom weights from weights used for other purposes (as partial exception may be mentioned Ninčić 2016, focused on use of ceramic weights in textile technology). We may only assume that some of them were used as weights for fishing nets.

Figure 7. Clay sling bullets from Pavlovac – Kovačke Njive (photo S. Vitezović).

Another potential type of hunting items are possible bullet slings made from clay. Occasionally, smaller globular or elliptical objects (without perforations) may be encountered among portable findings; unfortunately, though, they are rarely analysed or even published in excavation reports. Among other findings, six such items from the site of Pavlovac (location Kovačke Njive) in southern Serbia may be mentioned (Figure 7). They are rather small (average length 5-6 cm) and their form is solid (i.e., they do not have a perforation as weights). They were mostly biconical in shape, sometimes more rounded, and one of them is decorated with a row of crescent-shaped short incisions. They were produced from baked clay with lot of admixtures of quartz sand, often small pebbles, with rough outer surfaces, and have a rather substantial weight (presumably admixtures were used to add to their weight), which is why the interpretation as sling bullets is considered as the most plausible (Vuković *et al.* 2016: 192). Similar items, when mentioned in site reports, are rarely described in details, and have diverse interpretations – as grain models, as toys, weights, objects used for food heating, etc. (see Tringham and Stevanović 1990: 336, with references therein). For example, at least some of the items labelled as *cereal grain shapes* from Early Neolithic layers at Divostin may have been used as sling bullets (McPherron *et al.* 1988: 325, fig. 11.4/a-e).

Hunting and fishing equipment in the Late Neolithic Vinča culture

Archaeological background

The Late Neolithic Vinča culture occupied a similar territory as the Starčevo culture – present-day territories of Serbia, eastern parts of Croatia and Bosnia and Herzegovina, northern parts of Montenegro, as well as regions of Oltenia and Transylvania in Romania (Garašanin 1979; Srejović ed. 1989), in the period between 5300 and 4500/4450 cal (Borić 2009; Tasić *et al.* 2015). Subsistence and economy were also based on animal husbandry, again, with some regional differences.

At the site of Vinča – Belo Brdo, situated at the Danube river in the present-day suburb of Vinča in Belgrade, domestic species were predominant, with cattle as the most frequent (over 30% of total fauna), followed by pigs, caprines and dogs. Among wild species, red deer was the most frequent with approx. 9%, followed by wild pigs, roe deer, aurochs, and a limited number of bones belong to species such as bear, wolf (*Canis lupus*), fox (*Vulpes vulpes*), wild cat (*Felis silvestris*), hare, etc. (Bulatović 2018).

Faunal remains from the site of Gomolava, situated in Srem region on the river Sava bank, cattle was the most frequent, followed by domestic pig, sheep and goat. Dog was found as well, along with few remains of birds and fish (Clason 1979). In addition, remains of red deer, roe deer, equids, badger, beaver and fox were noted (Orton 2008).

The site of Selevac, situated in Pomoravlje region near the town of Smederevska Palanka, yielded faunal assemblage with predominantly domestic fauna, with cattle as the most frequent species, followed by caprinae and pigs. Red deer, roe deer and wild pigs were most common wild species, and in the earliest levels they were present as a considerable proportion of the fauna (Legge 1990). A. Legge noted that hunting was obviously an important activity at Selevac, especially in the earlier phases, and suggested that the rapid decline in later phases is an indicative of a large-scale environmental modification by Selevac farmers (Legge 1990: 236). The site of Selevac is also among rare Vinča culture sites where the fish remains were collected and analysed. The prehistoric settlement was located on the slopes near Vrbica stream, and at approximately 20 km from Velika Morava and Danube rivers. Fish remains included catfish (*Silurus glanis*), pike (*Esox lucius*), carp (*Cyprinus carpio*) and small amounts of other species (Brinkhuizen 1990).

Within the faunal assemblage from the Vinča culture layers at Divostin, cattle were predominant among all faunal remains with over 70% (Bökönyi 1988), and other species included sheep, goats, pigs, aurochs, red deer, roe deer, wild pigs, hare, etc. Small amounts of birds (great bustard – *Otis tarda*, and grey goose – *Anser anser*) were found, as well as fish remains.

The Vinča culture layers at the site of Drenovac, located near the Velika Morava river, near the modern town of Paraćin, yielded an assemblage with predominantly domestic fauna. Also, cattle were the best represented species here, with over 30% of the total fauna, followed by sheep, goats and pigs. Dogs were also present. Among wild species, red deer predominates again, with 11%, followed by roe deer and wild pigs. Other species, discovered in small amounts, include brown bear, wolf, fox, badger (*Meles meles*), beaver (*Castor fiber*), hare, etc. (Dimitrijević 2020).

Also in the Pomoravlje region, a small faunal assemblage was analysed from the site of Vitkovo, again, predominantly consisting of domestic fauna, but with caprinae as the most frequent species, with 55% of total, or 63% of domestic animals (Bulatović 2012).

The site of Pločnik, situated near the town of Prokuplje in southern Serbia, on the banks of the Toplica river, showed the predominance of domestic fauna as well, especially cattle. It was also possible to note a temporal trend of increasing cattle and decreasing wild fauna in the latest levels of the settlement (Bulatović and Orton 2021). Wild species present at the site included aurochs, red deer, roe deer, wild pigs, as well as small amounts of brown bear, wolf, fox, badger, beaver, wild cat, otter (*Lutra lutra*), marten (*Martes sp*.) and hare (Bulatović and Orton 2021: table 1).

On the other hand, two Vinča culture sites have rather unusual faunal assemblages, with a predominance of wild fauna, Petnica and Opovo. At Opovo, situated in in the Pannonian plain, a high ratio of roe deer was noted (Russell 1993). At Petnica, located in Western Serbia near Valjevo, cattle comprised approximately 30%, followed by pigs, while red deer comprised over 30%, and roe deer over 7% (Greenfield 1986; Orton 2008). Other wild species included fox, wildcat, beaver, badger, otter, hare, brown bear, etc. (Orton 2008: t. 6.27).

Hunting and fishing equipment from osseous raw materials

Hunting and fishing equipment from osseous raw materials includes fish hooks, harpoons and occasional finds of projectile points (Figure 8, 9, 10).

The richest assemblages of fish hooks have been discovered at the sites of Vinča – Belo Brdo and Gomolava, while occasional or single finds were reported from Jakovo–Kormadin, Drenovac, Selevac, and Pločnik (Bačkalov 1979; Russell 1990; Srejović and Jovanović 1959; Vitezović 2007, 2019, 2020, 2021).

The most common subtype of fish hooks are those made from antler (Figure 8a, b). They are particularly frequent at Vinča – Belo Brdo (Bačkalov 1979; Srejović and Jovanović 1959; Vitezović 2020) and Gomolava (Vitezović 2019)[2]; one was found at Selevac (Russell 1990: 530, pl. 14.3a) and few examples were noted at Jakovo–Kormadin[3].

These hooks were produced from cortex segments from red deer antler beams. Segments of outer cortex were taken out from the beams, probably by longitudinal splitting or by the cut-and-groove technique; thus obtained, elongated plates were modified into hooks by cutting with a chipped stone tool and by abrasion with sandstone. Hooks were more or less U-shaped or L-shaped, with relatively long shanks, usually approximately 70 mm long. The upper part of the shank is slightly profilated, i.e., it is in the shape of a rounded or biconical head, while the points can be simple, or barbed, with various numbers and various lengths of the barbs (barbed hooks are known from both Gomolava and Vinča, and the single find of a hook from Selevac also had a barbed point). In addition, at both Vinča and Gomolava semi-finished hooks were noted (Vitezović 2019, 2020).

The majority of hooks has slight polish from manipulation on their surfaces. Their points do not display any particular wear except from the general polishing of the entire distal part. Breakages occur most often at the mesial, curved portion of the hook, and they were probably the result of use. Heads also display a certain degree of polish, but there is no visible grooving from attaching, suggesting that attachment was probably performed with soft materials, and not firm.

[2] Only hooks stored today at the Regional museum in Ruma were analysed; hooks stored at the Museum of Vojvodina are on permament exhibition.

[3] Unpublished; two hooks were on display at the permanent exhibition of the Archaeological Museum in Zagreb.

Figure 8. Fish hooks from Vinča – Belo Brdo: a) large antler hook, b) barbed antler hook, c-d) lure hooks (photo S. Vitezović).

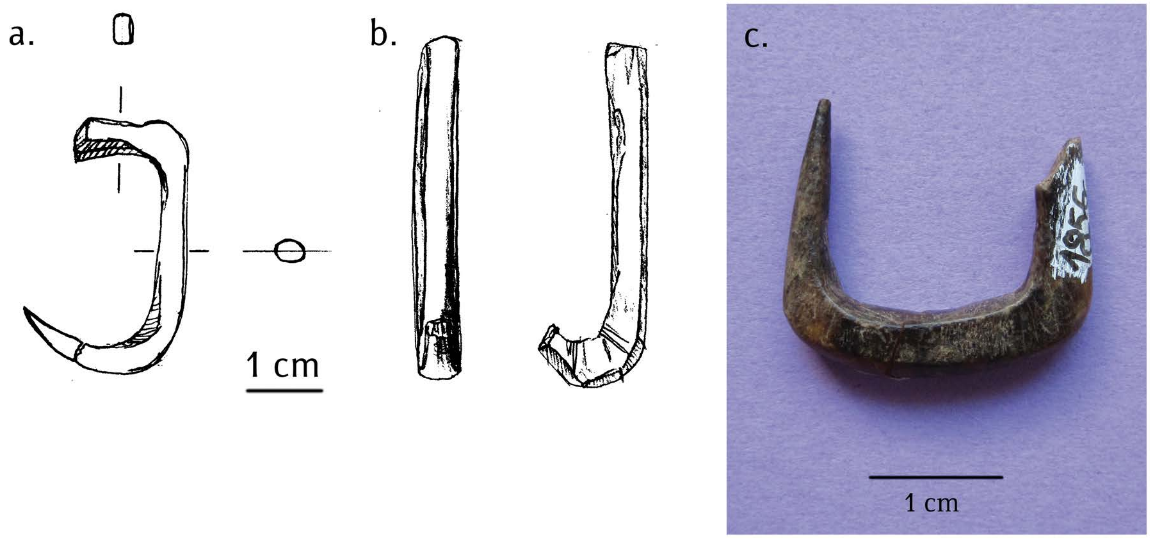

Figure 9. Fish hooks made from bones: a-b) Drenovac, c) Pločnik (drawing Ž. Utvar, photo S. Vitezović).

Barbed hooks may be encountered rarely on some other Neolithic sites in Europe (see Averbouh and Cleyet-Merle 1995), and this particular subtype – relatively large hooks produced from antler and with multiple barbs on the point, seem to be particularly characteristic for the Vinča culture.

Other subtypes are hooks made from boar tusks and bone, and they are quite rare. Just one hook from a boar tusk is known thus far, found at Vinča; it is simple in shape, rather small, and with a notch below the head and a fragmented distal end (Vitezović 2020). Bone hooks were found at the sites of Drenovac and Pločnik (Figure 9). At Drenovac, two hooks were found, produced from segments of diaphyses of larger long bones, finely polished with sandstone (Vitezović 2007: 120, 143; t. 36, 67) (Figure 9a, b). One of the hooks has its upper part protruding, i.e., the head is not simple but has an elongated prong. The point at the distal end of this hook is very sharp, while the point of the other hook, with a simple head, is fragmented. At Pločnik, single hook was found, also fragmented; the shank is broken, but the sharp point is preserved, and fine traces of burnishing are visible as well (Vitezović 2021: 57-58, fig. 32) (Figure 9c).

At the site of Vinča another subtype of fish hooks was noted, so-called lure hooks, made from diverse bone segments (segments of diaphyses of different long bones, rib segments, etc.) (Figure 8c, d). The results of the functional analysis indicate that these artefacts were parts of composite hooks, probably used to catch large predatory fish (Cristiani *et al.* 2016). As these hooks are sometimes somewhat *ad hoc* produced, it is possible that they were present at other sites as well, but remained unnoticed in the faunal material.

The sites of Vinča and Gomolava also yielded rather rich assemblages of antler harpoons (Bačkalov 1979; Srejović and Jovanović 1959)[4] (Figure 10). Also one complete harpoon was found at Žarkovo, site situated in southwestern part of Belgrade (relatively close to Vinča) (Perišić 1984: t. 18/136). Harpoons were all made from red deer antler segments, from cortex pieces extracted from beams. Their production included several stages of cutting with chipped stone tools in order to produce barbs, and occasionally some parts were additionally burnished. Harpoons are not uniform; they display a variety in dimensions and shapes, number and shape of dents and shape of their basal parts. Both uniserial and biserial harpoons were noted at Vinča and Gomolava (the specimen from Žarkovo is biserial), and biserial may be

Figure 10. Antler harpoon from Vinča – Belo Brdo (photo S. Vitezović).

symmetrical and asymmetrical (Figure 10). Some have a small widening at their basal part, presumably to secure the hafting or to attach a rope. However, as many of them are fragmented, it is not possible to quantify nor correlate these variations. This great variety is also in contrast with the high uniformity and standardisation noted among other bone artefact types (see e.g., Vitezović 2021), perhaps showing that harpoons were not produced on regular basis, but seldom, and perhaps even produced only for some specific, special occasions.

Antler harpoons were relatively frequent in the Mesolithic period in Europe (see Billamboz *et al.* 1995 and references therein); they dissapear in the Early Neolithic in south-eastern Europe, and reappear in the Late Neolithic.

Toggle harpoons were also mentioned from the site of Vinča – Belo Brdo (Bačkalov 1979), however, they are most likely from post-Vinča horizons. Another possible toggle harpoon was found at Divostin (Vitezović 2012b), made from red deer antler. Although this object morphologically resembles most of toggle harpoons, its function is uncertain and unclear – its tip is rather blunt and the entire object is curved, therefore not particularly convenient for a weapon.

Some of the massive pointed artefacts may be interpreted as projectile points, based on their overall morphology and specific use-wear traces. Few possible projectile points were reported from Selevac (Russell 1990).

Hunting and fishing equipment from lithic raw materials

Hunting and fishing implements made from lithic raw materials are scarce in the Late Neolithic, and include sling bullets and fishing weights. In addition, perhaps some other artefact types, in particular perforated tools (axes, hammers, mace heads), may be linked with hunting activities.

Sling bullets occur rarely, and it should be noted that their interpretation is sometimes questionable, since we cannot always be certain whether these were naturally polished stones or they have anthropogenic modifications. Rare examples of these tools have been found at Vinča (Antonović 1992),

Figure 11. Lithic sling bullets from Mali Borak – Jaričište (coal mine Kolubara), the Vinča culture layer (photo D. Antonović)

Belovode (Antonović 2000), Pločnik (Antonović 2003b) and some of the sites in the basin of the river Kolubara so far[5]. (Figure 11).

The use of large weights in fishing in the Iron Gates continued during the Vinča culture period as well. Identical weights that have been registered in the Mesolithic and Early Neolithic in this region have also been discovered at the only Vinča culture site in the area, Zbradila near Korbovo (Babović 1984; 1986). It can only be assumed that hunting large fish, such as beluga, sturgeon, catfish etc., from the Danube in the Iron Gates continued during the Vinča culture, and that implements which had proven to be efficient for such activities for centuries before (nets, sturgeon lines) continued to be in use in the Late Neolithic as well. Small fishing weights also occur rarely on Vinča sites and they have been discovered only at the site of Belovode in Eastern Serbia (Antonović 2000).

Figure 12. Perforated axes from Vinča – Belo Brdo (photo D. Antonović).

Small amounts of pebble axes (blunt axes), used during the Late Mesolithic and Early Neolithic in the Iron Gates, were also noted at Zbradila (Babović 1984).

Perforated tools appear near the end of the Vinča–Tordoš phase, and were used more during the later period of Vinča–Pločnik (Figure 12). The purpose of these tools in the Vinča culture hasn't been determined yet, but it is known for certain that they did have one, as witnessed by the fact that they had mostly been broken at their thinnest part, near the perforation. There are no clear use-wear traces noted on them which would indicate their function (Antonović 1992). These artefacts were sometimes even interpreted as weapons used in war.

All the perforated tools from the Vinča culture have a slightly conical, almost cylindrical opening for a handle, which is a sufficient reason not to consider them as working tools. The basic trait that allows us to determine if an item was a combat weapon, especially when it comes to axes, is a circular hole for the handle and the absence of traces typical for woodworking (Semenov 1976). A circular hole for the handle is very inadequate for

[5] Unpublished, material analysed by D. Antonović.

woodworking axes because the axe would spin around its axis with every strike on the wood. However, due to the hitting technique during hunting (or war), battle axes would be completely stable even on a handle set into a circular opening. Their cutting edges are rather blunt (the angle of the cutting edge is 65–122°), which would make their use in woodworking rather inefficient; furthermore, they are chipped, with impact traces and without use-wear traces typical of woodworking axes. All of this leads to the conclusion that perforated tools hadn't been made for use in everyday life, but could have been used instead as fierce weapons in hunting or in combat.

Maces also fit this rule. These tools are hemispherical or pear-shaped, with a perforation in the centre, they appear already in the older phase of the Vinča culture, but are very rarely found in Late Neolithic settlements in Serbia (Antonović 1992; 2003b). They have small dimensions (diameter of up to 10 cm, perforation diameter of up to 2 cm), hence, they couldn't have been used in some rougher domestic activities. These items are known from several Late Neolithic sites in Bosnia and Dalmatia, and were interpreted as hunting weapons (Benac 1971).

Perforated tools were being made from diverse types of rocks, most commonly from hard magmatic and metamorphic rocks, resistant to impact, which would corroborate the theory on their use as hunting or fighting weapons. They occur very rarely in the Neolithic of Serbia. For the time being, they have been registered, in small numbers, at Grivac, Crnokalačka Bara (Antonović 2003b), Divostin (Prinz 1988), Vinča (Antonović 1992), Čoka (Banner 1960), Benska Bara (Trbuhović and Vasiljević 1983), Predionica (Galović 1959), Žarkovo (Garašanin and Garašanin 1955), Selevac (Voytek 1990), etc.

Chipped stone artefacts that may be linked to hunting in the Late Neolithic are exceedingly rare, just as in the Early Neolithic. Only few findings of artefacts labelled as tanged points or arrowheads, presumably used as arrow points, may be mentioned, recovered from the sites of Vinča – Belo Brdo, Ratina – Divlje Polje and Petnica (Bogosavljević Petrović 2015: 457 ff.; and references therein). They were made from locally available raw material, whitish opal, and presumed produced locally.

Hunting and fishing equipment from clay

Similarly to the Early Neolithic Starčevo culture, a variety of clay weights are also frequently encountered at the Vinča culture sites. They are quite abundant at the sites of Selevac (Tringham and Stevanović 1990), Pavlovac (Vuković *et al.* 2016) , and many more. They may be globular, elliptical or more flat in shape, and they also display a variety in sizes and weights. Again, their functions may be diverse – beside weights for fishing nets, they could also have served as loom weights, etc. (for more detailed discussion on possible function, see Tringham and Stevanović 1990; Ninčić 2016).

Discussion

Artefacts that may be linked to fishing and hunting in the Neolithic period are relatively frequent, although their functional interpretation may not always be unambiguous. From the technological, typological, as well as functional viewpoint, these items show great diversity. They were produced from diverse raw materials (osseous, lithic, clay), by using a range of manufacturing procedures, and include both minimally modified items and carefully made objects, produced with large labour, time and skill investment. The predominant – or the most reliably interpreted – are those made from osseous raw materials. It is interesting to note that some techno-types are more frequent, while some occur rarely or even as single finds (such as boar tusk hooks in the Late Neolithic or chipped stone arrowheads in the Early and Late Neolithic). Furthermore, some of the artefact types have analogies in other periods and regions, for example, simple bone hooks or projectile points, while some are characteristic for the period (such as projectiles made from recycled spoons), or even limited region (such as stone artefacts used in the Iron gates). Certain Mesolithic traditions may be observed, in particular for some subtypes of Early Neolithic projectile points and for some lithic artefacts, while Early Neolithic projectiles from recycled spoons may be considered as Early Neolithic innovation (see Vitezović 2016a, 2016b).

Some of these artefacts were used directly as hunting and fishing weapons (i.e., as active component – projectiles, fish hooks, harpoons), while some were just a part of hunting and fishing equipment (such as weights for fishing nets).

Major regional differences may be noted. Sites located near large rivers in the Pannonian plain, Sava and Danube, where they flow rather slowly, creating marshy areas, may be considered as one group. In the Early Neolithic, the sites of Starčevo–Grad and Donja Branjevina, both near the Danube, have specific hunting and fishing equipment – bone projectile points, otherwise rare or completely absent on other Starčevo culture sites, and few fish hooks, completely absent on other sites. In the Late Neolithic, the sites of Gomolava and Jakovo–Kormadin on the river Sava and the site of Vinča – Belo Brdo on the river Danube share similar traits in hunting and fishing equipment that includes antler hooks, especially large barbed hooks, lure hooks, and harpoons.

Another group may be singled out, namely, sites in the Iron Gates area – this is a region where the course of the river Danube contains numerous gorges, small basins and whirlpools, convenient for catching certain fish species, such as large migratory fish, but also demanding the development of best-suited techniques. Both Early and Late Neolithic sites in this region have specific lithic items that are associated with fishing, especially stone net weights. Major Mesolithic traditions may be observed in this area – specific traits of the local environment were presumably the main driving force for this continuity.

The presence and abundance of hunting and fishing equipment does not directly reflect local variations in the faunal record; however, the faunal data are not systematic and sometimes sample bias is present, therefore these relations must be examined more rigorously. It is only in the Iron Gates area in the Early Neolithic that we may note both larger ratios of wild fauna and a somewhat more diverse hunting and fishing equipment, while in the Late Neolithic just one site is known (Zbradila), and information regarding the hunting and fishing implements only are available from it, while the faunal remains were not published[6]. Also, the information regarding possible hunting weapons for the two Vinča culture sites with large wild species ratios, Petnica and Opovo, are lacking.

These regional differences suggest that there was a certain type of regional specialisation, most probably linked to the specific local environment. Regarding the Late Neolithic, regional specialisation in subsistence practices was already mentioned as a hypothesis by D. Orton (2008: 110) and noticed in other segments of the economy (see Vitezović and Antonović 2020).

Regarding the role of hunting among the Vinča culture communities, David Orton noted that the three main wild species present on the Vinča culture sites, namely, wild pigs, red and roe deer, are all potential crop raiders, thus raising the possibility that some of the hunting activities were so-called "garden hunting", although he does not consider this to be the only or the main reason for hunting activities (Orton 2008: 112–113). According to Orton, hunting in the Late Neolithic "may often have taken place on

[6] Analysis was done by S. Blažić, but never published, only the preliminary results with list of species found (without percentages), are provided in Babović 1986.

an opportunistic and/or protective basis, but was probably a planned, targeted activity in at least some times and places" (Orton 2008: 115–116). Furthermore, Orton concluded that "Hunting might have been a specialist activity, with certain individuals or households relying on it to a greater extent than others [...] Given the probability of encounter hunting around crops, rigid specialization does not seem likely, but nor does equal involvement throughout the community" (Orton 2008: 115). We may assume that hunting had a similar role and significance in the Early Neolithic as well.

A certain symbolic role or social importance of hunting may be assumed, based on the presence of certain animal symbolism (including terrestrial wild species) in both the Early and the Late Neolithic (e.g., Vitezović 2015), however, very little may be said on the matter with the presently available data.

Fishing activities were most likely predominantly linked to subsistence, but the importance of aquatic resources in the diet is hard to assess with the available data, and carefully collected, sieved faunal assemblages are much needed for more detailed analyses of the role of fishing. Fishing was certainly not an unimportant activity, judging from carefully produced equipment, such as fish hooks and harpoons. Evidence for fowling is even more scarce.

Analysis of the role, importance, significance and frequency of hunting and fishing activities is complicated not only because of the insufficient amount of faunal data at present, but also because sample bias and problem of inadequate publishing and interpretation of hunting and fishing equipment, as well as the absence of detailed traceological analyses, prevents us from making any other type of conclusions other than preliminary. Furthermore, the problem of preservation is also very important. Ethnographic data, as well as prehistoric sites with exceptional preservation, showed that hunting and fishing techniques often included a usage of diverse constructions and objects made from organic materials (wood, ropes) – such as traps, baskets used in fishing, etc. (cf. e.g., Bosić 1981; Maigrot *et al.* 2013; Lozovski and Lozovskaya 2016). Finally, rare occurrences or complete absence of certain types of hunting and fishing artefacts and their uneven geographical distribution also raise the question of whether the preparations for hunting and fishing were carried out at the spot, i.e., outside of the habitation settlements.

Concluding remarks

Although the Neolithic period in the central Balkan area is marked by a predominance of domestic species in the faunal record, hunting and fishing were still practiced to a certain extent. The question of the importance of fishing (and perhaps fowling) in particular remains open for the moment, since the majority of excavations carried out in the 20th century did not practice sieving and sample bias is therefore present. Fishing equipment also seems to be more frequent, or at least better recognised in the material culture, especially in the Pannonian plain and in the Iron Gates gorge, where specific artefacts occur – stone net weights, fish hooks and harpoons. Some of these artefacts were carefully produced, with considerable time and skill invested.

Although numerous historical and ethnographic record show that hunting often plays important symbolic roles within human societies, it is difficult to make any hypotheses regarding a possible social and/or symbolic value of hunting and fishing activities within the Early and Late Neolithic communities.

