

Neolithic Dairy Technology at the European-Anatolian Frontier: Implications of Archaeozoological Evidence from Ulucak Höyük, İzmir, Turkey, ca. 7000-5700 cal. BC

Canan ÇAKIRLAR

Dr. Rer. Nat. (Universitaire docent)

University of Groningen Groningen

Institute of Archaeology Poststraat 6, NL-9712 ER Groningen (Netherlands)

c.cakirlar@rug.nl

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This paper discusses the archaeozoological evidence from Neolithic Ulucak Höyük (İzmir, ca. 7000-5700 cal. BC) in light of current debates on early dairy technologies. The paper aims to add new dimension to the current understanding of the role western Anatolia played in the evolution of early animal husbandry systems towards wider applications of dairy technologies. The evidence from Ulucak can potentially shed important new information on how these technologies were exchanged across the European-Anatolian frontier. To explore the appearance and evolution of milk use at Ulucak, the paper evaluates two main lines of archaeozoological data: mortality profiles – the most tangible archaeozoological evidence to detect the ways in which domestic animals were exploited (Payne 1973; Vigne and Helmer 2007), and diachronic changes in the contribution of cattle to subsistence economy, with reference to Evershed *et al.* (2008)'s proposal about a cattle-dairy link in northwestern Turkey. Results from Neolithic Ulucak are assessed in the context of relevant evidence from neighbouring sites in western Anatolia.

KEYWORDS

Neolithic dispersals
Anatolia
Ulucak
archaeozoology
milk exploitation
secondary products
animal husbandry
mortality profiles

RÉSUMÉ

La technologie laitière néolithique à la frontière de l'Europe et de l'Anatolie (Ulucak Höyük, İzmir, Turquie, ca. 7000-5700 av. BC.) : apports de l'archéozoologie

Cet article présente les résultats de l'étude archéozoologique du site néolithique d'Ulucak Höyük (İzmir, 7000-5700 av. J.-C.) à la lumière des débats actuels sur la naissance des technologies laitières. Il vise à apporter une nouvelle dimension à la compréhension du rôle joué par l'Anatolie occidentale dans l'évolution des premiers systèmes d'élevage d'animaux vers un développement plus large des technologies laitières. Le site d'Ulucak Höyük peut apporter des nouvelles informations déterminantes sur la manière dont ces technologies ont été échangées à la frontière entre l'Europe et l'Anatolie. Pour mettre en évidence l'apparition et l'évolution de l'utilisation de lait à Ulucak, cette étude prend en compte deux grands types de données archéozoologiques : les profils de mortalité – qui sont les données archéozoologiques les plus fiables pour mettre en évidence les manières dont des animaux domestiques ont été exploités (Payne 1973 ; Vigne & Helmer 2007) et l'évolution de la contribution des bovins à l'économie de subsistance – conformément à la proposition d'Evershed *et al.* (2008) concernant les relations entre bovins et exploitation du lait en Turquie du Nord-Ouest. Les résultats du Néolithique d'Ulucak sont interprétés dans le contexte des connaissances acquises à propos des sites voisins d'Anatolie occidentale.

MOTS CLÉS

diffusions du Néolithique
Anatolie
Ulucak
archéozoologie
exploitation laitière
produits secondaires
élevage
profils de mortalité

INTRODUCTION AND BACKGROUND

One of the most important debates in Eurasian prehistory concerns the origins and intensification of secondary products use, i.e. the innovation and development of ways to exploit life-time products (milk, fleece or wool, and traction power) from domesticated bovids. Although whether secondary products were used by ancient societies has been a topic of primary interest for a long time (Flannery 1965; Payne 1973; Bökönyi 1974), the so-called “Secondary Products Revolution” model formulated by A. Sherratt (1981) has become the trigger for much of the debate thereafter (for the most recent discussions, see: Greenfield 2010; Marciniak 2011). While the success of Sherratt’s model came from its theoretical integrity emphasizing a complex, supra-regional process involving a chain of novelties in farming and transport technology that led to the emergence of chiefdoms and state-level societies (Sherratt 1981), much of the research stimulated by Sherratt’s ideas has deviated from the model’s framework into a quest for the chronological and geographical origins of secondary products. Differences in approach and priority (origins vs. intensification leading to large-scale social impact) generated a growing corpus of research suggesting that the use of secondary products may not have been as negligible prior to ca. 5000–4000 BC as Sherratt’s model had proposed (e.g., Vigne & Helmer 2007). Unlike earlier discussions concerning secondary products (e.g. Bogucki 1984, 1986; Greenfield 1988; McCormick 1992), recent arguments are equipped with large series of coordinated analyses of archaeozoological assemblages from early farming contexts in southwest Asia and western Europe that demonstrates the diachronic diversity of human preferences in applying animal husbandry technologies (Helmer *et al.* 2007).

Amongst these debates, the issue of dairy technology has attracted arguably the most attention. The question of the origin of lactase per-

sistence in present European populations and research suggesting its relation to Neolithic population movements (Burger *et al.* 2007; Gerbault *et al.* 2009; Itan *et al.* 2009) have both fuelled and complemented the production of data testing the dairy aspect. The recently acquired ability to distinguish carcass fat from milk fat in archaeological lipid residues using stable carbon isotopic signatures was first put to test in Europe, revealing that dairy production was an aspect of early Neolithic economies in southeastern Europe before 5000 BC (Dudd & Evershed 1998; Copley *et al.* 2003, 2005). Pottery remains from a number of Neolithic sites between southeastern Europe and the southern Levant analysed with this method showed vigorous lipid residue evidence for dairy processing in northwestern Turkey, some dating to ca. 6400–6200 BC (Evershed *et al.* 2008; Thissen *et al.* 2010). Estimations of the contribution of beef to the meat yields based on faunal remains from these sites led Evershed and his colleagues (2008: Fig. 4) to link the strong milk signature from these sites with the relative importance of cattle herding in the Neolithic of this region in comparison to other Neolithic settlements that displayed weaker evidence for dairy processing. The impact of this research was immediately reflected in recent theoretical discussions about the role western Anatolia played in the dispersals of Neolithic subsistence systems from southwest Asia into Europe (Çilingiroğlu 2009a: 74, 357; Bami & Heyd 2011; Düring 2011: 197; Özdoğan 2011).

