

# ANCIENT NEAR EASTERN STUDIES

SUPPLEMENT 44

## ARCHAEOZOOLOGY OF THE NEAR EAST X

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# CHALCOLITHIC PIG REMAINS FROM ÇAMLİBEL TARLASI, CENTRAL ANATOLIA

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## ABSTRACT

The Late Chalcolithic site of Çamlıbel Tarlası (3590–3470 cal BC) located near Boğazkale in Anatolia was a rural settlement spanning an estimated time interval of 120 years. While the main domestic ungulates were represented by comparable numbers of bones among the faunal remains, this paper is aimed at studying pigs within the context of other animals. It seems that pig still played a major role in Chalcolithic meat diets at a site that shows little evidence of hunting. The domestic status of pigs was therefore studied from different angles, including traditional morphometry supported by ancient DNA studies and geometric morphometrics. All results point to the overwhelming dominance of domestic pig characteristics in the Chalcolithic assemblage. While the influence of local wild boar seems evident, most bones fall below the size range of the wild ancestor. Ancient DNA is indicative of local origins for these pigs. Geometric morphometric analyses revealed a domestic signature for nearly all the specimens analysed. The overall results are indicative of small scale, household-level animal husbandry in which pigs had a fair share before the onset of sheep and goat based systems of animal husbandry at the beginning of the Anatolian Bronze Age.\*

## KEYWORDS

Chalcolithic, domestic pig, wild boar, northern Anatolia, bone morphometry, ancient DNA, geometric morphometrics

## INTRODUCTION

The Late Chalcolithic settlement of Çamlıbel Tarlası was located in north Central Anatolia. The site was found near the modern village of Boğazkale some 200 km east of Ankara on the Anatolian plateau (Fig. 1) approximately 1000 m above sea level. Settlement remains were found on the surviving terraces of the small river called Karakeçili Deresi running some 2 km west of the village of Boğazkale. This is a heavily eroded landscape where very little of the prehistoric surface has been preserved. Excavations were carried out in three seasons (2007–2009) as a cooperation project between the German Archaeological Institute and Edinburgh University under the directorship of Ulf-Dietrich Schoop. Field work

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revealed the foundations of stone houses, numerous infant burials<sup>1</sup> and consistent evidence of utilizing locally available copper ore.<sup>2</sup> The settlement was established in a relatively narrow river valley, some three kilometres away from the main Budaközü Plain in which the later Hittite capital Hattuša is located. The rural settlement may be subdivided into four phases, interrupted by shorter periods of ephemeral use, spanning an estimated 120 years long occupation during the mid-fourth millennium (3590–3470 cal BC, 1 $\sigma$ ).<sup>3</sup> However, this distinction was not used in the current study of pig remains.

The animal remains available for study represent a time in Anatolian prehistory pre-dating the emergence of major urban centres, when meat from domestic ungulates (beef, mutton and pork) played relatively balanced roles in the diet. Although among the three the importance of pork subsequently declined, the assemblage from Çamlıbel Tarlası offers a good opportunity to study the heyday of pig exploitation in Anatolian prehistory.

#### MATERIAL AND METHODS

The animal bones under discussion here largely originate from food refuse. Evidence of bone manufacturing or articulated parts of the skeleton are rare. Although sieved samples are available from the site, the animal bones studied thus far had been collected by hand. These remains were recovered in sufficiently great numbers to make the targeted morphometric analysis of pig bones possible.

Ageing the material was carried out by a combination of gross tooth eruption sequences<sup>4</sup> and data on epiphyseal fusion in modern domesticates<sup>5</sup> derived from reference animals of known ages (Table 1). In the best represented domesticates skull fragments were aged using the state of cranial sutures.<sup>6</sup>

The sequence of absolute ages is quite similar between the three taxonomic groups (as it is between sheep and goat within the Caprinae subfamily).<sup>7</sup> This is expressed by the high and statistically significant coefficients of Spearman rank correlation calculated between the pairs of epiphyseal fusion sequences (cattle/caprine  $r=0.786$ ; cattle/pig  $r=0.975$ ; caprine/pig  $r=0.781$ ). Relative age groups between neonates and seniles used in this study fall within this age continuum.

However, given the different ossification regimes of epiphyseal plates in various long bones, only the *terminus post quem* absolute ages of animals could be established, a potential source of distortion seldom addressed in the literature. This means that calendar ages at death may look different in the sample depending on the skeletal part available for study.

<sup>1</sup> Schoop 2011a. See Schoop 2011b for the general cultural and chronological context.

<sup>2</sup> Rehren and Radivjević 2010; Marsh 2010.

<sup>3</sup> Schoop *et al.* 2009, p. 67.

<sup>4</sup> Schmid 1972, table X.

<sup>5</sup> Chaix and Méniel 2001.

<sup>6</sup> Barone 1995, p. 66.

<sup>7</sup> Zeder 2006.



Fig. 1. The map of modern-day Turkey with locations mentioned in the text.

The domestic status of these animals was established on the basis of phenotypic size. Firstly, withers height calculations were carried out using the greatest lengths of best preserved bones.<sup>8</sup> Additional measurements taken on the fragmented archaeological material were compared to a set of select measurements taken on ten modern female wild boar killed in the nearby Kızılcahamam area (Fig. 1) as reported by Sebastian Payne and Gail Bull.<sup>9</sup> The wild boar age groups represented included six individuals between 19–23 months of age, three between 31–35 months of age and a single sow older than 43 months. In addition to a need for increasing sample size, the rationale for considering young specimens in the comparison was that archaeological assemblages often contain early fusing epiphyses (*e.g.* distal ends of humeri and tibiae) possibly originating from subadult individuals.