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“Where are the wild things”: Wild animal exploitation during the Neolithic of the central Balkans

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Abstract

Until recently, the importance of hunted or wild animals during the Neolithic has been underestimated since most of the literature focused on domestic livestock. Yet, wild fauna are as relevant for understanding Neolithic adaptations as domestic fauna. After the Neolithic, the frequency of wild animal exploitation changes, with a dramatic decline in many hunted taxa, such as deer, bear, and others. By reconstructing the exploitation patterns of wild animals, it is possible to investigate whether wild fauna are an important resource on their own or only as supplements to domestic resources. The objective of this paper is to characterise the exploitation strategies of wild fauna from Neolithic sites in the central part of temperate SE Europe, which was the geographic focus of Greenfield’s long-term research program. Through a detailed examination of Greenfield’s published and unpublished data (presented for the first time), we attempt create a comprehensive picture of wild animal exploitation during the Neolithic of the region.

Keywords: Neolithic; Balkans; Hunting; Fauna; Starčevo; Vinča

Introduction

Long before the late seventh millennium BC, peoples across Europe subsisted primarily on hunting wild game, gathering wild foods, and fishing from rivers and oceans (Bogucki 1988; Price 2000; Whittle 1985). These subsistence strategies changed with the advent of the Neolithic as food producing economies and societies arrived in southeast (SE) Europe from the Near East (Bogucki 1988; Hofmanová *et al.* 2016; Mathieson *et al.* 2018; Price 2000; Whittle 1985). This shift appeared earliest in the regions adjacent to present day Turkey or Asia Minor and slowly expanded northward into the temperate zone of SE Europe during the late 7th and early 6th millennium BC.

In most parts of SE Europe, indigenous foragers were replaced by intrusive food producing communities (e.g., Greece). In a few places, foragers adopted the trappings of food producing societies (e.g., ceramics) and eventually became food producers themselves (Borić and Dimitrijević 2007; Garašanin and Radovanović 2001; Jovanović *et al.* 2021; Price 2000; Roksandić 1999). Over 50 years ago, it was already recognized that domestic animals came to dominate the animal exploitation strategies in temperate SE Europe by the Early Neolithic (Bökönyi 1974, 1987, 1989).

Until recently, the importance of hunted or wild animals during the Neolithic has been underestimated since most of the literature focused on domestic livestock (e.g., Legge 1990). Yet, wild fauna are as relevant for understanding Neolithic adaptations as domestic fauna (Bogosavljević Petrović and Starović 2016; Greenfield 1993, 2008a; Manning *et al.* 2013; Orton *et al.* 2016; Radmanović *et al.* 2013; Živaljević *et al.* 2017; Živaljević *et al.* 2021). After the Neolithic, the frequency of wild animal exploitation changes, with a dramatic decline in many hunted taxa, such as deer, bear, and others (Greenfield 1986a).

By reconstructing the exploitation patterns of wild animals, it is possible to investigate whether wild fauna were important resources on their own or only as supplements to domestic resources. The objective of this paper is to characterise the exploitation strategies of wild fauna from Neolithic sites in the central part of temperate SE Europe, which was the geographic focus of Greenfield's long-term research program. Through a detailed examination of Greenfield's published and unpublished data (presented for the first time), we attempt create a comprehensive picture of wild animal exploitation during the Neolithic of the region.

Variables that affect hunting in the Neolithic of the central Balkans

It is now recognised that wild fauna represent far more than material resources, such as meat and tools. They also have symbolic meaning (Orton 2008; Russell 1993, 1999, 2012). Orton (2008) proposed a useful analytical model for understanding the importance of the presence and relative frequencies of hunted wild fauna in Neolithic faunal assemblages from the region. He outlined six major driving forces to account for hunting practices across the region: micro-regional specialisation, availability of seasonal resources, risk buffering, raw material acquisition, garden hunting, and social roles. Each of these driving forces and examples from other studies in the region will be briefly discussed below.

Micro-regional specialisation

Micro-regional specialisation occurs when there is an abnormally high quantity of wild fauna in the environment surrounding sites (Orton 2008). The idea is that an increase in hunting may have been due to the site's location and the environment. This concept was first proposed for the Early Neolithic many years ago (Greenfield 1986a, 1991, 1993, 2008a, 2008b). The effect of environment is particularly visible in the difference between the Early Neolithic Iron Gates faunal assemblages and those outside of the region (Greenfield 1982, 2008b), where wild fauna always outnumber domestics (except where recovery was not systematic and the largest bones only collected). It is also seen along the edges of the marshland that bordered large river valleys, such as at Bukovačka Česma (Greenfield 1994). In both cases, the wild fauna outnumber domestic to varying extents. These communities are specialised fishing and hunting communities, within the context of the larger Early Neolithic pattern wherein domestics dominate.

In addition to environment and site location, the emphasis upon hunting may also be due to local traditions, such as in the Iron Gates. There is a large body of evidence (archaeological, genetic, isotopic, zoological, etc.) to suggest that some of the settlements were populated by a mixture of the local foragers and the incoming farmers (Borić and Dimitrijević 2007; Živaljević *et al.* 2017). This may account for why the subsistence strategies in the Iron Gates were so different from other Early Neolithic sites in the region where no Mesolithic presence has been documented (Greenfield 1993, 2008a).

Seasonal resources

Animal and plant resources are not equally and uniformly available through the year. For this reason, there will always be a seasonal aspect to wild animal exploitation (Bogucki 1988; Orton 2008). This would imply a seasonally changing labour requirement and cycle of activities (e.g., more hunting in the warmer months and less in the winter due to the cold). This labour cycle may vary between regional environments and taxa, depending on the spatial and temporal availability of wild fauna throughout the year. The seasonal exploitation of animals may also be dependent on when labour is available since the harvest and planting periods are labour intensive.

In general, red and roe deer are available in the Balkans year-round. However, it is likely that deer migrate between highlands and lowlands seasonally in mountainous regions, therefore making them harder to access in colder months (Chaplin 1977; Greenfield 2008b). Other wild fauna, such as fish and birds, are more readily available during the warmer months (spring and summer), but not in colder months (fall and winter) due to migrations or weather conditions. For example, in winter, most seasonal birds will migrate south to warmer regions and fish become inaccessible due to frozen rivers. Some large wild species, such as aurochs and boar, will be available year-round in the region.

However, the assumption that wild animal resources are exploited on purely seasonal basis may not always be the case. For example, red and roe deer were probably hunted year-round at Opovo (Greenfield 1986a; Orton 2008; Russell 1993). A similar pattern of high frequency of wild fauna exploitation was seen at Hajdučka Vodenica, where wild fauna were hunted year round. Further, different species were likely exploited on a seasonal schedule. This continuity in exploitation is likely due to the continuity in occupation between the Mesolithic and Early Neolithic at the site (Borić 2011; Borić and Miracle 2004; Dimitrijević *et al.* 2016; Greenfield 2008b).

Risk management/buffering

A common conception about the importance of hunting during the Neolithic is that it was of minor importance since wild resources were being replaced by those provided by domestic fauna. This original view of hunting has since been largely replaced in the literature in recent years with more nuanced understanding of the importance of wild animals (Gregg 1988; Orton 2008; Russell 1993; Greenfield 1993, 2008). Hunting in communities relying on agriculture or pastoralism is now viewed as not only providing furs, feathers, meat, skin and bone, but also as a means of risk management (Halstead 1989).

Risk is an unpredictable variable outcome that results from a behaviour that brings consequences to an organism's fitness or utility. Risk is different than hazard; hazards are the potential sources of harm (Martson 2011; Winterhalder and Smith 1981). There is always a risk of food shortage in any community that could be the result of uncontrollable events, such as droughts or disease. However, the actual outcome of food shortage is famine. This is the hazard that must be avoided at all costs, otherwise large numbers of people can die.

Risk would have been present during the Neolithic since this was a dynamic time in the spread of food producing communities. For example, the spread of early food producing communities from Mediterranean to the temperate zone increased the chance of food shortages as both agricultural and pastoral resources needed to adapt to the new environment. Plants and animals brought by early farmers from the Mediterranean region required a period of adjustment to the vastly different climates and growing seasons of a Central European climatic regime (Bartosiewicz 2008; Bogucki 1988; Gimbutas

1991; Greenfield 1993, 2008a; Jezik 1998; Sørensen and Karg 2012; Willis and Bennett 1994). Therefore, it is likely that early farmers used various adaptive strategies to lessen risk and prevent deadly hazards.

There are many ways early agriculturalists could lessen risk and prevent hazards during the Neolithic. These strategies fall into two categories: diversification and intensification (Martson 2011; Winterhalder *et al.* 1999). Diversification may include shifting to different crops (e.g. from wheat to barley), increasing cropping types (such as multi-cropping), changing herd composition, spatial diversification of fields and herds, seasonal and annual variations in food production schedules, shift toward different types of economic activities (e.g. from hunting and foraging to agro-pastoralism), and the transfer, exchange and sharing of resources between communities (Arnold and Greenfield 2006; Greenfield 1986a, 1991, 1999; Greenfield and Jongsma 2008; Martson 2011).

Intensification during the Neolithic may have included increasing crop and herd size (overproduction), irrigation and water management, increasing trade, exchange and sharing, etc. Overproduction can be seen archaeologically in the form of storage vessels and structures (non-residential buildings) to hold the extra produce. Irrigation can be seen archaeologically by the presence of plants that require excess amounts of water (i.e. rice), and irrigation installations in the landscape (Martson 2011).

Additional strategies for risk management involve social aspects of behaviour. These include raiding and theft, reducing consumers (moving members of families to relatives in other regions), and reducing demand for limited food by restricting non-food uses (Winterhalder *et al.* 1999). For the most part, these are usually archaeologically invisible. There is no direct evidence in the Early Neolithic of the region for such behaviour, but there is from the Middle and Late Neolithic in the form of enclosures/fortifications (Orton 2008). It is likely that such events happened, and risk management strategies were used in the Early Neolithic, as well.

Raw Materials

Raw material acquisition is often cited as one of the main reasons for the hunting of wild animals, such as meat, skin, fur, sinew, bones, antlers, etc. It is likely that most of the wild animals exploited during the Neolithic were used for various purposes. Larger taxa would have provided a significant quantity of meat, fat, sinew, and other fleshy resources. In contrast, smaller taxa (such as hares) are often considered more important for their fur, but their meat would be valued as well (particularly during times when other resources were lacking).

Different types of animals would have been hunted for different raw materials. Carnivores would have been hunted for their fur, claws, and status. They are present in most assemblages, but in very small numbers (Greenfield 1986a, 1991; Orton 2008). Larger herbivores, such as deer, would have been hunted for skin, meat, antler, bones, etc. Tendons and other tissues can be used to make sinew. Hooves can be boiled to make glues, etc. The body part representation at most sites support this assertion since they are largely represented by cranial and distal elements (Greenfield 1986a; Russell 1993).

Red and roe deer antler are found at almost every Neolithic site and were used for producing a wide variety of tools (handles, hafts, decorative items, and etc.) (Greenfield 1985, 1986a; Greenfield and Arnold 2014; Orton 2011; Orton 2008; Russell 1990, 1993; Tringham *et al.* 1992; Tringham *et al.* 1985; Tringham *et al.* 1980; Vitezović 2014, 2017, 2018; Vitezović and Antonović ed. 2014). Deer long bones (such as metacarpals and metatarsals) were highly sought during the Neolithic since they are relatively straight. They are optimal for making many piercing type tools, such as awls and needles, as well as handles for more complex tools. Aurochs would have provided a significant, if only occasional, source of protein. Their bones also were used as tools, while their horns were most likely used as containers, decoration, and status symbols. Wild boar provided meat, while their tusks were carved into tools or decorations (and status symbols) and skulls kept as trophies. Birds were hunted for their meat, feathers, and their straight and hollow bones (which were used for making musical instruments, fine and delicate tools, and ornaments). Even fish may have also been exploited for more than just their meat since their sharp and thin bones could be used to make items such as awls and needles for finer work.

Opportunistic/garden hunting

It is clear from the overwhelming abundance of artefactual and floral remains that early farmers were growing crops, conducting hoe cultivation likely in the equivalent of large field-like gardens (Orton 2008). Unfortunately, for early farmers, domestic field crops would be especially attractive to the three most common wild species found in Neolithic sites from the region: wild boar, red deer, and roe deer.

Purposeful hunting usually emphasizes older animals (subadults and adults) where the return on energy investment is higher (Cordain *et al.* 2000; Speth and Spielmann 1983). Opportunistic hunting implies less preference and less planning, which results in a wider range of age groups. Such an exploitation profile would include young animals (infants and juveniles) as well as older animals (subadults and adults). Garden hunting may have been one of several driving forces for hunting, especially when there was the potential for crop raiding by deer. Today, roe deer are endemic crop raiders (Chaplin 1977) and are specially known to raid crops close to settlements, and would therefore be more visible and available for hunting (Prior 1995). The question is whether opportunistic hunting occurred often enough to appear archaeologically visible or was a rarer phenomenon.

This can partly be answered by comparing taxonomic and age-at-death frequencies, When such taxa show up in very low frequencies in assemblages, it would suggest that they are background noise to the larger subsistence pattern – probably a result of opportunistic hunting. Bogucki (1988) argued many years ago - that the low frequency of wild fauna at Neolithic sites was because they were hunted while raiding crops and that there was little organized hunting behaviour. In this situation, they would be considered pests.

Orton (2008: 113) proposed that garden hunting can be identified based on seasonality and age-of-death studies of remains. He suggested that assemblages with fewer deer and other wild animals primarily killed as adults may be the result of a combination of either selective hunting or encounter based hunting, such as when they raid crops. However, he adds that the seasonal and age-of-death data from Vinča culture sites do not support such as proposal as there is no evidence of a spring/summer trend in mortality profiles. The study of season and age-of-death using dental histology, such as cementum annuli, from Opovo and Petnica (Russell 1993; Orton 2008) show year-round hunting of roe and red deer. They were mostly mature adults which suggests purposeful hunting, as opposed to opportunistic garden-related encounters. This pattern has been supported by more a recent study of Neolithic deer from a variety of other sites (Greenfield and Brown 2017). There is a clear preference for large adult red deer remains in the Neolithic assemblages which suggests a more purposeful, than simply haphazard, hunting pattern.

Social roles of hunting

Social roles are about the relationships that people and animals share, the construction of identity, and the issues that contribute to the decisions that individuals make in relation to those animals (Orton 2008). The act of hunting may have been a specialist activity, with a specific social identity in which specific people, households, or settlements specialise. These groups would have a specialized skill set and knowledge base involving wild animal behaviour, hunting strategies dependent on each species, how to maintain and make tools for hunting, etc. The combination of their special skill set, weapons, and knowledge would have given them the ability to take down large wild animals more safely and effectively, a feat often awarded with increased prestige (Russell 2012).

Hunting may have occurred either communally or individually depending on the time and place, and taxon. Since deer are often solitary by nature or live in small family herds, they can be hunted by a solitary hunter or a small group (Prior 1995). Wild boar, on the other hand, is most effectively hunted by a group of hunters using very different strategies. In the case of garden or opportunistic hunting, where crops were defended against species that would raid them (i.e. roe deer, red deer, and wild boar), the role of the hunter most likely fell to the individual who stumbles upon or who actively awaits the raider while guarding the field (Orton 2008).

Exchange, as a social factor, may have been the result of regional specialization in wild resources. As noted above, in the Iron Gates, it is likely that cultural continuity between the Mesolithic and Neolithic played an essential role in the higher wild mammal frequencies (Bogosavljević, Petrović and Starović 2016; Greenfield and Jongsma 2008; Gregg 1988; Kaczanowska and Koz1owski 2003; Todorova 1995; Tringham 1971; Živaljević *et al.* 2021). However, the abundance of wild animal products in Early Neolithic Iron Gates sites may have been the result of 1) hunting preferences of communities consisting of a mixture of indigenous foragers and the incoming farmers (based on genetic evidence within the Iron Gates (Borić and Price 2013), a situation also seen at sites outside the Iron Gates, such as at Tiszaszőlős-Domaháza in Hungary (Depaermentier *et al.* 2020; Gamarra *et al.* 2018) where different traditions and activities occured within the same settlements and/or 2) the exchange of wild and domestic goods between communities as suggested long ago by Gregg (1988) for the Iron Gates – where the abundance of wild resources are exchanged with settlements that specialised in production of domestic products.

Animals also serve a social role in the form of food. Data from both Opovo and Blagotin have been used as evidence of social feasting (Greenfield and Greenfield 2017; Russell (1999). This is supported by a variety of data, including special contexts, special taxonomic and age-at-death distributions, special tools and containers, etc. Large and often dangerous wild animals (such as red deer, roe deer and wild boar, particularly males) were most likely served during such competitive feasts as a display of prestige and wealth.

Animals can also fulfil other social roles besides being a protein source. Wild animals, similar to domestic animals, can serve as symbols, deities and taboos (Russell 2012). They can also become involved in ritual, become trophies (antlers), and represent wealth and prestige. As mentioned above, hunting itself can be a prestige activity, especially in association with large fauna, such as aurochs (Russell 1993, 2012). Animals also can be subjects of interaction with and between people in their own right (Overton and Hamilakis 2013).

Data

Chronology

The Neolithic period of the central Balkans is characterized by two culture groups and three temporal phases. The Starčevo-Criş culture is characteristic of the Early Neolithic (Porčić *et al.* 2020; Sabin, Suciu, and Dumitrescu 2011). The Early Neolithic is the time of initial colonization of the region by food producers expanding out of the Mediterranean, while the Middle and Late Neolithic represent a period of settling into the environment (Garašanin 1983; Tringham 2000). On the basis of recent radiocarbon analyses from the region, the Early Neolithic period lasted from c. 6200/6100-5600/5400 BC cal. with the beginning and ending at different times depending on the region (Borić 2009; Greenfield and Jongsma-Greenfield 2014; Sabin *et al.* 2011; Spataro 2019).

The Middle Neolithic, which is composed of Vinča A and B, also known as Vinča-Tordoš I and II cultures. Recent radiocarbon dates are also available for the chronology of the Vinča culture. The Vinča A phase began around 5400/5300 and ended sometime around 5200 cal BC. The Vinča B phase of the culture (Vinča-Tordoš II) occurred around 5200 cal BC and finished around 5000 cal BC (Borić 2009). These new dates push back the Vinča culture nearly 1000 years earlier from accepted dates from a generation ago.

The Late Neolithic begins c. 5000/4950BC cal. and ends around 4650/4600 BC cal. (Arnold and Greenfield 2006; Chapman 1981; Greenfield 1991). This period represents the continuation of the Vinča A and B culture. It is also divided into two phases and is characterized by a continuation of the Vinča culture. The earlier Vinča-Pločnik C (Vinča C) is dated to c. 5000/4950-4850 BC and the Vinča-Pločnik D (Vinča D) to c. 4850-4650/4600 BC (Borić 2009). The collapse of Vinča societies marks the end of the Neolithic in the region.

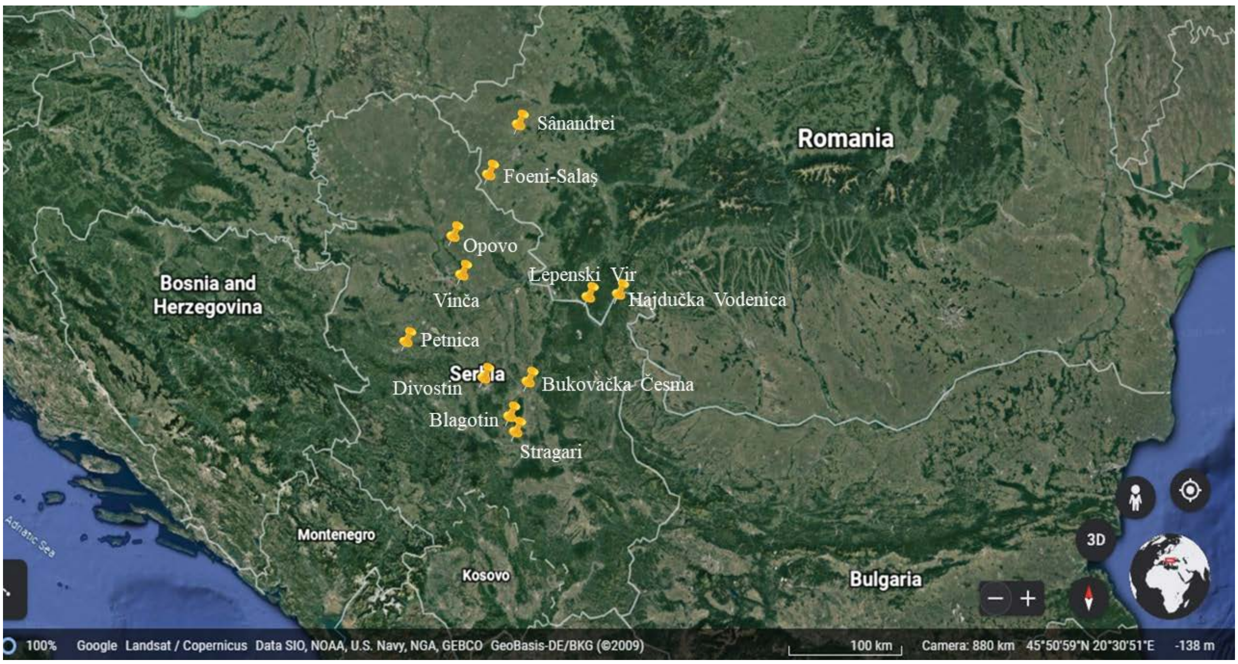

Figure 1. Map of the location of archaeological sites mentioned in this paper.

Sites

The data presented here derive from the analysis of the zooarchaeological assemblages from nine Neolithic sites from Serbia and SW Romania. These were all collected by Haskel and Tina Greenfield between 1982 and 1995. Most of the original specimens were left in their countries of origin. Some specimens were available for reanalysis by Annie Brown in the University of Manitoba Anthropology Laboratory (courtesy of Haskel Greenfield). The data include those from seven Neolithic sites in Serbia (Petnica, Stragari, Blagotin, Bukovačka Česma, Opovo, Hajdučka Vodenica, and Vinča) and two in Romania (Foeni-Salaş and Sânandrei) (Figure 1). The data from these nine sites that were analysed comparably to create a large enough sample for general patterns in subsistence to be visible over time. It was difficult to compare them with analyses conducted by other analysts (e.g., S. Bökönyi) because the published temporal and analytical criteria were different or not consistently available (e.g., age and sex).

The ensuing data are first summarised on a site-by-site basis for each period. This is followed by extensive discussion of trends in and between each period and region.

TABLE 1. DOMESTIC AND WILD FREQUENCIES FROM NEOLITHIC SITES IN THE TEMPERATE SE EUROPE.

Sites from Literature	Early Neolithic		Middle Neolithic		Late Nelithic	
	Domestic %	Wild %	Domestic %	Wild %	Domestic %	Wild %
Blagotin (Greenfield and Jongsma-Greenfield 2014)	91,71	8,29				
Bukovačka Česma (Greenfield 1994)	41,49	58,51				
Hajdučka Vodenica (Greenfield 2008)	33,33	66,67				
Foeni Salaş (Jongsma and Greenfield 2001)	79,07	20,93				
Stragari (Greenfield 2015b)			24	76		
Sânandrei (Jongsma & Greenfield 1996)			60,49	39,51		
Petnica (Greenfield 1986)			30,44	69,56	46,33	53,67
Vinča (Greenfield 2014)					70,64	29,36
Divostin I & II (Bökönyi 1988)	92	8			85	15

Data presented here may vary from that of the previously published data as new unpublished material are now included.

Table 2. Domestic and wild taxonomic frequencies based on Neolithic literature from the central Balkans (includes only on identified mammals).

Taxa	Early Neolithic								Middle Neolithic				Late Neolithic									
	Blagotin-Greenfield and Jongsma 2014		Bukovačka Česma - Greenfield 1994		Divostin I - Bokonyi 1988		Foeni- Salaş - Greenfield and Jongsma 2008		Petnica Vinča B - Greenfield 1986		Stragari - Greenfield 2015		Divostin II - Bokonyi 1988		Opovo - Greenfield 1986		Petnica Vinča C - Greenfield 1986		Petnica Vinča D - Greenfield 1986		Vinča D - Greenfield 2014	
Domestic	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Bos taurus	2684	30,83	70	25,5	1117	47	895	34,92	32	19,5	468	15,14	6763	63	194	30,1	103	34,7	36	33,6	354	18,04
Ovis/Capra	5170	59,38	13	4,7	981	41	1015	0,7	5	3	99	1,09	1228	11	12	2,7	7	2,3	5	4,7	143	7,29
Sus Scrofa dom.	115	1,32	21	7,7	84	4	99	39,6	36	21,9	168	1,85	1089	10	85	13,2	48	16,2	26	24,3	203	10,35
Canis familiaris	15	0,17	0	0	16	1	18	0,16	1	0,6	16	0,18	92	1	17	2,6	1	0,3			33	1,68
Wild Fauna																						
Bos primigenius	55	0,51	4	1,4	100	4	63	2,46	4	2,4	86	0,95	627	6	15	2,3	1	0,3			62	3,16
Canis lupus	4	0,05			4		7	0,27			2	0,02	5								1	0,05
Capreolus capreolus	188	2,16	19	6,9	13	1	87	3,39	15	9,1	506	5,56	44		40	6,2	22	7,4	6	5,6	20	1,02
Cervus elaphus	260	2,99	78	28,5	45	2	113	4,41	60	36,6	1586	17,43	416	4	232	36	82	27,6	31	29	145	7,39
Lepus europeanus	21	0,24			4		10	0,39	2	1,2	3	0,03	6		4	0,6	1	0,3			1	0,05
Sus scrofa fer.	80	0,92	27	9,8	32		39	1,52	4	2,4	147	1,62	495	5	23	3,6	23	7,7			24	1,22
Ursus arctos	6	0,07	1	0,4	1		2	0,08			4	0,04	2									
Castor Fibre			8	2,9	1				5	3	15	0,16	9				4	1,3				
Equus sp.							1	0,04													1	0,05
Felis silvestris											2	0,02									2	0,1
Martes martes											1	0,01			1	0,1						
Vulpes vulpes											1	0,01	2				1	0,3				

Site by site description of wild fauna

Bukovačka Česma

Wild fauna

At Bukovačka Česma, there are a total of 241 specimens from 11 different taxa found at the site during excavations (Table 3). Three of these taxa are domesticated animals (41.49%). The remaining eight were from wild taxa (58.51%).

