Revisiting Neolithic Caprine Exploitation at Suberde, Turkey

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This paper addresses the nature of sheep and goat exploitation at the Aceramic Neolithic site of Suberde, Turkey. Although previously interpreted as a Neolithic hunters' village, new demographic and measurement data indicate that the sheep and probably goats at Suberde represent the earliest appearance of managed populations in the Beyşehir region of central Anatolia. Kill-off data indicate that the caprines were carefully selected for slaughter within a narrow age range, while measurement data provide evidence for size diminution, a feature commonly seen in domestic populations. There is no evidence, however, to indicate that caprine management included the intensive culling of young males, a feature which is often considered to be characteristic of herding economies. This divergence from the expectations of various ethnographic models of pastoral management may represent highly localized "experimental" caprine management strategies in the earliest Neolithic settlements of central Anatolia.

Introduction

Forty years ago Dexter Perkins and Patricia Daly published a brief but important report describing animal exploitation at the site of Suberde, a late Aceramic Neolithic settlement in the Beyşehir region of south central Anatolia dating to the mid–late 8th millennium CAL B.C. (Perkins and Daly 1968). Although this now classic paper is often cited for its innovative interpretations of faunal data, particularly with regard to the discussion of skeletal part transport costs and the so-called "schlepp effect" (Perkins and Daly 1968: 104), it also represents an important and early contribution to the study of Neolithic animal exploitation and domestication.

In their study of the faunal remains Perkins and Daly (1968) argued that sheep, goats, cattle, and pigs at Suberde were wild and that the dog was the only domestic animal present at the site. The site was therefore described as "an unusual example" (Bordaz 1969: 60) of a Neolithic hunters' village. Suberde was thought to represent a community of settled farmers or collectors "who relied for their subsistence in large measure on the hunting of animals" (Bordaz 1969: 60), comparable to Epi-palaeolithic cultures in the Near East such as the Natufian and Mureybetian.

As the earliest known Neolithic site in the Beyşehir region, this interpretation of the subsistence economy at Suberde has important implications for understanding the processes by which Neolithic lifeways and technologies spread into central Anatolia and beyond (see Bellwood and Renfrew 2002; Harris 1996; Price and Gebauer 1995).

As more data have accumulated over the four decades since 1968, the interpretation of Suberde as a late Aceramic Neolithic hunters' village seems increasingly problematic. This is partly due to the fact that neither the excavation itself, nor the work of the specialists involved in the project, have ever been published in detail. In addition, the analytical models (below) that led Perkins and Daly to conclude that Suberde represents a hunters' village have been seriously questioned (Martin, Russell, and Caruthers 2002; Payne 1972). Finally, recent archaeofaunal studies have resulted in a detailed regional picture of the process of animal domestication, providing a regional context for the Suberde data that was nonexistent when the original study was carried out.

Current research suggests that sheep and goats first came under human control in adjacent regions almost a millennium before Suberde was first occupied (Horwitz et al. 1999; Peters et al. 1999; von den Driesch and Peters 1999; Zeder and Hesse 2000). Moreover, data from the nearby site of Çatalhöyük indicate that domestic sheep and goats were present at that site from the earliest levels (pre-XII–VII), which were roughly contemporaneous with the

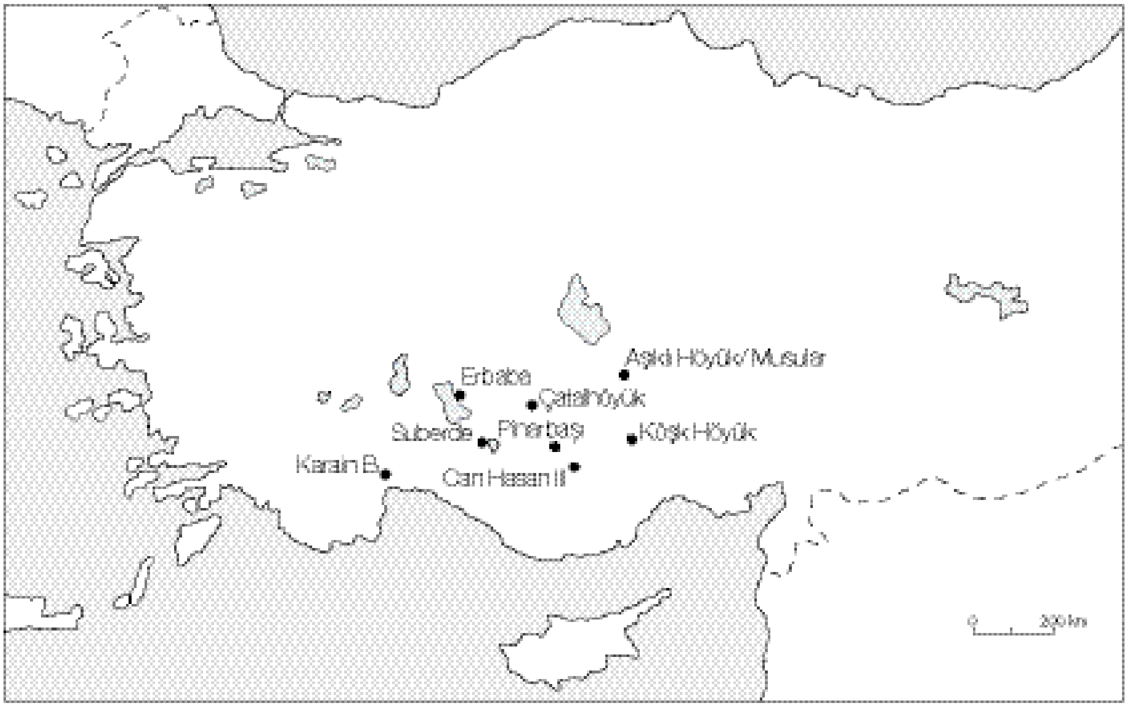

Figure 1. The location of Suberde and other early sites in central Anatolia.

occupation at Suberde (Russell and Martin 2005). Thus, to find a sedentary village settlement supported by an economy based on the exploitation of "prodomestic" (Dyson 1953: 662) but wild animals dating to this period and in this geographic location requires some explanation. It is thus essential to reevaluate this assemblage and to test the validity of Perkins and Daly's interpretation of the nature of caprine exploitation at this important site.

If Suberde does represent a case of Neolithic villagers continuing to hunt taxa that were domesticated by their neighbors, why did hunting continue to play such a central role? If Suberde does not represent a hunters' village, then what do the fauna indicate about early caprine management strategies in the region? Does the management of caprines in this early period fit with the expectations of model herding strategies in which herders maximize the production of primary, or postmortem, products such as meat?

In an attempt to answer these questions some 2000 specimens of the surviving faunal collection from Suberde were examined. Of these, 359 were diagnostic specimens that could be identified as either sheep or goat. Of these diagnostic specimens 84 were identified as sheep and 23 as goat, while the remainder were identified as one or the other of these morphologically similar taxa. In this study diagnostic specimens were defined as those from which measurements could be taken or which provided age data. These included the proximal and distal ends of long bones (both diaphyseal and epiphyseal portions), the innominate, the atlas and axis, the major tarsals (calcaneus and astragalus), as well as mandibles and mandibular teeth.

As is typical of early Holocene faunal assemblages in the Near East, the faunal remains from Suberde are highly fragmented and the sample of diagnostic specimens is limited. The recoverable sample of more than 300 diagnostic caprine specimens, however, is comparable in size to those described from many early sites in the Near East (e.g., Davis 1984; Payne 1985; Peters et al. 1999; Vigne, Carrere, and Guilaine 2003; Zeder 2005) and was adequate to test Perkins and Daly's interpretations of caprine exploitation.

The Site of Suberde

Suberde is located in the smaller of two linked intermontane basins in the Beyşehir-Suğla region of south central Turkey (Bordaz 1969: 43–44) (FIG. 1). The site is situated on a limestone ridge along the NW margin of Lake Suğla (now dry) at an elevation of 1070 m and sits just above the western margin of the Konya Plain.

Suberde was discovered during a survey by Ralph Solecki (1964) and was excavated for two seasons in 1964 and 1965 by Jacques Bordaz as part of the decade-long

Table 1. Radiocarbon dates from Suberde. The dates derived from bone collagen are new results and the dates from charcoal are from Bordaz (1969: 59). All dates were calibrated using the OxCal IntCal 04 curve.

Lab #	*Material*	*Strat. level*	*Radiocarbon years* B.P.	*Calibrated years* B.C.	*1 sigma*	*2 sigma*
OS-62229	bone collagen	?	8160 ± 45	7166 ± 72	7308–7060	7246–7066
OS-62226	bone collagen	?	8120 ± 40	7120 ± 58	7142–7058	7296–7043
OS-62227	bone collagen	?	8270 ± 40	7314 ± 85	7449–7191	7468–7178
OS-62370	bone collagen	?	8150 ± 45	7156 ± 70	7180–7065	7308–7056
P-1385	charcoal	III	7957 ± 88	6865 ± 127	7032–6713	7077–6637
P-1386	charcoal	III	8045 ± 76	6960 ± 133	7081–6823	7241–6688
P-1387	charcoal	III	8326 ± 289	7339 ± 377	7679–6837	8201–6639
P-1388	charcoal	III	8226 ± 79	7257 ± 113	7350–7084	7468–7067
P-1391	charcoal	III	8299 ± 91	7332 ± 119	7484–7190	7530–7083
I-1867	charcoal	III	8570 ± 140	7668 ± 195	7822–7477	8198–7319

Beyşehir-Suğla Project (Bordaz 1965, 1966, 1969, 1973; Bordaz and Alper-Bordaz 1977). Bordaz described four stratigraphic levels at the site. Levels II and III (Bordaz's "upper" and "lower prehistoric levels") included the remains of plastered floors and rectilinear mudbrick architecture with storage and bench features, while Level I was a mixed surface layer that contained Roman to Islamic period burials and a small number of Neolithic, Chalcolithic, and Bronze Age sherds. Level IV consisted of sterile sediments.

Six radiocarbon dates from Level III indicated occupation from ca. 7500–6900 CAL B.C. and four new dates derived from bone collagen confirm these results (TABLE 1). This suggests that Suberde was roughly contemporaneous with the last phase of occupation at Aşıklı Höyük, the earliest village settlement in central Anatolia, and the nearby special-purpose site of Musular, as well as with Can Hasan III and the lower levels (pre-XII–VII) at Çatalhöyük (FIG. 2) (Cessford 2001; Duru 2002; Esin and Harmankaya 1999; French 1968; Özbaşaran 1999; Payne 1972). Suberde predated the nearby Pottery Neolithic settlement at Erbaba Höyük by several centuries (Bordaz and Alper-Bordaz 1977, 1982).