These discussions focused mainly on the northern parts of western Turkey, where subsistence evidence has been available since the 1970s (Buitenhuis 1995). Central western Anatolia (Fig. 1), a niche of crucial interest to the transformation and transmission of Neolithic life ways (French 1965; Perlès 2001; Özdoğan 2005), has remained marginal to these debates, primarily due to the underdeveloped state of research in this area. Neolithic settlements in this area have been explored only since the mid 1990s (Çilingiroğlu *et al.* 2004; Çilingiroğlu & Abay 2005; Çilingiroğlu

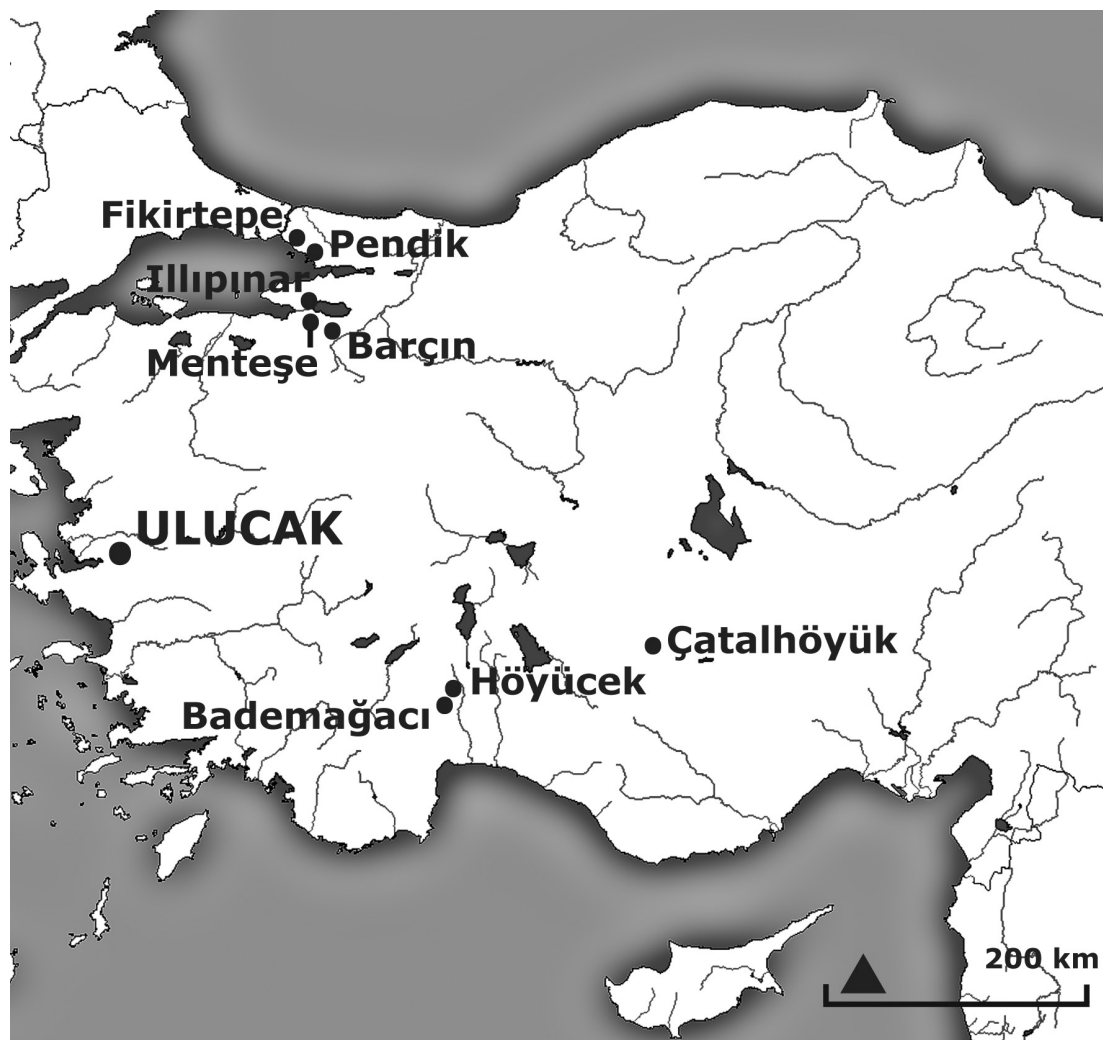


Figure 1.— Location of sites mentioned in the text.

& Çilingiroğlu 2007; Derin 2007; Sağlamtımur 2007; Derin *et al.* 2009). Moreover, the systematic investigation of subsistence in Neolithic cultures of the region was initiated as late as 2008; and then only at Ulucak Höyük, where excavations since 1995 are largely responsible for stimulating most of the subsequent Neolithic research in central western Anatolia.

This paper discusses the archaeozoological evidence from Neolithic Ulucak Höyük (ca. 7000–5700 cal. BC) in light of the above mentioned

debates, to add a fresh dimension to the current understanding of the role Anatolia played in the evolution of early animal husbandry systems towards wider applications of dairy technology and how these technologies were exchanged across the European-Anatolian frontier. To achieve this aim, the paper explores two main lines of archaeozoological data: mortality profiles – the most tangible archaeozoological evidence to detect the ways in which domestic animals were exploited (Payne 1973; Vigne &

Helmer 2007), and diachronic changes in the contribution of cattle to subsistence economy with reference to Evershed *et al.* (2008)'s proposal about a cattle-dairy link in northwestern Anatolia. Results from Neolithic Ulucak are evaluated in the context of relevant evidence from neighbouring regions in Anatolia.

NEOLITHIC ULUCAK AND ITS ENVIRONMENT

Ulucak Höyük is situated nine km east of the İzmir Bay on the western end of the Kemalpaşa Plain, 221 m above sea level near the Belkahve Pass (Fig. 2). Although the Kemalpaşa Plain is surrounded by high mountain ranges to the south and to the north, easy communication with the coast is enabled through the Belkahve Pass, which still serves as the main artery between coastal and inland central-western Anatolia. The current bed of the Nif Stream that waters the Kemalpaşa Plain runs few hundred meters to the west and south of the mound. Results of geomorphologic surveys around Ulucak revealed that no dramatic changes occurred in the course of the stream during the development of the mound (Kayan 1999; Çilingiroğlu *et al.* 2004:8). The mound's surface measures ca. three hectares (Çilingiroğlu *et al.* 2004: 2, 8; Çilingiroğlu & Abay 2005: 6).

The Neolithic sequence of Ulucak (Levels VI-IV) covers a long, seemingly uninterrupted occupational sequence spanning from ca. 7040 to 5660 cal. BC. Neolithic deposits at the mound underlay occupational phases dating to the Chalcolithic Period, the Bronze Age, and the Roman Period (Çilingiroğlu *et al.* 2004). The earliest Neolithic Level (VI), so far excavated in a single 10X10m area of the site, consists of several superimposed layers of red painted lime plaster floors and badly-preserved architectural remains with walls covered with painted plasters. The architectural remains of Level VI are associated with several fire-related installations

surrounded by ashy deposits. All Level VI deposits are entirely devoid of pottery and other clay objects (Çilingiroğlu & Çevik, forthcoming), representing the only radiocarbon dated 'aceramic' Neolithic in western Anatolia. Pottery at Ulucak appears in the subsequent Level V, along with wattle and daub architecture. An exception to the architectural styles of Level V is a partially-recovered building with massive stone foundations in Level Vd (Çilingiroğlu 2009a: 43). The latest Neolithic occupational level (Level IV) is characterized by mud-brick houses set on stone foundations laid out around an open area (Çilingiroğlu & Çilingiroğlu 2007). Thirty-one radiocarbon dates place Level IV between ca. 6040-5660 cal. BC; Level V to ca. 6600-6050 cal. BC; and Level VI to ca. 7040-6600 cal. BC (at the two sigma range; Çilingiroğlu & Çilingiroğlu 2007; Çilingiroğlu & Çevik, forthcoming). This chronological span corresponds roughly to the time period covered by the younger phases of Çatalhöyük East Mound Period XII and the beginnings of occupation at Çatalhöyük's West Mound (Çilingiroğlu 2009a). The occupational sequence in Bademağacı Höyük, located ca. 300 km east of Ulucak, in the Lake District of Anatolia provides the closest excavated parallel for Ulucak in terms of distance, material culture and chronology (Çilingiroğlu 2009a), with a few notable differences such as the lack of a basal 'aceramic' occupation and the full-hearted appearance of painted pottery at ca. 6000 BC at Bademağacı (Duru 2008: 17-19).

