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# Tracing Economic, Ritual, and Social Pathways to Neolithization in the Southern Levant through Human-Animal Relationships at Kfar HaHoresh

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Tracing Economic, Ritual, and Social Pathways to Neolithization in the Southern Levant  
through Human-Animal Relationships at Kfar HaHoresh

By Jacqueline Suzanne Meier

University of Connecticut, 2017

**Dissertation Abstract**

During the transition to agriculture in the southern Levant of Southwest Asia, the Pre-Pottery Neolithic B (PPNB) period is marked by the beginning of herd animal management, a florescence of ritual evidence and increasingly large settlements with diversified uses. These developments had observable impacts on the archaeological record, preserving human subsistence choices, activities, and use of space. The faunal assemblage recovered from the unique site of Kfar HaHoresh (KHH) in the southern Levant region enables the simultaneous study of these changes over time as it comprises the longest continuous PPNB faunal sequence in the Mediterranean Hills region (Early–Late periods, 10,600–8,700 cal. BP). This secluded mortuary site yields provocative evidence of ritual and subsistence activities involving animals, including remains of wild cattle feasting events as well as middens with food refuse. This dissertation research utilizes zooarchaeological analysis of the faunal assemblage to: 1) investigate nascent elements of animal management; 2) track changes in hunting patterns of humans and illuminate their relationship to emergent goat management; 3) document the range of ritual practice with animal remains; and 4) explore variation in faunal deposition across site contexts. This evidence is then situated within a regional context to establish the character of changing human-animal relationships across the PPNB in the Mediterranean Hills.

The analysis begins with the trade-off between wild and domestic progenitor taxa and ungulate demographic data to track changes in human control over herd animal movement and reproduction. Changes in subsistence intensification are then investigated using a behavioral ecology approach that compares hunting and processing of differently ranked prey in the diet over time. Next, ritual practices are explored by describing a new concentration of wild cattle (aurochs) bones at KHH. Finally, a combination of data on taphonomic histories, disposal patterns, and spatial distributions of faunal remains from KHH is used to characterize the depositional histories of individual archaeological contexts, including a monumental platform complex, human burials, two middens, and other features.

Results reveal a preference for wild animals at KHH. Nonetheless, changes in subsistence and demographic data fit changes recorded at other sites that support a regional shift from wild animal hunting to goat management by the Middle PPNB period (10,000–9,500 cal. BP). Additionally, evidence of aurochs deposits from KHH and across the region highlight a shift from large feasts and mortuary deposits to smaller-scale practices at the beginning of animal management. Depositional histories across contexts also reveal diverse practices and systematic refuse deposition that support organized site use. In all, these findings contribute new, nuanced insight into regional economic, ritual, and social changes in the PPNB and highlight the important role of a ceremonial site within the larger domestic community.

Tracing Economic, Ritual, and Social Pathways to Neolithization in the Southern Levant  
through Human-Animal Relationships at Kfar HaHoresh

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B.A. University of Louisville, 2006

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A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

at the

University of Connecticut

2017

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APPROVAL PAGE

Doctor of Philosophy Dissertation

Tracing Economic, Ritual, and Social Pathways to Neolithization in the Southern Levant  
through Human-Animal Relationships at Kfar HaHoresh

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## Chapter 1. Dissertation Introduction

### **Overview to the Problem**

The agricultural transition in Southwest Asia marks a pivotal turning point in human history, when foragers adapted to new farming economies and ways of life. This shift first occurred in Southwest Asia and has been the focus of seminal archaeological research on plant and animal domestication (Conklin 1959; Bökönyi 1969), demographic pressure (Binford 1968; Flannery, *et al.* 1969), climatic change (Childe 1971), and increased social demands (Cauvin 1994; Watkins 2005). The economic, ritual and social components of the agricultural transition (collectively termed Neolithization) varied across the regions of Southwest Asia (Conolly, *et al.* 2011; Vigne, *et al.* 2011) and had dramatic impacts on animal populations and their interactions with humans. Zooarchaeology provides a productive avenue to investigate Neolithization pathways as fauna can be used to simultaneously investigate patterns of economic, ritual and social change.

The florescence of ritual practice in the Pre-Pottery Neolithic (PPN) (Goring-Morris and Belfer-Cohen 2011) is cited as an important enabler of economic and social change during the agricultural transition (Verhoeven 2002a) and as evidence of an ideological shift that is the harbinger of more established formal religious systems to come (Cauvin 1994; Whitehouse and Hodder 2010). Yet, current theoretical approaches to the study of ritual in the Neolithic have grown increasingly divergent. Some researchers argue for a social or ritual cause for animal domestication, chiefly emphasizing the need for surplus to support ritual practice in the PPN and its potential to drive economic change (Maryanski and Turner 1992; Cauvin 1994; Hayden 2003). Others state that the PPN ideological shift was only possible after a change in subsistence

strategies allowed for the accumulation of surplus (Fuller and Grandjean 2001; Davis 2005).

Despite this dichotomy, archaeological evidence increasingly shows that changes in ritual practice, social organization and economy went hand in hand across this dynamic transition (Asouti 2006; Goring-Morris and Belfer-Cohen 2011; Zeder 2011), although more studies are needed to understand how these changes occurred over time in different regions.

Change in ritual practice is best understood within a wider social and economic context. Zooarchaeological research using the systematic analysis of demographic and body-size data has identified early evidence for herd animal management in the north central Fertile Crescent, likely the earliest center of animal management in Southwest Asia (Zeder and Hesse 2000). In previous decades, the southern Levant was a center of domestication research with some arguing that domestication first started there (Horwitz 1993; Bar-Yosef and Meadow 1995). More recent developments in the north have prompted a revised model featuring the spread of domestic animals from north to south (Zeder 2011) and encourage reconsideration of models for autochthonous goat domestication in the southern Levant (Horwitz 1989; Horwitz 2003). Further assessments of the state of ungulate management and related changes in the meat diet are needed to understand how domestication processes unfolded in the southern Levant.

In this dissertation, I utilize zooarchaeological methods to investigate economic, ritual and social change across the Pre-Pottery Neolithic B (PPNB) period (ca. 8500–6750 cal BC) in the Mediterranean Hills region of the southern Levant. For the most part, these topics have been treated separately in PPNB zooarchaeological research, yet they are highly integrated, especially as societies increased in size and complexity (Byrd 2005; deFrance 2009). Furthermore, when combined, analyses of economic, social and ritual change provide more comprehensive explanations for how Neolithization unfolded within a single region.

This dissertation contributes a synthesis of the process of animal domestication and the range of variability in ritual practice in the Mediterranean Hills, by integrating evidence from the animal remains recovered at Kfar HaHoresh (KHH) with data from surrounding sites. KHH is the only PPNB site in the greater southern Levant that served primarily as a ceremonial center (Goring-Morris, *et al.* 1998). The surge in the visibility of ritual practice during the PPNB is exemplified at KHH, which has yielded a large faunal assemblage from a variety of contexts, including feasting deposits, a monumental platform, human burials and a midden (Goring-Morris, *et al.* 2008). The provisioning of animals for ritual activities at KHH occurred within this context and thus special attention must be given to the status of animal management at the site. KHH provides a unique opportunity to investigate how economic processes in the region were translated to a ritual context.

The analysis of the KHH fauna reveals the range of practices featuring animals at this important and unique site. The analysis employs a wide range of zooarchaeological measures to detect the emergence of human management of animal populations and subsistence and ritual intensification. The range of human depositional practices and activities are reconstructed, as are taphonomic histories and how they varied across time and space at KHH. These analyses provide new insights into provisioning strategies for social and ideological practices at Kfar HaHoresh and situate them within the greater Mediterranean Hills region during the PPNB period.

### **Pathways to Change in the PPNB**

The PPNB (10,600–8,700 cal. BP) sits at an important crux of the agricultural transition in Southwest Asia. By this time, permanent, full-fledged agricultural communities had arisen (Price and Bar-Yosef 2011). Current research shows that human life-ways and demographics changed dramatically as plants and animals were gradually domesticated (Bocquet-Appel 2011) over the

course of about 4,000 years (Blockley and Pinhasi 2011; Zeder 2011; Colledge, *et al.* 2013). Although the cultivation and domestication of plants began earlier and was underway in the southern Levant by the PPNB (Weiss, *et al.* 2006; Fuller, *et al.* 2012), the domestication of animals, namely goats, was still in its early stages (Horwitz, *et al.* 1999; Zeder 2011). During the PPNB, larger sites arose with new and more compartmentalized forms of architecture that reflected more diverse permanent settlement organization and differentiated functional space within sites and homes (Byrd 1994; Goring-Morris and Belfer-Cohen 2008; Kuijt, *et al.* 2011).

As site use changed in the PPNB, the types of human activities also expanded, including the use of architecture and human burial practices (Kuijt 1996; Goring-Morris and Belfer-Cohen 2002). The impact of the diversification of activities on economic change across the region is still unclear. This is especially true of changes based on animal resources, since animals were selected as resources and symbols of a range of activities at different sites.

Recent faunal studies highlight multiple pathways to Neolithization across different regions of Southwest Asia. Variation has been detected in the pace of increased human control over food resources (Willcox 2005; Asouti 2006; Conolly, *et al.* 2011), the use of space (Byrd 2000; Goring-Morris and Belfer-Cohen 2008), and social and ritual practice (Verhoeven 2002b; Twiss 2008; Goring-Morris and Belfer-Cohen 2011; Goring-Morris and Belfer-Cohen 2013). Variation has also been detected in many regions within Southwest Asia (Zeder 2011; Asouti and Fuller 2013). Furthermore, this variation also exists among the different ecological zones within those regions (Horwitz, *et al.* 1999; Peters, *et al.* 1999; Martin and Edwards 2013). To minimize the influence of environmental variability, this research focuses on a single ecological zone—the Mediterranean Hills of the southern Levant region.

### ***Economic change in the south Levantine PPNB***

Growing zooarchaeological and genetic evidence from across Southwest Asia increasingly supports multi-regional trajectories of economic change toward plant and animal domestication (Naderi, *et al.* 2008; Willcox, *et al.* 2008; Fuller, *et al.* 2012; Stiner, *et al.* 2014). Recent studies have reconsidered the herd animal domestication process in the southern Levant (Martin and Edwards 2013; Sapir-Hen, *et al.* 2016). However, its trajectory within the different ecological zones requires further investigation to better understand how changing control over animals unfolded at the local level.

Within the Mediterranean Hills of the southern Levant, goats were the first ungulate taxon to be managed by humans (Horwitz 1989; Horwitz, *et al.* 1999). Management is one of the first stages of the domestication process and is marked by an increase in human control over the movement and culling of animal herds prior to the occurrence of morphological changes (Zeder and Hesse 2000; Zeder 2006a; Zeder 2008). Management has obvious impacts on the subsistence economy (Munro 2009; Stiner, *et al.* 2014; Sapir-Hen, *et al.* 2016), but it also transforms the symbolic value of animals once they become owned (Shanklin 1985). Increases in the relative abundance of goats over time suggest that the management of goats began in the southern Levant by the Middle PPNB (10,000–9,200 cal BP) (Horwitz 2003; Martin and Edwards 2013; Sapir-Hen, *et al.* 2016), about 500–900 years after their initial management further north (Zeder 2011). Although results from the region suggest that the transition from hunting to herding took place between the PPNB–PPNC (Horwitz, *et al.* 1999; Horwitz 2003; Martin and Edwards 2013), more data are needed from sites with consecutive PPNB periods to better elucidate the pace of the process of animal management in the region and track accompanying subsistence changes over time. KHH provides a unique opportunity to address questions surrounding how the processes leading to the management of domestic progenitor taxa (cattle, goat, and pigs) unfolded over time

at a unique ceremonial site, as the faunal assemblages there represent a continuous Early, Middle and Late PPNB sequence.

### ***Ritual in the PPNB***

Ritual and religion are central subjects of study in the Pre-Pottery Neolithic (PPN) due to the significant increase in the visibility of ritual activity over time across Southwest Asia (Goring-Morris and Belfer-Cohen 2011). Past studies identified significant broad patterns in the distribution of ritual artifacts (Kuijt 2008), but more often compared ritual patterns on a gross temporal scale (Verhoeven 2002a) or addressed single community-level ritual practices, such as feasting (Twiss 2008). Recent studies emphasize the importance of understanding different scales of ritual practice (Hodder and Cessford 2004; Twiss 2007), which can best be accomplished through context-specific studies.

Current research focuses on the expression of ritual in the archaeological record and its relationship to social and ideological change (Kuijt 2008a). Recent research has focused on direct evidence of ritual practice such as public architecture and burials (Kuijt 2008a), but more work is needed to define the material correlates for less obvious ritual activities such as small ritual meals and the maintenance of ceremonial space. To do so, methods must first be developed to identify a wider spectrum of ritual activities involving animals by testing and refining current criteria for detecting ritual faunal deposits (Twiss 2007; Yeshurun, *et al.* 2013). Across the agricultural transition in the southern Levant, evidence of diverse ritual practices involving animals have been documented, including feasting (Grosman and Munro 2016), the deposition of animal remains in architectural features (Tsuneki 2002; Russell, *et al.* 2009; Gubenko and Ronen 2014), and purposefully deposited animal parts in human graves (Grosman, *et al.* 2008), among other diverse practices.

Changes in ritual practice with animals across the PPNB are best understood within the context of changing human-animal relationships (Russell 2002; Twiss 2007). Given the highly integrated nature of ritual and mundane practices (Bell 1997; deFrance 2009), more research is needed to understand how increasing human control over domestic progenitor taxa impacted the symbolic roles of animals in PPNB ritual practice. The surge in the visibility of ritual practice during the PPNB is especially exemplified at the mortuary site of KHH, which has yielded a large faunal assemblage from a variety of contexts, including feasting deposits, a monumental platform, human burials and a midden (Goring-Morris, *et al.* 2008).

### **The PPNB Site of Kfar HaHoresh**

This dissertation uses faunal analysis to investigate multiple processes of Neolithization at the PPNB site of Kfar HaHoresh (KHH) and compares them to evidence of changes in the greater surrounding region. Dr. Nigel Goring-Morris, of the Hebrew University, began excavations at KHH in 1991 on behalf of the Israeli Antiquities Authority (Goring-Morris 1991) and continues to direct the excavations under the auspices of the Institute of Archaeology of the Hebrew University of Jerusalem. Diverse activities have been documented at the site, including ritual practices that involved animals (Goring-Morris, *et al.* 1998; Horwitz and Goring-Morris 2004a; Goring-Morris and Horwitz 2007), the production of lithic tools (Barzilai and Goring-Morris 2010), and the use of kilns for lime-plaster construction (Goren and Goring-Morris 2008). KHH is also highly integrated in extensive trade networks based on the diverse artifacts recovered at the site (i.e., malachite from the Dead Sea area and obsidian from southern Anatolia) (Goring-Morris, *et al.* 1998; Goring-Morris 2000). These networks influenced the trajectory of Neolithization across the region (Belfer-Cohen and Goring-Morris 2014), and impacted human-animal interactions at KHH over time.

The site of KHH differs from most PPN sites in the Levant that served primarily as locales for everyday habitation. KHH is the only known PPNB site in the southern Levant that served first and foremost as a ritual funerary center (Goring-Morris 1991). Despite its original interpretation as a typical PPNB habitation area, extensive testing and over twenty years of excavation still has not revealed domestic structures. Instead, only monumental architecture has been found, including a large plastered platform (10 × 18 m) and terrace walls (Goring-Morris, *et al.* 1998).

Although evidence of ritual practice and unusual burial treatment is common at PPNB sites, a wide range of evidence attests to the primarily ritual use of KHH, likely by the surrounding lowland communities of the Galilee region (Goring-Morris, *et al.* 1995; Birkenfeld and Goring-Morris 2015). The site itself is isolated in a valley in the Nazareth Hills that is poorly suited for agriculture (Birkenfeld and Goring-Morris 2014). Examples of ritual activity abound at KHH, where numerous human burials (n>85), many with curious treatments, were interred among the site's features. These include the intentional arrangement of a human skeleton that possibly depicts an ungulate, a secondary burial of half of a man, and plastered human skulls with modeled facial features and shell inset eyes (Goring-Morris 1991; Bonogofsky 2003). Unique groupings of material were also recovered, notably male-centric stone artifacts and figurines, and the remains of a large feast (Horwitz and Goring-Morris 2004a; Goring-Morris, *et al.* 2008). The feast participants dined on at least nine cattle which were later buried in a pit that was capped first by a human burial and finally with a layer of plaster (Goring-Morris and Horwitz 2007).

This dissertation research systematically investigates the faunal material recovered from the 2010–2012 excavation seasons at KHH. The assemblage includes material from diverse contexts that cover the full spectrum of time periods represented in the northern area of the site, including the Early, Middle and Late PPNB phases (10,600–8,700 cal. BP). Thus, this research

contributes a high-resolution, faunal database to investigate how activities at KHH were provisioned with animals over time.

## **The Faunal Sample**

High-resolution, faunal data was collected from KHH over a year-long data collection period from 2014–2015 supported by a National Science Foundation Dissertation Improvement Grant (Award #1355608). During this time, a sizable dataset was generated (NISP = 11,626). The excavation strategy employed at KHH enabled detailed comparisons of fauna to be made among a wide variety of features (loci) at the site. The site was excavated in  $50 \times 50 \times 5$  cm subunits, while exceptional finds such as well-preserved bones and concentrated bone deposits were piece plotted in three-dimensions, and drawn on maps with details about associated sediment and features. Fauna was recovered from diverse loci at KHH that range widely in function and include the monumental platform structure, middens, graves, hearths, layers of distinct sediment, caches of finds, walls, and pits associated with the onsite production of plaster, lithics and food. All loci are excavated separately with subunits defined within them to maximize the potential to reconstruct the depositional histories of whole deposits, including the fauna.

## **Dissertation Structure**

This dissertation research examines the fauna from KHH to simultaneously investigate multiple Neolithization processes over the course of the PPNB. The research is divided into four topics that have been prepared as journal articles:

First, the wild/domestic status of domestic progenitor ungulate taxa (goats, aurochs, pigs) at KHH is assessed based on measures of human control of herd animals and shifts in hunting

intensity. Changes in species abundance and demographic data are used to establish the degree of management for goats at KHH. Establishing the status of the process of the management phase of domestication at KHH will enable the investigation of the following questions:

1. Were the ritual activities at KHH provisioned with wild and/or managed animals?
2. How does the provisioning of KHH compare to neighboring domestic sites?

Second, faunal data from KHH is used to assess the role of wild cattle in ritual practices by establishing the character of new aurochs feasting deposits at the site. Aurochs feasting evidence is compared across sites spanning the agricultural transition in the southern Levant and to non-mundane aurochs deposits to investigate broader questions concerning Neolithic ritual practice. A series of questions were addressed including:

1. Is the PPNB surge in ritual evidence (Kuijt 2008) manifested in changing ritual practices at KHH?
2. Does ritual practice at KHH reflect the intensification of social interactions in the PPNB (Goring-Morris and Belfer-Cohen 2011; Hodder 2005)?
3. If yes, how does the timing of this shift relate to the trajectory of animal management?

Third, depositional patterns at KHH can reveal important changes in behavior over time, such as how humans used space, disposed of their trash, and the range of activities that they participated in during the PPNB. Depositional histories are reconstructed for fauna recovered from different contexts at KHH. This study utilizes a combination of faunal and taphonomic indicators to investigate the speed of deposition and burial across contexts at KHH. Faunal evidence is used to characterize the types of refuse represented in different contexts to reconstruct ritual and

mundane practices that utilized animals. This information is used to investigate the following questions:

1. Does the diversity of refuse types expand in the PPNB, and if so, how?
2. What does faunal deposition look like at a primarily ritual use site? Does depositional evidence from KHH support more organized use of space through refuse management, which is hypothesized to have begun by this time (Hardy-Smith and Edwards 2004)?
3. How are refuse management and permanent site occupation related across the agricultural transition?

Fourth, the state of hunting and processing carcasses of wild game at KHH is situated within the context of emergent animal management in the Mediterranean zone. Multiple measures of subsistence intensification are employed to address the following questions:

1. How did hunting and carcass processing decisions change in association with the beginning of goat management?
2. How does the selection and use of animals of different body-size at KHH reflect the length and intensity of site use?

The dissertation research utilized the high-resolution faunal data with good chronological control from KHH to detect economic, ritual and depositional change. Comparisons of the pace, intensification and interaction of these processes in one region provide new insights into the pathways of Neolithization in the southern Levant. A clearer picture of the process in the Mediterranean Hills region illuminates how the agricultural transition varied in different ecological zones of Southwest Asia.

Chapter 2. Provisioning the ritual Neolithic site of Kfar HaHoresh, Israel at the dawn of  
animal management

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## **Abstract**

It is widely agreed that a pivotal shift from wild animal hunting to herd animal management, at least of goats, began in the southern Levant by the Middle Pre-Pottery Neolithic B period (10,000-9,500 cal. BP) when evidence of ritual activities flourished in the region. As our knowledge of this critical change grows, sites that represent different functions and multiple time periods are needed to refine the timing, pace and character of changing human-animal relationships within the geographically variable southern Levant. In particular, we investigate how a ritual site was provisioned with animals at the time when herd management first began in the region. We utilize fauna from the 2010–2012 excavations at the mortuary site of Kfar HaHoresh—the longest continuous Pre-Pottery Neolithic B faunal sequence in the south Levantine Mediterranean Hills (Early–Late periods, 10,600–8,700 cal. BP). We investigate the trade-off between wild and domestic progenitor taxa and classic demographic indicators of management to detect changes in hunted animal selection and control over herd animal movement and reproduction. We find that ungulate selection at Kfar HaHoresh differs from neighboring sites, although changes in dietary breadth, herd demographics and body-size data fit the regional pattern of emerging management. Notably, wild ungulates including aurochs and gazelle are preferentially selected to provision Kfar HaHoresh in the PPNB, despite evidence that goat management was underway in the Mediterranean Hills. The preference for wild animals at this important site likely reflects their symbolic significance in ritual and mortuary practice.

## **Introduction**

The growing body of zooarchaeological and genetic evidence from Southwest Asia increasingly supports multi-regional trajectories toward domestication (Willcox 2005; Naderi, *et*

*al.* 2008; Fuller, *et al.* 2012; Stiner, *et al.* 2014). In particular, the process of animal domestication is marked by significant variation among regional zones, with regards to the timing of its first appearance and pace of change, and the type of faunal evidence available to document its early stages (Conolly, *et al.* 2011; Martin and Edwards 2013). Among the many explanations for this variation are differing rates of the spread of agricultural knowledge or animals, localized adaptations of management strategies, proximity to migration and trade routes, and the type of vegetation available for graze (Zeder 2008; Manning, *et al.* 2013). Most researchers agree that some form of animal management, at least of goats, had emerged in the southern Levant by the Middle Pre-Pottery Neolithic B (MPPNB) period, although whether it occurred locally or diffused from the north, is less widely agreed upon (see below). More faunal studies are needed from sites spanning PPNB periods to illuminate how local processes of animal management unfolded within the larger picture of human-animal relationships in southwest Asia.

Ritual practice also contributes to variation in PPNB provisioning decisions (Hayden 2009; Arbuckle 2014). The PPNB is characterized by increased archaeological visibility of ritual practice, especially rituals involving animals as food or symbols in events such as feasts, commemorations and funerals (Özdoğan 1999; Becker 2002; Horwitz and Goring-Morris 2004a; Russell, *et al.* 2009; Hodder and Meskell 2011). Provisioning these symbolic events was prescribed by ritual requirements for animals from certain species, ages, sexes, wild/tame statuses, or sizes (Kansa and Campbell 2004; Twiss 2008) and thus differed from the economic concerns of more routine subsistence provisioning. Further complexity is added by the close interaction of ritual and economic practice that likely fed back into the perceptions and use of animals over the course of the domestication process (Rappaport 1999; Spielmann 2002a; deFrance 2009).

This complexity is reflected in the archaeological record making it difficult to estimate the relative contributions of ritual and economic provisioning at Neolithic sites. Kfar HaHoresh (KHH) (ca. 10,600–8700 cal BP), Israel is a rare site in the Mediterranean Hills west of the Rift Valley that both coincided with much of the early period of animal management and served as a center for human burial and accompanying ritual practice rather than human habitation (Goring-Morris and Birkenfeld 2008; Birkenfeld and Goring-Morris 2015). New faunal data from the 2010–2012 excavations at KHH thus add a much-needed PPNB database that can conveniently contribute to central questions on both the emergence and timing of animal management and ritual provisioning.

The KHH record is especially important and unique because it provides the longest continuous PPNB sequence in the Mediterranean Hills. The sequence includes much needed samples from the Early (EPPNB), Middle (MPPNB) and Late PPNB (LPPNB) (Table 2.1)—the former and latter being two crucial, yet under-represented cultural phases essential for investigating the evolution of animal management in the Mediterranean Hills. Currently, EPPNB faunal samples from the Mediterranean Hills are restricted to the site of Motza (Sapir-Hen, *et al.* 2009). Even more important is the addition of the LPPNB sample, since only small LPPNB assemblages have been available to investigate continuity in the steps toward animal management and ritual practice up until now (Horwitz 2003; Martin and Edwards 2013). The picture of faunal use at KHH enables the investigation of steps toward animal management and ritual provisioning over the long-term at a single site.

Table 2.1. Southern Levant chronological framework.

Period	Date (cal. BP)*
PPNA	11,650–10,600
EPPNB	10,600–10,000
MPPNB	10,000–9,500
LPPNB	9,500–8,700
FPPNB (PPNC)	8,700–8,350
PN	8,350–7,450

Dates were compiled based on recent excavations in the region (Khalaily, *et al.* 2007; Helmer and Gourichon 2008; Ibanez, *et al.* 2010; Paz and Vardi 2014) and unpublished recent dates from

KHH. \*±50–100 years.

In this study of the 2010–2012 faunal assemblage from KHH, we evaluate whether human-animal relationships change across the E–LPPNB sequence. First, we seek evidence for emergent animal management in the relative abundance of wild game and domestic progenitor taxa in human diets. In particular, we examine how changes in the abundance of domestic progenitor taxa influence human hunting of wild ungulates, especially gazelle, which was intensively hunted by humans in the preceding Natufian and PPNA periods (Munro 2009). Next, we utilize classic indicators of herd management such as mortality profiles and body size change to investigate whether the domestic progenitor species at KHH were under some kind of human management and, if so, the nature of this control. This is achieved by investigating the relative frequencies, culling profiles and average body sizes of goat, pig and cattle populations over time. Finally, we consider the state of animal management in light of the ritual function of KHH to assess how the selection of animals compares with those from neighboring village settlements, such as Yiftah’el (Horwitz 2003; Sapir-Hen, *et al.* 2016).

## Background

### *Kfar HaHoresh (KHH)*

KHH is the only known PPNB site in the southern Levant that served primarily as a ritual center, likely for surrounding habitation settlements (Goring-Morris, *et al.* 1998). Seventeen excavation seasons at the relatively small site (~1.5 acres) have uncovered unusual architectural features such as a monumental plastered podium/platform (the Locus 1604 complex), L-shaped and free-standing stone walls, and plastered surfaces, but no domestic structures (Goring-Morris, *et al.* 2008). Numerous human burials ( $n > 85$ ) with an array of treatments including primary and secondary, single and multiple interments and unique secondary inhumations such as a burial of half of a male skeleton and a possible depiction of an animal arranged from human long bones, attest to the funerary role of the site (Horwitz and Goring-Morris 2004a). Iconic representations of ritual behavior tied to the south Levantine PPNB symbolic system have also been recovered, such as plastered human skulls with modeled facial features (Bonogofsky 2003; Slon, *et al.* 2014) and groupings of stone artifacts and figurines interpreted as male-centric items (Horwitz and Goring-Morris 2004a; Goring-Morris and Birkenfeld 2008; Goring-Morris, *et al.* 2008). Material acquired from distant sources including malachite from the Dead Sea area, marine mollusks from the Mediterranean and Red seas and obsidian from southern Anatolia, demonstrate that KHH had exchange connections within the larger PPNB interaction sphere (Goring-Morris and Birkenfeld 2008).

The function of KHH as a gathering place in the hills of the Galilee is supported by evidence for large-scale, collective rituals such as feasts (Horwitz and Goring-Morris 2004a; Goring-Morris and Horwitz 2007; Meier, *et al.* In press). Combined with the lack of arable land for agriculture on the hill slopes (Birkenfeld and Goring-Morris 2015) and the absence of domestic structures despite extensive testing and long-term excavation, this sets KHH apart from

PPNB habitation sites (Kuijt and Goring-Morris 2002; Simmons 2011). Furthermore, the site is located in the uppermost reaches of a valley surrounded entirely by steep hills. This sequestered location is hidden from the view of other sites, yet is located near a prominent landmark of the Lower Galilean landscape—the western ridge of the Nazareth Hills (Birkenfeld and Goring-Morris 2015). The apparent absence of domestic use, and its role as a ritual gathering place may have impacted how KHH was provisioned in comparison to neighboring PPNB settlements. This study lays out the economic background within which ritual practice at KHH occurred. Ultimately, this is essential for understanding how broader trends toward animal management in the southern Levant influenced decisions regarding the provisioning of animals at KHH.

### ***The Faunal Record: Intensive hunting prior to the PPNB***

Significant evidence for an intensive hunting regime in the southern Levant is provided by the Epipaleolithic and PPNA record that directly precedes the PPNB in the Mediterranean Hills (Munro 2009). Increased inclusion of prey with lower payoffs and higher energetic costs of capture (lower ranked prey) indicates intensified hunting with the onset of a more sedentary lifestyle, especially during the Natufian period (Stiner 2001; Munro 2004; Munro 2009). Intensive hunting is indicated by larger proportions of small-bodied gazelles in comparison to larger ungulates, high proportions of juvenile in comparison to adult gazelles, and increased abundances of small to large game (Munro 2004; Yeshurun, *et al.* 2014b), especially costly and more difficult to catch types. This pattern persists into the PPNA when low foraging efficiency is again indicated by high proportions of young gazelles (Davis 1982) and high ratios of fast to slow small game, indicating continued intensive hunting as sedentary horticultural communities became more entrenched (Tchernov 1993; Munro 2003; Davis 2005).

### ***Animal Domestication Research in the Southern Levant***

The goat (*Capra* sp.) was the first herd animal to be managed in the southern Levant likely by the MPPNB (10,000–9,500 cal BP) (Horwitz 2003; Zeder 2008), and thus postdates the earliest evidence for goat management in southeast Anatolia and the northern Levant by 900–1000 years (ca. 10,900–10,500 cal. BP) (Peters, *et al.* 1999; Zeder 2008). Given the greater time depth attributed to animal management in the north (Zeder 2011), it is important to establish how the southern Levant fits into the larger picture. Whether domestication occurred locally or managed animals were imported to this area is still a matter of debate. More data are needed to define local variation in the timing of onset and the pace of change across the region, particularly in the Mediterranean Hills.

The beginning of goat management in the southern Levant is typically identified by the frequency of goats in faunal assemblages. Although wild goats are native to the Levant, they were rarely hunted by Epipaleolithic or early Neolithic people (Davis 1982; Munro 2003; Bar-Oz, *et al.* 2004; Munro 2009). Nevertheless, goat abundance rose substantially from less than 1% in the Epipaleolithic (Davis 1982; Munro 2004; Bar-Oz, *et al.* 2004) to 10–55% by the MPPNB at Yiftah'el, Motza, Nahal Oren and Abu Gosh (Ducos and Horwitz 1997; Martin and Edwards 2013). Recent data from Motza suggests that this increase may have begun even earlier during the EPPNB (Sapir-Hen *et al.* 2009). Despite variability in the scale of increase, goat abundance rises in the absence of climatic change (Migowski, *et al.* 2006). It is becoming increasingly apparent that pig (*Sus scrofa*) and cattle (*Bos primigenius*) frequencies also began to increase slightly across the Mediterranean Hills as early as the EPPNB (Horwitz and Ducos 2005; Sapir-Hen, *et al.* 2016). Since clear evidence for the full-fledged domestication of pig and cattle does not appear in the region until later (Arbuckle and Makarewicz 2009; Arbuckle 2014), these changes have not been investigated as exhaustively as they have been for goats. Additionally,

sheep have been identified at Late Natufian and Harifian sites in the Negev region (Davis, *et al.* 1982) and appear in the Jordan Highlands ('Ain Ghazal) and northern Jordan Valley by the MPPNB, but do not appear in the Mediterranean Hills until the PPNC at Atlit Yam and Ashkelon (Horwitz, *et al.* 1999). Based on current data, it is generally agreed that the MPPNB marks the onset of animal management in the southern Levant (Horwitz, *et al.* 1999; Martin and Edwards 2013).

### ***The Beginning of Animal Management in the Mediterranean Hills***

Although relative taxonomic abundance, demographic profiles and average body size are key for identifying early dates for animal management, variability in these measures and the lack of data in any given period renders a murky understanding of how this process unfolded on a regional scale. Because evidence for animal management varies significantly across ecological zones in the southern Levant (Horwitz 1989; Horwitz 2003; Martin and Edwards 2013), we narrow our comparisons to the Mediterranean Hills (Fig 2.1). Two competing hypotheses for the emergence of managed animals continue to be debated for this region. The first suggests that animals were domesticated locally, while the alternative states that managed animals were imported from the north. The importation argument has been supported by earlier dates for goat management in the north (Peters, *et al.* 1999). Supporters of this argument cite the early appearance of managed goats at sites within the Levantine corridor as evidence that domesticated animals first spread down the Jordan Valley then to the western and eastern regions of the Levant (Bar-Yosef 2000). Managed goats are argued to have spread to neighboring regions within the southern Levant from there.

The autochthonous domestication scenario proposed for the Mediterranean Hills (Horwitz 2003) harnesses increases in goat abundance at several sites as evidence for a local transition

from hunting to herding across the PPNB–PPNC. Horwitz (1989) argues that increased goat abundance compared to previous periods reflects incipient domestication. Horwitz also cites high juvenile kill-off in the goat assemblage from MPPNB Yiftah'el, Munhatta and Abu Gosh and LPPNB Tell Ramad as evidence for human control of goats. The gradual rate of change across the PPNB is cited as evidence for an *in situ* process of animal management in the Mediterranean Hills with changes in goat exploitation that differ in timing from other regions (Horwitz 2003; Makarewicz, *et al.* 2016). Horwitz interprets variability in goat frequencies, mortality profiles and average body-size as evidence that communities had varying degrees of participation in a wider, local autochthonous domestication process (Horwitz 2003). Increased frequencies of goats, in particular of adult females, observed in a new sample from Yiftah'el, support the argument that humans were exerting some control over animal populations from the MPPNB and perhaps as early as the EPPNB (Sapir-Hen, *et al.* 2016). Clearly, more faunal data are needed to understand how these processes developed over time. With its multiple PPNB occupation phases, KHH provides exactly such a dataset.