Prehistoric Levels II and III at Suberde are thought to represent the remains of a small village settlement estimated to cover 0.5 ha (Bordaz 1969: 44), dating to the latest part of the Aceramic Neolithic or ECA (Early Central Anatolian) III (Özbaşaran and Buitenhuis 2002). Although five sherds of very coarse, primitive pottery were found in Level III, no ceramic remains were found in the overlying Level II deposits suggesting that, although the technology for simple ceramic production was known, it was not widely used by Suberde villagers (Bordaz 1969: 51).

Since very few palaeobotanical samples were recovered during excavation, the plant component of the subsistence economy at Suberde is largely unknown. Preliminary analysis of plant remains preserved in burned wall fragments revealed the presence of wheat, barley, pistachio, pea, and vetchling, but it is unclear whether these represent wild or domestic resources (Bordaz 1977: 32). Palaeobotanical studies from contemporary sites in the region, including Can Hasan III and Çatalhöyük, however, indicate that a wide range of domestic crops was potentially available in the region by the mid-eighth millennium CAL B.C. (Asouti 2003; Asouti and Fairbairn 2002; Fairbairn et al. 2002; Hillman 1978; van Zeist and Buitenhuis 1983).

The Faunal Assemblage

The faunal assemblage from Suberde was recovered through a combination of screening and collection by hand. Although it is said to have originally included more than 300,000 specimens the assemblage was reduced to less than one-tenth of that number as specimens deemed "useless" for analysis at the time (primarily long bone shaft fragments and unidentified fragments) were discarded (Perkins and Daly 1968: 97). The reduced assemblage was then transported to the United States for analysis and storage at Perkins' home where it remained until his death in 1983. At that time the assemblage was moved to the University of New Hampshire under the care of the late Howard Hecker and then finally to Fordham University where it is currently curated by Allan Gilbert. Only a small part of the already-reduced assemblage remains today and it is clear that post-recovery handling is one of the most significant taphonomic factors to have affected the assemblage.

The results of this study are derived from the measurement and demographic data salvaged from the remaining portion of the faunal assemblage. It seems likely that these types of data were minimally affected by the handling of the assemblage since they are based on larger diagnostic specimens which were the focus of recovery and curation. It is recognized that the state of the assemblage makes a detailed analysis of other features such as taphonomy, skele-

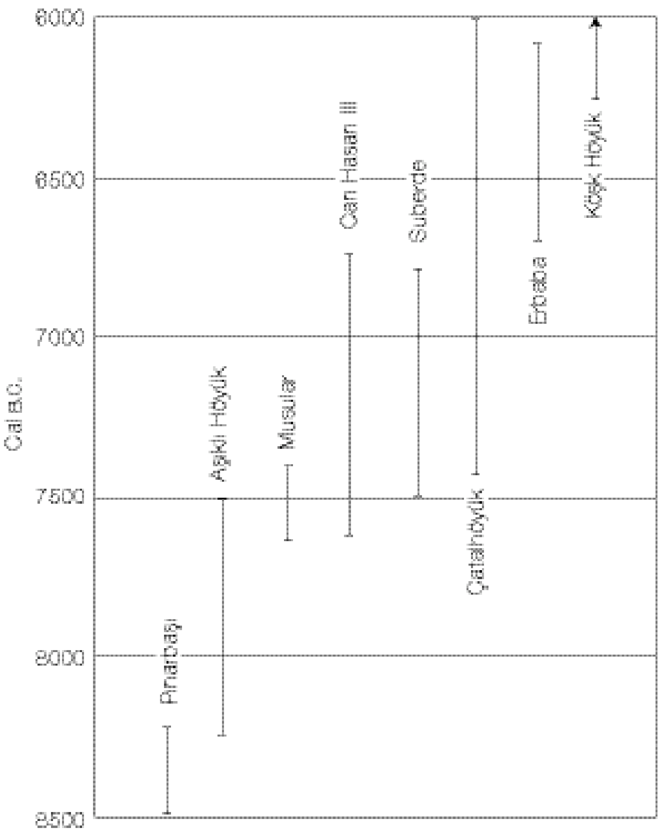

Figure 2. Approximate chronological relationships of Neolithic sites mentioned in the text based on radiocarbon dates (from Gérard 2002; Arbuckle 2006).

tal part representations, and archaeological context difficult. Due to the lack of detailed contextual information all deposits from Neolithic Levels II and III were treated in the present study as one analytical unit. Although this may mask both intrasite and diachronic variations in animal exploitation, the resulting coarse-grained picture of sheep and goat exploitation at Suberde is an important contribution to understanding regional early Neolithic subsistence strategies.

Zooarchaeological Identification of Hunting and Herding

There are many lines of evidence used by zooarchaeologists to distinguish the remains of hunted versus herded animals (Bökönyi 1969; Ducos 1978; Helmer 1992; Jarman and Wilkinson 1972; Meadow 1989; Perkins 1973; Reed 1959; Uerpmann 1979; Zeder 2006b). The most widely used focus on size decrease and other morphological changes that commonly occur in domesticated populations and on demographic data that indicate the age and sex distribution of the slaughtered animal population.

It is important to emphasize that all methods used to identify hunting and herding strategies are inherently problematic, particularly when they deal with the early stages of domestication (Meadow 1989). This is due, in part, to the fact that there is no single "domestic" mode of production that can be contrasted with a single "hunting" mode of production. Instead there is a wide range of variability in the relationship between humans and their animal prey (Higgs and Jarman 1969; Ingold 1980; Zeder 2006a: 107–108). In addition, the interpretation of zooarchaeological data is rarely straightforward, and most archaeological patterns can be construed as representing multiple exploitation strategies (e.g., Halstead 1998). As a result, reconstructing systems of animal exploitation based on zooarchaeological data is a major challenge.

One of the most widely used methods for studying the origins and spread of herding focuses on the identification of changes in morphology, including size, thought to be linked to the conditions of human management (Boessneck 1985; Meadow 1989; Uerpmann 1978, 1979; Zohary, Tchernov, and Horwitz 1998). These changes have been described in detail elsewhere and include changes in the shape of bovid horns and a decrease in body size (Arbuckle 2005; Davis 1987: 135–140; Meadow 1989). Among morphological changes, size decrease has been the evidence most used by archaeozoologists for identifying the transition from hunting to herding (Ducos 1968; Flannery 1983; Helmer 1992; Köhler-Rollefson 1989; Peters et al. 1999; Uerpmann 1979; von den Driesch and Peters 1999).

Since the observation that domestic animals tend to be smaller than their wild counterparts was first made more than a century ago (Rutimeyer 1862), size decrease, often identified using summaries of the log differences between archaeological populations and a standard animal (using the Logarithm Size Index [LSI] method [Meadow 1999]), has been the preferred line of evidence for identifying early domestic populations (e.g., Peters et al. 1999, although see Zeder 2006b; Zeder and Hesse 2000). Yet there are problems with using this method as the primary means to separate hunted from herded populations. In addition to domestication, many factors can have an impact on body size including hunting pressure, climatic changes, disease load, and nutrition. Moreover, an increase in the proportions of adult female animals in an archaeological assemblage can mimic the size changes associated with domestication especially when multiple measurements are conflated using the LSI method (Zeder 2001).

Finally, researchers have often questioned how quickly morphological changes, including size decrease, appeared in managed populations (Arbuckle 2005; Bökönyi 1976, 1989). Most recently, Melinda Zeder has made the argument that size decrease and other morphological changes are not characteristic of the earliest managed populations but made their appearance centuries after initial domestication (Zeder 2006b; Zeder and Hesse 2000; also see Dyson 1953: 662 and Perkins 1964: 1565 for earlier discussions). Thus, it is argued that the earliest herding economies will be associated with animals with body sizes similar to their local or regional wild counterparts and with little evidence for morphological changes, i.e., the earliest managed populations are expected to be "morphologically wild" (Vigne, Carrere, and Guilaine 2003; Zeder 2001, 2006b).

A second line of evidence widely used by zooarchaeologists to distinguish hunting from herding focuses on the analysis of demographic data: archaeofaunal indicators of the age and sex composition of a slaughtered population used to infer the method of exploitation. Researchers have long observed that herding practices tend to target young animals, particularly excess males, for slaughter, while hunting tends to target older individuals (Hesse 1982: 403; Hole, Flannery, and Neely 1969; Wright and Miller 1976; Zeder 2001).

As a result, the presence in the archaeological record of relatively high frequencies of immature individuals has often been interpreted as representing human management, or herding, while assemblages dominated by the remains of adult animals are typically interpreted as representing hunting (Chaplin 1969; Coon 1951; Reed 1959; Stampfli 1983; Vigne, Buitenhuis, and Davis 1999; Wright and Miller 1976).

By combining measurement and fusion data, Zeder (2001, 2005) recently developed a high-resolution method for analyzing both the age and sex composition of archaeofaunal assemblages. Fusion of the epiphyses of long bones occurs in sheep and goats during known age ranges and in a known order (Noddle 1974; Silver 1970; Zeder 2006c). For example, an unfused distal humerus indicates that the animal was killed sometime before it reached the oldest age at which that skeletal part fuses (ca. 10 months), while a fused distal humerus indicates that the animal was killed sometime after it reached the youngest age (ca. 6 months) at which that skeletal part fuses (Moran and O'Connor 1994). Since caprines exhibit a degree of sexual dimorphism and reach adult body sizes at relatively young ages (ca. one year) (Davis 1996; Zeder 2001), the size of fused and unfused skeletal parts can be used to identify the ages at which males and females were slaughtered (Hesse 1978; Zeder 2001; Zeder and Hesse 2000). This has allowed Zeder (2001, 2005; Zeder and Hesse 2000) to identify differences in the kill-off of males and females, particularly the slaughter of young males, as the defining characteristic of herding strategies and therefore the single best marker for initial management of animals such as sheep and goats.

As with size change, however, there are problems with using demographic evidence to identify animal domestication. Many researchers have expressed reservations about the use of such evidence to distinguish between hunting and herding, arguing that both can produce a wide variety of demographic patterns (Collier and White 1976; Simmons and Ilany 1975–1977; Wilkinson 1976; also see Atıcı and Stutz 2002; Binford and Bertram 1977) and that the method itself is fraught with taphonomic issues (Marean 1995; Munson 1991, 2000; Watson 1978). Despite these problems associated with interpreting them, demographic data do reflect human decision-making with regard to both the age and sex of the animals chosen for slaughter and that makes them particularly valuable for addressing the early period of animal management before morphological changes became apparent.

Evidence for Hunting at Suberde

Perkins and Daly's (1968) argument for sheep and goat hunting at Suberde was based on a combination of negative evidence for morphological changes and the interpretation of demographic data. W ith the exception of one fragment of a frontal bone from a hornless female sheep, no evidence for changes in morphology was noted. Possibly due to a lack of comparable datasets in the region at the time of their study, size diminution was not addressed for the caprines at Suberde.

