The evolution of sheep and goat husbandry in central Anatolia

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ABSTRACT
This paper explores the evolution of sheep and goat husbandry in central Anatolia through the analysis of new and published faunal data from Neolithic, Chalcolithic, and Bronze Age sites in the region. The major patterns of change over time in the pastoral system are discussed including the beginnings of herding, the appearance of the practice of young male kill-off, and the timing of the onset of the intensive use of secondary products. Results, including the discovery of longstanding differences in the management of sheep and goats as well as synchronic differences in herding strategies, have important implications for understanding the role of animal husbandry in central Anatolian communities and indicate that the history of pastoral production in the region is complex and multi-faceted.

KEY WORDS
Pastoralism,
herd management,
sheep,
goat,
domestication,
Neolithic,
Chalcolithic,
Bronze Age,
central Anatolia,
Turkey.

RÉSUMÉ
L'évolution de l'élevage des moutons et des chèvres en Anatolie centrale
Cet article aborde l'évolution de l'élevage des moutons et des chèvres en l'Anatolie centrale à travers l'analyse de données nouvelles et publiées

MOTS CLÉS
Pastoralisme, gestion du troupeau, mouton, chèvre, domestication, Néolithique, Chalcolithique, âge du Bronze, Anatolie centrale, Turquie.

provenant de sites de la région datant du Néolithique, du Chalcolithique et de l'âge de Bronze. Les principaux modes de changement dans le temps du système pastoral sont examinés, depuis les débuts de l'élevage, l'apparition de la pratique de l'abattage des jeunes mâle et le moment de l'apparition de l'utilisation intensive des produits secondaires. Les résultats, y compris la découverte de différences durables dans le gestion des moutons et des chèvres ainsi que de différences synchroniques dans les stratégies d'élevage, ont d'importantes implications pour la compréhension du rôle de l'élevage dans les communautés d'Anatolie centrale. Ils montrent que l'histoire de la production pastorale dans la région est complexe et multi-facettes.

INTRODUCTION

As one of the most important socioeconomic systems in the ancient and modern Near East, pastoralism, the herding of domestic hoofed ungulates, whether practiced by nomads, agro-pastoralists, within egalitarian tribes or stratified states, has been a major focus of anthropological research for more than a half century (de Planhol 1958, Barth 1959, Irons 1969, Salzman 1971; 2004, Dyson-Hudson 1972, Irons & Dyson-Hudson 1972, Bates 1973, Garthwaite 1978, Tapper 1979, Beck 1986, Black-Michaud 1986, Galaty & Johnson 1990, Borgerhoff Mulder & Sellen 1994, Azarya 1996). Archaeologists have been particularly interested in addressing three broad questions related to pastoralism including: 1) the origins of sheep and goat herding, which represents the first successful domestication of a food animal (Helmer 1992, Harris 1996, Horwitz *et al.* 1999, Peters *et al.* 1999, Zeder & Hesse 2000, Vigne *et al.* 2005), 2) the development of highly productive, milk and fiber producing herds (Sherratt 1981, Greenfield 1989), and 3) the appearance of large scale, mobile pastoral systems known from historical periods in the region (Barth 1961, Irons 1975, Matthews 1978, Beck 1986, Bar-Yosef & Khazanov 1992, Zeder 1994b, Bar-Yosef & Meadow 1995, Grigson 2000, Fleming 2004, Greenfield & Fowler 2005). It is widely recognized that each of these transitions represents major transformative events in the culture history of the Near East (Sherratt 1981; 1983, Bar-Yosef & Khazanov 1992).

In this paper we describe the broad patterns of change over time in this central socioeconomic system with a particular focus on examining evidence for sheep and goat husbandry in central Anatolia from the Neolithic through the Bronze Age. Despite a rapid increase in studies detailing the nature of animal economies in central Anatolia (*e.g.*, Boessneck & Wiedemann 1977, von den Driesch & Boessneck 1981, Hongo 1993; 1998; 1999; 2004, Zeder & Arter 1994, Buitenhuis 1996; 1997; 1999, De Cupere & Waelkens 1998, Howell-Meurs 2001; Martin *et al.* 2002, Atıcı 2003; 2005, Carruthers 2003, De Cupere & Duru 2003, von den Driesch & Pöllath 2004, Russell & Martin 2005, Russell, *et al.* 2005, Martin & Russell 2006) there have been few attempts to look at the broad patterns of change over multiple chronological/cultural periods and to synthesize results from multiple sites (although for the Neolithic period see Martin *et al.* 2002). As a result, a central component of the cultural history of the region remains poorly known.

By focusing on the evolution of pastoral production in the *longue durée*, the goal of this paper is to present a broad picture of the evolution of sheep and goat husbandry patterns in central Anatolia and to address important transitions including the initial appearance of pastoral economies as well as the development of more intensive pastoral management strategies including the use of herds for secondary, or antemortem, products (*i.e.*, milk, fiber) (after Vigne & Helmer 2007). In addition to representing an important increase in the productive potential of ancient herds, this last feature is often seen as a necessary precondition for the development of large scale, specialized and mobile forms of pastoralism, the development of which is also addressed.

The following discussion is based on a body of new and published faunal data from seven sites in central Anatolia representing Neolithic, Chalcolithic and Bronze Age settlements (Fig. 1; Table 1). Although chronological coverage is not complete, the current sample does provide a valuable means to address major questions of change over time in systems of caprine husbandry in this region.

BACKGROUND

In order to address questions concerning pastoral production we focus on a combination of age and measurement data for sheep and goats. Age data, based on the state of fusion of the epiphyses of long bones and the eruption and wear of mandibular teeth, can be used to interpret the age composi-

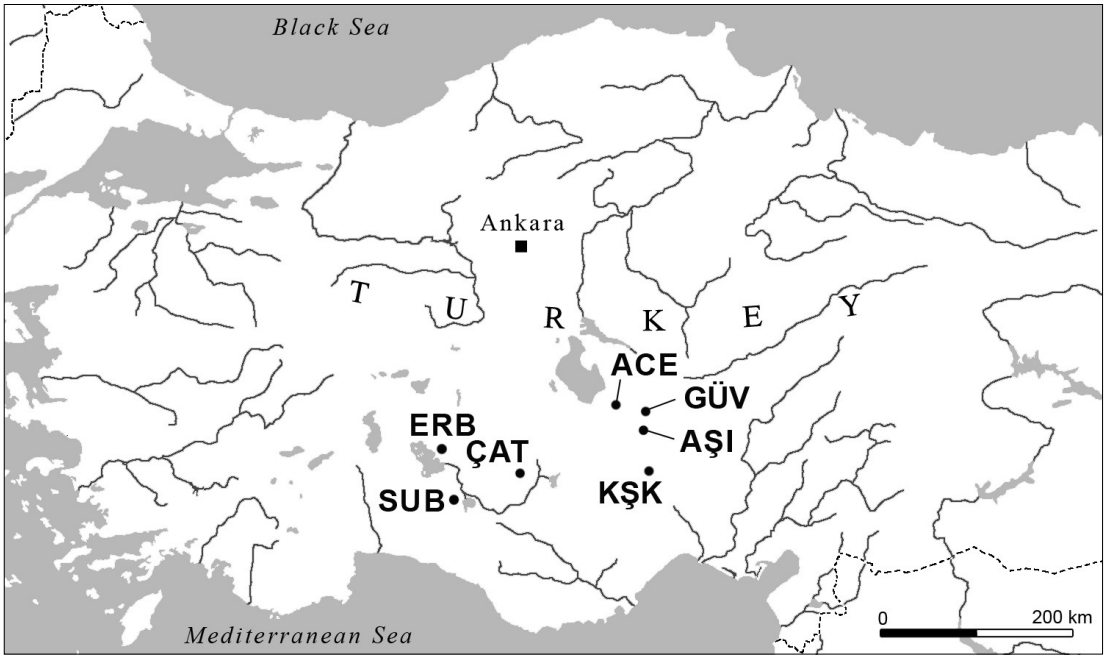


FIG. 1. — Map of Turkey showing the location of sites mentioned in the text. AŞI = Aşıklı; ERB = Erbaba; ÇAT = Çatalhöyük; SUB = Suberde; KŞK = Köşk Höyük; GÜV = Güvercinkayası; ACE = Acemhöyük.

TABLE 1. — Approximate chronological relationships of the primary sites mentioned in the text as well as the frequency of caprines and the ratio of sheep to goat in each assemblage (from Perkins & Daly 1968, Buitenhuis 1997, Cessford 2001, Thissen 2002, Martin & Russell 2005, Arbuckle 2006).

Site	Approx. date cal BC	% caprines	Sheep: goat ratio
Aşıklı Höyük	8200-7500	84	4.0:1
Suberde	7400-7000	82	5.6:1
Çatalhöyük pre-XII to IV	7400-6200	65-75	7.0:1
Erbaba	6500-6000	77	4.6:1
Köşk II-V	6200-5500	60	3.5:1
Köşk I	5200-4800	83	3.2:1
Güvercinkayası	5200-4800	81	4.3:1
Acemhöyük II-III	2000-1800	65	1.7:1

tion of the animals chosen for slaughter (Hesse & Wapnish 1985, Davis 1987, Lyman 1994). These are often presented in the form of survivorship curves, which visually represent the frequency of animals surviving increasingly old age categories, beginning with 100% at age category 1 and ending with none surviving past age category X (Payne 1973, Levine 1983, Lyman 1994). Although there are several methods for generating survivorship curves, this paper follows the life table method common in the wildlife literature (Deevey 1947, Quick 1963, Caughley 1966, Lyman 1994) in which each survivorship value (sometimes denoted as "lx") represents an estimate of the percentage of individuals surviving at the beginning of a given age category. In a recent paper focusing on the interpretation of mortality data, Vigne and Helmer (2007: 20-21) suggest that when calculating mortality profiles, a correction factor should be applied in order to account for the varying lengths of time represented by the most commonly used age stages (Payne's (1973) Mandibular Wear Stages A-I). However, since mortality data in this paper are presented in the form of survivorship curves, this suggested correction factor is not utilized. Since each survivorship (lx) value represents an estimate of the percentage of animals surviving at the beginning of age category X, differences in the length of each category (if within reason) are relatively unimportant. However, when mortality values (dx values in wildlife studies) representing the number of deaths in a particular age category are presented as the focus of analysis (as they are in Vigne and Helmer 2007) then it makes more sense to address the varying lengths of each age category with a correction factor (also see Payne 1973: Table 3, figures 15 and 16).