There are a total of 141 wild specimens, represented by red deer (56.03%), wild boar (19.86%), roe deer (11.35%), beaver (Castor fiber) (5.67%), unidentified fish (2.84%), aurochs (2.13%), land snail (1.42%), and brown bear (0.71%). These percentages show that red deer are most common wild taxon, followed by wild boar and roe deer.

Foeni-Salaş

Wild fauna

At Foeni-Salaş, there were a total 2571 identified specimens and 34 different taxa. Of the 34 taxa, 28 were from wild animals. These taxa account for 538 identified specimens (20.93%) (Table 4). The wild taxa are unidentified fish (25.84%), red deer (21%), roe deer (16.36%), aurochs (11.71%), wild boar (7.25), unidentified bird (5.02%), European turtle (*Emys orbicularis*) (3.90%), European hare (1.86%), land snail (1.12%). The percentages show that fish, red deer, and roe deer are the most common taxon among the wild fauna.

Middle Neolithic Vinča A

Sânandrei

Wild fauna

At Sânandrei, there are a total of 567 identified specimens. Of these specimens, 224 are from wild taxa which account for 39.51% of the total assemblage (Table 5). There are a total of 6 wild taxa found at Sânandrei. The most common of these taxa are red deer (44.20%), wild boar (33.04%), and roe deer (20.98%). All other wild fauna are below 1% as shown in Table 5.

Stragari

Wild fauna

In the Middle Neolithic levels at Stragari there are a total of 2332 identifiable specimens. Of these specimens, there are 2178 identifiable specimens from wild fauna accounting for up to 75.94% of the faunal assemblage (Greenfield 2014a, 2017) (Table 6). In this sample there are over 18 wild faunal specimens. The most common of these wild fauna are red deer (66.92%), roe deer (21.35%), wild boar (6.20%), and aurochs (3.63%).

Table 3. Taxonomic frequencies for Bukovačka Česma
(Greenfield 1994 and Greenfield’s unpublished database).

Taxa	NISP	NISP%	Wild only NISP	Wild Only NIS%
Domestic				
Bos Taurus	69	28,63%		
Ovis/Capra	12	4,98%		
Sus scrofa dom.	19	7,88%		
Wild				
Bos primigenius	3	1,24%	3	2,13%
Capreolus capreolus	16	6,64%	16	11,35%
Castor fiber	8	3,32%	8	5,67%
Cervus elaphus	79	32,78%	79	56,03%
Fish (unidentified)	4	1,66%	4	2,84%
Unio sp.	2	0,83%	2	1,42%
Ursus arctos	1	0,41%	1	0,71%
Sus scrofa fer.	28	11,62%	28	19,86%
Grand Total	**241**	**100,00%**	**141**	**100,00%**

Middle Neolithic Vinča B

Petnica

Wild fauna

During the Vinča B period at Petnica, a total of 2451 identifiable specimens were identified. Of these specimens, the wild taxa account for 1705 specimens (69.56%) (Table 7). The most common wild fauna are red deer (70.09%), roe deer (11.67%), wild boar (9.62%), aurochs (4.11%), and beaver (2.05%) (Table 8). During this period, red and roe deer are the most common wild taxa exploited at the site.

Late Neolithic Vinča C

Wild fauna

The total number of specimens from Petnica’s Vinča C levels drops significantly from 2451 to 971. Concomittantly, the wild taxa frequencies drop from 1705 to 529 identifiable specimens. The wild taxa make up 54.40% of the sample (Table 7). Among the wild fauna, the most common taxa are red deer (63.23%), roe deer (15.87%), wild boar (15.34%), beaver (1.58%), and aurochs (1.32%) (Table 8).

Late Neolithic Vinča D

Wild fauna

There are a total of 384 identifiable taxa from the Vinča D levels at Petnica. In this sample, wild taxa account for 203 identifiable specimens (52.86%) (Table 7). The seven different identified taxa are: red deer (73.48%), roe deer (15.91%), and wild boar (7.58%) (Table 8). The Vinča D period is marked by a noticeable drop in the number of wild taxa present at the site. However, wild fauna still continue to outnumber the domestic fauna, as they had in previous periods.

Late Neolithic Vinča

Opovo

Wild fauna

There are a total of 712 identified specimens from the Late Neolithic levels of Opovo. In this sample, 393 are from wild taxa, accounting for 55.20% of the assemblage (Greenfield 1986a, 1991) (Table 9). The most common wild taxa at Opovo are red deer (32.72%), snails (9.97%), roe deer (5.76%), wild boar (2.81%), and aurochs (1.69%).

Late Neolithic Vinča

Vinča

Wild fauna

At the site of Vinča, there are a total of 1037 identified specimens. 303 (29.22%) of these specimens are from wild taxa (Table 10). There are a total of 14 different wild taxa found at Vinča. The most common wild taxa are red deer (13.98%), aurochs (5.98%), snail (2.31%), roe deer (1.93%), and wild boar (2.31%) (Table 10).

Discussion

Changes in hunting in the Neolithic by period

As shown by the examples above of the six primary motivations for hunting, it is clear that there was never a single motivation at play at any site. Most likely, nearly all motivations were at play at any given time. As time progressed throughout the Neolithic, there were inevitably some shifts in the way people subsisted and interacted with the environment around them.

Table 4. Taxonomic frequencies from Foeni-Salaş.

(Greenfield and Jongsma 2008 and Greenfield's unpublished database).

Taxa	NISP	NISP%	Wild Only NISP	Wild Only NISP%
Domestic	**2033**	**79,07%**		
Bos taurus	898	34,93%		
Canis familiaris	18	0,70%		
Capra hircus	77	2,99%		
Ovis aries	272	10,58%		
Ovis/Capra	669	26,02%		
Sus scrofa dom.	99	3,85%		
Wild	**538**	**20,93%**		
Anas platyrhynchos	2	0,08%	2	0,37%
Anas querquedula	1	0,04%	1	0,19%
Anas sp. (cf A. platyrhy	2	0,08%	3	0,56%
Anseriformes (cf A. plat	2	0,08%	1	0,19%
Anseriformes small (An	1	0,04%	1	0,19%
Aves sp.	32	1,24%	32	5,95%
Bos primigenius	63	2,45%	63	11,71%
Buteo buteo	1	0,04%	1	0,19%
Canis lupus	7	0,27%	7	1,30%
Capreolus capreolus	88	3,42%	88	16,36%
Cervus elaphus	113	4,40%	113	21,00%
cf Egretta garzetta	1	0,04%	1	0,19%
Ciconia Ciconia	1	0,04%	1	0,19%
Columba palumbus	1	0,04%	1	0,19%
Emys orbicularis	21	0,82%	21	3,90%
Fulica atra	1	0,04%	1	0,19%
Lepus europaeus	10	0,39%	10	1,86%
Otis tarda	1	0,04%	1	0,19%
Perdix perdix	1	0,04%	1	0,19%
Pica pica	1	0,04%	1	0,19%
Pisces sp.	139	5,41%	139	25,84%
Sus scrofa fer.	39	1,52%	39	7,25%
Tetrao tetrix	1	0,04%	1	0,19%
Turdus cf merula	1	0,04%	1	0,19%
Unio pictorum	6	0,23%	6	1,12%
Ursus arctos	2	0,08%	2	0,37%
Grand Total	**2571**	**100,00%**	**538**	**100,00%**

TABLE 5. TAXONOMIC FREQUENCIES FOR SÂNANDREI

(JONGSMA AND GREENFIELD 1996 AND GREENFIELD'S UNPUBLISHED DATABASE).

Taxa	NISP	NISP%	Wild Only NISP	Wild Only NISP%
Domestic	**343**	**60,49%**		
Bos taurus	224	39,51%		
Canis familiarus	7	1,23%		
Capra hircus	3	0,53%		
Equus caballus	1	0,18%		
Ovis aries	10	1,76%		
Ovis/Capra	43	7,58%		
Sus scrofa dom.	55	9,70%		
Wild	**224**	**39,51%**		
Aves sp.	1	0,18%	1	0,45%
Bos primigenius	1	0,18%	1	0,45%
Canis lupus	2	0,35%	2	0,89%
Capreolus capreolus	47	8,29%	47	20,98%
Cervus elaphus	99	17,46%	99	44,20%
Sus scrofa fer.	74	13,05%	74	33,04%
Grand Total	**567**	**100,00%**	**224**	**100,00%**

Early Neolithic Starčevo

During the Early Neolithic, while domestic fauna dominates in the environments of central Serbia and the Banat, sites in these regions show a high diversity in wild taxa (Foeni-Salaş and Blagotin) and low frequencies of the wild fauna (Foeni-Salaş, Blagotin, and Divostin I). This reflects less selectivity of what was hunted around the site, possibly due to low availability of wild fauna and the suitability of the environment to agriculture and pastoralism. At some of these sites, such as Foeni-Salaş, there is a high possibility that many of the wild taxa were hunted seasonally. It would seem that every wild species that was available around them was being hunted for both food and other resources.

The Iron gates and marshland sites found elsewhere, on the other hand, show a fairly low diversity of fauna and a high frequency of wild fauna (Hajdučka Vodenica, Lepenski Vir, Mihajlovac-Knjepište, and Bukovačka Česma) (Bökönyi 1971, 1992; Greenfield 1982, 1994). This suggests that there was a high availability of wild fauna in the surrounding environment of the sites, accounting for the emphasis on wild fauna. The sites that also show a low diversity of wild fauna, and therefore these sites may be specialising in hunting specific species as opposed to hunting all species available around them.

There are two evident patterns of wild animal exploitation during the Early Neolithic. The first is where domestic fauna are much more frequent than wild fauna. In these cases, wild fauna account for < 20% of assemblages. This is illustrated at a variety of sites, such as Blagotin, Foeni-Salaş, Divostin I, etc. (Table 1 - Domestic vs wild frequencies only). For example, wild fauna only account for 13.8% of

Table 6. Taxonomic frequencies from Stragari.

(Greenfield 2017 and Greenfield’s unpublished database).

Taxa	NISP	NISP%	Wild Only NISP	Wild Only NISP%
Domestic	**154**	**6,60%**		
Bos taurus	117	5,02%		
Capra hircus	4	0,17%		
Ovis aries	3	0,13%		
Ovis/Capra	9	0,39%		
Sus scrofa dom.	21	0,90%		
Wild	**2178**	**93,40%**		
Aves (unidentified species)	2	0,09%	2	0,09%
Bos primigenius	20	0,86%	20	0,92%
Canis lupus	1	0,04%	1	0,05%
Capreolus capreolus	501	21,48%	501	23,00%
Castor fiber	14	0,60%	14	0,64%
Cervus elaphus	1580	67,75%	1580	72,54%
Emys orbicularis	1	0,04%	1	0,05%
Felis Silvestri	2	0,09%	2	0,09%
Fish (unidentified species	3	0,13%	3	0,14%
Lepus europaeus	1	0,04%	1	0,05%
Lepus sp.	2	0,09%	2	0,09%
Martes martes	1	0,04%	1	0,05%
Meles meles	3	0,13%	3	0,14%
Rodent	2	0,09%	2	0,09%
Sus scrofa fer.	39	1,67%	39	1,79%
Unio pictorum	1	0,04%	1	0,05%
Ursus arctos	4	0,17%	4	0,18%
Vulpes Vulpes	1	0,04%	1	0,05%
Grand Total	**2332**	**100,00%**	**2178**	**100,00%**

the sample at Foeni-Salaş (Greenfield 1994; Greenfield and Jongsma 2008). Divostin also displays this pattern, with roughly 8% of the overall assemblage from wild taxa (Bökönyi 1988). This holds true even where collection strategies differ (Greenfield 2008a).

The second pattern is where wild taxa far outnumber domestic taxa. Bukovačka Česma (overlooking the Morava River floodplain), Hajdučka Vodenica, and Lepenski Vir III (in the Iron Gates) are examples. Unusually, high numbers of wild fauna are present at each site with 61.5%, 82%, and 74.5% respectively, as shown in Table 1 (Bökönyi 1971; Greenfield 1993, 1994, 2008b).

There are several possible reasons for these patterns (Greenfield 2008a). The first is sample size. However, while assemblage size has a dramatic effect on diversity, it does not appear to account for the unusually

Table 7. Domestic and wild taxonomic frequencies from Petnica
(Greenfield 1986a and Greenfield's unpublished database).

Taxa	Vinča B - Middle Neolithic		Vinča C - Late Neolithic		Vinča D - Late Neolithic	
	NISP	NISP%	NISP	NISP%	NISP	NISP%
Domestic	**746**	**30,44%**	**442**	**45,52%**	**181**	**47,14%**
Bos taurus	385	15,71%	258	26,57%	103	26,82%
Canis familiaris	7	0,29%	9	0,93%	1	0,26%
Capra hircus	5	0,20%		0,00%	1	0,26%
Ovis aries	13	0,53%	4	0,41%	2	0,52%
Ovis/Capra	45	1,84%	34	3,50%	18	4,69%
Sus scrofa dom.	291	11,87%	137	14,11%	56	14,58%
Wild	**1705**	**69,56%**	**529**	**54,48%**	**203**	**52,86%**
Bos primigenius	70	2,86%	12	1,24%	1	0,26%
Canis lupus	5	0,20%		0,00%		0,00%
Capreolus capreolus	199	8,12%	74	7,62%	26	6,77%
Castor fiber	35	1,43%	11	1,13%	4	1,04%
Cervus elaphus	1195	48,76%	345	35,53%	137	35,68%
Emys orbicularis	4	0,16%	1	0,10%	1	0,26%
Felis silvestris	5	0,20%		0,00%		0,00%
Lepus europaeus	4	0,16%	3	0,31%		0,00%
Martes martes	11	0,45%	1	0,10%		0,00%
Pisces sp.	8	0,33%	2	0,21%		0,00%
Sus scrofa fer.	164	6,69%	79	8,14%	32	8,33%
Ursus arctos	3	0,12%		0,00%	2	0,52%
Vulpes vulpes	2	0,08%	1	0,10%		0,00%
Grand Total	**2451**	**100,00%**	**971**	**100,00%**	**384**	**100,00%**

high or low numbers of wild fauna found at some sites. Second, sites where recovery techniques such as sieving and floatation were not used likely missed many of the smaller wild fauna (e.g., birds, fish and rodents). This is probably true, particularly along riverine or lacustrine environments. However, it does not appear to have an effect on the sites farther away from such environments (e.g. Divostin, Blagotin, etc.). Third, sites with high concentrations of wild fauna were located in those environments where it was not particularly beneficial to raise domestic ruminants. In such environments, wild fauna would be more numerous. In those environments, it was more advantageous to hunt rather than rely purely on domesticated fauna. This is especially the case for sites located in the Pannonian lowland plains and the mountainous Iron Gates region (Bartosiewicz 2005, 2013; Kovács *et al.* 2010). Many parts of the Pannonian plains are marshy which is not an environment well suited for keeping of domesticated fauna such as cattle, sheep and goat. The Iron Gates sites, on the other hand, are located toward valley bottoms with steep highlands, hills, and mountains. Most of the Iron Gates sites are located on or close to the banks of the Danube River and surrounded by dense forests. Therefore, land suitable for farming or herds of domesticates was not easily accessible or as abundant in comparison to that available for wild resources.

Table 8. Wild taxonomic frequencies from Petnica.
(Greenfield 1986a and Greenfield's unpublished database).

Taxa	Vinča B - Middle Neolithic		Vinča C - Late Neolithic		Vinča D - Late Neolithic	
	NISP	NISP%	NISP	NISP%	NISP	NISP%
Wild						
Bos primigenius	70	4,11%	12	2,27%	1	0,49%
Canis lupus	5	0,29%		0,00%		0,00%
Capreolus capreolus	199	11,67%	74	13,99%	26	12,81%
Castor fiber	35	2,05%	11	2,08%	4	1,97%
Cervus elaphus	1195	70,09%	345	65,22%	137	67,49%
Emys orbicularis	4	0,23%	1	0,19%	1	0,49%
Felis silvestris	5	0,29%		0,00%		0,00%
Lepus europaeus	4	0,23%	3	0,57%		0,00%
Martes martes	11	0,65%	1	0,19%		0,00%
Pisces sp.	8	0,47%	2	0,38%		0,00%
Sus scrofa fer.	164	9,62%	79	14,93%	32	15,76%
Ursus arctos	3	0,18%		0,00%	2	0,99%
Vulpes vulpes	2	0,12%	1	0,19%		0,00%
Grand Total	**1705**	**100,00%**	**529**	**100,00%**	**203**	**100,00%**

Three possible reasons have been proposed for the unusual high numbers of wild taxa at Iron Gates and lowland sites (Greenfield 2008b). The first is the high concentrations of wild fauna may be due to the sites being in an ecologically rich area, where high numbers of wild fauna are present (e.g. marsh lands). The second possibility is that these sites were originally inhabited by Mesolithic hunters and gatherers that adopted domestic farming and herding, but maintained their Mesolithic hunting traditions (Borić and Dimitrijević 2007; Borić *et al.* 2018; Borić and Price 2013; Cramp *et al.* 2019; Gregg 1988; Mathieson *et al.* 2018). Lastly, these sites may be specialised hunting and trading settlements since they are in the centre of regions with an abundance of wild resources. Given the vagaries of equifinality, several of these proposals may have contributed to the patterns observed.

Middle Neolithic Vinča A-B/Tordoš I-II

The Middle Neolithic suggests two different patterns of domestic and wild frequencies. However, this difference may be due to collection strategies between different archaeological schools.

The site of Sânandrei is a good example where collection strategies emphasized large animals, whereas collection strategies were much better at the sites of Petnica and Stragari. In the Romanian Banat, domestic fauna dominate the assemblage, while wild frequencies remain low, with a low wild fauna diversity (Sânandrei). This suggests that the subsistence strategies for Sânandrei more heavily relied on domestic and less on wild taxa. However, the hand-collection strategy employed at Sânandre focused largely on the larger taxa. This may explain the drastic difference in the variety of wild taxa found at Sânandrei than at nearby Foeni-Salaş.

Table 9. Taxonomic frequencies from Opovo.
(Greenfield 1986a and Greenfield's unpublished database).

Taxa	NISP	NISP%	Wild Only NISP	Wild Only NISP%
Domestic	**319**	**44,80%**		
Bos taurus	197	27,67%		
Canis familiaris	20	2,81%		
Capra hircus	1	0,14%		
Ovis aries	4	0,56%		
Ovis/Capra	14	1,97%		
Sus scrofa dom.	83	11,66%		
Wild	**393**	**55,20%**		
Bos primigenius	12	1,69%	12	3,05%
Capreolus capreolus	41	5,76%	41	10,43%
Cervus elaphus	233	32,72%	233	59,29%
Helix sp.	6	0,84%	6	1,53%
Lepus sp.	4	0,56%	4	1,02%
Meles/Nutra sp.	1	0,14%	1	0,25%
Rupicapra rupicapra	2	0,28%	2	0,51%
Sus scrofa	3	0,42%	3	0,76%
Sus scrofa fer.	20	2,81%	20	5,09%
Unio sp.	71	9,97%	71	18,07%
Grand Total	**712**	**100,00%**	**393**	**100,00%**

Central Serbian sites, on the other hand, show an increase in the frequency and diversity of wild fauna (Table 1 - Petnica and Stragari) (Greenfield 1986b; Greenfield 2015; Greenfield 2017; Jongsma and Greenfield 1996; Orton 2008). In general, the Middle Neolithic continues many of the same regional trends in animal exploitation strategies as seen previously in the Early Neolithic – lowland marshy environments in Pannonia versus rolling hills of central Serbia.

Late Neolithic Vinča C-D/Pločnik I-II

The Late Neolithic followed the same basic wild animal exploitation patterns as seen in the Middle Neolithic. Both Russell (1993) and Greenfield (1986b) found that Opovo, unlike many earlier Neolithic sites, had more wild fauna than domestic fauna (roughly 70% and 50.8% of the assemblage) (Table 1). Other sites, such as Petnica, Gomolava, Vinča, and Divostin II have more domesticated taxa than wild. Interestingly, there were some shifts in the percentages of wild fauna over time. Greenfield reports that Petnica has fewer wild than domestics (Greenfield 1986b), while Orton (Orton 2008) states that there are slightly more wild taxa than domestic. This difference may be that they analysed material from different excavation areas where there were differences in collection strategies. The earlier excavations used mostly hand-collection (and some sieving), while the later excavations employed sieving more

Table 10. Taxonomic frequencies from Vinča-Bela Brdo
(Greenfield 2014c and Greenfield's unpubllished database).

Taxa	NISP	NISP%	Wild Only NISP	Wild Only NISP%
Domestic	**734**	**70,78%**		
Bos taurus	354	34,14%		
Canis familiaris	33	3,18%		
Capra hircus	7	0,68%		
Equus caballus	1	0,10%		
Ovis aries	28	2,70%		
Ovis/Capra	108	10,41%		
Sus scrofa dom.	203	19,58%		
Wild	**303**	**29,22%**		
Aves sp.	2	0,19%	2	0,66%
Bos primigenius	62	5,98%	62	20,46%
Canis lupus	1	0,10%	1	0,33%
Capreolus capreolus	20	1,93%	20	6,60%
Cervus elaphus	145	13,98%	145	47,85%
Ciconiidae (storks)	1	0,10%	1	0,33%
Emys orbicularis	1	0,10%	1	0,33%
Felis silvestris	2	0,19%	2	0,66%
Lepus europaeus	1	0,10%	1	0,33%
Lutra lutra	1	0,10%	1	0,33%
Meles meles	1	0,10%	1	0,33%
Pisces sp.	18	1,74%	18	5,94%
Sus scrofa fer.	24	2,31%	24	7,92%
Unio sp.	24	2,31%	24	7,92%
Grand Total	**1037**	**100,00%**	**303**	**100,00%**

systematically. The other possible explanation is spatial in that the types of Neolithic deposits analysed were different – Greenfield's Neolithic levels were mostly between structures, while Orton's also included the structures.

The Late Neolithic levels at Divostin show an increase in the hunting of wild taxa (15%) over that of the Early Neolithic (8%) (Table 3). An additional shift was that wild boar began to outnumber red and roe deer at most sites, while red and roe deer became the second and third most common taxa respectively (Bökönyi 1988).

Late Neolithic Sânandrei exhibits a shift in the composition of fauna at the site as well. Unlike the Middle Neolithic, where the wild and domestic animals nearly equalled each other, the wild fauna dropped dramatically from 22.5% in the Middle Neolithic to 16.54% (Table 2) (Jongsma and Greenfield 1996). The most common wild fauna found at the site also shifted from wild boar as the most common wild taxa during the Middle Neolithic to red deer, followed by roe deer and then wild boar in the Late Neolithic.

Another issue to be considered is that the changing frequencies of wild fauna during the Late Neolithic are because of the skill levels of the analyst, as well as spatial variation in where the faunal assemblage comes from in a site. Two sites were studied by more than one analyst and yield different percentages. At Vinča, Greenfield's (Greenfield 2014b) wild fauna frequencies are vastly lower than that reported by Dimitrijević (Dimitrijević 2006). It is that this is result is not due to a change in collection strategy as Dimitrijević was also hand-collected. The difference may lie in that a different phase of occupation was investigated by each one of them. Unfortunately, the fauna from Greenfield's analysis were not preserved by Bökönyi after he analysed the remains (Bökönyi 1990; Greenfield 2014c). There is a drastic difference, as well, in the number of wild fauna between Greenfield and Russell (1993), who worked on the material from the joint American-Serbian excavations with its extensive sieving operations, while Greenfield's (1986a) earlier study is based on the hand-collected assemblage from the Serbian-led excavations at the site. The problem is that they have all excavated different parts of the site, with different recovery methods, and sometimes different occupation levels. Despite these changes, the general pattern remains the same as it has been during the Early Neolithic, in which overall, the domestic fauna out-number wild at most sites, with a few exceptions, as is distinguished by regional variation similar to what was discussed earlier for the Early Neolithic.

Regional trends during the Neolithic (environment)

Uplands of Central Serbia

The typical environments observed in central Serbia are mid-altitude locations with well drained soils and nearby rolling hills (or gentle slopes). These features make this region very attractive for agriculture. Four sites from our sample are found in this environment: Divostin, Blagotin, Stragari, and Petnica (Greenfield 2000, 2014b; Greenfield and Jongsma-Greenfield 2014; Orton 2008). All are distant from major rivers or floodplains. In these locations, there is less diversity of wild fauna year-round. The reason for this is there are no major rivers, flood plains or marshlands that would attract a large number and variety of wild animals. The inhabitants in these areas are also far away from large rivers that would be ideal for fishing.

In consequence of being distant from lacustrine environments, Blagotin (8% wild, 92% domestic), Divostin I (8% wild, 93% domestic), and Divostin II (15% wild, 85% domestic) (Bökönyi 1988) all show low frequencies of wild taxa. Very surprisingly, Petnica (64% wild, 36% domestic) and Stragari (80% wild, 20% domestic) have very high frequencies of wild taxa in all Neolithic periods - they are consistently over 50%. This difference in taxonomic frequency may be in part due to Petnica and Stragari's relative proximity to streams which are parts of tributaries (the Kolubara and Riljačka streams respectively) of large rivers (the Sava and Morava rivers, respectively). However, these sites are not in large floodplains.