The mean values and standard deviations obtained for this set of ten modern wild boars have been used in calculating standard scores for the measurements from Çamlıbel Tarlası for the purposes of pooled representation.

The first set of comparisons was based on phenotypic size in which inherited and environmental effects cannot be separated. The risk of circular reasoning is evident: any conspicuously large bone would be set aside as “wild”. Size, however, is a complex phenomenon determined by age, sex and “residual” variability,<sup>10</sup> the latter including both inherited and acquired traits. Therefore, in addition to traditional archaeozoological methods, we co-analysed pig mandibles containing M<sub>2</sub> and M<sub>3</sub> teeth with ancient DNA (aDNA) and geometric morphometrics (GMM). While looking at inheritance directly, aDNA can reveal

<sup>8</sup> Coefficients developed by Teichert 1969.

<sup>9</sup> Payne and Bull 1988, pp. 55–56.

<sup>10</sup> Payne and Bull 1988.

Skeletal element	Absolute ages (months)			Age class
	Cattle	Caprine	Pig	
metapodia proximal	–	–	–	neonate
P <sub>1</sub>	–	–	6	neonate
M <sub>1</sub>	6	6	6	neonate
radius proximal	12–15	3–6	12	juvenile
M <sub>2</sub>	14	12	12	juvenile
humerus distal	15–20	3–4	12	juvenile
I <sub>1</sub>	22	14.4	12	juvenile
P <sub>3</sub>	24	21.6	12	juvenile
tibia distal	24–30	12–18	24	subadult
metapodia distal	24–30	16–18	24	subadult
P <sub>2</sub>	26	18	12	subadult
I <sub>2</sub>	26	21.6	14.4	subadult
M <sub>3</sub>	26	21.6	18	subadult
P <sub>4</sub>	34	24	14.4	adult
I <sub>3</sub>	36	33.6	9.6	adult
calcaneus	36	36	24–30	adult
femur proximal	36	20–26	36	adult
ulna distal	36	26–32	36	adult
radius distal	40–48	23–30	42	adult
femur distal	42	18–26	42	adult
ulna proximal	42	25–35	42	adult
humerus proximal	42–48	25–36	42	mature
C	46	45.6	9.6	mature
tibia proximal	48	20–26	42	mature
vertebral epiphyses	54–60	48–60	48–84	mature

**Table 1.** Absolute ages (months) of tooth eruption (permanent) and epiphyseal fusion in modern domesticates, classified into age groups. Gross relative age groups increasing from juvenile to mature are distinguished by shading.

the geographic origin and subsequent patterns of dispersal of organisms.<sup>11</sup> GMM is instrumental in investigating subtle morphological variation allowing the separate analysis of size and shape. Previous studies revealed the efficiency of GMM for the study of pig domestication.<sup>12</sup>

These results may be considered a prelude to evaluating temporal and geographic variation in Neolithic to Bronze and Iron Age pig populations in Anatolia, combining DNA and geometric morphometrics within the framework of a major multidisciplinary project.<sup>13</sup>

<sup>11</sup> Larson *et al.* 2007a.

<sup>12</sup> Larson *et al.* 2007b; Cucchi *et al.* 2009, 2011.

<sup>13</sup> Ottoni *et al.*, 2013.



## RESULTS

*General characteristics of the Çamlıbel Tarlası faunal assemblage*

The composition of the assemblage is shown in **Table 2** both by the number of identifiable specimens (NISP) and by weight. Weighing individual bones was chosen as a method to account for differential fragmentation in the material often not manifest in raw bone counts.

	NISP	Weight		Mean weight	
	n	%	g	%	g
Cattle ( <i>Bos taurus</i> , L. 1758)	1053	40.9	40,361	59.6	38.3
Sheep ( <i>Ovis aries</i> , L. 1758)	182	7.1	4204	6.2	23.1
Goat ( <i>Capra hircus</i> , L. 1758)	24	0.9	996	1.5	41.5
Sheep or goat, caprine (Caprinae, Gray 1852)	387	15.0	2105	3.1	5.4
Pig ( <i>Sus domesticus</i> , Erxl. 1777)	864	33.6	19,141	28.3	22.2
Dog ( <i>Canis familiaris</i> , L. 1758)	39	1.5	383	0.6	9.8
Hare ( <i>Lepus europaeus</i> , Pall. 1778)	14	0.5	25	0.0	1.8
Red deer ( <i>Cervus elaphus</i> , L. 1758)	3	0.1	23	0.0	7.7
Wild sheep ( <i>Ovis orientalis</i> , Gmel. 1774)	1	0.0	384	0.6	384.0
Red fox ( <i>Vulpes vulpes</i> , L. 1758)	4	0.2	6	0.0	1.5
Equid	1	0.0	82	0.1	82.0
Identifiable total	2572	100.0	67,710	100.0	26.3
Canid	1		1		1.0
Felid	1		3		3.0
Rodent	1		1		1.0
Large ungulate	196		769		3.9
Small ungulate	281		380		1.4
Bird	1		5		5.0
Spur-thighed tortoise ( <i>Testudo graeca</i> )	14		25		1.8
Non-identifiable total	495		1184		2.4