## **Methods**

This study investigates whether animal management emerges during the PPNB at KHH and if so, when. Next, it highlights how human-animal interactions developed over the course of the PPNB to address long-term change at the site level. We investigate these changes by laying out expectations for animal management in relative taxonomic abundance indices, ungulate mortality profiles and body-size indices and then compare them with data from KHH. The results from KHH are also compared to other PPNB period sites in the region including Yiftah'el, Motza and Abu Gosh to reassess the timing and scale of early animal management in the region.

## ***Expectations for Animal Management***

### *Wild game hunting*

The emergence of animal management at KHH is investigated by examining changes in hunting intensity and the relative frequency of domestic progenitor taxa in the faunal assemblage. Animal management and ultimately, domestication reflect increasing human control over animal movement, reproduction and diet (Zeder 2008). Limiting the movement of high-ranked ungulate taxa with characteristics amenable to human control, ultimately increases their encounter rate and reduces search costs (Stiner, *et al.* 2014). Although the control of animals can be costly, confinement and ultimately reproductive control increases their population density and eventually their rate of population growth (Winterhalder and Golland 1993). As human control over and accessibility to high-ranked domestic taxa increases, these taxa should increase in faunal assemblages. Because they are highly ranked, a narrowing of the diet will ultimately reduce hunting intensity and increase foraging efficiency (Stiner, *et al.* 2000; Stiner and Munro 2002). Animal management is thus expected to result in reduced taxonomic diversity (Horwitz 1996), higher proportions of domestic progenitor taxa in comparison to wild game (Clutton-Brock 1987; Tchernov 1993) and associated decreases in lower-ranked game including smaller-bodied ungulates, such as gazelles, small game taxa (tortoises, hares and birds) and juveniles in comparison to adult gazelles (Munro 2004; Munro 2009). Taxonomic diversity is calculated with PAST software using Simpson's D (Hammer and Harper 2008). The relative abundance of juvenile and adult gazelles is investigated using classic measures of ungulate mortality including tooth wear and eruption sequences and bone epiphyseal fusion (Payne 1973; Davis 1980; Munro, *et al.* 2009).

### *Human interaction with domestic progenitor populations*

Animal use goals are expected to shift over the transition from hunting to herding as the conception of animals changes from resources to property (Russell 2002). Further human control over animal reproduction is expected to maximize animal resources to meet herd security goals, starting with the optimization of meat production (Payne 1973). Small-scale animal management strategies are expected to promote herd security by culling the less essential male animals early in life, and maximizing the number of productive adult females needed to maintain the herd (Redding 1981; Zeder 2006a; Hongo, *et al.* 2009). Measures of population mortality of domestic progenitor taxa are used to investigate whether there was a shift from an immediate to a delayed returns strategy of animal use (Davis 2005; Zeder 2006). Mortality profiles are created based on bone fusion for goats (Zeder 2006b), cattle (Grigson 1989) and pigs (Hongo and Meadow 2000). Samples of teeth from these taxa were too small to crosscheck with wear and eruption data.

Management frequently results in a decline in the average body size of animal taxa (Bökönyi 1969). Initially, this decline is at least partially related to the change in demographic structure mentioned above—a higher adult female to adult male ratio (Zeder 2006a). Since females are smaller bodied than males on average, the average size of the population should decline when juvenile males are preferentially culled (Zeder 2006a). The Logarithmic Size Index (LSI) (Meadow 1999) is used to investigate the average body size of domestic progenitor taxa from KHH over the course of the PPNB. The LSI compares the size of individual elements to a standard animal and combines measurements from different elements to increase sample size. Here we use the Uerpmann and Uerpmann (1994) standard animal for goat and Grigson's (1989) standard animal for cattle. Wild boar sample sizes were too small for LSI analysis. The skewing of the LSI distribution is used to investigate sex ratio—positive or negative skewing suggests

more small-bodied (likely females) or large-bodied animals in the population, while no skewing indicates a normalized distribution that reflects a living population structure (Wolverton 2008).

## **Materials**

The faunal sample studied here includes the material recovered during the most recent excavation seasons at KHH (2010–2012). The sample derives from the most securely dated contexts and loci spanning Early, Middle and Late PPNB (EPPNB, MPPNB, LPPNB) periods. Chronological assessments were made based on stratigraphic correlations and radiocarbon dates (Birkenfeld and Goring-Morris 2014). The density of fauna and other material at KHH increased significantly through time, likely due to increased occupation intensity (Birkenfeld and Goring-Morris 2015). The faunal sample originates from loci in the northern part of the site. Sampled loci range widely in function and include densely packed middens with embedded stone-lined garbage deposits, deposits sandwiched between layers of plaster applied on architectural features, graves, hearths, caches of finds such as flint, and pits associated with the on-site production of plaster, lithics and food. Thirty-nine percent (NISP=16,905) of the recovered fragments were identified to element and to animal body-size category or more specific taxonomic group and attest to the good quality of preservation at the site. Specimens were identified using the comparative vertebrate collections in the National Natural History Collections of the Hebrew University, Jerusalem. Statistical analysis was performed with PAST software (Hammer and Harper 2008).

## **Ethics Statement**

Excavations were directed by one of the authors (A.N. Goring-Morris) from the Hebrew University, Jerusalem on behalf of the Israeli Antiquities Authority (excavation licenses G-29/2010, G-43/2011, G-60/2012). The zooarchaeological specimens (#1–8498) can be accessed at the National Natural History Collections of the Hebrew University, Jerusalem.

## **Results**

### ***Hunting Intensity***

#### *Taxonomic diversity and relative abundance*

At KHH, species diversity decreased significantly between the EPPNB and later periods from 0.83 to 0.73 (Simpson's D, t-test of similarity: E–M  $t=-8.11$ ,  $p<.01$ , E–L  $t=-11$ ,  $p<.01$ , M–L  $t=-1.7$ ,  $p=.08$ ) (Fig 2.2). This shift reflects the increasing abundance of high-ranked ungulates in lieu of lower-ranked small game and carnivores over time (Fig 2.3a). These results fit a drop in taxonomic richness observed by Horwitz (Horwitz 1996) across the southern Levant from the PPNA to the MPPNB (Menhenick Index,  $D_{mn}=1.3$  to 0.4). Ungulates dominate the KHH assemblage in all periods, but increase from 61 to 72% over time (Fig 2.3a). This corresponds to a decline in small game abundance from 28 to 17% from the E–LPPNB. Carnivore abundance fluctuates from 10 to 12% between the E–LPPNB.

Gazelle, the dominant taxon consumed by humans in the southern Levant throughout the Epipaleolithic (~83–98%) (Davis 1982; Tchernov 1993; Munro 2004) and the PPNA (73–88%) (Davis 1982), is less common in all PPNB phases at KHH (Fig 2.3b) than in preceding periods in the Mediterranean Hills. Again, this fits with similar trends across the region (Horwitz 1989;

Munro 2003), but this is where the similarity ends. Unlike the general decline in gazelle abundance across the Levant that continues into the PPNB, the relative abundance of gazelles out of all ungulates increases significantly at KHH between the EPPNB (56%) and MPPNB (70%) and then stabilizes in the LPPNB (70%) at KHH (Fig 2.3b).

### *Mortality profiles for gazelle*

The abundance of juvenile gazelle in all PPNB phases represented at KHH (24–36%) is less than at earlier Natufian (up to 45%) and PPNA (59%) sites in the region (Munro 2004; Davis 2005). Nevertheless, the ages of gazelles represented at KHH changed little over time. Analysis of gazelle survivorship based on bone fusion indicates that the kill-off of juvenile gazelles less than 18 months of age remained stable at 35% and 39% in the E–MPPNB and then decreased to 24% in the LPPNB (Fig 2.4a). The tooth wear results from KHH are similar and indicate that juvenile gazelle survivorship changes, but not significantly (K-S test  $p=.88$ ) from the MPPNB (23%)(Fig 2.4b) to the LPPNB (34%)(Fig 2.4c). There are slightly fewer old and prime-aged animals in the LPPNB. Gazelle tooth sample sizes from the EPPNB were too small for analysis. In all cases, juvenile representation is similar to or less than the 33% of young animals present in stable modern gazelle populations (Mendelssohn and Yom-Tov 1999). Thus, gazelle demographics at KHH resemble a natural population structure, and do not reflect prime-dominated hunting as expected if hunting intensity had continued to decline. The KHH gazelle data is similar to gazelles from EPPNB Motza (28% kill-off before 18 months of age) (Sapir-Hen, *et al.* 2009) and the recent findings from MPPNB Yiftah'el (26% kill-off before 18 months of age) but differs in abundance from later PPNB sites in the region (Sapir-Hen *et al.* 2009; Sapir-Hen, *et al.* 2016).

## ***Indicators of Animal Management***

### *Relative ungulate abundance*

Together, the three domestic progenitor taxa are represented in much higher frequencies in all PPNB layers at KHH than in earlier Epipaleolithic and Neolithic sites in the Mediterranean Hills (Fig 2.3b). In particular, the abundance of *Capra* (16–18%) in relation to other ungulates at KHH is significantly higher in all PPNB periods than at Epipaleolithic (<1%) (Davis 1982; Bar-Oz, *et al.* 2004; Munro 2004), PPNA (1–3%) (Davis 1985; Tchernov 1994; Horwitz, *et al.* 2010), and EPPNB (3%) (Sapir-Hen, *et al.* 2009) sites in the region. The percentage of goats at EPPNB KHH (16.3%) is higher than expected—and is most similar to MPPNB sites in the Mediterranean Hills, including Yiftah'el (Areas C&D)(16.6%), Motza (15.7%), and PPNB Ard el-Samra (19%), albeit significantly lower than MPPNB Abu Gosh (54%), which stands apart from other sites in the region (Ducos and Horwitz 2003; Horwitz 2003; Getzov, *et al.* 2009; Sapir-Hen, *et al.* 2009).

Also, unlike the region-wide trend, the abundance of *Capra* remains steady over time at KHH (*Capra*:16–18%). The same is true of the ratio of goat to gazelles, which is typically used to track the onset of goat management (gazelle:goat EPPNB 3.4:1; LPPNB 4.3:1) (Fig 2.5). Although other faunal assemblages from the Mediterranean Hills are dominated by gazelle during the PPNB (Horwitz, *et al.* 1999), the gazelle to goat ratio decreases over time at other sites. This is especially clear from the E–MPPNB at Motza (20:1 to 4:1) (Sapir-Hen, *et al.* 2009) and at Yiftah'el (MPPNB 3.7:1; Final PPNB/PPNC 0.1:1 Areas A, B, C) (Horwitz 2003).

The increase in gazelle at KHH coincides with a decrease in *Bos* over time, especially from the EPPNB (25%) to the MPPNB (8%) (Fig 2.2b). Like *Capra*, the relative abundance of *Sus* remains low and steady over time (*Sus*: 3–5%). No sheep were identified in the assemblage.

The relative abundance of cattle compared to other ungulates in the EPPNB (25%) at KHH is higher than many other sites in the area, including EPPNB (3%) and MPPNB Motza (4%), Nahal Oren (2.4%), Yiftah'el Areas C&D (10%), and some MPPNB layers at Abu Gosh (3–19%) (Legge 1973; Ducos 1978; Ducos and Horwitz 2003; Horwitz 2003; Sapir-Hen, *et al.* 2009). In contrast, *Sus* abundance at KHH is similar to earlier PPNA sites in the area, such as Hatoula (2%) and Nahal Oren (3.5%) and is lower than MPPNB sites in the area including Yiftah'el Areas C&D (10%), Abu Gosh (10–11%), and Motza (13%), but not MPPNB Nahal Oren (4.6%) (Legge 1973; Ducos 1978; Davis 1985; Ducos and Horwitz 2003; Horwitz 2003; Sapir-Hen, *et al.* 2009).

#### *Mortality profiles for goat, cattle, and pig*

The mortality profiles based on the bone fusion of domestic progenitor taxa from KHH show some change over the course of the PPNB. *Capra* mortality drops only slightly from the E–MPPNB, but the survivorship of animals less than 48 months of age drops significantly from 75% to 32% between the M–LPPNB (Fig 2.6). This is lower than the survivorship of a modern wild population of *C. aegagrus* from Pakistan (60% to 48 months of age) (Edge and Olson-Edge 1990). *Capra* demographics at KHH are consistent with PPNB sites in the region, such as MPPNB Abu Gosh (31% survivorship at 39 months) (Ducos and Horwitz 2003) and Final LPPNB/PPNC Yiftah'el (33% survivorship at 42 months) (Horwitz 2003) that have been interpreted as early managed populations.

In contrast, there is a significant increase in the survivorship of cattle less than 48 months of age at KHH from 18% in the EPPNB to 60–66% by the M–LPPNB (Fig 2.7). Although comparisons are limited by very small sample sizes, a rise in the survivorship of adult cattle to 48 months of age was also noted at Yiftah'el from the MPPNB (40–75%)(Areas C and D; n=9) to

the FPPNB/PPNC (100% by 36 months of age) (Areas A and B; n=6) (Horwitz 2003) and at other PPNC sites in the region (Horwitz and Ducos 2005). Sample sizes at Yiftah'el are not large enough to be as certain of whether a shift in survivorship occurred over time.

Of the *Sus* assemblages, only the LPPNB sample is large enough for mortality analysis based on fusion data (n=23). This assemblage provides the first *Sus* mortality data from the LPPNB in the Mediterranean Hills. It shows that most of the population was culled before adulthood (Fig 2.8). Forty-four percent survived to one year of age. This is less than the survivorship to one year of age in modern wild *Sus* populations in Spain in mountainous (58.6%) and riverine habitats (75%) (Herrero, *et al.* 2008). Survivorship of *Sus* to one year of age (44%) is also lower at LPPNB KHH than at MPPNB Abu Gosh (98%) (Ducos and Horwitz 2003) and Yiftah'el (60%), and at PPNC (80%) Sha'ar HaGolan (Marom and Bar-Oz 2013).

#### *Average body-size of domestic progenitor taxa*

At KHH, the average body-size of goats decreases slightly from the E-MPPNB (-0.004 to -0.019) (Fig 2.9, S6A–C Tables). This decline is not statistically significant (t-test for similarity of means, p=.55). Notably, LSI distributions of fused elements are skewed substantially to the right in all periods (Early 0.7, Middle 1.05, Late 0.8) (Figs 2.9, 2.10A–D), suggesting a high proportion of smaller-bodied females in the population. In the LPPNB assemblage, an increase in young male caprine kill-off is suggested by the fact that 73% of unfused elements have larger LSI values than fused specimens of the same element (Figs 2.10C, 2.10D)—the unfused elements are likely males, which can exceed females from the same population in size as early as 12 months of age (Zeder 2001).

LSI data for south Levantine goat populations around the time of the transition to agriculture are spotty, but substantial enough for comparisons to earlier wild and later managed

populations. The average LSI for the KHH goats from the M–LPPNB periods (Mean LSI -0.019 to -0.015) is smaller than wild populations from the Natufian period (Eynan, 0.034), but significantly larger than the fully domesticated herds from the western highlands of Jordan in the Yarmoukian period ('Ain Ghazal, -0.044) (Martin and Edwards 2013). The same is true of all other measured populations of MPPNB goats from the Mediterranean southern Levant including Abu Gosh (0.008) (Ducos 1978), and Yiftah'el (0.004) (Horwitz 2003). Nevertheless, there is variation among the Mediterranean PPNB populations. The average LSI values from KHH are smaller than those from MPPNB Yiftah'el (Horwitz 2003) and Abu Gosh (Ducos and Horwitz 2003), even when unfused specimens are removed from the analyses. Results of the new analysis of fauna from Areas G and I at MPPNB Yiftah'el include unfused specimens and are smaller on average (-0.011) than specimens from Horwitz's (2003) MPPNB sample from the site. They are more positively skewed (-0.1) toward the smaller end of the population than *Capra* from EPPNB Motza (-0.7), despite prime-dominated age profiles (Sapir-Hen In Press). The KHH distributions are more skewed to the right (positive) than the Abu Gosh distribution, which is skewed only slightly to the right. Larger average body size at Abu Gosh may relate to the inclusion of *C. ibex* measurements in the LSI data (Kahila Bar-Gal, *et al.* 2003), but the LSI distribution is positively skewed, and likely indicates a slight female bias. The *Bos* LSI distribution from KHH combines measurements from all PPNB phases to maximize sample size and includes many measurable bones that could be dated only to the PPNB. *Bos* from KHH are similar in size to those from other south Levantine PPNB sites (Fig 2.11). Although geographic variation likely influenced *Bos* body-size, there is a significant decline from the EPPNB to the PN in sites from the Mediterranean Hills and Jordan Valley. Cattle from KHH are significantly smaller than those from E–MPPNB Motza (Mann-Whitney Pairwise test for similarity of means,  $p < .005$ ), but significantly larger than those from the PN phase from Sha'ar HaGolan ( $p < .001$ ) (Fig 2.10). The

decline in *Bos* body-size is most pronounced between the FPPNB and the PN at Sha'ar HaGolan (Marom and Bar-Oz 2013). *Bos* LSI distributions from KHH are negatively skewed and likely favor males, much like distributions from Motza and Abu Gosh, but differ from the positively skewed distribution at Ard el-Samra and PPNC Sha'ar HaGolan and the normal distributions from Yiftah'el (Areas C&D) and Mishmar HaEmek.

## **Discussion**

### ***Hunting Intensity at KHH***

In comparison to Epipaleolithic and PPNA sites in the Mediterranean Hills, the fauna from KHH reveal a narrowing of dietary breadth and an increase in foraging efficiency over time (Broughton 1994; Stiner, *et al.* 2000; Stiner and Munro 2002). This fits a region-wide trend reflecting a trade-off between small game and domestic progenitor species from the Natufian to the PPNB (Horwitz 1989; Munro 2003). In addition, there is a clear increase in the abundance of adult gazelle compared to the juvenile-dominated assemblages of the PPNA and Natufian (Davis 1982; Munro 2004). At KHH, both the decline in taxonomic diversity and the decrease in small game abundance indicate the continuation of this trend toward increased foraging efficiency through the PPNB. Nevertheless, high abundances of gazelle across the PPNB occupation at KHH signify the opposite trend. The increase in the lowest-ranked gazelles at the expense of the highest-ranked cattle indicates a decline in ungulate foraging efficiency at KHH over time.

Thus, some changes in wild game proportions at KHH follow expectations for an economy that includes nascent animal management and support a trajectory toward less intensive hunting from the Natufian and PPNA through the end of the PPNB, while others do not. Reduced hunting intensity corresponds to the increase in domestic progenitor taxa in the ungulate fraction of the assemblages and thus fits expectations of emergent management of some ungulate taxa

according to regional faunal trends (see also Horwitz 1996; Horwitz and Tchernov 1998).

Although the relative abundance of domestic progenitor species in the PPNB is significantly greater than assemblages that came before, the steady emphasis on gazelles throughout the PPNB at KHH reveals a leveling off of this trajectory at least in the ungulate component. Continued reliance on gazelles during the PPNB at KHH differs from the steady increase in domestic progenitor species seen across the southern Levant more generally from the MPPNB through the PN, which has been associated with greater control of these taxa over time (Horwitz, *et al.* 1999; Munro 2003).

### ***Animal Management at KHH***

Increasing frequencies of *Capra* are commonly cited as markers for the beginning of caprine management at PPNB sites in the Levant (Clutton-Brock 1979; Davis 1982; Horwitz 2003; Martin and Edwards 2013). KHH fits the established regional pattern of increased *Capra* abundance compared to the Epipaleolithic and PPNA. Interestingly, however, the rise occurs earlier than expected in the EPPNB. The proportions for *Capra* in all phases at KHH are most similar to MPPNB sites in the region (16–19%) (Horwitz 2003; Sapir-Hen, *et al.* 2009; Getzov, *et al.* 2009), with the exception of Abu Gosh, which is higher (Ducos and Horwitz 2003). This suggests that human control over goats may have begun earlier than previously established for the Mediterranean Hills (see also (Sapir-Hen, *et al.* 2016; Sapir-Hen In Press)). Nevertheless, despite the initial increase, goat abundance remains stable over time at KHH and thus, diverges from the trajectory of increase that typifies later LPPNB sites in adjacent regions such as Beisamoun (53%) (Bocquentin, *et al.* 2011).

Other features of the KHH *Capra* populations also resonate with those detected at other Mediterranean Hills sites by the MPPNB. The KHH *Capra* LSI body-size data are similar to

those from neighboring PPNB sites suggesting that a region-wide shift in goat body size occurred over time. These goat populations were slightly smaller than the Natufian wild assemblage from Eynan, but not as small as later PN assemblages. Additionally, by the LPPNB goat mortality profiles at KHH approach 30% survivorship by 36 months of age (37% survive to 30 months at KHH based on bone fusion categories), as expected for modeled caprine populations managed for meat (Payne 1973). Although *Capra* survivorship varies across the region, KHH is most similar to sites with the lowest juvenile survivorship that have been interpreted as early managed populations (MPPNB Abu Gosh and Final LPPNB/PPNC Yiftah'el) (Horwitz 2003; Ducos and Horwitz 2003).

Evidence for small-scale size diminution and a younger average age of culling in the EPPNB and MPPNB at KHH compared to earlier periods illuminates very early signs of a shifting relationship between humans and goats during the period leading up to animal domestication in the region. These changes are not sufficient to argue for full-fledged animal management, but they do suggest a shift in the relationship between goats and humans that is similar to other Mediterranean Hills sites. Positively-skewed LSI distributions at MPPNB Yiftah'el and KHH suggest that humans might have first gained control over smaller females that were likely easier to control than males. This very early stage of human control likely precluded directed reproduction and selective culling, but aimed to cut costs by improving access to high-ranked animals and reducing search time. Ultimately, this was followed by targeted culling of younger, likely male animals once they neared full body-size, just prior to sexual maturity. Constraining the movement of wild goats would have decreased search and capture costs and made it increasingly worthwhile to harvest goats rather than gazelles at Mediterranean Hills sites. What makes KHH so interesting is its continued focus on gazelle hunting despite increasing

availability of lightly managed goats in the Mediterranean Hills. In this sense, the trajectory of change from the MPPNB onward at KHH diverges from the rest of the region.

The relative abundance of *Bos* in all PPNB phases at KHH, especially in the EPPNB phase, is notably higher than in preceding periods elsewhere in the southern Levant. Interestingly, *Bos* abundance peaks in the EPPNB and then declines over time counter to expectations for cattle management. In contrast, the abundance of *Sus* at KHH is not significantly different from earlier periods in the region and increases only slightly over time. Like *Capra*, the abundance of large domestic progenitor taxa at KHH from the MPPNB onward do not significantly increase as they do at other sites such as Yiftah'el (Sapir-Hen, *et al.* 2016). Archaeological contexts suggest that species abundance is likely an unreliable marker for *Bos* management at KHH, as cattle were mainly recovered from concentrated EPPNB deposits probably related to feasting or other special activities (Meier, *et al.* In press). Thus, *Bos* abundance, at least in the EPPNB, best reflects specific, short-term activities.

Comparison of *Bos* data from KHH to that from other sites in the region highlights a decline in average body size across the PPNB, indicating that KHH follows a similar pattern to sites in the Mediterranean Hills and in the Jordan Valley. The sample of *Bos* measurements from PPNB sites is very limited, but *Bos* LSI values are smaller on average than those from E–MPPNB Motza, suggesting that the decline in average cattle size may have begun earlier than the PPNC (Ducos and Horwitz 1997; Horwitz and Ducos 2005) or PN (Davis 1981) as previously believed. This new data for *Bos* parallels and is coeval with the trend toward goat diminution and could similarly reflect the impact of increased human control over these domestic progenitor taxa in the region. Nevertheless, sex biases in cattle populations suggested by skewness of the LSI values vary widely on a regional scale and unlike goats, do not exhibit the female-biased adult populations characteristic of managed herds. This may be at least partially attributable to the

small sample of *Bos* bones (Horwitz and Ducos 2005). The increased survivorship of juvenile cattle also does not fit expectations for increased human control of *Bos* populations at KHH. This differs from the more juvenile, female-biased, or smaller cattle populations at LPPNB sites in Jordan (Basta, Beidha, 'Ain Ghazal) that have been interpreted as likely managed herds (von den Driesch and Wodtke 1997; Horwitz, *et al.* 1999; Becker 2002; Horwitz and Ducos 2005).

Accordingly, demographic evidence does not support *Bos* management at KHH. Instead, changes in the *Bos* age structure likely reflect a reduction in hunting pressure on wild cattle, similar to that shown by gazelles at the site. The alleviation of hunting pressure on *Bos* populations suggested by increased juvenile survivorship at KHH may reflect a trade-off resulting from intensified use of other domestic progenitor taxa, as is suggested by the age profiles of gazelles. In the Jordan Valley, a similar drop in the kill-off of juvenile cattle occurs later between the PPNC and the PN at Sha'ar HaGolan (Marom and Bar-Oz 2013). Marom and Bar-Oz (Marom and Bar-Oz 2013) interpret this as evidence for the beginning of conservation of cattle herds in the PN in response to overhunting in the PPNC. Thus, even though the *Bos* data from KHH fit the regional body size pattern, the relative abundance and demographics of cattle populations at the site better fit a wild population rebounding from hunting pressure that was selected for specialized use in specific ritual practices (see below).

Finally, although small sample sizes prevent tracking of demographic change in *Sus* populations over time, the survivorship of juvenile pigs from LPPNB KHH is similar to survivorship at PN Sha'ar HaGolan (Marom and Bar-Oz 2013), where it has been treated as evidence for domestic animals at the site. The survivorship of juvenile *Sus* at KHH is also lower than at earlier PPNB sites (Hongo and Meadow 2000; Ducos and Horwitz 2003; Horwitz 2003). Still, diverse potential pig management strategies (Rowley-Conwy, *et al.* 2012) are known to cause significant demographic variability in domestic populations, leading to equifinality in *Sus*

demographic profiles. Hunting is also expected to produce higher proportions of juveniles than in other progenitor taxa since more young *Sus* are naturally available due to high rates of fecundity (Arbuckle 2013). Thus, the *Sus* data is suggestive and hints at a small degree of human control, but this pattern is equivocal compared to the *Capra* data. Evidence of *Sus* management demands further investigation in the Mediterranean Hills region. Despite the high rate of juvenile culling, *Sus* abundances at KHH remain steadily lower than at other PPNB sites, and differ from regional trends reflecting increased use of *Sus* across the course of the PPNB.

### ***Provisioning a Ritual Site***

In terms of the overall decline in hunting intensity, changes in the demographic profiles and body size of goats, and perhaps the demographics of pigs, the faunal populations that were drawn from to provision KHH resemble those used to provision surrounding PPNB sites in the region. In this sense, the fauna reflects region-wide trends of emergent early animal management, at least for goats by the MPPNB. Nevertheless, despite these similarities, the relative abundance of taxa selected to provision KHH differs significantly from the selection of taxa and the trajectory of change in species abundance at other PPNB sites— specifically, wild taxa continue to be emphasized at KHH even as animal management becomes more entrenched throughout the southern Levant. In particular, wild cattle are common at EPPNB KHH, gazelles abound throughout the sequence, and domestic progenitor taxa remain stable from the MPPNB onward. Residents of KHH clearly selected ungulates (early managed goats and possibly pigs, wild gazelle and wild cattle) from the same pool of animals accessed by residents of PPN sites in the surrounding area, but they made different choices about the relative quantities of these animals when provisioning the site.

This difference likely reflects the nature of activities that were performed at KHH compared to other sites in the region. As reviewed above, KHH lacks domestic areas and provides clear evidence for special ritual activities, often associated with burial events. Animal selection at KHH likely reflects provisioning decisions related more to the social and ideological goals of ritual practice such as feasting, than those of other sites (Horwitz and Goring-Morris 2004a). The more mundane processes involved in the nascent management of *Capra* and possibly *Sus* populations likely occurred near more permanent neighboring settlements than at this isolated mortuary site.

The preference for wild animals, in particular gazelles, over domestic progenitor species is maintained at KHH across the PPNB. Although gazelles are more common in Mediterranean Hills assemblages (Horwitz, *et al.* 1999; Martin and Edwards 2013), the stability of gazelle hunting at KHH strongly contrasts with the broader pattern of intensified animal management both in the Mediterranean Hills and throughout the southern Levant and greater Southwest Asia once animal management begins. A continued preference for wild gazelles despite the focus on increasingly managed animals at contemporaneous sites, suggests an inversion of the norms of food selection—a common feature of ritual practice (Bell 1997; Rappaport 1999). Wild gazelle preference at KHH is undoubtedly related to its important role in PPN ritual practices, especially once the process of animal management began. The importance of gazelle in ritual practice is attested by unusual deposits at PPNB sites including a headless gazelle carcass burial associated with a plastered human skull at KHH (Horwitz and Goring-Morris 2004a), a pair of burned gazelle horns in a human grave at Motza (Khalaily, *et al.* 2007), a gazelle skull placed in a wall niche at LPPNB 'Ain Jammam (Waheeb and Fino 1997), and several gazelle horn pairs recovered on the floor of a building and, in the courtyard outside, an articulated gazelle carcass with burned feet at LPPNB 'Ain Ghazal (Rollefson 1998).

Additionally, persistent use of wild gazelles as the primary source of meat provisions at KHH may have solidified traditions of feeding site visitors/congregants by producing continuity with past ritual performances. Similarly, PPNB mortuary practices that were centered around ancestors reaffirm connections with the past, such as those involving the reopening of graves and plastering of human skulls with sculpted facial features (Goring-Morris 2000; Verhoeven 2002a). The continuity of gazelle hunting over time, despite the abundance of goats available at KHH by the EPPNB, reveals that the social benefits of using this wild species at the site exceeded the caloric benefits of using controlled taxa.

Abundant cattle in the EPPNB is clearly also related to the role of this wild species in ritual practices at the site and elsewhere (Goring-Morris and Belfer-Cohen 2002; Verhoeven 2002a; Horwitz and Goring-Morris 2004a; Meier, *et al.* In press). Cattle were recovered from more structured deposits than other taxa in the 2010–2012 faunal sample at KHH. These included an EPPNB pit (Locus 2268) with highly concentrated *Bos* remains associated with the monumental Locus 1604 complex podium and M–LPPNB midden deposits (Meier, *et al.* In press). These deposits comprise the majority of the *Bos* assemblage and inflate the abundance of *Bos* during the EPPNB phase. Additionally, the presence of more complete carcass portions in the EPPNB pit disproportionately affects the relative NISP of wild cattle in relation to the more even spatial distribution of other ungulate specimens, including goats (Lyman 2008). This pit deposit shares similarities with another pit of wild cattle remains, Locus 1005 (also under the L1604 complex), previously described at KHH (Horwitz and Goring-Morris 2004a) and highlights the importance of *Bos* in ritual practice, which undoubtedly influenced the selection of taxa for provisioning the site during the EPPNB.

The important symbolic role of wild animals such as cattle has been established based on the art, figurines and burial goods found across the PPN *koine* (i.e. Göbekli Tepe and

Çatalhöyük) (Cauvin 1994; Peters and Schmidt 2004; Twiss and Russell 2009). Wild animal hunting likely held particular symbolic importance, which became especially poignant as the division of labor and labor scheduling were reconfigured during the development of animal management and cultivation (Shanklin 1985; Goring-Morris 2000; Goring-Morris and Belfer-Cohen 2002; Arbuckle, *et al.* 2009). Wild animal hunting may have sent a more costly signal of group membership than that of controlled animals during many types of rituals at KHH, such as feasts featuring the communal hunting of multiple dangerous wild cattle individuals (Horwitz and Goring-Morris 2004a). Feasts and other rituals practiced at varying scales during the PPNB (Hodder and Cessford 2004) were important for creating a sense of place and for integrating communities by maintaining traditions of shared symbolic practices with food (Kuijt 1996; Watkins 2005; Russell, *et al.* 2009).

## Figures for Chapter 2



Figure 2.1. Map of south Levantine sites referenced in the text. The location of Kfar HaHoresh is marked with a hollow circle ( $32^{\circ}42'20''$  N  $35^{\circ}16'28''$  E). Mediterranean Hills sites are outlined with a dashed line.

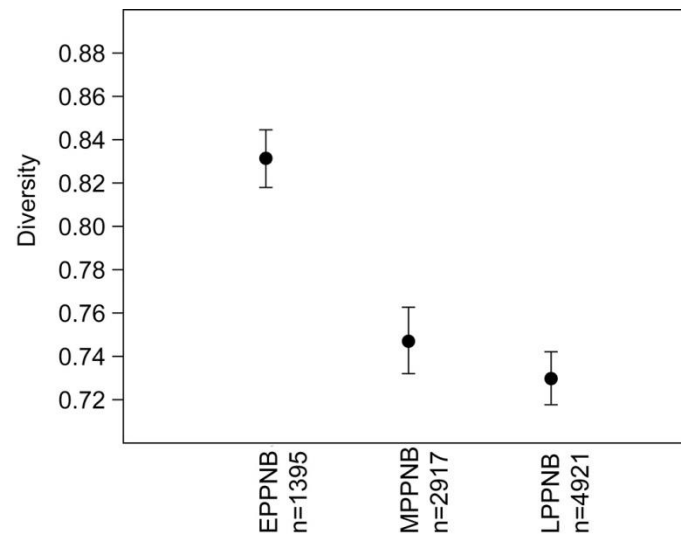


Figure 2.2. KHH Simpson's diversity index by site occupation phase.