All sites located in the central Serbian environmental region, Blagotin (11 wild taxa, 5 domestic taxa), Stragari (18 wild taxa, 5 domestic taxa), Divostin I (10 wild taxa, 6 domestic taxa), Divostin II (13 wild taxa, 6 domestic taxa) (Bökönyi 1988), and Petnica (13 wild taxa, 5 domestic taxa) all show high diversity in the wild taxa found at the site, with each site featuring over 10 different species found. It should be noted that Stragari had the highest taxonomic diversity.

Lowlands of Pannonia

The southern part of the Pannonian Plain, especially along the Danube River and its major tributaries, contains numerous sites. It is a relatively flat alluvial plain environment with habitats that are very good year-round exploitation of wild fauna. The rivers, and their flood plains and marshlands, provide a great year-round source of food and shelter for the animals in the area. The floodplains are optimal for hunting since they provide year-round shelter for wildlife. Additionally, the soils in this environment are often water-logged and are not as suitable for farming.

Sites, such as Opovo, are surrounded by wetlands and have high wild frequencies (55 % wild, 45 % domestic) similar to those seen in the Iron Gates. The high wild faunal frequency and diversity at Opovo (10 wild taxa, 6 domestic taxa) suggests that there was a higher variability and availability of wild fauna in its immediate environment. However, the near equal balance between the wild and domestic fauna may also indicate that some pastoral activities were taking place near the site, which suggests seasonally available pastures for livestock.

Farther away from the major rivers, the environment is better drained with only seasonal marshes. The better drainage also allows for more forms of food production (agro-pastoralism). The sites of Foeni-Salaş and Sânandrei are located in such environments. Both Foeni-Salaş (21% wild, 79% domestic) and Sânandrei (40% wild, 60% domestic) feature a very high percentage of domestic taxa and a moderately high percentage of wild taxa. Wild taxa most likely were more available during the warmer seasons when marshes were flooding (during the spring and early summer). Taxonomic diversity however is dramatically different between the two sites: Foeni-Salaş (28 wild taxa, 6 domestic taxa) and Sânandrei (6 wild taxa, 7 domestic taxa). This may be indicative of the collection methods used rather than the environment surrounding the site, since Foeni-Salaş was systematically sieved and floated while Sânandrei was only hand-collected.

On the south bank of the Danube, with the Serbian hill country at its rear, Vinča (14 wild taxa, 6 domestic taxa) has an unusually high diversity in the wild fauna. The diversity in taxa is even greater than at Opovo. However, the overall wild frequencies are much lower than seen elsewhere in the lowlands (29% wild, 71% domestic). The reason for this may be in part since Vinča is located on a tell site, constructed on the loess terrace, which would provide good agricultural soils. This may explain why there is more extensive exploitation of domestic fauna as opposed to the wild fauna. Opovo, Foeni-Salaş, and the other sites located in the lowlands to the north of the Danube River are surrounded by seasonally flooded marshlands, which makes farming less attractive. Exploitation of wild fauna becomes a more viable pastime in such situations.

Iron Gates

The Iron Gates region is located where the Danube River flows through a narrow gorge between the Balkan Mountains on the southern or Serbian shore and the Carpathian Mountains on the northern or Romanian shore. This region runs along the banks of the Danube River as it flows towards the Black Sea. Sites located in this region are found primarily along the bank of the Danube, in marshlands, and gorges.

Environments in the region surrounding the sites of the Iron Gates include rivers, shorelines, small meadows, and high altitude deciduous and evergreen forests (Bailey 2000; Chapman 1990; Greenfield 1986a; Markotić 1984; Navy 1944; Srejović 1972).

The Iron Gates sites are especially known for their unusually high frequencies of wild fauna. All the three sites discussed above, excavated in the 1960s. In each of them wild fauna dominate - Hajdučka Vodenica (67% wild, 33% domestic), Lepenski Vir (74.5% wild, 25.5% domestic) (Bökönyi 1971; Srejović 1972), and Padina B (66% wild and 33% domestic) (Clason 1980). They all feature higher wild frequencies than found elsewhere in the region. At the more recently excavated site with more systematic recovery systems, e.g. Schela Cladovei, this pattern is borne out (c. 67%) (Bartosiewicz *et al.* 1995; Bartosiewicz *et al.* 2001; Dinu 2010). The high frequencies of wild fauna in Iron Gates sites is largely because of the importance of aquatic (fish) exploitation and hunting of wild mammals (Živaljević *et al.* 2017). The steep and heavily forested slopes behind each of the Iron Gates sites are less suitable for agriculture or pastoralism compared to the central Serbian region.

Taxonomic diversity also increases within the Iron Gates. For example, the sites of Hajdučka Vodenica (5 wild taxa, 3 domestic taxa) (Greenfield 2008b), Lepenski Vir (19 wild taxa, 4 domestic taxa) (Bökönyi 1971; Srejović 1972), Padina B (27 wild taxa, 4 domestic taxa) (Clason 1980), and Schela Cladovie (14 wild taxa; 5 domestic taxa) (Bartosiewicz *et al.* 1995) all show high levels of diversity in wild taxa. Each site features over ten different taxa (except for Hajdučka Vodenica), while the diversity of domestic fauna is low, often below five taxa. The low diversity of wild taxa at Hajdučka Vodenica may in part be due to its sample size or may indicate specialization toward a specific taxon. Most likely, the low frequencies are due to the smaller sample size (NISP=43).

Overall, the taxonomic frequencies observed at these sites may be indicative of the unique environment surrounding the sites, as well as population continuity between the Mesolithic and Early Neolithic in the Iron Gates. The high abundance of wild fauna found at each of the sites suggests both continuity in exploitation from the Mesolithic into the Neolithic, as well the potential for specialisation in wild taxa exploitation.

Morava River Valley

Only one site is in the Morava River Valley: Bukovačka Česma. The environment around Bukovačka Česma features both marshlands and rolling hills. This environment is very similar to the Pannonian Plain environment surrounding Opovo, but less marshy. This environment has a high availability of wild taxa, but also good soils for agriculture and pastoralism in certain areas (Greenfield 1986a, 1994). Bukovačka Česma (59% wild, 41% domestic) features higher frequencies of wild fauna than domestic. This is probably a reflection of the environment around the site. At Bukovačka Česma, there is a moderately high taxonomic diversity of wild fauna compared to domestic (8 wild taxa, 3 domestic taxa). However, the relatively low values in wild fauna availability may be in part due to the smaller samples size (NISP 544) and the unsystematic collection strategies used when the site was excavated.

Conclusion - Are wild fauna a significant part of the diet?

During the Early Neolithic, the wild and domestic animals are generally of equal importance (Arnold and Greenfield 2006; Manning *et al.* 2013; Orton *et al.* 2016). If viewed individually, most sites exploited more domestic than wild animals. Additionally, the percentage of wild versus domestics also changes in a south to north gradient with an increase in wild towards the north as the climate becomes cooler and more temperate. An example of this are the Körös sites on the Pannonian plain, which have higher percentages of wild than domestic fauna than their Starčevo-Criş neighbours to the south (Gronenborn 1999). Another example is the sites located in the Iron Gates region which primarily exploited wild animals, unlike the sites outside this region that predominantly subsisted on domestics (Greenfield 2008a). This gradient within the faunal assemblages may be due to the fact that sheep and goats had to adjust to the temperate climate to the north before they could be properly exploited there (Arnold and Greenfield 2006; Bartosiewicz 2008; Bogucki 1988; Gronenborn 1999; Tringham 1971). Unlike the frequencies of domestic animals, the percentage of wild fauna at most sites is low, the exception being sites located in the Iron Gates region, as mentioned above. Among the wild fauna, the most common are red and roe deer, followed by wild boar and aurochs (Arnold and Greenfield 2006; Greenfield and Jongsma 2008). Other wild resources, such as fish and waterfowl, have been documented at sites located near water sources, regardless of whether sieving was conducted or not, attesting to their significance (Blažić 2005; Brinkhuizen 1990).

Subsistence patterns during the Middle Neolithic continued the pattern of strong dependence on domestic resources (Arnold and Greenfield 2006; Greenfield 2017; Tringham 1971). During the Middle Neolithic, wild fauna (particularly deer) begin to slowly increase in frequency, but mostly remained secondary to domestic fauna. At this time, there is a marked increase in the occurrence of wild boar (possibly related to domestication of wild stock).

While both the Early and Middle Neolithic cultures primarily subsisted on domestic fauna, the Late Neolithic data suggests a heavier reliance on wild fauna in some regions, and less in others (Greenfield 1991; Greenfield and Jongsma 2008; Orton 2008). During the Late Neolithic, the shift in the increased exploitation of wild fauna continued. Wild fauna became increasingly important (Greenfield 1986a, 1991, 2014c; Greenfield and Fowler 2005; Greenfield and Jongsma-Greenfield 2014; Orton 2011; Orton 2008). Red deer are the most commonly exploited wild mammal, while roe deer remain the second most common wild animal exploited. Wild boar became increasingly important in the assemblages (Arnold and Greenfield 2006; Jongsma and Greenfield 1996; Tringham *et al.* 1985). The wild animal exploitation patterns during the Late Neolithic are also affected by the ecological location, particularly sites located in lowlands and highlands. There appears to be more wild animals at lowland sites, while there are fewer wild animals at highland sites. This is likely because lowlands are often surrounded by wetlands (e.g., Opovo, Foeni-Salaş, and Sânandrei) (Arnold and Greenfield 2006; Greenfield 1986a, 1991).

In conclusion, every site has some wild fauna. They represent a significant part of each assemblage, but in varying frequencies (Table 3). Yet, the differences in frequencies may be due to a variety of factors, including time, environment, and recovery methods (Greenfield 1991, 2008a). In spite of this variation, they were an integral part of the diet, economy, and social world of the peoples living in the central Balkans during the Neolithic period (Orton 2008; Russell 1993).

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Hunting and fishing weapons, land and marine resources, technology and ways of life in the Neolithic sites of the Strait of Gibraltar region

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Abstract

This chapter presents the interdisciplinary study (involving research on prehistoric archaeology, terrestrial fauna and marine fauna by the Universities of Cadiz, Córdoba, Cantabria and CSIC-Barcelona) of hunting and fishing implements from various periods of prehistory in the region around the Strait of Gibraltar, including along both European and North African shores. Recently excavated Neolithic sites include Benzú Cave (Ceuta) in North Africa, Campo de Hockey (San Fernando, Cádiz), La Esparragosa (Chiclana de la Frontera, Cádiz) and SET Parralejos (Vejer de la Frontera, Cádiz), on the Spanish coast. Using carbon dating, these sites have been dated to the 6th-4th millennium BC. The economies of these sites were largely agriculture based, but the hunting and fishing instruments are of special interest owing to proximity of the coast. This study investigates a wide range of issues, from the archaeobotanical, terrestrial and marine fauna records to lithic technology and functionality studies. Together with hunting, the exploitation of marine resources (fish and shellfish) was important for people's diet in this Atlantic–Mediterranean region.

Keywords: Gibraltar Strait region; Hunter-gatherers; Neolithic societies; Microliths; Marine resources; Hunting; Fishing

Introduction

The exploitation and consumption of marine resources is of great interest for prehistoric studies. In the Iberian Peninsula, it was believed until recently that these resources were exploited only by anatomically modern humans (Straus 1992). However, recent research in the region around the Strait of Gibraltar – at sites such as Gibraltar (Stringer *et al.* 2008; Fa *et al.* 2016), Bajondillo (Cortés *et al.* 2011) and along the Portuguese coast (Zilhao *et al.* 2020) – has demonstrated that they were also exploited by Neanderthal groups which used Mousterian-Mode 3 technology.

In North Africa, the exploitation of marine resources in the site of Benzú dates back to at least 270 Ka. (Cantillo 2017; Ramos *et al.* 2016). Anatomically modern humans have been attested at the nearby site of Djebel Irhoud (Hublin *et al.* 2017), but no human remains have been documented in Benzú to date, and, based on the technological features of the stone tools found, we believe that the site was occupied by Neanderthal groups (Ramos-Muñoz *et al.* 2019; Clemente-Conte *et al.* 2019b).

The continued exploitation of marine and hunting resources throughout the Upper Palaeolithic period in the region seems obvious, and is also attested by other sites such as Cueva de Nerja (Aura *et al.* 2001, 2016).

This chapter argues that, in parallel with hunting, the exploitation of marine resources played a significant role in the economy and everyday life of the last groups of hunter-gatherers and the earliest Neolithic agricultural tribal societies (Ramos Muñoz ed. 2008). For more than 20 years we have been studying, from the theoretical position of Social Archeology (Arteaga 1992; Bate 1998; Vargas 1987), the transition from hunter-gatherer to tribal societies in the Strait of Gibraltar region, during the Pleistocene and Holocene (Ramos Muñoz ed. 2008).

The natural environment: The geohistorical region of the Strait of Gibraltar

The natural region of the Strait of Gibraltar is a mid-latitude warm zone straddling Europe and Africa. It extends over the Iberian Moroccan Gulf to the north (Vanney and Menanteau 2004), the Bay of Cadiz and the coastal area of Campo de Gibraltar to the west, and the Bay of Malaga to the east. In North Africa, it stretches from Tangier peninsula to the Alborán Basin, including the hinterland of Tangier, the coast of Tetouan and the Eastern Rif and Oued Moulouya.

The region's peculiar geographical features and historical evolution are a result of its unique location between the Atlantic and the Mediterranean (Arteaga and Hoffmann 1999; Arteaga *et al.*, 2008).

This chapter analyses several sites located along the Atlantic coast of Cádiz and its agricultural hinterland, as well as a site in Ceuta, North Africa.

All these areas are very similar in terms of geology (Gutiérrez *et al.* 1991; Gracia *et al.* 2000; Zazo and Goy 2000), geography, environment, climate, wildlife, vegetation and resources. These areas are regarded as a historical region (Braudel 1988) because of their homogenous historical and economic development over time. The region's peculiar geographical features and historical evolution are a result of its unique location between the Atlantic and the Mediterranean (Arteaga and Hoffmann 1999).

Therefore, the area is of interest because of the presence of soils with great agricultural potential and great diversity in terms of land wildlife. As we shall see presently, the economic potential of the land (Guerra *et al.* 1963) was accompanied by the exploitation of marine resources from the Middle Pleistocene and, especially, the Holocene.

The sites

This section presents the geographical location and a brief description of the sites that we shall be considering in more detail below. As illustrated in Figure 1, all of these sites are located along the Atlantic coast of Cádiz (Embarcadero del río Palmones, SET Parralejos, La Esparragosa, Campo de Hockey and El Retamar), except for the Benzú Cave, which is situated near the autonomous city of Ceuta, on the African shore of the Strait of Gibraltar.

Figure 1. Sites with evidence of agricultural and fishing activity presented in the chapter.

Except for Embarcadero de río Palmones, where no organic material suitable for radiocarbon dating was recovered, at least in the earliest excavation campaigns, all the remaining sites have yielded radiocarbon dates, which are presented in Table 1. These dates range from 6118/5701 cal BC in El Retamar to 3007/2854 cal BP in La Esparragosa (cf. Table 1).

The last hunter-gatherer groups

Embarcadero del río Palmones (Algeciras, Cádiz)

This prehistoric settlement is located along the lower course of the Palmones River, in the northwest part of the Bay of Algeciras, Campo de Gibraltar (Figure 1:2) (Gutiérrez *et al.* 1991; Domínguez-Bella *et al.* 2004), on the southern tip of the Iberian Peninsula. In terms of environment and vegetation, the area presents the characteristics typical of the region of the Strait of Gibraltar.

The site is located on a fluvial terrace over the Palmones River (T 3, + 12-15 m), constituted by fluvial deposits. The excavation of Trench 2 (36 m^2) led to the discovery of a number of dismantled hearths. The lithic remains found at the site include a large proportion of geometric flakes and back-edged microliths characteristic of Epipaleolithic–Mesolithic contexts. The site has also yielded evidence for the exploitation of land fauna, molluscs and plants (Ramos Muñoz and Castañeda 2005).

Two TL dates taken from a fragment of burnt sandstone and a pottery fragment dated these archaeological contexts to the 4th millennium BC (Millán and Benéitez 2005: 346).

Early Neolithic tribal societies, 6th-5th millennium BC

El Retamar (Puerto Real, Cádiz)

This site is located in an area of rolling hills in the northeast of the Bay of Cádiz, at 18 m.a.s.l., approximately 800 m from the current coastline (Figure 1:6). A rescue excavation in 1995-1996 documented numerous features, including 62 hearths, 10 shell middens and 24 stone clusters, as well as cardium, plain and grooved ceramic wares, and numerous lithic instruments and remains of terrestrial and marine fauna.

The site is dated to the 6th-5th millennium BC (Table 1) (Ramos Muñoz and Lazarich 2002; Ramos *et al.* 2004). The site is illustrative of a society in transition which practised animal herding, but for whom fishing, hunting and mollusc gathering were still significant economic activities.

Campo de Hockey (San Fernando, Cádiz)

The settlement of Campo de Hockey is located in the southeast of the Bay of Cádiz, at 15-20 m.a.s.l. During the Neolithic, this area was surrounded by water (Figure 1:5). The site is dated to the 5th-4th millennium BC (Vijande *et al.* 2015, 2018). This is one of the oldest permanent settlements in the south of the Iberian Peninsula, and has yielded evidence of agriculture and animal herding, but the exploitation of marine resources would also have played a prominent economic role.

TABLE 1. C14 DATES HAVE BEEN CALIBRATED WITH OXCAL 4.3.2 AND THE CURVES INTCAL13 AND MARINE13.

Site	Laboratory	Dating System	Sample	Context	BP Date	Cal ANE date (2σ)	Bibliographic reference
El Retamar	Sac-1676	Carbon-14	Shell	Conchero 6	7400±100	6118/5701 calANE	Ramos Muñoz 2004: 78-79
El Retamar	Sac-1525	Carbon-14	Shell	Hogar 18	7280±60	5936/5662 calANE	Ramos Muñoz 2004: 78-79
El Retamar	Beta-90122	Carbon-14	Shell	Hogar 18	6780±80	5499/5203 calANE	Ramos Muñoz and Lazarich 2002: 172
Benzú Cave (North Africa)	MAD-3076	Thermoluminescence (TL)	Pottery	-AXIX-XX-2 / Stratum II	7136±433		Millán and Beneítez 2003: 347
Campo de Hockey	CAN 664	Carbon-14	Shell (*Phorcus lineatus*)	Double burial in megalithic mound Grave 11 UE 1406	5650±40	4221/3987 calANE	Vijande 2009
Campo de Hockey	CAN 833	Carbon-14	Shell	Burial seven 7 (single) Trench 7	5665±50	4244/3982 calANE	Vijande et al. 2015
Campo de Hockey	CNA 835	Carbon-14	Shell	Circular structure (pit) Corte 2 UE-205	5485±30	3986/3802 calANE	Vijande et al. 2015
Campo de Hockey	ETH-88972	Carbon-14	Human bone	Double burial in megalithic mound Grave 11 (Individual 1)	5364±24	4326/4066 calANE	Sánchez-Barba et al. 2019
Campo de Hockey	CAN 360	Carbon-14	Human bone	Grave 10 (double) Trench 15	5020±50	3951/3705 calANE	
Set-Parralejos	CNA 4	Carbon-14	Shell	Silo 119-UE 1030	4930±50	3906/3638 calANE	Villalpando y Montañés 2016
Set-Parralejos	CNA 1	Carbon-14	Human bone	Silo 106-UE 1025	4610±50	3622/3112 calANE	Villalpando and Montañés 2016
Set-Parralejos	CNA 3	Carbon-14	Bone cánido	Silo 116-UE1031	4495±45	3356/3029 calANE	Villalpando and Montañés 2016
Set-Parralejos	CNA 2	Carbon-14	Human bone	Silo 106-UE 1037	4480±50	3631/3362 calANE	Villalpando and Montañés 2016
La Esparragosa	MAD-3961	Thermoluminescence (TL)	Pottery	Estructura AV-2-(3) Enterramiento	5255±433		Ramos Muñoz, coord. 2008: 344
La Esparragosa	MAD-3962	Thermoluminescence (TL)	Pottery	Estructura AV-2-(6) Enterramiento	5129±476		Ramos Muñoz, coord. 2008: 344
La Esparragosa	CNA 4238.1.1.	Carbon-14	Shell	Estructura AV-2 Enterramiento	4644±31	3007/2854 cal BC	Vijande et al. 2018
La Esparragosa	Beta-501265	Carbon-14	Human bone	Silo DII-Enterramiento 2	4410±30	3309/2917 calANE	Vijande et al. 2019a
La Esparragosa	Beta-501262	Carbon-14	Bone fauna	Silo AIV-9-21	4390±30	3092/2918 calANE	Vijande et al. 2019a
La Esparragosa	Beta-501263	Carbon-14	Bone fauna	Silo AIV-9-43	4370±30	3089/2907 cal BC	Vijande et al. 2019a
La Esparragosa	Beta-501261	Carbon-14	Bone fauna	Silo BV-11	4350±30	3081/2901 calANE	Vijande et al. 2019a

Two excavation campaigns were undertaken. The 2007-2008 season (Campo de Hockey 1) led to the discovery of two dwelling structures and five storage pits, as well as a large necropolis with 60 burials and 73 bodies (Vijande 2009). The presence of some exotic products (amber, variscite, turquoise, sillimanite, etc.) in the most elaborate burials suggests a degree of social inequality (Vijande *et al.* 2015; Sánchez-Barba *et al.* 2019). The second excavation campaign (Campo de Hockey 2) was undertaken in 2019, and it documented 15 hearths and three shell-middens. The large number of hearths and the abundance of malacological and ichthyological remains (some of them are thermoaltered) suggests that a fish-processing and consumption area may have existed in the settlement.

Benzú Cave (Ceuta)

Benzú Cave is located on the African shore of the Strait of Gibraltar, in western Ceuta (Figure 1:1). The cave is barely 25 m^2 and is divided into two chambers. The archaeological deposits, approximately 1 m deep, consist of fine sands and include two occupational levels: Late Neolithic and Early Bronze Age. Excavations were undertaken annually from 2002 to 2005, and in 2007 (Ramos Muñoz *et al.* 2013). In total, we excavated 21 units of 1 × 1 m^2. These have enabled us to map the different areas of activity in the cave. Although Benzú Cave is not large, it has yielded a wide array of archaeological evidence that, as we shall demonstrate below, sheds new light on the ways of life of Neolithic communities in North Africa; however, the projectiles found during the excavation suggest that hunting continued (Cantillo 2017; Vijande Vila *et al.* 2019b).

The Late Neolithic contexts are TL dated (based on a ceramic fragment) 7136 ± 433 BP (Millán and Benéitez 2003) (Table 1). The material assemblage is characterised by plain pottery and rhomboid microliths, which is similar to that found in nearby caves such as Gar Cahal (Vijande *et al.* 2011), Caf That El Ghar (Ramos Muñoz *et al.* 2008) and Tangier (Gilman 1975).

Sedentary Neolithic tribal societies, 4th millennium BC

La Esparragosa (Chiclana de la Frontera, Cádiz)

The site of La Esparragosa is located a few kilometres from Chiclana de la Frontera (Ramos Muñoz *et al.* 2010). It is located on a prominent plateau over the Iro River and the associated marshland, at 27-30 m.a.s.l. The plateau is constituted by yellow Pliocene detritic sands, overlaid by a layer of red sands associated with a fluvial terrace (Figure 1:4).

The site is characterised by a large number of grain storage pits, subcircular in plan and variable in section (cylindrical and bell-shaped) and depth (1-1.40 m). The fills contained terrestrial fauna, malacofauna, lithic instruments and hand-worked ceramics. They correspond to a stratigraphically homogenous abandonment level. The excavation also attested a large burial feature (2 x 2 m) associated with stone tools, ceramics, terrestrial fauna and malacofauna (Vijande Vila *et al.* 2019a).

The chronology (Table 1) ranges from 3309/2907 cal BC (human bone from the burial) to 3007/2854 calBC. Therefore, the settlement was active at the turn of the 3rd millennium BC.

SET Parralejos (Vejer de la Frontera, Cádiz)

This site is located between the hamlets of Parralejos, La Muela and Patría, in the municipality of Vejer de la Frontera (Figure 1:3), on a hilltop that dominates the surrounding farmlands of La Janda, on the coast of Cádiz (Villalpando and Montañés 2009).

The site was discovered in 2008, during the construction of an electric substation. The site comprises an extensive field of silos, similar to that found in La Esparragosa. Two excavation campaigns were undertaken, in 2008-2009 and 2012 (Villalpando and Montañés 2009, 2016; Cantillo *et al.* 2017), and a total of 65 silos were identified, of which 40 were fully excavated. The silos are of various shapes (cylindrical, bell-shaped, rhomboid and sub-rectangular). Most silos were a single archaeological context, and contained knapped and polished stone tools, handmade ceramics (globular pans, ridged dishes, lenticular cups and semispherical bowls), fauna and marine malacofauna (Villalpando and Montañés 2016).

The site is carbon dated to the late 4th millennium calBC (Villalpando and Montañés 2016) (Table 1).

Archaeological record: Malacofauna and ichthyofauna

Fishing and mollusc-gathering among the final hunter-gatherer societies on the northern shore of the Strait of Gibraltar have been attested in Embarcadero del río Palmones. The main species is the bivalve *Chamelea gallina* (297 remains; MNI: 119) (Table 2) (Cantillo 2017). Many of these remains were found in association with small burned pebbles, which suggests that these bivalves were cooked before they were eaten.