**Table 2.** The taxonomic distribution of the archaeological assemblage by NISP and weight.

The number of identifiable specimens exceeded 2500, weighing 68 kg. Another 500 small bone fragments (1.1 kg) were either not identifiable or belonged to spur-thighed tortoise that may not have been exploited by the settlement's inhabitants. The proportion between the remains of domesticates at Çamlıbel Tarlası shows the dominance of beef in the meat diet, predominantly originating from mature individuals. Percentages of the main identifiable animal taxa may be visually appraised by both NISP and weight in **Figure 2**. While NISP values are rather evenly divided between pig and caprines (**Fig. 2**, top) the weight of cattle bones contributes almost two-thirds to the assemblage (**Fig. 2**, bottom).



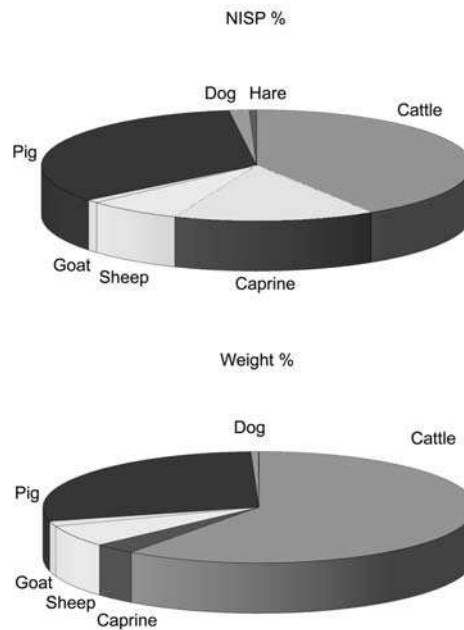


Fig. 2. The proportions between main animal taxa by the Number of Identifiable Specimens (NISP, top) and the weight of bones (bottom).

Preservation was good, the identifiable fragments of domestic animals weighed on average over 20 g each. The only important exception was bones representing the Caprinae subfamily, a category describing non-distinguishable skeletal fragments of sheep and goat. In contrast with identifiable sheep and goat remains, bones in this general group weighed only 5 g on average. Subtle morphological differences between sheep and goat could not be seen in this heavily fragmented fraction. Non-identifiable bone splinters were likewise of small sizes. While one may assume that the overwhelming majority of large ungulate bones originate from cattle, non-identifiable fragments representing the large ungulate category were ten times smaller than identifiable cattle bones (3.9 g *vs.* 38.3 g).

The remains of wild animals are sporadic (0.9 per cent of fragment numbers, 0.8 per cent by weight) and not even necessarily related to meat provisioning. Two of the three red deer remains are antler fragments that could be procured by gathering rather than hunting. The only sheep bone unambiguously attributable to the wild form is a very large and robust fragment of a ram's skull with the base of the right horn core. Most importantly from the viewpoint of this study, no pig bones of similarly outstanding size were found. The marked absence of hunting was also observed in the small contemporaneous animal bone assemblage from Yarikkaya near Boğazköy<sup>14</sup> yielding the only comparable contemporaneous animal bone assemblage in the area. At that site, however, pig seems to have been even more commonly eaten than at Çamlıbel Tarlası resulting in a significant difference between the taxonomic compositions of the two assemblages in terms of NISP values (Fig. 3).

<sup>14</sup> Boessneck and Wiedemann 1977, p. 107.

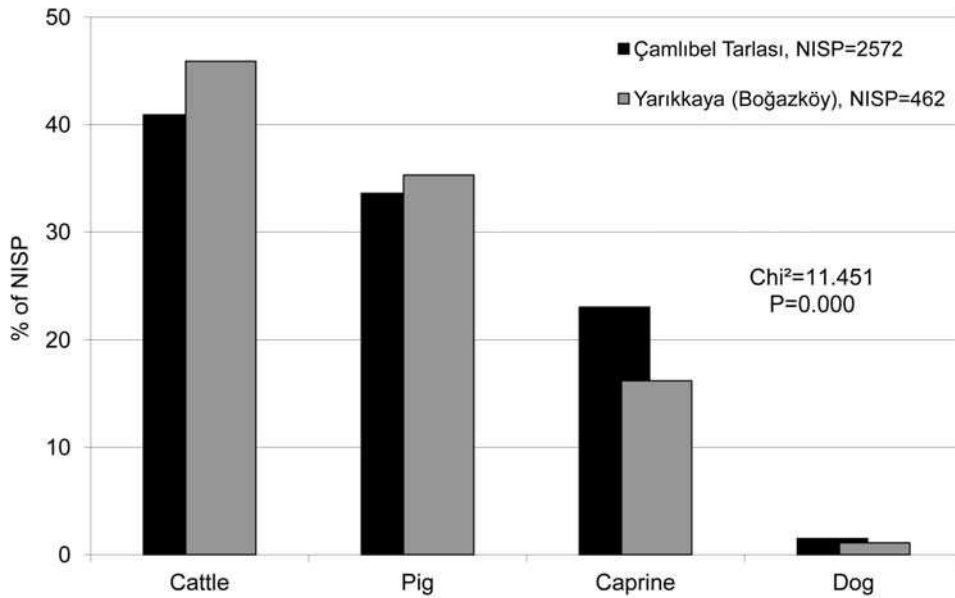


Fig. 3. Comparison between the relative frequencies of main domesticates (NISP) at Çamlıbel Tarlası and Yarıkaya.