Reconstructed potential vegetation maps for western Anatolia (van Zeist & Bottema 1991: Fig. 4) and palynological records from southwest Turkey (Eastwood *et al.* 1999; Vermoere *et al.* 1999) indicate humid and forested conditions during the Early Holocene. These favourable conditions may have deteriorated due to a global rapid cooling event at ca. 8200-8000 BP (Pross *et al.* 2008), according to some scholars (Weninger *et al.* 2006; Clare *et al.* 2008), with 'triggering' effects in the spread of early farming in Anatolia and southeast Europe. Other schol-

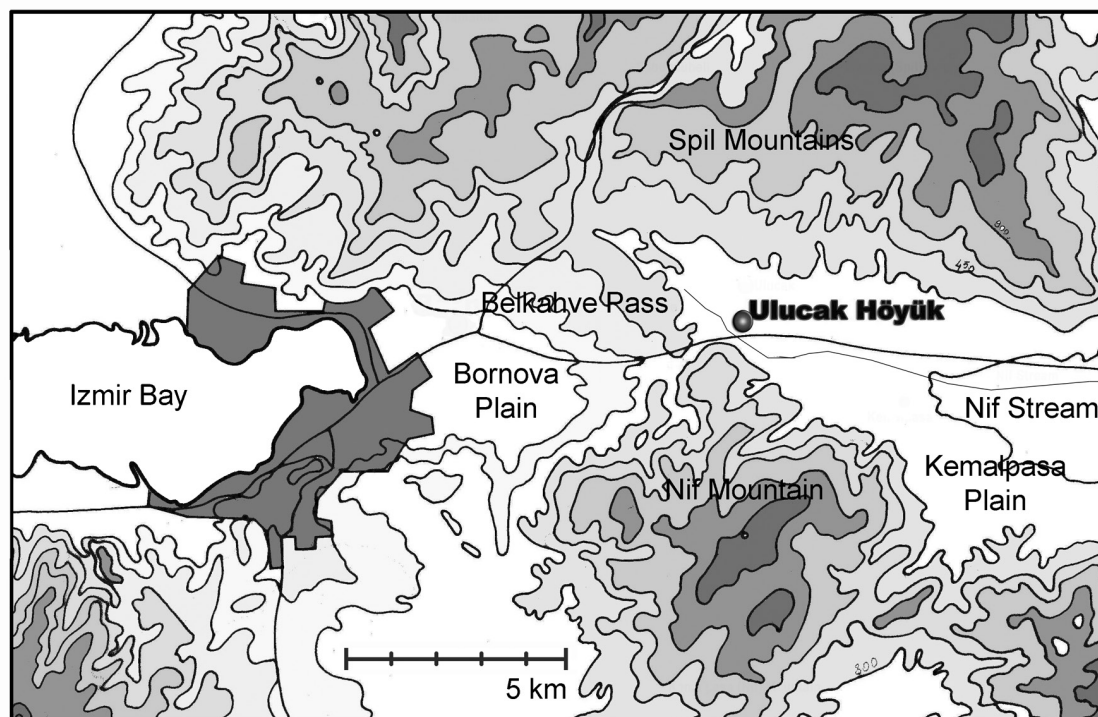


Figure 2.— Location of Ulucak and the geographical features in its surroundings.

ars interpret the cultural consequences relating to the so-called 8200 BP event with more caution (Biehl & Rosenstock 2011; Düring 2011: 124-5; van der Plicht *et al.* 2011). There is, at present, no well-dated, fine-grained palaeoenvironmental proxies from Ulucak or its vicinity to address the archaeozoological evidence from Neolithic Ulucak in light of this discussion, representing an important avenue for future palaeoclimatic research in central-western Anatolia. The sole archaeological evidence about the vegetation cover near the site during the Neolithic consists of a few remains of acorn (*Quercus* sp.) from a small archaeobotanical sample (Megaloudi 2005). Wood charcoal and the bulk of the macrobotanical samples from the site are currently under study.

Limited research was conducted on the faunal remains from Neolithic Ulucak before Trantalidou (2005) published a pilot study on a total of 307 vertebrate specimens from the Neolithic occupation Ulucak. Because Trantalidou

(2005) published combined results from Levels IV and V, her results are not integrated into the present analysis. Excavations and the analyses of material culture and archaeobiological remains continue at Ulucak.

MATERIAL AND METHODS

The majority of Ulucak's faunal assemblage has been recovered through hand-collecting techniques. A considerable portion of the archaeological deposits has been wet-sieved since 2009. The analysis of these units are still under way and not considered in this paper. Potential biases of hand-collecting on analytical results (Payne 1972; Lyman 1994) are taken into account in the interpretations (for a detailed description of the taphonomic attributes of the assemblage, see Çakırlar 2012).

All faunal specimens were counted and weighed to a precision of 0.1–0.5 g. In addition to taxonomic identification, several other pieces of descriptive information were recorded for each specimen. These observations include anatomical element and portion, symmetry when possible, ageing (ossification and fusion states of long bones; eruption and wear stages of teeth following Grant 1982 for the main domesticates and Payne 1973 for sheep and goat¹), sex (based on non-metric observations on all ruminant acetabulae, horn core morphology of sheep and goats, canine teeth in pigs), traces of human-induced modifications, pathological alterations, and taphonomic markers such as traces of gnawing, burning, weathering, and water abrasion. The interpretations of the present paper are based primarily on raw data for taxonomy, ageing, and sex.

Taxonomic identifications were conducted with the aid of a personal reference collection which contains complete skeletons of *Bos taurus* (domestic cattle), *Ovis aries* (domestic sheep), *Capra hircus* (domestic goat), *Sus scrofa* (wild boar), and *Dama dama dama* (European fallow deer) among other taxa. Domestic cattle, sheep, goat and pigs were distinguished from their wild counterparts using mainly the LSI (Logarithmic Size Index) method described by Uerpmann 1979 and Meadow 1981 (see Çakırlar 2012 for further discussion on the appearance of domestic food animals in western Anatolia during the first half of the seventh millennium BC). The notorious problem of distinguishing archaeological sheep and goat remains has been approached with the aid of recent publications. The post-cranial bones of sheep and goat were differentiated following Zeder and Lapham (2010); cranial bones and innominate bones were identified according to Boessneck *et al.* (1964); mandible teeth were identified based on Zeder and Pilaar (2009).

1. With the exception of the fourth permanent premolar, tooth wear stages described by Grant (1982) were found to be fairly compatible with those described by Payne (1973).

Several caprine mandibulae and loose teeth in the Ulucak assemblage were found to display morphological characteristics of both sheep and goat, resulting in a considerable amount of caprine mandibles described as either sheep or goat. As a recent assessment also indicates (Gillis *et al.* 2011), the criteria to distinguish caprine teeth are not entirely unequivocal.