The Neolithic record, on the other hand, suggests that sea species played a prominent economic role. El Retamar, for example, seems to have been a seasonal settlement that specialised in the exploitation of marine resources. A total of 25 species have been attested, including 11 species of bivalves (MR: 3449 NR; MNI: 1850), 12 of gastropods (NR: 664; MNI: 589) and two of crustaceans (NR: 51; MNI: 44) (Table 2) (Cantillo 2017). The most abundant species are the bivalves *Solen marginatus* and *Ruditapes decussatus*, and the gastropods *Hexaplex trunculus* and *Bolinus brandaris*. It seems clear that priority was given to species that live in soft sandy soils. The reproduction cycle of sea breams, which takes place in shallow waters between October and December, may explain the seasonal nature of the settlement (Ramos Muñoz and Lazarich 2002: 429).

In Benzú Cave, the record is similar, and includes *Ostrea* sp., *Mytilus* sp., *Chlamys* sp. and patellae gastropods, and again there is evidence of cooking. This assemblage also presents a significant number of crustaceans (Vijande Vila *et al.* 2019a). It is also important to note the presence of perforated shells of *Patella* sp., *Trivia monacha* and *Nassarius pfeifferi*, which were probably used as personal adornments. This would be in line with the use of the cave as a funerary space.

In the 5th-4th millennium, the island site of Campo de Hockey presents an interesting faunal assemblage. The assemblage includes a wide variety of molluscs, of which 48 species have been identified (Table 2). Especially abundant are the *Phorcus lineatus* and the *Ruditapes decussatus*, both of which are very nutritious. The taphonomic studies undertaken on specimens of *P. lineatus* indicate that these molluscs were processed before being consumed (Cantillo 2017). There is also a large number of perforated shells, some of them found *in situ* in association with adult skulls and, in one case, near the neck of a child (Vijande *et al.* 2015).

Concerning the 4th millennium BC, the sites of La Esparragosa and SET Parralejos, both of which are characterised by the presence of a large number of silos, also present evidence for the systematic gathering of *R. decussatus* (Table 2). Especially of note is the presence of 477 specimens of this species, some of which were still closed, covering a burial in La Esparragosa (Cantillo 2017; Vijande Vila *et al.* 2019a).

Concerning ichthyofauna, the taxa identified reveal a clear preference for the Sparidae family (Table 2), including such species as *Lithognathus mormyrus*, *Diplodus* sp. and *Dentex* sp. in El Retamar (Soriguer *et al.* 2002); *Sparus aurata*, *Diplodus* sp. and *Pagrus* sp. in Campo de Hockey (Corona 2019); and undetermined sparids in Benzú Cave (Cantillo and Soriguer 2013). Other taxa are occasionally found: for instance, *Argyrosomus regius*, *Thunnus thynnus* and *Galeorhynus galeus* in El Retamar (Soriguer *et al.* 2002), and members of the Lamnidae and Clupeidae families and the Rajiforme order in Campo de Hockey (Corona 2019).

Sparidae are the predominant group. This family is composed of gregarious fish species that are found in demersal, pelagic and coastal waters. They reproduce in spring and summer (Lloris 2015), and seek the shelter of the coast (Pérez and Rodríguez del Valle 2001). The best time to capture them must have been autumn, summer and spring, especially at sundown, when the fish would have abandoned their daytime shelters (Espinar, M.C. online). The remaining taxa attested share certain features, such as coast-bound reproductive migrations (Pérez and Rodríguez del Valle 2001) in shoals (Lloris 2015).

Table 2: Marine species gathered and fished along the coast of Cádiz in late prehistory.

Taxa	Embarcadero Río Palmones		El Retamar		Campo de Hockey		Benzú Cave		La Esparragosa		SET Parralejos	
Marine bivalves	**NMI**	**%**	**NMI**	**%**	**NMI**	**%**	**NMI**	**%**	**NMI**	**%**	**NMI**	**%**
Acanthocardia sp.			1	0.04					2	0.13		
Acanthocardia tuberculata	8	4.23			2	0.15						
Aequipecten commutatis					2	0.15						
Aequipecten sp.					2	0.15						
Acanthocardia sp.												
Anomia ephippium	1	0.52							25	1.64		
Barbatia barbata					1	0.07						
Indeterminate bivalve	1	0.52			6	0.47	6	15.4	2	0.13	1	0.47
Callista chione	1	0.52							1	0.06	24	11.32
Cardiidae									1	0.06		
Cerastoderma edule	1	0.52	11	0.44					1	0.06	2	0.94
Chamelea gallina	119	62.96										
Chlamys sp.			6	0.24	163	13	1	2.56	52	3.42	16	7.54
Chlamys varia					47	3.75					2	0.94
Crassostrea sp.									50	3.29		
Crassostrea angulata			20	0.8	2	0.15						
Donax trunculus	21	11.11										
Glycymeris glycymeris					14	1.11						
Glycymeris sp.	4	2.11	1	0.04	69	5.49			9	0.59	2	0.94
Laevicardium sp.					1	0.07			2	0.13		
Lutraria lutraria					1	0.07						
Mactridae									1	0.06		
Mytilus galloprovincialis			1	0.04								
Mytilus sp.					2	0.15	1	2.56				
Ostrea edulis			1	0.04	32	2.55			1	0.06		
Ostreidae					1	0.07	1	2.56	42	2.76		
Panopea glycymeris							1	2.56	1	0.06	1	0.47
Pecten sp.			1	0.04	10	0.79						
Pecten maximus					38	3.02			143	9.42	11	5.18
Pholas dactylus			3	0.12					23	1.51		
Ruditapes decussatus	6	3.17	557	22.4	167	13.3			1081	71.21	130	61.32
Scrobicularia plana			73	2.94	1	0.07			25	1.64		
Solen marginatus	2	1.05	1175	47.3	127	10.1			10	0.65	9	4.24
Veneridae					3	0.23					2	0.94
Venus verrucosa	5	2.64			2	0.15					1	0.47
Total Bivalves	**169**	**89.41**	**1850**	**74.5**	**700**	**55.7**	**10**	**25.6**	**1472**	**96.96**	**201**	**94.81**

Taxa	Embarcadero Río Palmones		El Retamar		Campo de Hockey		Benzú Cave		La Esparragosa		SET Parralejos	
Marine gastropods	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Astraea rugosa			4	0.16								
Bolinus brandaris	8	4.23	113	4.55	17	1.35						
Calliostoma zizyphium			2	0.08								
Capulus ungaricus									11	0.72		
Cerithium vulgatum			64	2.57	47	3.75						
Charonia lampas	2	1.05			16	1.28			1	0.06	1	0.47
Columbella rustica					1	0.07	1	2.56				
Conus mediterraneus					1	0.07	1	2.56				
Cymatium parthenopeum					1	0.07						
Cymbium olla									4	0.26		
Cypraeidae					1	0.07						
Indeterminate gastropods					2	0.15	1	2.56				
Hexaplex trunculus	4	2.11	350	14.1	155	12.3					1	0.47
Hinia reticulatus			7	0.28	11	0.87			1	0.06		
Hydrobia ulvae			18	0.72					1	0.06		
Muricidae					1	0.07						
Nassarius pfeifferi							2	5.12				
Ocenebra erinaceus			1	0.04	2	0.15						
Omalogyra sp.			1	0.04								
Patella sp.	2	1.05	6	0.24	7	0.55	14	35.9			5	2.35
Patella caerulea	2	1.05					1	2.56				
Patella ferruginea							1	2.56				
Patella nigra											1	0.47
Patella rustica					1	0.07						
Patella ulyssiponensis					1	0.07						
Phorcus lineatus	2	1.05	21	0.84	250	19.9			1	0.06		
Phorcus sp.					2	0.15						
Phorcus turbinatus					5	0.39						
Rissoa sp.			2	0.08								
Siphonaria pectinata					3	2.23	1	2.56				
Stramonita haemastoma					5	0.39	1	2.56			1	0.47
Trivia monacha							3	2.56				
Turritella communis									1	0.06		
Zonaria pyrum					5	0.39					1	0.47
Total Gastropods	**20**	**10.59**	**589**	**23.7**	**534**	**42.5**	**26**	**66.7**	**20**	**1.31**	**10**	**4.71**
Freshwater bivalves	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Potomidas littoralis									1	0.06		
Melanopsis sp.							2	5.12				
Total Freshwater bivalves							**2**	**5.12**	**1**	**0.06**		
Crustaceans	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Brachyura sp.			35	1.41	3	0.23	1	2.56	12	0.79		
Balanus balanoides			9	0.36								
Balanus sp.					16	1.28			4	0.26		
Total Crustaceans			**44**	**1.77**	**19**	**1.51**	**1**	**2.56**	**16**	**1.05**		
Echinoderms	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Paracentrotus lividus									9	0.59		
Cephalopods	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Sepia sp.					1	0.07						
Cnidarians	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%	NMI	%
Coral					2	0.15					1	0.47
TOTAL	**189**	**100**	**2483**	**100**	**1256**	**100**	**39**	**100**	**1518**	**100**	**212**	**100**
Ichthyofauna	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%
Argyrosomus regius			4	0.22	5	1.49						
Clupeidae					1	0.29						
Dentex sp.			9	0.51								
Diplodus sp.			7	0.39	5	1.49						
Galeorhynus galeus			2	0.11								
Indeterminates					14	4.17						
Lamnidae					1	0.29						
Lithognathus mormyrus			5	0.28								
Pagrus sp.					5	1.49						
Rajiforme					10	2.98						
Sparidae					286	85.4	4	100				
Sparus aurata			1725	98.2	8	2.38						
Thunnus thynnus			4	0.22								
Total Ichthyofauna			**1756**	**100**	**335**	**100**	**4**	**100**				

Terrestrial fauna

The site of Embarcadero del río Palmones (Algeciras), occupied by one of the last hunter-gatherer groups in the region, has yielded a few remains of *Equus ferus*, *Cervus elaphus*, *Canis lupus* and *Bovidae indet.* (Ramos *et al.* 2004).

Concerning the first Neolithic tribal societies, in the 6th-5th millennium BC, we have evidence provided by El Retamar (Puerto Real), Campo de Hockey (San Fernando) and Benzú Cave (Ceuta). In El Retamar, wild animals were more abundant than domesticated animals; the economic strategy of the inhabitants of this settlement seems to have been based on fishing and hunting, but some domesticated animals were also kept (Cáceres 2003) (Table 3).

In Campo de Hockey, the assemblage found in the site's 'production area' (trenches 1-5) predominantly constitutes wild fauna, including rabbits, deer, lynxes and horses. Domesticated species include cows, sheep, goats, pigs and dogs, which are present from the earliest layers. The key species is the rabbit, although many of the remains correspond to young individuals in anatomical connection with no trace of hunting or butchering marks, so they may be later intrusions. It is curious the presence of articulated remains of wild species, either partially (in the case of deer) or totally (in the case of the lynx) represented, without any relation with human remains either in burials (Morris 2011) or in hut floors. In this case, wild species were maybe exploited for food and/or other raw-materials, as hide. Such activities can be understood as part of the economy of groups that gradually assimilated domestication techniques, but for which hunting continued to be an everyday practice (Vijande *et al.* 2015) (Table 3).

The analysis of the remains of wild fauna in Benzú Cave has led to the identification of species which are still common in the area (such as hedgehogs), and none of the remains can be safely attributed to domesticated species. Therefore, the existing remains should likely be linked to the occupation of the cave by wild animals, rather than to human activity. The human use of the cave is, however, beyond doubt, as it was used as a funerary space, and, in fact, some of the human bones found appear to have been gnawed by hedgehogs after burial. The absence of bones corresponding to domesticated animals, therefore, suggests that the cave was used as a shelter by various species of carnivores and rodents. The presence of occasional burnt bone remains must be associated with funerary activity (Riquelme Cantal 2013) (Table 3).

Finally, concerning the 4th-millenium BC tribal societies, our evidence comes from La Esparragosa (Chiclana de la Frontera) and SET Parralejos (Vejer de la Frontera). In the case of La Esparragosa, the analyzed materials indicate a predominance of skeletal remains belonging to domesticated animals: cattle, ovicaprines, pigs and dogs. Advanced sheep- and goat-herding techniques were implemented: for instance, the preferential slaughter of young males, whereas females were slaughtered only at an advanced age to maximise their by-products and reproductive capacity. Sheep may have outnumbered goats. Concerning pigs, the fact that most were slaughtered young suggests that they were primarily used as a source of meat after a short rearing period. However, the discovery in silos A-IV and C-III of large suidae remains (no exact measurements could be taken) indicates that wild boars may have been hunted. Cow remains are scarce in comparison to those of other domesticated species. Most were slaughtered when adults. All the bones present traces of fire, which suggests that the meat of these animals was also consumed as food. The most abundant remains correspond to dogs, which are found in anatomical position. Wild fauna is represented by deer and two species of lagomorph: rabbit and hare. These animals, along with the wild boar, were hunted for food (Vijande Vila *et al.*, ed. 2019a) (Table 3).

In SET Parralejos, again, domesticated species clearly outnumber wild species. The remains of sheep and goats are the most abundant in terms of number, bulk weight of remains and MNI. Sheep and

TABLE 3. NUMBER AND PERCENTAGE OF IDENTIFIED REMAINS (NIR) IN THE SITES EXAMINED IN THE CHAPTER.

	El Retamar		C. Hockey		Benzú		La Esparragosa		SET Parralejos	
	NRD	%	NRD	%	NRD	%	NRD	%	NRD	%
Bos taurus	4	0.65	14	1.21			11	2.90	17	5.69
Ovis aries	5	0.80					3	0.79	5	1.67
Ovis/Capra	8	1.29	31	2.70			80	21.05	130	43.48
Capra hircus	12	1.93							1	0.33
Sus domesticus	5	0.80	8	0.70			58	15.26	38	12.71
Canis familiaris	7	1.13	1	0.09			117	30.79	72	24.08
Equus ferus	3	0.49	1	0.09						
Rhinocerontidae indet.					1	0.08				
Bovidae indet.					4	2.27				
Cervus elaphus	77	12.40	63	5.49			55	14.47	8	2.68
Sus scrofa					4	2.27				
Oryctolagus c.	489	78.74	933	81.27	13	7.39	55	14.47	28	9.36
Lepus capensis	6	0.97			2	1.14	1	0.27		
Gazella sp.					74	42.04				
Gazella/ Ammotragus					75	42.61				
Ammotragus lervia					1	0.57				
Hyaena cf. hyaena					1	0.57				
Lynx pardina			97	8.45						
Canis sp.					2	0.17				
Genetta genetta					1	0.08				
Hystrix cristata					24	2.00				
Herpestes ichneumon					1	0.57				
Carnivorae sp.					1	0.57				
Alectoris rufa	5	0.80								
Determinated	621	100	1148	100	176	100	380	100	299	100

goats have been primarily identified through joints and diagnostic sections of long bones. Pigs are also abundantly represented. The size of some of the pig bones is more characteristic of wild boars, but the evidence is inconclusive. Large mammals are sparsely represented, the only identifiable species being the cow, which would have been used in agricultural tasks and only slaughtered at an advanced age. Dog bones were also found, but not in large numbers; most of these remains correspond to animals found in anatomical position and probably buried in a ritual fashion. Wild fauna is rare and involves only two species, deer and rabbits, although, as noted above, it is possible that wild boars were also present (Riquelme Cantal 2019) (Table 3).

Except for Embarcadero del río Palmones and Benzú Cave, domesticated animals are present from the beginning of all stratigraphic sequences and constituted the main source of meat. In 6th-5th-millennium BC sites, their remains are not the most numerous, but in terms of biomass their presence is significant. In 4th-millenium BC sites, in comparison, domesticated animals clearly predominate (cows, sheep, goats and pigs), which confirms the keeping of substantial herds and the use of well-established herding techniques. Wild fauna, on the other hand, are sparsely represented and limited to a few species: deer, rabbits and wild boars. It is possible that these animals were hunted to defend cultivated fields and to limit the competition posed to domesticated animals in grazing areas (Table 3).

Tools and/or weapons related to hunting and/or fishing used by Neolithic agricultural societies along the Atlantic coast of Cádiz and Ceuta (North Africa)

Microliths, geometric flakes/arrowheads

The development of productive economies in the region around the Strait of Gibraltar is in many ways a *sui generis* process, including the lithic industries. Although significant regularities exist in this regard across all Western Mediterranean societies (emergence of regional exchange hubs, which channelled the circulation of raw materials and finished products, growing specialisation in production and the widespread adoption of pressure flaking), not all changes were adopted at the same pace in all areas, and significant regional differences exist.

It has been argued that the adoption of productive economic systems did not lead to a radical change in the ways of life in the early stages of the Neolithic (Ramos Muñoz 2006). As such, hunting implements remain among the most common finds in archaeological contexts, including geometric microliths and arrowheads (Figure 2).

In Retamar and Embarcadero de río Palmones, most of the geometric microliths found are trapezoidal in shape (Figure 2); these pieces tend to be fairly symmetric with straight or slightly concave retouches. A total of 107 geometric microliths were found, accounting for 11.22% of all retouched tools. The percentage of hunting-related tools in Embarcadero de río Palmones is much lower (4.47%; 17 pieces in total) (Ramos Muñoz and Castañeda 2005). In both cases, these were made *in situ* and probably abandoned after use, as indicated by use-mark analysis (Clemente Conte and Pijoan 2005). The remains of terrestrial fauna found in El Retamar have been identified as belonging to *Oryctolagus cuniculus* (30%) and *Cervus elaphus* (7.4%); it is likely that the projectiles were used largely to hunt the latter of these species. In this case, the presence of a greater number of remains of wild fauna than of domesticated animals (12.6%) strongly suggests that hunting was still a key economic activity.

Trapezoidal shapes are found across a wide area, especially in the coastal regions of the Iberian Peninsula in both Mesolithic and Neolithic contexts (Clemente Conte *et al.* 2020). Narrower and asymmetric shapes are also found in the Mesolithic of Alentejo, along the Atlantic coast of Portugal (Soares *et al.* 2018), although the arrival of the Neolithic witnessed the widespread adoption of segments with abrupt retouches (Soares *et al.* 2016). These are the most characteristic hunting weapon in the southern Iberian early Neolithic (Cortés Sánchez *et al.* 2012; Rodríguez-Rodríguez *et al.* 2013), alongside segments with abrupt retouches on the Mediterranean coast of Africa (Broich *et al.* 2020), as attested in Ifri n'Etsedda (Eastern Rif). Within this context, the geometric microliths in El Retamar and Embarcadero de río Palmones, which are inspired by Mesolithic traditions, are exceptional.

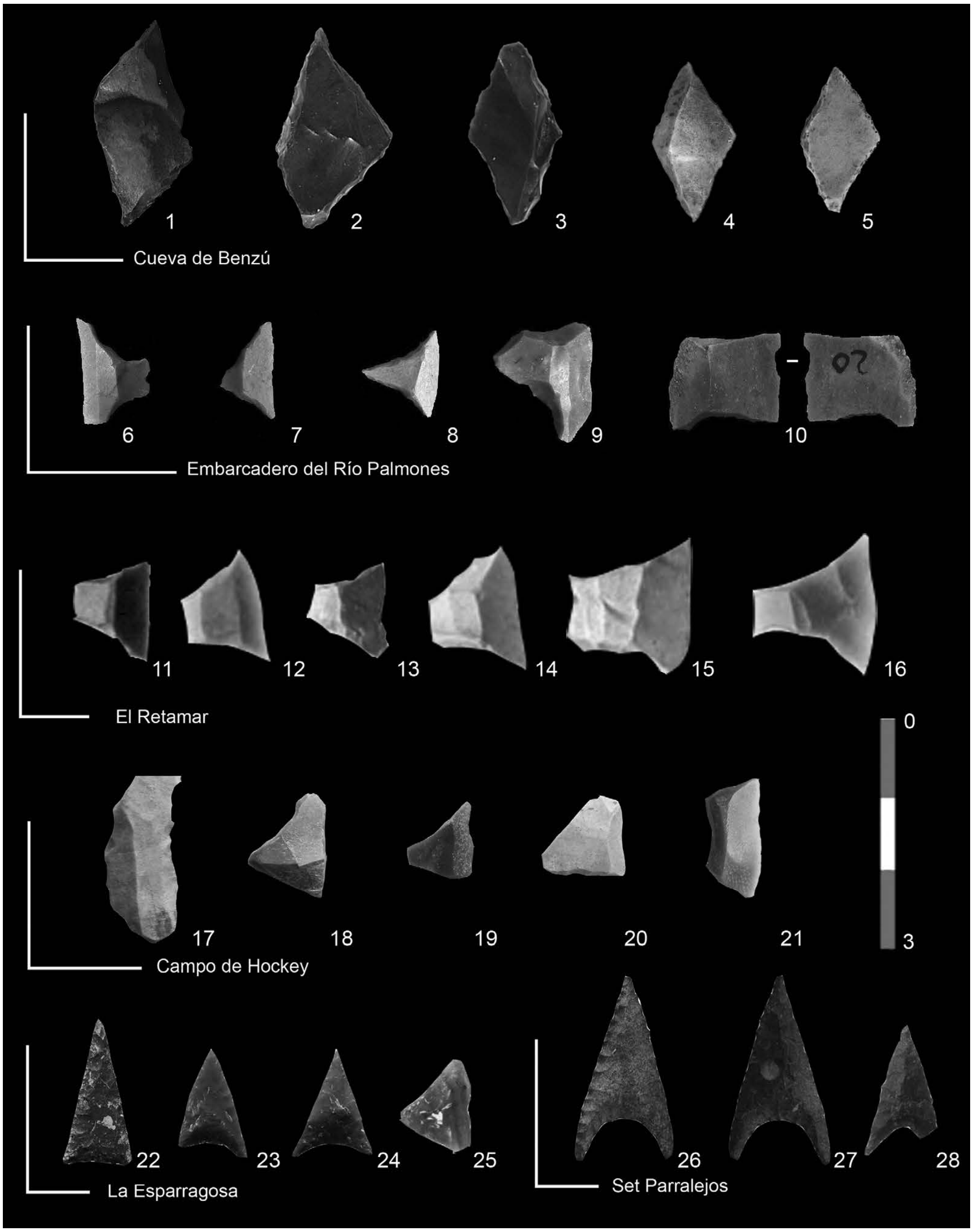

Figure 2. Microliths and arrowheads from the sites under consideration. 1-5: Benzú Cave (Ceuta); 6-10: Embarcadero del río Palmones (Algeciras); 11-16: El Retamar (Puerto Real); 17-21: Campo de Hockey (San Fernando); 22-25: La Esparragosa (Chiclana de la Frontera); and 26-28: SET Parralejos (Vejer de la Frontera).

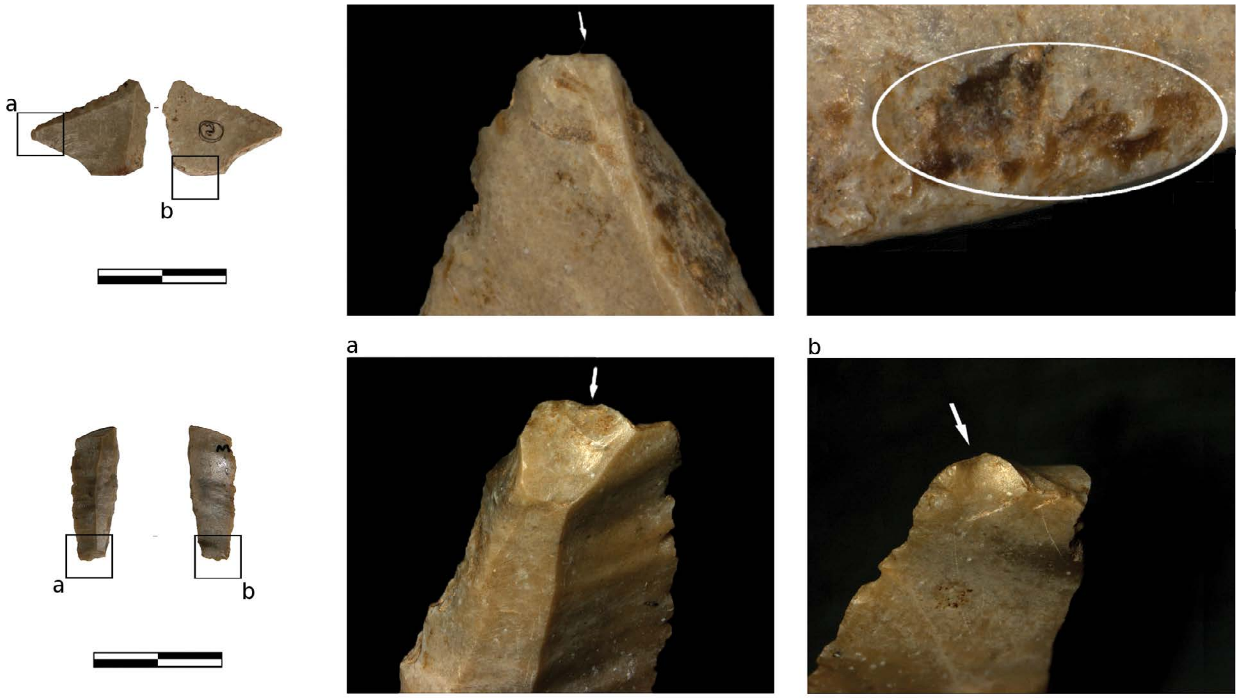

Figure 3. Small fractures, probably due to impact, and potential remains of resin used for hafting.