Given this lack of evidence for morphological change, Perkins and Daly turned to the interpretation of demographic data. Using age at death estimates presumably generated from the state of fusion of longbones (as in Perkins 1964), they compared the frequencies of caprine juveniles (< 15 months old) and adults (> 15 months old) at Suberde to an Iron Age assemblage from Europe and to the proportions of those age groups in a living herd of bighorn sheep (Murie 1944). They argued that the frequency of specimens representing juvenile animals at Suberde (ca. 25%) more closely matched that of the wild herd and was considerably lower than that from the Iron Age site (ca. 45%). Since it was thought that the remains of immature animals were not represented in sufficient quantity to indicate herding, they concluded that the Suberde villagers must have been hunters.

In addition, Perkins and Daly (1968: 102) noted "that no sheep specimens represented animals younger than three months or older than three years." This very narrow range of age was used to support the interpretation of

Table 2. Approximate frequencies of identified taxa from the Neolithic levels at Suberde (Perkins and Daly 1968: 98).

Taxa	*N*	*%*
Caprines *(Ovis* and *Capra)*	9000	81.5
Pig *(Sus)*	1400	12.7
Red deer *(Cervus)*	340	3.1
Cattle *(Bos)*	300	2.7
Fallow deer *(Dama)*	present	
Roe deer *(Capreolus)*	present	
Hare *(Lepus)*	present	
Hedgehog *(Erinaceus)*	present	
Dog *(Canis domesticus)*	present	
Jackal *(Canis aureus)*	present	
Fox *(Vulpes)*	present	
Bear *(Ursus)*	present	
Wildcat *(Felis)*	present	
Marten *(Martes)*	present	
Badger *(Meles)*	present	

hunting since it was argued that "the old animals and the very young animals are precisely the ones that are taken by wild predators" (Perkins and Daly 1968: 102). This suggested to the authors not only that the Suberde villagers were hunters but that they hunted in "cooperative drives, slaughtering whole flocks at a time" (Perkins and Daly 1968: 102).

In the years since Perkins and Daly's analysis, many researchers have found this demographic argument for hunting problematic (e.g., Martin, Russell, and Carruthers 2002; Payne 1972). Although the frequency of juvenile individuals from Suberde parallels that of wild sheep herds, Murie's (1944) data indicate that most of a typical living wild herd is composed of animals older than three years (also see Caughley 1966; Deevey 1947; Garcia-Gonzales et al. 1992; Hoefs and Bayer 1983; Papageorgiou 1979). Yet these animals were reported to be largely absent at Suberde.

Since sheep and goats segregate into male and female herds for most of the year (Schaller 1977), it is possible that the summer hunting of nursery herds composed of females and their young might result in an over-representation of immature and subadult individuals in the archaeological record, as has been suggested by Hesse (1978) for the earliest level at Ganj Dareh (but see Zeder and Hesse 2000). However, this would not produce the pattern described for Suberde in which mature and senile adults are largely absent. The seasonal hunting of nursery herds would also produce a distinctive absence of adult males; this pattern has not been identified at the site. Instead, the presence of a narrow range of ages suggests that Suberde villagers were not harvesting entire herds, but rather were intentionally selecting animals for slaughter based on age-related criteria (also see Martin, Russell, and Carruthers 2002; Payne 1972).

Faunal Data from Suberde

Species Frequencies

Because Perkins and Daly had access to a much larger sample than is presently available, their descriptions of the composition of the assemblage are reviewed here. In both Levels II and III, the remains of caprines are dominant, comprising ca. 81.5% of the identified faunal remains, with pig, red deer, and cattle present in lower frequencies (TABLE 2). Eleven other mammalian taxa were identified in small quantities, as well as tortoise, unspecified bird (possibly pelican), freshwater mollusks, and fish (Perkins and Daly 1968: 98). In addition, sheep reportedly outnumbered goats at a ratio of 5.6 : 1.

My reanalysis of the assemblage has also found that sheep outnumber goats, although to a slightly lesser degree, ca. 3.7 : 1. These differences may be the result of variability between researchers in the identification of these morphologically similar taxa, as well as variations in the composition of the samples available for analysis. The results of both studies of the Suberde fauna, however, indicate that sheep is the dominant taxon, a pattern that is typical of Neolithic sites across much of Anatolia (Arbuckle 2006: 13–14; Arbuckle and Özkaya 2006; Martin, Russell, and Carruthers 2002; Peters et al. 1999; Russell and Martin 2005).

Measurement Data

Measurement data are presented both as LSI values and individual measurements of skeletal elements. Using the LSI method, log-transformed measurements are compared with those from standard animals, in this case a modern female *Ovis orientalis* from Iran and the averaged measurements of a modern male and a modern female *Capra aegagrus* from the Taurus mountains in Turkey (following Uerpmann and Uerpmann 1994). Although there are some potential problems with utilizing animals from a different region and time period as the standard (Meadow 1999; Russell and Martin 2005; Zeder 2001), these standard animals are widely used in the literature and are used here in order to aid comparison with previous and future studies.

In Figure 3, LSI values for specimens identified as sheep and sheep/goat from Suberde are compared with those for sheep from Aşıklı Höyük, the lower levels of Çatalhöyük, and the late Neolithic levels of Köşk Höyük. The Suberde results are based on a sample of measurements from 69 different specimens that correspond to those measurements

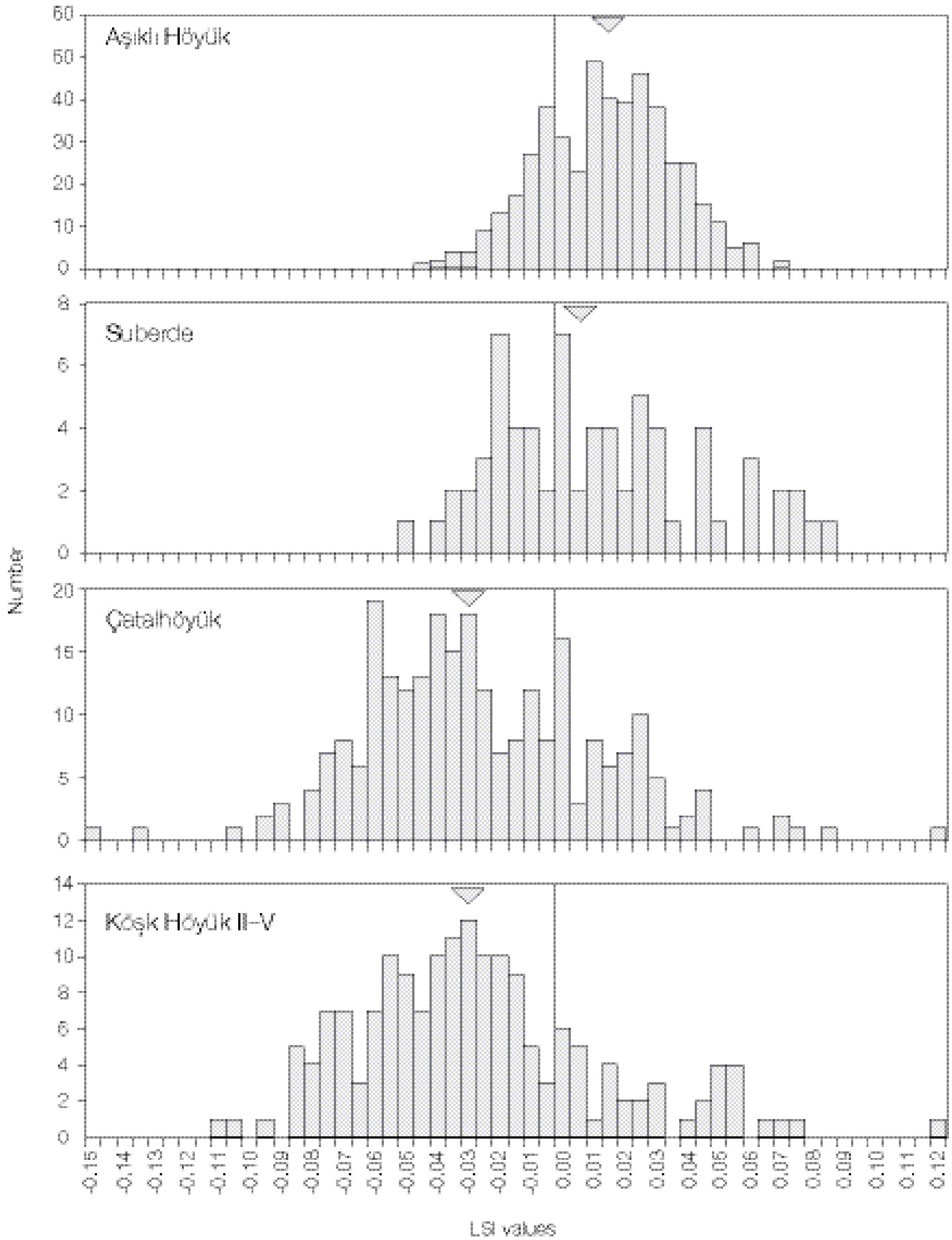

Figure 3. Logarithm Size Index (LSI) values for sheep and sheep/goat specimens from Suberde (n = 69) compared to those from Aşıklı Höyük (n = 470), Çatalhöyük levels pre-XII–IV (n = 256), and Köşk Höyük II–V (n = 170) (Arbuckle 2006; Hijlke Buitenhuis, personal communication 2005; Russell and Martin 2005). Triangles indicate median values.

presented by Margarethe Uerpmann and Hans-Peter Uerpmann (1994) for the standard animal. Since sheep outnumber goats at Suberde at a ratio of almost 4 : 1, and the majority of specimens identified as sheep/goat therefore likely represent sheep (also see Arbuckle 2006: 133–134), measurements from specimens identified as sheep/goat are