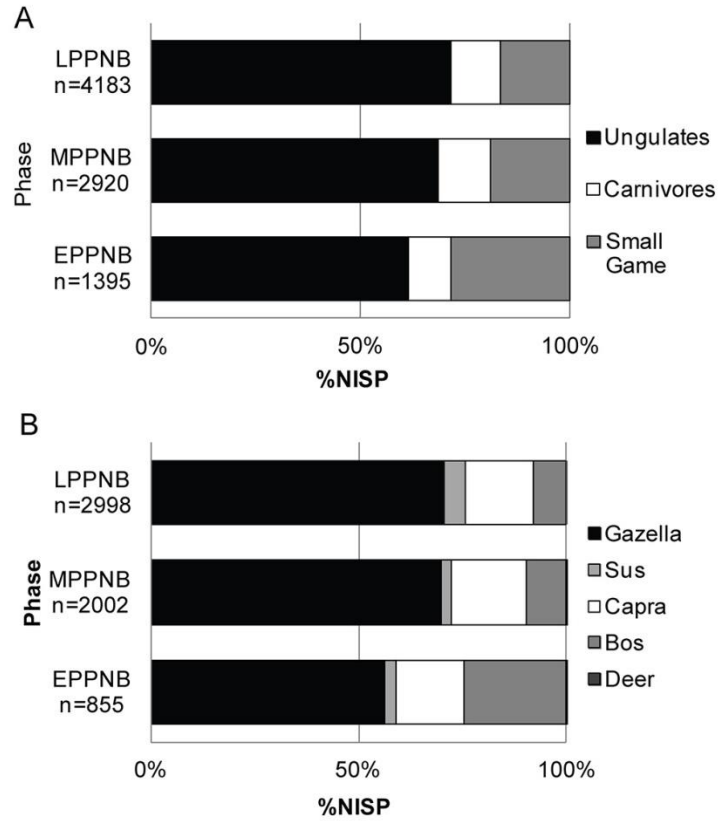


Figure 2.3. KHH relative abundance of (A) broad taxonomic groups and (B) relative ungulate species abundance based on %NISP per taxa (S1).

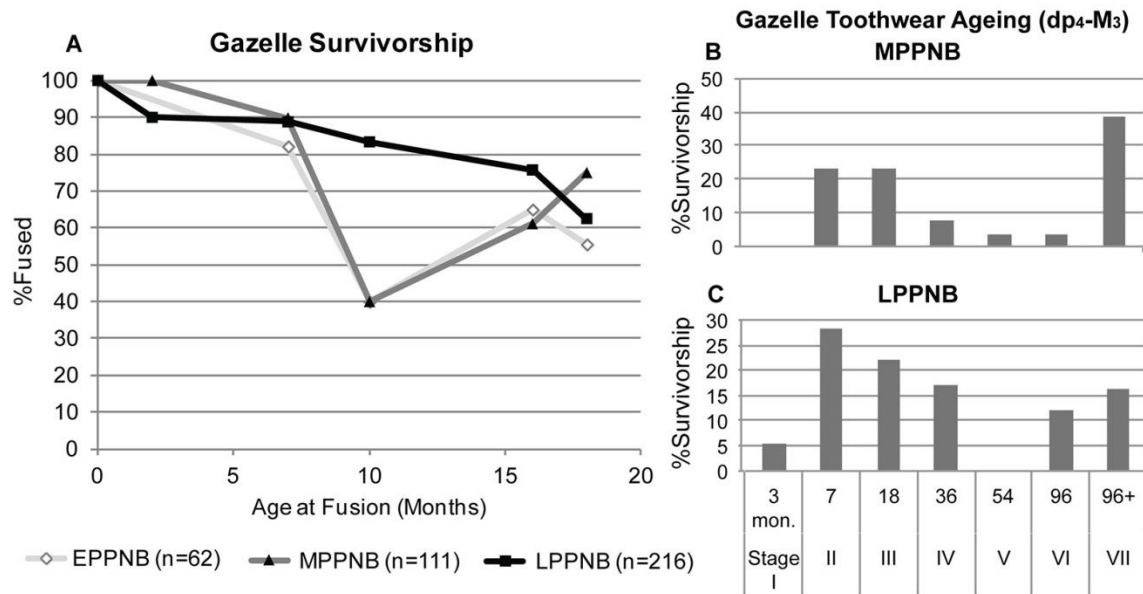


Figure 2.4. Gazelle survivorship curves (A) based on percentage of fused bone elements (see S2 Table for MNE values). Changes are not significant based on Kolmogorov-Smirnov test (K-S) (p values: E to M=.75, M to L=.69, E to L=.25). Gazelle age stages based on toothwear (following Munro et al. 2009) for the (B) MPPNB (n=13) and (C) LPPNB (n=16) phases.

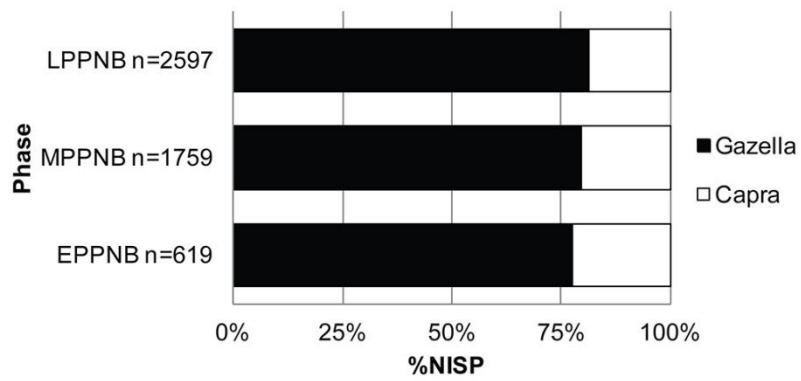


Figure 2.5. KHH *Capra* (white) to *Gazella* (black) ratio over time (%NISP).

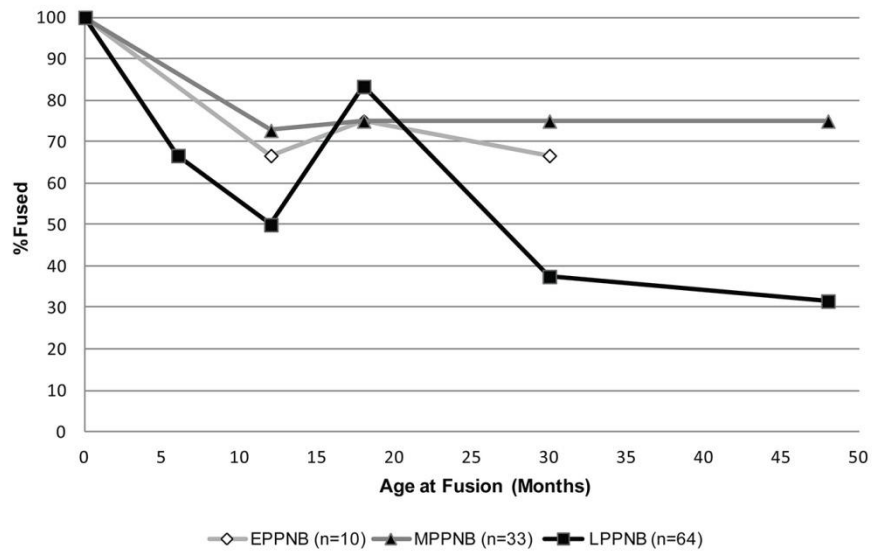


Figure 2.6. KHH *Capra* Survivorship by PPNB phase. There is a significant difference between the M and LPPNB profiles (K-S test  $p = .036$ ). Elements with fewer than three total fused and unfused specimens were removed (see S3 Table ), including proximal humeri from all periods.

No data for age stage 6 (>48 months).

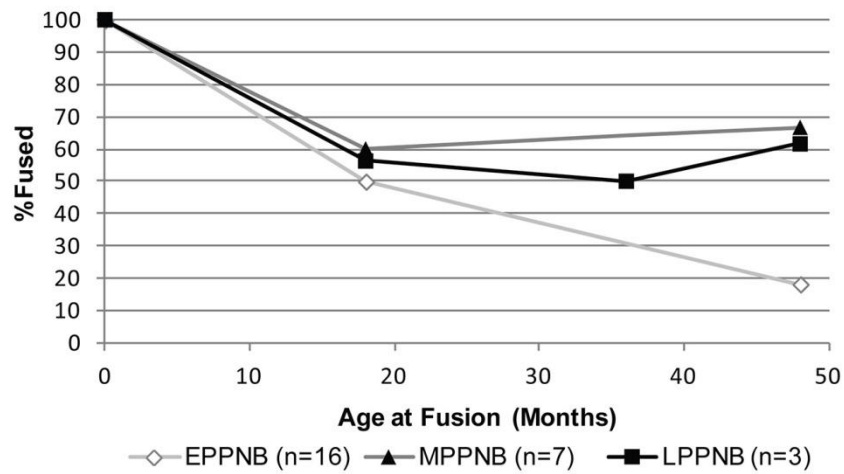


Figure 2.7. *Bos* survivorship curve based on fusion data. Elements with total MNE < 3 were not plotted (see S4 Table). There is a significant difference (K-S test) between the Early and Middle PPNB profiles ( $p=.03$ ) and Early and Late PPNB profiles ( $p=.031$ ), but no significant difference between the Middle and Late PPNB profiles ( $p=.31$ ).

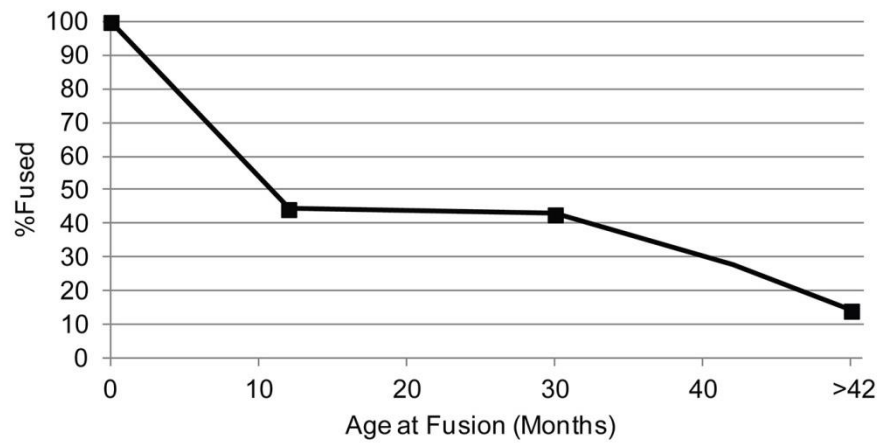


Figure 2.8. Survivorship curve for *Sus* (n=23) at LPPNB KHH based on age at bone fusion (Hongo and Meadow 2000). See S5 Table for MNE values. Elements with MNE < 3 were not plotted.

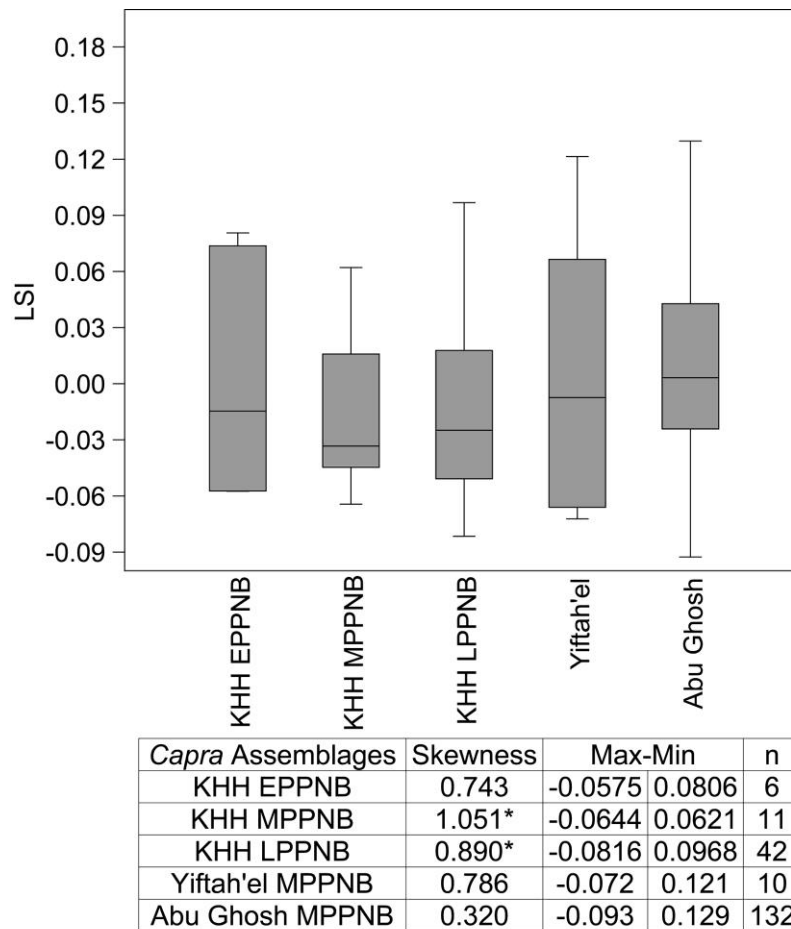


Figure 2.9. Box plots of LSI value medians, inter-quartile ranges, maximum and minimum for KHH *Capra* compared to Yiftah'el (Horwitz 2003) and Abu Gosh (Ducos 1978). Only one measurement included per specimen, only breadth/depth measurements were used (S6A–C Tables) following (Meadow 1999). Yiftah'el sample from Areas C and D. \*Outside 90% range for normal symmetric population given the sample sizes (Doane and Seward 2011).

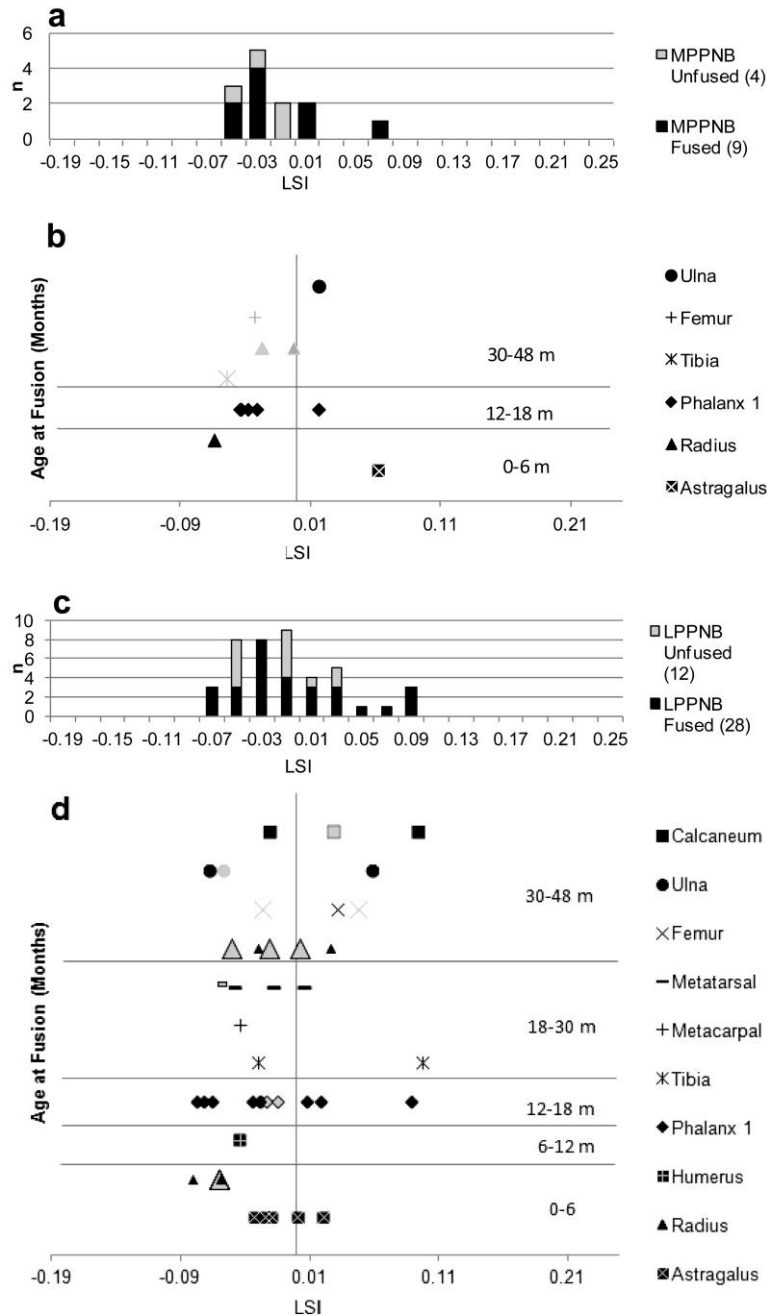


Fig 2.10. *Capra* LSI based on comparison to standard (Uerpmann and Uerpmann 1994) from (A) the KHH MPPNB assemblage and (B) MPPNB single-element LSI values (S6B Table) in order of age at fusion. (C) LPPNB *Capra* LSI and (D) LPPNB single-element LSI values from KHH Elements (S6C Table) in order of age at fusion. Unfused elements shown in grey, fused elements shown in black.

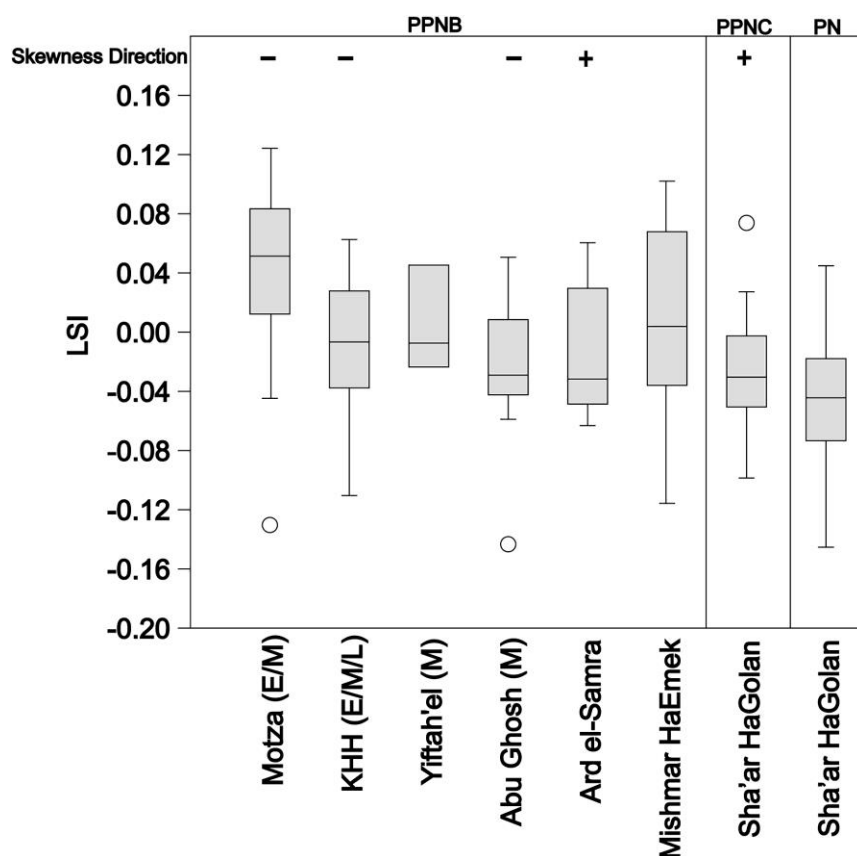


Figure 2.11. *Bos* LSI box plots ( $\pm 1$  SD shown) from KHH (S7 Table) and other Neolithic sites in the Mediterranean zone and Jordan Valley over time. Box plots of *Bos* LSI value medians, inter-quartile ranges, maximum and minimum values with outliers (open circles) based on comparison to the standard female from Grigson (1989). Sites listed with PPNB phase when possible (E=Early, M=Middle, L=Late). KHH measurements (n=24) include four previously published values (Horwitz and Goring-Morris 2004a). Sources of other measurements: Motza (n=17) (Sapir-Hen In Press), Yiftah'el (n=4)(Horwitz 2003), Abu Gosh (n=14) (Ducos 1978), Ard el-Samra (n=8)(Getzov, *et al.* 2009). Mishmar HaEmek PPNB (n=28), Sha'ar HaGolan PPNC (n=18), PN (n=44) (Marom and Bar-Oz 2013). Direction of skewness noted for right (+) and left (-) skewed assemblages when skewness is substantial ( $\leq -0.5$  or  $\geq 0.5$ ).

Chapter 3. Aurochs bone deposits at Kfar HaHoresh and the southern Levant across the  
agricultural transition (25,000–8,350 cal. BP)

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## Introduction

Across the transition to agriculture, mortuary rituals and feasting were widespread in Southwest Asia and highlight cultural connections across a broad interaction sphere (Bar-Yosef and Belfer-Cohen 1989). As the archaeological record expands, more detailed exploration of ritual evidence is needed on a regional scale to better delineate specific pathways of social and ideological change. This is pressing in light of growing evidence for multiregional Neolithization pathways, including plant and animal domestication (Willcox 2005; Asouti 2006). The integration of wild cattle (or aurochs; *Bos primigenius*), into ritual practice is pervasive across Southwest Asia (Twiss and Russell 2009), but varies tremendously in its context, associated ritual evidence and likely its function and meaning. To explore this variation, we present a survey of cattle use from Epipaleolithic and Pre-Pottery Neolithic (PPN) period sites in the southern Levant to identify potential regional differences in practices and explore pathways of social change across the transition to agriculture.

We examine patterns of ancient cattle use in light of new data from the Pre-Pottery Neolithic B (PPNB) site of Kfar HaHoresh (KHH) in the Lower Galilee of Israel and neighboring sites. Details are presented on a new concentration of cattle remains from KHH, where a large feasting deposit was previously documented (Horwitz and Goring-Morris 2004a). Ultimately, we broaden the discussion to investigate the nature of cattle use in the southern Levant and whether local traditions were maintained as the economic and symbolic roles of animals shifted from hunted prey to domesticated property. The role of cattle is of special interest in the PPN of the southern Levant, since cattle is the last livestock taxon in the region to be managed by humans, likely beginning in the PPNC or Pottery Neolithic (PN) period (Horwitz and Ducos 2005; Marom and Bar-Oz 2013). Still, how aurochs use may have been impacted by

shifting human-animal relationships once goat management began in the region by the Middle PPNB period remains unclear (Horwitz, *et al.* 1999; Martin and Edwards 2013; Sapir-Hen, *et al.* 2016). We focus on spatially segregated aurochs concentrations and deposits associated with graves, structures or pits to examine how non-mundane behaviors changed across the agricultural transition.

### **Cattle in Southwest Asian Ritual Contexts (25,000–8,350 cal. BP)**

Animals were integral symbolic and victual components of ritual during the transition to agriculture in Southwest Asia. Given that ritual and economic change are highly integrated (Bell 1997; Rappaport 1999), changing human-animal interactions at the beginning of livestock management likely impacted the roles of cattle in ritual, even though cattle were not the first domestic progenitor taxa to be managed in most regions (Arbuckle 2014). The earliest evidence of cattle management was detected in the Euphrates region by the Early–Middle PPNB (Peters, *et al.* 1999; Helmer, *et al.* 2005; Helmer and Gourichon 2008). Yet in the southern Levant, demographic, body-size and morphological data indicate that cattle management likely began later during the PPNC–PN periods or in subsequent periods (Davis 1981; Horwitz and Ducos 2005; Marom and Bar-Oz 2013). Data from KHH confirm that the cattle remains derive from wild aurochs throughout the PPNB. *Bos* body size and mortality profiles reveal large animals within the aurochs body-size range and prime dominated body size profiles (Meier, *et al.* 2016).

Wild cattle played an important role in ritual practice, both as symbols and suppliers of considerable calories (Twiss and Russell 2009). The variety of archaeological features that include aurochs skeletal remains or depictions highlight their symbolic importance at this time across Southwest Asia (Rollefson 2008). Exceptional aurochs finds in the northern Levant

inspired Cauvin's (2000) classic hypothesis that a bull cult was central to the ideology of early farmers. Other studies focus on the socially integrative function of rituals featuring aurochs, generated by cooperative hunting (Goring-Morris and Horwitz 2007), communal sacrifices (Carter 2012; Russell 2012), and abundant meat that arguably encouraged sharing and minimized social differentiation (Kuijt 1996). Social uses beyond food have also been studied, including how aurochs remains served as reminders of past events and reinforced shared symbols (Hodder and Cessford 2004), such as vitality (Verhoeven 2002a).

Neolithic rituals featuring aurochs are best known from Anatolia and the Euphrates Valley. Earlier evidence of aurochs rituals from Epipaleolithic sites is rare in this region, but includes a possible depiction in wall art from Öküzini cave (Otte, *et al.* 1995). Neolithic evidence for ritual aurochs use begins with the striking stone carvings at PPNA/EPPNB Göbekli Tepe (Peters and Schmidt 2004). Aurochs bucrania were recovered from a variety of locations in structures at PPN sites in the northern Levant (for review see Twiss and Russell 2009), including an aurochs bucranium in a large PPNA building termed House A at Hallan Çemi (Zeder and Spitzer 2016), as well as bucrania scattered around a pit at PPNA/EPPNB Tell Qaramel, attached to walls and concealed in benches at PPNA/PPNB Jerf el-Ahmar and PPNA Tell 'Abr 3, and buried within walls at PPNA Mureybet (Cauvin 2000; Helmer, *et al.* 2004; Yartah 2005; Kanjou, *et al.* 2013). At Neolithic Boncuklu, an installation of two attached aurochs bucrania was recovered from the wall of a structure, another bucranium was found in a wall collapse, a partial bucranium was attached to a storage bin, and a horn was attached to an entranceway (Baird, *et al.* 2016). Other exceptional evidence includes a subfloor pit containing multiple aurochs crania and horns with human skeletons at PPN Çayönü (Özdoğan 1999). Notable, later finds from PN Çatal

Höyük include numerous aurochs bucrania embedded in architectural features and an iconic painted aurochs hunting scene (Hodder and Meskell 2010).

Recently discovered evidence indicates that aurochs also figured prominently in south Levantine ritual before and during the agricultural transition at sites ranging from the Epipaleolithic through the PPNB (Table 3.1). Concentrated deposits of aurochs remains (Goring-Morris and Horwitz 2007; Munro and Grosman 2010) have received attention in the south, but further studies of aurochs use are needed to understand inter-regional variation. New finds from KHH offer the opportunity to define the character of *Bos* use in the south.

Table 3.1. Dates for south Levantine sites with aurochs deposits.

<b>Period</b>	<b>Date (cal. BP)*</b>
Early Epipaleolithic	25,000-19,000
Middle Epipaleolithic	19,000-15,000
Early Natufian	15,000-13,500
Late/Final Natufian	13,500-11,650
PPNA	11,650–10,600
EPPNB	10,600–10,000
MPPNB	10,000–9,500
LPPNB	9,500–8,700
FPPNB (PPNC)	8,700–8,350
PN	8,350–7,450

### ***Kfar HaHoresh***

As the only primarily ritual PPNB site in the southern Levant (Birkenfeld and Goring-Morris 2015), KHH provides a natural setting to begin our investigation. Evidence of ritual practices involving animals abound at KHH, which spans the Early, Middle and Late PPNB periods (EPPNB, MPPNB, LPPNB) (10,600–8,700 cal. BP). These include a plastered human skull found with a headless gazelle carcass, associations between fox and immature human remains, a possible animal depiction made from arranged human bones (L1155) (Goring-Morris,

*et al.* 2008), and concentrated aurochs remains produced by funerary feasts (Horwitz and Goring-Morris 2004a).

#### *Aurochs Remains from Previous Excavations at KHH*

Aurochs remains were recovered from several formerly described contexts at KHH. Human bones were arranged with some aurochs, boar and gazelle bones around the edge of a kidney-shaped ash deposit in Locus 1003 (L1003) (Goring-Morris, *et al.* 1998). Numerous aurochs specimens were also recovered from a pit described below (L1005). Aurochs remains were largely absent from grave contexts presented in the current and previous (Horwitz and Goring-Morris 2004a) analyses. Artistic representations of aurochs include a single complete figurine and a few broken figurine horns (Biton 2010).

#### *Bos Pit L1005*

Previous publications (Goring-Morris and Horwitz 2007; Horwitz and Goring-Morris 2004) describe the contents of an EPPNB pit (L1005; “*Bos* pit”) associated with a monumental (20×10 m) platform/podium (L1604) in the northwestern portion of the site dated to the same phase (Goring-Morris 2008). The pit (1.5m maximum diameter, 60 cm depth) was dug into sterile sediment beneath the three plastered surfaces of the L1604 podium, and contained 356 aurochs bones, as well as one fox and one goat bone and a groundstone fragment (Goring-Morris and Horwitz 2007). The aurochs assemblage included mostly complete meaty elements—some broken *in situ* and oriented vertically. Others were articulated, including long-bone joints (n=3), groups of carpals/tarsals (n=6), and vertebrae (n=4) (Horwitz and Goring-Morris 2004a). Most lacked signs of butchery. The assemblage derived from at least eight aurochs, most of them adult

females, and included at least one juvenile of unknown sex and one adult male. A limestone slab covered the pit and a flexed, partially-articulated, headless human skeleton of a young adult male was interred above it. The grave was capped with plaster. Horwitz and Goring-Morris (2004a) interpret the contents of the pit as the remnants of a funerary feast that served to alleviate scalar stresses at KHH. Another *Bos* concentration in a pit (L1006) dug into sterile sediments was noted in the eastern section of the mechanically dug Trench I ca. 2m north of L1005, which also underlies the L1604 platform but remains to be excavated (Goring-Morris, *et al.* 1995: Plan 1).

### ***A New Bos Concentration***

A new pit discovered during the 2011 excavations revealed a second concentrated EPPNB (10,600–10,000 cal. B.P.) aurochs deposit (L2268) in the northwestern sector of the site (Figure 3.1B). Composed nearly entirely of aurochs (Table 3.2), the bone concentration was found in a large (1.5×1.5×0.2m), sub-elliptical pit dug into sterile sediments at 592–609 cm below datum. L2268 is located in squares O-P68-69 abutting the monumental platform. A cache (L2267) of 13 flint blades deposited at the same level in sterile sediment (P68a) may be associated with L2268. Less clearly associated is a headless, flexed, primary human burial with a stone marker (L2266) situated in sterile sediment about one meter away from the pit (O-P65-66). Square P68 in L2268 is partially covered by later MPPNB midden deposits (L2257) to the west and square O68-P68 in the same locus is capped by a concentration of tightly packed burned stones and a probable plaster kiln (L2251) to the east (Boness *pers comm*). A flat dolomitic stone with incised edges was recovered from square O69. The association between L2268 and the burial, the kiln, and the stone is unclear.

Table 3.2: Number of identifiable specimens (NISP) in L2268 by excavation square. Medium carnivore category includes wildcat, fox and similarly-sized carnivore specimens.

<b>Taxa</b>	<b>O68</b>	<b>O69</b>	<b>P68</b>	<b>P69</b>	<b>Total NISP</b>	<b>MNI</b>
<b>Aurochs (<i>Bos primigenius</i>)</b>	61	58	23	3	145	4
<b>Goat-sized (<i>Capra sp.</i>)</b>	4	8	1		13	1
<b>Medium Carnivore</b>		1	1	1	3	1
<b>Hare (<i>Lepus capensis</i>)</b>	2		4		6	1
<b>Falconiformes</b>		1			1	1
<b>Gazelle (<i>Gazella gazella</i>)</b>	6	9	5	4	24	1
<b>Tortoise (<i>Testudo graeca</i>)</b>	8	1	3		12	1
<b>Total</b>	<b>81</b>	<b>78</b>	<b>37</b>	<b>8</b>	<b>204</b>	<b>11</b>

Fauna in the pit consists primarily of aurochs remains (71%; n=204) (Table 3.2), most of which were packed amongst dense quantities of fire-cracked angular stone into the base of the pit (~16 cm) (Figure 3.2). The remaining 57 specimens belong to other taxa (see below). The aurochs fragments derive from 34 elements (Table 3.3) from at least four animals. The body parts are dominated by lower hindlimbs (Figure 3.3), and all anatomical regions (Stiner 1994) except for horns are represented. Ages at death based on the state of fusion of tibiae and humeri reveal that one aurochs reached at least 42 months of age while the other three were younger. Low-intensity weathering (Stages 1–3) (Behrensmeyer 1978) was common on the aurochs remains (45%) (Table 3.4A). Cutmarks were absent. Many aurochs bones were broken during excavation and new excavation breaks are common. Of the fractures not formed during excavation (n=37), the majority are spiral breaks (67.6%) (Table 3.4B), made when the bones were fresh, and the remainder were transverse (16.2%) or dry breaks (16.2%) indicating post-depositional breakage. L2268 aurochs element completeness is low due to fragmentation (NISP:MNI) (Table 3.4C)— only two nearly complete carpal bones were recovered. The average maximum fragment length of aurochs bones is longer in L2268 (47 mm) than in other EPPNB

deposits excavated during the 2010–2012 seasons (38 mm). Burning is rare (2%) (Table 3.4D).

The tip of a flint point was lodged in an aurochs humerus fragment from L2268.

Table 3.3. *Bos* element representation (MNE and NISP) in L2268.

<b>Element</b>	<b>NISP</b>	<b>MNE</b>
<b>Cranium (half)</b>	3	1
<b>Mandible (half)</b>	3	1
<b>Atlas</b>	1	1
<b>Axis</b>	1	1
<b>Cervical</b>	9	1
<b>Thoracic Vertebra</b>	18	2
<b>Ribs</b>	4	1
<b>Lumbar Vertebra</b>	21	4
<b>Vertebra (indeterminate)</b>	5	1
<b>Sacrum</b>	4	1
<b>Innominate</b>	4	1
<b>Scapula</b>	15	1
<b>Humerus</b>	17	3
<b>Scaphoid</b>	1	1
<b>Sesamoid</b>	1	1
<b>Femur</b>	3	1
<b>Patella</b>	1	1
<b>Tibia</b>	26	6
<b>Calcaneum</b>	1	1
<b>Lateral Malleolus</b>	1	1
<b>Metatarsal</b>	3	1
<b>Metapodial</b>	1	1
<b>2nd Phalanx</b>	2	1
<b>Total</b>	<b>145</b>	<b>34</b>

Table 3.4. Taphonomic data on *Bos* remains from L2268 and other EPPNB contexts from the KHH 2010–2012 excavations. (A) Weathering follows Behrensmeyer's (1978) stages; low=1–3 and high=4–6; %weathered includes stages 1–6. (B) Type of Breakage. %Green (spiral/split) does not include specimens with new breaks. New breaks include specimens with one or more excavation breaks; (C) Fragmentation measured as NISP:MNE; (D) Burned *Bos* bones.