In this paper, measurement data including those derived from both fused and unfused specimens are used to identify size diminution associated with the process of domestication (Bökönyi 1969, Ducos 1978, Uerpmann 1979, Davis 1987, Meadow 1989, Zeder 2006) and, in combination with survivorship curves, to determine the proportions of males and females slaughtered within specific age groups (Hesse 1978, Zeder & Hesse 2000, Zeder 2001).

In order to use these sources of data to interpret the goals of pastoral production, we focus on models that link the age and sex composition of animals chosen for slaughter with general goals of pastoral production. The link between these variables has been discussed by many researchers (*e.g.* Higham 1967, Ducos 1968, Redding 1981; 1984, Zeder 1991; 2001, Helmer 1992, Vigne & Helmer 2007) but has been described most influentially in the form of predictive models by Payne (1973). These models define the basic relationships between the goals of herd management — whether focused on maximizing the production of primary (or post-mortem) products such as meat or secondary (or antemortem) products such as milk or fiber — and the sex and age composition of the animals chosen for slaughter.

Briefly, the meat model predicts that when the goal of production is primarily meat, most young males will be killed when they reach an optimum point in weight-gain — between 18-30 months (Payne 1973: 281-82; also Digard 1981, Redding 1981, Black-Michaud 1986, Salzman 2004). The age at which males will be slaughtered within this range (or even outside of it) may vary depending on a variety of factors including the cost/availability of fodder and graze, the availability of labor to supervise herds, the immediate financial or other needs of the herder, environmental conditions, and cultural/market preferences for lamb or the meat of other specific demographic groups. This model predicts that when meat is the primary goal of production, the resulting survivorship curve drops precipitously for males some time in the first 2.5 years while female survivorship declines much more gradually through adulthood. As a result, in the meat model the vast majority of animals surviving into adulthood are females (80-98% based on ethnographic examples (Bates 1973: 147, Redding 1981)).

The fiber model predicts that when the primary goal of production is wool or hair, herders shift their management strategy towards culling adult individuals (Payne 1973: 282). As a result, this model predicts that when fiber is the primary goal of production, the majority of animals will survive well into adulthood, and, in contrast to the meat model, the adult population will consist of both females and males (often castrated) since both are effective fiber producers. Identification of both of these features is critical to the identification of the fiber model and for distinguishing fiber production

from a meat profile in which the juveniles have been deleted by taphonomic factors.

Payne's third model describes the management expectations when the goal is the intensive production of milk. This model predicts that when milk is the primary goal of production herders will slaughter most males as young lambs so as to maximize the milk available for human consumption. This model is distinguishable from the meat model in its focus on the slaughter of males in the youngest age categories. Of all of the production models there has been the most discussion concerning the application of the milk model to archaeological contexts (see Halstead 1998 and references therein). Arguments have tended to fall into three categories.

First, although slaughter of surplus animals in the first 6-8 weeks following birth is common practice among modern dairy producers and acts to maximize the milk available for human consumption, some have raised doubts as to whether primitive domestic breeds could produce milk in the absence of an infant (Clutton-Brock 1981, McCormick 1992, Balasse 2002). Isotopic work by Balasse and Tresset (2002) has suggested that this may have been the case for Neolithic cattle in Europe, which appear to have been weaned at 6-9 months rather than in the first weeks. However, this issue of milk let-down may be a less serious issue for caprines (Halstead 1998: 5-6).

Secondly, Payne's milk model describes a system of highly intensive milk production focused on producing for large-scale markets and its applicability to prehistoric socioeconomic contexts has been questioned. Halstead (1998) has suggested that this type of management system is probably most likely under conditions in which herders are highly dependent upon animal products, have large herds, and are highly integrated into a market economy (*i.e.*, specialized pastoralists). Smaller scale, subsistence-oriented producers are more likely to space the slaughter of surplus rams out over an extended period of months or even years sacrificing the quantity of milk available but providing a "walking larder" as a hedge against future potential insecurities (see Redding (1981) for a detailed discussion of risk reduction as a herding strategy). This delayed slaughter of surplus lambs is likely to look very much like Payne's meat model and thus the non-intensive production of herds for milk in addition to meat may be indistinguishable from the range of variation expected within the meat model. Finally, the interpretation of dairy production from mortality profiles is characterized by the problem of equifinality. Like all archaeological patterns, mortality profiles similar to the milk model could potentially be explained by a host of behaviors other than dairy production (Halstead 1998). In particular, production systems focused on very young tender meat, the presence of high infant mortality (as in cases of crowded penning and stalling), or sampling from areas containing high proportions of infant remains (*e.g.*, shrines or temples) could produce mortality patterns that mimic the milk model. Halstead (1998: 14) has pointed out that while taphonomic biases, particularly those affecting the remains of the youngest individuals, are likely to mask archaeological evidence for intensive milk production (*e.g.*, Munson 2000), they are less likely to artificially create it (also Vigne & Helmer 2007: 16). However, as discussed above, convergent mortality patterns resulting from different management strategies (*e.g.*, subsistence production of milk vs intensive meat production) remain a major obstacle to the interpretation of the goals of pastoral production.

Moreover, Halstead has also rightly pointed out the fundamental weakness in mortality evidence for dairying: that while the intensive culling of surplus lambs does "imply that herd management enhanced the *potential* for production of milk rather than [other products]" (Halstead 1998: 7, original emphasis), it does *not* prove that milk was actually exploited. As a result, multiple interpretations are always possible and milk production remains one of the most difficult management systems to identify archaeologically.

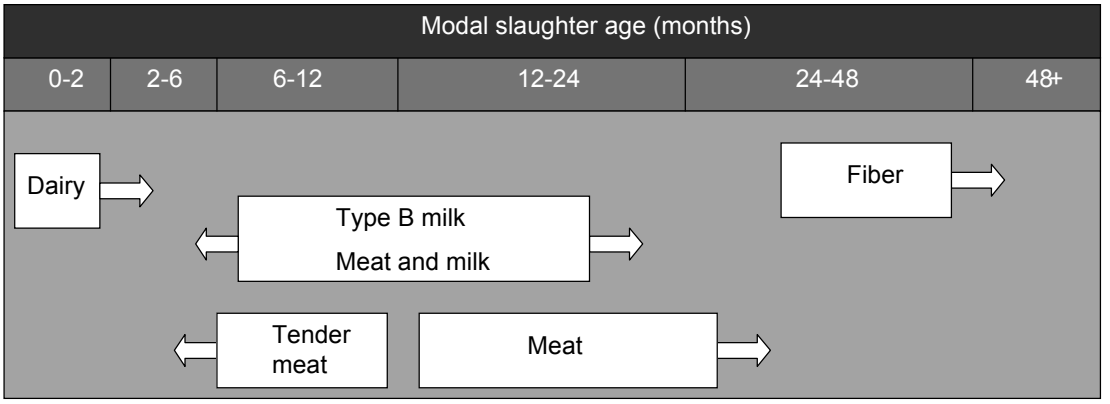
Payne's three models represent theoretical constructs that describe patterns of herd management expected under optimizing conditions. As a result, they are best viewed as heuristic devices, which serve as a starting point from which to interpret archaeological patterns, which themselves are not expected to represent optimization (Halstead 1998: 4-5). As Payne (1973: 282) noted, herders rarely focus on a single product and must instead balance between conflicting requirements represented by management for multiple products, as well as in response

to a host of social, political, and environmental variables. However, instead of representing a weakness, the theoretical nature of these models is also their greatest strength, as it is through the process of identifying deviations from optimality that we begin to interpret the complex management behaviors of herders.

Although rarely discussed, Payne (1973: 282) provides several examples of the interpretation of deviations from his optimization models illustrating how multiple production goals might be balanced. For example, if both meat and milk are produced and milk is of primary importance and either labor or winter graze/fodder is restricted or expensive, then most male lambs will slaughtered before their first winter at 6-9 months. If the production of meat is of greater importance, if winter feeding poses few problems, and if labor is available then surplus males are likely to be slaughtered in their second and even third years. However, if winter feed is expensive or unavailable and labor is in short supply then surplus lambs may again be slaughtered before their first winter. In this way, deviations from the expected models can be interpreted in terms of variables including mixed production goals, costs of fodder, availability of winter pasture, availability of labor, as well as the influence of markets.

Vigne and Helmer (2007 and references therein) have recently made an important contribution to the interpretation of management strategies by proposing two new models in addition to those defined by Payne. These include a "type B milk" model and a "tender meat" model. In contrast to Payne's model (termed the "type A milk" model), the "type B milk" model is characterized by the delayed slaughter of lambs throughout their first year similar to the situation described above for non-intensive village herders (Halstead 1998: 9, also Payne 1973: 282). This model produces mortality peaks among older lambs, from 6-12 months, and then again for adult females between 2-4 years. The "tender meat" model predicts a kill-off of young rams between the ages of 6-12 months rather than between 18-30 months as in Payne's meat model (also see Payne 1973: 282). These models are presented to fill perceived gaps in the Payne models and represent "intermediate" management strategies, which are then used by Vigne and Helmer to interpret complex "mixtures" of different types of production goals including tender meat + type B milk, or fiber + meat, based largely on the location of modal mortality age. Although the development of more detailed models with which to interpret mortality data is beneficial, one must always be mindful of the inherent weaknesses in the use of mortality data to interpret management strategies. Perhaps the most important of these — as discussed earlier as a criticism of Payne's milk model — is equifinality, both through the likelihood that multiple strategies with different production goals can produce similar mortality profiles (*e.g.*, tender meat, type B milk, mixed meat and milk) as herders make complex and often conflicting management decisions in response to dynamic social and environmental conditions, as

Table 2. — Summary of the relationship between modal slaughter age and the goals of herd management.



well as through the alteration of mortality profiles through taphonomic processes.