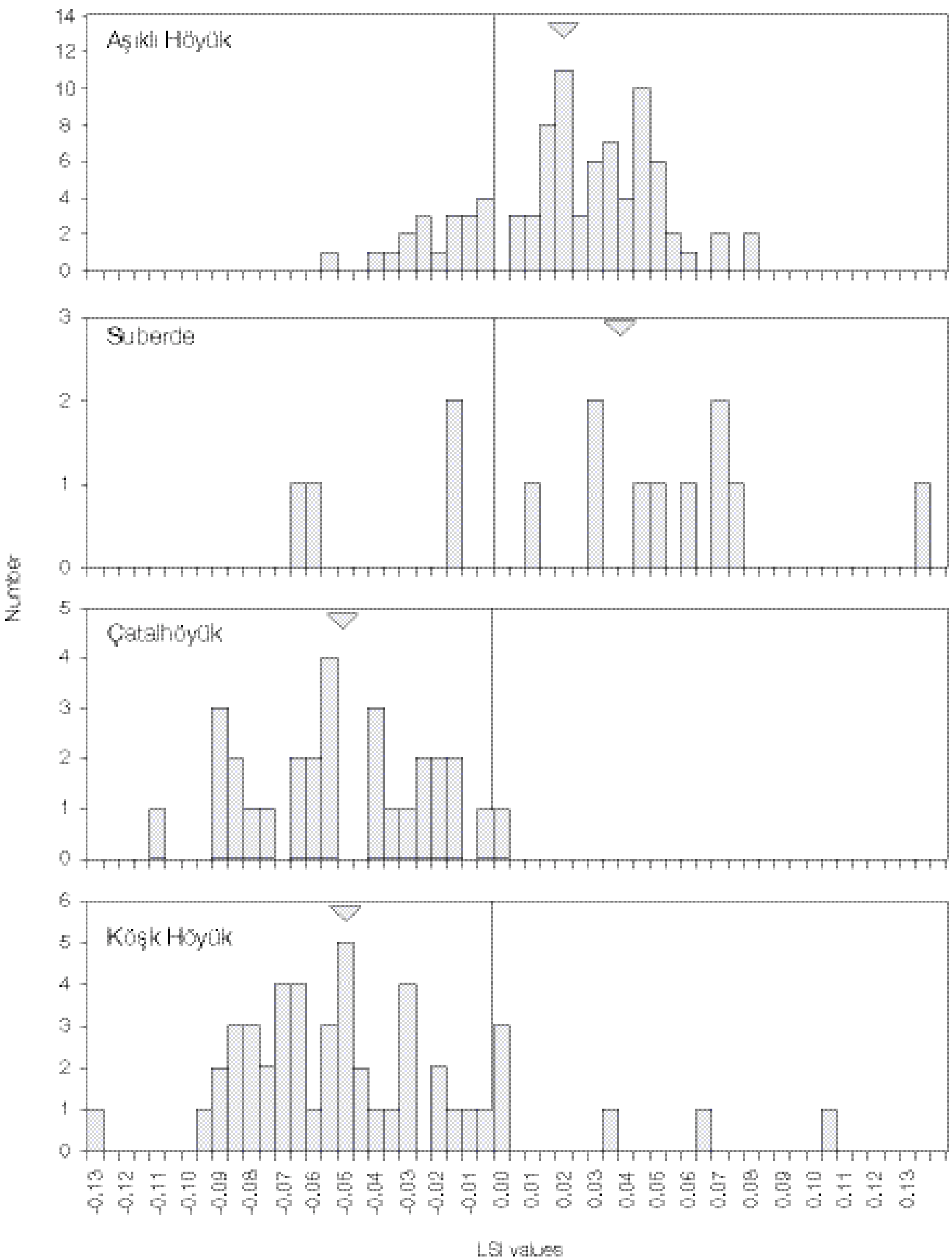

Figure 4. LSI values for goat specimens from Suberde (n = 14) compared to those from Aşıklı Höyük (n = 87), Çatalhöyük levels pre-XII–IV (n = 30), and Köşk Höyük II–V (n = 48) (Arbuckle 2006; Hijlke Buitenhuis, personal communication 2005; Russell and Martin 2005). Triangles indicate median values.

included with the sheep values in this figure. Although it is possible that one or more of these sheep/goat specimens might represent goats, their addition does not alter the overall shape or range of the LSI distribution but does provide a more robust sample for comparison.

The Suberde sheep are comparable in size to the stan-

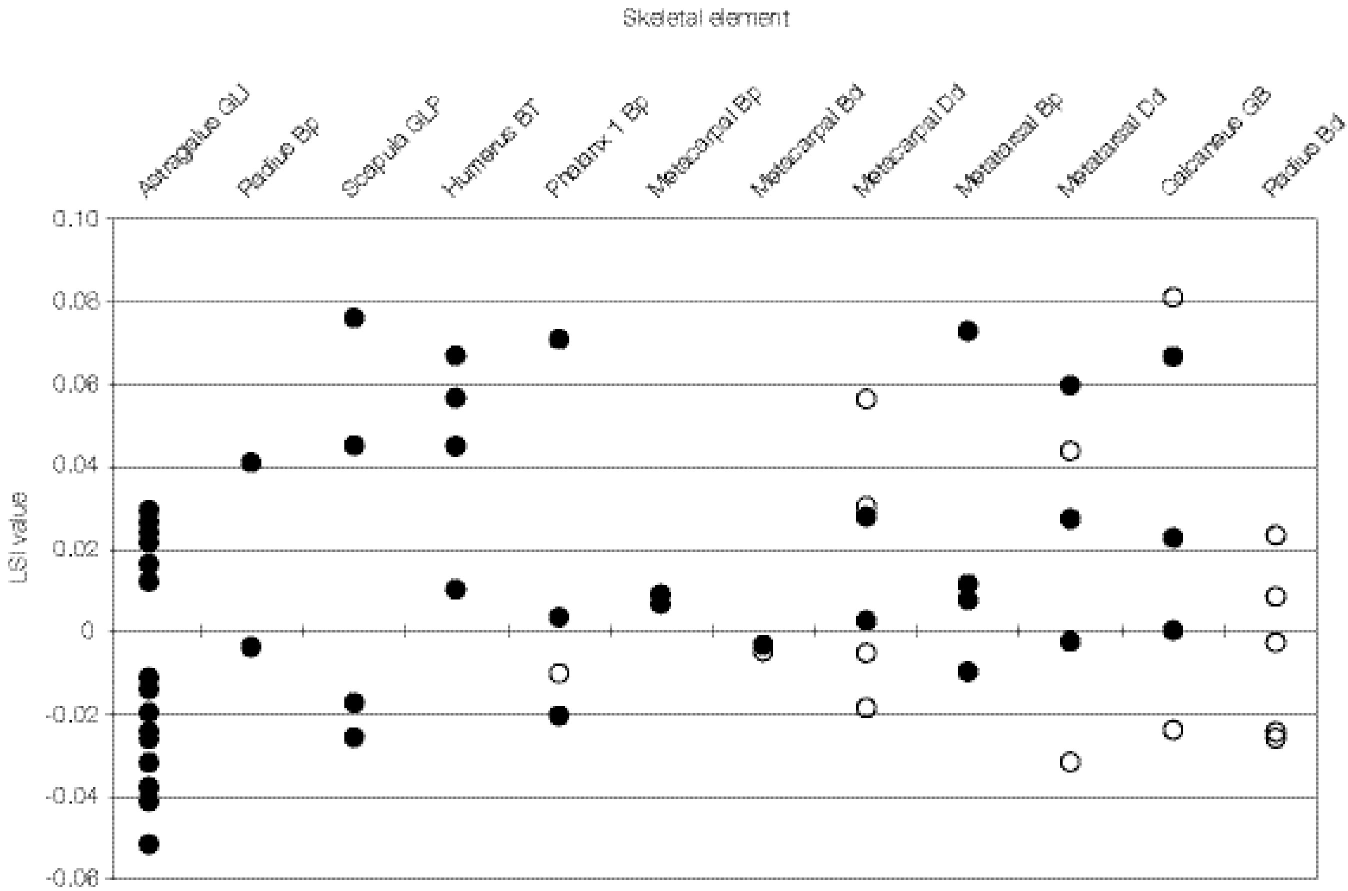

Figure 5. LSI values for individual skeletal measurements (after von den Driesch 1976) for fused and unfused specimens identified as sheep and sheep/goat. Filled circles represent fused specimens while open circles represent unfused specimens. State of fusion is not applicable for astragalus and proximal metapodials. GL1 = greatest length of the lateral half, Bp = breadth of the proximal end, GLP = greatest length of the processus articularis, BT = breadth of the trochlea, Bd = breadth of the distal end, Dd = depth of the distal end, GB = greatest breadth.

dard animal and are clearly larger than the earliest morphologically domestic populations in the region at Çatalhöyük and at Köşk Höyük. They also exhibit similar LSI values to those from Aşıklı Höyük, although there are more individuals in the small end of the size range at Suberde, and the median LSI value from Suberde is smaller. The sheep and goat remains from Aşıklı Höyük represent large-bodied, morphologically wild populations and provide a baseline for the size of early Holocene wild caprines in the region. The population from Aşıklı Höyük is comparable in size to other morphologically wild populations in the Near East dating to the Late Pleistocene such as at Karain B on the Turkish Mediterranean coast (A. L. Atıcı, personal communication 2006).

LSI values for goats from Suberde show a pattern very similar to that for sheep (FIG. 4). Suberde goats are comparable in size to the large-bodied, morphologically wild population from Aşıklı Höyük and are considerably larger than the small-bodied, morphologically domestic populations at Çatalhöyük and at Köşk Höyük.

In Figure 5, LSI values for specimens identified as sheep and sheep/goat are presented for both fused and unfused skeletal parts. Due to small sample sizes, comparable data are not presented for goats. One of the problems with using the LSI method is that differences in body proportions between the standard animals and the archaeological population (i.e., nonallometric scaling) can potentially skew results. The data presented in Figure 5 indicate no major discrepancies between the standard sheep, a modern ewe from Iran, and the Suberde population, with most LSI values ranging between -0.02 and 0.08 on the LSI scale. The only exception is the length of the astragalus, which is proportionately slightly shorter in the Suberde population (see Meadow 1999). Measurements from several skeletal

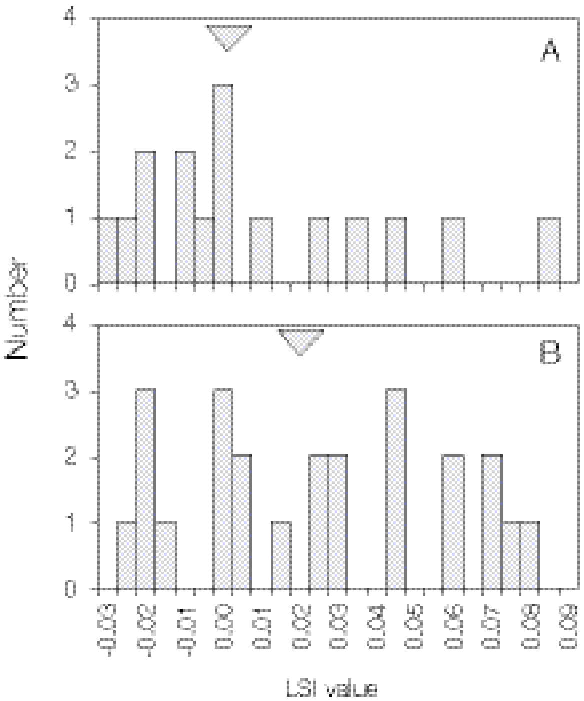

Figure 6. LSI values for skeletal parts identified as sheep and sheep/goat. Triangles represent median LSI values. A) Unfused; and B) Fused.