<b>A. Weathering</b>	<b>Low</b>	<b>High</b>	<b>%Weathered</b>
<b>L2268 <i>Bos</i></b>	63	3	45%
<b>Other EPPNB <i>Bos</i></b>	31	1	34%

<b>B. Type of Breakage</b>	<b>N=</b>	<b>Spiral/Sliced NISP</b>	<b>Transverse NISP</b>	<b>Dry NISP</b>	<b>Total Ancient Break NISP</b>	<b>%Green</b>	<b>New break NISP</b>
<b>L2268 <i>Bos</i></b>	145	25	6	6	37	67.5%	109
<b>Other EPPNB <i>Bos</i></b>	93	29	5	6	40	72.5%	51
<b>M-LPPNB <i>Bos</i></b>	543	216	74	45	335	64.5%	231

<b>C. Fragmentation</b>	<b>NISP</b>	<b>MNE</b>	<b>NISP:MNE</b>
<b>L2268 <i>Bos</i></b>	145	28	5.2
<b>Other <i>Bos</i> (2010-2012 sample)</b>	1041	161	6.4

<b>D. Burning</b>	<b>Burned</b>	<b>Unburned</b>	<b>%Burned</b>
<b>L2268 <i>Bos</i></b>	3	143	2%
<b>Other <i>Bos</i> (2010-2012 sample)</b>	246	790	24%

Gazelle (n=24) is the second most common taxa in L2268 (Table 3.2). All anatomical units are represented. One scapula fragment showed pathological lipping and one male horncore fragment was burned. Head, neck and limb elements from goat-sized ungulates (n=13) and hare (n=6) were represented, as well as tortoise shell and limb fragments (n=12), a raptor (*Buteo* sp.) and a wildcat phalanx, and tibia and caudal vertebrae fragments from a medium-sized carnivore.

The distribution of taxa within L2268 points to some admixture of the topmost deposit layers with the later midden deposits and kiln. In contrast, aurochs bones at the base of the locus were not disturbed (Figure 3.2). Weathering was most prevalent in square P68 (69% lightly weathered), where the deposit may have been more disturbed. Some closely associated, adjoining elements were noted during faunal analysis, including distal metatarsals and first phalanges in O68 and P68, a tibia and tarsal and scapulae and humeri in O68, and a proximal tibia and patella in O69. This suggests minimal bone movement or primary deposition (Yeshurun, *et al.* 2014a).

Within the EPPNB faunal loci excavated from 2010–2012, aurochs remains are most abundant in L2268 (62% of aurochs NISP). This contributed to the high relative abundance of aurochs among the ungulates in the EPPNB assemblage at KHH and lower aurochs abundances in the MPPNB and LPPNB assemblages (Meier, *et al.* 2016). Although L2268 is dominated by hindlimbs, other EPPNB cattle deposits in this sample comprised mainly forelimbs (Figure 3.3). Aurochs remains from L2268 were clearly processed for marrow based on breakage and fragmentation evidence, but the larger size of aurochs fragments in this context suggests that they were processed less intensively than those from EPPNB midden contexts (Table 3.4).

### *Feasting at KHH*

Feasts, or large communal meals that provisioned many people (Dietler 2001), increased in frequency in the PPN period (Twiss 2008). Aurochs figure prominently in feasts, both because they provide sizable amounts of meat and because of their symbolic roles, which may be associated with the danger of capture, among other things (Verhoeven 2002a; Twiss and Russell 2009). The *Bos* concentrations indicate that consumption of multiple aurochs and subsequent

structured deposition of remains occurred more than once at EPPNB KHH. L2268 and L1005 are less than 8 meters apart on the northwestern side of KHH and both are associated with the monumental podium, as is L1006. While both are located close to human burials, L1005 is most convincingly associated with a burial. Both concentrations contain the remains of several aurochs of different ages. L1005 has a higher MNI (8) than L2268 (4), and about twice the NISP (Table 3.5). Both are dominated by high-utility parts (humeri, tibiae, femora) based on food utility index estimates (Binford 1981). Carnivore and gazelle remains are more common in L2268. Both deposits show minimal evidence of bone processing and minimal post-depositional movement as indicated by articulated (L1005) and/or anatomically-associated elements (L2268) and the lack of cut marks. Remains from L1005 were less modified, while some aurochs bones from L2268 were broken when fresh and few bones were complete. Weathering and taxonomic distributions within L2268 also suggest that it was disturbed, unlike L1005 (Horwitz and Goring-Morris 2004a).

Table 3.5. Aurochs NISP and MNI in Natufian–LPPNB *Bos* concentrations from the southern Levant<sup>1</sup>.

Site	Period	Deposit	Bos NISP	Bos MNI	MNI young	MNI adult
<b>Hayonim Terrace</b>	Natufian	Structure 8	49	2	1	1
		Structure 7	13	1		
<b>Hilazon Cave</b>	Natufian	Structure B	112	3	1	2
<b>KHH</b>	EPPNB	L1005	356	8	1	7
	EPPNB	L2268	145	4	3	1
<b>Motza</b>	EPPNB	L4005	57	4	1	3
<b>Yiftah'el</b>	MPPNB	Area I	12*	1		
<b>Basta</b>	LPPNB	Area C	480	2	1 fetal	1

<sup>1</sup>References in Table 3.6. \*Values in MNE.

L1005 is a feasting deposit associated with funerary activities. L2268 is more heavily processed and less structured than L1005. Nevertheless, the remains of four aurochs in L2268

evidence the consumption of a substantial amount of meat in a single episode and suggest feasting. Several close associations among anatomically associated elements imply rapid burial. The fact that these remains were deposited in a pit dug into sterile soil in close proximity to a public-use monumental structure, suggests that this feast was associated with a communal ritual event (Hill 1996). Ritual, purposefully-buried feasting deposits like the two found at KHH are notable due to their rarity at Natufian and PPN sites. Feasting can be difficult to detect in aggregations of food rubbish formed over long periods of time.

### **Aurochs Deposits in the Southern Levant**

To situate the *Bos* concentrations at KHH within a regional context, a survey of aurochs deposits from Epipaleolithic and PPNB south Levantine sites was undertaken. These include *Bos* concentrations like those found at KHH, concentrations of diverse fauna including aurochs, and human mortuary or architectural feature deposits including aurochs.









### ***Bos Concentrations***

Here, a *Bos* concentration is defined as an aggregation of faunal remains dominated by cattle (>70%), in a structured/constructed deposit. Most south Levantine *Bos* concentrations date to the Late Natufian–EPPNB with few later examples (Table 3.5). The largest Late Natufian *Bos* concentration (n=112, MNI=3) was deposited in a small structure capped by a human burial at the mortuary site of Hilazon Tachtit (Munro and Grosman 2010). Most of the bones were opened for marrow, and three articulations were present. Smaller aurochs concentrations were found in Structures 7 (n=13, MNI=1), and 8 (n=49, MNI=2) at Hayonim Terrace. The former concentration included four articulated carpals and two articulated tarsals, while the latter

included three articulated phalanges (Munro 2012). EPPNB evidence includes the two examples from KHH and a concentration of mostly postcranial aurochs remains with some articulated and cut-marked bones from Motza (n=57, MNI=4) (Sapir-Hen In Press). This deposit was found near a human burial in the northern sector of Motza— an area with a prominent red-plastered structure (Sapir-Hen, *et al.* 2009). MPPNB concentrations include an articulated aurochs pelvis, sacrum, thoracic and lumbar vertebrae and two limb elements (estimated MNE from photo=12) found in a pit that appears to have been cut into a plaster surface in Area I at Yiftah'el (Khalaily, *et al.* 2008). A nearby pit contained a single aurochs horncore. Area I includes a midden containing elements of gazelle, goat and aurochs in anatomical association (Horwitz 2003; Alhaique and Horwitz 2012) and most (72%) of the MPPNB-LPPNB primary and secondary burials from the 2007–2008 excavations (Milevski, *et al.* 2008). Finally, a Late PPNB *Bos* concentration at Basta includes cut-marked adult and unmodified neonate aurochs bones (n=480, MNI=2) interred in "a, more or less, anatomically correct arrangement" (Becker 2002, 124), in a pit less than one meter from a red ochre-covered human burial and near a midden of articulated smaller ungulate limbs.

Documented *Bos* concentrations range widely in size from small deposits at Yiftah'el and Hayonim Terrace to the large L1005 assemblage at KHH. All represent multiple individuals of different ages, except Yiftah'el. All nine anatomical body regions (Stiner 1994) are represented by elements in concentrations at Hilazon Tachtit, Basta and KHH L1005, and only horns are absent at Hayonim Terrace, KHH L2268 and Motza. At Yiftah'el, only a limb section is represented (Table 3.6). Body parts of taxa besides aurochs were also found in anatomical association in middens/deposits near *Bos* concentrations (Hilazon Tachtit, KHH, Yiftah'el, Basta).

Table 3.6. Assemblage and feature attributes of *Bos* concentrations<sup>2</sup>.

Site Period	Ref.	Body Parts Represented	Deposit	Articulations	Human Burial	Artifacts	Burned bones	Butchery	Plaster Assoc.	Other taxa in deposit
Hayonim Terrace Natufian	(Munro 2012)		Str.8	✓	Several at site	nd	Ash present	✓ Opened	n/a	✗
Natufian	(Munro 2012)		Str. 7	✓	Several at site	nd	✗	✗	n/a	✗
Hilazon Tachtit Natufian	(Munro and Grosman 2010)		Str. B	✓	One individual on top of slab	Knapped, ground stone and bone tools, seashells, rock slab	Very little	✓ Opened	n/a	✓
KHH EPPNB	(Goring-Morris and Horwitz 2007)		L1005	✓	Young adult male on top	Grinding stone, core, marker stone	✗	✗	✓	Fox, goat
EPPNB (This study)			L2268	✓ ?	Burial nearby	Blade cache, marker stone?	✓	Fresh breaks, flint embedded	✓ ?	Gazelle, goat, wild cat, tortoise. Nearby later midden.
Motza EPPNB	(Sapir-Hen n.d.)		L4005	✓	In area	nd	✗	✓ <sup>3</sup>	Near red plastered structure	✗
Yiftahel MPPNB	(Gubenko and Ronen 2014)		Area I	✓	Many in area	nd	nd	nd	Plastered Floor?	Nearby concentration: gazelle, goat, cattle
Basta LPPNB	(Becker 2002)		Area C	✓	Burial of adult male nearby	Shell with human burial	nd	✓ Cut	✗	Nearby midden: 8 goat, 1 gazelle MNI

<sup>2</sup>Bone articulations include published field observations of bones in anatomical position.

Identifications of human remains listed when possible. nd=no data.

Human remains were near all concentrations (most within one meter), although whether these are meaningfully associated is not always clear. This is true when cattle concentrations do not directly intersect human interments in sites with abundant evidence for mortuary practices, (Hilazon Tachtit, Hayonim Terrace, Yiftah'el), or are located in pits about one meter from human burials (Motza, KHH L2268, Basta). The L1005 and Hilazon Tachtit concentrations are capped with stone slabs and burials, with L1005 clearly linked to a mortuary event. Additionally, multiple concentrations are present at Hayonim Terrace, Yiftah'el and KHH.

Although anatomical connections were present in all *Bos* concentrations indicating limited bone processing, cut-mark and breakage data suggest that bones from most deposits were

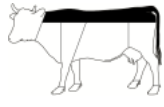




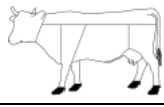
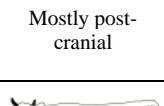

butchered for meat and sometimes marrow, especially the earlier concentrations. The concentrations also commonly show structured deposition, including anatomically-positioned elements and placement in constructed pits suggesting single-deposit events. The *Bos* concentration at Basta differs most in its placement and treatment, as the aurochs remains were largely in anatomical association and the fetal aurochs was not butchered. In summary, at south Levantine sites from the Natufian–LPPNB periods, carcass processing evidence suggests that most aurochs remains found in concentrations were butchered for food and deposited in pits that are often separated from associated/nearby features (e.g. by slabs/plaster layers), suggesting primary aurochs refuse disposal.

### ***Mortuary Contexts***

Aurochs remains are frequently found in human mortuary contexts (n=10; Table 3.7). In chronological order, two deposits were excavated from Early Epipaleolithic Kharaneh IV—one cache of burned aurochs and gazelle horncores associated with isolated human remains interred above (Structure 2) and five articulated aurochs vertebra from the floor of Structure 1, which also contained the burials of two males excavated during a different campaign with unclear association. The vertebrae were situated about one meter from three concentrations of pierced shells (n>1000) (Maher, *et al.* 2012). Also, an aurochs patella and carved aurochs radius bone were found in Grave I at Middle Epipaleolithic ‘Uyun al-Hammam (Maher, *et al.* 2011). Examples from Natufian sites include an aurochs tail in partial articulation in the shaman burial at Hilazon Tachtit (Grosman, *et al.* 2008) and one complete aurochs horncore with three perforations and several fragmented aurochs horncores recovered just above a minimum of eight interred individuals at Natufian Azraq 18 (Bocquentin and Garrard 2016). During the PPNA, a

woman was buried with an aurochs bucranium at Hatoula (grave H09) (Le Mort 1989), while at E/MPPNB Mishmar Ha'Emek, a woman (Homo 6) was interred with an articulated aurochs foot (Barzilai and Getzov 2008). The LPPNB bone arrangement (L1003 KHH; see above) was comprised mostly of human remains. At PPNC/FPPNB Atlit Yam, one cattle horncore was recovered from a grave of an adult male and one from that of a child (Galili, *et al.* 2005).

Table 3.7. Mortuary deposits with aurochs remains.

Site	Reference	Deposit Type	Anatomical Area Present	Articulations	Human Bones	Artifacts	Tools	Burn-ing	Butch-ery	Plaster Assoc.	Other taxa in deposit
<b>Kharaneh IV</b> Early Epi	(Maher, <i>et al.</i> 2012)	St.1: foundation deposit		✓	2 males	Ground stone, red ochre, pierced shells	nd	Char-coal	nd	n/a	nd
<b>Early Epi</b>		St.2: Cache		✗	2 males	nd	Chipped stone debris	✗	nd	n/a	Burned gazelle horncores, Covered by bone midden
<b>‘Uyun al-Hammam</b> Mid-Epi	(Maher, <i>et al.</i> 2011)	Burial Inclusion		✗	2 adults	Red ochre	Chipped, ground-stone tools	nd	nd	n/a	Fox, deer, gazelle, tortoise
<b>Hilazon Tachtit</b> Natufian	(Grosman, <i>et al.</i> 2008)	Burial Inclusion St. A		✓	Adult female	Basalt bowl, pol. pebble	Bone tool	nd	nd	n/a	Tortoise, gazelle horncore, shell, eagle, marten, leopard, wild boar
<b>Azraq 18</b> Natufian	(Bocquentin and Garrard 2016)	Burial Marker		✗	8 individuals	nd	nd	nd	nd	nd	nd
<b>Hatoula</b> PPNA	(Le Morte 1994)	Burial Inclusion		✗	Adult female	nd	nd	nd	nd	nd	nd
<b>Mishmar HaEmek</b> E/MPPNB	(Barzilai and Getzov 2008)	Burial Inclusion		✓	Adult female	Perforated cowrie	nd	nd	✗	✓	shell
<b>KHH</b> LPPNB	(Goring-Morris, <i>et al.</i> 1998)	Bone Arrangement L1003	Mostly post-cranial	✗	Human bones	Pierced cowrie, pol. pebble	Axe, blade, stone polisher	Ash	nd	✓?	Human bone arrangement with articulated gazelle bones
<b>Atlit Yam</b> PPNC	(Galili, <i>et al.</i> 2005)	Two burials with inclusions		✗	Adult & child	clay	nd	nd	nd	nd	nd

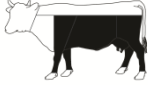
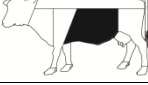



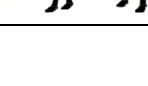
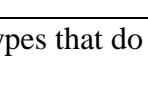
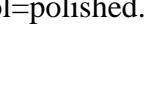
Mortuary deposits identified by published interpretations. Burning and butchery descriptions for these *Bos* remains are rare. n/a (not applicable) indicates sites that predate common plaster manufacturing. St=Structure. pol=polished. nd=no data.

### Other Aurochs Deposits

Many isolated aurochs remains were also found in structural features, or within bone arrangements and concentrations of remains from diverse taxa that are distinct from typical scattered refuse (n=8; Table 3.8). Although the PPNA faunal assemblage from Wadi Faynan 16

has not yet been studied, abundant aurochs remains were reported from a large communal space associated with decorated benches (Structure O75) (Finlayson, *et al.* 2011). Aurochs figurines and three aurochs metapodials with carved longitudinal incisions were deposited together in a plastered stone installation at MPPNB 'Ain Ghazal (Rollefson 1986). Aurochs rib and long bone shaft fragments were carved into four figurines at PPNB Nehal Hemar (Bar-Yosef and Alon 1988) and a rib was shaped into a wand with two carved human faces from the 'funerary level' at E/MPPNB Tell Qarassa North (Ibáñez, *et al.* 2014). At MPPNB Ghwair I, one cattle and four goat bucrania were recovered from the surface of a plastered floor in a structure containing a subfloor infant burial, blade cache and polished stones (Simmons and Najjar 2006). In addition to the *Bos* concentration in Area D of Yiftah'el, a pit also contained articulated elements from aurochs (two phalanges, a rib with lumbar vertebra), gazelle, goat, and fox (NISP=34) (Alhaique and Horwitz 2012). Aurochs remains recovered in Installation 9/2 near Structure 9 at FPPNB/PPNC Atlit Yam may also represent a *Bos* concentration; however, most of the faunal remains recovered from the site were found near this structure (n=78; 54%) and it is unclear whether this deposit is distinct from the other faunal remains (Horwitz and Tchernov 1987).

Table 3.8. Other distinct deposits with aurochs remains.

Site	Ref.	Deposit Type	Anatomical Area Present	Articulations	Human Bones	Artifacts	Tools	Burning	Butchery	Plaster Assoc.	Other taxa in deposit
WF 16	(Finlayson, PPNA <i>et al.</i> 2011)	Communal Building Fill		nd	nd	nd	nd	nd	nd	nd	More <i>Bos</i> than rest of site. Other taxa present.
Nehal Hemar Cave	(Bar-Yosef and Alon 1988)	General Area		nd	nd	nd	nd	nd	nd	nd	Gazelle, goat, fox, hare, hedgehog
Tell Qarassa North	(Ibáñez, <i>et al.</i> 2014)	Funerary Level		nd	nd	nd	nd	nd	nd	nd	
'Ain Ghazal	(Rollefson 1986)	Feature Inclusion		✗	✗	<i>Bos</i> figurine	✗	✗	Carved	Plaster lined	✗
Ghawir I	(Simmons and Najjar 2006)	Architectural Display		✗	Infant in area	Malachite blanks, polishing stone	Blade and point cache	nd	nd	Plaster floor	4 Goat crania
Yiftah'el	(Alhaique and Horwitz 2012)	Concentration Sq. J20 Area D		✓	Burial 1 meter away	Miniature votive axe	nd	Low freq.	nd	nd	Gazelle, goat, fox (with articulations)
KHH	2010-2012 sample	Midden		✓	Scattered remains in area	Pol. pebbles, very diverse artifacts	Flint (debitage, finished), bone tools	More on <i>Bos</i> , tortoise	✓	✓	All taxa. Gazelle, <i>Bos</i> , tortoise articulations
Adlit Yam	(Horwitz and Tchernov 1987)	Concentration at Structure 9		nd	nd	nd	Flint debitage, tool concentration	nd	nd	nd	Goat, pig and fish

Includes diverse deposit types that do not fit *Bos* concentration criteria and are less clearly associated with burials. pol=polished. nd=no data.

### Summary of Aurochs Deposits

Although cattle remains are found in diverse contexts, some patterning is apparent. Aurochs horncore fragments are common in mortuary contexts. In all context types, cattle remains are usually articulated or in close anatomical association (Hilazon, Kharaneh IV, KHH midden, Mishmar HaEmek, Ghwair I, Yiftah'el, Basta). Articulated elements from other taxa are also often associated (Hilazon, 'Uyun al-Hammam, KHH midden, Yiftah'el), such as gazelle, goat, and fox. In contrast, there is no pattern in the types of artifacts associated with cattle bones or the burning data. Importantly, aurochs deposits are most commonly found near human

remains (n=21). This is especially true of Epipaleolithic contexts (n=8 of 8 contexts). From the MPPNB onward, mortuary contexts (n=8 of 13 contexts) are more diverse, associations with structures are more common (n=3), and concentrated bone deposits were not dominated by aurochs remains, but included remains of diverse species and cattle.

## **Discussion**

### ***Epipaleolithic–EPPNB (25,000–10,000 cal. BP)***

In the south Levantine Epipaleolithic–EPPNB record aurochs remains that do not constitute typical food refuse are most often found as concentrated remnants of large communal meals. Smaller distinct secondary deposits are primarily found in graves, and occasionally in caches near human bones. In one case, aurochs comprise a majority of bones in the fill of a communal structure at Wadi Faynan 16. In summary, these aurochs remains are most closely associated with public mortuary events such as funerals and feasts and in one case perhaps with a large meal or abandonment event associated with a communal structure.

### ***Feasts***

The presence of multiple aurochs in single concentrations implies the rapid consumption of large quantities of meat and therefore group events. Their association with mortuary practices implies that these communal events represent funerary feasts (Hayden 2001). Funerary feasts presented opportunities for public food sharing (Twiss 2008). Many skeletal elements are missing from these concentrations, suggesting that some meat was consumed elsewhere (Horwitz and Goring-Morris 2004a). Still, the purposeful burial of many cattle parts at one time likely publically conveyed and commemorated the socially integrative aspect of feasting to the

participants (Dietler 2001). Large funerary feasts may also lead to social exchanges that facilitate community integration, or social competition (Hayden 1990; Kuijt 1996). Moreover, the continuity of feasting practices from the Natufian–EPPNB in the southern Levant indicates that this tradition was upheld as plant cultivation was adopted, and humans first began to control animals. Thus, ritualized aurochs feasting was most common at the important beginning of agricultural life-ways and possibly served to reinforce and negotiate local social identities during this dynamic social transition (Asouti and Fuller 2013).

The *Bos* concentrations also highlight the atypical treatment of feast refuse from the Natufian to EPPNB (Munro and Grosman 2010). Evidence of anatomical associations and placement of aurochs parts in constructed pits differentiates these concentrations from the scattered, gazelle-dominated food waste typical of these periods (Hardy-Smith and Edwards 2004; Yeshurun, *et al.* 2014b), and indicates purposeful burial more akin to human burial practices (Goring-Morris 2000). This may relate to shared rules about disposal practices for ritual objects that held symbolic importance, or 'ceremonial trash' (Walker 1995). This is similar to the regulated deposition of ritual objects in designated repositories, such as *favissa* in Roman period temples or statue caches at 'Ain Ghazal (Garfinkel 1994). Regardless of the exact rules surrounding disposal of garbage from feasts, the atypical deposition of these remains clearly reflects perceptions of ceremonial food that included rules about disposal.

The disposal of ceremonial trash may also reflect planning for the long-term use of public mortuary spaces. Discrete refuse deposits in mortuary areas display purposeful burial of refuse in concentrated locales. More formalized disposal of bulky aurochs remains was likely necessary to preserve public ritual spaces for recurring activities in or by human graves, such as skull removal practices (Belfer-Cohen and Goring-Morris 2014). Even though more typical scattered refuse is

also present and visitors likely came and went, hints of refuse maintenance may reflect planning for longer-term site use (Kent 1992). Additionally, repeated use of areas at sites for burial (e.g., Raqefet and Eynan) (Perrot and Ladiray 1988; Yeshurun, *et al.* 2013), also suggests that memories of the function of these areas persisted over time (Goring-Morris and Belfer-Cohen 2013).

### ***MPPNB–PPNC (10,000-8,350 cal. BP)***

Aurochs depositional practices from the MPPNB onward mark a pivotal shift in the regional signature of aurochs use in the southern Levant. *Bos* concentrations are fewer, with only one small example from MPPNB Yiftah'el and the anatomically-positioned carcasses at LPPNB Basta. Both are less clear examples of communal feasts. Instead, between the MPPNB–PPNC, cattle deposits are more commonly associated with architectural features or concentrations of diverse faunal remains, and continue to be interred with human burials. Overall, fewer public feasting events involving aurochs are represented by the MPPNB, although public practices continued in mortuary contexts. This decline in aurochs feasting across the PPNB is also reflected in the decreasing relative abundance of aurochs at KHH following peak levels detected in the EPPNB (Meier, *et al.* 2016). Notably, other distinct types of aurochs deposits begin to appear by the MPPNB.

### ***Small-scale practices***

Most aurochs deposits dating to the MPPNB and later in the southern Levant are smaller and more idiosyncratic than in earlier periods. High levels of bone completeness and anatomical associations in the south Levantine cases distinguish these deposits from routine garbage

disposal, but they are more taxonomically diverse, contain fewer body parts, derive from more variable contexts, and are less often associated with mortuary contexts than earlier Natufian–EPPNB *Bos* concentrations interpreted as remains of *in situ* feasts (Horwitz and Goring-Morris 2004a; Grosman and Munro 2016). This suggests that south Levantine cattle use shifted away from communal to more small-scale practices in the MPPNB.

With the exception of the cattle bucranium in a structure at MPPNB Ghwair I, south Levantine aurochs deposits differ from more visible cattle horns or skulls displayed in structures in the north (Twiss and Russell 2009). In the southern Levant, aurochs deposits were more hidden and thus were less likely to have visibly promoted costly competitive social actions, such as dangerous aurochs hunts or rites of passage (Verhoeven 2002a), or served as regularly viewed reminders of past events promoting community integration (Kuijt 1996). Instead, these less visible cattle deposits may have served to mark events at the time of deposition, link current and past participants in ritual events, and commemorate shared symbolic depositional actions (Turner 1969), thus promoting social memory construction (Kuijt 2001).

Additionally, from the MPPNB onward, concentrations of fauna that included aurochs parts may reflect the continuation of earlier practices of ceremonial trash disposal and long-term use of mortuary areas. Articulations present in these contexts indicate minimal bone movement (Yeshurun, *et al.* 2014a) and more deliberate deposition of refuse in mortuary areas, similar to remains in middens near *Bos* concentrations at Yiftah'el, Basta and KHH. This atypical treatment suggests that other food remains found in these areas may also have been considered ceremonial trash. Alternatively, these remains may represent mundane trash produced by visitors to mortuary areas that was intentionally deposited to make room for anticipated practices at a later date or to maintain the sanctity, or unchanging quality (Rappaport 1992), of the mortuary space.

In all, purposeful deposition of aurochs remains among with other taxa suggests the continuation and expansion of the differential treatment of consumption refuse in mortuary spaces from the MPPNB onward.

### *Cattle Deposits and Neolithization*

Cattle played important roles beyond food provisioning across Neolithic Southwest Asia and this use has its own regional character from the Natufian–EPPNB in the southern Levant, after which point, cattle depositional practice begins to change. Although the shift suggests a move away from the earlier pattern of more public deposition, refuse disposal practices continued to treat ceremonial trash distinctly and to encourage the long-term use of mortuary areas. This suggests that a shared practice of symbolic cattle use spanned many generations in the southern Levant and shifted in form by the MPPNB, but maintained some depositional rules that likely contributed to the long-term construction and expression of social memory through ritual practice (Kuijt 2008b).

The shift in the local signature of cattle deposition in feasts and mortuary contexts by the MPPNB in the southern Levant, suggests increasingly small-scale practices and changing social interactions that reflect the greater Neolithization process across Southwest Asia. Similar social changes are reflected in PPNB architecture, such as the development of spatially-segregated buildings with independent domestic and non-domestic areas (Byrd 1994). Additionally, reduced evidence for feasting hints at a shift toward other mechanisms of community integration by the MPPNB.

The shift in the ritual use of aurochs by the MPPNB may also be associated with new economic roles for herd animals in the southern Levant—the first clear evidence for goat

management also emerges in the MPPNB (Horwitz, *et al.* 1999; Horwitz 2003; Sapir-Hen, *et al.* 2016). The close timing of these shifts accentuates the similar pace of local-scale ritual and economic change, highlighting their close integration along the pathway to Neolithization in the southern Levant. Further comparative spatial studies of faunal disposal patterns across different regions, site functions, and time periods are merited to better detect the trajectory of social change at the local level.

### Figures for Chapter 3

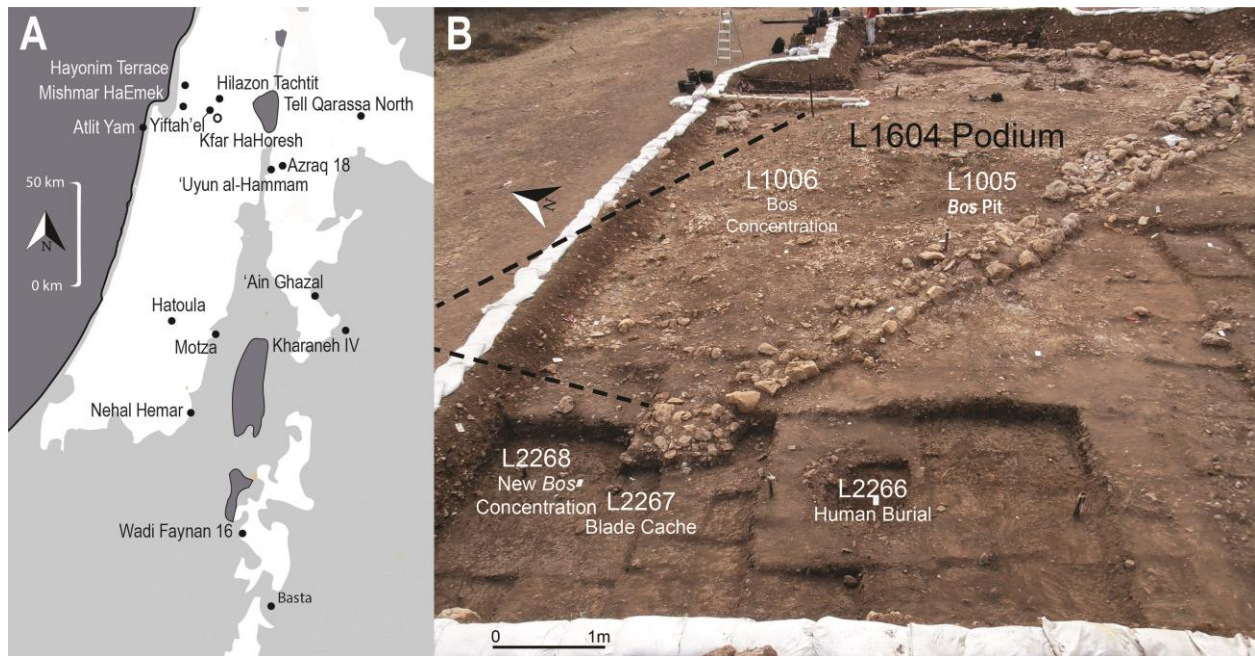


Figure 3.1. (A) Locations of south Levantine sites mentioned in the text including KHH (open circle). (B) Photo of L2268 and nearby features facing east in 2011. Taken by Goring-Morris.

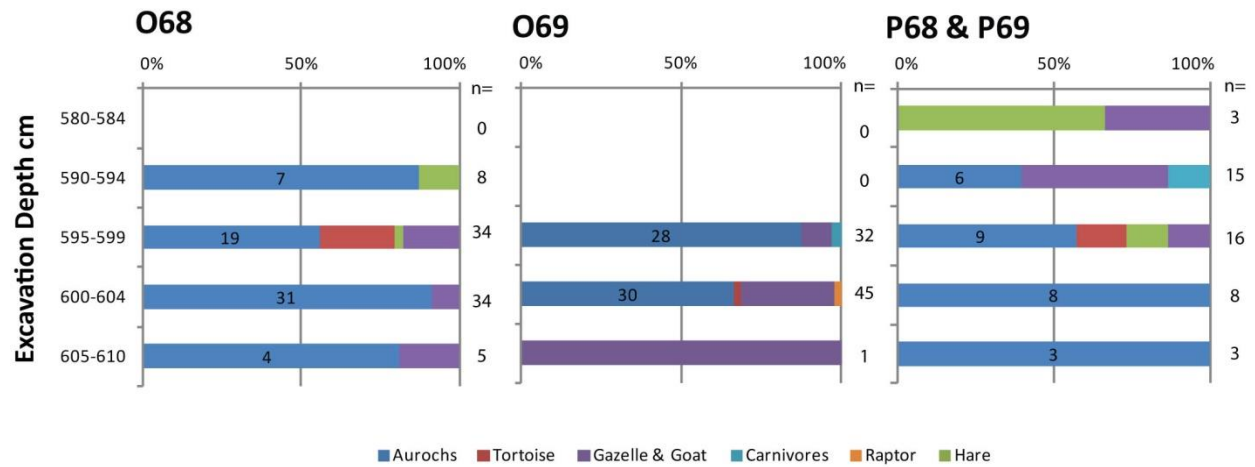


Figure 3.2. Relative taxonomic representation (%NISP) in L2268 by excavation square. *Bos* NISP labeled by depth of 2010–2012 excavation spits, with total NISP of spits at the right of each barchart (n=204).

Aurochs remains are more concentrated in squares O68-O69 from depths 595–604 cm.

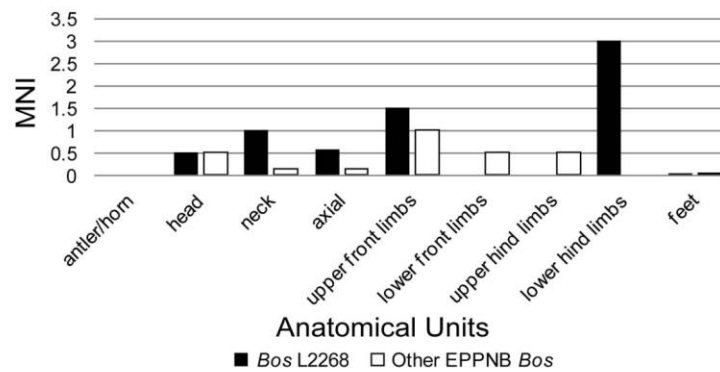


Figure 3.3. Minimum number of aurochs individuals (MNI) in L2268 and other EPPNB KHH contexts from 2010–2012 excavations.