Partial and complete skeletons, jaws with teeth, and fragments that fit together and were found in the same context have been counted as single specimens. While the analyses of species compositions are based both on NISP (Number of Identified Specimens) and WIS (Weight of Identified Specimens) (as shown in Table 1), WIS is the preferred analytical unit in estimating the relative contribution of ungulate taxa to primary (i.e. meat) dietary production from these mammals at Neolithic Ulucak (Figs. 2B, 3). Since bone weight correlates with body mass, WIS is considered to provide a more direct proxy for the contribution of different taxa to the diet when dealing with closely related mammal species (Uerpmann 1973; Vigne 1991; Reitz & Wing 2008: 210–212). Manipulations of the raw data with reductionist analytical tools, such as MNI (Minimum Number of Individuals), MNE (Minimum Number of Elements), etc., have been avoided as they were considered to be unsuitable for this highly fragmented assemblage stemming from primarily arbitrary units of excavation representing limited exposures of the settlement. NISP and WIS calculations are better fit not only for the intra-site analyses of Ulucak, but also for comparative reasons, since relevant archaeozoological data from the surrounding geography are commonly presented using NISP or its percentages (e.g., Boessneck & von den Driesch 1979; Buitenhuis 2008; Cantuel *et al.* 2008; for an analysis of taxonomic abundances from continental and insular Greece; De Cupere & Duru 2003; De Cupere *et al.* 2008; Gourichon & Helmer 2008). The several discrepancies involving the use of NISP calculations for inter-settlement com-

Taxonomic descriptions	LEVEL VI				Level V Early				Level V Late				Level IV			
	NISP	% of NISP among food domesticates	WIS (gr)	% of WIS among food domesticates	NISP	% of NISP among food domesticates	WIS (gr)	% of WIS among food domesticates	NISP	% of NISP among food domesticates	WIS (gr)	% of WIS among food domesticates	NISP	% of NISP among food domesticates	WIS (gr)	% of WIS among food domesticates
<i>Bos taurus</i> (cattle) (ca.)	336	15.0	6798	48.0	394	19.2	8913	47.5	391	16.6	8696	37.6	335	16.6	9170	46.9
<i>Ovis aries</i> (sheep)	168	7.5	1291	9.1	96	4.7	1153	6.1	140	5.9	1840	7.9	143	7.1	1312	6.7
<i>Capra hircus</i> (goat)	42	1.9	293	2.1	55	2.7	709	3.8	47	2.0	505	2.2	62	3.1	724	3.7
<i>Ovis aries</i> / <i>Capra hircus</i> (sheep or goat)	1531	68.4	4930	34.8	1215	59.3	4978	28.5	1248	53.0	6093	26.3	1142	56.5	4766	24.4
<i>Sus domesticus</i> (pig) (ca.)	161	7.2	865	6.1	289	14.1	3015	16.1	527	22.4	6019	26.0	338	16.7	3599	18.4
Domestic food mammals total	2238		14177		2049		19768		2353		23153		2020		19571	
<i>Canis familiaris</i> (dog)	1		2		1		7		10		146		18		201	
<i>Bos taurus</i> / <i>Bos primigenius</i> (cattle or aurochs)	17		1491		1		117		2		85		3		143	
<i>Capra hircus</i> / <i>Capra hircus</i> (goat or wild goat)	3		33		5		94		9		136		10		186	
<i>Canis familiaris</i> / <i>Vulpes vulpes</i> (dog or red fox)	1		1		2		6		5		21		13		28	
Cervidae	54		406		56		586		78		1062		199		2688	
<i>Sus scrofa</i> (wild boar) (ca.)	5		113		7		176		6		130		19		288	
Medium sized wild carnivores	6		7		4		32		4		19		20		68	
<i>Lepus europaeus</i> (European hare)	20		22		36		64		30		66		147		224	
Rodentia (rodents)	2		1										3		2	
Reptilia indet. (reptiles)	3		3		0		0		3		7		15		60	
Aves (birds)	2		1		10		32		7		13		6		3	
Pisces (fish)													1		0	
Unidentified mammals	5557		7909		2117		6233		1444		4515		3227		8633	
Totals	7912		24164		4288		26112		3851		23983		5701		32071	

Table 1.— Summary of taxonomic compositions based on NISP (=Number of Identified Specimens) and WIS (=Weight of Identified Specimens, in grams) per occupational level.

parisons of taxonomic abundances, most notably stemming from differential recovery and fragmentation (Lyman 2008: 29-30), are acknowledged and results are thus approached with caution.

Kill-off patterns for sheep and goats, and to a lesser extent, cattle are used as primary evidence to detect the chronological patterns of animal husbandry technologies. Kill-off data for all three taxa have been generated from teeth that were found still attached to mandibular bones. Although Payne (1973)'s method of ageing mandibles was taken as a basis to produce mortality profiles for sheep and goats, the size and nature of the available sample allowed for some divergences from the original Payne method. For example, instead of correcting mandible counts by excluding the mandibles with missing deciduous fourth premolars (d4 hereafter) or permanent fourth premolars (p4 hereafter) as suggested by Payne (1973), mandibles from each occupational level were laid out on a table and checked in terms of size, wear patterns and taphonomic condition in order to ascertain that no mandible was represented with both sides. The sample size was small enough for this task to be practical. In rare instances when both sides of a mandible were found in the same excavation unit, only one side was included in the analysis of dental ageing. Each mandible was assigned to a Payne (1973) class (A-I). Allocations of some specimens that could not be assigned to a single class was not done according to the rigid mathematics suggested by Payne (1973), but by attributing them to the most likely class as suggested by the more precisely assigned mandibles in the sample. This data is presented in Tables 2 and 3, to enable reproducibility.

Inferences about the diachronic patterns of taxonomic and mortality patterns were consolidated by statistical analyses (chi-square and z-test).

Results of the archaeozoological analyses are discussed according to the established stratigraphic phasing of Ulucak (Çilingiroğlu 2009a)

in four chronological clusters. These clusters represent Level IV, Level V Late (Va-c), Level V Early (Vd-f), and Level VI. The division made here between the earlier and later phases of Level V is somewhat arbitrary, taking the large stone building of unknown layout and function in Level Vd as a stratigraphic dividing line, although cultural continuity throughout Level V is uninterrupted. This was done to identify finer-tuned diachronic patterns while maintaining sufficient sample sizes that would allow reasonable conclusions.

RESULTS

Results are based on a sample of 21852 vertebrate specimens weighing altogether ca. 111,710g. The sizes of chronologically-grouped subsamples are distributed fairly evenly (Table 1).

The hand-collected faunal assemblage from Neolithic Ulucak is dominated by domesticated mammals. Preliminary results from sieving experiments indicate that the main taxonomic configuration, especially in WIS counts, is unlikely to change with the addition of the sieved samples. Osteometric and mortality analyses (tooth eruption and wear, as well as epiphyseal fusion, Table 4) indicate that the four 'founder' food domesticates were present from the beginning of occupation at Ulucak during the first half of the seventh millennium BC (Çakırlar 2012). Dog remains also occur in the assemblage, but there is no indication (such as cut marks) that dogs have contributed to human diet at Ulucak. The relative weight of specimens suggests that beef was the principal part of the Neolithic meat diet, followed by caprine meat.