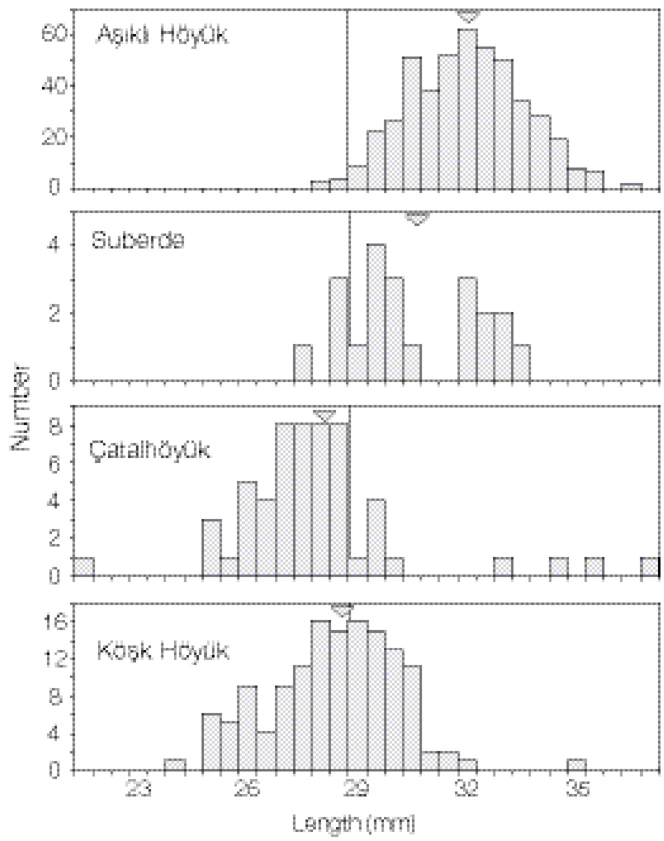

Figure 7. Comparison of the lateral length of the astragalus for sheep from Aşıklı Höyük (n = 470), Suberde (n = 21), Çatalhöyük (n = 56), and Köşk Höyük (n = 137). (Hijlke Buitenhuis, personal commuication 2005; Russell and Martin 2005; Arbuckle 2006). Triangles represent mean values.

parts fall into two groups, which likely represent sexual dimorphism (Davis 1996), and each of these groups includes both fused and unfused specimens.

The sizes of fused and unfused specimens are compared in greater detail in Figure 6 in order to test for evidence that kill-off was focused on a specific demographic group (e.g., young males, old females, etc.). Figure 6 is limited to data from later fusing skeletal parts (i.e., proximal phalanx 1 and 2, distal metapodials, calcaneus, distal radius) since it is in these skeletal parts that the size difference between males and females is most likely to be visible, even in young unfused specimens (Zeder 2001).

If young males were slaughtered we would expect unfused specimens, primarily representing large-bodied males, to cluster at the larger end of the range while fused specimens, primarily representing smaller females, would cluster at the smaller end of the range. If slaughter were undertaken without regard to sex, then we would expect fused and unfused specimens to be similar in size. Finally, if older males were targeted for slaughter, as is often the case in hunting strategies, we would expect fused specimens to cluster at the larger end of the range with unfused specimens exhibiting a wide range of values.

Figures 6A and 6B indicate that the median value for unfused specimens is slightly smaller than that for fused specimens but provide no evidence for the preferential culling of any specific demographic group (e.g., young males, old females, etc.). A Mann-Whiney U-test indicates that the fused and unfused samples are not significantly different ($U = 339.5$, $p = 0.067$). Instead both males and females were slaughtered at both younger and older ages.

The size of the Suberde caprines was also addressed through the analysis of measurements of the astragalus, the most abundant element in the assemblage. Since measurements of length, breadth, and depth of the astragalus all exhibit similar patterns only those results for astragalus length are discussed here. In Figures 7 and 8, measurements of astragalus length for sheep and goats from Suberde are compared with those from Aşıklı Höyük, Çatalhöyük, and Late Neolithic Köşk Höyük (Levels II–V).

Astragalus measurements indicate that the Suberde sheep are intermediate in size between the large-bodied population at Aşıklı Höyük and the small-bodied popula-

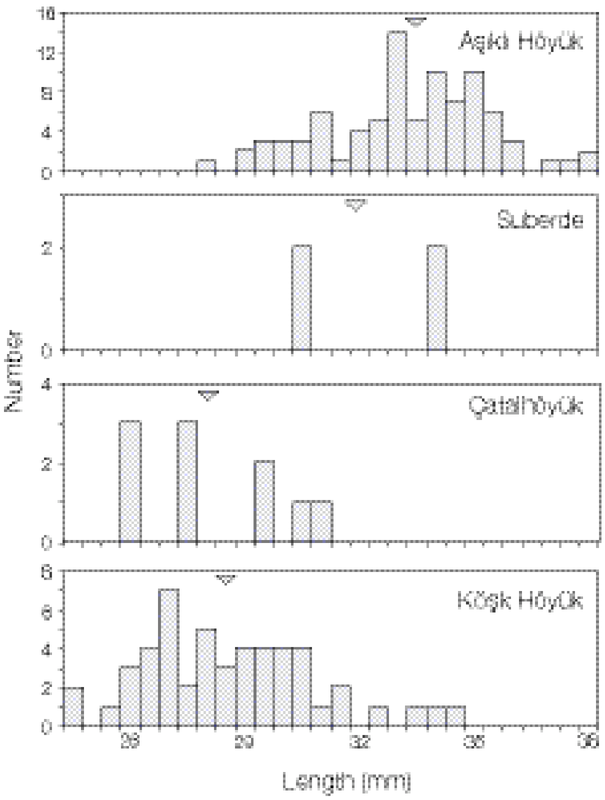

Figure 8. Comparison of the lateral length of the astragalus for goats from Aşıklı Höyük (n = 87), Suberde (n = 4), Çatalhöyük (n = 10), and Köşk Höyük (n = 50). (Hijlke Buitenhuis, personal communication 2005; Russell and Martin 2005; Arbuckle 2006). Triangles represent mean values.

tions from Çatalhöyük and Köşk Höyük. Although there is a high degree of overlap between the Suberde and Aşıklı Höyük populations, the mean value for Suberde sheep is smaller than that from Aşıklı Höyük and the smallest specimens from Suberde fall outside of the range of the smallest Aşıklı Höyük sheep. Two-tailed Mann-Whitney U-Tests indicate both that the difference in size between these two populations is highly significant ($U = 7119.0$; $p = 0.004$), and that the difference between measurements of astragalus breadth from Aşıklı Höyük and Suberde sheep is also highly significant ($U = 7018.0$; $p < 0.001$). The smallest individuals from Suberde are comparable in size to the morphologically domestic populations represented at nearby Çatalhöyük and Köşk Höyük, although the majority of Suberde specimens are clearly larger than those from these sites.

The small sample of measureable goat specimens makes interpretation of measurement data difficult. As with the sheep, some of the Suberde goats are larger than the morphologically domestic animals in the region at Çatalhöyük and at Köşk Höyük, although some are also well within that range. Although less clear, the results for goats appear to parallel those for sheep, indicating that the Suberde caprines as a whole can be characterized as intermediate in size, somewhat smaller than the morphologically wild populations, but larger than the early morphologically domestic populations in the region.

Survivorship

Survivorship data at Suberde are derived from tooth eruption and wear and the state of fusion of the epiphyses of long bones (FIGS. 9, 10). In the absence of complete mandibles, survivorship data from tooth eruption and wear for combined sheep and goats were generated (following Payne 1973) from loose mandibular teeth, specifically the deciduous fourth premolar (dp/4) and the third molar (FIG. 9). Since the dp/4 is typically shed around the same time that the third molar erupts (Payne 1973), using these two teeth reduces the risk of double counting loose teeth from a single individual.

Figure 9 indicates that the majority of caprines at Suberde were slaughtered between the ages of one and three years with a clear peak around two years of age. A few caprines were slaughtered in their first year and also as mature adults.

Survivorship based on fusion of the long bones is presented in Figure 10 in the form of a survivorship curve, showing the percentages of caprines from a theoretical cohort surviving past the youngest age at which fusion occurs in four skeletal parts. The four skeletal parts used in this figure are the most abundant in the assemblage and represent a cross-section of survivorship from three months of age to three years. In order to increase sample size, specimens identified as sheep and sheep/goat (but not goat) are pooled together in Figure 10. Sample sizes do not permit goat survivorship to be addressed.

Survivorship data for the Suberde sheep indicate that kill-off is overwhelmingly concentrated in the first three years with ca. 75% of sheep surviving past their first year, 50% past two years, and only 8% surviving past 36 months, the approximate age of fusion of the distal radius. This is in general agreement with Perkins and Daly's (1968: 102) statement that "no sheep specimens represented animals younger than three months or older than three years." This convergence of results with those of the original study, in which Perkins and Daly had access to the complete assemblage, is positive evidence that the surviving sample of the assemblage provides an adequate source of data for reconstructing sheep and goat exploitation at the site.

In Figure 10, survivorship data for Suberde sheep are

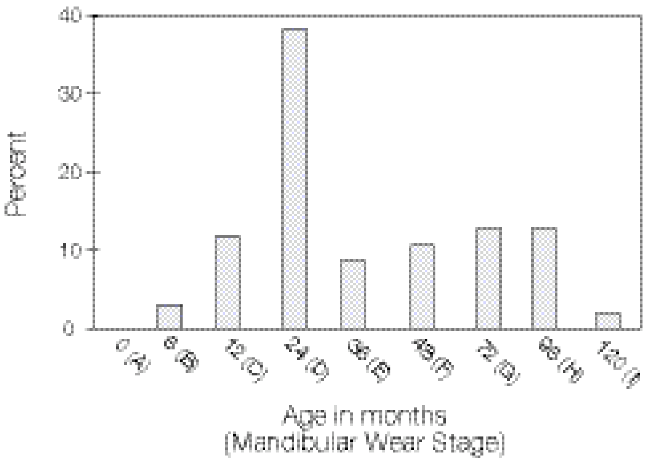

Figure 9. Frequency of loose mandibular teeth falling into each of Payne's (1973) Mandibular Wear Stages (MWS). Results are based on 18 loose deciduous fourth premolars and third molars for sheep and goats.

further compared with those for caprines from the Upper Palaeolithc site of Yafteh Cave (Hole, Flannery, and Neely 1969), sheep and goats from Ganj Dareh (Hesse 1978; Zeder and Hesse 2000), and caprines from Köşk Höyük (Arbuckle 2006). The caprines from Yafteh Cave and the sheep from Ganj Dareh are thought to represent wild hunted populations and exhibit high survivorship values with ca. 67% of caprines surviving past 3 years of age, while the Ganj Dareh goats and Köşk Höyük caprines are thought to represent domestic herded populations and exhibit very low survivorship (< 25%) past 3 years of age. Survivorship data for the Suberde sheep are similar to those for the Ganj Dareh goats and Köşk Höyük caprines, which suggests, contrary to Perkins and Daly's interpretation, that the demographic pattern at Suberde falls well within the range of variation of herding practices.