Chapter 4. Depositional Histories of Faunal Remains from the Neolithic Cultic Site of Kfar

HaHoresh, Israel

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## Introduction

Many significant social changes in the prehistory of Southwest Asia can be traced back to the increasingly sedentary human communities that arose as foragers became farmers. In the southern Levant region, greater site permanence is first evidenced by more invested site features and increasingly structured use of space in the Epipaleolithic (21,500–11,600 cal BP) (Bar-Yosef and Belfer-Cohen 1989; Belfer-Cohen and Bar-Yosef 2002; Goring-Morris and Belfer-Cohen 2003; Maher, *et al.* 2016). By the start of the Pre-Pottery Neolithic B (PPNB) period (10,500 cal BP), larger sites with new forms of compartmentalized architecture reflect changes in settlement organization and more differentiated functional space within sites and homes (Byrd 1994; Goring-Morris and Belfer-Cohen 2008; Kuijt, *et al.* 2011). As the reliance on agricultural life-ways and sedentism increased, the diversity of human activities practiced at occupation sites, including ritual practice, also expanded (Kuijt 1996; Goring-Morris and Belfer-Cohen 2002). Changes in the structure of archaeological sites had observable impacts on how humans used space, the range of activities that they undertook and how they disposed of their trash. These changes are captured in the patterns of deposition of material remains at archaeological sites.

Understanding how larger questions of site function are related to patterns of ritual and mundane deposition can thus be conveniently explored by reconstructing the sequences of events that formed and impacted deposits in different contexts (LaMotta and Schiffer 1999; Kunen, *et al.* 2002). Such studies have begun for Epipaleolithic (Maher, *et al.* 2011; Yeshurun, *et al.* 2014a; Grosman and Munro 2016) and PPN sites (Horwitz 2003; Portillo, *et al.* 2009; Bogaard, *et al.* 2009). Yet, further exploration of depositional practices is needed to investigate the relationship between intensified site occupation, the organization of space, diversified site use, and their links to the agricultural transition.

The ceremonial site of Kfar HaHoresh (KHH) in the Lower Galilee of Israel (Figure 4.1) provides a remarkable opportunity to study both sacred and mundane aspects of depositional histories of faunal remains from the PPNB period. The site is interpreted as a communal cult center based on abundant human burials (85+), striking ritual practices such as feasting on wild cattle, and a lack of habitation structures (Goring-Morris, *et al.* 1998; Goring-Morris 2000; Goring-Morris and Horwitz 2007). A strong relationship between animal use and ritual practice has been detected (Horwitz and Goring-Morris 2004a; Meier, *et al.* 2016) and thus it is an exceptional location to study faunal deposition across diverse sacred and secular contexts. KHH also offers the rare opportunity to investigate change in site use across the PPNB owing to its multiple phases of occupation (EPPNB–LPPNB) (Birkenfeld and Goring-Morris 2015). Here, we combine classic zooarchaeological methods and taphonomic analyses to explore differential faunal deposition among numerous contexts and to obtain insight into ritual and mundane behaviors at a ceremonial site.

In recent multivariate studies of contextual variation in faunal assemblages, researchers have developed new methods to explore the nuances of depositional histories at earlier Natufian sites. These studies combine detailed histories of contexts and assemblages to highlight site use (Yeshurun, *et al.* 2014b), and both domestic (Yeshurun, *et al.* 2016), and ritual (Grosman and Munro 2016) human behaviors. Faunal remains are especially useful for exploring the history of archaeological deposits as bone records evidence multiple anthropogenic and natural processes that may be used to discern rates of deposition and burial (Bar-Oz and Munro 2004; Munro and Bar-Oz 2005).

This study of the 2010–2012 faunal assemblage from KHH explores intra-site patterns of deposition. The presence of middens at KHH (Goring-Morris 1991; Barzilai and Goring-Morris 2010) and evidence of cleaned surfaces at Beidha and ‘Ain Ghazal have been associated with a

regional shift towards more organized depositional practices and site use that became necessary as settlement size expanded (Hardy-Smith and Edwards 2004). Nevertheless, the ritual function of these depositional contexts must also be considered to better understand changing site use patterns in the PPNB. As a non-habitation site, KHH enables the examination of patterns of deposition that were not governed by the confines of living area space constraints and the domestic activities found at other sites.

In this study, we use indicators of the speed of faunal deposition and burial to illuminate human behaviors associated with different features and how they reflect overall site function and the intensity of site use. We utilize these faunal depositional histories to investigate how space was organized in the absence of long-term habitation areas and compare this to earlier Natufian settlement organization. Finally, we examine how different types of refuse deposition may reflect the interaction of sacred and mundane behaviors at a ritual site.

## **Background**

A variety of faunal discard and burial practices reveal changing site use and behaviors across the agricultural transition in Southwest Asia. Faunal deposits from the periods just before and during the shift to farming (Epipaleolithic–PPN) have been linked to a variety of ritual and mundane behaviors. These range from large concentrations to small scatters of faunal remains and from highly symbolic and/or structured deposits that reflect ritual practice to everyday trash deposits created by mundane activities.

Symbolic deposits of animal parts are commonly found in grave features beginning in the Epipaleolithic and continuing into the PPNB (Belfer-Cohen and Goring-Morris 2014). These include Natufian human burials with fox and dog skeletal elements at sites such as Uyun el-Hammam, Hayonim Terrace and Eynan (Tchernov and Valla 1997; Valla 2009; Maher, *et al.*

2011), and unusually well-preserved animal parts such as an aurochs tail, eagle wing, wild boar forearm, marten skulls and tortoise carapaces in the grave of an old woman interpreted as a shaman from the burial cave of Hilazon Tachtit (Grosman, *et al.* 2008). Later PPN examples of faunal inclusions in human graves include aurochs parts at PPNA Hatoula and E/MPPNB Mishmar Ha'Emek (Le Mort 1989; Barzilai and Getzov 2008), gazelle remains at E/MPPNB Motza (Sapir-Hen In Press), and wild boar remains at PPNB 'Ain Ghazal (Rollefson 1986). Red fox were also prevalent in grave contexts previously excavated at KHH that also included the remains of gazelle, goat, hare, tortoise, rodent and snake (Horwitz and Goring-Morris 2004a).

Structured or intentionally placed faunal deposits are also associated with ritual practice during the agricultural transition. These include small faunal concentrations of cattle bones found in Natufian deposits at Hayonim Terrace (Munro 2012). Additionally, installations of animal parts were recovered from PPN structures, like the cattle bucrania found on walls at Anatolian and North Levantine sites, including PPNA/PPNB Jerf el-Ahmar, PPNA Hallan Çemi and PPNA Tell 'Abr 3 among others (Helmer, *et al.* 2004; Yartah 2005; Twiss and Russell 2009; Zeder and Spitzer 2016).

Examples of rapidly deposited, structured faunal remains produced by ritual activities likely fall into the category of ceremonial trash (Walker 1995). Examples include the large aurochs concentrations deposited immediately following feasts from Epipaleolithic and PPN sites in the southern Levant, such as the large deposit at Natufian Hilazon Tachtit and two aurochs concentrations from EPPNB levels at KHH (Horwitz and Goring-Morris 2004a; Goring-Morris and Horwitz 2007; Munro and Grosman 2010; Meier, *et al.* In press). Additionally, dense faunal deposits formed by more punctuated deposition following smaller ritual meals, include those deposited with human remains from at least seven individuals in a bedrock crevasse at Natufian Raqefet Cave (Yeshurun, *et al.* 2013) and the middens in outdoor spaces at Neolithic Boncuklu in

Anatolia, which have been interpreted as the remains of large-scale food preparation events, possibly for feasts (Baird, *et al.* 2016).

Mundane human behaviors are also clearly reflected in depositional histories. Middens have been identified both within architectural features and in open spaces, and reflect changing disposal behaviors and patterns of site use over the agricultural transition. Midden deposits from Epipaleolithic sites include accumulations spread across living floors at el-Wad and Eynan (Valla 2009; Yeshurun, *et al.* 2014b), and dense deposits of material excavated near cooking activity areas at Pinarbaşı (Baird 2012), within the burial ground of ‘Uyun al-Hammam, and overlying the huts at Kharaneh IV (Maher, *et al.* 2011; Maher, *et al.* 2012). Although the large Epipaleolithic sites from the Azraq Basin of Jordan (Jilat 6, 8, and 9, and Kharaneh IV) have massive middens, the refuse appears to have accumulated over multiple phases spanning thousands of years of site use, which likely indicates a lack of systematic refuse management during the Epipaleolithic (Hardy-Smith and Edwards 2004). Typical mundane Natufian (Late Epipaleolithic) deposits are formed from gradually-accumulated, haphazard primary refuse, whose distribution is largely confined by architectural and natural boundaries (Grosman and Munro 2007; Yeshurun, *et al.* 2014a).

More formal garbage placement and removal is associated with the organization of space at PPN sites in the Levant based on evidence for cleaning and refuse disposal in middens located beyond active living areas (Hardy-Smith and Edwards 2004). In the PPNA, middens containing refuse swept from hearths were identified at el-Hemmeh (White and Makarewicz 2012). Middens or trash dump areas were also recorded at KHH (Goring-Morris, *et al.* 1998) and PPNA 'Dhira (Kuijt, *et al.* 2007) and in open areas between structures or in abandoned buildings at PPNB Beidha (Kirkbride 1966) and PPNC Atlit Yam (Galili, *et al.* 1993). Abandoned rooms were also used as rubbish dumps for fauna at PPNB Ghwair I (Simmons and Najjar 2006).

Although PPN middens likely reflect some everyday site maintenance, evidence for ritual and mundane behaviors are frequently combined within midden deposits in this period. For example, trash middens at Middle PPNB 'Ain Ghazal contained 12 human burials (Rollefson, *et al.* 1992). Small faunal middens were also recovered near ritual faunal deposits, such as articulated gazelle, goat and cattle elements recovered from an ashy pit associated with human burials at Middle PPNB Yiftah'el (Horwitz 2003) and a midden containing abundant goat and gazelle remains situated close to whole aurochs carcasses buried in a ritual deposit at Late PPNB Basta (Becker 2002).

Patterns of faunal deposition also reflect more compartmentalized, or spatially segregated site use in the PPN, particularly at sites in the northern regions of Southwest Asia. For example, a large midden in an open area at PPNA Nemrik 9 seemingly divided the northern and southern areas of the site (Kozłowski 1989). A recent study of Neolithic Boncuklu in Anatolia showed that 'clean' and 'dirty' household areas were segregated; refuse like hearth sweepings and small bone fragments were separated by a lip in the floor (Baird, *et al.* 2016). Finally, middens were often located in segregated spaces and may be associated with floor cleaning at the later site of Çatal Höyük (Martin and Russell 2000; Hodder and Cessford 2004).

The many types of depositional contexts represented at sites from the Epipaleolithic through the PPN reflect changes in site use across the forager-farmer transition. Recent research at KHH illuminates nuanced depositional processes, such as the removal of waste created in a single flint knapping episode to a prepared shallow pit (L1007) (Barzilai and Goring-Morris 2010). Other, structured deposits of chipped stone tools at KHH reflect diverse depositional histories from the caching of high quality raw material for later use to the symbolic caching of complete unretouched blades (Davidzon and Goring-Morris 2007; Barzilai and Goring-Morris 2007). Human remains interred in single and multiple burials recovered during previous excavations at

KHH also reflect diverse taphonomic histories including planned and prepared secondary internments (Simmons, *et al.* 2007). Similarly diverse processes undoubtedly contributed to the formation of other archaeological deposits. More work is needed, in particular, to refine the depositional histories of faunal remains at KHH. Gaining a better understanding of faunal depositional histories at this atypical site will reveal more detailed aspects of site use in the PPNB.

### **Methodological Approach**

Combining measures of refuse disposal (Schiffer 1972) with spatial and taphonomic data provides a robust approach for characterizing the depositional histories of individual archaeological contexts. We employ such an approach to establish the faunal and depositional histories of different context types from KHH. Special attention is paid to the midden contexts. We examine how they differ from other built contexts to assess whether refuse management, which is commonly associated with the presence of middens at sites, was practiced systematically over time at KHH or reflects more diverse uses including secondary movement associated with feature construction or abandonment. This approach allows for nuanced reconstructions of midden formation processes over time.

Here, we combine methods presented in published works with new analyses. We apply spatial and taphonomic analyses to differentiate primary, secondary and tertiary deposits and use these results to reconstruct depositional behaviors related to site use, maintenance, and other activities (Yeshurun, *et al.* 2014a; Grosman and Munro 2016). This approach builds upon a multivariate taphonomic method that aims to reduce equifinality in interpretations of depositional histories by differentiating anthropogenic from natural processes that impacted faunal deposits (Bar-Oz and Munro 2004; Munro and Bar-Oz 2005). Intra-site comparisons based on multiple methods will illuminate the processes that created structured deposits (Grosman and Munro 2016),

including *in situ* deposition, the placement of remains in specific contexts (Hill 2000; Lyman 2008), and the speed of deposition and burial (Yeshurun, *et al.* 2013).

### ***Primary, Secondary and Tertiary Refuse***

Refuse is categorized into primary, secondary and tertiary categories based on the relationship of the ultimate disposal location to the original activity area (Schiffer 1972). Primary refuse refers to trash deposited in place at the site of the activity. Depending on the speed of deposition and burial, primary refuse may be gradually accumulated through mundane activities such as butchery, consumption and bone working (Yeshurun, *et al.* 2014b), or quickly deposited and buried following a single activity or event (Yeshurun, *et al.* 2013; Grosman and Munro 2016). Primary deposited faunal remains often reflect formal practices, such as the intentional disposal of trash following feasts or the interment of food remains or animal body-parts with human burials (Kuijt 1996; Grosman, *et al.* 2008; Munro and Grosman 2010). Secondary refuse refers to select remains that were moved from their location of use and deposited elsewhere. This includes faunal refuse removed from primary locations, as well as formal practices involving the provisional discard or placement of curated parts in select locations (LaMotta and Schiffer 1999). Another example includes caches of select parts, such as bones removed from food waste deposits that were stored in a discrete location for later bone tool working (Edwards and Le Dosseur 2013). Finally, tertiary or *de facto* refuse refers to garbage that was moved and deposited beyond the secondary deposit location (LaMotta and Schiffer 1999). Tertiary deposits include refuse moved during large-scale cleaning or earth-moving activities such as the filling in of abandoned structures (Schiffer 1972).

Further exploration of depositional attributes is needed to make the more nuanced distinction between primary deposits characteristic of living areas and secondary deposits that may

have resulted from cleaning of those areas (Yeshurun, *et al.* 2014a). Nevertheless, all three refuse types reflect different categories of refuse management that may be used to distinguish the remains of systematic and more haphazard disposal practices.

Although middens are most often formed by secondary processes (LaMotta and Schiffer 1999), the depositional history of midden refuse can be complex. Archaeological middens are generally defined as dense deposits of occupational refuse, yet they may vary significantly in size, composition and function depending on the permanence of site use, and the socioeconomic status and size of the population that generated the refuse (Needham and Spence 1997). Middens are characterized by limited prior deposition and evidence for deliberate refuse placement (i.e., primary or secondary refuse). They can range from gradually accumulated mounds to more horizontally-dispersed refuse deposits (Needham and Sørensen 1988). Understanding processes of midden formation is essential for determining trash disposal behaviors and how systematically they were practiced over time at KHH.

#### *Rate of Deposition and Burial*

Species diversity can vary according to a range of processes, but in combination with other measures it provides a good indicator of the speed of faunal deposition, since fewer species have the opportunity to accumulate in a quickly formed deposit. By contrast, diverse taxa reflect slower deposition, most often of gradually accumulated remains that were built up in place as primary refuse or moved from other deposits to create secondary or tertiary refuse (Wilson 1994).

Primary and some secondary deposits are typically characterized by minimal disturbance after deposition, due to quicker rates of deposition and/or burial than *de facto* refuse. Yeshurun *et al.* (2014a) coined the term Evidence of Minimal Movement (EMM) to capture this feature of trash that was deposited *in situ* and left undisturbed until excavation. In this study, EMM is provided by

closely associated articulated elements, refits of bones with old breaks, and higher percentages of complete or nearly complete bones. Localized refits or articulations are usually noted in the field (Hill 1979a; Hill 1979b) or in the lab if the bones were collected in the same analytical unit. Some researchers have tried to identify other associated elements from an individual animal by refitting anatomical joints, comparing elements of the same size, or matching paired elements using bilateral symmetry (Lyman 2008), but these methods are laborious and have low success rates. A new, more efficient method for identifying anatomically associated bones using ArcGIS Near 3D analysis is described below and provides additional EMM.

Size sorting and bone breakage also reflect the speed of deposition and burial. Primary refuse deposited quickly in place is less likely to be size sorted prior to deposition (Yeshurun, *et al.* 2014a). Assemblages with no size sorting may also reflect tertiary refuse from highly disturbed contexts with slower deposition. Size sorting often occurs during cleaning when larger items are more likely to be swept up and moved, while smaller items are more often left behind. Thus when cleaning takes place, smaller items are typical of primary contexts, while larger items typify secondary deposition. Cleaning may also impact the size of bones deposited in areas that were frequently swept and/or resurfaced with plaster or clay over time (Hodder and Cessford 2004). Finally, remains that were deposited and buried more slowly should show more dry breakage since they were at or close to the surface for longer periods and had more opportunities to be broken by trampling and other processes. In contrast, more fresh breakage is typical of butchered faunal remains that were rapidly buried.

Weathering and burning damage can further differentiate the burial speed of faunal refuse. Fauna that is buried more slowly and exposed for longer periods to sun, or temperature and humidity changes are more likely to become weathered than rapidly buried remains (Bunn and Kroll 1986). Rapidly buried bones are also more likely to be protected from post-depositional

damage caused by the many fires at KHH evidenced by the small hearth deposits and fire-cracked rock that blanket the site, but even so, buried bone may be burned indirectly if fire heats the immediate area (Stiner, *et al.* 1995). Therefore more quickly buried faunal material is expected to show infrequent weathering and carbonization, while more exposed, slowly buried bone has a greater chance of being directly exposed to fire and the subaerial climate, which should lead to more burned and weathered bones (Behrensmeyer 1978).

### *Expectations*

The zooarchaeological and taphonomic expectations for identifying primary, secondary and tertiary contexts are laid out in Table 4.1. Primary faunal refuse from single events should be rapidly deposited and buried and thus include a narrow range of well-preserved taxa with little weathering, burning or dry bone breakage. Primary deposits that are formed slowly in place by long-term mundane activities will include more diverse taxa, reflecting slightly slower rates of deposition and burial. Both scenarios should produce well-preserved remains with EMM and no size sorting or variation except for the removal of fragments large enough (3–5 cm) to impede the use of the area (Binford 1978; Yeshurun, *et al.* 2014a).

Secondary refuse is expected to accumulate more slowly than primary refuse, resulting in size-sorted assemblages with less EMM. Intentionally cached faunal remains should be rapidly buried and consequently represented by a narrower range of taxa, more freshly broken bones and articulated elements and lower rates of weathering and burning. More diverse size-sorted and disarticulated elements, more intense weathering, moderate burning and more dry fractures are expected in more slowly buried faunal deposits following cleaning (Yeshurun, *et al.* 2014a). Cleaning should also produce secondary refuse containing larger bone fragments if the refuse was removed from primary deposits as a part of maintenance behaviors such as sweeping, tossing or

dumping (Binford 1978; Metcalfe and Heath 1990; Simms and Heath 1990) and smaller bone fragments in spaces that were maintained for routine activities with variation by depth if areas were cleaned systematically over time (Hodder and Cessford 2004; Yeshurun, *et al.* 2014a).

Finally, tertiary refuse should reflect highly diverse taxa with no EMM that were slowly deposited following intensive cleaning or massive disturbance (Yeshurun, *et al.* 2014a).

Additionally, more dry breakage and abundant weathered and burned bones should reflect the slow burial of tertiary refuse.

Table 4.1. Zooarchaeological expectations for primary, secondary and tertiary faunal refuse deposits

Refuse type	Primary		Secondary	Tertiary
Depositional speed	Fast		Slow	
Burial speed	Fast	Slow	Fast	Slow
Diversity	Low	Medium-to-High	Low (caching), Medium (cleaning)	Highest
EMM	High	High	Low	None
<i>refits</i>	High	Medium-to-High	Low	None
<i>complete bones</i>	High	High	Low	None
<i>articulations</i>	No	Minimal	Yes	No
Size sorting	No	Minimal	Yes	No
Breakage	Fresh	More fresh than dry	Fresh and dry	Dry
Weathering	No	Low	Low	High
Burning	Mostly unburned	Some burning	Mostly unburned	More burning
Potential depositional scenarios	Single-event deposit	Habitation area deposition	Caching/ selective deposition, cleaning	Intensive cleaning, disturbed deposits (anthropogenic or natural agents)

## Methods

### *Data collection*

Fauna was recovered from several context types from the 2010–2012 KHH excavations (Figure 4.2; Table 4.2). Three of these are large delineated areas that include multiple loci; the

monumental platform structure (the L1604 complex) and the east and west middens. The *Bos* concentration located in a pit on the western side of the site is considered separately. This aurochs deposit is described in detail elsewhere (Meier, *et al.* In press) and shares many features in common with a previously identified *Bos* pit (L1005) at KHH (Horwitz and Goring-Morris 2004a). Context types that pool loci from similar, non-adjacent features include human burials, stone features (stone concentrations, semi-circular/semi-rectangular stone arrangements, hearths, a potential kiln and oven, and areas with overlying plaster/clay patches), wall features and pits. Finally, the east and west general areas are open spaces with no embedded features or loci. These contexts are especially useful as comparisons to measure the discreteness of the east and west midden contexts.

Faunal specimens recovered during the 2010–2012 excavation seasons at KHH were identified to the most specific taxonomic level (or body-size category), element and portion of element possible (NISP=11,626) (Stiner 2004). Taphonomic data (Lyman 1994) was recorded for all specimens, including bone breakage with spiral or transverse outlines indicating fresh and dry breaks respectively (Villa and Mahieu 1991), burning intensity (Stiner, *et al.* 1995), weathering (Behrensmeyer 1978) and greatest length (mm). Given the contextual focus of this study, specimens that were recovered while cleaning excavation units are excluded from analysis. Data collection took place at the National Natural History Collections at the Hebrew University, Jerusalem.

Table 4.2. Description of KHH contexts with fauna from loci excavated in 2010-2012.

Loci by Context	NISP	Loci	PPNB Phases	Description
<i>Bos</i> Concentration	203	2268	Early	Concentration of mostly aurochs remains with stones.
Burials	64	2266, 2361, 2357	Early, Middle–Late, Late	Primary human burial in a pit and groups of human bones in articulation
East Midden	1167	2206, 2225, 2106, 2104	Early, Middle, Late	Dense deposits of remains, some sloping to north or semi-circular.
Pits	94	2107, 2156, 2222, 2264, 2367, 2355, 2359	Early, Early–Middle, Middle, Late	Round depressions, either cut pits or postholes, or possibly natural indentions.
Platform (‘L1604 complex’)	1146	2220, 2120, 2208, 2212, 2213, 2211, 2205, 2101, 2102, 2111, 2117, 2215, 2115, 2216, 2116	Early, Early–Middle, Middle, Middle–Late, Late	Early and Middle PPNB layers, and installations with fauna in the monumental structure. Some Late PPNB pits.
Stone Features	658	2064, 2068, 2110, 2113, 2152, 2160, 2214, 2218, 2219, 2221, 2223, 2255, 2256, 2260, 2263, 2354, 2362, 2363, 2365, 2369, 2370	Early, Early–Middle, Middle, Late, no date	Groups of stones, plaster patches, lumps of clay, hearths, and a kiln.
Wall	142	2227, 2228, 5950, 6202, 5504, 6150, 6001	Early, Early–Middle, Middle–Late, Late	Rows of stones, some possibly related to platform but cut by later disturbances.
West Midden	7158	2252, 2250, 2253, 2257, 2364, 2150, 2353, 2356	Middle, Late, no date	Rich deposits of material, some very concentrated.
East General Area	1259	n/a	n/a	Fauna from the east area with no assigned locus.
West General Area	3155	n/a	n/a	Fauna from the west area with no assigned locus.

Some contexts are securely dated to Early (10,600–10,000), Middle (10,000–9,500), and Late (9,500–8,700) PPNB phases, while others could only be dated more broadly to multiple PPNB phases.

#### *Primary, Secondary or Tertiary Refuse*

Several analyses were performed to categorize the types of faunal refuse in different types of contexts. First, taxonomic diversity is explored using the Shannon-Wiener Diversity H index

(Krebs 1989) to assess the speed and type of deposition. Next, we detect EMM by identifying *in situ* refits of single elements and articulating elements from the same excavation subsquare using GIS analysis. Refits of old dry breaks were first detected during lab identification of specimens excavated from subsquare excavation units. Given the highly fragmented nature of PPNB faunal assemblages, the ArcGIS Near 3D tool, a Proximity Tool from the Spatial Analysis toolset, was used to identify point-to-point spatial associations between fragments of articular portions of anatomically associated bones (i.e. Voeller 2015) by examining elements plotted in the same subsquare and excavation layer during excavation. Finally, the percentage of complete bones of all taxa was calculated out of the total number of specimens in each context (Bar-Oz and Munro 2004). Each type of analysis was then repeated for the deposits from different time periods within the east and west middens to compare the depositional histories of the middens over time.

The Near geoprocessing tool found within the 3D Analyst Toolbox of ArcGIS, was used to detect anatomically associated elements within the same subsquare (50×50 cm) and excavation spit (5cm). The subsquare and lowest level of an excavation spit were used to plot a point for each faunal specimen. To do this, an Excel database recording the contextual data for each faunal specimen was added as point data to a map of an excavation grid produced using the fishnet tool and designating subsquare names as addresses. Using an address locator, each point was added to the center of the subsquare where it was excavated; the lower spit depth for each specimen was used as the z value. Once each point was plotted, the USGS split-by-attribute add-on tool was used to divide the points into groups of proximal and distal ends for each limb element by taxa. Finally, the Near 3D tool was used in batch mode to analyze the dataset for proximal end fragments that were in the same subsquare and excavation depth as distal end fragments of anatomically associated elements from the same taxa (e.g. proximal phalanx fragments near distal metapodial

fragments). This analysis detects fragments as mapped points with a distance of 0 from fragments of elements that are adjacent in the body.

This GIS Near Analysis was undertaken on gazelle and aurochs bone portions that form limb joints. These taxa were chosen since gazelle is the best represented taxon at KHH and there is evidence for special aurochs use at the site (Horwitz and Goring-Morris 2004a; Meier, *et al.* In press). The results were exported to an Excel table. The percentage of specimens that were in the same subsquare and level as anatomically associated elements was calculated out of the total number of limb elements tested for anatomical associations from each taxa. The chance that spatial and anatomical bone associations occurred randomly was calculated by comparing the number of bone elements expected to be anatomically adjacent to each limb bone in a complete animal, standardized for the number of times each element occurs in a complete skeleton. After combining the likelihood ratios for all of the limb bones, we find that there is a 2.5% chance that anatomical associations occurred in spatial proximity by random chance.

Next, we considered significant differences in taphonomic variables of faunal assemblages within and between contexts using chi-square tests (Grayson, *et al.* 1988; Lyman 1994; Bar-Oz and Dayan 2003). First, we explored variation in fragment length by investigating the ratio of bone fragments greater than 3 cm to those less than 3 cm in length for specific taxa across contexts, excluding fragments with new breaks (Yeshurun, *et al.* 2014a). Then, chi-square tests were used to detect differences in the ratio of bones that were broken when fresh to those broken when dry, excluding bones with excavation breaks (Villa and Mahieu 1991; Munro and Bar-Oz 2005). The proportion of bones that were weathered (Behrensmeyer 1978) or burned (Stiner, *et al.* 1995) were also compared across contexts. Given variable sample sizes across contexts, multi-level chi-square tests of independence (SPSS software) were chosen to compare the proportion of each of these nominal taphonomic variables for all taxonomic groups combined, and for select taxa among

contexts. Most taxa were identified to the genus and species level (aurochs, gazelle, goat, pig, tortoise, hare), but less well-represented taxa were grouped more broadly to family or order (Cervids, carnivores, raptorial birds, other small game) to increase sample size. Taphonomic attributes for select/grouped taxa that differ significantly across contexts were described in detail.

Composite chi-square values were used to test for homogeneity among contexts by identifying significant deviations from the average proportion for each attribute, then by the proportion of specimens with each attribute for each of the select taxa. Tests of homogeneity by depth were performed for the platform and tests for homogeneity over time were undertaken for the middens since the largest assemblages come from these contexts. Fauna from within the platform layers were also tested for change in average fragment size and the proportion of green breaks in units with increasing depth measured in 10 cm increments from the surface. These attributes were chosen to distinguish size sorting caused by cleaning of applied plaster surfaces (Hodder and Cessford 2004), from size sorting caused by post-depositional damage of remains within the platform, such as by trampling (Gifford-Gonzalez, *et al.* 1985).

Next, adjusted standardized residuals (AR) of the chi-square values were computed to detect the most different samples (Grayson and Delpech 1998; Grayson and Delpech 2008). ARs account for sample size by dividing the standardized residuals by the standard deviation of all residuals to yield standard normal deviates, excluding table cells with values less than five (Everitt 1977). AR deviates of  $\geq 2$  or  $\leq -2$  thus have a low probability of occurring due to chance when assessed at a significance threshold of  $\alpha=.05$ , or  $\alpha=.01$  for an AR range of  $\geq 4$  and  $\leq -4$  (Grayson and Delpech 2008; Yeshurun, *et al.* 2014a). AR values were plotted as barcharts for easy visual comparison following Yeshurun *et al.* (2014a).

## Results

### *Diversity and EMM Analysis*

A Shannon test of taxonomic diversity reveals significant variation among contexts at KHH ( $\chi^2$  of taxa NISP= 2997.6; df 497;  $p<.0001$ ) (Figure 4.3). Taxonomic diversity (H) is remarkably low in the *Bos* concentration (1.0), but significantly ( $p<.0001$ ) and consistently higher in all other contexts (1.7–2.1) (Supplementary Table 1).

ArcGIS Near analysis in 3D (Table 4.3) indicates that anatomical associations of aurochs bones within a single excavation subsquare and level are most common in the *Bos* concentration (25%). Higher than random expected anatomical associations ( $>2.5\%$ ) of aurochs limb bones are also present in the west midden (6%). Fragments of anatomically associated gazelle elements are more common than expected by chance in the west midden (15%), as are those in the stone features (6%). Although anatomical refits of gazelle appear common in wall contexts (9%), the frequency is inflated by one refit of two limb elements and a small total sample size ( $n=15$ ). Refits of old breaks on specimens from all taxa are rare in the *Bos* concentration ( $n=1$ ), stone features ( $n=2$ ), and the east ( $n=2$ ) and west ( $n=3$ ) general areas. Refits are more common in the platform area ( $n=6$ ), and especially in the east ( $n=19$ ) and west middens ( $n=10$ ).

The percentage of complete elements also varies significantly by context. The highest percentages are found in the pits (17%) and the walls (13.8%). However, the complete bones in these contexts, as well as in the burials, represent small compact elements from small taxa in contrast to the more diverse complete elements in other contexts. High completeness of diverse elements from large and small taxa is found in the west general area (13.2%), and platform (12.3%). Complete elements are rarest in the *Bos* concentration (2.5%).

Table 4.3. Evidence of Minimal Bone Movement (EMM)

	<b>Bos concentration</b>	<b>West Midden</b>	<b>East Midden</b>	<b>Platform</b>	<b>Stone Features</b>	<b>Burials</b>	<b>Pits</b>	<b>Walls</b>	<b>East general area</b>	<b>West general area</b>
<b>%AA (n)</b>										
Aurochs	25% (20)	6% (50)	0% (1)	0% (4)	0% (5)	0% (0)	0% (1)	0% (1)	0% (0)	0% (0)
Gazelle	0% (11)	15% (696)	1% (103)	3% (154)	6% (47)	0% (5)	0% (6)	9% (15)	4% (127)	5% (426)
<b>Dry refits</b>										
Aurochs	MT sh		<u>EPPNB</u> Rib sh Sesamoid <u>LPPNB</u> MC sh Tibia sh	Rib sh						
Gazelle		No date Tibia sh MC dst_ <u>MPPNB</u> Radius prx Lumbar vt Tibia sh MT prx_ <u>LPPNB</u> Ulna prx Humerus*	<u>EPPNB</u> Scapula Rib sh Humerus sh Femur dst Tibia sh <u>LPPNB</u> Premolar* Rib sh Femur dist Tibia sh Lumbar	Thoracic-vt Rib sh Radius dst				Thoracic- vt (3 total)	Tibia prx Lumbar*	
Goat		<u>MPPNB</u> Lacrimal <u>LPPNB</u> Ulna prx	<u>LPPNB</u> Rib sh Scapula sh	Rib sh	Rib sh (2 total)					Tibia sh
Fox			<u>EPPNB</u> MT sh Scapula prx							
Hare		<u>MPPNB</u> Rib sh	<u>EPPNB</u> Tibia prx						MT sh	
Tortoise and lizard		<u>LPPNB</u> 2 Plastron segments attached	<u>EPPNB</u> 6 Peripheral segments attached	Pleural; segments attached	Lizard vt				4 carapace segments attached	2 carapace segments attached
<b>%Comp</b>	2.5%	11.1%	8%	12.3%	8.7%	7.8%	17%	13.8%	9.8%	13.2%

%AA (n)= percent of tested limb elements in anatomical association, total number of limb bone

fragments tested in parentheses. \*=>50% complete dry refits. (Abbreviations: prx=proximal

fragment, dst=distal fragment, sh=shaft fragment, vt=vertebrae). %Comp= percentage of nearly

complete (>90% complete) elements of all taxa.

### ***Chi-square test results***

The proportion of large bone fragments out of the large (>3cm) and small (<3cm) specimens from all taxa varied significantly by context ( $\chi^2 = 64.657$ , df 9;  $p < .001$ ) (Figure 4.4). Significant differences in the proportion of large fragments by context are also apparent in the aurochs ( $\chi^2 = 21.05$ ; df 9;  $p < .05$ ) and gazelle assemblages ( $\chi^2 = 23.56$ ; df 9;  $p < .01$ ) (see Supplementary Table 2). The highest proportion of large aurochs bone fragments is present in the *Bos* concentration ( $p < .001$ ) while the lowest proportions occur in the stone features and platforms ( $p < .05$ ). The proportion of large gazelle fragments is high in the west midden ( $p < .05$ ) and low in the east midden ( $p < .05$ ). A low proportion of large fragments of all taxa is present in the platform.

The relative proportion of fractured bones with spiral fractures only differs significantly for the gazelle assemblage ( $\chi^2 = 17.196$ ; df 9;  $p < .05$ ) (Figure 4.5; Supplementary Table 3). Gazelle bones with spiral fractures are significantly more common than bones with transverse fractures in the platform and east general area contexts ( $p < .05$ ) than in all other areas, while spiral fractures are significantly underrepresented in the west general area ( $p < .05$ ).