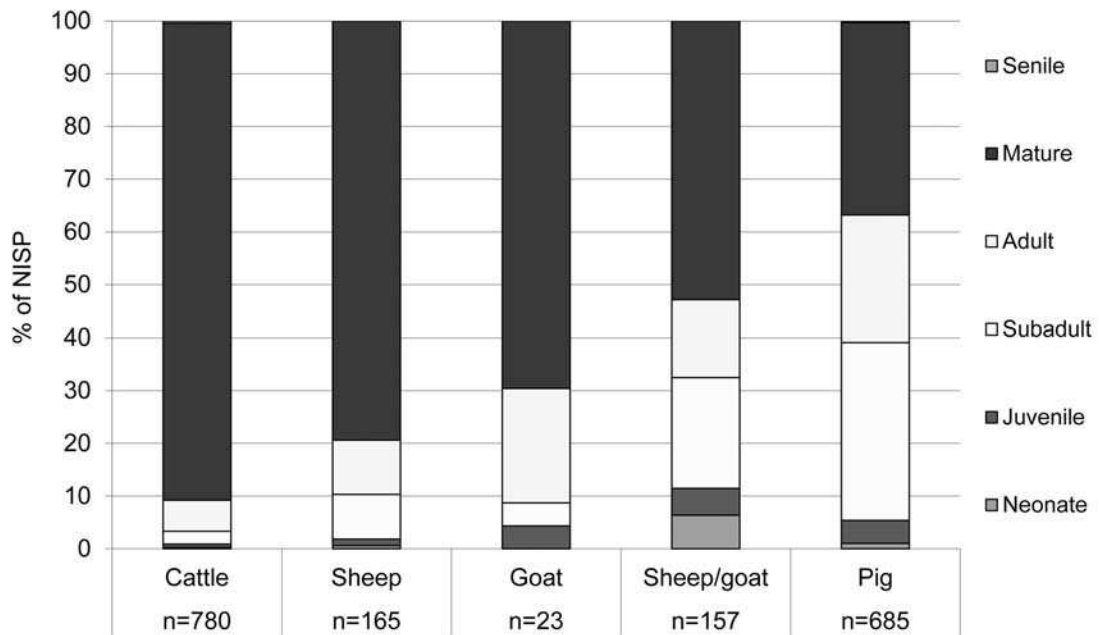


Fig. 4. The proportions between ageable bones (NISP) among domestic ungulates. See Appendix for details.

Relative frequencies (NISP per cent) of ageable skeletal elements at Çamlıbel Tarlası indicate well-known differences between species rooted in their patterns of exploitation (Fig. 4; Appendix). Longevity is most characteristic of cattle, probably related to their high value, slow reproduction and exploitation for dairy products as well as potential use in traction. Single meat purpose pigs represent the other extreme, a prolific, multiparous animal whose numerous offspring can be slaughtered for meat at relatively young ages. Caprine age profiles (including those of identifiable sheep and goat) fall in-between. Note that the general “caprine” group includes numerous bones, whose species identification is impossible due to their young age. The high proportion of young animal bone in this case is related to inevitable observer bias rather than exploitation *per se*.

#### *Pigs at Çamlıbel Tarlası*

Pig remains, numbering almost 900 at the site, represent most body regions evenly when compared to weight proportions within a standard skeleton.<sup>15</sup> Underrepresented parts include vertebrae and ribs, usually highly fragmented and thus not always identifiable. Small metapodia and phalanges are also relatively rare among the hand-collected pig bones. On the other hand, due to the survival of mechanically resistant teeth, fragments from the mandibular region make up over one quarter of the bone weights (Fig. 5). These deviations from the norm are consonant with known taphonomic characteristics of the porcine skeleton.