The suite of models discussed above provides the framework for interpreting management goals from mortality profiles with the full acknowledgement of their inherent shortcomings. Together they provide several points along a continuum of possible management strategies each focused on increasingly aged animals (see Table 2). These models are not viewed as the final answers to questions of pastoral production but instead are used as suggested points of entry into the process of interpreting the management decisions of ancient herders.

There are two additional issues that must also be addressed when interpreting mortality evidence for herd management. The first is the issue of mobility and the fact that mortality data derived from one site may reflect an incomplete sample of a husbandry system (Meadow 1980). If management strategies include seasonal movements to and from summer pastures, for example, then the archaeological patterns derived from either summer or winter residence sites will represent a truncated mortality profile reflecting only a portion of the complete system (*e.g.*, Cribb 1984, Vigne & Helmer 2007: 22). As Vigne and Helmer (2007) point out this represents a significant "trap" for archaeologists that can be addressed only through regional sampling of different types of sites (*e.g.*, Helmer *et al.* 2005).

The second issue is one of provisioning. Particularly in the context of complex societies, the provisioning of settlements with meat, often by specialized producers, can have a significant impact on the interpretation of mortality data (*e.g.*, Stein 1987, Wapnish & Hesse 1988; 1991, Crabtree 1990; 1996, Zeder 1991). Urban systems are often characterized by systems in which rural producers provision urban consumers. Stein (1987) has contrasted "consumer" mortality profiles characterized by a relatively narrow range of ages and "producer" patterns, which are expected to include a dearth of market-aged animals. Thus the movement of animals of particular demographic groups to and from producer and consumer sites has the potential to create mortality profiles that primarily represent systems of distribution rather than production (Zeder 1991) and must be taken into account when interpreting mortality data, particularly in (but not limited to) complex societies.

SITES AND DATA

The sites examined in this paper represent a range of settlement types including large and small Neolithic and Chalcolithic agricultural villages as well as one large Bronze Age center (Fig. 1; Table 1). Age and measurement data from these sites allow us to address the character of systems of caprine husbandry in the region and their change over time from the earliest Neolithic to the Bronze Age.

AŞIKLI HÖYÜK

Aşıklı Höyük is a large mound site located in the mountainous region of Cappadocia (Esin & Harmankaya 1999) (Fig. 1). The site represents an early phase of the colonization of central Anatolia by sedentary farmers in the Aceramic Neolithic and dates to the late ninth and early eighth millennia cal BC (middle PPNB in the Levant) (Table 1) (Thissen 2002).

Buitenhuis (1997) found that the animal economy at Aşıklı was dominated by caprines (Table 1). However, questions remain concerning how caprines were exploited at this site, and whether they were herded or hunted (Vigne *et al.* 1999, Martin *et al.* 2002). Survivorship curves based on epiphyseal fusion indicate that the Aşıklı caprines were slaughtered primarily between the ages of 1-3 years, with relatively few animals surviving past the age of fusion of the distal radius (c. 36 months) (Fig. 2). In addition, Buitenhuis noted the presence of a

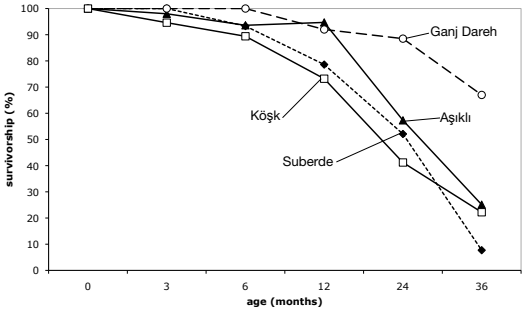


FIG. 2. – Survivorship curves based on epiphyseal fusion for sheep/goats for Aşıklı Höyük (n = 2806) (from Buitenhuis 1997), Köşk Höyük I-V (n = 473), Suberde (n = 95) (from Arbuckle 2008a) and wild sheep from Ganj Dareh (n = 2112) (from Hesse 1978).

significant number of neonatal caprine remains in the assemblage. The focus on culling animals within a narrow age range is commonly associated with human management, while hunting often (but certainly not always) results in higher proportions of "prime-aged" adult individuals (Stiner 1990) (compare curves for Köşk and Ganj Dareh in Fig. 2). Moreover, the remains of neonatal animals are not uncommon at Neolithic and later period sites characterized by herding economies, but they can also be an indicator of spring hunting (*e.g.*, Davis & Fischer 1990). Together, these mortality data have been used to suggest that the Aşıklı caprines were "appropriated" resources (Vigne & Buitenhuis 1999: 58, Martin *et al.* 2002) and were subject to an early form of herd management that Buitenhuis (1997) referred to as "proto-domestication".

Moreover, Buitenhuis has argued that the Aşıklı caprines represent a morphologically wild population, *i.e.*, they exhibit no evidence for a decrease in size or other morphological changes often associated with the process of domestication, throughout the occupational sequence of the site, a period spanning c. 400 years. Although morphological changes are not expected to characterize the earliest stages of human management over animals populations (Zeder & Hesse 2000, Zeder 2006), the lack of evidence for the development of morphological changes over this extended period of time is interesting and suggests that animals may not have been under intensive human management and/or were not reproductively isolated from local wild caprine populations (Arbuckle 2005).

In addition, Buitenhuis (1997: 659) reports that the sex ratio for sheep at Aşıklı is slightly biased in favor of females, while for goats it is skewed towards males. These results are evident in the distribution of astragalus measurements presented in Figures 3 and 4. For sheep, these measurements are skewed slightly towards the left indicating an abundance of smaller individuals (females), while the graph for goats is skewed towards the right indicating a concentration of larger males. These two patterns are often associated with different exploitation systems with herding practices often (but not always) producing sex ratios skewed towards smaller females (see Figs 3: Çatalhöyük, Köşk; 4: Ganj Dareh), and hunting strategies often (but not always) resulting in concentrations of large males (see Fig. 3: Ganj Dareh) (Helmer 1988, Helmer *et al.* 2005, Russell & Martin 2005). This suggests that sheep and goats were likely subject to different exploitation strategies at Aşıklı.

Recent analysis of carbon and nitrogen isotope values from Aşıklı caprine remains has indicated that both sheep and goats were characterized by a homogeneous and "restricted" diet (Pearson *et al.* 2007: 2178), which was interpreted as possibly reflecting an early stage in the management of the caprine populations. However, the limited variation in C and N values in the Aşıklı caprines is identified as "unusual" when compared to the wider spread of values characteristic of later Neolithic sites including Çatalhöyük (Pearson *et al.* 2007: 2178), while a similar pattern of limited variation has been identified in ancient wild ungulate populations in the southern Levant (Makarewicz 2007; personal communication 2008). Thus isotope data add to the picture that caprine exploitation at Aşıklı was significantly different from later Neolithic management strategies but do not clarify the nature of those strategies, which may have been more similar to wildlife management than intensive husbandry.

Suberde

The site of Suberde is located in an inter-montaine basin in the Beysehir-Sugla region of southwestern central Anatolia (Fig. 1). Suberde represents the remains of a small village settlement of the latest Aceramic Neolithic and is the earliest excavated Neolithic settlement in the Beyşehir region. Radiocarbon dates indicate that the Neolithic occupation of Suberde spanned the second half of the eighth millennium cal BC (Bordaz 1965; 1966; 1969; 1973, Bordaz & Alper-Bordaz 1977, Arbuckle 2008a).

Although originally interpreted as representing a "Neolithic hunters' village" (Perkins & Daly 1968), recent reanalysis of the Suberde assemblage has shown that both survivorship curves and metrical data suggest that sheep and possibly goats were under human management at this site (Arbuckle 2008a). Survivorship curves for the Suberde caprines indicate that the vast majority of animals were selected for slaughter between the ages of 1-3 years, with dental wear data indicating a peak between 12-24 months as predicted by models of meat or

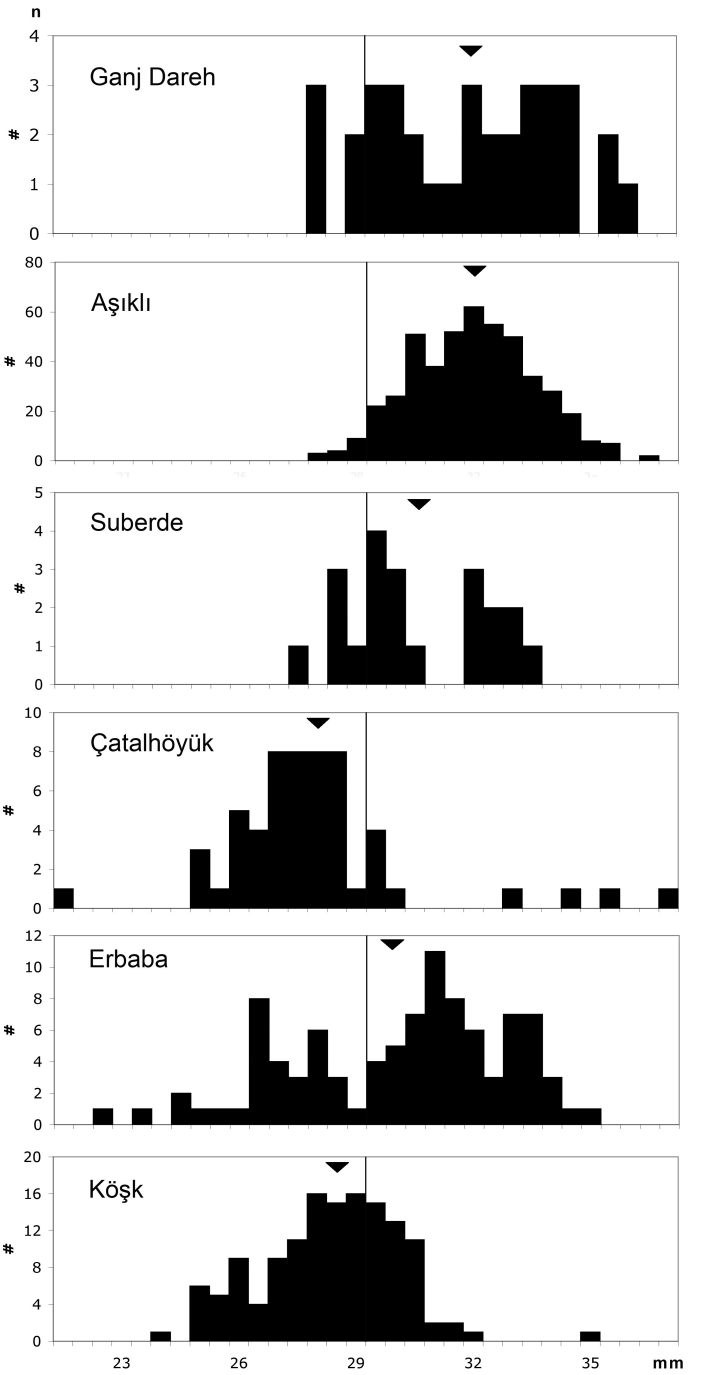


Fig. 3. — Greatest length of the astragalus (GLl) for sheep from Ganj Dareh (n = 34) (from Hesse 1978), Aşıklı Höyük (n = 470), Suberde (n = 21), Çatalhöyük pre-XII to IV (n = 56) (from Russell & Martin 2005), Erbaba (n = 95) and Köşk I-V (n = 137). Triangles represent mean values.