The degree of weathering for all taxa combined also differs significantly by context ( $\chi^2 = 210.375$ , df 9;  $p < .001$ ) (Figure 4.6). Significant variation in the proportion of weathered bone is also apparent for aurochs, goat, gazelle, and carnivores ( $p < .05$  in all cases) (Supplementary Table 4). The west midden assemblage has significantly less weathered bone overall ( $p < .001$ ), and weathered bone is underrepresented for aurochs, goat, gazelle, and tortoise specimens in particular ( $p < .05$ ). By contrast, weathered bones are numerous in the *Bos* concentration ( $p < .001$ ), especially the aurochs ( $p < .001$ ) and gazelle specimens ( $p < .001$ ). Bones from the stone features were also more commonly weathered ( $p < .05$ ), as were the gazelle remains ( $p < .05$ ), but weathered aurochs bones were significantly less common in this context ( $p < .05$ ). Weathered bones of all taxa are significantly more common in the east midden as are weathered bones of aurochs, tortoise and

carnivore specimens ( $p<.05$ ). Weathered bones were also more common in the east and west general areas ( $p<.05$ ), particularly carnivore remains in the east ( $p<.05$ ) and gazelle bones in the west ( $p<.05$ ) general areas. In the burials, no significant differences in weathered bones were present when all taxa were combined, but when divided by taxa, weathering is higher for aurochs and goat than in other contexts ( $p<.05$ ).

Significant differences in the proportion of burned bones of all taxa were observed across contexts ( $\chi^2=75.201$ ; df 9;  $p<.001$ ) (Figure 4.7). Analyses of individual taxa also show significant variation in the proportion of burned aurochs, gazelle, pig, and tortoise remains across contexts ( $p<.001$ ) (Supplementary Table 5). Bones from pits were significantly more burned ( $p<.05$ ). This pattern is repeated in the gazelle assemblage ( $p<.05$ ). Carbonized bones were also more abundant in the west midden ( $p<.05$ ), where burned aurochs ( $p<.001$ ) and tortoise bones ( $p<.001$ ) were better represented. By contrast, significantly fewer burned bones were recovered from the *Bos* concentration ( $p<.001$ ). The same pattern is true of aurochs bones ( $p<.001$ ). Burned bones were less numerous in the east midden ( $p<.001$ ), particularly aurochs ( $p<.05$ ), gazelle ( $p<.05$ ), and tortoise ( $p<.001$ ) remains, but a higher proportion of burned pig bones are found in this context ( $p<.05$ ). Burned bones were also less common in the stone features ( $p<.05$ ).

### ***Intra-context results***

#### *The platform*

In addition to abundant small fragments of all taxa, the specimens from the platform are smaller on average ( $18.6 \text{ mm} \pm 9\text{mm}$ ) than those from the adjacent east midden ( $22.2 \text{ mm} \pm 13\text{mm}$ ). The average size of bone fragments increases marginally (from 15mm to 31mm) but significantly ( $n= 671$ ,  $R^2=0.86$ ,  $p<.001$ ) with depth below the platform surface (Figure 4.8). The maximum fragment size also becomes increasingly truncated with depth. Nevertheless, the proportion of

fresh breaks on gazelle bone fragments from the platform does not vary significantly by depth (81–91%), and thus rates of dry bone breakage are not greater closest to the modern day surface. Thus change in average fragment length over time in the platform layers is likely not driven by post-depositional damage, but rather by size sorting due to the removal of the larger, more impeding fragments from layers closer to the surface. This is likely explained by an increase in cleaning (size sorting) with each re-plastering of the platform, rather than greater rates of post-depositional breakage closer to the surface.

### *The middens*

Intra-contextual analysis also highlights variation in the depositional histories of the middens over time. Shannon diversity H indices indicate significant variation over time in the east midden, but not in the west midden. Diversity decreases over time in the east midden (EPPNB 2.04; MPPNB 1.93; LPPNB 1.76) and changes significantly between the EPPNB and LPPNB (Figure 4.9A) (t-test:  $p < .0001$ ). Diversity is low and statistically similar across all time periods in the west midden (Figure 4.9B) (E-MPPNB 1.41; MPPNB 1.76; LPPNB 1.76; No date 1.34).

A comparison of the proportion of modified bones from all taxa within the middens reveals significant variation over time in the proportion of weathered (east midden:  $\chi^2 = 21.946$ , df 4,  $p = .000$ ) (west midden:  $\chi^2 = 54.19$ , df 8,  $p < .001$ ) (Supplementary Table 6) and burned remains in both middens (east midden  $\chi^2 = 62.45$ , df 4,  $p < .001$ ) (west midden:  $\chi^2 = 47.92$ , df 8,  $p < .001$ ) (Supplementary Table 7). Fauna from MPPNB loci in each midden is significantly more weathered than fauna from other periods ( $p < .001$ ) (Figure 4.10). By contrast, less weathered remains are found in the LPPNB deposits in the east ( $p < .001$ ) and west middens ( $p < .05$ ). Burned specimens are most common in the MPPNB in both the east ( $p < .001$ ) and west middens ( $p < .05$ ).

(Figure 4.11). Burned remains are less common from LPPNB contexts in the east midden than other periods ( $p < .001$ ).

Significant variation in types of gazelle bone breakage over time is found in the west midden ( $\chi^2 = 12.42$ , df 2,  $p < .005$ ) (Supplementary Table 8). Dry breaks are significantly more common on gazelle bones in LPPNB contexts ( $p < .05$ ). No significant variation in breakage is detected in the east midden over time. Additionally, no significant variation is detected over time in the proportion of large and small gazelle bone fragments in either midden.

EMM is present for all phases of deposition in the west midden but not the east midden (Table 4.3). According to the GIS Near analysis of the east midden, few anatomically associated gazelle limb bone elements within an excavation subsquare and level occur in MPPNB contexts (3.3% of  $n=30$  tested with Near analysis) and none are present in other phases. By contrast, a higher percentage of gazelle limb elements are detected in anatomical association in the west midden samples from MPPNB (11% of  $n=234$ ) and LPPNB (17% of  $n=515$ ) contexts. Refits of ancient breaks are only present from the EPPNB and LPPNB in the east midden and from all phases in the west midden, except for in the small E-MPPNB sample. Articulated tortoise shell segments are identified in EPPNB loci in the east midden ( $n=6$ ) and LPPNB loci of the west midden ( $n=2$ ). Slightly more complete bones are recovered in the east midden from the EPPNB (10% of  $n=500$ ), than the MPPNB (5% of  $n=275$ ) and LPPNB (7% of  $n=384$ ). In the west midden, complete bones are more common in the MPPNB (11% of  $n=2146$ ), LPPNB (11% of  $n=4455$ ) and undated (12% of  $n=435$ ) samples.

Table 4.4. Summary of depositional history indicators by context.

	<i>Bos</i> Concen- tration	West Midden	East Midden	Platform	Stone Features	Burials	Pits	Walls	East general area	West general area
Diversity	Low*	Medium	High	High	High	Medium	High	High	High	High
EMM	High	High	Low	Low	Low	Scarce	Scarce	Scarce	Low	Low
Size sorting	Larger*	Larger	Smaller	Smaller	Smaller	-	-	-	-	-
Breakage	-	-	-	Green	-	-	-	-	Green	Dry
Weathering	High*	Low*	High	-	High	High	-	-	High	High
Burning	Low*	High	Low*	-	Low	-	High	-	-	-
Deposition rate	Fast	Fast	Moderate	Moderate	Moderate	Slow	Slow	Slow	Moderate	Moderate
Burial rate	Fast	Fast	Mixed?	Mixed?	Slow	Slow	Slow	Slow	Slow	Slower
Refuse type	Primary	Primary	Secondary	Secondary	Primary	Tertiary	Tertiary	Tertiary	Primary	Primary
Potential depositional scenarios	Single deposit event, later disturbed	Many singular deposit events	Complex use, cleaning deposits	Cleaned area	Haphazard deposits in activity areas	Intrusive fill	Disturb- ed deposit	Disturb- ed deposit	Open area	Open area

Statistically significant results ( $p < .05$ ) described for all indicators with the exception of EMM.

\*=highly sig. ( $p < .001$ ) for all taxa combined. Contexts with no significantly different proportion of bones with or without the described attribute are marked with a dash. Level of EMM was evaluated based on presence across different types of EMM described in Table 4.3.

## Discussion

### *Depositional histories*

A comparison of zooarchaeological and taphonomic attributes revealed nuanced differences in the depositional histories of fauna among contexts at KHH (Table 4.4), suggesting that multiple types of refuse are represented in the 2010–2012 sample.

*Rate of deposition.* Rates of deposition vary among contexts. Deposition was most rapid in the *Bos* concentration, which is characterized by abundant aurochs bones and multiple lines of EMM. Higher taxonomic diversity in all other contexts suggests less discrete depositional events. The combination of moderately low diversity and high EMM from the Early–Late PPNB in the

west midden suggests rapid deposition primarily of multiple small concentrations of gazelle remains. In the east midden, an increase in taxonomic diversity with depth, suggests that the rate of deposition increased in speed over time.

EMM in the *Bos* concentration and west midden assemblages is markedly more pronounced than in other KHH contexts. By contrast, EMM is rare in the east midden, platform, stone features, and east and west general areas. EMM is also consistently rare in all PPNB phases represented in the east midden. Together the evidence suggests a moderately slow pace of faunal deposition over time. EMM is even rarer in burial, pit and wall contexts. Taxonomic diversity is high and nearly all of the complete elements are small and compact. Together these lines of evidence suggest that deposition was slow in the burial, pit, and wall contexts. Slow burial following post-depositional movement likely took a toll on less-compact bones in these contexts.

*Rate of burial.* Although they cannot be completely distinguished from indicators of depositional speed, several faunal attributes highlight variable rates of burial among contexts at KHH. More rapid burial that limited the amount of post-depositional damage is evidenced by larger average fragment size, especially of aurochs in the *Bos* concentration and gazelle in the west midden. Additionally, fauna from the *Bos* concentration is rarely burned, while weathered bone is rare in the west midden, suggesting more rapid burial in these contexts. Evidence of light weathering is prevalent in the *Bos* concentration, but likely occurred when this area was disturbed by the construction of a kiln. Higher frequencies of burned aurochs and tortoise remains in the west midden suggest a slower rate of burial or that the assemblage was burned during food preparation activities such as roasting tortoises in the shell (Munro and Grosman 2010) or roasting defleshed aurochs bones to extract marrow (Gifford-Gonzalez 1989). Intra-contextual comparisons suggest that although burial speed was generally rapid in the west midden, it was slowest during the MPPNB, when weathered and burned remains were more common, and fastest during the

LPPNB, when weathering was rare. Additionally, elevated proportions of dry breaks on LPPNB gazelle bones suggest that the most recently deposited fauna in the west midden was less protected from *in situ* breakage than prior deposits.

Smaller than average gazelle bone fragments and higher rates of weathering suggest that burial was slower in the east midden and platform areas than in the *Bos* concentration and the west midden. Decreased frequencies of weathered and burned bones in the east midden reveal an increase in the rate of burial from the MPPNB to the LPPNB. Smaller bone fragments and increased size sorting with depth on the platform suggest a slower rate of deposition and burial overall, but faster burial rates are evidenced by consistently high frequencies of fresh bone breaks over time in the platform layers.

High rates of weathering suggest a slower rate of burial in the stone features and east and west general areas. These were likely active hubs of human activity, which is not surprising given that the stone features include hearths and other constructed features. Minimal size-sorting indicates a moderately slow speed of deposition or burial in the stone features, where only the largest fragments of the largest taxon were likely removed because they impeded activities. Although slow overall, a more rapid rate of bone deposition and burial in the east than in the west general area is suggested by the higher rates of spiral fractures in the west.

A high number of burned remains in the pits and heavily weathered remains of large aurochs and goat bones in the burials, suggest slower rates of burial in these contexts. Size sorting is also absent from both contexts. In all, this evidence likely reflects burial after disturbance of the remains from prior deposits.

### ***Refuse categorization and context function***

Evidence of rapid deposition and burial in the *Bos* concentration and west midden suggest that these contexts contain primary refuse. Lower taxonomic diversity and abundant EMM suggest that the larger fragment size detected in these contexts is more likely related to the selection of certain body-parts of specific taxa for particular activities, than size sorting denoting secondary refuse. Fauna in the *Bos* concentration was deposited rapidly in a constructed pit as part of a single event. This refuse was likely generated by a feast featuring the consumption of multiple aurochs by a substantial crowd (Meier, *et al.* In press). The west midden also reflects a primary refuse deposit evidenced by multiple episodes of rapid deposition and burial in Early-Middle, Middle and Late PPNB contexts. Although the west midden was used over several phases, it was less disturbed by later processes than the *Bos* concentration. Additionally, more frequent burning of aurochs and tortoise remains suggests that some taxa in the west midden were treated differently from others prior to burial but were ultimately deposited and buried in the same rapid manner characteristic of primary refuse.

Fauna from the stone features and east and west general areas was also deposited quickly, but buried more slowly. This pattern also suggests primary refuse deposition. However, the gradually deposited refuse in these contexts differs from the primary refuse deposited in single events or discrete episodes in the *Bos* concentration and west midden. Size sorting suggests that the deposition of fauna in the east midden and platform areas was likely secondary, although conflicting indicators make it difficult to determine the speed of deposition and burial in these contexts.

Finally, fauna from wall, pit and burial contexts evidences slow deposition and burial that reflect tertiary deposition in these contexts. In the pits, more frequent carbonized gazelle bones and low EMM likely suggest that tertiary faunal refuse was removed from prior deposits and then

exposed to post-depositional damage and movement prior to reburial. Additionally, high frequencies of weathering in the burials indicate markedly slower deposition and burial.

### ***Refuse variation and site occupation***

In summary, the refuse types represented at KHH show marked variability. Primary refuse generated in single events and secondary refuse comprise 64% of the assemblage and reflect more formally placed refuse in a majority of the faunal sample. Thirty-four percent of the assemblage reflects primary refuse that was gradually deposited *in situ* in the stone features and the east and west general areas. Finally, a mere 2% of the faunal remains in the sample represent tertiary refuse of disturbed or intrusive fill from the burial, pit and wall contexts.

The presence of diverse refuse deposits at KHH differs from the largely homogenous disposal practices detected at Natufian sedentary sites (Yeshurun, *et al.* 2014a). For example, over the nine phases of occupation at el-Wad Terrace, primary refuse was deposited inside and around the mundane living area of Structure II and no secondary or tertiary refuse was detected. Yeshurun *et al.* (2014a) suggest that food preparation, consumption and *in situ* deposition occurred in areas where other common habitation activities also took place and that organization of space for food activities was not rigidly constructed at this or other similar Natufian sites. By contrast, the wider variety of refuse represented at KHH suggests that organization of space differed from that of earlier Natufian sites.

Furthermore, the types of refuse deposition at KHH vary in their discreteness and reflect mixed indicators of site use intensity. Even though a majority of the refuse at KHH indicates more structured primary deposition, considerable amounts of other less formally deposited refuse is also present. Formal deposition may point to longer, planned use of KHH as suggested by modern mobile societies that typically place refuse in discrete locations like middens when they expect to

use a site for a long time (Kent and Vierich 1989). KHH lacks habitation structures that would support long-term occupation and instead suggests periodic site use (Goring-Morris 2005), but the presence of middens and secondary refuse fit some expectations for typical deposition in a sedentary settlement where trash was moved and some areas were used more intensively than others. Thus, the wide diversity of depositional contexts reflects organization of space at the site for long-term use despite the evidence that it was used periodically.

This behavior is a possible extension of the greater regional shift in site organization by the PPNB, but also may reflect complex use patterns related to the ceremonial function of the site. For example feasting on aurochs may have generated refuse that required special deposition because of its sheer volume and/or the perceived symbolic value of the refuse itself (Horwitz and Goring-Morris 2004a; Meier, *et al.* In press). Likewise, refuse may have been cleared from the monumental platform area to allow re-plastering of the surface or kept to a minimum in other areas to enable access to primary human burials for secondary ritual uses (Goring-Morris 2000; Goring-Morris and Belfer-Cohen 2013). Given that ritual perpetuates social practices (Rappaport 1999), the types of refuse present at KHH indicate that mundane PPNB site organization behaviors were highly integrated with the management of sacred space.

### ***Depositional histories and associated human activities at KHH***

#### ***Structured primary deposition***

Intentional, structured primary refuse deposition is apparent in the *Bos* concentration and the west midden at KHH. High percentages of anatomical refits point to more structured deposition in these contexts. In the west midden, some of the fauna was deposited in small discernible concentrations among other refuse composed of small burnt stones and debitage. The *Bos* concentration is especially unusual because the large assemblage was rapidly deposited in a

single event and aurochs remains are rare in other contexts. Many of the west midden deposits are less discrete, but highly structured. Fauna from both contexts likely represent special meals as the bones were routinely opened for marrow, but many limb joints were deposited in articulation. The atypical contents of these assemblages, their treatment as food, and their discrete deposition, suggests that they represent formally deposited ceremonial trash that retained symbolic meaning from their use in ritual activities (Walker 1995; Meier, *et al.* In press).

The focus on gazelle in west midden deposits is also curious due to evidence for very early goat management in the region by the MPPNB (Horwitz 1989; Sapir-Hen, *et al.* 2016). This preference may reflect the symbolic importance of gazelle in ritual practices at KHH—a more obvious example of which is a headless gazelle skeleton interred with a plastered human skull in the upper area of the excavation (Locus 1004) (Goring-Morris, *et al.* 1994-95; Goring-Morris 2000; Horwitz and Goring-Morris 2004a). Although the refuse in the west midden is dominated by gazelle, remains of diverse taxa are present. Furthermore, several concentrations of fire-cracked rock suggest that cooking activities took place in the west midden. Still, high EMM in all PPNB phases represented in the west midden, suggest that reuse of this area for specific activities was not common or the deposits would be more disturbed.

#### *Haphazard primary refuse*

Refuse in the stone features and the east and west general areas was gradually accumulated and then buried *in situ*. The absence of loci in the general areas supports less structured refuse deposition in open areas at the site. Primary refuse related to cooking or manufacturing was also haphazardly deposited in the stone features, including all but the largest aurochs fragments that may have impeded activities in construction areas (concentrations of plaster or grouped stones) or around hearths where visitors likely congregated and may have prepared food. Slight variation in

the speed of primary deposition and burial among these contexts likely reflects varied intensity of use of these features, while differences in the quality of preservation are likely related to the range of structures and features represented.

### *Cleaning*

Evidence for the post-depositional movement of bones suggests that deposits in the east midden were secondarily deposited. Smaller fragments in the east midden likely indicate that the assemblage was impacted by *in situ* attrition as most of the EMM consisted of dry bone refits. This points to the continued use of the midden surface as a traffic area, possibly as a common passage to and from the adjacent platform, as well as an area for secondary refuse deposition. This context may be considered a “secondary refuse aggregate” following Wilson’s (1994) definition of a dense deposit with a complex history of deposition and use.

The presence of secondary refuse in the east midden suggests that this context served as a repository for faunal refuse from elsewhere, such as the surface of the adjacent monumental platform structure. The secondary deposits then suffered further post-depositional fragmentation in their new location. This is supported by the significantly higher proportion of small bone fragments across the entire platform. Additionally, the smaller average size of fragments from the platform suggest that larger materials were cleaned and removed from the structure and possibly moved to the east midden, where average fragment size is larger. Both the east midden and platform include loci from the complete KHH occupational sequence (Early to Late PPNB). Thus refuse from these areas may not only reflect the removal of large fragments from the platform and their deposition in the midden, but the continuation of this practice over time. Still, different post-depositional histories suggest that size sorting in the east midden was also caused by processes other than the deposition of cleaned refuse that resulted in more *in situ* breakage.

Notably, the significant positive relationship between average bone fragment size and depth within the alternating thin plaster and sediment layers in the platform indicate that size sorting became more pronounced with greater distance from the surface. Gazelle specimens from different layers within the platform have similarly high proportions of fresh breaks regardless of their distance from the surface, indicating that fauna in platform deposits of all depths were protected from *in situ* breakage by the repeated plastering of the platform structure and this was not likely the cause of the size sorting. Furthermore, size sorting by depth was not likely caused by trampling as the average fragment size for all taxa increased with depth in this area, which is the reverse of the size trend typically observed for trampled bone assemblages (Gifford-Gonzalez, *et al.* 1985). Thus post-depositional breakage did not cause the increase of fragment size by depth on the platform.

Size sorting on the L1604 platform complex more likely occurred prior to burial and increased in intensity over time, such as from more thorough cleaning of large fragments from the platform surface prior to the addition of each new plaster layer. Increasing use of this area is supported by artifact densities and evidence for architectural reorganization that points to a shift toward more intensive site occupation on the eastern side of the site including the platform area, over time (Birkenfeld and Goring-Morris 2014). This supports the hypothesis that low densities of lithic artifacts on and around plastered surfaces observed across KHH likely reflect cleaning of these surfaces (Birkenfeld and Goring-Morris 2014). Thus evidence for size-sorting of material from the platform supports refuse management and more intensive cleaning in this context at KHH that may also reflect the greater intensity of use of the platform complex by visitors, as the intensity of use of this area increased from the Early to Middle PPNB.

### *Disturbance*

Finally, tertiary refuse from burial, pit and wall contexts likely represents fill where trash was moved and slowly deposited, then was slowly buried *in situ*. Fewer remains are represented in these contexts and scarce EMM suggests that bones were trapped and thus protected by the boundaries of the features, such as pit depressions in the burial contexts or the stones that comprised the walls. Evidence of disturbance of primary and secondary human burials is well-documented at KHH as many of the grave loci were exposed or damaged by later burial processes, and in one case by the later re-arrangement of human remains into a possible animal depiction (Simmons, *et al.* 2007). Evidence of this behavior suggests more intensive reworking of the site than at preceding Natufian sites, such as at el-Wad where no tertiary faunal deposits were detected and new construction was layered on top of the old (Yeshurun, *et al.* 2014a).

### ***Sacred and mundane disposal behaviors***

#### ***Trash disposal in middens***

Although the depositional histories of the east and west middens at KHH differ, with primary refuse disposal predominant in the west and secondary refuse more common in the east, deposition in both middens reflects systematic practices of trash disposal throughout the PPNB. Importantly, the refuse in the east and west middens differs from that of the surrounding general areas. More discrete disposal in middens supports organized deposition in at least two areas at KHH, but the primary refuse in the general areas supports continued haphazard deposition in most areas across the site.

Nonetheless, the fact that two middens were used for long-term refuse deposition at KHH supports a change in the use of space from earlier Natufian sites and fits the larger regional shift in site use patterns that has been detected at habitation sites by the PPNB (Hardy-Smith and Edwards 2004). Even though large middens are present at many earlier Epipaleolithic sites in Southwest

Asia, (e.g. Pinarbaşı, ‘Uyun al-Hammam and Kharaneh IV) (Maher, *et al.* 2011; Maher, *et al.* 2012; Baird 2012), these are largely interpreted as abandonment or living-area deposits accumulated on living floors. They differ from the middens at KHH that preserve evidence for cleaning and repeated single-event disposal.

More formalized disposal in the KHH middens may reflect mundane organization of refuse placement and/or structured disposal of ritual trash (Turner 1969). Dual ritual and mundane aspects of refuse deposition are prominent in the east midden, which was likely associated with the ritual use of the monumental platform complex. Yet, decreasing faunal diversity over time in the east midden also reflects a narrowing of dietary breadth, which fits a larger pattern of animal selection typical of domestic sites in the region as ungulates became managed by the MPPNB (Martin and Edwards 2013; Sapir-Hen, *et al.* 2016). The west midden stands apart due to its low degree of disturbance and consistently low diversity emphasizing the selection and processing of wild gazelle remains. Thus, many of the deposits in the west midden differ from those in the east midden and more likely reflect the provisioning of ritual activities throughout the PPNB occupation of the site.

The larger-sized fragments of primary refuse in the west midden are similar to the large bone fragments rapidly deposited in an extramural midden at Neolithic Boncuklu in Anatolia, which likely contained some feasting remains (Baird, *et al.* 2016). Other Neolithic middens in Southwest Asia include abandonment deposits with notably high proportions of cattle remains at Çatal Höyük and a midden associated with a human and aurochs burials at Basta, which have both been associated with ritual meals based on evidence for structured deposition, high levels of preservation, and low levels of bone processing (Martin and Russell 2000; Becker 2002). In all of these cases, the authors associated more structured faunal deposits featuring high bone completeness with ritual meals. These attributes can also be used to describe the fauna from the

west midden; however, these types of deposits are still difficult to distinguish from the more mundane systematic deposition of everyday refuse. Nevertheless, at KHH, such practices may reflect formalized site maintenance related to its cultic function. The deposition of refuse in middens may have served to curate the sanctity of the area, shape the form of ritual performances (Rappaport 1999) and improve the perceived efficacy of repeated rituals by reducing pollution from previous practices (Legare and Souza 2012). The maintenance of a sacred setting for activities at KHH may have also been important for effectively promoting and priming prosocial behaviors that were essential for the transition to agricultural life-ways, such as cooperation and group solidarity (Xygalatas 2013).

Additionally, there is no evidence that deposits in the west midden were placed in large pits like the *Bos* concentration. Instead, for the most part, the midden was likely an above ground feature that was clearly visible within the site. It's obvious visual appearance may have served other symbolic functions typical of some middens described in ethnographic studies, such as territory markers or displays of affluence to site visitors, in a manner similar to monumental architecture (Needham and Spence 1997). Disposal in the west midden may have also marked the site boundary in the west. Visible middens may also have served as regularly viewed reminders of past events that promoted community integration (Turner 1969; Kuijt 1996), possibly through shared practices of deposition signaling group commitment (Sosis 2000) to site visitors that likely came from many settlement sites in the region (Birkenfeld and Goring-Morris 2015).

### *Ritual refuse deposition*

More obvious examples of structured ceremonial deposition of fauna in features such as human burials or inside walls identified at PPNB sites (Twiss and Russell 2009; Goring-Morris and Belfer-Cohen 2013) are not common in the 2010–2012 sample from KHH. However, one

context clearly associated with ritual deposition is the structured deposit of aurochs remains in the *Bos* concentration. The *Bos* concentration is similar to a previously documented *Bos* pit at KHH (Goring-Morris and Horwitz 2007). This reflects a repeated communal ritual practice with aurochs at a number of sites dated to the Late Natufian through the EPPNB in the southern Levant that suggests continuity in the intentional practice of ceremonial trash deposition (Meier, *et al.* In press).

Repeated cleaning of the platform at KHH over time also highlights disposal behavior previously associated with PPNB ritual practice. Cleaning in this area was likely related to maintaining the platform surface for communal activities by routinely refreshing the plaster (Belfer-Cohen and Goring-Morris 2014). Routine cleaning and resurfacing the platform over the course of the E–MPPNB therefore reflects a formal practice of systematic refuse management. These repeated actions may have served to reiterate and construct social memory at KHH (Kuijt 2008b) by maintaining a conspicuous feature that was visible from several surrounding sites (Goren and Goring-Morris 2008; Birkenfeld and Goring-Morris 2015).

The routine maintenance of areas associated with ritual activity also occurs at other Neolithic sites in Southwest Asia. White plaster and clay surfaces were cleaned at Çatal Höyük, where a higher ratio of small to large bone and chipped stone fragments and a lower density of fragments overall, were recovered from white clay floors (Hodder and Cessford 2004). This practice was interpreted as an integral component of the daily process of social memory construction at the site. Cleaning is also associated with ritual structures at PPNB sites in the Levant, such as the flagstone and gravel floors from the “sanctuary” area at Beidha (Kirkbride 1966). Cleaning may also be associated with the floors of large ritual structures containing “altars” at ‘Ain Ghazal that were devoid of artifacts (Rollefson 2005), but may be more closely associated with specific events than increased site maintenance activity, since complex burial practices at the

site reflect both structured and haphazard interments (Rollefson 2000; Goring-Morris and Belfer-Cohen 2010). Thus the cleaning of the platform at KHH and evidence for frequent re-plastering of this monumental complex support the symbolic importance of maintaining communal ritual structures in the PPNB.

### ***Site function and the organization of space at KHH***

The variety of depositional histories represented by the fauna from KHH reflect diverse human behaviors and support its interpretation as a ritual-use site. The studied deposits also reflect more organized use of space typically associated with PPNB settlement sites (Hardy-Smith and Edwards 2004). Overall, variation in the refuse from different contexts illustrates how diverse sacred and secular behaviors interacted to create different context types and two different middens. Both sacred and secular behaviors likely governed systematic deposition related to ritual site maintenance, but more haphazard deposition continued in activity zones and less discrete areas, reflecting more periodic site use. In all, these findings show that systematic refuse deposition was not limited to habitation sites in the PPNB, but extended to cultic areas for reasons that went beyond structured deposition of ritual paraphernalia.

## Figures for Chapter 4

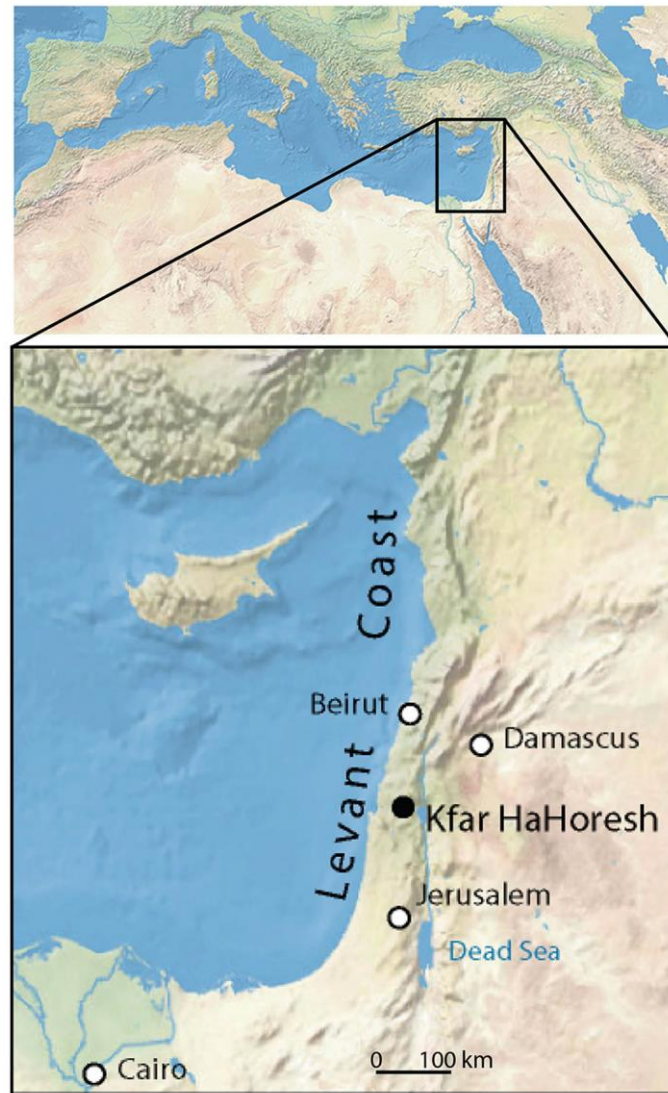


Figure 4.1. Location of Kfar HaHoresh in the southern Levant.

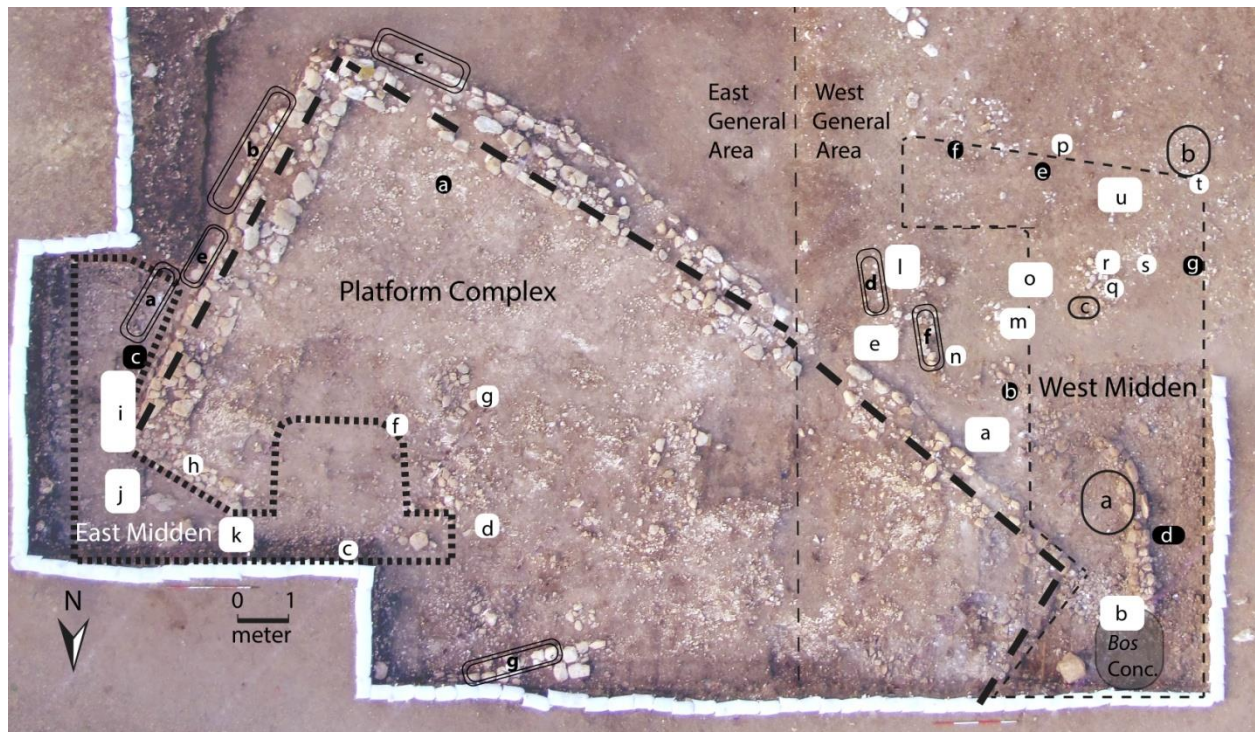


Figure 4.2. Map of contexts with fauna from the 2010–2012 excavation seasons at KHH. Photo by Goring-Morris. The outermost borders are outlined for large delineated areas that include multiple loci, including the Platform complex (thick dashed outline), east midden (square dashed outline), and west midden (thin dashed outline). General locations for loci from each type of context are marked on the map with the following corresponding letter designations in parentheses. Shaded circle with *Bos* conc. represents the *Bos* concentration, L. 2268. Open circles=Human burials L.2266 (a), L.2357 (b), L.2361 (c); Black filled in circles=Pits, L.2107 (a), L.2156 (b), L.2222 (c), L.2264 (d), L. 2355 (e), L.2359 (f), L.2367 (g); White-filled circles=Stone features, L.2064 (a), L. 2068(b), L.2110(c), L.2113(d), L.2152(e), L.2160(f), L.2214(g), L.2218(h), L.2219(i), L.2221(j), L.2223(k), L.2255(l), L.2256(m), L.2260(n), L.2263 (o), L. 2354(p), L.2362(q), L.2363(r), L.2365(s), L.2369(t), L. 2370 (u); Double circle =Wall, L.2227 (a), L.2228 (b), L.5504 (c), L.5950(d), L.6001(e), L.6150(f), L.6202(g).