The relative proportions of domestic food animals fluctuate significantly through time (Tables 2 and 3).² Quantified analyses of tapho-

2. Note that statistical tests applied on unmanipulated data from fragmented assemblages assume that each specimen represents a separate individual, and same goes for each gram of bone when working with the WIS.

	Cattle		Sheep and goat		Pig	
	WIS	NISP	WIS	NISP	WIS	NISP
VI to V Early	0.2887	-3.6679	5.5040	8.1471	-8.7875	-7.3737
V Early to V Late	6.4809	2.2581	-0.0031	3.9080	-7.7761	-7.0622
V Late to IV	-6.1395	0.0292	1.1499	-3.9041	5.9320	4.6879

Table 2.– Z-test for relative proportions of represented taxa.

	Cattle				Sheep and goat				Pig			
	WIS	%	NISP	%	WIS	%	NISP	%	WIS	%	NISP	%
VI to V Early	1	0.0%	24.43	12.7%	365.7	10.7%	32.64	17.0%	3055.2	89.3%	135.66	70.5%
V Early to V Late	481.87	25.5%	8.18	6.1%	0.01	0.0%	11.52	8.6%	1408.33	74.5%	114.88	85.3%
V Late to IV	445.98	49.7%	0	0.0%	14.55	1.6%	10.7	26.9%	436.11	48.6%	28.96	73.0%

Table 3.– Chi-square summary of relative proportions of represented taxa.

Mandibles with teeth	Grant Stages (1982)							Loose mandibular permanent molars	Grant Stages (1982)					
	Level	Side	d4	p4	m1	m2	m3		Level	Side	p4	m1	m2	m3
	IV	L		k					V Late	R				d
	IV	L			l	l	l		V Late	R				a
	IV	L			k	i			V Late	L				a
	V Late	R		p	o				V Late	R				e
	V Early	R	g		1/2				V Late	L		m		
	V Early	R			k				V Early	R		g		
	V Early	L		d		j			V Early	L		e		
									V Early	R			h	
							V Early	L				h		
							VI	R		g				

Table 4.– Tooth wear and eruption data from cattle by occupation levels, recorded according to Grant (1982).

nomie effects indicate that diachronically differential taphonomic histories have little impact on the significant differences in NISP and WIS among chronologically grouped subsamples (Çakırlar 2012). The possibility remains that continuing excavations and archaeozoological work will enhance the implications of the present data substantially. Although it is difficult to deduce the exact reasons for these observed changes, some plausible explanations can be suggested.

The most significant change in the proportional configuration of domestic taxa seems to take place sometime between the basal Level VI and early Level V, caused largely from an increase in the relative proportion of pig remains and a corresponding decrease in sheep and goat specimens (Tables 2 and 3). Since no significant change occurs in the caprine kill-off from Level VI and V Early (Tables 5 and 6), it is likely that the observed change is related to modifications in the exploitation of pigs. The significant decrease in

the WIS proportion of cattle in Level V Late can be explained by a further increase in the relative weight of pig remains, representing an additional value put on pork production. It is only during the latest Neolithic occupational phase that the relative proportion of cattle increases as the relative proportion of pigs decreases, indicating yet another change in animal exploitation strategies, this time probably caused by a shift from pork to beef production. It is important to note, however, that this last shift probably represents a renewed interest in cattle, rather than a major divergence from the established pattern at the beginning of the Neolithic.

Aside from an apparent and significant change from Level V Late to Level IV, the relative proportions of caprines among the remains of domesticated food animals remain mostly stable after the early shift at the transition from Level VI to V Early. The observed change in Level IV is more pronounced in the NISP proportions than in the WIS. This situation may be the result of the significant shift in the pattern

of caprine kill-off (see below) or the shift in the taphonomic properties of sheep and goat specimens, or both. The proportion of sheep to goats is ca. 4:1 at the beginning of the settlement, but becomes ca. 2:1 in Level V Early. This change in the sheep: goat ratio is statistically significant (z -test value = 3.46; critical value = 1.96). No major changes take place in the sheep: goat ratios in Level V Late or Level IV; the ratio remains at ca. 3:1.

To summarize, the most significant change in the composition of the remains of domestic taxa involves the pig remains, first during the shift from Level VI to V Early, and then probably again in Level IV. Caprines remain the most frequently represented taxa throughout the Neolithic sequence in Ulucak, with a significant shift concerning the sheep: goat ratio in Level V Early. In view of these small and large diachronic changes in the proportions of domestic taxa, some degree of change in the culling patterns of domestic herds was expected.

The small amount of recordable mandibles in the studied assemblage posed a difficulty to determine definitive conclusions about the kill-off strategies used in managing caprine and cattle herds. In the case of cattle, though additional information from loose teeth was also sought, the dataset is still too small to discern diachronically comparable mortality profiles (Table 4). Present data demonstrate the presence of both post-prime age cattle and calves (0-10 months old, based on fusion data; Çakırlar 2012: Fig. 5) among culled individuals.

While the dataset for the mortality profiles of caprines is considerably larger, it is not without shortcomings (Tables 5 and 6). The number of observations for goat mandibles is too low to make any reasonable suggestions on how goats were exploited. The number of observations on sheep mandibles is larger. These observations indicate emergent chronological trends in the distribution of reconstructed mortality profiles of sheep herds. Since sheep seems to make up the majority of caprine herds, data from caprine mandibles that could not be ascribed either to

sheep or goat are also considered, as a rough substitute proxy for sheep mortality.

Accordingly, no large overall changes can be observed between the datasets from Level VI, V Early and V Late, neither in sheep nor in sheep/goat mortality. The occurrence of a large number of mandibles representing culling events between four and six years (Stage G) in the assemblages from Level VI and V Early is significant. Also remarkable is the significant decrease in the proportion of these mandibles in Level V Late despite any general changes in the overall age composition of the individuals selected for culling. In Level IV, the proportion of sheep mandibles representing individuals that were between three and four years of age (Stage F) increases significantly as the proportion of mandibles that represent individuals culled between six and twelve months (Stage C) decreases. This outcome is principally replicated by the combined sheep and sheep/goat mortality data. In other words, the most significant overall change in the mortality rates of sheep seems to occur in the last two phases of the Neolithic occupation in Ulucak, first with a decrease in survivorship until old age in Level V Late, and finally in Level IV with a decrease in individuals culled between six to twelve months.