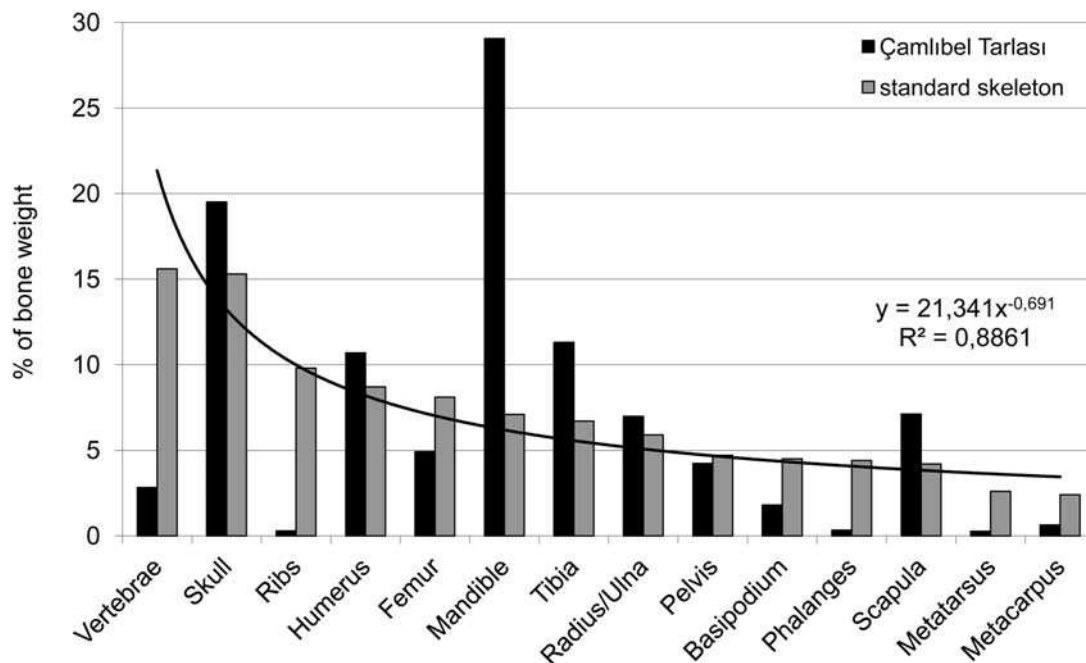
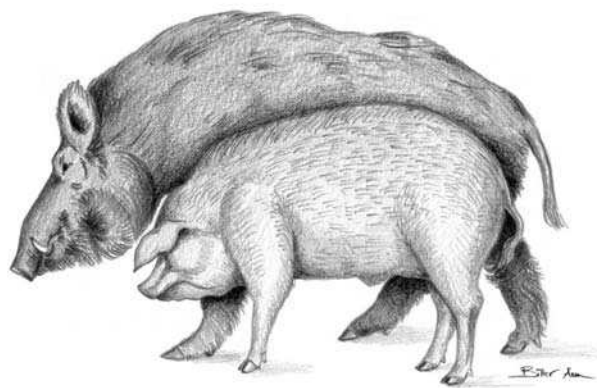


Fig. 5. The weight distribution of pig skeletal parts (NISP=864, all phases pooled) at Çamlıbel Tarlası compared to a standard domestic pig skeleton.

<sup>15</sup> Bartosiewicz 2009, p. 104, fig. 6.

During hands-on identification the assessment of domestic status was based on fundamental characteristics brought about by domestication; visible both in the size and shape of certain skeletal remains, especially the skull. These are a direct reflection of the animals' phenotype, a reduced withers height as well as a shortened facial skull being most typical of the domestic form. Differences shown in **Figure 6**, however, evolved only by the early Modern Age. Meanwhile numerous transitional individuals have existed between wild boar and domestic pig,<sup>16</sup> partly due to the possibility of back-crossing with the wild ancestor amply documented in the historical and ethnographic literature.<sup>17</sup>



**Fig. 6.** Comparative drawing emphasizing differences between wild boar and domestic pig. The actual degree of differences is dependent on the breed and geographical variability in wild boar.

In addition to the possibility of hybridisation, a natural trend of size increase was observed along both a south-north cline and a west-east cline in modern Eurasian wild boar by Umberto Albarella *et al.*<sup>18</sup> In the first step, withers heights were estimated using the greatest lengths of 17 complete bones (1 radius, 2 calcanei, 14 astragali) from Çamlıbel Tarlası (**Table 3**). Withers height estimates based on astragali, however, are not fully reliable in terms of the animal's actual height as they attain their final size at a relatively early age. Resulting values thus would be closer to the adult age withers height of the animals.

The mean value falls behind even the withers heights of female wild boar in Europe.<sup>19</sup> Even bone dimensions of prehistoric wild boar from east-central Europe<sup>20</sup> exceed those from Çamlıbel Tarlası, although European wild boar is known to be significantly smaller than the Asiatic subspecies even if small insular forms are excluded from the comparison.<sup>21</sup>

<sup>16</sup> Matolcsi 1975, p. 170.

<sup>17</sup> Bartosiewicz *et al.* 2010, p. 92.

<sup>18</sup> Albarella *et al.* 2009, p. 132.

<sup>19</sup> Faragó 2002, pp. 366–367.

<sup>20</sup> Bökönyi 1995.

<sup>21</sup> Albarella *et al.* 2009, p. 112, table 3.

n	17
Minimum	674.3
Maximum	804.8
Mean value	738.9
Standard deviation	36.9
Median	735.7
Skewness	0.130
Kurtosis	-1.097

**Table 3.** Univariate statistics of withers height estimates (mm) for pig from Çamlıbel Tarlası using Teichert's (1969) coefficients.

In spite of the small number of complete pig bones from Çamlıbel Tarlası, resulting withers height estimates calculated using Manfred Teichert's<sup>22</sup> coefficients show a symmetric but somewhat flat distribution (**Fig. 7**, top).

Measurable bone fragments occurred in far larger numbers than the 17 complete skeletal elements used in estimating withers heights as summarised in the top histogram of this figure. Measurements of ten modern female wild boars were collected by Sebastian Payne and Gail Bull<sup>23</sup> from Kızılcahamam, Anatolia in the relative proximity of our site (**Fig. 1**). The same measurements were available on 88 Chalcolithic pig bones from Çamlıbel Tarlası. In order to obtain a higher resolution picture of the trend shown by estimated withers heights, individual pig bone measurements from our site were converted into standard scores using the mean values and standard deviations of the modern wild boar measurements from Kızılcahamam and plotted in a histogram whose zero value corresponds to the average of modern female wild boar (**Fig. 7**, bottom).