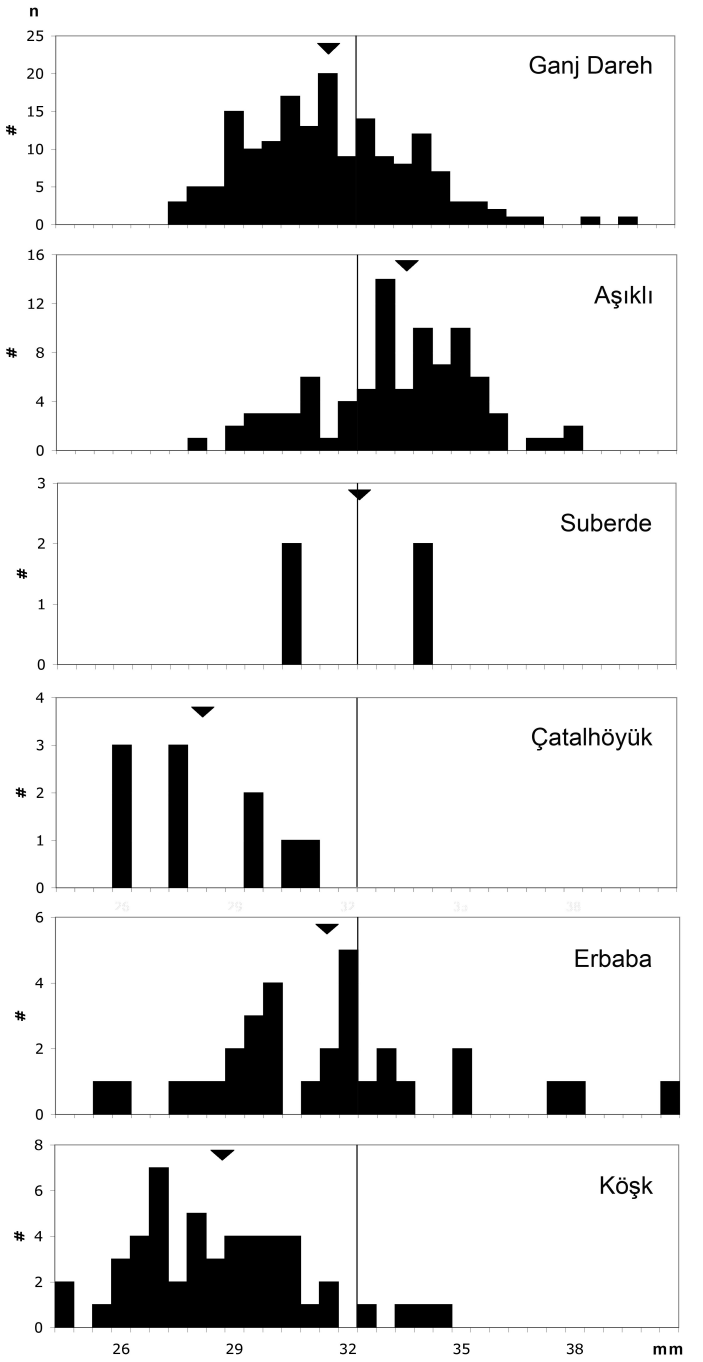


FIG. 4. – Greatest length of the astragalus (GLl) for goats from Ganj Dareh (n = 170) (from Hesse 1978), Aşıklı Höyük (n = 87), Suberde (n = 4), Çatalhöyük pre-XII to IV (n = 10) (from Russell & Martin 2005), Erbaba (n = 30), and Köşk I-V (n = 50). Triangles represent mean values.

meat and milk exploitation (Fig. 2). However, unlike the case at Aşıklı where no morphological changes are evident, measurement data suggest that sheep exhibit a decrease in size when compared to morphologically wild populations in the region such as Aşıklı (Mann-Whitney U test, U = 7119.0, p = 0.004) and Karain B, an Epi-paleolithic site on the Turkish Mediterranean coast (L. Atıcı personal communication 2006) (see Fig. 3). In light of the mortality data it seems reasonable to interpret this decrease in size as being associated with caprines living and breeding under conditions of human management (Davis 1987, Meadow 1989, Arbuckle 2005). Although the decrease in size and the focus on culling young caprines is strong evidence that Suberde caprines were herded, there is currently no evidence to suggest that young males were the focus of kill-off (Arbuckle 2008a). Thus although the age at which caprines were selected for slaughter fits with models of herd management, the lack of evidence for slaughtering surplus males — a fundamental feature of herding economies (Zeder & Hesse 2000, Salzman 2004, Vigne *et al.* 2005: 8) — is a puzzling characteristic of caprine exploitation at Suberde.

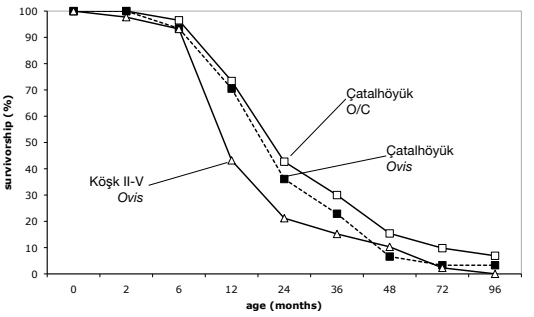


FIG. 5. – Survivorship based on mandibular tooth wear for sheep (n = 61) and sheep/goat (n = 143) from Çatalhöyük levels pre-XII through IV (from Russell & Martin 2005) compared to that for Köşk II-V sheep (n = 44).

ÇATALHÖYÜK

The site of Çatalhöyük is located on the semi-arid Konya Plain on the floodplain of the Çarsamba river (Fig. 1). The site is a unique 'mega-village' known for its large size, densely packed architecture, and elaborately decorated rooms, sometimes referred to as "shrines" (Mellaart 1967, Hodder & Matthews 1998, Hodder 2005). The long occupational sequence at the site dates from the mid eighth millennium cal BC (pre-XII levels) to c. 6000 cal BC (levels I-II) (Cessford 2001).

In their analysis of the faunal remains from the pre-XII levels through level IV, Russell and Martin (2005) have convincingly argued that the caprines at Çatalhöyük represent domesticated populations, likely from the earliest levels of the settlement. The location of the site on the Konya Plain, outside the natural habitat of wild caprines, as well as unambiguous evidence for size diminution (see Figs 3 and 4) clearly support this interpretation.

Survivorship curves for sheep based on tooth wear indicate that most caprines were slaughtered between the ages of 1-3 years. Although the small number of goat mandibles does not allow a separate survivorship curve for goats to be generated, survivorship for combined sheep and goats is higher than that for sheep, suggesting that goats were slaughtered at older ages (Fig. 5). The focus on culling young caprines fits well with the expectations of models for meat or meat and non-intensive milk production in which some older lambs (6-12 months) are slaughtered but with kill-off focused on animals in their second year, and then continuing through years three and four. This suggests that there was no great social demand for the production of young lamb, or of large quantities of dairy products, and that labor and fodder/graze were widely available to see surplus animals through their first winter. The wide range of C and N values identified in the bones of sheep and goats (Pearson *et al.* 2007) fits with this interpretation suggesting that herds had access to a wider range of plant resources, including C4 plants, than is common for many wild ungulates and may reflect the emergence of foddering practices in central Anatolia (Makarewicz & Tuross 2006, Makarewicz 2007).