The analytical results presented above indicate that animal husbandry constituted the main pillar of the protein sector of the food economy at Ulucak since the beginning of the seventh millennium cal. BC. Ulucak represents the westernmost spot on the extremely patchy map of seventh millennium BC Anatolia where diverse animal husbandry strategies were practiced. While animal husbandry involved all four initial farm animals at Ulucak, sheep and goat seem to have remained the only domesticated food animals that became integrated into the economic system of central Anatolia until the last quarter of the seventh millennium BC (Russell *et al.* 2005; Arbuckle & Makarewicz 2009). The four-tiered animal husbandry system was also adopted in the Lake District (De Cupere & Duru 2003; De Cupere *et al.* 2008) and Yumuk-

Payne (1973) stages →	A	B	C	D	E	F	G	H	I	Total
Level VI										
OVIS (sheep)										
L		1	5				3	1		10
R		1	1	2		1	5			10
CAPRA (goat)										
L							2			2
R			1							1
OVIS/CAPRA (sheep or goat)										
L				1						1
R			1		1					2
VI Total		2	8	3	1	1	10	1		26
Level V Early										
OVIS (sheep)										
L			2	2			1			5
R		1	3	2			2			8
CAPRA (goat)										
L			1	1						2
R							1			1
OVIS/CAPRA (sheep or goat)										
L			1			1	4	2		8
R			2		1	1	1			5
V Early Total		1	9	5	1	2	9	2		29
Level V Late										
OVIS (sheep)										
L		1	5		1	1				8
R			3	3			1			7
CAPRA (goat)										
L				1						1
LR				1						1
OVIS/CAPRA (sheep or goat)										
L		1	4	1	3	1				10
R			3			2			1	6
V Late Total		2	15	6	4	4	1		1	33
Level IV										
OVIS (sheep)										
L				2		2				4
R			1	3	2	2	1			9
CAPRA (goat)										
L				1		1				3
R							1			1
OVIS/CAPRA (sheep or goat)										
L				1	2		2			5
R	1		2			4		1		8
IV Total	1		3	7	4	9	5	1		30
Total	1	5	35	21	10	16	25	4	1	118

Table 5.– Tooth wear and eruption data from sheep and goat mandibles by occupation levels, recorded according to Payne (1973), where A = 0-2 months, B = 2-6 months, C = 6-12 months, D = 1-2 years; E = 2-3 years, F = 3-4 years, G = 4-6 years, H = 6-8 years; and I = 8-10 years.

Mandible Payne Stages	Sheep			Sheep and sheep or goats		
	VI to V Early	V Early to V Late	V Late to IV	VI to V Early	V Early to V Late	V Late to IV
A	0.00	0.00	0.00	0.00	0.00	0.00
B	0.07	0.02	0.87	0.70	0.55	1.68
C	0.31	0.86	5.08	0.00	3.13	7.30
D	5.61	0.57	2.22	0.11	0.12	2.09
E	0.00	0.00	0.00	0.00	0.00	0.00
F	0.65	0.00	11.33	0.67	0.00	6.43
G	0.93	1.75	0.02	0.12	7.64	5.57
H	0.65	0.00	0.00	0.67	0.00	0.00
I	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.– Chi-square summary of sheep mortality data (Significant differences are highlighted).

tepe (Buitenhuis & Caneva 1998), but at another corner of Anatolia on the eastern coast of the Marmara Sea, husbandry systems involved ruminants (sheep, goat and cattle) exclusively, apparently avoiding domestic pigs (Boessneck & von den Driesch 1979; Buitenhuis 2008; Çakırlar *et al.* in preparation). In summary, apart from the single case of Fikirtepe in Istanbul, the domestic herds of seventh millennium Anatolia were dominated by caprines. All the analysed seventh millennium sites in Anatolia (altogether seven sites) except Bademağacı in the Lake District (De Cupere *et al.*, unpubl.; note that only seven shards have been analyzed from this site so far) revealed isotopic evidence for milk in pot sherds (Evershed *et al.* 2008; Thissen *et al.* 2010). Was Ulucak one of the Neolithic settlements in western Anatolia where caprines and/or cattle were exploited for their secondary products, in particular milk? If so, how important was milk to the Neolithic community of Ulucak?

The obvious limitation to answering these questions for the biomarker approach for Ulucak is the total absence of pottery in the pre-6500 BC Level VI. Direct evidence for milk from lipid residues is currently missing from the subsequent pottery bearing levels. Lipid extraction from a small sample of pot sherds has so far not been successful (H. Özbal, personal communication). Analyses of a larger sample are currently underway. As a result, archaeozoological data constitutes the only tangible line of evidence to address these questions. Given the scarcity of tooth eruption and ware data from cattle specimens, the most substantial evidence from Ulucak is available in the form of reconstructed caprine kill-off patterns. It should be noted that, regardless of the sample size, the presence of very old and very young specimens, both the tooth eruption and ware data, and the fusion data from cattle specimens (Çakırlar 2012) indicate that cattle's use at Neolithic Ulucak was not limited to meat production.

The culling rates reconstructed from caprine mandibles can be interpreted according to a

variety of production models (Payne 1973; Greenfield 1988; Halstead 1998; Helmer *et al.* 2007; Vigne and Helmer 2007), many of which cannot be distinguished statistically (Marom & Bar-Oz 2009). Based on ethnographic models, it is generally accepted that when milk is among the production goals of traditional decentralized economies, most female individuals are kept alive as long as they remain gainfully reproductive and are able to produce healthy offspring at a steady rate. From a purely economic point of view, keeping female caprines beyond this stage can only be useful for producing course fibre (wool and/or fleece). In some societies milk lambs are killed before two months of age (Helmer *et al.* 2007), although there is no record of this practice in eastern Mediterranean contexts (Tani 2005; Vigne & Helmer 2007). In addition, it is difficult to distinguish from the archaeological record whether deaths between birth and two months of age represent culling events for milk production purposes or whether they represent natural deaths. Evidence for culling events involving past prime meat age female caprines can be considered as the least ambiguous archaeozoological evidence for milk production in prehistoric societies.

As mentioned, goats are infrequently represented in the assemblage of Neolithic Ulucak. Therefore the interpretations for Ulucak refer to sheep more than goats. Culling events targeting individuals presumably well beyond prime meat production, reproduction, and milk production age seem to have occurred in notable frequencies already at the earliest occupational phase in Ulucak. Similarly high frequencies of culling events targeting old individuals have previously been interpreted as indicative of for the presence of fleece production in eighth millennium settlements in northern Mesopotamia (Helmer *et al.* 2007). As in the case of Ulucak, it is an unlikely supposition that significant portions of Neolithic flocks were kept alive for six to eight years specifically for the purpose of fleece production. Moreover, material cultural evidence for weaving such as spindle whorls and

loom weights do not occur at Ulucak before the younger layers of the Level V occupation (Çilingiroğlu 2009b) and this kind of evidence alone does not suffice to identify the raw material used for weaving. So as an alternative to a strictly product-based explanation, it should be surmised that keeping animals up to six to eight years was an aspect of a herd management strategy, where, in one possible scenario, some animals which could still breed (even if at low rates) and lead the rest of the herd were not culled unless absolutely necessary. Without speculating about the role of livestock as commodities or beef as subject of costly signalling, for which there is no tangible archaeozoological evidence at Neolithic Ulucak, it is possible to perceive an animal husbandry strategy that was not strictly defined by cost-benefit calculations to maximize profit, but one in which risk buffering as well as herd stability were important motives (Redding 1984; Halstead 1992; Greenfield 2010). In the absence of unambiguous evidence for the use of cattle in traction (Çakırlar 2012), this sort of herd management mentality could also explain the presence of old individuals in the cattle population (cf. Table 2). Herd security, although missing from the more recent models of ancient animal husbandry systems, was probably of primary importance as it would be expected in a small community organized in households. Although it is not reasonable to rule out completely that the long-lived caprines (mainly sheep) of pre-6500 BC Ulucak may have been used simultaneously for their meat, milk and fleece, a significant decrease in the proportion of these late culling events raise in the subsequent level (V Early) implies that these older individuals' value for the society as risk buffers is more plausible, especially given that we are dealing with a society of agriculturalist pioneers at a frontier region. The major change in the kill-off patterns of sheep (and perhaps also goat) populations takes place roughly at the turn of the millennium, in Level IV. The tradition of culling a good portion of prime-meat juveniles is largely abandoned at