The similarity between sheep survivorship data at Suberde and those from sites where herding was practiced is not definitive proof that the sheep at Suberde were themselves herded. It has been shown that both hunting and herding practices can produce a wide variety of survivorship curves (Simmons and Ilany 1975–1977; Wilkinson 1976) and, in fact, a pattern of kill-off of caprines in their first three years has also been identified at sites such as Hallan Çemi, Körtik Tepe, and Cafer, which are interpreted as representing hunting economies (Arbuckle and Özkaya 2006; Helmer 1988; Redding 2005). In addition, survivorship data for morphologically domestic caprines from the earliest levels (pre-XII) at Çatalhöyük indicate a considerably older kill-off than for the Ganj Dareh goats, Köşk Höyük caprines, or Suberde sheep (Russell and Martin 2005: 73). Thus, although sheep were consistently chosen for slaughter within a narrow age range at Suberde, the survivorship data alone do not clarify the nature of the exploitation system and whether it took the form of traditional herding or a less intensive strategy more akin to wildlife management (e.g., Hecker 1982; Ingold 1974).

Discussion and Conclusions

The faunal data generated from this reexamination of the Suberde assemblage suggest a complex picture for the earliest system of Neolithic animal exploitation in the Beyşehir region of central Anatolia. Measurement data based on the coarse-grained LSI method suggest that the sheep and goat populations there were similar in size to morphologically wild populations in the region. More detailed investigation of astragalus measurements, however, indicates that the Suberde sheep were significantly smaller than the morphologically wild populations at other sites in the region, while at the same time they were larger than the morphologically domestic populations on the Konya Plain and in Cappadocia (i.e., at Çatalhöyük and at Köşk Höyük). Thus it seems that the sheep, and possibly the goats, at Suberde are characterized by a mild expression of size diminution, a feature widely seen as indicating a managed and domestic population (Peters et al. 1999; Uerpmann 1978, 1979).

On a regional scale it is tempting to see the smaller size at Suberde as a transitional stage linking the large morphologically wild caprines at Aşıklı Höyük with the small domesticates at Çatalhöyük and Köşk Höyük. The morphologically domestic caprines in the lowest levels at Çatalhöyük (pre-XII–VII), however, were contemporaries of those much larger animals at nearby Suberde. This discrepancy in size between neighboring populations can be addressed by examining the causes of morphological changes such as size diminution in the first place.

Researchers have argued that size diminution and other characteristics of the "domestication syndrome"—that suite of traits characteristic of a wide range of domesticates (Hemmer 1990)—are the result of a combination of reproductive isolation from wild populations and exposure to, and breeding within, an intensely anthropogenic environment (Arbuckle 2005; Davis 1987: 135–140; Price 1998; Zohary, Tchernov, and Horwitz 1998). One can argue that the sheep and goats at Çatalhöyük, located on the Konya Plain outside of the range of wild caprines, were subject to both of these conditions while those at Suberde, located within the wild habitat of both species, were not. In addition to the possibility of regular interbreeding between wild and managed sheep, it is also possible that management strategies at the small site of Suberde did not in-

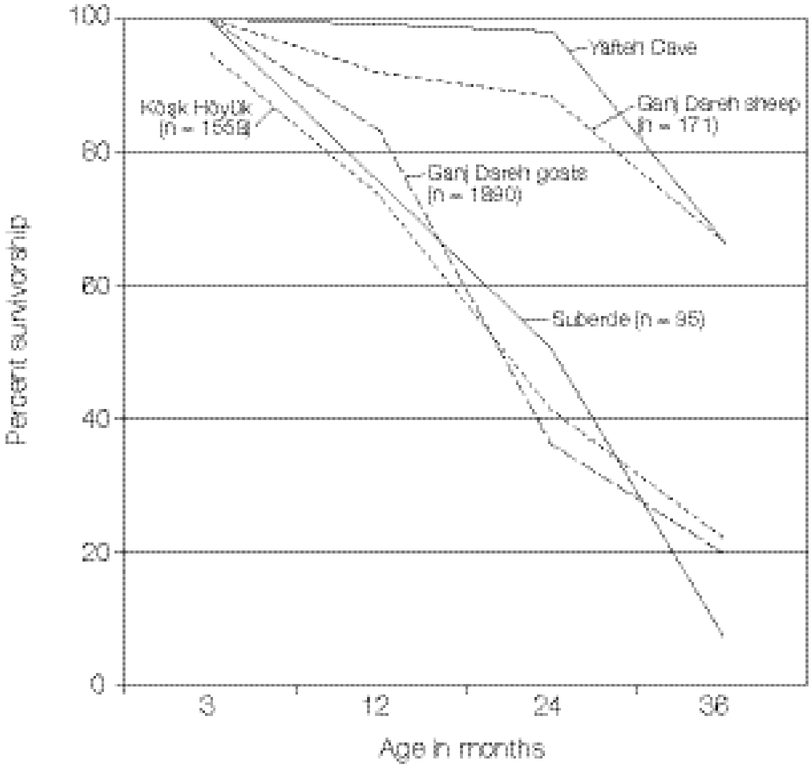

Figure 10. Survivorship curves generated from the state of fusion of the proximal radius (3 months), proximal first phalanx (12 months), distal metapodials (24 months), and distal radius (36 months) for specimens identified as sheep and sheep/goat from Suberde compared with those for sheep and goats from Ganj Dareh (Zeder and Hesse 2000), Yafteh Cave caprines (sample size unknown) (Hole, Flannery, and Neely 1969), and Köşk Höyük caprines (Arbuckle 2006).

volve intensive exposure to an anthropogenic environment as they did at the larger village of Çatalhöyük. Although it is tempting to attribute the lack of remains of perinatal sheep at Suberde to their vulnerability to taphonomic factors (Munson 2000; Vigne and Helmer 2007: 17), the lack of these remains may suggest that caprines were not present within the settlement, at least during the birthing season, as they were at Çatalhöyük (Russell and Martin 2005: 73–74).

Survivorship data suggest that the culling of sheep at Suberde was highly selective with regard to age but not sex. This pattern fits neither the most common models for hunting, in which older, mature individuals in their prime are slaughtered (Hole, Flannery, and Neely 1969; Stiner 1990; Wright and Miller 1976), nor those for herding in which young males are culled (Zeder and Hesse 2000). It seems clear that caprines were under some form of human control at Suberde, but until more specific and precise data regarding aspects of caprine exploitation such as seasonality, mobility, and foddering (e.g., Makarewicz and Tuross 2006) are examined, the exact form that management took will remain difficult to address.

That there is no evidence for the intensive culling of young males, a pattern thought by some to be the best marker of a herding economy (Zeder and Hesse 2000), is interesting and raises questions concerning both how herds were managed at Suberde as well as the universal validity of that model when applied to the early Neolithic in Anatolia. Although there are other potential explanations for the lack of evidence for young male kill-off (e.g., seasonal movements of herds away from the site), it is possible that herds at Suberde were subject to a management strategy that did not involve the focused slaughter of young males and which does not conform to models of herd management based on ethnographic analogy. It may be that in the earliest Neolithic communities in the region, the set of circumstances unique to initial colonization by villagers resulted in the development of a management system that has no modern analog.

Caprine exploitation at Suberde, therefore, may represent one example of a variety of "experimental" exploitation systems present in early sedentary sites in Anatolia (e.g., Hallan Çemi, Körtik Tepe, Cafer) in which caprines were selected with regard to age but which do not seem to exhibit evidence for "typical management" including young male kill-off.

Although not described here in detail, caprine exploitation at Aşıklı Höyük, the earliest excavated Neolithic village in central Anatolia, may also fit into this "experimental" category. Caprine exploitation at Aşıklı Höyük, representing a form of management referred to as "proto-domestication," included selective culling of morphologically wild animals between the ages of 2–4 years as well as a relatively large number of neonatal individuals (Buitenhuis 1997). Although caprine exploitation at both Suberde and Aşıklı Höyük exhibits selective slaughter of juvenile and young adult animals, management practices at Suberde resulted in size diminution, whereas there is no evidence for any morphological changes through the more than 400 year sequence at Aşıklı Höyük (Hijlke Buitenhuis, personal communication 2005). This suggests that these two sites were characterized by different management strategies and, with the addition of a third distinct system documented in the early levels at Catalhöyük, supports the idea that central Anatolia was characterized by a mosaic of different management strategies in the Neolithic, each unique to its own geographic and sociocultural context.

The lack of evidence for young male kill-off and the lack of fit with the usual models of pastoral management may suggest that early Neolithic herd management at Suberde was fundamentally dissimilar to the practices of herders at sites such as Ganj Dareh and at later sites in the region such as Köşk Höyük, which do conform to these models (Arbuckle 2006). As a consensus emerges regarding the high level of variation in early Neolithic subsistence economies (Mithen et al. 2000; Redding 2005; Rosenberg 1999; Weiss, Kislev, and Hartmann 2006), it may be that Suberde can be seen as representing an example of an early Neolithic experiment in caprine exploitation that was replaced by more intensive husbandry systems in the region in the Pottery Neolithic. Thus, although Perkins and Daly's interpretation of Suberde as a Neolithic hunters' village is no longer supported, the site continues to provide valuable insights not only into the emergence of pastoralism in the Beyşehir region of central Anatolia, but also concerning the complex nature of the spread of agro-pastoral lifeways throughout SW Asia and beyond.

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Arbuckle, Benjamin S.

2005 "Experimental Animal Domestication and Its Application to the Study of Animal Domestication in Prehistory," in Jean-Denis Vigne, Joris Peters, and Daniel Helmer, eds., *First Steps of Animal Domestication: New Archaeozoological Approaches. Proceedings of the 19th Conference of the International Council of Archaeozoology, Durham, August 2002.* Oxford: Oxbow Books, 18–33.

2006 *The Evolution of Sheep and Goat Pastoralism and Social Complexity in Central Anatolia*. Ph.D. dissertation, Harvard University, Cambridge, MA. Ann Arbor: University Microfilms.

Arbuckle, Benjamin S., and Vecihi Özkaya

2006 "Animal Exploitation at Körtik Tepe: An Early Aceramic Neolithic Site in Southeastern Turkey," *Paléorient* 32: 113–136.

Asouti, Eleni

2003 "Woodland Vegetation and Fuel Exploitation at the Prehistoric Campsite of Pınarbaşı, South-central Anatolia, Turkey: The Evidence From the Wood Charcoal Macro-remains," *Journal of Archaeological Science* 30: 1185–1201.

Asouti, Eleni, and Andrew Fairbairn

2002 "Subsistence Economy in Central Anatolia During the Neolithic: The Archaeobotanical Evidence," in Frédéric Gérard and Laurens Thissen, ed., *The Neolithic of Central Anatolia: Internal Developments and External Relations During the 9th–6th Millennia* CAL B.C. Istanbul: Ege Yayınları, 182–192.

Atıcı, A. Levent, and Aaron J. Stutz

2002 "Mortality Profile Analysis of the Ungulate Fauna from Okuzini: A Preliminary Reconstruction of Site Use, Seasonality, and Mobility Patterns," in Ofer Bar-Yosef, ed., *La Grotte d'Okuzini: Evolution du Paleolithique Final du Sud-*

Ouest de l'Anatolie. Liège: Études et Recherches Archéologiques de L'Université de Liège 96, 101–108.

Bellwood, Peter, and Colin Renfrew
2002 *Examining the Farming/language Dispersal Hypothesis. McDonald Institute Monograph.* Cambridge: McDonald Institute.