However, comparison of the distal breadth of fused and unfused metacarpals, measurements which can be used to identify the proportions of males and females among unfused young (<24 months) and fused older (>24 months) individuals, does not suggest that young males were the focus of slaughter (Fig. 6). Instead, the mean values for fused and unfused specimens are indistinguishable,

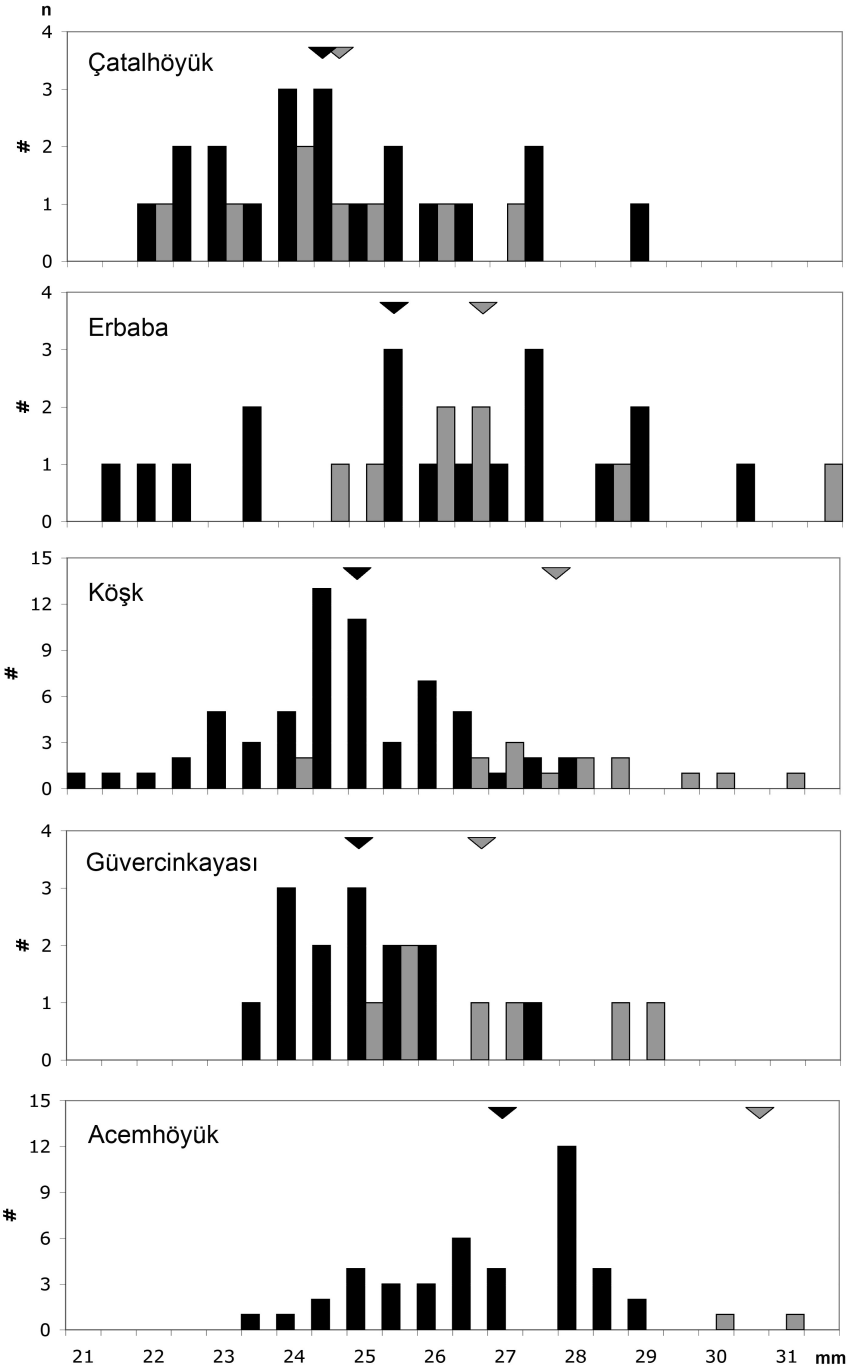


FIG. 6. – Bar graphs showing distributions of measurements of the distal breadth of sheep metacarpals for fused (black) and unfused (grey) specimens from Çatalhöyük pre-XII to IV (n = 28) (from Russell & Martin 2005), Erbaba Höyük (n = 27), Köşk I-V (n = 77), Güvercinkayası (n = 21), and Acemhöyük (n = 44). Mean values for fused and unfused specimens are indicated by black and grey triangles.

indicating that both large (male) and small (female) specimens are well represented among both young and old animals, and providing no evidence for the practice of young male kill-off. As at Suberde, this lack of evidence for preferential slaughtering of surplus males is puzzling. It suggests either that modern management strategies do not provide adequate analogs for those of the early Neolithic, or that the mortality data from Çatalhöyük do not represent a complete system of caprine management. Addressing the latter possibility, the presence of small temporary camp-sites such as Pinarbaşı A/B on the Konya Plain (Baird 2003) may indicate that large portions of the landscape surrounding Çatalhöyük were utilized in an extensive system that was at least partially responsible for provisioning this Neolithic mega-village.

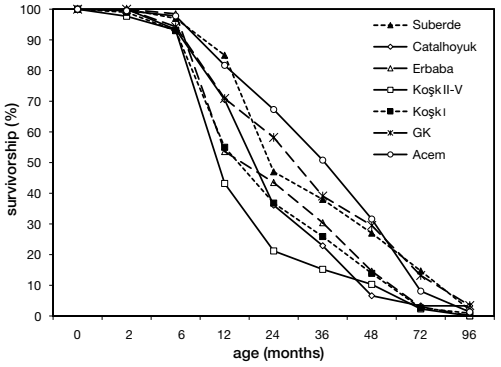


FIG. 7. – Survivorship curves based on mandibular tooth wear for sheep from Suberde (n = 17), Çatalhöyük pre-XII to IV (n = 61) (from Russell & Martin 2005), Erbaba Höyük (n = 68), Köşk II-V (n = 44), Köşk I (n = 133), Güvercinkayası (n = 79), and Acemhöyük II-III (n = 205).

ERBABA HÖYÜK

Erbaba Höyük is located on alluvial deposits on the east side of Lake Beyşehir, c. 50 kilometers northwest of the site of Suberde (Fig. 1). The site represents the remains of a small agricultural village of the Pottery Neolithic period dating to the mid to late seventh millennium cal BC (Bordaz 1970; 1973, Bordaz & Alper-Bordaz 1977; 1978; 1979; 1982, Arbuckle 2006).

Recent reanalysis of the Erbaba assemblage has shown that sheep and goats are the most abundant taxa with sheep outnumbering goats at a ratio of 4.6:1 (Table 1). Survivorship curves indicate that kill-off at Erbaba was concentrated on animals between the ages of 6-12 months decreasing gradually to senility (Figs 7 and 8). In a previous analysis of the assemblage, the prevalence of adult caprines in these curves led Perkins (Bordaz & Alper-Bordaz 1976; 1979) to argue for an early shift towards the use of herds for secondary products at Erbaba. However, measurement data suggest that both large wild and small domestic caprines are represented in the assemblage (Figs 3 and 4) (Arbuckle 2006; 2008c). Since hunting strategies often target adult individuals, it is expected that the presence of wild, hunted caprines in the assemblage has the effect of increasing overall survivorship, resulting in an overestimation of survivorship for the domestic caprines, especially in the older age categories. The presence of a significant number of lambs and yearlings at

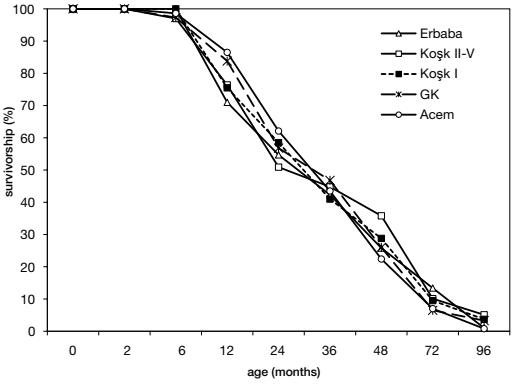


FIG. 8. – Survivorship curves based on mandibular tooth wear for goats from Erbaba Höyük (n = 24), Köşk II-V (n = 17), Köşk I (n = 47), Güvercinkayası (n = 37), and Acemhöyük II-III (n = 179).

Erbaba fits with the expectations for the production of meat or a combination of meat and milk. In addition, there are differences in survivorship between sheep and goats at Erbaba with goats exhibiting higher survivorship for every age category. Although difficult to interpret due to the combination of hunting and herding strategies represented in the assemblage, these differences suggest that sheep and goats were subject to broadly different exploitation strategies (Arbuckle 2006; 2008c). Although evidence for young male kill-off is difficult to address due to the presence of multiple exploitation

strategies at Erbaba, measurements of fused and unfused metacarpals do provide some indication of how domestic herds were managed at the site. The lack of measureable, unfused metacarpals for goats makes interpretation of goat management difficult. However, for sheep, the mean value for measurements of unfused distal metacarpals, representing young sheep, is larger than that for fused specimens, representing adult sheep, and the largest specimens are unfused (Fig. 6). This indicates that large males are disproportionately represented among those sheep slaughtered young, whereas smaller females are represented almost entirely by fused, adult specimens. Although the pattern is weakened by the overprint of hunting (Student's T-test, df = 26, p = .146), these data suggest that young, domestic rams were likely subject to intensive culling in their first two years. Based on the current dataset, this represents the earliest identification of the strategy of young male kill-off in central Anatolia.

Köşk Höyük

Köşk Höyük is a mound site located at a strategic point on the eastern margin of the Bor Plain and in close proximity to the resource rich Taurus and Melendiz mountains (Fig. 1). The lower levels of the site (II-V) date from c. 6200-5500 cal BC and represent a late Neolithic village known for well-preserved architecture, distinctive relief-decorated pottery, and the practice of removing and plastering human skulls (see Silistreli 1989, Öztan 2002; 2003; 2007, Bonogofsky 2005, Arbuckle 2006 for summary of 14C dates; 2008b). The upper level of the site (level I) dates to the period from c. 5300-4800 cal BC (Early Chalcolithic) and, although exhibiting a material culture clearly related to the lower levels, includes evidence for major changes in the internal organization and function of the settlement (Öztan 2003; 2007, Öztan & Faydalı 2003). These changes include the abandonment of the agglutinative architectural plan typical of the central Anatolian Neolithic (Duru 2002) in favor of distinctive linear banks of houses, as well as increased variation in house size, which may be linked with increasing levels of social differentiation within and between descent groups at the site.

In the lower levels at Köşk, morphologically domestic caprines are the most abundant taxa, representing 65% of the faunal assemblage (Table 1). Survivorship curves based on tooth wear indicate that sheep were slaughtered at very young ages, with kill-off primarily taking place between 6-12 months and then secondarily between 12-24 months (Fig. 7). These results fit with the expectations of the "tender meat" and mixed meat and milk models and suggest that Köşk herders typically did not allow surplus lambs to live through their first winter. This strategy could be related to a variety of factors including a lack of available labor for managing young ram herds, a lack of fodder or limited availability of winter graze, and/or a high social demand for lamb and/or dairy products.

Survivorship for goats is consistently 15-20 percentage points higher than that for sheep indicating that goats were subject to a very different management system that was not focused on the production of tender meat (Fig. 8). Goats were slaughtered at a variety of ages with some slaughtered as older kids (6-12 months) and with kill-off continuing through their second, third, and fourth years (Mandibular Wear Stage G). The slaughter of a significant number of goats as older adults fits with the predictions of the fiber model and suggests that in addition to meat and milk, hair may have been an important goal of goat management.