The lithic typology attested in Benzú Cave is found elsewhere in North Africa but not in the Iberian Peninsula (Gilman 1975; Ramos *et al.* 2008; Vijande 2017; Vijande *et al.* 2011; Vijande Vila *et al.* 2019a, 2019b). Rhomboid, retouched flake-based points, generally worked on three sides (only one example has two worked sides instead of three) and leaving one side free of retouches to fit the haft (Figure 2: 1-5). Similar pieces are documented in Caf Taht el Ghar Cave, in Tetouan, in association with cardial ceramics, in contexts that have been dated to the 7th-6th millennium BC (Bouzouggar and Barton 2006; Ramos *et al.* 2008). Most of the animal remains found in Benzú Cave correspond to wild fauna, with *Gazella* sp. and *Gazella/Ammotragus* being especially abundant. Although the preservation of organic remains in Benzú is generally poor (the animal remains are small and heavily fragmented), other data from North Africa suggest that hunting was an important economic activity for early Neolithic societies (Ramos *et al.* 2008). Use-wear analysis confirms that these points were used as arrowheads, and the traces of resin and, potentially, ochre offer some interesting evidence for hafting (Figure 3).

Based on this evidence, it is argued that a variety of technical traditions coexisted, probably rooted in the persistence of hunter-gatherer-fisher cultural habits and lithic technologies.

The Late Neolithic was characterised by increasing technical complexity. Pressure flaking predominated in La Esparragosa, including lever-assisted pressure flaking (Morgado and Pelegrin 2012). Hunting implements become rarer over time, accounting for barely 3% of all lithic instruments found (Clemente-Conte *et al.* 2020). Geometric shapes are still found during this period, pressure-flaked leaf-shaped forms being the most abundant (Ramos Muñoz 2006). The species found are largely the same as those found in the earlier contexts (*Cervus elaphus* and *Oryctolagus cuniculus*), although their remains are much less numerous than those of domesticated species in the Late Neolithic (Table 3) (Ramos Muñoz *et al.* 2013).

The use of leaf-shaped points as arrowheads is also attested in the nearby SET Parralejos (Figure 2: 26-28). The study of lithic remains from this site is ongoing, but no geometric shapes have been found to date; hunting implements are, thus far, represented by three leaf-shaped points with retouches on two sides and a concave base. Geometric shapes are attested in Campo de Hockey, including BT-geometric-trapeze and segments (Vijande 2009). At both sites, faunal remains include domesticated species, but wild fauna predominates, including *Cervus elaphus*, *Lynx pardina* and *Oryctolagus cuniculus*.

Lithic tools: Use-wear analysis as evidence of productive activities

In general, the archaeological sites presented in this chapter are found on sandy soils which, alongside the strong winds that are characteristic of the region, have subjected prehistoric remains to significant taphonomic processes that hamper use-wear analysis. As a result, only two of our sites have yielded sufficient evidence: La Esparragosa and SET Parralejos.

These taphonomic processes are attested in Embarcadero del río Palmones (Clemente Conte and Pijoan 2005). Of 649 lithic implements, only 29 edges presented solid evidence for use wear, and another 36 were labelled 'possible', in addition to the above-noted microliths (cf. Figure 2). Most of the pieces that can be securely labelled as tools were used to work mid-hard/hard tissues (wood or bone), which left substantial use traces. The sandy soils tend to polish the stone surface, obscuring use traces of work on soft tissues. In Benzú, similar taphonomic processes have also blurred use-wear marks, and only impact fractures could be attested (cf. *supra*, Figs. 2 and 3). The lithic remains from El Retamar and Campo de Hockey are still pending analysis, so the information presented in this chapter is, in this regard, partial. However, the evidence from La Esparragosa and SET Parralejos is valuable; the remains suggest that, in addition to herding (cf. Table 3), the economic system of these 4th-millenium human groups involved agricultural tasks, butchering, the processing of animal by-products, and fish processing and storing activities (Clemente Conte *et al.* 2010).

As noted, use-wear analysis is an experiential technique (Semenov 1964; Clemente Conte 1997) that can be combined with various observation methods. We used binocular magnifying glasses (5X to 75X) and reflected light or metallographic microscopes (50X and 400X) for both stone and shell implements (cf. *infra*). This methodology also provides important evidence concerning the degree of technological development and the economy of the human groups that used these implements (Clemente Conte 2017). Let us examine the differences and similarities between the productive activities attested in these two sites. We will also explain how we have reached our conclusions, given that these sites are also found in predominantly sandy sediments. Both sites La Esparragosa and SET Parralejos, are silo fields, and the silos were cut into clayey or silty layers. The silos were used as refuse pits after use (Vijande Vila *et al.* 2019a), and were not subject to further taphonomic processes; as a result, the lithic implements found within were better preserved. Although both sites yielded flakes with cutting edges on which use-wear marks were identified, most of the implements bearing use-wear marks correspond to microblades that were shaped using different techniques and were mostly attached to some kind of haft, alone or in combination with others to form a long and sharp blade. Some of them still bear traces of the resin used for this purpose (Clemente Conte and García Díaz 2008). Use-wear analysis of blades and microblades reveal the versatility of these instruments. Blades allows for the production of long as well as short edges (with angles between 25º and 40º) which are easy to haft on either side (Figure 4). They were often refreshed and thoroughly reused, and some of the examples found in archaeological contexts were heavily retouched and worn.

The results of the macro- and microscopic use-wear analysis in La Esparragosa are consistent with the exploitation of plant, animal and mineral resources. The processing of animal tissue included deboning and filleting fish, suggesting that fishing was an important economic activity during this period (Clemente Conte and Mazzucco 2019). Nearly 30% of the 388 remains analysed present use-wear traces.

Most of these are blade and microblade fragments (*c*.80%), which greatly outnumber the flakes (5.2%); the remainder (4.3%) are arrowheads.

A total of 164 edges bearing use marks were attested, but the specific use could not be discerned for 18 of them, and so the percentages will be calculated using the remaining 146 specimens (cf. Table 4). A small number of edges (3) were related to mineral-working (2%), and 24 edges bear traces of having been used on vegetal fibres. About half of them exhibit traces of having been used on hard fibres (wood or bark). In all cases, this activity was attested on central or distal edges, and involved longitudinal motions (cutting, sawing), and only two present signs of scrapping motions. The remaining edges (12; 8.2%) used on plant materials belong to sickles and present the typical polished lustre which is often associated with cereal harvesting.

Of the 146 edges included in this analysis, 119 edges on 76 different implements are likely or very likely to have been used to process animal tissues. Nearly all of them are on blades, and mostly on the central or proximal sides. Of these, only four (2.7%) are related to butchering. We should try to explain why so few edges are related to this productive activity. These micro traces are often invisible owing to preservation issues; an important proportion of the pieces from La Esparragosa present thermo alterations or are polished by the sandy soil, and this may be masking the most subtle traces. Butchering activities take longer to leave traces, and often they are limited to miniscule notches on the sharpest blades. It is also very likely that hafted blades were used for multiple purposes; they were used first for butchering and then for other activities, such as deboning fish, which leave greater traces on the blades. In general, use-wear analysis can only be used to determine the latest use to which a lithic instrument was put.

Hide-working was identified on 19 edges (13%) on 12 blades, generally on central and distal sides. Various actions were attested. Five present traces of lateral motions, which generally appear on edges with an angle of 40° or more. Another 10 edges present angles between 25° and 35°, used in cutting motions and, in one case, longitudinal-lateral motion. In La Esparragosa, we also found two blades (LE-CII-1-Nº1 and AIV-9-Nº2) which were retouched on one end to bore holes in hides.

The remaining edges on which use traces were found are related to fish processing (García Díaz and Clemente Conte 2011; Clemente-Conte *et al.* 2020). This includes 96 edges, accounting for 65.7% of the total at La Esparragosa. This suggests that fish played a primary role in the diet of this human group.

In SET Parralejos, 39 edges with use-wear traces were found on 23 implements. One tool with three edges (2012-E4-UE400-18) used to work on hard matter, probably wood, is not included in the percentages. Most activities attested are related to agricultural tasks, especially cereal harvesting; 41.6% (15) of the edges that were found to have use marks are related to activities on non-woody plants (such as cereals), and a not-inconsiderable 36.1% (13) are related to fish processing. In addition, 19.4% (7) were related to butchering, and 2.8% (1) to woodworking (Table 4).

Shell tools

Traditionally, use-wear analysis has been used to study lithic instruments, but its application for tools made from other materials, such as bone and shell, is much more limited. However, the number of use-wear studies on shell instruments has slowly increased during recent years (Cuenca-Solana and Clemente-Conte 2017). These new developments have allowed us to identify the use of these tools among Iberian hunter-gatherer groups in both the Palaeolithic and the Mesolithic (Cuenca-Solana *et al.* 2013a; Cuenca-Solana 2015; Cuenca-Solana *et al.* 2016a, 2016b), as well as among Neolithic farmers (Clemente

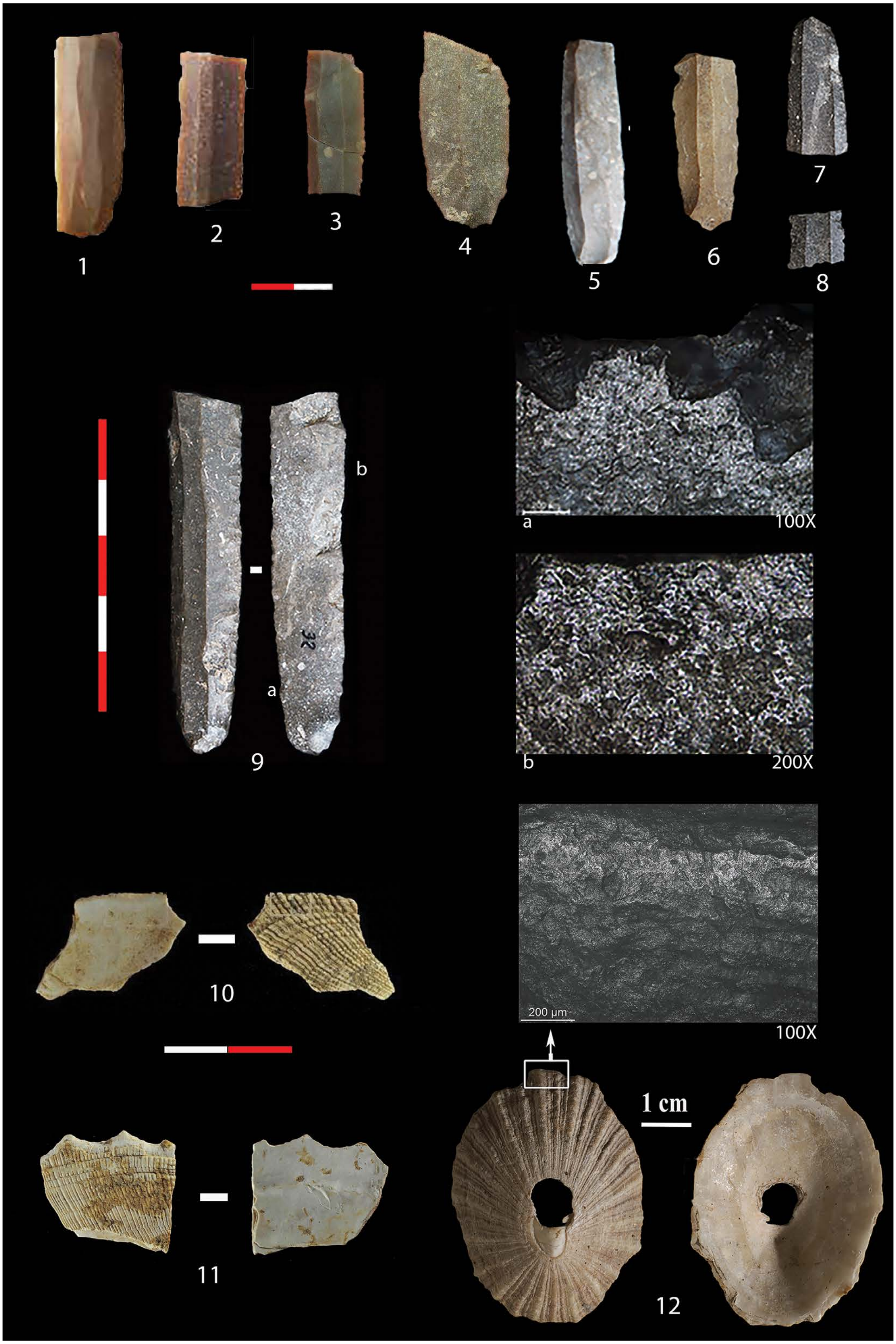

Figure 4: 1-4: Blades/fragments from La Esparragosa; 5-8: Blades/fragments from SET Parralejos; 9: Blade from SET Parralejos with fish-processing wear traces; 10: Fragment of Ruditapes decussatus *used as a tool from Campo de Hockey; 11: Fragment of* Ruditapes decussatus *with denticulated edge from SET Parralejos; and 12:* Patella *sp. or perforated limpet with wear traces related to pottery production.*

and Cuenca-Solana 2011; Clemente-Conte *et al.* 2014; Cuenca-Solana *et al.* 2010, 2014; Gutiérrez-Zugasti *et al.* 2011). Recently, malacological remains found in archaeological contexts in the region of the Strait of Gibraltar (Figure 1) have been subject to this methodology, including Embarcadero del río Palmones (62 remains), Campo de Hockey (356), La Esparragosa (233) and SET Parralejos (1,413); a selection of 14 well-preserved implements from Benzú was also analysed. Therefore, the analysed assemblage amounts to 2,078 remains (whole shells or fragments), and 13 shell tools were identified. No evidence for the use of shell tools was attested in Embarcadero del río Palmones and Esparragosa; 7 were found in SET Parralejos, and 3 each in Campo de Hockey and Benzú. These use wear were found in shells of *Ruditapes decussatus* and, in Benzú, also *Patella* sp., which were also consumed as food. Most of the traces found correspond to lateral transversal actions (scraping) on plant, animal and mineral matter. By comparing these use wear traces with similar ones attested archaeologically and experimentally, we have been able to link the traces found in a perforated shell of *Patella* sp. found in Benzú with pottery production (Figure 4: 12) (Vijande Vila *et al.* 2019a), and similar traces were found in a specimen from Coro Trasito (Tella-Sin, Huesca) (Clemente Conte *et al.* 2019a). A shell fragment of *R. decussatus* from SET Parralejos has been associated with the processing of plant fibres (Cuenca-Solana 2013), which may be indirectly related to hunting and/or fishing activities, in which plant fibres played a key role. From a different perspective, SET Parralejos has also yielded one of the few knapped shell tools found in the Iberian Peninsula. It is a fragment from a *R. decussatus* shell, which was worked to present a denticulate edge (Figure 4:11). Unfortunately, the marks are not sufficiently developed to determine the matter processed with this implement. None of the shell fragments yielded by our five sites can be linked to hunting practices. However, 2 of the tools analysed can be associated indirectly with hunting as they were used to process animal by-products. Specifically, 2 fragments of *R. decussatus* from Campo de Hockey were used for scraping fresh hide (Figure 4:10) (Cuenca-Solana 2013).

It is likely that preservation issues, especially in open-air sites, has greatly reduced the number of shell tools found, as well as limited our ability to ascertain their function and economic role.

Discussion: Functional and historical analysis

The sites examined present a clear diachronic picture of late prehistoric hunting and fishing in the region of the Strait of Gibraltar (Table 1), including the latest groups of hunter-gatherers and the earliest agricultural groups.

The size and characteristics of the sites under study and the areas of activity attested reveal considerable functional variability (Ramos Muñoz 2004, 2006, 2008).

Hunting, fishing and shellfish gathering played an important economic role in open-air seasonal sites located near a river: for instance, Embarcadero del río Palmones (Ramos Muñoz and Castañeda 2005).

We also possess evidence of societies in transition from hunter-gatherer practices to more sedentary groups for which shellfish gathering and fishing were a central economic activity, but which also present evidence for herding (but not agriculture): for instance, in El Retamar (Ramos Muñoz and Lazarich 2002).

We have attested seasonal sites where hunting and shellfish gathering was the specialty, but where evidence for agriculture and herding is also present: for instance, in Benzú (Ramos Muñoz *et al.* 2013; Clemente Conte and Mazzucco 2013; Vijande 2017).

Other sites were clearly permanent settlements, such as Campo de Hockey, in which economic, domestic and funerary practices were spatially differentiated (Vijande *et al.* 2015).

We also have important settlements, with storage facilities and permanent occupation, such as La Esparragosa (Vijande Vila *et al.* 2019a) and SET Parralejos (Cantillo *et al.* 2017).

We have argued that shellfish gathering and fishing played an important economic role for these groups. The use of the shells as tools and elements of personal adornment, as well as food, supports this idea: the fact these shells were used as tools, adornment and food means these resources were systematically exploited and had multiple functions.

The fact that the assemblages include multiple taxa, with different biological and ecological features, suggests the use of various types of fishing tackle, and the predominance of remains of members of the Sparidae family demonstrates not only that these human groups exploited shore areas but also had a profound knowledge of the habits of seasonal fish species.

The fact that other fish species also feature in the assemblages can mean two things: that the inhabitants of these sites took advantage of the fish shore-bound migrations to capture them, or that they used less selective fishing tackle, such as nets and traps, in combination with more selective ones such as harpoons. It is possible that some of the geometric microliths identified were used in harpoons (Rozoy 1978; Ramos Muñoz and Lazarich 2002; González and Cerrillo 2015). No evidence for traps has been found at our sites, but they have been attested in waterlogged sites: for example, at the Mesolithic site of Oleslyst (Halsskov, Dinamarca) (Pedersen 1995), where an underwater fence made with wooden posts and plant screens surrounded a cluster of traps (Pedersen 1995).

We have direct evidence for the use of fishing nets in El Retamar, specifically a sandstone net weight (Ramos and Lazarich 2002) similar to those found in the late prehistoric site of Canalejas I (Cáceres) (González and Cerrillo 2015). Generally, these weights are the only evidence of the use of fishing nets, as the remaining elements were made of plant fibre and have not survived. The presence of members of the Clupeidae family in Campo de Hockey is also indirect evidence of the use of nets, as this species can only be captured in this way (Pérez and Rodríguez del Valle 2001).

The results indicate that 4th-millenium BC settlements on the coast of Cádiz had a mixed economic regime (Figure 5) that combined agriculture and advanced herding with fishing, which had a significant presence in the diet. However, although all these activities are attested in both SET Parralejos and La Esparragosa, the evidence corresponding to them appears in very different proportions. For example, herding (Table 3) is much more abundantly documented in SET Parralejos than in La Esparragosa; in SET Parralejos, sheep and goat remains clearly predominate the overall bone assemblage (45.4%) whereas they account for only 21.8% in La Esparragosa. It can also be argued that agricultural activities were

Table 4. Functions assigned to the lithic instruments found in La Esparragosa (Chiclana de la Frontera) and SET Parralejos (Vejer de la Frontera).

	Mineral	%	Hide	%	Butchering	%	Fish	%	Wood	%	Non-woody plants	%	N. of edges used	%
La Esparragosa	3	2%	19	13%	4	2.7 %	96	65.7%	12	8.2%	12	8.2%	146	100%
Set Parralejos	0	-	0	-	7	19.4%	13	36.1%	1	2.8%	15	41.6%	36	100%

more important in SET Parralejos than in La Esparragosa: 41.6% of use-wear marks in SET Parralejos are related to cereal harvesting, compared to 8.2% in La Esparragosa. Conversely, use-wear marks related to fish processing are much more numerous in La Esparragosa (65.7%) than in SET Parralejos (36.1%) (Table 4). This is clearly related to the coastal location of the site. Significant evidence for the exploitation of marine resources is also present in El Retamar and Campo de Hockey.

The combination of zooarchaeological and technological evidence (essentially microliths) reveals that, although in El Retamar and Campo de Hockey wild fauna was predominant, the use of leaf-shaped microliths in 4th-millenium BC contexts (for instance in La Esparragosa or SET Parralejos) tends to increase over time, suggesting that the economic weight of hunting decreased and that hunting practices became more selective.

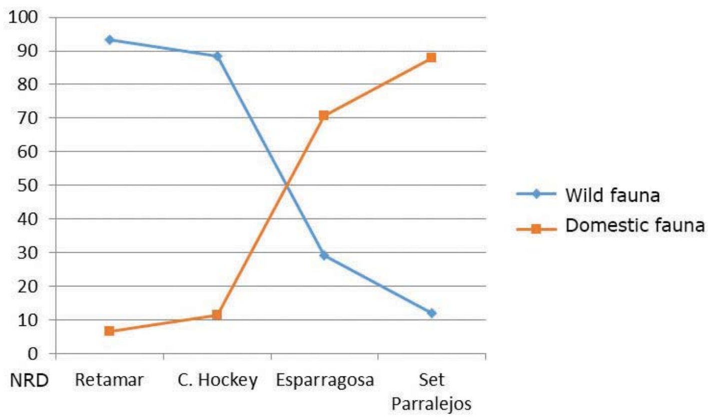

Figure 5. Percentage of wild and domesticated animal species in sites on the Atlantic coast of Cádiz.

Conclusions

This chapter analyses the last hunter-gatherer groups and the earliest agricultural societies in the region around the Strait of Gibraltar and is concerned with chronology, settlement patterns, technology and faunal remains.

The topic presents very interesting future avenues of research, such as the potential contacts between human groups in North Africa and in the south of the Iberian Peninsula (Ramos Muñoz 2012).

It is argued, based on the evidence available, that fishing and shellfish gathering played a significant role in the *modus vivendi* of these societies.

Also, attention has been paid to faunal remains, distinguishing between domesticated and wild species, especially in sites dated to the 6th-5th millennia BC.

The technological sequences presented by these sites is similar, including geometrical and leaf-shaped microliths and multifunctional tools, which would have been used both for the processing of fish and as arrowheads.

The funerary record in Campo de Hockey has also yielded evidence for social differentiation, which is a characteristic feature of permanent settlements. These were the beginnings of the processes of social hierarchisation that eventually led to the development of stratified societies in the south of the Iberian Peninsula (Arteaga *et al.* 2008).

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Hunting practices in Neolithic sheepfold caves in the Iberian Peninsula: El Mirador cave (Sierra de Atapuerca, Burgos) and Cova Colomera (Serra del Montsec, Lleida)

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Abstract

Prehistoric caves were intrinsically related to the beginning of husbandry practices during the Neolithic period. They are very specific archaeological sites where sheep and goat remains are predominant in faunal samples. The present work focuses on the role of hunting in two Neolithic sheepfold caves in the Iberian Peninsula: El Mirador cave and Cova Colomera. The aim is to study the role of hunting in the economic organization and diet of these producer groups. The faunal sample from Cova Colomera was produced during Early Neolithic occupations (6th millennium cal BC). The occupations of El Mirador sheepfold cave date to the period between the Early Neolithic and the Late Neolithic (6th millennium–4th millennium cal BC). These samples were examined in accordance with zooarchaeological and taphonomic methods, involving the study of taxonomic and anatomical composition and the identification of human butchering and consumption marks. The results show certain variability in the practice of hunting at the two sites directly associated with the practice of grazing. At El Mirador cave, hunting was probably practised for meat and for the protection of the herds and fields. In Cova Colomera, hunting was a food supplement, with no particular impact on the diet, taking place during short seasonal occupations of the cave.

Keywords: Sheepfold caves; Neolithic; Iberian Peninsula; Hunting; Domestic herds

Introduction

The period of expansion of agriculture and husbandry in Europe lasted about two millennia (Halstead and Isaakidou 2013; Vigne 2008), reaching the Iberian Peninsula around the second half of the 6th millennium cal BC (Bernabéu and Molina 2009; Cortés Sánchez *et al.* 2012; Oms *et al.* 2016).

From the Early Neolithic, some caves began to be used as sheepfolds; these sites were intrinsically related to the stockbreeding economy. This particular use of caves was to continue over many years, with cases documented in the mid-20th century (Acovitsioti-Hameau *et al.* 2000; Brochier *et al.* 1992).

From the Early Neolithic until the Iron Age, the most significant feature of sheepfold caves was their sedimentological sequences formed by accumulations of burned and unburned dung, called *fumiers* (Angelucci *et al.* 2009). These accumulations were produced by the stabling of the herds and the subsequent burning of the dung, carried out for the sanitation of these spaces (Angelucci *et al.* 2009; Bergadà 1997; Boschian and Montagnari-Kolelj 2000; Brochier 1991; Courty *et al.* 1991; Goldberg and Macphail 2006). Micromorphologically, these sequences are characterized by the presence of faecal spherulites (Brochier 1983, 2002; Brochier *et al.* 1992).

This type of deposit was particularly widespread throughout the Mediterranean area, although they have also been documented in inland and mountainous contexts (Angelucci *et al.* 2009; Chataigner *et al.* 2020; Clemente *et al.* 2016; Martin 2011). In the Iberian Peninsula, the oldest use of caves as a sheepfold dates from the second half of the 6th millennium BC (Badal *et al.* 2012; Morales *et al*. 2013; Oms *et al.* 2013; 2019; Vergès *et al.* 2016).

These caves were sometimes used not only for husbandry activities but also for other domestic activities. The occupation of the sites was thus very variable in time and intensity, varying according to whether the activities carried out in them corresponded to seasonal or to more prolonged uses, and whether they were used exclusively as a sheepfold or also as a habitat (Brochier 1991; 2005).

The faunal assemblages recovered in these caves are consistent with this use as a fold, and domestic species are the most abundant, in particular domestic caprines (Brochier *et al.* 1992; Helmer *et al.* 2005; Martín 2015). In some cases, however, the percentages of hunted species (i.e. lagomorphs or wild ungulates) are still notable, constituting more than 40% of the total of identified specimens (Altuna 1980; Chiquet 2009; 2013; Iborra and Martínez 2009; Pérez Ripoll 2006).

In general, regardless of the type of site (i.e. cave or open-air), the role of hunting decreases in importance from the Early Neolithic on. Over the prehistory of the Iberian Peninsula, hunting undergoes an evolution, always in parallel with other economic activities such as agriculture or metallurgy and with the environmental conditions of each site, and usually as a secondary resource. The main wild species hunted are those also documented during the Epipalaeolithic: chamois, ibex, roe deer, aurochs, red deer, wild boar and rabbits, with particular emphasis on the latter three (Saña 2013).