Binford, Lewis R., and J. B. Bertram
1977 "Bone Frequencies and Attritional Processes," in Lewis R. Binford, ed., *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling.* New York: Academic Press, 77–153.

Boessneck, Joachim
1985 "Die Domestikation und ihre Folgen," *Tierarztliche Praxis–Supplement* 13: 479–497.

Bökönyi, Sandor
1969 "Archaeological Problems and Methods of Recognizing Animal Domestication," in Peter J. Ucko and G. W. Dimbleby, eds., *The Domestication and Exploitation of Plants and Animals.* Chicago: Aldine Publishing, 219–229.
1976 "Development of Early Stock Rearing in the Near East," *Nature* 264: 19–23.
1989 "Definitions of Animal Domestication," in Juliet Clutton-Brock, ed., *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*. London: Unwin Hyman, 22–27.

Bordaz, Jacques
1965 "Suberde Excavations, 1964," *Anatolian Studies* 15: 30–32.
1966 "Suberde, 1965," *Anatolian Studies* 16: 32–33.
1969 "The Suberde Excavations, Southwestern Turkey: An Interim Report," *Türk Arkeoloji Dergisi* 17: 43–71.
1973 "Current Research in the Neolithic of South Central Turkey: Suberde, Erbaba, and their Chronological Implications," *American Journal of Archaeology* 77: 282–288.
1977 "Beyşehir-Suğla Basin, 1976," *Anatolian Studies* 27: 32–33.

Bordaz, Jacques, and Louise Alper-Bordaz
1977 "Beyşehir-Suğla Basin Project," *American Journal of Archaeology* 81: 291.
1982 "Erbaba: The 1977 and 1978 Seasons in Perspective," *Türk Arkeoloji Dergisi* 26: 85–93.

Buitenhuis, Hijlke
1997 "Aşıklı Höyük: A 'Protodomestication' Site," *Anthropozoologica* 25/26: 655–662.

Caughley, Graeme
1966 "Mortality Patterns in Mammals," *Ecology* 47: 906–918.

Cessford, Craig
2001 "A New Dating Sequence for Çatalhöyük," *Antiquity* 75: 717–725.

Chaplin, Raymond E.
1969 "The Use of Non-morphological Criteria in the Study of Domestication from Bones Found in Archaeological Sites," in Peter J. Ucko and G. W. Dimbleby, eds., *The Domestication and Exploitation of Plants and Animals*. Chicago: Aldine, 231–245.

Collier, S., and J. P. White
1976 "Get Them Young? Age and Sex Inferences on Animal Domestication in Archaeology," *American Antiquity* 41: 96–102.

Coon, Carleton S.
1951 *Cave Explorations in Iran, 1949.* Philadelphia: University of Pennsylvania Museum.

Davis, Simon J.
1984 "The Advent of Milk and Wool Production in Western Iran: Some Speculations," in Juliet Clutton-Brock and Caroline Grigson, eds., *Animals and Archaeology 3: Early Herders and Their Flocks. BAR International Series* 202. Oxford: B. A. R., 265–278.
1987 *The Archaeology of Animals*. New Haven: Yale University Press.
1996 "Measurements of a Group of Adult Female Shetland Sheep Skeletons from a Single Flock: A Baseline for Zooarchaeologists," *Journal of Archaeological Science* 23: 593–612.

Deevey, Edward S.
1947 "Life Tables for Natural Populations of Animals," *The Quarterly Review of Biology* 22: 283–314.

Ducos, Pierre
1968 *L'origine des animaux domestique en Palestine. Publications de Prehistoire de l'Universite de Bordeaux* 6. Bordeaux: Université de Bordeaux.
1978 "'Domestication' Defined and Methodological Approaches to its Recognition in Faunal Assemblages," in Richard H. Meadow and Melinda Zeder, eds., *Approaches to Faunal Analysis in the Middle East. Peabody Museum Bulletin* 2. Cambidge, MA: Peabody Museum, 53–56.

Duru, Güneş
2002 "Some Architectural Indications for the Origins of the Central Anatolian Neolithic," in Frédéric Gérard and Laurens Thissen, eds., *The Neolithic of Central Anatolia: Internal Developments and External Relations During the 9th–6th Millennia CAL B.C.* Istanbul: Ege Yayınları, 171–180.

Dyson, Robert H., Jr.
1953 "Archaeology and Domestication of Animals in the Old World," *American Anthropologist* 55: 661–673.

Esin, Ufuk, and Savaş Harmankaya
1999 "Aşıklı," in Mehmet Özdoğan and Nezih Başgelen, eds., *Neolithic in Turkey: The Cradle of Civilization*. Istanbul: Arkeoloji ve Sanat Yayınları, 115–132.

Fairbairn, Andrew, Eleni Asouti, Julie Near, and Daniele Martinoli
2002 "Macro-botanical Evidence for Plant use at Neolithic Çatalhöyük," *Vegetation History and Archaeobotany* 11: 41–54.

Flannery, Kent V.
1983 "Early Pig Domestication in the Fertile Crescent: A Retrospective Look," in P. Mortensen, ed., *The Hilly Flanks: Essays on the Prehistory of Southwestern Asia Presented to Robert J. Braidwood, November 15, 1982. Studies in Ancient Oriental Civilization* 36. Chicago: Oriental Institute, University of Chicago, 163–188.

French, David
1968 "Excavations at Can Hasan 1967," *Anatolian Studies* 14: 45–56.

Garcia-Gonzales, R., R. Hidalgo, J. M. Ameztoy, and J. Herrero
1992 "Census, Population Structure and Habitat Use of the Chamois Population in Ordesa N. P. Living in Sympatry with Pyrenean Wild Goat," in S. Aulagnier, ed., *Ongules/Ungulates 91 Proceedings of the International Symposium "Ongules/Ungulates 91."* Paris: S.F.E.P.M.–I.R.G.M, 321–325.

Gérard, Frédéric
2002 "Appendix II. CANeW Archaeological Sites Database, Central Anatolia, 10,000–5000 CAL B.C.," in Frédéric Gérard and Laurens Thissen, eds., *The Neolithic of Central Anatolia: Internal Developments and External Relations During the 9th–6th Millenia CAL B.C.* Istanbul: Ege Yayınları, 340–348.

Halstead, Paul
1998 "Mortality Models and Milking: Problems of Uniformitarianism, Optimality, and Equifinality Reconsidered," *Anthropozoologica* 27: 3–20.

Harris, David R.
1996 *The Origins and Spre ad of Agriculture and Pastoralism in Eurasia.* Washington, D.C.: Smithsonian Press.

Hecker, Howard
1982 "Domestication Revisited: Its Implications for Faunal Analysis," *Journal of Field Archaeology* 9: 217–236.

Helmer, Daniel
1988 "Les animaux de Cafer et des sites preceramiques du sudest de la Turquie: Essai de synthese," *Anatolica* 15: 37–48.
1992 *La Domestication des Animaux Par les Hommes Préhistoriques.* Paris: Masson.

Hemmer, Helmut
1990 *Domestication. The Decline of Environmental Appreciation.* Cambridge: Cambridge University Press.

Hesse, Brian
1978 *Evidence for Husbandry from the Early Neolithic Site of Ganj Dareh in Western Iran.* Ph.D. dissertation, Columbia University, New York. Ann Arbor: University Microfilms.
1982 "Slaughter Patterns and Domestication: The Beginnings of Pastoralism in Western Iran," *Man* 17: 403–417.

Higgs, Eric, and Michael R. Jarman
1969 "The Origins of Agriculture: A Reconsideration," *Antiquity* 43: 31–41.

Hillman, Gordon C.
1978 "On the Origins of Domestic Rye—*Secale cereale:* The Finds from Aceramic Can Hasan III in Turkey," *Anatolian Studies* 28: 157–174.

Hoefs, M., and M. Bayer
1983 "Demographic Characteristics of an Unhunted Dall Sheep *(Ovis dalli dalli)* Population in Southwest Yukon, Canada," *Canadian Journal of Zoology* 61: 1346–1357.

Hole, Frank, Kent V. Flannery, and James A. Neely
1969 *Prehistory and Human Ecology on the Deh Luran Plain. Museum of Anthropology, University of Michigan Memoir* No. 1. Ann Arbor: Museum of Anthropology, University of Michigan.

Horwitz, Liora K., Eitan Tchernov, Pierre Ducos, Cornelia Becker, Angela von den Driesch, Louise Martin, and Andrew Garrard
1999 "Animal Domestication in the Southern Levant," *Paléorient* 25: 63–80.

Ingold, Tim
1974 "On Reindeer and Men," *Man* 9: 523–538.
1980 *Hunters, Pastoralists, and Ranchers: Reindeer Economies and Their Transformation.* Cambridge: Cambridge University Press.

Jarman, Michael R., and Paul F. Wilkinson
1972 "Criteria of Animal Domestication," in Eric S. Higgs, ed., *Papers in Economic Prehistory.* Cambridge: Cambridge University Press, 83–96.

Köhler-Rollefson, Ilse
1989 "Changes in Goat Exploitation at 'Ain Ghazal between the Early and Late Neolithic: A Metrical Analysis," *Paléorient* 15: 141–146.

Makarewicz, Cheryl, and Noreen Tuross
2006 "Foddering by Mongolian Pastoralists is Recorded in the Stable Carbon (d13C) and Nitrogen (d15N) Isotopes of Caprine Dentinal Collagen," *Journal of Archaeological Science* 33: 862–870.

Marean, Curtis W.
1995 "Of Taphonomy and Zooarchaeology," *Evolutionary Anthropology* 4: 64–72.

Martin, Louise, Nerissa Russell, and Denise Carruthers
2002 "Animal Remains from the Central Anatolian Neolithic," in Frédéric Gérard and Laurens Thissen, eds., *The Neolithic of Central Anatolia: Internal Developments and External Relations During the 9th–6th Millennia CAL B.C.* Istanbul: Ege Yayınları, 193–216.

Meadow, Richard H.
1989 "Osteological Evidence for the Process of Animal Domestication," in Juliet Clutton-Brock, ed., *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation.* London: Unwin Hyman, 80–96.
1999 "The Use of Size Index Scaling Techniques for Research on Archaeozoological Collections from the Middle East," in J. Schibler, ed., *Historia Animalium Ex Ossibus: Beitrage zür Palaoanatomie, Archaologie, Agyptologie, Ethnologie, and Geschichte der Tiermedizin.* Rahden: Verlag Marie Leidorf, 285–300.

Mithen, Steve, Bill Finlayson, Anne Pirie, Denise Carruthers, and Amanda Kennedy
2000 "New Evidence for Economic and Technological Diversity in the Pre-Pottery Neolithic A: Wadi Faynan 16," *Current Anthropology* 41: 655–663.

Moran, N. C., and T. P. O'Connor
1994 "Age Attribution in Domestic Sheep by Skeletal and Dental Maturation: A Pilot Study of Available Sources," *International Journal of Osteoarchaeology* 19: 181–204.