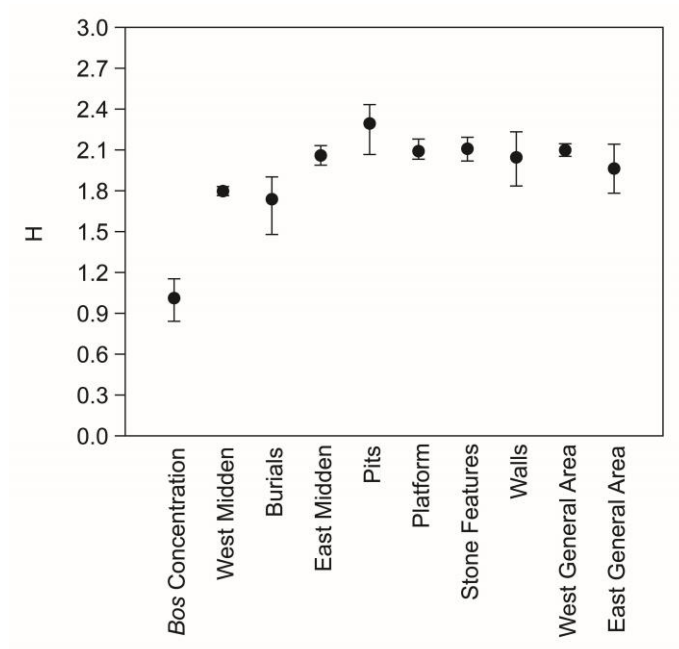


Figure 4.3. Taxonomic diversity by context.

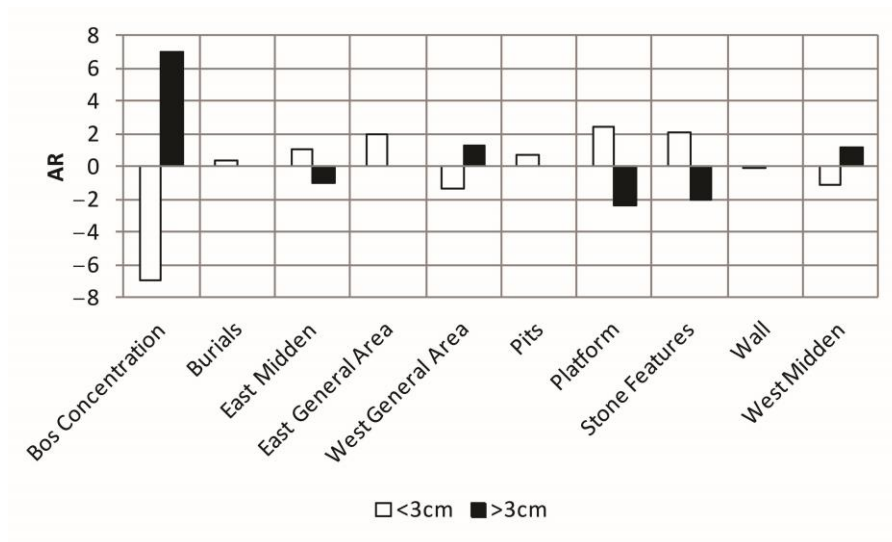


Figure 4.4. Cross-context comparison of chi-square adjusted residuals (AR) of bone fragment maximum lengths (over and under 3 cm, all elements included, fragments with excavation breaks excluded) for all taxa combined. AR values  $\geq 2$  or  $\leq -2$  indicate context samples that are significantly different from the mean ( $p=.05$ ). AR values  $\geq 4$  or  $\leq -4$  indicate highly significant variation from the mean ( $p=.001$ ).

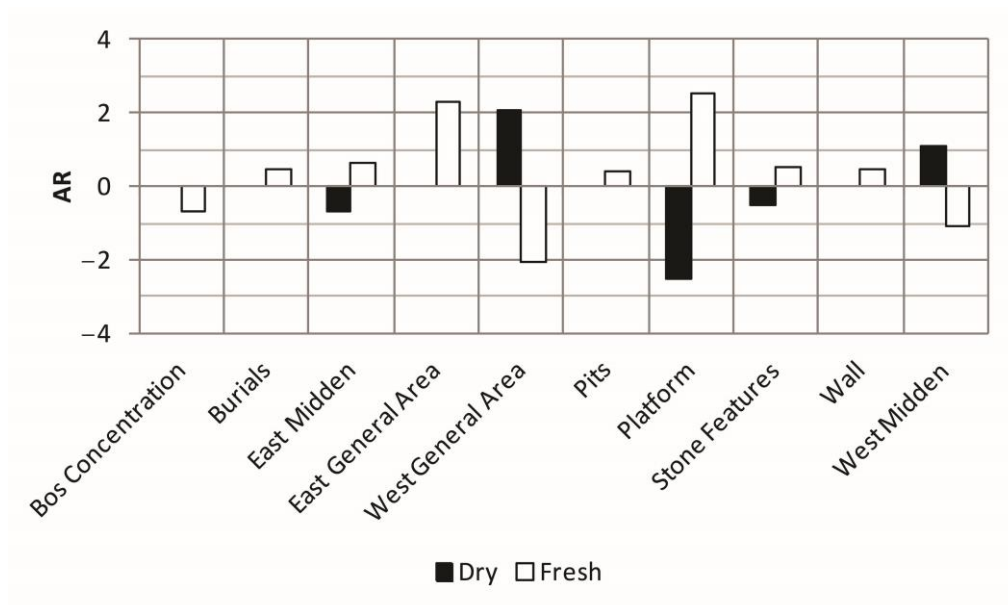


Figure 4.5. AR of gazelle bone fracture types across contexts (bones with excavation breaks, and teeth are excluded).

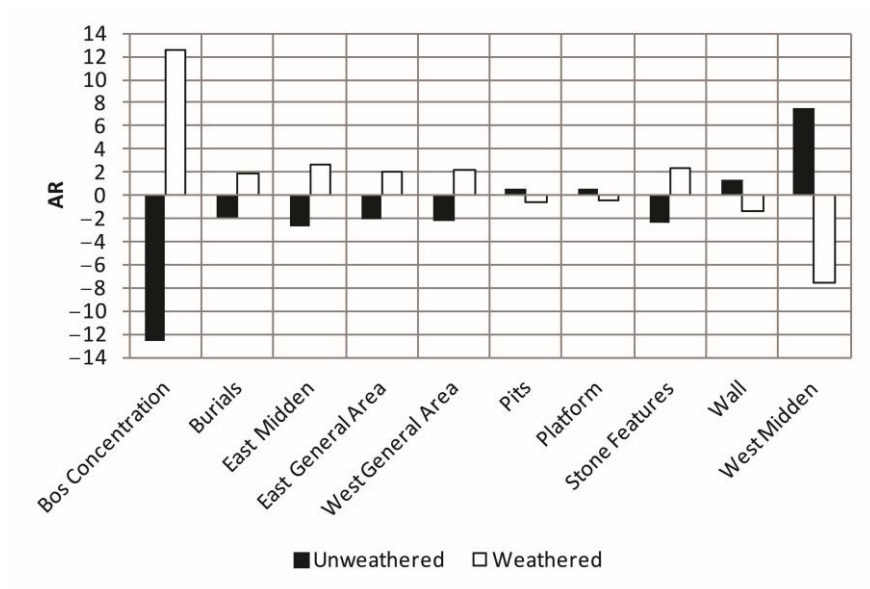


Figure 4.6. Chi-Square AR values for bone weathering across contexts (all taxa).

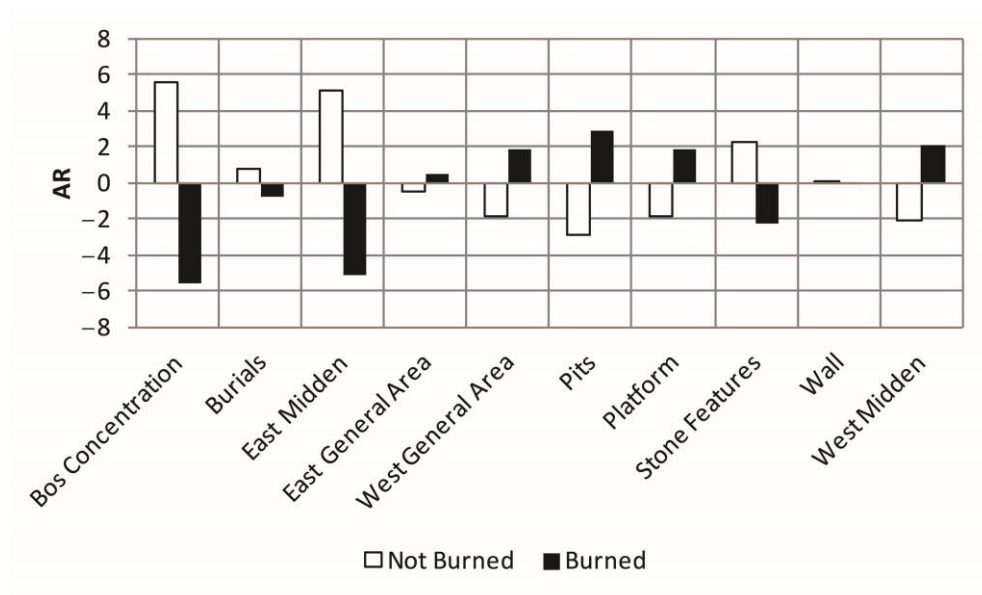


Figure 4.7. Chi-Square AR values for bone burning of all specimens across contexts.

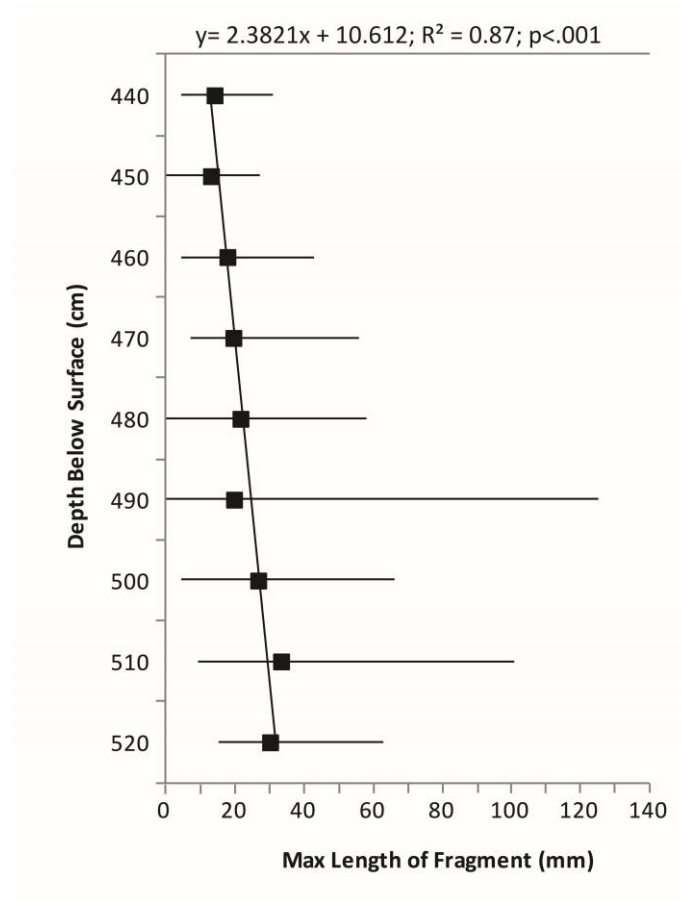


Figure 4.8. Average length of bone fragments (black squares) divided by 10 cm layer within the platform complex, size ranges are indicated by horizontal black lines through squares.

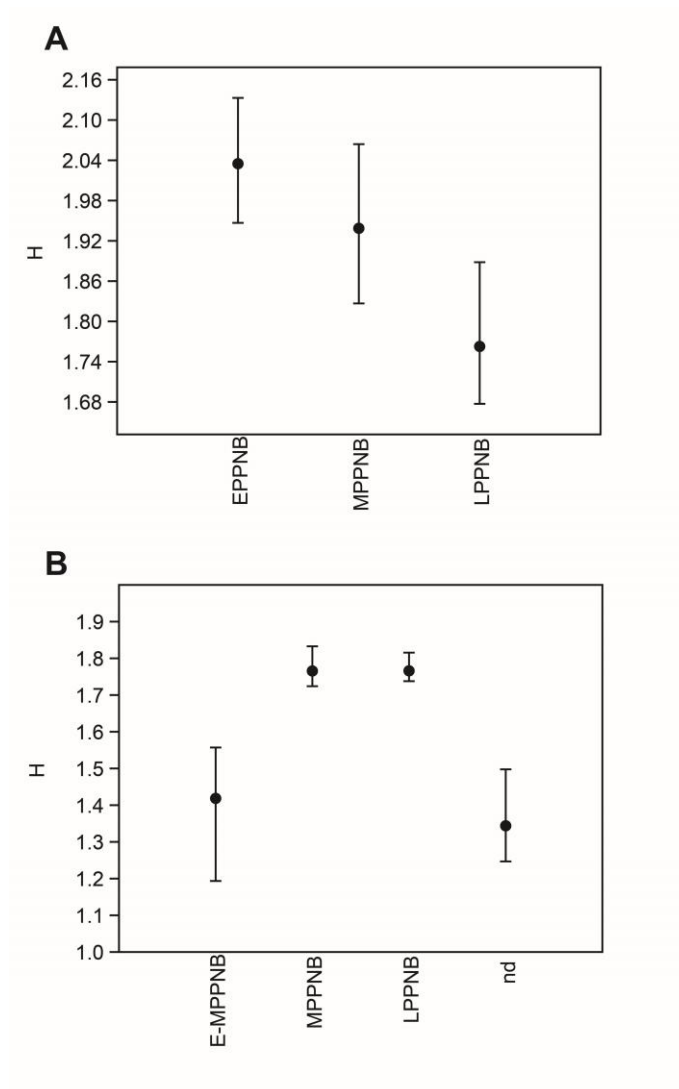


Figure 4.9. Shannon H index of taxonomic diversity over time in the (A) east midden and (B) west midden.

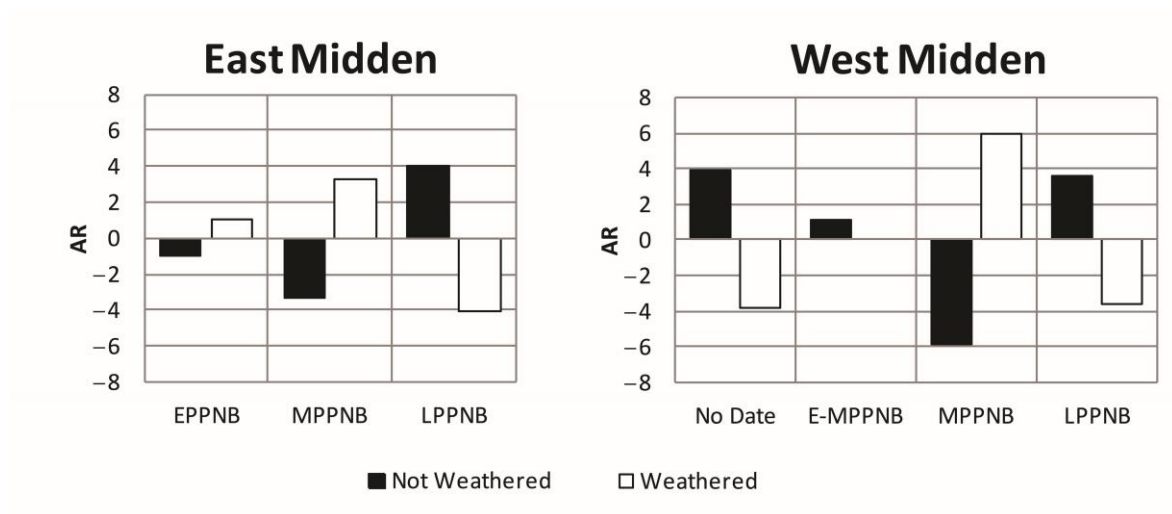


Figure 4.10. Chi-Square AR of weathered bones for all PPNB phases in the east and west middens.

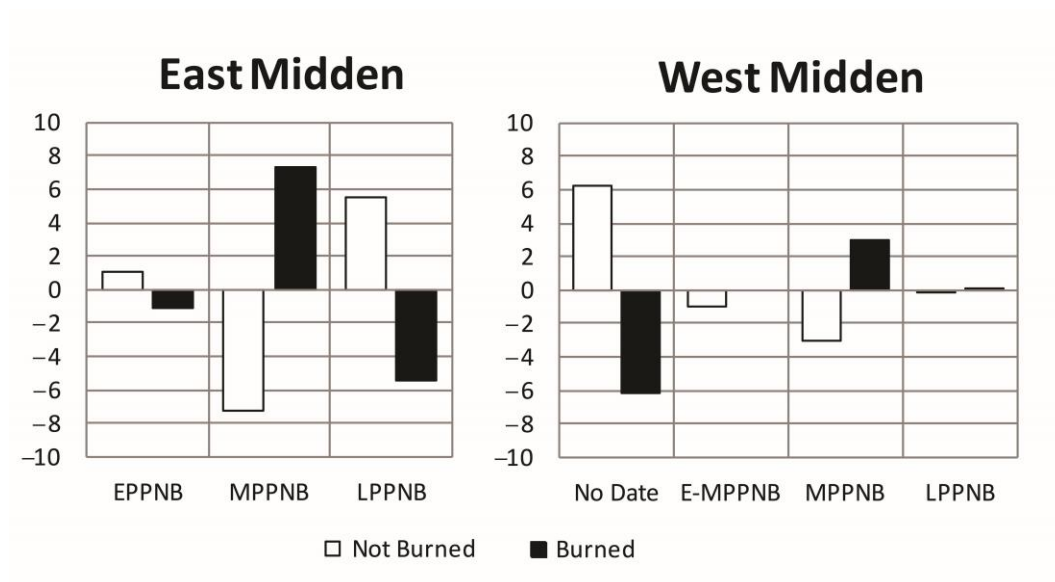


Figure 4.11. Chi-Square AR of burned bones for all PPNB phases in the east and west middens.

Chapter 5. Gazelle exploitation, subsistence intensification and the beginning of goat  
management at Kfar HaHoresh and neighboring Neolithic sites

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## Introduction

Increasing human control over herd animals had a transformative impact on broader strategies of animal procurement and use during the transition to agriculture. Intensification was an important strategy for coping with increases in the demands of larger, more sedentary human populations as they shifted from foraging to farming (Munro 2009). Intensification can increase both subsistence (Munro 2004) and social benefits (Boyd 1985; Spielmann 2002b; Hayden 2009) gained from a resource. Thus, analysis of intensification can be utilized for a more nuanced exploration of how sites and activities were provisioned with animals, as ritual and mundane practices were highly integrated across the agricultural transition (Goring-Morris and Belfer-Cohen 2011).

The timing of changes in intensification associated with the forager-farmer transition varies according to the local ecological conditions in Southwest Asia (Conolly, *et al.* 2011; Fuller, *et al.* 2012; Martin and Edwards 2013; Belfer-Cohen and Goring-Morris 2014). In the Mediterranean Hills of the southern Levant, hunting intensified in the Natufian period prior to the emergence of agriculture, as growing human populations and increased sedentism lead to increased resource pressure (Tchernov 1993; Munro 2004; Yeshurun, *et al.* 2014b). Later, in the Pre-Pottery Neolithic (PPN) periods, the beginning of plant cultivation signals further subsistence intensification (Bar-Yosef, *et al.* 1991; Fuller 2007). Recent studies of faunal evidence from the Early, Middle and Late PPNB periods (EPPNB, MPPNB, LPPNB) have focused on the trade-off between intensive wild game hunting and animal management in the Mediterranean Hills (Horwitz 1989; Sapir-Hen, *et al.* 2016; Meier, *et al.* 2016). However, a more detailed picture of intensification is needed to understand differential site use across the agricultural transition. This can be achieved by documenting variability in animal exploitation at sites with different functions and occupation intensities across the agricultural transition.

The site of Kfar HaHoresh (KHH) is a unique location to investigate intensification of animal resources, because exceptional finds such as a monumental platform, numerous burials (>85), and the lack of domestic architecture indicate that the site served a unique ceremonial function for the community occupying nearby sites from the EPPNB to LPPNB periods (10,600–8,700 cal. BP) (Goring-Morris, *et al.* 1998; Goring-Morris 2000). A study of the fauna recovered from the 2010-2012 excavation seasons recently revealed differences in the selection of animals at KHH compared to other sites in the region, as gazelles continued to dominate the taxa used to provision the site and are also associated with a variety of ritual and mundane contexts at KHH (Meier, *et al.* 2016; Meier *et al.* *Under review*). More research is needed to understand how gazelle exploitation varies with their diverse use at KHH and other PPN sites.

We compare animal resource intensification at KHH to that of nearby Mediterranean Hills sites to investigate subsistence strategies at sites across the beginning of herd animal domestication. This situates animal selection choices at KHH within those of the broader region to consider subsistence variation across sites with varying functions. In addition, we explore gazelle exploitation for activities related to the different midden contexts at the site to better understand intra-site variation in subsistence practices.

## **Background**

### ***Intensification in the Mediterranean Hills***

Multiple lines of evidence point to subsistence intensification in the southern Levant at the end of the Epipaleolithic (Munro 2003; Bar-Oz, *et al.* 2004; Yeshurun, *et al.* 2014b). At this time, the highest-ranked ungulates, such as aurochs, red and fallow deer, were rarely encountered and thus form only a minor subsistence component at Natufian sites (Davis 1982; Bar-Oz, *et al.* 2004; Munro 2004). Intensive hunting allowed the Natufians to meet their demands for meat by targeting

gazelle, a smaller ungulate species (Munro 2009). The Natufian people also intensively processed gazelle carcasses as evidenced by highly fragmented gazelle bones including those with even very small quantities of marrow. This indicates a low point of diminishing returns for marrow processing (Munro and Bar-Oz 2005; Bar-Oz and Munro 2007; Munro 2009).

Later, in the PPNB, control over the wild animal taxa that were ultimately domesticated by humans eventually reduced their cost of capture. In the Mediterranean Hills region, this is first expressed in the management of goats (Horwitz, *et al.* 1999; Martin and Edwards 2013; Meier, *et al.* 2016). The new focus on goat management released hunting pressure on wild resources, as indicated by the reduction of low-ranked wild taxa in human diets, and the intensity of carcass processing. For example, at MPPNB Yiftah'el higher completeness of gazelle long bones suggests a decline in fragmentation compared to Natufian assemblages (Sapir-Hen, *et al.* 2016). More studies of carcass processing intensity are required to track subsistence changes in the Neolithic and to relate these changes to the beginning of animal management.

### ***Gazelle hunting and the beginning of goat management***

Recent studies have elucidated the pace and character of the beginning of ungulate management in the Mediterranean Hills (Horwitz 2003; Sapir-Hen, *et al.* 2016; Meier, *et al.* 2016). The most reliable indicator for early goat management is an increase in the abundance of goats, which are rare in Paleolithic, Epipaleolithic (1%) (Davis 1982; Munro 2004; Bar-Oz, *et al.* 2004) and PPNA (1–3%) assemblages (Davis 1982; Davis, *et al.* 1994). Goat abundance begins to rise in the EPPNB (Sapir-Hen, *et al.* 2016; Meier, *et al.* 2016) and is significantly greater in all Mediterranean Hills sites by the MPPNB (10–55%) (Martin and Edwards 2013). Along with steeper goat mortality profiles indicating greater kill off of younger animals and a shift in the skewness of goat body size data towards populations with more small females, this confirms that

goats were managed in the Mediterranean Hills by the MPPNB (Horwitz, *et al.* 1999; Horwitz 2003; Ducos and Horwitz 2003; Sapir-Hen, *et al.* 2016; Meier, *et al.* 2016).

Although evidence supports increasing control over goats in the southern Levant, at least by the MPPNB, gazelle remain abundant at all Mediterranean Hills sites and distinguish this region from the Jordan Valley and southern Jordan where caprines outnumber gazelle (Martin and Edwards 2013). Notably, at KHH, gazelle remain abundant across the Early to Late PPNB despite changes in goat demographic data (age and sex) and decreasing dietary breadth, which support the region-wide emergence of goat management by the MPPNB (Meier, *et al.* 2016). Given the unusual abundance of gazelle and its stability at KHH, more detailed analysis of gazelle exploitation is needed to understand its unique role at this ritual site and its relationship to the larger trend toward caprine management in the Mediterranean Hills proper.

### ***Kfar HaHoresh (KHH)***

New data on gazelle exploitation from KHH provide a baseline to investigate resource intensification over time, but also suggests that provisioning of KHH differed from other sites in the Mediterranean Hills (Meier, *et al.* 2016). The prominence of ritual activities at the site, including feasting and mortuary practices, impacted the selection of taxa (Goring-Morris 2000; Horwitz and Goring-Morris 2004b; Meier, *et al.* In press). Still, some degree of mundane provisioning for site visitors also likely occurred (Meier *et al.* *Under review*). The intensity of site use at KHH increased over time (Birkenfeld and Goring-Morris 2014) and likely also impacted hunting intensity at the local level (Munro 2009). A more nuanced depiction of hunting conditions across KHH will aid the exploration of resource intensification and its relationship to the emergence of goat management, site use intensity, and the diversity of activities with animals at a ceremonial site.

### ***Assessing subsistence intensification in the PPNB***

Previous research on human hunting in the southern Levant investigated subsistence intensification across the agricultural transition (e.g. Stiner, *et al.* 2000; Munro 2004; Munro 2009; Sapir-Hen In Press). Intensification occurs when there is an imbalance between human demands and the food supply (Winterhalder and Smith 2000; Munro 2009), and can be rectified by intensifying resource extraction. Here, we utilize a behavioral ecology approach interpret how changes in subsistence intensification relate to hunting and processing decisions in the Mediterranean Hills region before and after the beginning of goat management.

Subsistence intensification may be expressed in both hunting and processing decisions (Munro 2009). Hunting intensification refers to an overall decline in the cost/benefits of animal procurement, or a decline in foraging efficiency (Winterhalder and Smith 2000). The benefits of this equation are most intimately associated with prey body size (Winterhalder and Smith 2000), while the escape strategy of the prey largely determine the costs, which increase with the capture of faster, more elusive and more dangerous game (Stiner, *et al.* 2000). Processing intensification refers to a decline in the cost/benefits of food procurement from carcasses, or a decline in processing efficiency (Munro 2004). The benefits are determined by the utility of different carcass parts most often measured in calories, while the costs are defined by the energy spent to extract meat, marrow, nutrients and fat with varying degrees of difficulty across parts (Binford 1981; Church and Lyman 2003; Munro and Bar-Oz 2005).

More specialized subsistence intensification can also be explored at the context level. This is useful for unraveling intra-site variation in subsistence choices, especially during the PPNB when site activities diversify dramatically (Kuijt and Goring-Morris 2002; Byrd 2005). Intensification evidence may vary within a single site where contexts were formed by diverse

subsistence behaviors. For example, the particular requirements for ritual meals can influence resource procurement and processing decisions (Hill 1995; Dietler 2001; Spielmann 2002b) that differ from mundane subsistence decisions, even though they are highly integrated within the same dynamic set of cultural norms (Bell 1997). Analysis of subsistence intensification in specific site contexts has the potential to highlight how different subsistence behaviors interacted across sites.

## **Methods**

Subsistence intensification is investigated using methods that reconstruct (a) hunting intensification and (b) processing intensification. Intensification is examined at both the regional and site level. Hunting and processing intensification at KHH are first examined at the site level using combined data from all contexts for each PPNB phase, including the Early (10,600–10,000 cal. BP), Middle (10,000–9,500 cal. BP), and Late PPNB (9,500–8,700 cal. BP) phases. The data is then set within the broader PPNB context through comparisons with published data from other PPNB sites in the Mediterranean Hills (Figure 5.1). Finally, intra-site comparisons are made between the two midden contexts to further examine different subsistence behaviors at KHH. Given the marked abundance of gazelles at KHH (Meier, *et al.* 2016), we focus on them most heavily.

### ***Assessing intensification in the Mediterranean Hills***

Hunting intensity is measured using taxonomic abundance indices that compare low to high-ranked prey in human diets. Lower ranked taxa, such as hares and other small game, yield a lower payoff than higher ranked taxa after accounting for energetic costs of capture (Stephens and Krebs 1986; Smith and Winterhalder 1992). In this study, body-size is used as a proxy for prey

rank (Broughton, *et al.* 2011). When body-size is similar, as is the case with many of the smaller-bodied prey species, the taxa are ranked by costs of capture determined by their speed and ease of detection (Stiner and Munro 2002).

We measure hunting intensity at Kfar HaHoresh and other PPNB sites in the Mediterranean Hills using three relative abundance indices based on NISP (Number of Identifiable Specimen) values that compare the proportions of differentially ranked taxa in the diet. First, we compare the relative abundances of lower-ranked small-bodied ungulates (gazelles and roe deer) to higher-ranked larger ungulate taxa (Equids, aurochs, red and fallow deer, goat, and pigs) (Stiner, *et al.* 1999). Next, we compare the abundance of lower-ranked small game resources (tortoise, hare, and fish) to higher-ranked gazelles to isolate selection decisions for wild game other than domestic progenitor taxa. Finally, we examine hunting intensification at the local scale (Tchernov 1993; Stiner and Munro 2002) by comparing abundances of differentially ranked small game with limited home ranges (Stiner 2001; Stiner and Munro 2011). This index compares the abundance of small game taxa with low costs of capture (tortoises) to those with higher costs (hare) (Stiner, *et al.* 2000; Munro 2009). A rise in each of these indices (more low-ranked game) is expected to indicate hunting intensification.

Hunting intensity can also be investigated by comparing the selection of low to high ranked groups within the same taxon. For example, juvenile animals are ranked lower than adults, because they are smaller-bodied and thus yield smaller packages of meat and fat (Munro 2009). The proportion of young animals in a population may also reflect population depression, since the proportion of juveniles increases as mortality increases and populations begin to grow (Caughley 1977). Thus population depression can result in increased rates of encounter with juvenile animals during hunting (Munro 2009). The intensity of gazelle hunting is examined by comparing the proportion of juvenile to adult animals based on bone fusion. Juveniles are defined by the

proportion of unfused elements based on the %MNE (Minimum Number of Elements) that fuse between 10–18 months of age (proximal humerus, tibia, and ulna, distal femur, radius and ulna) (Davis 1983; Stiner 2005; Munro, *et al.* 2009). A rise in this index indicates that more lower-ranked young gazelle individuals were selected and thus signifies that hunting intensification or population depression occurred.

Subsistence can also be intensified by extracting more nutrients out of traditional foods. For example, increased investment into the transport and processing of the carcasses of staple animals like gazelles will enable more food to be extracted from each prey item, albeit at a higher cost per unit returned. The cost/benefits of transporting and processing different prey carcass parts varies by their utility (Blumenschine and Madrigal 1993; Brink 1997) and cost of extraction (Binford 1978; Jones and Metcalfe 1988; Enloe 2003). The transport of large animal carcasses can be intensified by increasing the proportion of low to high-utility body parts transported to a site (Stiner 1994). Likewise, the use of individual carcasses can be intensified by increasing the extraction of more costly nutrients, such as bone fat and grease (Speth 1989; Speth 2000). Intensive fat extraction is reflected by bone fragmentation indices and the marrow yield of the elements that people routinely accessed. Smaller, more compact elements contain less fat and are more difficult to break. Thus they provide a good measure of how far people were willing to go to extract fat (Jones and Metcalfe 1988; Munro and Bar-Oz 2005; Morin 2007).

The transport of ungulate body parts to Mediterranean Hills sites is investigated by comparing the representation of parts with differing utility (Binford 1981). For this, we calculate ratios of the MAU (Minimum Anatomical Unit) values of low to high-utility anatomical regions (Stiner 1991) of gazelle, as it was the most highly represented taxon. Low-ranked, low-utility parts are represented by feet, and compared against high-ranked, high-utility upper limb regions (humeri and femora). Potential biases in part representation were also examined across ungulate taxa by

comparing anatomical region profiles calculated based on the %MAU for nine different carcass regions (Stiner 1991, p. 460) of gazelle, aurochs, pig, and goat.

Fragmentation of marrow-bearing limb bones (mandibles, long bones, calcanei, phalanges) (Bar-Oz and Munro 2007) is measured using NISP:MNE ratios (Church and Lyman 2003; Lyman 2008) of gazelle. The intensity of bone marrow extraction is measured by examining the completeness (%MNE) of gazelle elements with small marrow stores (first, second and third phalanges, and calcaneus), and then comparing these in order of marrow content to determine the point of diminishing returns (Bar-Oz and Munro 2007). Carcass processing by humans is differentiated from post-depositional destruction by examining the relative abundance of fresh (spiral fractures) and dry (transverse fractures) breaks and the frequency of cut marks (Villa and Mahieu 1991; Abe, *et al.* 2002). The relationship between limb bone element fragmentation (NISP:MNE) and marrow content of each element was also explored over time (Bar-Oz and Munro 2007). Data on carcass transport and extraction efficiency at KHH will be compared to published data from other Mediterranean Hills sites when possible.

### ***Assessing intensification by context***

We focus our intra-site analyses on the midden assemblages excavated at KHH during the 2010–2012 field seasons as faunal middens are often formed as a result of the organized deposition of subsistence refuse (Needham and Spence 1997). Recent analysis of fauna from different contexts at KHH indicates that both middens contain the remains of fauna that were processed for food (Meier *et al.* *Under review*).