The present work is based on a study of the faunal remains of wild species in two caves in the Iberian Peninsula: El Mirador and Cova Colomera. These two sites present two of the oldest Neolithic occupations in the Iberian Peninsula. In addition, El Mirador cave is one of the sites with the longest use as a sheepfold in this region. Both sites were excavated following the same methodology, which facilitates the comparison of data.

In these predominantly domestic contexts, we focused on the role of hunting. Given this general objective, we proposed several specific aims:

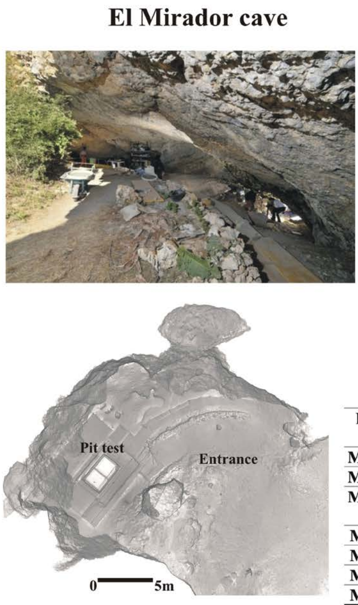
- To study the species hunted, their origin and the hunting techniques used, in order to analyse the investment of time that this activity represented for the shepherds.

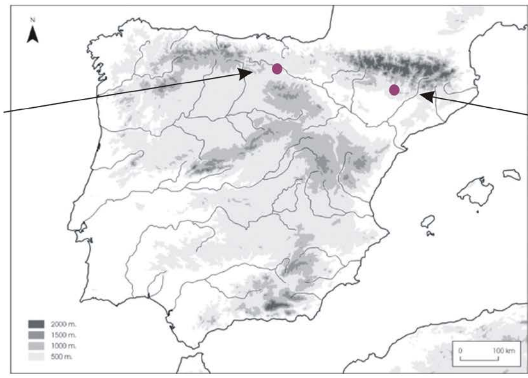
- To analyse how these animals were used.

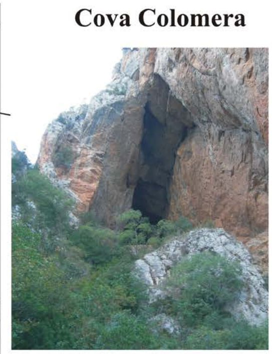
- To analyse the importance of these animals in the diet of the Neolithic shepherds.

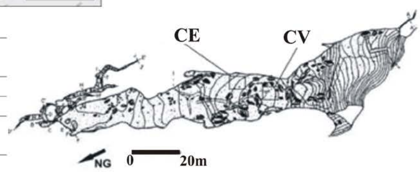
Archaeological sites

The caves of El Mirador and Cova Colomera are located in the Iberian Peninsula. El Mirador cave is located in the Sierra de Atapuerca in the Submeseta Norte region, in the midst of several natural communication routes between the basins of the rivers Ebro and Duero. Cova Colomera is located in the "Congost de Mont Rebei" in the "Serra del Montsec", at a natural border between the valleys and the mountainous area of the Pyrenees (Figure 1). The main data from both sites have already been published (Oms *et al.* 2013; Vergès *et al.* 2016) and are summarized in Table 1. These data come from several pit tests conducted in both caves (Figure 1, Table 1).









Level	Sample	Ref.	Data Cal 2σ
MIR 24	Triticum dicoccum	Beta-220914	5110-4870
MIR 23	*Triticum dicoccum*	Beta-208134	5380-5180
MIR 22	*Triticum aestivum/durum*	Beta-208133	5250-4890
MIR21	*Quercus* sp.	Beta-197385	5440-5240
MIR20	*Triticum dicoccum*	Beta-197384	5120-4840
MIR19	*Quercus* sp. deciduous	Beta-182040	5260-4900
MIR18	*Triticum dicoccum*	Beta-208132	5130-4890
MIR16	*Quercus* sp.	Beta-181088	4730-4370
MIR14	*Triticum aestivum/durum*	Beta-220913	4390-4230
MIR13	*Triticum dicoccum*	Beta-208131	4360-4200
MIR11	*Quercus* sp. evergreen	Beta-181087	4350-3990
MIR9	*Triticum aestivum/durum*	Beta-220912	3990-3710
MIR8	*Quercus* sp. evergreen	Beta-181086	3820-3620
MIR6	*Quercus* sp. evergreen	Beta-153367	3680-3400

Area	Sample	Ref.	Data Cal 2σ
CE12	*Buxus* sp.	Beta-248523	5060-4780
CE13-14	*Triticum a/d*	Beta-240551	5250-4960
CE14	*Triticum a/d*	OxA-23634	5250-5010
CV	*Buxus* sp.	Beta-279478	5250-5010

Figure 1. Location of Cova Colomera and El Mirador cave; plans of the caves and radiocarbon dates of the Neolithic occupations mentioned in this work. Radiocarbon dating of Cova Colomera after Oms et al. *(2013). The radiocarbon data from El Mirador are a summary of a total of 22 dates published in Vergès* et al. *(2016).*

Both sites are among the oldest sheepfold caves in the Iberian Peninsula, defined by *fumier* deposits (Oms *et al.* 2013; Vergès *et al.* 2016). However, there are differences between two caves regarding this use as a sheepfold. In Cova Colomera, two different areas are documented according to their use: a habitat area (CV) in the cave entrance, and a sheepfold area (CE) in the first hall of the cave (Figure 1). The habitat area is defined by a set of combustion structures, two occupation levels, pits and post-holes, with scattered archaeological remains. Waste from domestic activities, such as skeletal remains of consumed animals, is also found in the sheepfold area. At El Mirador, no habitat area in the strict sense has been documented so far. However, as in the Cova Colomera sheepfold, waste from domestic activities is found.

Table 1. Main characteristics of the two sites studied. Environmental data from El Mirador after Rodríguez *et al.* (2016) and Expósito *et al.* (2017). Palaeoclimatic data after Bañuls-Cardona and López-García (2016)

	El Mirador	Colomera
Location	1033 m asl, Sierra de Atapuerca (Burgos). Submeseta Norte region	670 m asl, Serra del Montsec (Lleida), Pre-Pyrenees region
Excavation areas	2: test pit (6 m^2) and sector 100 area	2: CV (26 m^2) and CE (13 m^2)
Use	Sheepfold*	habitat (CV), sheepfold (CE)
Cultural characteristics	Early – Late Neolithic and Middle Bronze Age	Cardial Early Neolithic
Levels/occupations	19 in test pit (MIR24-MIR3) and 5 in sector 100 (MIR102-106)	3 in CE (CE12, CE13, CE14) and 1 in CV
Economic activities	Agriculture and husbandry	Agriculture and husbandry
Domestic activities	Processing and consumption of the carcasses, crop processing.	Processing and consumption of the carcasses, crop processing.
Archaeological remains	Pottery: 1058 (6th); 1039 (5th); 73 (4th); Lithics: 1144 (6th); 974 (5th); 126 (4th); Faunal: 2877 (6th); 4230 (5th); 389 (4th)	Pottery: 350 (CE); 439 (CV) Lithics: 13 (CE); 7 (CV) Faunal: 882 (CE); 327 (CV)
Environmental dada	Mosaic of woody areas (deciduous and evergreen oaks), crop fields and open prairies (from palynological, carpological and anthracological data)	Mosaic of woody areas and pastures (from carpological and palynological data)
Palaeoclimatic data	Temperatures similar to current ones, precipitation higher	Temperatures 2.4ºC lower than current ones, precipitation higher

Domestic caprines predominate in the faunal assemblages recovered from all levels of both caves. In the case of El Mirador, the abundance of foetal and neonatal domestic caprines suggests that it was used as a breeding site and birthplace (Martín *et al.* 2016a).

Cattle and pigs complete the domestic herds of the two caves (Figure 2). In the case of El Mirador, horses were probably also bred in Bronze Age levels (Martín *et al.* 2016b). Distinguishing domestic pigs and horses from their wild agriotypes is difficult because of their anatomical proximity, the low number of remains (especially in Cova Colomera), and the high degree of fracturing in these assemblages (Martín

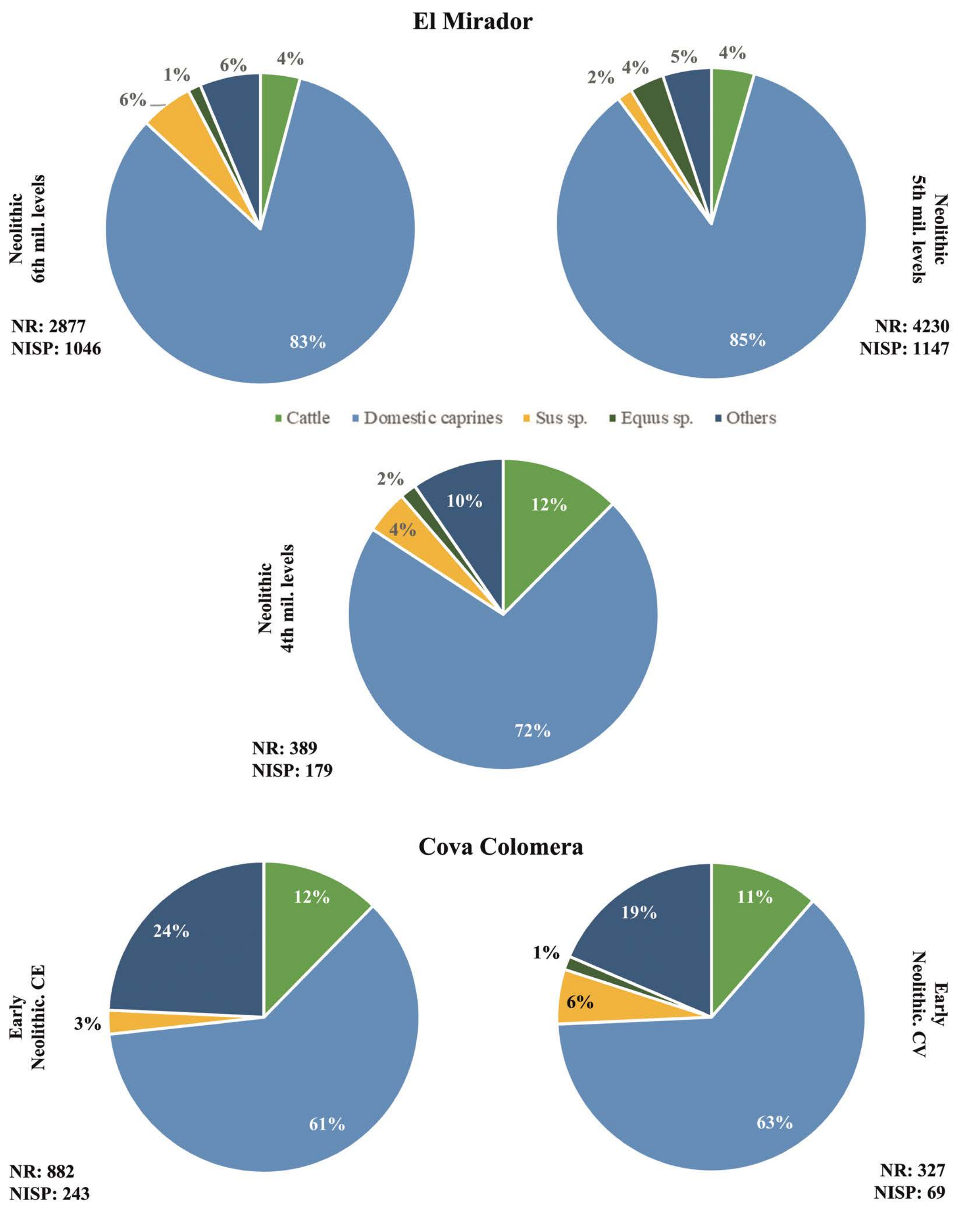


Figure 2. Graphic representation of the percentages of NR and NISP of El Mirador cave and Cova Colomera.

2015). Many of the measurements that have been taken in El Mirador fall within the range of variation of domestic pigs (Martín 2015). In the case of the suids of Cova Colomera, it has not been possible to take any measurements. Whatever the case, considering the characteristics of the environment at the two sites, the presence of wild boars cannot be ruled out.

The presence of domestic horses in El Mirador is possible in Bronze Age levels but very unlikely in the older levels (Martín *et al.* 2016b). Accordingly, the horse will be considered as hunting animal in this work.

Material and methods

The present work is a study of the wild animal remains recovered from the Neolithic levels of the sheepfold caves of El Mirador and the Early Neolithic levels of Cova Colomera. In the case of Cova Colomera, the remains come from both the sheepfold (CE) and the habitat (CV) areas. We considered it relevant to compare the information from the two areas as they are synchronous or near-synchronous occupations.

The remains from the two sites stem from different excavation campaigns but were recovered and documented following the same methodology (Oms *et al.* 2013; Vergès *et al.* 2008, 2016). The location of all remains studied was documented, and to all remains in question a corresponding inventory number were given. The mainly rabbit remains that appeared in burrows affecting the sequences of both sites were excluded from the study to avoid possible intrusions of a non-anthropic origin.

The wild animal remains were examined according to ascertain their taxonomic status and anatomical composition (Davis 1980, 2008; Hillson 2005; Peters 1998; Schmid 1972; Varela and Rodríguez 2004).

The remains were quantified using several indexes: the number of identified specimens (NISP), the minimum number of individuals (MNI), the minimum number of skeletal elements (MNE), and the meat weight (MW), and diversity of taxa (n_{TAXA}) (Lyman 2008). The MW was calculated from the MNI using the references for carnivores and rabbits (Jones *et al.* 2009), equids (Pérez 1999), red deer (Carranza 2017) and roe deer (Mateos-Quesada 2017). This index provides an approximate view of the importance of wild animals in terms of the meat provided. For animals represented only by isolated elements without meat content (i.e. isolated teeth or antlers), the MW was not calculated.

The anthropogenic exploitation of these animals was also assessed in terms of the marks resulting from butchering, culinary processing and consumption. The surface of the remains was inspected microscopically using an OPTHEC 120 Hz model, at up to 60x magnification. Special attention was paid to the identification of cut marks (Shipman and Rose 1983), fracturing (Blumenschine 1994; Blumenschine and Selvaggio 1988), cremation and boiling (Bosch *et al*. 2011; Solari *et al.* 2015; Trujillo-Mederos *et al.* 2012) and human tooth marks (Binford 1981; Maguire *et al.* 1980; Saladié 2009; Saladié *et al.* 2013).

The butchering process was reconstructed by studying the morphology, orientation and location of the cut marks (Binford 1981; Nilssen 2000).

Results

El Mirador

In the Neolithic levels of El Mirador, a total of 199 wild animal remains were recovered, representing 19% of the total NISP and 26.1% of the total MNI of the assemblages (Tables 2 and 3). The 5th millennium occupations provided the highest NISP, both in general and for wild animals (Table 2). However, the occupations with the greatest n_{TAXA} are the oldest ones from the 6th millennium, which also have the highest MNI of wild species at El Mirador (Table 3).

The wild species of El Mirador cave include herbivores (equids and cervids), carnivores (canids and felids), lagomorphs (rabbits) and birds. As far as possible, the remains were identified to a species level or, if not, to a family, order or even class level in the case of birds (Table 2). The latter were particularly

Table 2. Representation of the wild species in El Mirador cave, NISP and MNE grouped in each of the Neolithic occupations. The %NISP represents the percentage of wild taxon specimens over the total NISP of each occupation. The %MNE represents the percentage of the minimum number of wild taxon elements over the total MNE of each occupation.

	Neo. VI mil.				Neo. V mil.				Neo. IV mil.			
	NISP	%NISP	MNE	%MNE	NISP	%NISP	MNE	%MNE	NISP	%NISP	MNE	%MNE
Horse (*Equus* sp.)	14	1.3	14	1.7	41	3.6	45	4.5	5	2.8	5	3.3
Red deer (*Cervus elaphus*)	16	1.5	17	2.0	19	1.7	17	1.7	3	1.7	3	2
Roe deer (*Capreolus capreolus*)	5	0.5	5	0.6	9	0.8	8	0.8	0	0	0	0
Cervids	6	0.6	6	0.7	1	0.1	1	0.1	0	0	0	0
Fox (*Vulpes vulpes*)	3	0.3	3	0.4	5	0.4	5	0.5	0	0	0	0
Canids	3	0.3	3	0.4	1	0.1	1	0.1	0	0	0	0
Badger (*Meles meles*)	1	0.1	1	0.1	0	0	0	0	0	0	0	0
Mustelids	0	0	0	0	1	0.1	1	0.1	1	0.6	1	0.7
Wild cat (*Felis silvestris*)	2	0.2	2	0.2	1	0.1	1	0.1	0	0	0	0
Carnivora	1	0.1	1	0.1	2	0.2	2	0.2	0	0	0	0
Rabbit (*Oryctolagus cuniculus*)	22	2.1	17	2.3	11	0.1	11	1.1	13	7.3	9	6
Corvid (*Corvus* sp.)	1	0.1	1	0.1	0	0	0	0	0	0	0	0
Tawny owl (*Strix aluco*)	1	0.1	1	0.1	0	0	0	0	0	0	0	0
Birds	4	0.4	4	0.5	7	0.6	7	0	0	0	0	0
Total	**79**	**7.5**	**75**	**8.9**	**98**	**8.5**	**99**	**9.1**	**22**	**12.4**	**18**	**12**

Table 3. Representation of the wild species in El Mirador cave, MNI and MW grouped in each of the Neolithic occupations. The %MNI represents the percentage of the minimum number of individuals for the wild taxon over the total MNI of each occupation. The %MW represents the percentage of the meat weight of the wild taxon elements over the total MW of each occupation.

	Neo. VI mil.				Neo. V mil.				Neo. IV mil.			
	MNI	%MNI	MW	%MW	MNI	%MNI	MW	%MW	MNI	%MNI	MW	%MW
Horse (*Equus* sp.)	5	4.1	950	22.0	9	7.6	1665	33.3	2	4.5	380	14.6
Red deer (*Cervus elaphus*)	5	4.1	221	5.1	4	3.4	215	4.3	3	6.8	130	5.0
Roe deer (*Capreolus capreolus*)	3	2.4	40	0.9	4	3.4	60	0.1	0	0	0	0
Cervids	3	2.4	0	0	1	0.8	0	0	0	0	0	0
Fox (*Vulpes vulpes*)	2	1.6	9.6	0.2	2	1.7	9.6	19.3	0	0	0	0
Canidae	2	1.6	0	0	1	0.8	0	0	0	0	0	0
Badger (*Meles meles*)	1	0.8	11.7	0.3	0	0	0	0	0	0	0	0
Mustelidae	0	0	0	0	1	0.8	0	0	1	2.3	0	0
Wild cat (*Felis silvestris*)	2	1.6	9.1	0.2	1	0.8	4.6	0.1	0	0	0	0
Carnivora	1	0.8	0	0	2	1.7	0	0	0	0	0	0
Rabbit (*Oryctolagus cuniculus*)	7	5.7	11.1	0.3	2	1.7	3.2	0.1	2	4.5	3.2	12.2
Corvids (*Corvus* sp.)	1	0.8	0	0	0	0	0	0	0	0	0	0
Tawny owl (*Strix aluco*)	1	0.8	0	0	0	0	0	0	0	0	0	0
Birds	3	2.4	0	0	3	2.5	0	0	0	0	0	0
Total	**36**	**29.2**	**1253**	**29.1**	**30**	**25.4**	**1957**	**57.1**	**8**	**18.2**	**513**	**31.8**

difficult to identify due to the scarcity and the high fracture rate of their remains. It was only possible to identify one remnant to the species level (*Strix aluco*) and another one to the genus level (*Corvus* sp.).

Equids are best represented in the 5th millennium levels, and rabbits in the 4th and 6th millennium levels, but the differences with respect to the representation rates of other taxa are not significant.

The anatomical representation is, in general, partial, particularly in the case of carnivores (Figure 3). Equids, cervids and birds are mainly represented by elements of the postcranial skeleton, especially appendicular bones. Rabbits have a more complete anatomical representation, including elements of the cranial and postcranial skeleton.

In the 5th millennium levels, the amount of meat as a percentage of the total (%MW = 57.1) stands out, showing their importance as a resource in these levels. This is in part due to the relatively high MNI of equids (Table 3). The contribution of meat and viscera from wild taxa in the other two Neolithic

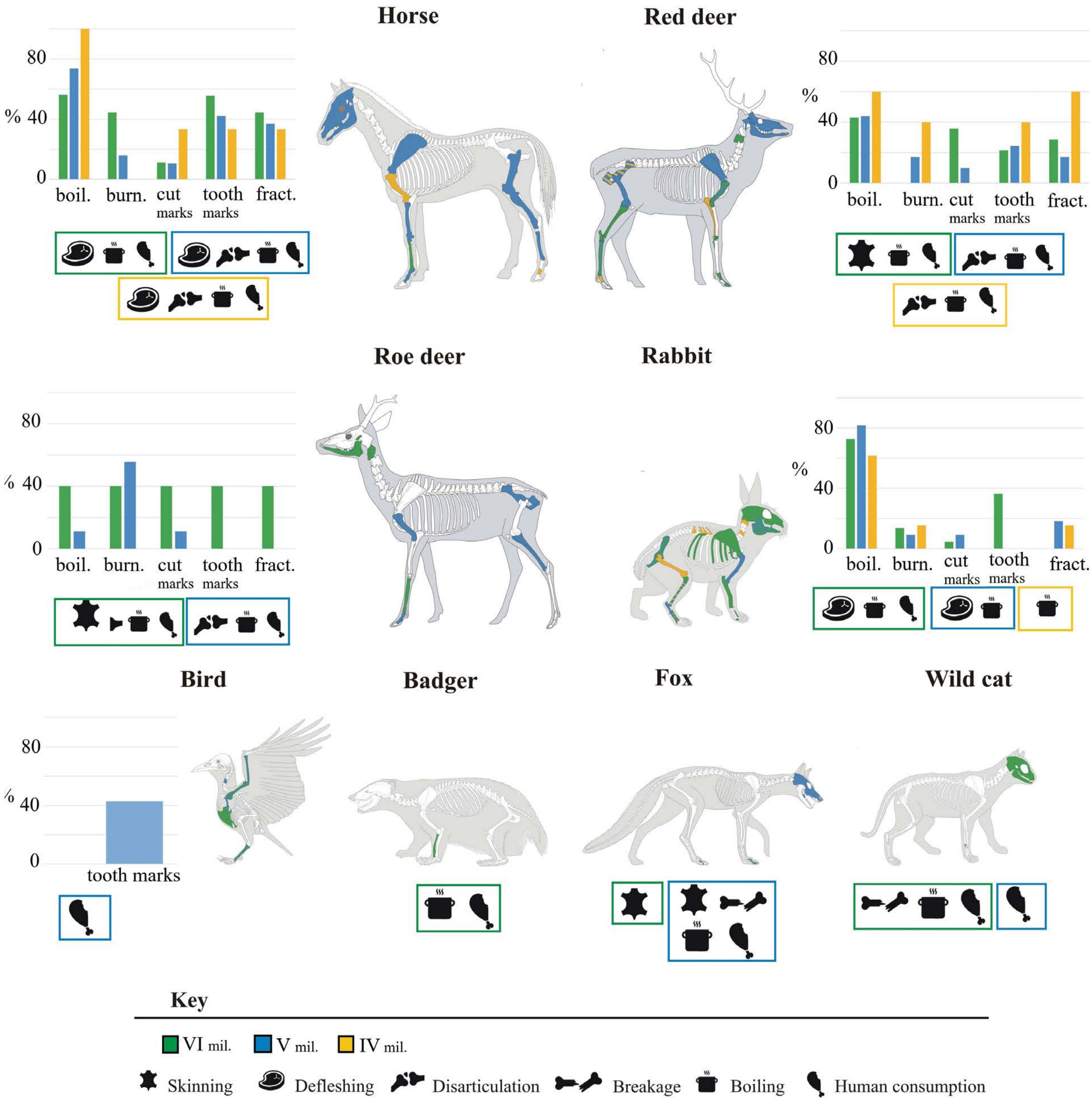


Figure 3. Anatomical representation and evidence of processing and consumption of the remains identified to species and, in the case of birds, to class level, in El Mirador cave. The silhouettes represent the elements represented by taxon. The graphics present the %NISP with processing and consumption marks for each taxon. In the case of carnivores, the %NISP with marks is not shown due to the low number of remains.

occupations of El Mirador is lower and is consistent with the generally low levels of representation of these animals.

All wild taxa from El Mirador cave present some evidence of processing and/or human consumption.

Except for birds, all taxa show evidence of thermal alteration, either by cremation or by boiling. However, caution is due in interpreting burned bones as evidence of culinary processing, given the burning of dung at the site.

Some of the bird remains from the 5th millennium levels display evidence of human tooth marks. Neither the tawny owl nor the corvid show evidence of processing or consumption. This could be due to the fact that they are of non-anthropogenic origin. Another possible explanation is that, due to the small size of these animals, the handling of them for consumption is less intense or not necessary at all.

One of the most remarkable aspects of El Mirador is the evidence of the butchering and consumption of carnivores, even though they are represented by a very low NISP. Some of these marks could be associated with the exploitation of the fur of these animals, particularly the skinning marks on the wild cat. However, what is most notable is the evidence that these animals have been cooked by boiling, as well as the presence of human tooth marks on the badger and fox remains (Martín *et al.* 2014).