Metacarpal measurements for sheep indicate that unfused (young) specimens primarily represent large males, providing exceptionally clear evidence that young rams were intensively targeted for slaughter (Fig. 6). For goats, the pattern is less clear with the one measureable, unfused specimen located in the size range of small females (Fig. 9). The near absence of large fused specimens suggests that male goats were predominantly targeted for slaughter in their first and second years. The absence of unfused specimens representing young male goats is more difficult to interpret. If it reflects a husbandry strategy, it could suggest that kids were not kept in the vicinity of the site and were not available for consumption. This strategy seems unlikely given the abundant evidence for lambs at Köşk, and the absence of may instead reflect a combination of taphonomic loss of delicate unfused parts and small sample size.

In the upper level at Köşk I, caprines increase in frequency to 83% of the faunal assemblage (Table 1).

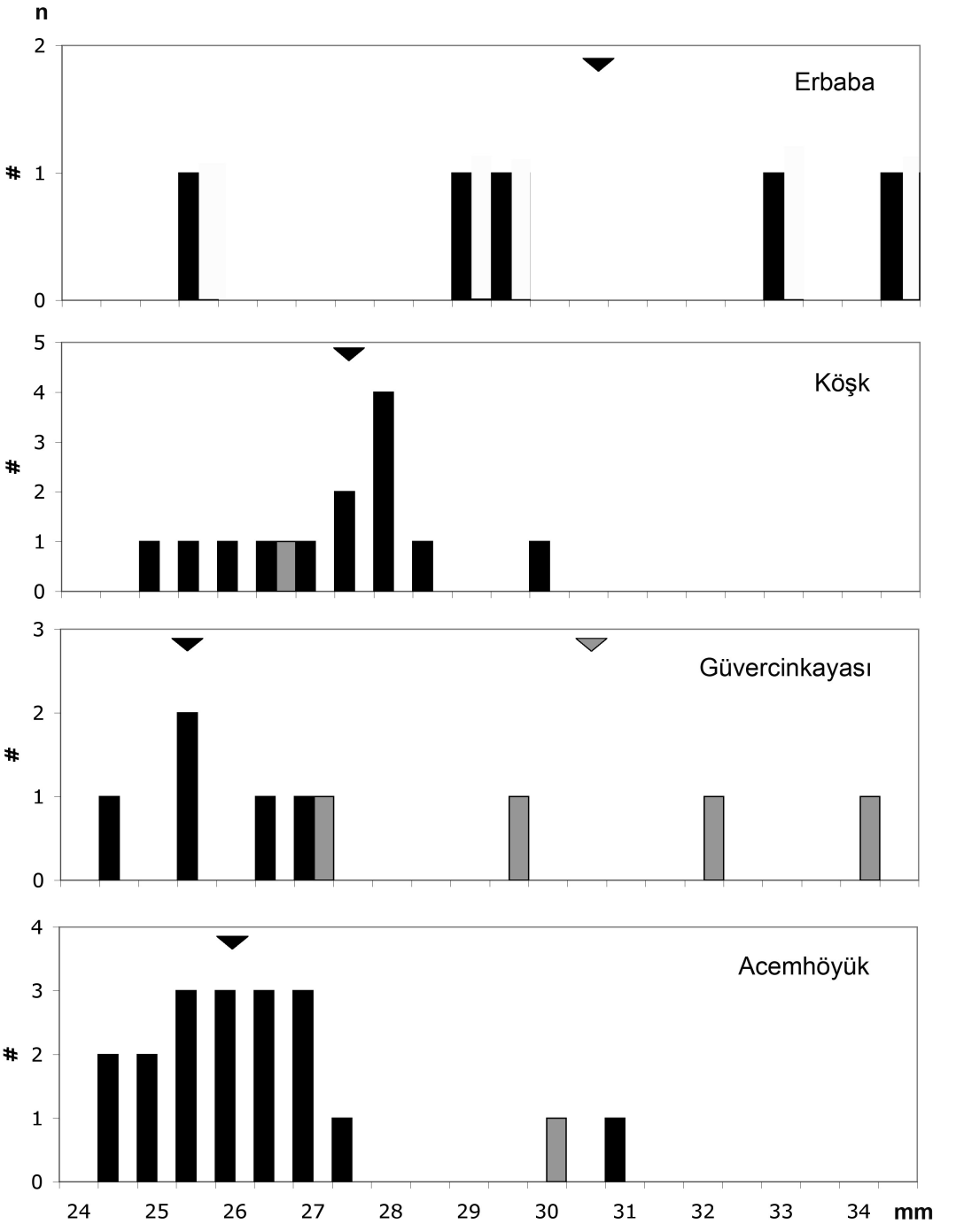


Fig. 9. – Bar graphs showing distributions of measurements of the distal breadth of goat metacarpals for fused (black) and unfused (grey) specimens from Erbaba Höyük (n = 5), Köşk I-V (n = 14), Acemhöyük (n = 19), and metatarsals from Güvercinkayası (n = 9). Mean values for fused and unfused specimens are indicated by black and grey triangles.

In addition, the survivorship data indicate an increase in the age at which sheep were slaughtered compared to the intensive culling of lambs characteristic of levels II-V (Fig. 7). Goat survivorship remains unchanged in Köşk I from previous levels (Fig. 8). Metrical data indicate a continued focus on the slaughter of young males, for both sheep and goats, as in previous levels.

The combination of an increase in the importance of caprines at the site and the increase in the age of slaughter of sheep suggests that the Chalcolithic management system differed from that of the Neolithic. In the Chalcolithic, lambs and yearlings were the focus of slaughter, as they were previously, but the frequency of animals slaughtered in their third year or older more than doubles indicating an increased desire for the products of adult sheep, which include milk and wool as well as meat. This pattern fits the expectations of the "type B milk" model in which older lambs and yearling males are slaughtered while the remainder represent females in their third, fourth, and fifth years whose productivity has declined.

These changes in the age of slaughter may be related to an increase in the availability of labor to manage larger herds with larger numbers of lambs, increased availability of fodder and winter graze which may have made intensive slaughter of lambs unnecessary, or a decline in the social demand for lamb and a desire for increased production of dairy. These changes may reflect a shift towards more intensive, specialized, and mobile forms of sheep husbandry in the Chalcolithic (Arbuckle 2006), which coincide with the evidence for of a more complex and heterogeneous social environment in central Anatolia at this time (Gülçur 1999).

Güvercinkayası

The site of Güvercinkayası represents the remains of a small Middle Chalcolithic village settlement located on a steep rocky bluff overlooking the Melendiz river valley in the region of Cappadocia (Fig. 1). The site is contemporaneous with the level I occupation at Köşk and also exhibits evidence for increasing levels of cultural complexity and internal differentiation (Gülçur 1997; 2004, Gülçur & Kiper 2003, Gülçur & Fırat 2005, Kiper & Gülçur 2005, Arbuckle 2006).

As at Köşk I, domestic caprines represent over 80% of the faunal assemblage at Güvercinkayası with sheep outnumbering goats by more than 4:1 (Table 1). Demographic data indicate that both sheep and goats were slaughtered at relatively old ages with survivorship declining only gradually from six months to six years (Figs 7 and 8). Following the slaughter of young males aged 6-12 months, kill-off focused on animals in their third to sixth years to an extent not seen at earlier or contemporaneous sites in the region. This emphasis on older animals suggests that secondary, or antemortem, products were a central goal of pastoral management at Güvercinkayası and fits the expectations of both "type B milk" and fiber production models (Buitenhuis 1999, Arbuckle 2006).

Metapodial measurements for both sheep and goats indicate that unfused specimens are larger than fused specimens providing clear evidence that young males were targeted for slaughter (Figs 6 and 9). Thus despite generally high survivorship, there is little evidence to suggest that male caprines were allowed to survive into adulthood. This suggests that fiber was not the primary goal of pastoral production at Güvercinkayası but that management was instead likely geared towards the production of a combination of products including milk, meat, and fiber. Rather than representing a direct reflection of systems of caprine production, it is possible that the concentrations of the remains of older animals at Güvercinkayası may also reflect involvement in an inter-site provisioning system. Following the predictions of Stein's (1987) producer model, the dearth of the remains of 1-2 year old caprines at Güvercinkayası may indicate that these animals were produced for consumption elsewhere (*e.g.*, at larger sites like Köşk). Alternately, although less likely, it is also possible that, in addition to some local production indicated by the presence of small numbers of lambs and kids, Güvercinkayası was itself provisioned with the remains of older caprines whose usefulness in milk and fiber producing herds had waned. Either of these interpretations would suggest that Güvercinkayası participated within a much larger and more complex regional socioeconomic system than has previously been suggested (see Arbuckle 2006: 514-520). However, given increasing evidence for economic complexity, sett-

lement hierarchy, mobility, and regional interaction within the contemporaneous Halaf sphere of influence (Watson & Leblanc 1990, Akkermans & Verhoeven 1995, Kansa & Campbell 2004, Özbal *et al.* 2004), the potential presence of intra-regional economic integration and productive specialization is also worth considering for the late sixth millennium cal BC in central Anatolia.

Acemhöyük II-III

Acemhöyük is a large (100 hectare) mound site located on the Aksaray plain in eastern central Anatolia (Fig. 1) (Özgüç 1977). It represents the remains of a powerful political center that dominated the region for much of the Bronze Age (Özgüç 1979, Veenhof 1995, Öztan 2000; 2001). Faunal materials were analyzed from the Middle Bronze Age levels II and III (c. 2000 cal BC) and derive from both domestic and palatial contexts on the central mound (Arbuckle 2006). Since the site represents a large urban center, it is expected that mortality data will primarily reflect the nature of the provisioning system, and that management goals will be more difficult to identify.