Munson, Patrick J.
1991 "Mortality Profiles of White-Tailed Deer from Archaeological Sites in Eastern North America: Selective Hunting or Taphonomy?" in James R. Purdue, Walter E. Klippel, and Bonnie W. Styles, eds., *Beamers, Bobwhites, and Blue-points: Tributes to the Career of Paul W. Parmalee. Illinois State Museum Scientific Papers* 23. Springfield: Illinois State Museum, 139–151.
2000 "Age-correlated Differential Destruction of Bone and Its Effect on Archaeological Mortality Profiles of Domestic Sheep and Goats," *Journal of Archaeological Science* 27: 391–407.

Murie, Adolph
1944 *The Wolves of Mount McKinley.* Washington, D.C.: United States Department of Interior, National Park Service Publications.

Noddle, Barbara
1974 "Ages of Epiphyseal Closure in Feral and Domestic Goats and Ages of Dental Eruption," *Journal of Archaeological Science* 1: 195–204.

Özbaşaran, Mihriban
1999 "Musular: A General Assessment on a New Neolithic Site in Central Anatolia," in Mehmet Özdoğan and Nezih

Başgelen, eds., *Neolithic in Turkey the Cradle of Civilization*. Istanbul: Arkeoloji ve Sanat Yayınları, 147–156.

Özbaşaran, Mihriban, and Hijlke Buitenhuis
2002 "Proposal for a Regional Terminology for Central Anatolia," in Frédéric Gérard and Laurens Thissen, eds., *The Neolithic of Central Anatolia: Internal Developments and External Relations during the 9th–6th Millennia CAL B.C.* Istanbul: Ege Yayınları, 67–77.

Papageorgiou, Nicholaos
1979 *Population Energy Relationships of the Agrimi* (Capra aegagrus cretica) *on Theodorou Island, Greece*. Hamburg: Verlag Paul Parey.

Payne, Sebastian
1972 "Can Hasan III, The Anatolian Aceramic and the Greek Neolithic," in Eric S. Higgs, ed., *Papers in Economic Prehistory*. Cambridge: Cambridge University Press, 191–194.
1973 "Kill-off Patterns in Sheep and Goats: The Mandibles from Asvan-Kale," *Anatolian Studies* 23: 281–303.
1985 "Animal Bones from Aşıklı Höyük," *Anatolian Studies* 35: 109–122.

Perkins, Dexter P.
1964 "Prehistoric Fauna from Shanidar, Iraq," *Science* 144: 1565–1566.
1973 "The Beginnings of Animal Domestication in the Near East," *American Journal of Archaeology* 77: 279–282.

Perkins, Dexter P., and Patricia Daly
1968 "A Hunters' Village in Neolithic Turkey," *Scientific American* 219: 96–106.

Peters, Joris, Daniel Helmer, Angela von den Driesch, and Maria Saña Segui
1999 "Early Animal Husbandry in the Northern Levant," *Paléorient* 25: 27–47.

Price, Edward O.
1998 "Behavioral Genetics and the Process of Animal Domestication," in Temple Gradin, ed., *Genetics and the Behavior of Domestic Animals*. Boston: Academic Press, 31–65.

Price, T. Douglas, and Anne B. Gebauer, editors
1995 *Last Hunters, First Farmers*. Santa Fe: School of American Research.

Redding, Richard
2005 "Breaking the Mold: A Consideration of Variation in the Evolution of Animal Domestication," in Jean-Denis Vigne, Joris Peters, and Daniel Helmer, eds., *First Steps of Animal Domestication: New Archaeozoological Approaches. Proceedings of the 19th Conference of the International Council of Archaeozoology, Durham, August 2002*. Oxford: Oxbow Books, 41–48.

Reed, Charles A.
1959 "Animal Domestication in the Prehistoric Near East," *Science* 130: 1629–1639.

Rosenberg, Michael
1999 "Hallan Çemi," in Mehmet Özdoğan and Nezih Başgelen, eds., *Neolithic in Turkey: The Cradle of Civilization: New Discoveries*. Istanbul: Arkeoloji ve Sanat Yayınları, 25–33.

Russell, Nerissa, and Louise Martin
2005 "The Çatalhöyük Mammal Remains," in Ian Hodder, ed., *Inhabiting Çatalhöyük: Reports from the 1995–1999 Seasons*. Cambridge: McDonald Institute for Archaeological Research, 33–98.

Rutimeyer, Ludwig
1862 *Die Fauna der Pfahlbauren der Schweiz*. Zurich: Druck von Zilteher und Furrer.

Schaller, George B.
1977 *Mountain Monarchs: Wild Sheep and Goats of the Himalyah*. Chicago: University of Chicago Press.

Silver, I. A.
1970 "The Aging of Domestic Animals," in Don R. Brothwell and Eric Higgs, eds., *Science in Archaeology: A Survey of Progress and Research*. London: Thames and Hudson, 283–299.

Simmons, Alan H., and G. Ilany
1975–1977 "What Mean these Bones?," *Paléorient* 3: 269–274.

Solecki, Ralph S.
1964 "An Archaeological Reconnaissance in the Beyşehir-Suğla Area of South Western Turkey," *Türk Arkeoloji Dergisi* 13: 129.

Stampfli, Hans R.
1983 "The Fauna of Jarmo with Notes on Animal Bones from Matarrah, the Amuq, and Karim Shahir," in Robert J. Braidwood, ed., *Prehistoric Archaeology Along the Zagros Flanks. Oriental Institute Publications* 105. Chicago: Oriental Institute, 431–483.

Stiner, Mary C.
1990 "The Use of Mortality Patterns in Archaeological Studies of Hominid Predatory Adaptations," *Journal of Anthropological Archaeology* 9: 305–351.

Uerpmann, Hans-Peter
1978 "Metrical Analysis of Faunal Remains from the Middle East," in Richard H. Meadow and Melinda Zeder, eds., *Approaches to Faunal Analysis in the Middle East. Peabody Museum Bulletin* No. 2. Cambridge, MA: Peabody Museum of Archaeology and Ethnology, 41–45.
1979 *Probleme der Neolithisierung des Mittelmeeraums*. Wiesbaden: Verlag.

Uerpmann, Margarethe, and Hans-Peter Uerpmann
1994 "Animal Bone Finds from Excavation 520 at Qala'at al-Bahrain," in H. H. Anderson, ed., *Qala'at al-Bahrain. Volume 1. The Northern City Wall and the Islamic Fortress. Jutland Archaeological Society Publications* 30.1. Aarhus: Jutland Archaeological Society, 417–444.

van Zeist, Willem, and Hijlke Buitenhuis
1983 "A Paleobotanical Study of Neolithic Erbaba, Turkey," *Anatolica* 10: 47–89.

Vigne, Jean-Denis, and Daniel Helmer
2007 "Was Milk a 'Secondary Product' in the Old World Neolithisation Process? Its Role in the Domestication of Cattle, Sheep, and Goats," *Anthropozoologica* 42: 9–40.

Vigne, Jean-Denis, Hijlke Buitenhuis, and Simon Davis
1999 "Les premiers pas de la domestication animale à l'ouest de l'Euphrate: Chypre et l'Anatolie centrale," *Paléorient* 25: 49–62.

Vigne, Jean-Denis, Isabelle Carrere, and Jean Guilaine
2003 "Unstable Status of Early Domestic Ungulates in the Near East: the Example of Shillourokambos (Cyprus, IX–VIIIth millennia CAL. B.C.)," in Jean Guilaine and Alain Le Brun, eds., *Le Neolithique de Chypre. Actes du colloque international organise par le Department des Antiquites de Chypre et l'Ecole Française d'Athenes, Nicosie 17–19, Mai 2001*. Athens: Ecole Française d'Athenes, 239–251.

von den Driesch, Angela
1976 *A Guide to the Measurements of Animal Bones from Archaeological Sites*. *Peabody Museum Bulletin* 1. Cambridge, MA: Peabody Museum of Archaeology and Ethnology.

von den Driesch, Angela, and Joris Peters
1999 "Vorläufiger Bericht über die archäozoologischen Untersuchungen am Göbekli Tepe und am Gürcütepe bei Urfa, Türkei," *Istanbuler Mitteilungen* 49: 23–39.

Watson, J. P. N.
1978 "The Interpretation of Epiphyseal Fusion Data," in D. R. Brothwell, K. D. Thomas, and Juliet Clutton-Brock, eds., *Research Problems in Zooarchaeology. Institute of Archaeology Occasional Publication* No. 3. London: Institute of Archaeology, 97–101.

Weiss, Ehud, Mordechai E. Kislev, and Anat Hartmann
2006 "Autonomous Cultivation Before Domestication," *Science* 312: 1608–1610.

Wilkinson, Paul F.
1976 "Random Hunting and the Composition of Faunal Samples from Archaeological Excavations: A Modern Example from New Zealand," *Journal of Archaeological Science* 3: 321–328.

Wright, Gary, and Susanne Miller
1976 "Prehistoric Hunting of New World Wild Sheep: Implications for the Study of Sheep Domestication," in Charles Cleland, ed., *Cultural Change and Continuity: Essays in Honor of James Bennett Griffin*. New York: Academic Press, 293–318.

Zeder, Melinda
2001 "A Metrical Analysis of a Collection of Modern Goats *(Capra hircus aegagrus and C. h. hircus)* from Iran and Iraq: Implications for the Study of Caprine Domestication," *Journal of Archaeological Science* 28: 61–79.

2005 "A View from the Zagros: New Perspectives on Livestock Domestication in the Fertile Crescent," in Jean-Denis Vigne, Joris Peters, and Daniel Helmer, eds., *The First Steps of Animal Domestication: New Archaeological Approaches. Proceedings of the 19th International Council of Archaeozoo logy Conference, Durham, August 2002*. Oxford: Oxbow, 125–146.

2006a "Central Questions in the Domestication of Plants and Animals," *Evolutionary Anthropology* 15: 105–117.

2006b "A Critical Assessment of Markers of Initial Domestication in Goats *(Capra hircus)*," in Melinda Zeder, Daniel G. Bradley, Eve Enshmiller, and Bruce D. Smith, eds., *Documenting Domestication: New Genetic and Archaeological Paradigms*. Berkeley: University of California Press, 181–208.

2006c "Reconciling Rates of Long Bone Fusion and Tooth Eruption and Wear in Sheep *(Ovis)* and Goat *(Capra)*," in D. Ruscillo, ed., *Ageing and Sexing Animals From Archaeological Sites*. Oxford: Oxbow, 87–118.

Zeder, Melinda, and Brian Hesse
2000 "The Initial Domestication of Goats *(Capra hircus)* in the Zagros Mountains 10,000 Years Ago," *Science* 287: 2254–2257.

Zohary, Daniel, Eitan Tchernov, and Liora K. Horwitz
1998 "The Role of Unconscious Selection in the Domestication of Sheep and Goats," *Journal of Zoology* 245: 129–135.