In addition, the anthropogenic processing of a number of remains unidentified to species level has also been established. In the 6th millennium levels, there were three canid remains with cut marks that show their disarticulation. Translucent remains with polished edges were also identified, interpreted by various authors as evidence of the boiling process (Bosch *et al.* 2011; Solari *et al.* 2015; Trujillo-Mederos *et al.* 2012). Several carnivore (NISP = 1) and cervid (NISP = 3) remains also show such signs of boiling. In the 5th millennium levels, one canid and one cervid remains were found to display evidence of burning.

Cova Colomera

The representativeness of the wild animals is very similar in two areas studied in Cova Colomera, i.e. the sheepfold (CE) and the habitat area (CV). In general, wild animals are represented by a low number of remains belonging to red deer, roe deer, rabbits and birds. The representation of red deer, with only one fragment of humerus in in CE, is particularly limited. Unlike El Mirador, the presence of wild carnivores was not documented.

Wild species in Cova Colomera represent 23.9% of the total NISP in the sheepfold (CE) and 18.8% in the habitat area (CV). The importance of these animals increases if the rest of the quantification indexes are taken into account (Tables 4 and 5). This is particularly significant in the case of the %MNI, with wild species representing 40% of the total in CE and 50% in CV, and in the case of the %MNE in CE (59.8%). In general, no significant differences are observed between the two areas of the cave.

The importance of wild animals in Cova Colomera is low in terms of their contribution of meat to the total of the two groups. We consider it appropriate not to quantify the MW contribution of the equids identified in CE because there is only one specimen identified by a tooth.

The information available on the consumption and processing of wild animals is more limited than in the case of El Mirador, as the NISP of Cova Colomera is lower (Figure 4).

Table 4. Representation of the wild species in Cova Colomera, NISP and MNE grouped in each of the Early Neolithic areas. The %NISP represents the percentage of wild taxon specimens over the total NISP of each area. The %MNE represents the percentage of the minimum number of wild taxon elements over the total MNE of each area.

	CE				CV			
	NISP	**%NISP**	**MNE**	**%MNE**	**NISP**	**%NISP**	**MNE**	**%MNE**
Horse (*Equus* sp.)	0	0	0	0	1	1.4	1	2.2
Red deer (*Cervus elaphus*)	1	0.4	1	1.2	0	0	0	0
Roe deer (*Capreolus capreolus*)	3	1.2	3	3.7	0	0	0	0
Cervids	0	0	0	0	1	1.4	1	2.2
Rabbit (*Oryctolagus cuniculus*)	43	17.7	35	42.7	8	11.6	8	17.4
Bird	11	4.5	10	12.2	3	4.3	3	6.5
Total	**58**	**23.9**	**49**	**59.76**	**13**	**18.79**	**13**	**28.2**

Table 5. Representation of the wild species in Cova Colomera, MNI and MW grouped in each of the Early Neolithic areas. The %MNI represents the percentage of the minimum number of individuals for the wild taxon over the total MNI of each area. The %MW represents the percentage of the meat weight of the wild taxon elements over the total MW of each area.

	CE				CV			
	MNI	%MNI	MW	%MW	MNI	%MNI	MW	%MW
Horse (*Equus* sp.)	0	0	0	0	1	12.5	*	*
Red deer (*Cervus elaphus*)	1	2.9	35	2.7	0	0	0	0
Roe deer (*Capreolus capreolus*)	2	5.7	25	1.9	0	0	0	0
Cervids	0	0	0	0	1	12.5	60	9.5
Rabbits (*Oryctolagus cuniculus*)	7	20	11.1	0.9	1	12.5	1.6	0.3
Birds	4	11.4	0	0	1	12.5	0	0
Total	**14**	**40**	**71.1**	**5.5**	**4**	**50**	**61.6**	**9.8**

The rabbits and birds present direct evidence of consumption through the presence of human tooth marks. Defleshing was documented in the case of roe deer and rabbits, as it was boiling in all species except red deer and horses. The latter are the only two wild taxa that do not display any evidence of processing or consumption.

Discussion

The practice of hunting by shepherds

It is not always possible to be sure that the presence of wild species recovered from archaeological sites is due to the practice of hunting. The presence of some animals may be due to natural activities such as the use of caves as burrows or nests. For this reason, both in El Mirador and in Cova Colomera, two criteria are used to identify the species that were hunted. Firstly, during the fieldwork, remains recovered inside burrows were not coordinated. Secondly, marks of anthropogenic manipulation were considered criteria in identifying the remains of hunted wild animals. On the basis of these criteria, features are observed that are common to the two sites, but there is certain variability between them too.

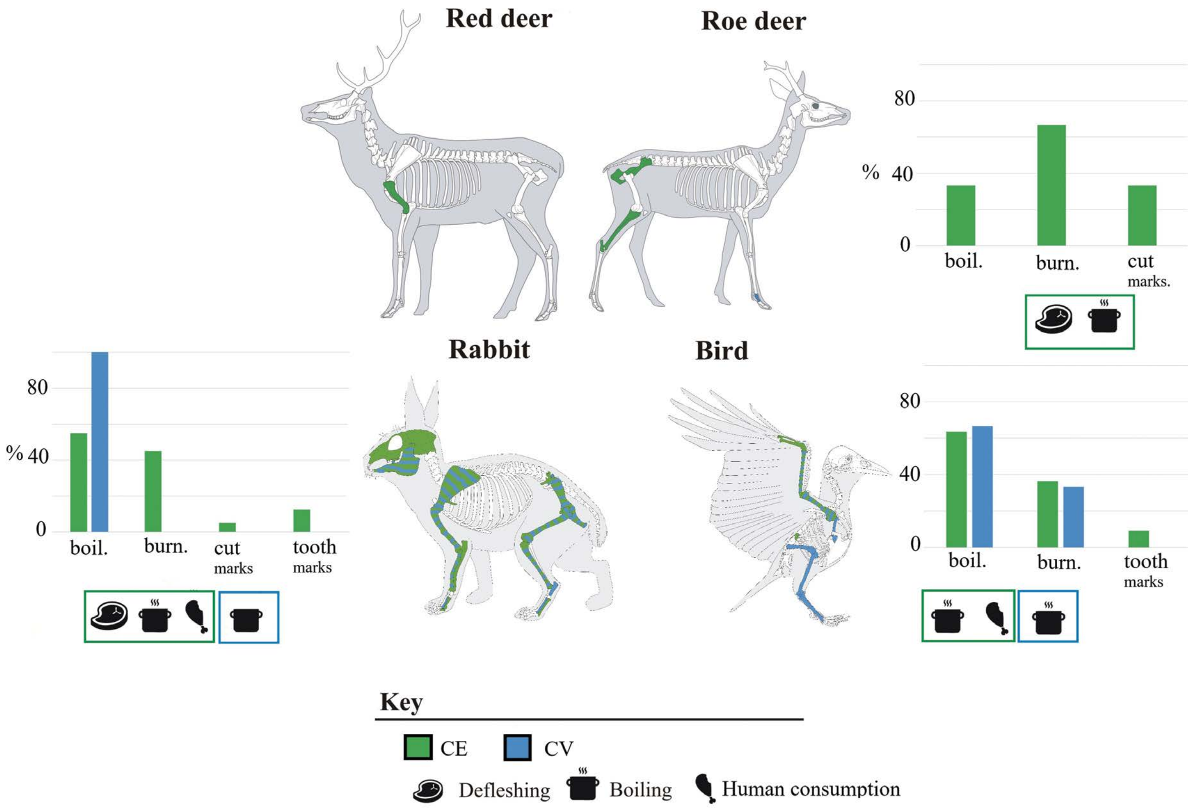


Figure 4. Anatomical representation and evidence of processing and consumption of the remains identified to species and, in the case of birds, to class level, in Cova Colomera. The silhouettes represent the elements represented by taxon. The graphics present the %NISP with processing and consumption marks for each taxon. Red deer has no processing or consumption marks.

The importance of hunting in the caves of El Mirador and Cova Colomera varies with the index of quantification under consideration (Figure 5). At El Mirador cave, the importance of wild animals is low in terms of the number of remains. However, it is greater if the %MNI and especially the %MW are taken into account. This is especially significant in the 5th millennium occupations, where the number of equids is relatively high. In contrast, in Cova Colomera, the importance of hunted animals is greater in terms of %NISP but is considerably lower in terms of %MW. This is because the %MW of the most abundant taxa is very low.

Nine taxa of hunted animals are identified at El Mirador, including both herbivores and carnivores: equids, red deer, roe deer, rabbits, foxes, badgers and cats. In addition to these, there are several bird remains, as well as remains of cervids, canids, carnivores and mustelids, which show evidence of handling but could not be identified to a species level.

The diversity of animals hunted in Cova Colomera is lower (n_{TAXA} = 3) and does not include carnivores, comprising roe deer, rabbits and birds. It was not possible to ascertain the hunting of the red deer, represented by one unfused distal humerus epiphysis, with no evidence of processing or consumption.

All the species documented at both sites are typical of their surrounding environment. The environment of Cova Colomera during the Neolithic period was characterized by a mosaic of forests and pastures (Bañuls-Cardona and López-García 2011). It would have been a very similar environment to that which currently characterizes the Congost de Mont Rebei and the Sierra del Montsec, although now there is a

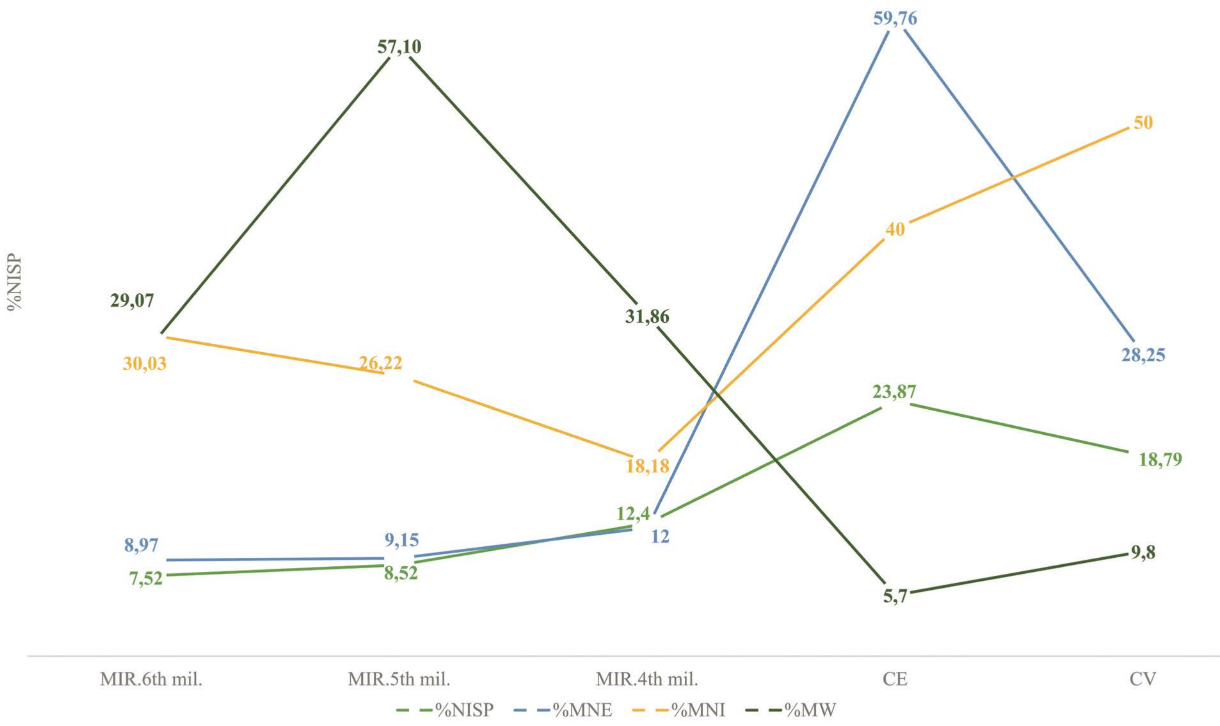


Figure 5. Graphic representation of the indexes of quantification (%NISP, %MNE, %MNI and %MW) of the wild species in the different Neolithic occupations of El Mirador and in those of the Early Neolithic of Cova Colomera.

greater degree of anthropization due to agricultural and husbandry activity (Ruiz *et al.* 1987). At present, the wooded area around Cova Colomera is made up of conifer forests and mixed Mediterranean forests.

El Mirador cave was also located within a mosaic environment, composed of forests (deciduous and evergreen oaks, *Fraxinus* and *Corylus*), open prairies and crop fields during the Neolithic period (Expósito *et al.* 2017; Rodríguez *et al.* 2016).

In general, all wild species documented at the two sites are characterized by great ecological plasticity. Red deer, wild cats, badgers and rabbits are particularly suited to the mosaics of vegetation that characterize the environment of the two caves (Carranza 2017; Gálvez-Bravo 2017; Virgós 2017). The roe deer and tawny owl have a greater preference for woods (Mateos-Quesada 2017; SEOBirdlife 2008), and the equids and foxes are adapted to all types of environments (López-Martín 2017; Moehlman 2002). Almost all species found at the two sites are documented in the present-day environment of the sites. The exception is deer in the case of La Colomera. Today, the nearest area with deer is about 25-30 km from the cave. The presence of the wild boar is also documented in these environments, so it is possible that they were also hunted at both sites, although the difficulty of distinguishing the suids to species level precludes confirmation of this.

All these data indicate that the practice of hunting could have taken place in the most immediate vicinity of El Mirador cave and Cova Colomera. The data are in line with the analyses of the lithic resource catchment of the Cova Colomera, which has a radius of action of less than 10 km (Mangado *et al.* 2012).

This availability of wild taxa as resources suggests several possible explanations for the differences observed in the representation and taxonomic diversity of the two sites.

The studies carried out seem to indicate that El Mirador cave must have been used more intensively and recurrently than Cova Colomera. The mortality profiles of domestic animals at El Mirador cave seem to indicate certain continuity in the occupation of the cave and/or its surroundings throughout the year (Martín 2015). The faunal data from Cova Colomera seem to indicate more seasonal occupations, as also evidenced by the lithics, which appear already configured and are found abandoned in the cave (Oms *et al.* 2013).

Furthermore, the archaeological remains recovered at both sites (including fauna) are significantly more extensive at El Mirador than at Cova Colomera (Oms *et al.* 2013; Vergès *et al.* 2016). The pattern observed at El Mirador cave is similar to that noted at other sites that also show prolonged and/or recurrent use as a sheepfold (Boschian and Montagnari 2000; Bernabéu and Molina 2009; Fernández 2008; Iaconis and Boschian 2007; Miracle and Forenbaher 2005). On the other hand, the Cova Colomera shows similarities with other caves used for seasonal occupation, such as Pupićina Cave (Boschian and Miracle 2007) (Table 6) and Abric de la Falguera (García Puchol and Aura Tortosa 2006).

The prolonged stays of the shepherds in El Mirador cave and the vicinity could have helped maximize the capture of resources from the surroundings, including by hunting.

The differences observed between the two sites are also documented in other sheepfold caves. The domestic species that appear in them are usually also representative of the immediate environment. However, they also present differences in terms of taxonomic composition and diversity and the representative importance of each species (Table 6).

A total of 21 different taxa have been identified in the caves consulted; in all cases these are mammals since these studies do not usually include the remains of birds (Table 6). Carnivores show the highest species diversity, whereas artiodactyls are the most numerous quantitatively, especially red deer. In some sites, lagomorphs or small carnivores have the highest %NISP, although this figure should be taken with caution as it is not always specified whether these are possible natural intrusions.

As regards the evolution of hunting in El Mirador cave, a slight increase in the number of wild animal specimens is observed in the Late Neolithic period (4th millennium) (Figure 5). This phenomenon is linked to a decrease in the NISP of domestic caprines, especially of fetal and neonatal (less than a month old) individuals, and an increase in cattle remains (Figure 1), which is also documented in other caves in the Adriatic region (Miracle 2006). In the case of El Mirador cave, it is also associated with a decline in the diversity of hunted taxa and is confirmed in the levels of the Middle Bronze (Martín 2015). These changes could be related to a shift in the pattern of use of the caves, perhaps towards more seasonal occupations or towards more complex phenomena associated with an intensification of agricultural activity, a diversification in the breeding of domestic taxa, or an increase in herd mobility (Martín 2015; Miracle 2006). Whatever the case, it can be seen how hunting, though a secondary phenomenon, is maintained and evolves in parallel with the predominant farming system.

Hunting techniques and the exploitation of wild animals by shepherds

Ethnographic sources show the farmers to be occasional hunters (Leizaola 2008; Represa 1998). This hunting was carried out with two objectives: 1) to obtain an extra supply of proteins and raw materials, 2) to protect the herds from vermin and the crop fields from wild herbivores. To achieve the first aim, big-game hunting was usually practised (i.e. red deer, roe deer, chamois). To achieve the second, mainly

Table 6. %NISP of the total of wild species, in different sheepfold caves. The "X" denotes the presence of one wild species in that particular site. Abbreviations: EN (Early Neolithic); MN (Middle Neolithic); LN (Late Neolithic) (References: Arene Candide (Ligure, Italy) (Rowley Conwy 2000); Grotta Azzurra (Trieste Karst, Italy) (Cannarella and Cremonesi 1967), Grotta dell'Edera (Trieste Karst, Italy) (Boschin and Riedel 2000); Grotta dei Piccioni (Abruzzo, Italy) (Wilkens 1987); Grotta Sant'Angelo (Abruzzo, Italy) (Wilkens 1996); Cova de Les Cendres (Alicante, Spain) (Iborra and Martínez 2009); Grotte Gardon (Jura, France) (Chiquet 2009, 2013), Pupićina Cave (Adriatic, Croatia) (Miracle 2006); Abric de la Falguera (Alicante, Spain) (Pérez Ripoll 2006); Los Husos (Alava, Spain) (Altuna 1980).

	Are.Candide. EN	Azzurra. EN	Edera.EN	Piccioni.EN	Sant'Angelo.EN. Impr	Sant'Angelo.EN. Catig	Sant'Angelo.EN. Rip	Cendres. MN.IB	Cendres. MN.IC1	Cendres.MN. IC2	Gardon. MN I
%NISP	14.4	39.0	6.0	36.0	22.6	38.8	6.5	56.0	50.5	24.6	80.6
Horse (*Equus* sp.)									X		
Auroch (*Bos primigenius*)					X						
Red deer (*Cervus elaphus*)	X	X	X	X				X	X	X	X
Roe deer (*Capreolus capreolus*)	X	X	X	X		X		X	X		X
Chamois (*Rupicapra rupicapra*)				X							X
Wild boar (*Sus scrofa*)		X	X	X		X					X
Brown bear (*Ursus arctos*)						X					X
Wolf (*Canis lupus*)			X	X							X
Fox (*Vulpes vulpes*)		X	X			X	X				X
Wild cat (*Felis silvestris*)			X	X	X	X	X				X
Marten (*Martes* sp.)				X	X	X					X
Badger (*Meles meles*)		X	X	X							X
Polecat (*Mustela putorius*)		X									X
Otter (*Lutra lutra*)											X
European Beaver (*Castor fiber*)											
Hare (*Lepus* sp.)			X	X	X	X	X	X			X
Rabbit (*Oryctolagus cuniculus*)								X	X	X	
Red squirrel (*Sciurus vulgaris*)					X						
European hedgehog (*Erinaceus europaeus*)											X
Mediterranean monk seal (*Monachus monacus*)											

	Gardon. MN II	Pupicina.MN.H	A.Falguera.LN	Los Husos.LN	Pupicina.LN	Pupicina.MN.I	BOull.NM	Are.Candide. MN I	CObs.NM	Are.Candide. MN II
%NISP	41.9	10.2	46	40.3	7.4	3.7	3.6	2.6	2.3	1.2
Horse (*Equus* sp.)	X									
Auroch (*Bos primigenius*)				X						
Red deer (*Cervus elaphus*)	X	X	X	X	X	X	X	X	X	X
Roe deer (*Capreolus capreolus*)	X	X	X	X	X	X	X	X	X	X
Chamois (*Rupicapra rupicapra*)										
Wild boar (*Sus scrofa*)	X			X						
Brown bear (*Ursus arctos*)	X									
Wolf (*Canis lupus*)										
Fox (*Vulpes vulpes*)	X	X		X		X				
Wild cat (*Felis silvestris*)	X	X								
Marten (*Martes* sp.)	X			X						
Badger (*Meles meles*)	X				X	X				
Polecat (*Mustela putorius*)	X									
Otter (*Lutra lutra*)										
European Beaver (*Castor fiber*)	X									
Hare (*Lepus* sp.)	X									
Rabbit (*Oryctolagus cuniculus*)			X	X						
Red squirrel (*Sciurus vulgaris*)	X									
European hedgehog (*Erinaceus europaeus*)	X									
Mediterranean monk seal (*Monachus monacus*)										

small-game hunting and trapping were practised, although hunts were also undertaken to capture wolves or bears.

The taphonomic alterations documented in the wild animals of El Mirador cave and Cova Colomera do not yield any information about how they were hunted. However, the above-mentioned ethnographic references suggest possible hunting techniques that may have been used: bow hunting and different trapping techniques. Some of the flint tips and bone tools found at El Mirador could be related to these activities.

These same taphonomic alterations do provide information on the possible uses of these animals by the Neolithic groups of Cova Colomera and El Mirador cave. Evidence of processing, cooking and/or consumption is documented on the remains of practically all the taxa, indicating an exploitation of the protein content of these animals. We would highlight in particular the consumption of small carnivores at El Mirador (Martín *et al.* 2104) because these are rare in the human diet, although there are references to their sporadic consumption by shepherds (Leizaola 2005, 2008). As already mentioned, the hunting of small carnivores is common among shepherds. These animals pose a major threat to pregnant females and their young (Represa 1998). Considering the abundance of this age group in El Mirador cave, it is not surprising that the shepherds carried out this type of hunting (Martín *et al.* 2014, 2016a).

The consumption of these animals by traditional shepherds was a practice that optimized natural resources, and an element of differentiation between the diet of the shepherds and other sectors of the population. In addition, some of the wild animals (e.g. foxes and badgers) were even valued for the culinary quality of their meat (Leizaola 2005, 2008).

There are a few references to the hunting and use of these small carnivores in the Neolithic period, the case of some sheepfold caves being particularly noteworthy (Chiquet 2009; Llorente 2015; Miracle 2006). The butchering of them for consumption has been more difficult to establish, but some cases have been documented in the Grotte Gardon (Chiquet 2009, 2013).

Documenting the use of secondary products, such as skin, bones or antlers, is much more complicated. Skinning has been documented in some cases (Figure 3) but always on animals that also show evidence of cooking and/or consumption. However, it is very likely that these products were used to produce different objects of daily use (Rodríguez Pascual 2012). The use of the skin of small carnivores has been identified in some Neolithic sheepfold caves (Chiquet 2009).

In El Mirador, the appearance of bones and worked antlers could be related to this practice. Likewise, in the levels of Pupićina, the selective transport of deer antlers and metapodials within the cave is documented. This practice is associated with the possible use of these elements as support for the creation of tools (Miracle 2006).

In terms of meat intake, wild animals are of a moderate importance in the diet of the population of El Mirador cave. Wild animals represent between 7.5% and 12.4% of the total NISP, but between 29% and 57.1% of the total MW (Figure 5). This is especially significant in the 5th millennium levels due to the abundance of equids. This taxon is not very common in the sheepfold caves; the Neolithic occupations of El Mirador are where the greatest number of such remains has been found. In addition to horses, deer also provide a significant amount of meat.

The importance of meat from wild animals could be associated with strategies in herd management. In the cave of El Mirador, husbandry is based on caprines, and the group of fetal and neonatal individuals is very abundant. The low quantity of meat provided by these immature animals means that the importance of the larger species increases if what is considered is the %MW, although the NISP or MNI of these individuals is low. Ethnographic sources thus report how wild animals become the main source of meat for shepherds, who thus avoid having to kill domestic animals and thereby preserve the herd (Halstead 1993, 1996, 2006; Seguí 1999; Solecki 1979).

The case of Cova Colomera is different. Wild animals are quantitatively important in terms of %NISP but not in terms of the quantity of meat (Figure 5). This is because the main taxa documented are rabbits and birds. This could in turn be related to the seasonality of the occupations of Cova Colomera and the relationship of the cave with herds that have certain mobility through the territory. These small preys do not require as much effort to capture as big game and are easier to transport.

Conclusions

The Neolithic sheepfold caves, despite being clearly linked to the practice of husbandry, show that hunting continues to be important and is adapted to the environmental, occupational and economic characteristics of each group.

Although the production economy is fully consolidated, hunting is still used as a source of resources, in the caves of El Mirador and Cova Colomera.

In El Mirador cave, it is also a practice that shows continuity throughout the Neolithic period, acquiring more and more importance in the levels of the 4th millennium.

The wild species in both sites are representative of the most nearby environments, which suggests that hunting could have taken place in the surrounding area. This means that it could have been pursued in parallel with husbandry practices.

The hunting of equids is of great importance in El Mirador, especially during the 5th and 4th millennia, both in terms of the number of individuals and the quantity of meat they provide.

In Cova Colomera, wild animals are very important in terms of the NISP but not if we consider the amount of meat they provide. This is because the most abundant wild animals are rabbits and birds.

The main purpose of hunting of these animals could have been to obtain meat. This would have been especially significant in the case of El Mirador. It could have been a part of a strategy to maintain the balance of the herd, making it unnecessary to sacrifice domestic animals in order to obtain proteins.

In the case of the Cova Colomera, the low meat content provided by the wild animals makes them a simple complement to the diet.

Hunting could also have been used as a strategy for protecting the herds and fields. This is especially significant in El Mirador cave, where carnivores were hunted and consumed, and is also a clear example of the optimization of resources.

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