Caprines represent 65% of the faunal assemblage at Acemhöyük and the sheep to goat ratio is the lowest among sites examined at 1.7:1 (Table 1). Survivorship curves indicate that the caprines consumed on the mound settlement overwhelmingly represent the remains of adult animals between the ages of 3-7 years with very low frequencies of lambs, kids or yearlings (Figs 7 and 8). This pattern does not fit well with Stein's (1987) model of a consumer mortality profile, which he predicted would include primarily surplus males in their first and second years (also see Wapnish & Hesse 1988; 1991), but instead suggests that the palace was provisioned with the meat of old sheep and goats.

Metacarpal measurements for sheep indicate that the few unfused (young) specimens are large and clearly represent males, while fused specimens can be divided two groups based on size (Fig. 6). The first group (between 23-27 mm) likely represents small-bodied females, while the second group (between 28-29 mm) may represent wethers, *i.e.*, castrated males. While larger than females, wethers are often more slender than rams (Davis 2000). For goats, metacarpal measurements indicate that the vast majority of adult goats were females and that young males were the focus of slaughter (Fig. 9). The combination of extended survivorship and measurement data suggesting the presence of large numbers of adult males (and possibly wethers) is a strong indication that the system that provisioned the elite center of Acemhöyük with meat drew individuals from herds managed intensively for the production of wool (and probably secondarily milk as well). Data for goats indicate that, although survivorship was also high and kill-off focused on adult animals, there is no evidence that large numbers of male goats were allowed to survive into adulthood and used intensively for the production of hair. The absence of young male goats at Acemhöyük indicates that they were not available to consumers in the urban center and suggests that young male goats were probably consumed by producers in other locations. As a result, the goat mortality profile at Acemhöyük clearly represents only a portion of a larger management system and it is difficult to interpret the original goals of goat management.

As is often the case for urban centers, the metric and mortality data from Acemhöyük reflect the nature of systems of both caprine production and provisioning. They indicate that wool was the central feature of sheep management, a fact supported by textural data from contemporary sites in Anatolia and neighboring regions (Veenhof 1972; 1995, Matthews 1978, Yener 1982, Fleming 2004), while goats were not subject to the same intensive production strategy employed in the management of sheep herds. They also indicate that systems of urban provisioning need not focus on the meat of young surplus males, as has often been assumed (Stein 1987, Wapnish & Hesse 1988; 1991), as the meat of young caprines seems not to have been involved in provisioning the elite center of Acemhöyük at all.

DISCUSSION

The data presented above provide a unique opportunity to address the major changes in pastoral production in central Anatolia from the early Neolithic to the Bronze Age, including the nature of the

Table 3. — Summary of taphonomic indices. See text for explanations.

	Erbaba	Köşk II-V	Köşk I	Güvercin.	Acem.
Humerus index	12.3	10.7	9.6	12.3	8.5
Completeness index	3.91	3.97	4.29	3.79	3.97
Digestion %	2.8	5	3.2	5.3	0.1
Gnawing %	4.5	4.6	5	10.5	0.5

earliest systems of herd management in the Neolithic, and the evolution of management practices in later periods, particularly the appearance of the strategy of young male kill-off and the intensive use of antemortem products.

Taphonomy

Before addressing the interpretation of caprine husbandry in central Anatolia we briefly address the impact of taphonomic processes on the mortality patterns described above. The primary issue is to identify the extent to which the patterns identified in the archaeological record can be explained as the result of taphonomic processes, particularly the loss of the remains of young individuals. To this end, summaries of several important taphonomic indices are presented in Table 3 for Erbaba, Köşk, Güvercinkayası, and Acemhöyük.

The humerus index describes the abundance of fragments of the proximal humerus, which is characterized by low bone density values, as a percentage of the total number of specimens representing both the proximal and distal humerus, which is characterized by higher bone density values. In every assemblage the proximal humerus is highly under-represented indicating that density mediated destruction of skeletal parts is an important taphonomic issue at every site.

The completeness index describes the completeness of all medium mammal astragali, second phalanges, and petrosals using five categories: (1) 0-25% complete; (2) 25-50%; (3) 50-75% complete; (4) 75-99% complete; and (5) 100% complete (after Marean 1991). Since these elements are relatively small and do not contain significant nutritional value, damage to them is likely to reflect natural transformation factors such as dog gnawing, abrasion, and chemical weathering within the soil rather than cultural factors such as butchery. As with the humerus index, this index indicates similar completeness values across assemblages.

Finally, Table 3 also presents data describing the frequency of evidence for carnivore gnawing and digestion in the assemblages. These results indicate that dogs had an impact on bone survival in every assemblage. However, there is some variation as carnivores had the greatest potential impact on the Güvercinkayası assemblage, and the least impact on the assemblage from Acemhöyük, where carnivore damage is rare.

Where differences in taphonomic biases are evident, such as in the impact of dogs at Güvercinkayası and Acemhöyük, they are relatively minor and may affect the strength with which mortality patterns are expressed — either increasing or diminishing them — but they are unlikely to generate entirely new patterns themselves. Many of the patterns of variation between assemblage such as the presence of perinatal caprines at Aşıklı and the intensive slaughter of lambs at Neolithic Köşk show up despite a presumed bias against these age groups, which are characterized by low bone density values and are vulnerable to deletion by taphonomic processes. In addition, increases in survivorship evident at Köşk I and Acemhöyük are difficult to explain solely as the result of the deletion of the remains of younger caprines since there is no indication that these assemblages were affected more severely by taphonomic processes.

Overall, these indices indicate that each assemblage was subject to a roughly similar set of taphonomic processes resulting in the differential destruction of low-density skeletal parts. As a result, each assemblage seems to suffer from similar biases, suggesting that taphonomic process alone are unlikely to explain the variations in mortality profiles described above.

Early systems of herd management

Data from Aşıklı, Suberde, Çatalhöyük and Erbaba provide a window into the nature of early caprine husbandry systems in central Anatolia as well as their evolution from the early to the later Neolithic and beyond. The system of caprine exploitation in the earliest Neolithic at Aşıklı Höyük remains unclear. The fact that the Aşıklı caprines exhibit no evidence for morphological changes over a period of more than four centuries suggests that they were not subject to intensive human control and/or were not reproductively isolated from wild populations (Arbuckle 2005). However, the clearly selective harvesting of specific age groups and the presence of perinatal remains may suggest some form of intentional management, which regularly brought animals to the vicinity of the site (Buitenhuis 1997, Vigne *et al.* 1999, Pearson *et al.* 2007). Moreover, based on apparent differences in sex ratios, it is likely that sheep and goats were exploited in different ways at Aşıklı. However, whether these systems of exploitation were more akin to herding or a form of wildlife management (or see Ingold (1980) for another possibility) is difficult to address with the current data. What is clear is that the caprine exploitation system practiced at Aşıklı was quite different from those of later periods.

Representing the latest Aceramic Neolithic and early Pottery Neolithic periods, Suberde and Çatalhöyük (pre-XII through IV) provide the first evidence for morphologically domestic caprines in central Anatolia. Both sites provide evidence for size diminution thought to be associated with living and breeding under conditions of human management, although this is much more clearly evident at Çatalhöyük. The focused culling of young caprines at these sites fits with the expectations of models of herd management with the goals of meat or mixed meat and milk production. However, evidence for the harvesting of surplus young males — a near universal character of herding strategies — appears to be lacking at both Suberde and the lower levels of Çatalhöyük.

Although present at Erbaba at c. 6500 cal BC, and at every subsequent site examined in this study, there is no evidence that young male kill-off, the management practice often thought to be at the core of pastoral economies, was practiced by the earliest herders in central Anatolia. It is possible that this is the result of sampling biases, taphonomic factors, or the presence of geographically extensive herding systems that provisioned sites like Suberde and Çatalhöyük with animals representing a wide range of demographic groups. In the latter case the lack of evidence for the slaughter of young males may represent the nature of systems designed to provision early villages rather than providing a direct reflection of strategies of herd management. If, however, this pattern does reflect management decisions, as might be expected if herding were organized primarily as a system of village-based pastoralism, then this suggests that early Neolithic herders may have practiced a form of pastoral management without modern analogs. At Çatalhöyük, where there is abundant evidence that animals and their physical remains were highly imbued with symbolic meaning (see Russell *et al.* this volume), perhaps the slaughter and consumption of adult male caprines, with their prominent horns and large size, played an important role in social and ritual occasions making young male kill-off disadvantageous in the social realm despite its efficiency as an economic system. Whatever the explanation, this system which may represent an adaptation to the unique social and environmental landscapes associated with initial agricultural colonization, was replaced in the Pottery Neolithic (c. 6500 cal BC) by a more intensive and efficient pastoral system that was characterized by young male kill-off (Arbuckle 2008a, c), which then became the dominant caprine husbandry strategy in the region.

Antemortem Products

Addressing the timing and scale of the use of antemortem, or secondary products, such as milk and fiber has been a major focus of archaeological inquiry since Sherratt's (1981; 1983) influential work on this topic in the 1980s (Chapman 1983, Davis 1984, Greenfield 1988; 1989, Kohler-Rollefson 1992, Halstead 1996; 1998, Grigson 2000, Greenfield & Fowler 2005, Vigne & Helmer 2007). In contrast to Sherratt's original idea that the use of a range of secondary products became prominent only in the fourth millennium, increasingly, researchers have argued that milk and fiber were part of Neolithic subsistence strategies and therefore weren't

'secondary' in a chronological sense at all (Russell 1988 from Hesse 1993: 99, Köhler-Rollefson 1992, Meadow 1992: 264, Hesse 1993: 99, Evershed *et al.* 2004, Copley *et al.* 2005, Helmer *et al.* 2007, Vigne & Helmer 2007).

Particularly important in regards to the identification of the origins of the widespread use of antemortem products has been the development of new methods for the analysis of chemical residues in pottery that can provide direct evidence for the presence of ruminant dairy fats in archaeological contexts (*e.g.*, Copley *et al.* 2005). These methods are starting to show evidence that dairy was widely used in the Neolithic in Europe and probably the Near East as well (Evershed *et al.* 2004; Schoop 1998; see Vigne and Helmer 2007:13 and references therein). In addition, imagery on two sherds from Neolithic Köşk apparently showing cattle being milked suggests that dairy production was a fact of life at least by the late seventh millennium cal BC in Anatolia (Silistreli 1985a: 130; 1985b: 200, Öztan 2007: fig. 16). Thus it seems more and more likely that antemortem products were being used throughout the Neolithic period (see Helmer *et al.* 2007, Vigne & Helmer 2007) although the intensity of their use is difficult to gauge. There remains, however, a fundamental ambiguity when using faunal evidence to address the use of these products, particularly when addressing their origins. Faunal data do, however, provide a unique and effective means to address patterns of diachronic change in management strategies, which becomes a more important question if secondary products were used throughout the Neolithic. These diachronic patterns are explored below, first for sheep then for goats.