Both size comparisons place the overwhelming majority of pig remains from Çamlıbel Tarlası within a size range notably smaller than the modern wild form. This is in spite of the inclusion of relatively young female wild boar from Kızılcahamam that somewhat lowered the mean values and broadened the standard deviations used in calculating the standard scores. In **Figure 7** (bottom), only three of the largest bones from Çamlıbel Tarlası reach the average of modern female wild boar (0 value), the rest peak around a “safe” distance of -3 standard deviation from the wild female mean. Some very small measurements in the archaeological sample in the left side of the graph may be attributed to subadult individuals whose early fusing epiphyses could not be precisely aged in the absence of the unfused half of the same bone.

These gross trends are also supported by dimensions of lower third molar teeth, fully erupting only in adult individuals. In **Figure 8** lower third molar measurements from Çamlıbel Tarlası form a distinct, sexually non-dimorphic, cluster, clearly separate from data on wild boar published by Albarella *et al.*<sup>24</sup> Lower third molars from mature Turkish wild boar from Kızılcahamam<sup>25</sup> used as the “standard” in comparing bone measurements appear

<sup>22</sup> Teichert 1969.

<sup>23</sup> Payne and Bull 1988, p. 39–40, Figure 1.

<sup>24</sup> Albarella *et al.* 2009, p. 117, fig. 9a.

<sup>25</sup> Payne and Bull 1988.

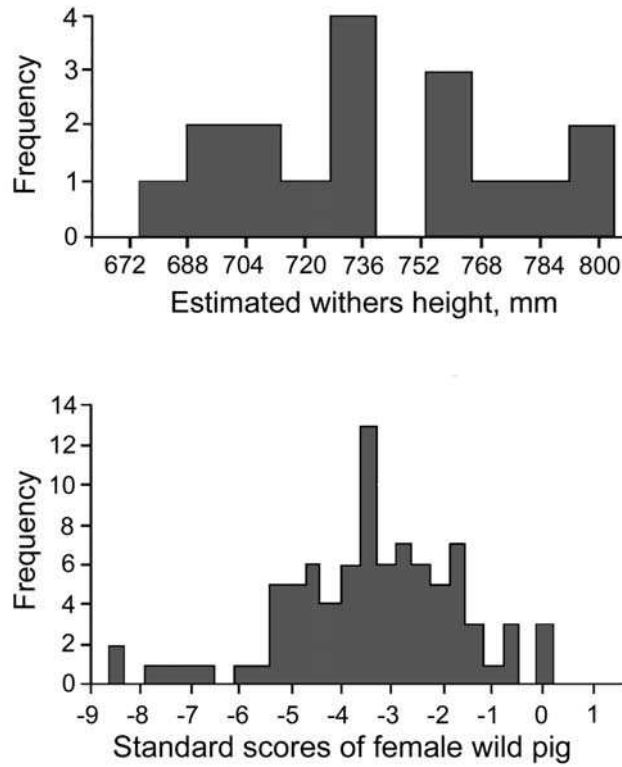


Fig. 7. Analysis of phenotypic sizes of pig from Çamlıbel Tarlası. Top: the distribution of estimated withers heights (Teichert 1969). Bottom: the distribution of bone measurements as standard scores of modern wild boars from Kızılcahamam (Payne and Bull 1988).

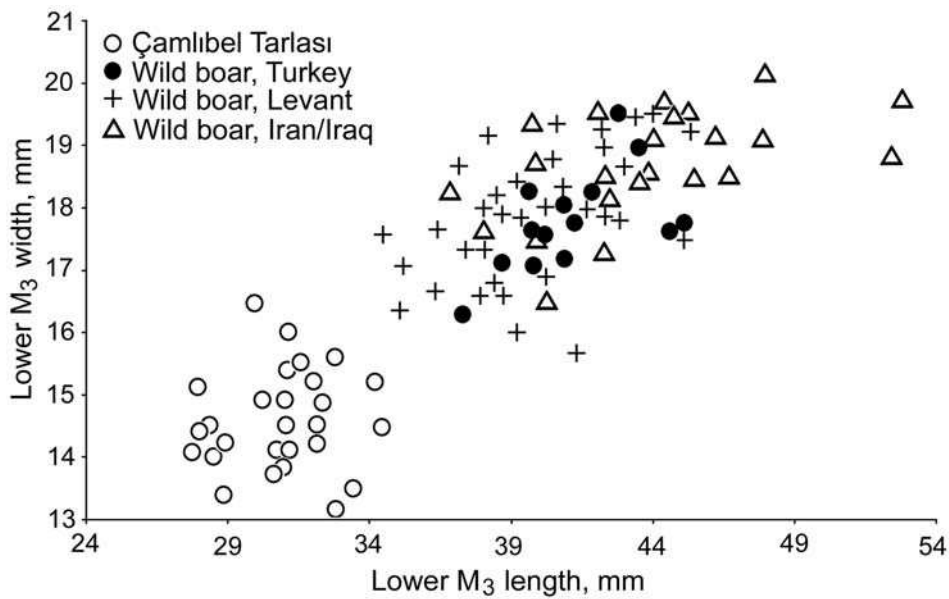


Fig. 8. The greatest length and width (anterior cusp) of third mandibular molars from Çamlıbel Tarlası in comparison with modern wild boar from the Near East (Albarella *et al.* 2009).

to be particularly large. The aforementioned east-west cline is also illustrated by even larger specimens from Iran and Iraq.<sup>26</sup>