this time. Culling animals at the end of their productive and reproductive capacity becomes more frequent, which indicates that milk had become an important production goal. It is highly likely that other ante-mortem products such as fleece were also exploited along with milk. This strategy required a large portion of the herd to be kept beyond the first twelve months, thereby allowing a larger number of individuals to reproduce more than once. This did not only accelerate milk production but also boosted herd growth. Although changes in WIS proportions indicate that the consumption of meat from sheep (and possibly goats) became less frequent, more meat could be obtained at each culling. Moreover, an important portion of the meat demand was met by exploiting small and large game (hare and deer) at the time (cf. Table 1). The causes of observed changes in meat production strategies in Level IV may be attributed to an economic and social reorganization of the settlement, in which expanding consumption groups led to a change in the patterns of distribution among the community, resulting in a necessity to produce larger quantities of meat at a time. The appearance of large storage jars (Çilingiroğlu 2009a: 9) and high concentrations of wheat discovered in buildings of Level IV (Megaloudi 2005; Çilingiroğlu 2009a: 72) may also be associated with these changes that required increased consumption unit size. In this sense, the data suggests that the last occupational phase of Ulucak (ca. 6200-5700 BC) witnessed an intensification of all economic activities through optimizing the exploitation of various seemingly unrelated resources from game in the landscape to milk from sheep.

DISCUSSION

It is difficult to place the observed patterns of animal husbandry at Neolithic Ulucak in a relevant and useful framework. Archaeozoological data from other Neolithic excavations

in the İzmir area are currently not available, while excavations at contemporary sites elsewhere in western Anatolia are rare. Moreover, radiocarbon dates indicating Neolithic occupation prior to 6500 BC in western Anatolia are virtually absent. The same is true for Aceramic layers. At present, three Neolithic sites to the east of the Sea of Marmara, Fikirtepe (Boessneck and von den Driesch 1979), Menteşe (Gourichon and Helmer 2008) and Ilıpınar (Buitenhuis 2008), and two sites in the Lake District, Bademağacı (De Cupere *et al.* 2008) and Höyücek (De Cupere & Duru 2003) are the closest archaeozoological neighbours of Ulucak. Still each of them is located at no less than 300km distance.

Among these, Bademağacı Höyük in the Lake District represents the most direct chronological comparison with Ulucak, with the so-called 'Early Neolithic I' layers corresponding to the early layers of Ulucak Level V Early, the 'Early Neolithic II' layers to the later layers of Level V, and the 'Late Neolithic/Early Chalcolithic' layers to Level IV at Ulucak (Çilingiroğlu 2009a). While the radiocarbon dates from Höyücek indicate contemporaneity with Ulucak Level V, the archaeozoological sample from this site is too small to allow for accurate inter-site comparisons in terms of secondary product use (De Cupere & Duru 2003). In the eastern Marmara region, Menteşe emerges as a settlement that is roughly contemporary with the later phases of Ulucak Level V (Thissen 2005; Çilingiroğlu 2009a). The later Neolithic occupational layers of Ilıpınar in the same region are roughly contemporary with Ulucak Level IV, whereas the basal layer (Ilıpınar X) of the same site is dated roughly to 6400-6000 BC. Fikirtepe, on the other hand, is generally seen as a contemporary of Ilıpınar X (Thissen *et al.* 2010).

In addition to scarcity of data, there is the problem of data compatibility. It is extremely difficult to compare assemblages at the inter-site level when data is not acquired and presented with shared methodology. The importance of standardized methods for accu-

rate inter-site comparisons has been stressed before on numerous occasions (e.g. Halstead 1998; Helmer *et al.* 2007). For western Anatolia one-on-one inter-assemblage comparisons are impossible without losing large amounts of information. Despite these impediments, a summary of the available archaeozoological data may help create some inferences about possible forms of early animal husbandry in western Anatolia.

At Bademağacı in the Lake District, also a multi-period settlement mound, a four-tiered animal husbandry seems to have been established at the beginning of the settlement during the first half of seventh millennium BC.³ Few changes seem to occur in the important patterns of animal husbandry at this site throughout the Neolithic.⁴ The proportion of specimens representing cattle among the remains of food domesticates seems to increase drastically at the turn of the millennium (De Cupere *et al.* 2008: Table 5). While this change is statistically significant (z -test=12.9), the potential negative effect of radically diminished sample size for this period (by ca. 80 % from the previous layer) on this value cannot be overlooked. The simultaneous shift in the proportion of juvenile culling of cattle after the turn of the millennium (De Cupere *et al.* 2008: Table 8) is notable, and can be interpreted as a method of early weaning to enhance milk production (Legge 2005; Mulville *et al.* 2005). Sample sizes are too small ($n=8$ and $n=14$), however, to argue firmly for a substantial change in the culling patterns of cattle. When the archaeozoological evidence for caprine management at Bademağacı is considered, a tendency towards more emphasis on later cullings, i.e. a shift from first year to second year, is

3. The earliest settlement phase (Early Neolithic I) at Bademağacı is dated to the beginnings of the seventh millennium BC based on a single radiocarbon date (De Cupere *et al.* 2008: Table 2). The Early Neolithic I at this site includes pottery remains.

4. The chronological terminology used at Bademağacı denotes the first quarter of sixth millennium BC as 'Late Neolithic/Early Chalcolithic'. According to radiocarbon dates, this phase is contemporary with Ulucak IV.

observed again after the turn of the seventh millennium (De Cupere *et al.* 2008: Table 7). This proportional change appears to be statistically insignificant (z -test=1.12). The overall character of caprine management at Bademağacı was interpreted as representative of secondary products exploitation (De Cupere *et al.* 2008).

At Ilıpınar in northwestern Anatolia, the Neolithic occupation covers a sequence similar to that observed at Bademağacı. All radiocarbon samples post-date 6500 BC and there is no aceramic phase (Buitenhuis 2008: Fig. 7). The proportional composition of major food taxa varies diachronically. Most relevant are the absence of morphologically domestic pigs at the earliest settlement phase (X) and a moderately maintained “number of remains” of cattle throughout the Neolithic (Buitenhuis 2008: Table 1). Caprine kill-off for Ilıpınar was evaluated with no distinction between sheep and goats. According to proportional representations of culling ages based on tooth eruption and wear patterns (Buitenhuis 2008: Fig. 18), and no notable changes are observed throughout the Neolithic occupation at the site. On average, more than 70 % of the individuals were culled before twelve months, with only a minority surviving into old age. Although these survivors suggest that both milk and fleece exploitation may have taken place at this settlement, the fact remains that a very large proportion of the caprines were slaughtered during their first year in life, for meat production. Although milk was detected in sherd residues from the neighbouring and partly contemporary settlement of Barçın (Thissen *et al.* 2010), archaeozoological analyses are yet to clearly indicate whether subsistence patterns at these two sites have similar characteristics. Excavations at Ilıpınar ante-date the ‘biomarker revolution’ (Evershed 2008).