Management of sheep

Overall, mortality data indicate that systems of sheep production in central Anatolia were characterized by significant changes over time (Fig. 7). In the earliest Neolithic at Aşıklı the extent to which caprines were under human control is unclear but most were selected for slaughter between the ages of 1-3 years which fits with models of meat and possibly non-intensive milk production. At Suberde and in the lower levels of Çatalhöyük the focus was on culling yearling sheep along with some older lambs, again suggesting that production was oriented towards either the production of meat (following Payne's model) or a combination of meat and milk. However, the lack of evidence for the slaughter of young males is a puzzling aspect of these early management systems and makes the interpretation of their management goals uncertain. Evidence for the intensive slaughter of young rams is first evident at Erbaba where the presence of older lambs and yearlings conforms to the predictions of Payne's meat and combined meat/milk models. In the late Neolithic at Köşk, sheep production involved the intensive culling of lambs and yearlings indicating management was focused on the production of tender lamb and dairy as well. Since imagery suggests that cattle were milked at this time at Köşk, it is likely that dairy was an important part of the caprine husbandry system as well. The presence of a high proportion of infantile and juvenile remains from the contemporaneous occupation of Çatalhöyük's West Mound suggests that a very similar strategy of management for tender lamb and dairy may have been practiced there indicating that this management strategy may have been widespread across central Anatolia at this time (Gibson *et al.* 2004: Chart I).

In the Chalcolithic period, faunal data from Köşk I and Güvercinkayası indicate a shift in sheep management characterized by an increase in the economic importance of caprines compared to other taxa, and an increased emphasis on culling adult ewes. At Köşk I, the mortality data fit the predictions of "type B milk" production while at Güvercinkayası the emphasis on adult females suggest a combination of "type B milk" and fiber production as well. There is no evidence that sheep were managed intensively for wool as rams seem to have been slaughtered primarily as yearlings indicating that production goals were mixed rather than focused on a single product. The presence of all age groups including lambs and adult ewes suggests that sheep husbandry at the Köşk I village was organized primarily as a system of village-based herding utilizing extensive grazing areas surrounding the site. However, it is possible that the dominance of adult ewes at Güvercinkayası reflects that site's incorporation into a larger economic system in which Güvercinkayası herders either produced lamb and yearlings for consumption

elsewhere or else received older animals as part of provisioning system. Either of these interpretations suggest that Güvercinkayası may have been part of a more complex and larger-scale system of sheep husbandry than existed previously in the region.

Finally, by the Middle Bronze Age at Acemhöyük there is clear evidence for a highly intensive and, likely, highly specialized system of sheep herding focused on the production of wool and probably also dairy. Textural data from neighboring regions confirm that wool was an important commodity at this time and suggest not only that pastoral production was focused on producing textiles for regional markets but that it may have been organized by highly specialized and nomadic, tribal pastoralists (Matthews 1978, Fleming 2004).

One of the most prominent trends in the sheep mortality data is an apparent increase in the average age of slaughter over time in central Anatolia. Regional studies of the evolution of caprine husbandry have identified broadly similar diachronic patterns in the Levant, Iran, and the Balkans as well (Davis 1984, Greenfield 1988, Grigson 2000). This pattern has often been interpreted as reflecting an increased reliance on the antemortem products of adult animals, particularly milk and fiber in the Late Neolithic and Chalcolithic (Bordaz & Alper-Bordaz 1976; 1979, Levy 1983, Davis 1984, Greenfield 1988; 1989, Zeder 1994a, Schoop 1998; 2005, Campbell *et al.* 1999, Grigson 2000, Abdi 2003, Özbal *et al.* 2004) (although see Köhler-Rollefson 1992, Hesse 1993). Grigson (2000) has suggested that this represents a two-step process by which first milk and then fiber were incorporated into management systems.

However, simply equating an increase in survivorship with an increase in antemortem products usage is problematic, particularly since the intensive use of herds for dairy may, in fact, result in the slaughter of a high frequency of lambs (*e.g.*, Neolithic Köşk). These broad changes may instead reflect the development of increasingly complex and large-scale pastoral systems characterized by greater degrees of mobility as well as an intensive focus on antemortem products. It is possible that the increased frequency of adult caprines in Chalcolithic sites in Anatolia and elsewhere reflects an increase in the scale and seasonal mobility of husbandry systems with herders moving between spatially distinct summer and winter grazing zones. This type of seasonal movement would decrease the availability of lambs at village sites and increase the representation of adult ewes. The pattern of increasing survivorship may therefore reflect changes in the complexity, scale and spatial organization of sheep husbandry in the Chalcolithic in addition to, or, perhaps, rather than, a dramatic reorientation of management goals themselves.

Management of goats

The pattern of diachronic change for goats is quite different. Goats exhibit elevated survivorship in every assemblage for which data are available and show little evidence for major shifts in management through time, suggesting that antemortem products may have been an important part of goat management since the Neolithic (Fig. 8). Although it is not clear if goats were herded at Aşıklı and sample sizes are not yet large enough to address goat management at Suberde, with the appearance of morphologically domestic goats at Çatalhöyük, these animals seem to have consistently been culled at older ages than sheep. This pattern is present at every subsequent site in the region until the Bronze Age when sheep were raised primarily for wool.

The consistently high survivorship of goats in contrast to that for sheep indicates that sheep and goats were managed with fundamentally different production goals and that these differences in management extend well back into the Neolithic (also see Hesse 1978, Vigne *et al.* 2003, Vigne & Helmer 2007). In general, surplus male goats were slaughtered as older kids, from 6-12 months, and as yearling. The peak of slaughter, however, took place among females in their third, fourth, fifth and sixth years. This fits the expectations of a combination of the "type B milk" and fiber production models. In addition, the generally high ratio of sheep to goats at sites in central Anatolia suggests that the scale of goat management was consistently smaller than that for sheep. This combination of small-scale herding, elevated survivorship, and lack of change over time suggests that goats were subject to a highly conservative and multi-functional management system that included the production of milk and hair in addition to meat. This system

is clearly identifiable first at Late Neolithic Köşk but if elevated survivorship is an indication, it may have its roots in Aceramic Neolithic sites such as Çatalhöyük.

CONCLUSION

Sheep and goat herding has played a central but poorly understood role in every period of central Anatolian prehistory. In this paper we have attempted to address this major gap in our understanding of cultural dynamics in central Anatolia by providing the first broad synthesis addressing the macro-scale patterns of change over time in sheep and goat husbandry in the region from the Neolithic to the Bronze Age. Although the task is by no means complete we have provided a first outline of the evolution of this important cultural system, which provides a firm foundation for more detailed future work focusing on inter-site synchronic variation and inter-regional comparison.

This study has argued that, although the nature of caprine exploitation in the earliest Neolithic at Aşıklı Höyük remains unclear, systems of sheep and goat husbandry seem to have been in place at Suberde and the early (pre-XII) levels of Çatalhöyük by the latter half of the eighth millennium cal BC. Interestingly, these early pastoral systems provide no evidence for the common pastoral practice of culling young males, which makes its first appearance at Erbaba Höyük in the Pottery Neolithic (c. 6500 cal BC), and subsequently becomes the dominant management strategy in the region. The apparent lack of sex biased culling at these early sites may represent an early stage in the development of pastoral management strategies in the region in which management decisions were not focused on maximizing the production of meat or any other product but rather seem to have been directed by social requirements for animals of specific ages and sexes. This may indicate that early strategies of animal management were characterized by a high degree of variation, which represents an important and continuing focus for future research (Redding 2005).

Finally, data from central Anatolia indicate that the emergence of strategies utilizing antemortem products was a complex and multi-faceted process that proceeded along two distinctive historical threads. One thread represents strategies for the management of goats. Goats seem to have been used for the conservative and small-scale production of meat, milk and hair from the early Neolithic onwards, with little evidence for change over time in management strategies. The other thread represents systems of sheep management, which were much more dynamic over time. With the appearance of management strategies that included the culling of young rams in the Pottery Neolithic, sheep herding appears to have focused on producing meat and potentially milk. By the late Pottery Neolithic at sites such as Köşk and possibly also Çatalhöyük sheep were likely managed intensively for a combination of lamb and milk. In the Chalcolithic, the sheep management system changed again with an increased focus on the production of adult ewes representing a shift towards "type B milk" and wool production and possibly the emergence of more mobile and specialized forms of pastoralism in the region. Finally by the Bronze Age, sheep management was characterized by the intensive production of wool for regional markets, likely by a specialized pastoral sector.

While valuable and larger herds of sheep were used to produce wealth and prestige through the production of mutton, milk and wool, the primary role of goats seems to have been to provide subsistence security and to hedge against the uncertainties of valuable but potentially vulnerable sheep herds (see Redding 1981). These differences in the use of sheep and goats have important implications for understanding the complex and multifaceted nature of systems of pastoral production and must be the focus of further research. Moreover, these differences also reaffirm that fact that the common practice of combining sheep and goat remains into a single category of "sheep/goat" or "ovicaprid" can be highly problematic. Since sheep and goats were clearly managed with different production goals combining sheep and goat categories is likely to produce results that accurately describe the exploitation of neither taxa.

As more data become available it has become apparent that the history of sheep and goat husbandry

in central Anatolia is even more complex than has previously been suggested. Future work targeting topics such as the apparent absence of evidence for young male kill-off in early Neolithic villages in central Anatolia, the nature of more complex pastoral systems in the Chalcolithic, and differences in the management of sheep and goats will help to clarify and contextualize the role of this dynamic socioeconomic system in the culture history of this important region.

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