The good preservation of molar teeth made additional analyses possible. Fifteen specimens were sampled for DNA analyses and 13 of them were successfully extracted and sequenced for an 80 base pair diagnostic fragment of the mitochondrial control region.<sup>27</sup> The success rate of DNA retrieval from Çamlıbel was exceptional. Among the 13 specimens that provided DNA sequences, eight specimens possessed the Arm1T haplotype and six specimens possessed the Y1 haplotype.<sup>28</sup> The Arm1T haplotype is ubiquitous across the Near and Middle East and particularly frequent in eastern Anatolia, the southern Caucasus and western Iran.<sup>29</sup> Interestingly however, the Y1 haplotype is rare outside western and central Anatolia, and completely absent east of Hassek Höyük in eastern Anatolia (**Fig. 1**), revealing a genetic cline across the region. These observations have led to the suggestion that pigs in eastern Turkey were domesticated through a long-term process and the presence of Y1 in domestic pigs further was probably not an independent ‘event’, but instead reflects the capture of mtDNA signatures from local wild boar following hybridisation with imported domestic pigs.<sup>30</sup> Recent aDNA analyses also revealed that early Neolithic domestic pigs in Europe carried the Y1 haplotype while it was completely absent in pre-Neolithic and Neolithic wild boar in that region, suggesting that it was introduced during the Neolithic transition, at least as early as 5500 BC.<sup>31</sup>

Twenty-four second and third lower molars corresponding to 18 specimens were analysed using two-dimensional landmark- and sliding landmark-based geometric morphometric methods.<sup>32</sup> The specimens from Çamlıbel were compared to a modern referential including both wild boars from all the west Palaearctic (n=58 for the lower M2, n= 129 for the lower M3) as well as ten different breeds of domestic breeds (n=53 for the lower M2, n=42 for the lower M3). Using the modern referential and a predictive approach based on a linear discriminant analysis, 17 specimens present a domestic signature in their teeth shape whereas one presents a tooth shape closer to the modern wild reference. These results based on GMM are congruent with the observations made on the traditional size that fall in line with the dominance of phenotypes at Çamlıbel Tarlası smaller than the modern wild form (**Fig. 7** and **Fig. 8**).

## DISCUSSION AND CONCLUSIONS

Today, the deforested and heavily eroded environment of Çamlıbel Tarlası seems better suited for the keeping of sheep, goat and even cattle than pig. Nevertheless, pig was consistently present in all chronological phases at the Chalcolithic site. In terms of bone weights pork (c.30 per cent) was evidently more important than mutton (10 per cent). This must be indicative of a sufficiently forested and at least seasonally humid habitat that could be

<sup>26</sup> Flannery 1983; Stampfli 1983.

<sup>27</sup> Larson *et al.* 2007a, but see Ottoni *et al.* 2013.

<sup>28</sup> Defined by Larson *et al.* 2007a.

<sup>29</sup> Larson *et al.* 2005, 2007a–b; Ottoni *et al.* 2013.

<sup>30</sup> Ottoni *et al.* 2013.

<sup>31</sup> Larson *et al.* 2007b.

<sup>32</sup> Similar protocol to Cucchi *et al.* 2011; Evin *et al.* 2013.



profitably exploited by pig keeping. One of the questions is whether we can use the data from Çamlıbel Tarlası to formulate a model of animal husbandry that would be specific to north Central Anatolia? Such a model could be contrasted especially with the more “south-west Asian” models in south-eastern Turkey and northern Syria. Across south-west Asia, percentages based on the number of identifiable remains tend to show that the ratios between domesticates are largely dependent on the natural environment.<sup>33</sup>

For example, at the site of Habuba Kabira on the right bank of the Euphrates in Syria, pig keeping never gained much significance in coeval periods, probably due to the arid conditions.<sup>34</sup> Pig is entirely missing from arid sites such as El Kowm 2-Caracol (fourth millennium BC), located 100 km south of the Euphrates in Syria.<sup>35</sup> Forested and hilly Anatolia, on the other hand, seems to have supported Chalcolithic pig keeping.<sup>36</sup> At Arslantepe in central Anatolia (Fig. 1), a major shift toward caprine herding took place only at the turn of Periods VII (3800–3350 BC) and VIA (3350–3000 BC).<sup>37</sup> Çamlıbel Tarlası, however, still represents heavier reliance on pigs than on sheep or goat. On the other hand, a comparison with Yarıkaya,<sup>38</sup> shows that the percentual contribution by pigs to that small sample is even greater than at Çamlıbel Tarlası.

The picture thus far reconstructed for these rural settlements seems to correspond to the definition of a modern “forest village”,<sup>39</sup> a small agricultural community subsisting in forest clearings, gradually expanding its fields and animal pasturage. It is remarkable that hunting played no visible role in meat provisioning at Çamlıbel Tarlası. Historically, grazing in forests has been very important in Turkey, with goats having a leading role in exploiting forests this way.<sup>40</sup> During the Chalcolithic woodland habitats could still be sustained by keeping cattle and pigs on a household level. Beginning with the Bronze Age, however, intensive grazing by small ruminants precluded the recovery of forests, thereby closing the loop between deforestation and ever-increasing sheep/goat keeping, often by emerging large, centralised settlements. Spatial isolation from forests may also explain why pigs re-introduced from Europe millennia later don’t take on the appearance of the local Anatolian wild boar: because settlements were big enough to sever the link between pigs in the cities and the wild boar on the outside, thus significantly limiting gene flow. However, according to Ottoni *et al.*, this breakdown of gene flow would have happened between ~1600 and 600 BC.<sup>41</sup> Both the natural habitat and the socio-economic niche of pig seem to have dwindled across the Near East.