At Menteşe, a mere 25km south of Ilıpınar, cattle make up more than 60% of the domestic food animals in terms of NISP (Gourichon and Helmer 2008). The beginning of settlement at Menteşe is considered to be slightly older than Ilıpınar X (Çilingiroğlu 2009a, Thissen *et*

al. 2010). Gourichon and Helmer (2008) argued for the production of cows’ milk at this settlement, primarily based on high (though corrected for probability) frequencies of infant and juvenile mortality. According to these researchers cattle at Menteşe were also used for their traction power. Evidence for cattle traction came from three pathological specimens indicating weight-related modifications on feet. Both interpretations should be approached with caution: First, the number of observations on cattle tooth eruption and wear are small, even when both loose teeth are added to the sample of mandibles and observations are multiplied with the probability correction method (Helmer & Vigne 2007). In addition, high infant and juvenile mortalities may represent natural deaths, signifying poor management techniques (Mulville *et al.* 2005). Secondly, deformations in cattle extremities, especially those in low degrees, can stem from factors relating to how individuals cope with the terrain (De Cupere *et al.* 2000).

At Fikirtepe farther north near Istanbul, cattle remains form the majority (54% NISP) of the vertebrate remains. Interpreting this proportion poses a challenge, especially with regard to the apparent lack of morphologically domestic pig at this settlement (Boessneck & von den Driesch 1979: Table 16). Cattle kill-off at Fikirtepe peaks at ca. 18 months and continues until ca. age four in high frequencies (Boessneck & von den Driesch 1979: Table 5). Animals older than 48 months were very rare. Boessneck & von den Driesch (1979: 21) interpreted these proportions as indicative of meat production. With some of the individuals culled at rather young ages and some adults being kept until quite old ages, milk production may also have been practiced. In managing Fikirtepe caprines, even though the dental ageing data have been described arbitrarily (e.g. m2 +/-, m3 + etc.) and are not easy to decipher (Boessneck & von den Driesch 1979: 23; Table 6B), it seems that culling targeted individuals between one to two years, when the third molar has not yet been

abraded (Payne 1973's class D) and individuals between three and four years when the third molar has been worn slightly (Payne 1973's class E or, more likely, F). Boessneck and von den Driesch (1979: 25-26) argue that exploitation of sheep and goats for dairy products, if at all, took place at a small scale.

In summary, there are six published Neolithic faunal assemblages from western Anatolia including Ulucak. In at least one (Höyücek), the sample size is too small to detect accurate herd management patterns. The methods and theories used to interpret herd management strategies at the remaining five Neolithic sites differ immensely, making it difficult to reflect on the 'big picture' with a high level of confidence. Present attempts at attaining an overall understanding of the early management practices are problematic precisely for these reasons. Calculations imply that the relative weight of cattle remains at Fikirtepe (Boessneck & von den Driesch 1979: Table 1) was taken as a rough baseline to estimate the so-called beef percentages in Evershed *et al.* (2008: Fig. 4).⁵ The proposal that frequent milk signatures in northwestern Anatolia should be related to the importance of cattle herding was thus formulated. Although the 81% 'Fundgewicht' ($\approx$ WIS) of cattle remains at Fikirtepe is admittedly inspiring in that it has more in common with the milk producing economies of Middle and northern Europe (Copley *et al.* 2003, 2005) than the caprine-based economies of Anatolia and the northern Levant, the intra-site accuracy of this 81% percentage and its application for northwestern Anatolian Neolithic are highly questionable. Fikirtepe was investigated dur-

ing the early 1950s in a salvage excavation and there are marked differences between counts produced by Boessneck and von den Driesch (1979) and those provided by Röhrs and Herre (1961), who studied the faunal remains from the first year of excavations at Fikirtepe. Cattle NISP proportions in northwestern Anatolia are highly varied, with Menteşe at one extreme and Ilıpınar at another. Menteşe is the earlier of the two, and apparently has more cattle. The fact that these two sites are located only 25km apart from each other demonstrates well that at least some of the observed variation remains to be explained in a more satisfactory way than the presumed milk and cattle connection in northwestern Anatolia.

CONCLUSIONS

Animal husbandry dominated the animal sector of the subsistence economy of Ulucak throughout its Neolithic occupation. Taxonomic abundances, estimation of the relative proportions of meat gain per domestic taxa, and mortality profiles generated for sheep and goats all indicate that during the seventh millennium BC the established pattern of animal management at Ulucak focused on maintaining caprine and cattle herds, while pork production was of considerable importance in Level V, during the earliest pottery phase roughly covering the period between ca. 6500 and 6000 BC. Animal husbandry strategies appear to have taken a marked turn during the first half of the sixth millennium BC, as pork production declined and the interest in beef production was renewed. Although it cannot be ruled out that secondary products may have been part of animal husbandry strategies since the beginnings of settlement at Ulucak, evidence from Level IV indicates that established culling choices changed significantly at that time, most probably for the systematic production of milk. How the renewed interest in

5. Average specimen weights for cattle, sheep/goat, and pig/boar at Fikirtepe are 29g, 7g, and 19g respectively (Boessneck & von den Driesch 1979: Table 1). In the absence of any other mathematical explanation provided by Evershed *et al.* (2008), I am inclined to postulate that the (x 2) factor for pigs and the (x5) factor for sheep were at least inspired by the Fikirtepe 'Fundgewicht/Fundmenge' calculations. Other methods to estimate the contributions of different taxa to the meat diet allow for much greater (x28 sheep or more) meat yield for large animals such as cattle (Clason 1973; Russell & Martin 2005).

cattle herding configured with the beginning or intensification of milk production is not clear from the evidence at hand. Interpretations of culling strategies are based on observations on sheep and sheep/goat mandibles. Lipid residue analyses of ceramic remains from Ulucak are currently under way; the results will complement the implications of the archaeozoological record discussed here.

Changes in animal husbandry patterns observed for Ulucak Level IV may have been caused by a reorganization in the social life of the settlement that both required and enabled the immediate or delayed consumption of larger units of food distributed among larger groups of individuals. Such a reorganization would likely have influenced the demand for milk. Alternatively, changes in the animal exploitation patterns may reflect adaptive moves to cope with a changing landscape. This possibility may be supported by the marked shift in the proportion of cervids in Level IV assemblages.

Induced by environmental or social processes, or both, given the large interaction sphere of Ulucak, it is highly probable that the innovations in husbandry were influenced by interactions with other cultural groups, close and afar. Although the emergence of archaeozoological signatures for milk production at Ulucak roughly coincide with the appearance of unequivocal evidence for dairy production in northwest Turkey, there is currently no cultural evidence to suggest a causal relationship between the two sets of observed patterns. While the cattle-milk link suggested for northwest Anatolia needs to be clarified, the present evidence from Ulucak allows for an approach that points more solidly at a caprine-milk link. The available archaeozoological data from western Anatolia display high variability not only among sub-regions, but also among closely located sites. The diverse picture of early animal husbandry in western Anatolia stems at least partially from the patchiness of the archaeozoological data that were collected, presented and interpreted in a variety of largely incompatible ways. Open questions

involving how early animal husbandry technologies, dairy or else, were transformed across western Anatolia and beyond can only be addressed with future research with inter-regional and diachronic scope.

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