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- <sup>33</sup> Clason and Buitenhuis 1998, p. 236, fig. 3.  
<sup>34</sup> von den Driesch 1993, p. 53.  
<sup>35</sup> Vila 1998, pp. 120–121.  
<sup>36</sup> Bökönyi 1983.  
<sup>37</sup> Bartosiewicz 1998, 2005, p. 98; 2010, p. 122.  
<sup>38</sup> Boessneck and Wiedemann 1977, p. 107.  
<sup>39</sup> Izbirak 1976, p. 179.  
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<sup>41</sup> Clason and Buitenhuis 1998; Bartosiewicz 2010; Ottoni *et al.* 2013.

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## APPENDIX

*Age distributions by skeletal part summarized in Figure 4.*

Cattle	Neonate	Juvenile	Subadult	Adult	Mature	Senile
neurocranium	1		1	4	71	
maxilla	1					
mandibula			1	1	55	
tooth			2		67	2
cervical vertebra				6	34	
thoracic vertebra			1	1	10	
lumbar vertebra				2	6	
sacral vertebra				1	10	
ribs					12	
scapula				1	14	
humerus proximal				1	7	
humerus diaphysis				1	20	
humerus distal					5	
radius proximal					16	1
radius diaphysis			1	2	9	
radius distal			1		7	
ulna proximal			1	1	12	
carpal					22	
metacarpus complete				1	4	
metacarpus proximal				1	15	
metacarpus diaphysis				1	3	
metacarpus distal					6	
phalanx proximalis					50	
phalanx media				2	26	
phalanx distalis				1	18	
ilium		1	1	1	5	
pelvis		1			10	
acetabulum pelvis					10	
femur complete					2	
femur proximal				2	4	
femur diaphysis			1		31	
femur distal			1	2	4	
tibia complete		1				
tibia proximal			2	4	4	
tibia diaphysis			2		22	
tibia distal				2	12	
astragalus					15	
calcaneus proximal			3	5	10	

Cattle	Neonate	Juvenile	Subadult	Adult	Mature	Senile
centrotarsal			1	2	19	
metatarsus complete					3	
metatarsus proximal					9	
metatarsus diaphysis					5	
metatarsus distal		1		1	15	
phalanx media		1			26	
Total	2	5	19	46	705	3

Sheep	Neonate	Juvenile	Subadult	Adult	Mature	Senile
neurocranium	1	2		3	23	
maxilla			1	1	4	
mandibula			1	1	22	
tooth					8	
cervical vertebra				1	6	
scapula					2	
humerus proximal				1		
humerus diaphysis					1	
humerus distal				2	5	
radius proximal			1		12	
radius distal					3	
ulna proximal			1		1	
metacarpus complete					1	
metacarpus proximal					1	
metacarpus diaphysis				1		
metacarpus distal					4	
acetabulum pelvis				1		
femur proximal			3		2	
femur diaphysis					1	
femur distal			2	2	3	
tibia proximal					2	
tibia distal			1		15	
astragalus				1	6	
calcaneus proximal				3		
centrotarsal					1	
metatarsus complete					1	
metatarsus proximal			1		6	
metatarsus diaphysis			3			
metatarsus distal					1	
Total	1	2	14	17	131	0

Goat	Neonate	Juvenile	Subadult	Adult	Mature	Senile
neurocranium		1		5	14	
tooth			1			
metacarpus complete					1	
phalanx proximalis					1	
Total	0	1	1	5	16	0

Pig	Neonate	Juvenile	Subadult	Adult	Mature	Senile
neurocranium	1	3	23	16	26	
maxilla		3	12	10	29	
mandibula		7	28	18	40	2
tooth		4	8	15	30	
cervical vertebra		3	1	5	17	
thoracic vertebra			1			
lumbar vertebra			2		1	
sacral vertebra				1		
ribs					3	
scapula	1		22	19	4	
humerus complete			1			
humerus proximal			1		2	
humerus diaphysis			25	1	3	
humerus distal		1	9	3	26	
radius complete	2				1	
radius proximal		1	7	11	5	
radius diaphysis			1			
ulna proximal			10	6	4	
ulna distal				9		
metacarpus complete		1	4		5	
metacarpus proximal			6	1	2	
metacarpus diaphysis			1			
metacarpus distal			1			
phalanx proximalis			2		2	
phalanx media			4		1	
phalanx distalis			1			
pelvis			1	3		
acetabulum pelvis			5	9	8	
femur proximal		2	1	1	1	
femur diaphysis		1	17	5	5	
femur distal			2		2	
tibia complete			1	3		



Pig	Neonate	Juvenile	Subadult	Adult	Mature	Senile
tibia proximal			3	2		
tibia diaphysis		3	13	9	6	
tibia distal	2		4	10	15	
astragalus			2	4	9	
calcaneus proximal	1	1	8	1	2	
centrotarsal				1		
metatarsus complete			1		1	
metatarsus proximal				2		
metatarsus diaphysis			1			
metatarsus distal			2			
Total	7	30	231	165	250	2