The same analyses of hunting and processing intensification were undertaken at the site level and used to compare evidence of subsistence intensification across the two middens. All three taxonomic abundance tests and the same measures of carcass transport and processing are

repeated for the midden assemblages over time. Gazelle is also the focus of the intra-site analysis of processing intensity as it is the most common taxon at KHH.

### ***Data collection***

Faunal specimens recovered during the 2010–2012 excavation seasons at KHH were identified to the most specific taxonomic level (or body-size category), element, and bone portion possible (Stiner 2004). Taphonomic data (Lyman 1994), including cut marks, impact fractures (Abe, *et al.* 2002), and bone breakage (spiral or transverse outlines indicating fresh and dry breaks respectively) (Villa and Mahieu 1991) was collected when present. Bone fusion age stages were recorded for gazelles following Munro *et al.* (2009). Data collection took place at the Israeli National Natural History Collections at the Hebrew University, Jerusalem.

Fauna analyzed for this study was recovered from several different contexts excavated during the 2010–2012 field seasons at KHH, including two middens, a monumental platform structure (the L1604 complex), a large deposit of mainly aurochs remains termed the *Bos* concentration (Meier, *et al.* In press), and other non-adjacent features (human burials, stone features, wall features and pits) (Meier *et al.* *Under review*). This study first focuses on the most securely dated fauna from each time period across all contexts, and then on more detailed analysis of fauna recovered from the east and west middens.

Comparative data from the Mediterranean Hills region of the southern Levant were obtained from published PPNB faunal assemblages. Besides KHH, the only sizeable Early PPNB sample derives from Motza (Sapir-Hen *et al.* 2009). Appropriate MPPNB samples come from Motza, Yiftah'el, and Abu Gosh. The MPPNB faunal assemblage from Motza was limited, since the occupation of the site was less intensive at that time (Sapir-Hen In Press). Two faunal samples from MPPNB Yiftah'el also provide important comparisons. The Yiftah'el faunal assemblage

studied by Horwitz (2003) derives from Area C which encapsulates two building phases of a rectangular structure (Kislev 1985; Garfinkel, *et al.* 1988), and Area D, home to a domestic courtyard with several installations (Horwitz 2003). MPPNB fauna was also recovered from later excavations in Areas G and I at Yiftah'el studied by Sapir-Hen and colleagues (Sapir-Hen, *et al.* 2016). These areas contain human graves, numerous installations, and evidence of ritual behavior (Milevski, *et al.* 2008). A sizeable MPPNB assemblage from Abu Gosh provides a final important point of comparison (Ducos and Horwitz 2003).

## **Results**

### ***Hunting intensification***

#### *Small vs. larger ungulates*

At most PPNB sites in the Mediterranean Hills region, small ungulates outnumber larger ungulates with the marked exception of Abu Gosh (Figure 5.2). The percentage of small ungulates differs substantially at the two EPPNB sites, with 39% at KHH and 67% at Motza. In the MPPNB, the percentage of smaller ungulates is less variable with values of 54% at KHH, 50% at Yiftah'el and 45% at Motza, although small ungulates are much less abundant at MPPNB Abu Gosh (8%). Small ungulate abundance remains high at KHH (55%) during the LPPNB and is similar to MPPNB values at most sites.

#### *Small game vs. gazelle*

Gazelle are more common than small game (hares, ground birds, tortoises and fish) at KHH and other PPNB sites in the Mediterranean Hills (Figure 5.3). At KHH, the percentage of lower-ranked small game is higher than at other sites and decreases from the EPPNB (40%) to the MPPNB (25%) and LPPNB (22%). The opposite pattern occurs over time at Motza, where small

game increases substantially from 11% in the EPPNB to 28% in the MPPNB, but not to the high levels detected at KHH in the EPPNB. Small game are also rare at MPPNB Yiftah'el (14%) and Abu Gosh (5%). Thus the selection of lower ranked small prey decreased over time at KHH, but not to the extent typical of other MPPNB sites in the region except for Motza.

#### *Hare vs. Tortoise*

The relative abundance of lower-ranked fast game is higher than the abundance of slow game at KHH, and higher than that of fast game at other PPNB sites in the Mediterranean Hills (Figure 5.4). The relative abundances of hare (46%) and tortoise (54%) are nearly even at EPPNB KHH, though hare are less common at EPPNB Motza (37%). In the MPPNB, hare abundance remains steady at KHH (48%), but hare are substantially less common at MPPNB Motza (5%), Yiftah'el (22%), and Abu Gosh (19%). Hares only begin to decrease in abundance during the LPPNB at KHH (32%), but this does not fall as low as at other MPPNB sites. The use of large quantities of low-ranked small game continues at KHH well beyond the time that it begins to decline at other PPNB sites in the region.

#### *Juvenile Gazelle Kill-Off*

Gazelle mortality analysis based on bone fusion data indicates that approximately one third of gazelles from KHH were killed before they reached adulthood (before 18 months of age) (Figure 5.5). This figure remains steady across the Early (35.5%), Middle (36.7%), and Late PPNB (30.5%). Somewhat lower percentages of juvenile gazelles were detected based on bone fusion analysis at other sites in the region, including Area I (25.6%) and Area C (25%) from MPPNB Yiftah'el (Horwitz 2003; Sapir-Hen, *et al.* 2016) and the MPPNB gazelle assemblage from Abu Gosh (32%) (Ducos and Horwitz 2003). However, the percentage of juveniles is similar at EPPNB Motza (28%) based on tooth wear (Sapir-Hen, *et al.* 2009). For the most part, the proportion of

young gazelles represented across PPNB sites in the Mediterranean Hills resembles the proportion of juveniles that are typically represented in modern stable gazelle populations (33%) (Mendelssohn and Yom-Tov 1999). These numbers are much lower than those represented at Natufian (45%) and PPNA (59%) sites in the region where intensive gazelle hunting was detected (Munro 2004; Davis 2005; Munro 2009).

### ***Processing Intensification***

#### *Carcass transport*

Ratios were used to estimate differences in MAU of low-utility gazelle feet to high-utility upper limb parts (humeri and femora) transported to KHH over time (Stiner 1994). Similar ratios of low-to-high utility parts are represented in the EPPNB at KHH (0.7 feet : humeri; 0.5 feet : femora) and at EPPNB Motza (0.6; 0.7) (Table 5.1). In the MPPNB, the representation of low-utility parts becomes nearly equal to high-utility parts at KHH (0.8; 0.9) and slightly higher proportions of low utility parts are found at Motza (0.8; 2.5). Finally, representation of low-utility body-parts declines at KHH in the LPPNB (0.6; 0.6).

By comparison, ungulate body part representation (%MAU) changes little over time at KHH (Figure 5.6). All anatomical regions are represented in all periods and the slight variation in representation of different body parts is seemingly random. The representation of gazelle body-parts at other Mediterranean Hills PPNB sites is similar to that of KHH. In all cases, the full range of body-parts are represented, including at Motza (Sapir-Hen *et al.* 2009), Yiftah'el (Horwitz 2003) and Abu Gosh (Ducos and Horwitz 2003). Thus, whole carcasses of gazelles were clearly transported by people to Mediterranean Hills sites, with a slight bias toward higher-utility limb parts. Additionally, no relationship was detected when the MAU's of each anatomical region of gazelle was regressed against the ranked utility of those parts (MGUI) at the site level over time.

Table 5.1. MAU ratios of low (feet) to high (humerus, femur) utility body parts of gazelle.

	Feet:Humerus	Feet:Femur
KHH EPPNB	0.7	0.5
Motza EPPNB	0.6	0.7
KHH MPPNB	0.8	0.9
Motza MPPNB	0.8	2.5
KHH LPPNB	0.6	0.6

### *Carcass processing*

Fresh (spiral) breaks on marrow-bearing elements are common for all ungulate taxa (82–90% of broken bones) (Table 5.2). The degree of fragmentation (NISP:MNE) is more or less constant over time (2.9–6.1), with slightly higher fragmentation of aurochs and gazelle bones than goat and pig bones. In all periods, marrow-bearing bone completeness is low (0–1.7%) and gazelle and goat are the only ungulates represented by complete bones. The frequency of cutmarks (2–10.5%) and impact fractures (0–1%) is low for all ungulates. No relationship was detected between the degree of fragmentation of marrow-bearing elements (NISP:MNE) and marrow yield at KHH over time.

Table 2. Measures of gazelle, goat, cattle and pig marrow-bearing bone (mandibles, long bones, calcanei, phalanges) processing at KHH.

	Sample size	NISP:MNE	Green Breaks	>90% complete	% Cut	% Impact Fractured
<b>Gazelle (<i>Gazella gazella</i>)</b>	<b>614</b>	<b>5.4</b>	<b>85.7%</b>	<b>0.3%</b>	<b>2.1%</b>	<b>1.0%</b>
EPPNB	78	4.9	94.9%	0.0%	1.3%	1.3%
MPPNB	222	6.0	86.9%	0.5%	3.2%	1.4%
LPPNB	314	5.3	82.5%	0.3%	1.6%	0.6%
<b>Goat (<i>Capra sp.</i>)</b>	<b>121</b>	<b>3.7</b>	<b>81.8%</b>	<b>1.7%</b>	<b>4.1%</b>	<b>0.8%</b>
EPPNB	17	2.3	64.7%	5.9%	11.8%	0.0%
MPPNB	44	4.4	84.1%	0.0%	6.8%	2.3%
LPPNB	60	3.9	85.0%	1.7%	0.0%	0.0%
<b>Pig (<i>Sus scrofa</i>)</b>	<b>19</b>	<b>2.9</b>	<b>89.5%</b>	<b>0.0%</b>	<b>10.5%</b>	<b>0.0%</b>
EPPNB	2	1.6	100.0%	0.0%	0.0%	0.0%
MPPNB	2	3.0	100.0%	0.0%	0.0%	0.0%
LPPNB	15	3.4	86.7%	0.0%	13.3%	0.0%
<b>Aurochs (<i>Bos primigenius</i>)</b>	<b>118</b>	<b>6.1</b>	<b>84.7%</b>	<b>0.0%</b>	<b>1.7%</b>	<b>0.8%</b>
EPPNB	26	6.5	88.5%	0.0%	0.0%	0.0%
MPPNB	41	7.8	85.4%	0.0%	0.0%	2.4%
LPPNB	51	5.3	82.4%	0.0%	3.9%	0.0%

Only fragments from the most securely dated contexts are included.

Gazelle bone fragmentation (NISP:MNI) is more intensive in all PPNB phases at KHH (96–199) than in Areas C and D of MPPNB Yiftah’el (29) and EPPNB and MPPNB Motza (~41) (Table 5.3). Additionally, the percentage of fresh breaks on gazelle limb bones at KHH changes little over time (EPPNB=90%, MPPNB=88%, to LPPNB=82%). This is similar to the breakage pattern at EPPNB Motza (92% fresh). Numerous spiral fractures indicate that human processing was responsible for the high rate of gazelle bone fragmentation at both sites. Fresh bone breaks were less common in Areas G and I of Yiftah’el in the MPPNB (62%). This may be related to the quality of the preservation of the bone assemblages.

Even though the fragmentation results indicate that bone preservation at KHH is compromised, the completeness of compact bones varies by marrow content (Figure 5.7). In the EPPNB assemblage, compact bone completeness is especially low, even for elements that bear no marrow, indicating poorer preservation. By the MPPNB and LPPNB, the percentage of completeness of compact gazelle bones, including those with little to no marrow (astragali, second and third phalanges), increases. This indicates that preservation likely improves in the MPPNB and LPPNB deposits and humans did not invest much into the extraction of very small marrow stores. Compact bone completeness is higher in Areas G and I at Yiftah’el, nevertheless, higher fragmentation of first phalanges that contain more marrow than the other compact bones in the MPPNB and LPPNB points to more intensive marrow processing at KHH over time.

Table 5.3. Gazelle bone fragmentation at KHH, Yiftah’el and Motza

Gazelle Assemblages	NISP	MNI	NISP/MNI
KHH EPPNB	480	5	96
KHH MPPNB	1399	7	199.9
KHH LPPNB	2113	11	192.1
Yiftah’el MPPNB (C&D)	893	31	28.8
Motza EPPNB	2881	69	41.8
Motza MPPNB	289	7	41.3

Yiftah’el and Motza fragmentation calculated from published data (Horwitz 2003; Sapir-Hen In Press)

### *Intra-site analysis of gazelle use at KHH*

#### *Relative taxonomic abundance*

There is significant variation in the relative abundance (%NISP) of high and low-ranked game (%NISP) across the middens at KHH over time. Lower-ranked small ungulates are slightly less common in comparison to larger ungulates in the east midden (63–70%) than in the west midden (70–72%) (Figure 5.8). Also, lower-ranked small game are even more common than

gazelle in the east midden (37–28%) than in the west midden (21%) (Figure 5.9). Finally, the proportion of lower-ranked hare in comparison to tortoises in the east midden (46%–63%) is greater than in the west midden (39–32%) (Figure 5.10).

#### *Gazelle body-part representation in the middens*

Ratios of low to high utility gazelle body-parts are low in the east (0.2 feet : humeri, 0.2 feet : femora) and west middens (0.3, 0.4) (Table 5.4). The east midden ratio is markedly lower than ratios for combined site contexts (see above). Parts from all anatomical regions are represented in both middens (Figure 5.11).

Table 5.4. Frequencies and ratios of loci-specific anthropogenic damage and preservation of gazelle bones at KHH.

Gazelle Bone Measures	East Midden	West Midden
Body-Part Utility Ratios (MAU)		
Feet: Humeri	0.2	0.3
Feet: Femora	0.2	0.4
NISP:MNE ratio of marrow-bearing elements	5.7 (201:35)	5.2 (1203:231)
% Fresh breaks	85.0%	78.3%
% Cut	1.9%	2.5%
% Impact Fractured	0.9%	0.6%
% Complete	1.9%	7.2%
% Complete small compact bones		
First Phalanx	0%	37%
Second Phalanx	60%	69%
Calcaneus	n<5	44%

#### *Gazelle bone processing across contexts*

Bone fragmentation ratios (NISP:MNE) indicate similar marrow processing intensity in both midden contexts (Table 5.4). Fresh breaks dominate both midden assemblages (78–85%).

Bones with cut marks or impact fractures are scarce in both middens (~2% cut; <1% impact fractured).

The percentage of complete marrow-bearing gazelle elements is lower in the east (2%) than the west midden (7%). The completeness of compact gazelle bones also varies across contexts. First phalanges are complete more often than second phalanges and calcanei in the east midden. In the west midden, first phalanges are complete more often than in the east midden. The degree of breakage is similar to calcanei, but lower than for second phalanges. Also, a significant positive relationship between gazelle marrow-bearing element fragmentation and the marrow content index is detected in the east midden (Figure 5.12). No significant correlations between element fragmentation and density were detected for gazelle assemblages in any contexts, time periods, or at the site level.

## **Discussion**

Multiple indices evidence the abundance of high-ranked game at Kfar HaHoresh during the PPNB. Gazelle mortality data also reveal efficient hunting strategies at the site. Other PPNB sites in the region (Motza and Yiftah'el) reveal a similar pattern, although inter-site variation increases from the Early to the Late PPNB. Below we summarize variation in hunting efficiency across the PPNB to assess the relationship of changing hunting intensification and the emergence of goat management in the Mediterranean Hills.

### ***Resource extraction in the Early PPNB***

Hunting intensity varies among EPPNB sites in the Mediterranean Hills. The lower abundance of low-ranked small ungulates, mostly gazelles, to high-ranked larger ungulates,

namely aurochs and goat, indicates that hunting was more efficient at EPPNB KHH than at EPPNB Motza. However, small game are less abundant in comparison to small ungulates at Motza than at KHH during this early period, suggesting the opposite pattern. The somewhat even ratios of slow to fast small game in the EPPNB at both Motza and KHH reflect low hunting efficiency on the local scale.

Juvenile gazelle mortality data reflect region-wide hunting pressure, since gazelle populations have wider home ranges (Mendelssohn and Yom-Tov 1999; Munro, *et al.* 2009). Tooth wear aging results from EPPNB Motza reflect light hunting pressure on gazelle populations (Sapir-Hen, *et al.* 2009). Similarly low proportions of juvenile gazelle at EPPNB KHH, suggest low hunting pressure at the regional scale in the Mediterranean Hills in the EPPNB.

Processing intensity was variable in the EPPNB. During this period, whole gazelle carcasses were transported to Motza and KHH. Also, fewer low- than high-utility gazelle parts are represented at EPPNB KHH. By contrast, there are more low utility parts at EPPNB Motza. The percentage of fresh bone breakage is high at both KHH and Motza, confirming that the bones were processed by humans. Gazelle bone fragmentation (NISP:MNI) was more intensive at KHH than Motza, although this may be related to more aggressive post-depositional processes at KHH. Small compact bones containing marrow, like the first and second phalanx, were frequently broken at KHH, but low completeness of compact bones that do not contain marrow (third phalanx and astragalus) show that this is at least partially related to preservation. Still, marrow-bearing compact elements are broken more often than those with almost no marrow, indicating that humans were targeting small marrow stores at least part of the time. Marrow-bearing ungulate bones (NISP:MNE) were also commonly fragmented at KHH in the EPPNB.

### ***Resource extraction in the Middle PPNB***

Goat management begins in the Mediterranean Hills in the MPPNB. This coincides with reduced proportions of small compared to large ungulates at MPPNB Motza, Yiftah'el, and Abu Gosh. By contrast, at KHH the proportion of small ungulates increased in the MPPNB indicating that hunting efficiency was lower at KHH in the MPPNB.

Other evidence reveals a more detailed picture of hunting intensity in the Mediterranean Hills. Hunting efficiency increases on a local scale at MPPNB Motza as slow small game grows to outnumber fast small game. The small game index at Motza is similar to other MPPNB sites with the exception of KHH where fast small game are more common. Nonetheless, the proportion of juvenile gazelles at MPPNB sites is similar to the EPPNB sites in the region, indicating that there was no change in the intensity of gazelle hunting.

In the MPPNB, whole gazelle carcass transport is typical in the region. The even representation of low and high utility gazelle parts in the MPPNB at KHH differs from Motza, where low utility parts are more common. Gazelle bone fragmentation (NISP:MNI) is higher at MPPNB KHH than at Yiftah'el and Motza than the EPPNB, indicating intensive bone processing for marrow. By the MPPNB, evidence for fresh bone breakage is also more prevalent at KHH than at Yiftah'el. Bone fragmentation at KHH was clearly caused by human processing for subsistence. Together, this evidence suggests that carcass processing was less efficient at KHH than at Yiftah'el and Motza during the MPPNB.

### ***Resource extraction in the LPPNB***

Finally, KHH is the only LPPNB data point for animal subsistence in the Mediterranean Hills. All three LPPNB abundance measures indicate more low-ranked resources and juvenile gazelles in the diet than at earlier MPPNB sites in the region, and thus lower hunting efficiency at

KHH. Complete gazelle carcasses were transported to the site, and low and high-utility body parts are equally represented. Compact bones were also broken more often at LPPNB KHH than at MPPNB Yiftah'el. This shows that even though ungulate hunting and processing intensity remains stable at KHH through the LPPNB, hunting intensity actually declines in comparison to other MPPNB sites in the Mediterranean Hills. This could suggest an increase in region-level hunting intensity in the LPPNB, but a continued focus on wild resources for ritual practice at this ceremonial site is a much more parsimonious scenario given the divergence of data from MPPNB KHH from other MPPNB sites in the region. Moreover, considering that KHH is located at a distance from other settlement sites, this may have led site visitors engaging in time-intensive plaster making and burial preparation practices in the LPPNB to engage in more wild game hunting than at habitation sites, where controlled goats were likely more available.

### ***KHH and hunting intensity in the Mediterranean Hills in the PPNB***

Together the faunal evidence indicates a trend toward increased hunting efficiency from the EPPNB to the MPPNB in the Mediterranean Hills region. Evidence of processing intensity is more variable over time. The drop in hunting intensity in the MPPNB corresponds to evidence for the start of goat management across the region (Meier, *et al.* 2016), suggesting it was caused by changing subsistence priorities.

Even though gazelles were preferred over goats at KHH, decreased body size and a younger age of kill-off for the goats at KHH indicates that the goats utilized at the site were under some form of human control at least by the MPPNB (Meier, *et al.* 2016). The goats at KHH are thus in a similar stage of management as neighboring MPPNB sites. This suggests that the people that frequented KHH were tapping into early managed goat herds that were more likely raised at neighboring agricultural occupation sites than at ceremonial KHH.

A slight increase in hunting efficiency by the LPPNB at KHH fits a regional reduction in hunting intensification in the Mediterranean Hills, suggesting that ungulate resources were selected from the same pool of animals available at other sites in the region. Increased hunting intensity is supported by a decline in small game resources, which likely represents the release of hunting pressure related to increased investment in managed taxa, namely goats and potentially pigs (Meier, *et al.* 2016).

Carcass processing at KHH is also more intensive than at other contemporaneous sites. Comparisons of carcass processing are difficult to make without also considering the taphonomic histories of each assemblage (Bar-Oz and Munro 2004). Nevertheless, evidence of intensive fragmentation of gazelle long bones across all periods and low levels of completeness of marrow-bearing first phalanges suggests that gazelles were more intensively processed for food across the duration of site use at KHH than at other sites in the region.

The transport of gazelle parts to KHH changes little over time and is more efficient than at Motza. This contrasts with other processing evidence suggesting intensified carcass use at KHH over time. Even so, variation in carcass transport further differentiates the provisioning of activities at KHH from other sites. It may also reflect more periodic use of KHH than Motza. At Motza, longer term site use and more permanent populations may have lead to the distribution of carcasses across a wide array of households.

### ***Site occupation intensity***

Intensified hunting of local small game species with limited home ranges is a sensitive proxy for increased occupation intensity and increased hunting pressure on large ungulate resources (Munro 2004). Both KHH and Motza have sufficient small game samples to calculate a fast-slow small game index (Munro 2003). The increase in the abundance of slow small game at

MPPNB Motza suggests that hunting pressure was reduced more than at KHH. A drop in site occupation intensity is supported by architectural evidence at Motza (Sapir-Hen In Press). Nevertheless, low occupation intensity is also suggested by the architecture at KHH (Birkenfeld and Goring-Morris 2014). The more obvious reduction of fast small game use at Motza likely also reflects the increased reliance on goats in the MPPNB (Sapir-Hen, *et al.* 2009).

By contrast, small game hunting remained intensive at KHH through the MPPNB and the drop in fast small game hunting begins in the LPPNB. This suggests a more subtle decrease in site occupation intensity by the LPPNB. It also likely reflects the steady proportion of domestic progenitor taxa in the assemblage. Overall, the degree of focus on managed domestic progenitor taxa appears to have impacted hunting intensity more substantially over time than site occupation intensity.

### ***Intra-site variation in resource extraction***

The analysis of subsistence evidence from the two middens excavated in the 2010–2012 seasons at KHH reveals nuanced intra-site variation in hunting efficiency. All three abundance indices indicate a higher ratio of low to high-ranked taxa in the west than the east midden, reflecting lower hunting efficiency in the west midden. Notably, more small than larger ungulates are represented in both middens over time, and in both cases outnumber the average proportion of small ungulates from the complete site assemblage in all time periods.

Carcass processing also differs in the middens. Although all gazelle anatomical regions were represented, the presence of fewer low than high-utility parts indicates efficient transport of gazelles for activities associated with both middens. This contrasts with more even ratios of high and low-utility gazelle parts at the site level.

The frequency of cultural damage to bones (fresh breakage, cut marks, impact fractures) is similar in the two middens, except that the completeness of marrow-bearing bones is higher in the west midden. More marrow extraction is evidenced in the east midden, where fragmentation and marrow content are positively related and small compact elements were also processed for marrow. Previously established variation in the depositional histories of the two middens supports the different treatment of faunal remains in the two middens. Secondary deposits of typical food refuse occur in the east midden while refuse from the west midden contains repeated primary deposits from single events over time (Meier *et al.* *Under review*).

### **Subsistence provisioning at KHH**

Lower hunting efficiency, higher transport efficiency, and variable, but low processing efficiency are associated with the middens at KHH. Variation was detected not only between the midden contexts but also between the middens and the combined site sample, of which the middens comprise 60% of the fauna. This suggests that the subsistence practices related to the middens were a major source of the variation in subsistence intensity between KHH and other sites.

Given the ceremonial function of the site, midden activities at KHH may reflect a combination of ritual and mundane subsistence behaviors. Even though more atypical food refuse (i.e., focus on higher utility body parts and less intensive bone processing) was detected in the west midden, high levels of fresh bone breakage for marrow indicate that both midden contexts reflect subsistence practices. Therefore, the higher degree of hunting and processing intensity at KHH extends to smaller, more common meals deposited in the middens at the site. This suggests that the provisioning decisions that set KHH apart from other sites in the region are related to more diverse subsistence provisioning strategies than feasting alone.

Moreover, subsistence evidence at KHH represents a spectrum of ritual meals from large communal feasts to smaller practices. These varying scales reflect the diverse social roles of food in Neolithic subsistence practices (Twiss 2007). Intensified subsistence practices persisted across generations of visitors that used KHH for ceremonial practices. This reflects a tradition of cuisine (Crabtree 1990) and thus may also reflect a shared group identity (deFrance 2009) of individuals who perpetuated atypical provisioning and preparation of meals at KHH.

In all, the diverse nature of the activities undertaken with animals at KHH suggests more varied evidence for foraging and processing efficiency than in the greater region. However, this evidence suggests less efficient resource extraction than implied by the more obvious evidence of feasting. Moreover, varying degrees of site occupation intensity add a further source of variation to subsistence data in the Mediterranean Hills region across the beginning of goat management.

## Figures for Chapter 5

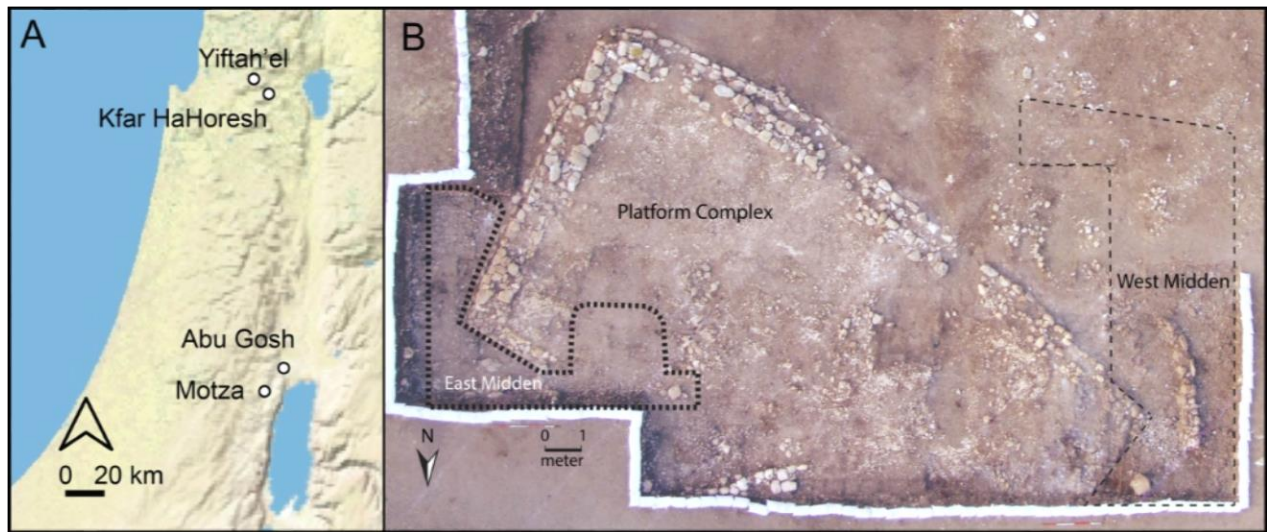


Figure 5.1. Map of (A) Mediterranean Hills sites with sizable PPNB faunal assemblages and (B) the location of the KHH middens included in this study.

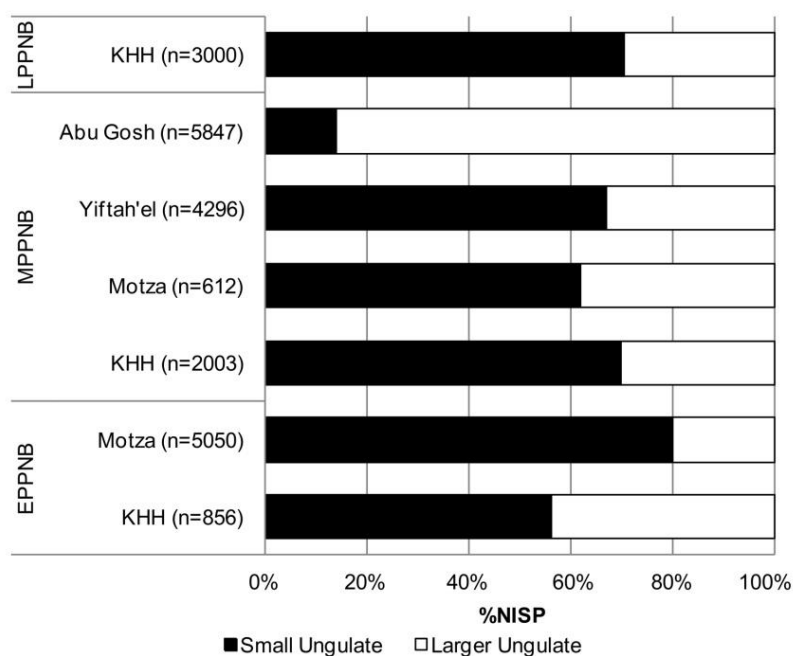


Figure 5.2. The relative abundance of small (gazelle, roe deer) to larger ungulates (equids, aurochs, red and fallow deer, goat, and pigs) at Mediterranean Hills sites dating to the Early, Middle and Late PPNB periods including KHH, Motza (Sapir-Hen *et al.* 2009), Yiftah'el (Horwitz 2003; Sapir-Hen, *et al.* 2016) and Abu Gosh (Ducos and Horwitz 2003).

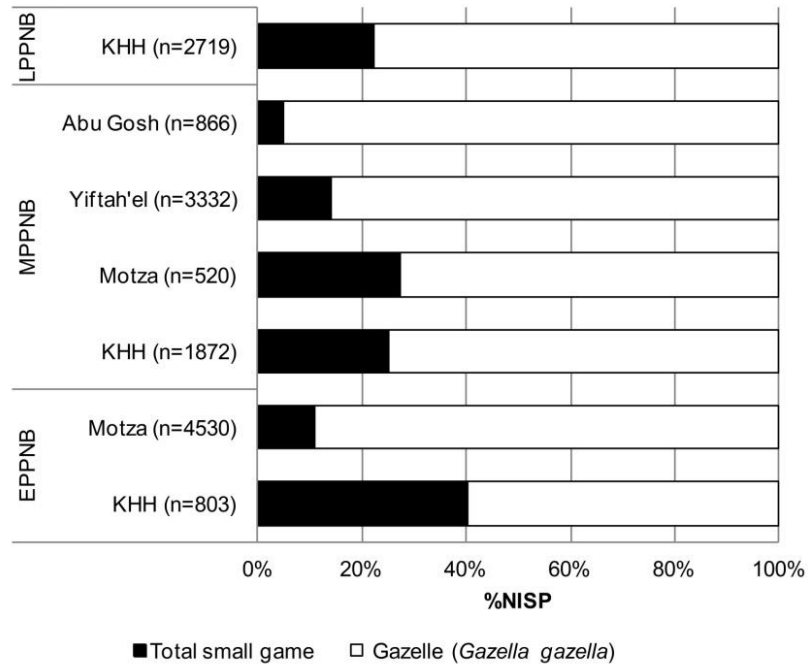


Figure 5.3. The relative abundance of small game (tortoise, hare, fish) to gazelle at Mediterranean Hills sites dating to the Early, Middle and Late PPNB periods including KHH, Motza (Sapir-Hen *et al.* 2009), Yiftah'el (Horwitz 2003; Sapir-Hen, *et al.* 2016) and Abu Gosh (Ducos and Horwitz 2003).

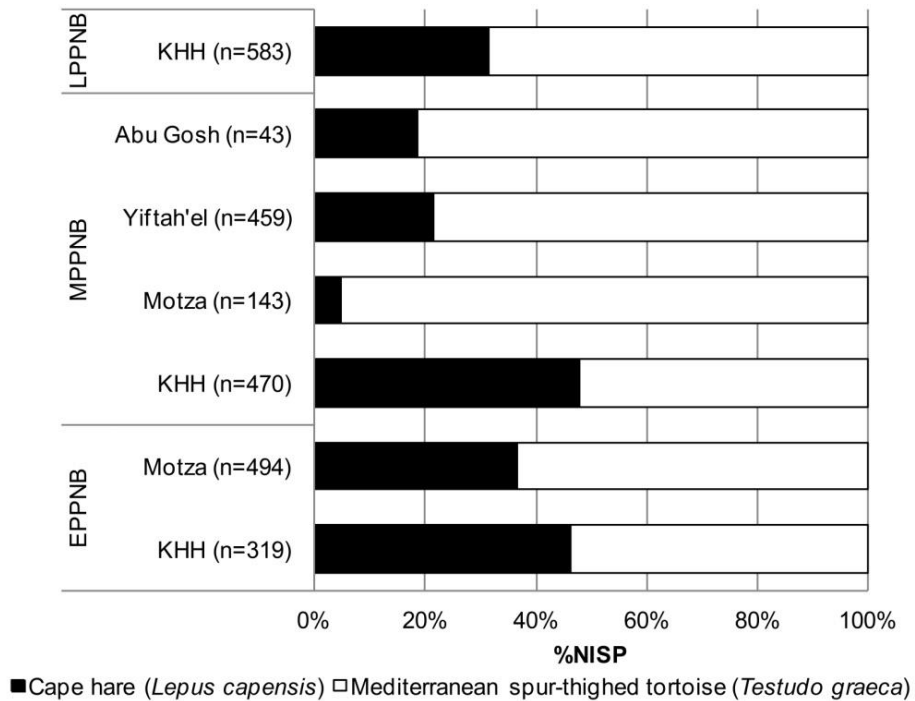


Figure 5.4. Relative abundance of fast to slow moving small game over time at Mediterranean Hills sites including KHH, Motza (Sapir-Hen *et al.* 2009), Yiftah'el (Horwitz 2003; Sapir-Hen, *et al.* 2016) and Abu Gosh (Ducos and Horwitz 2003).

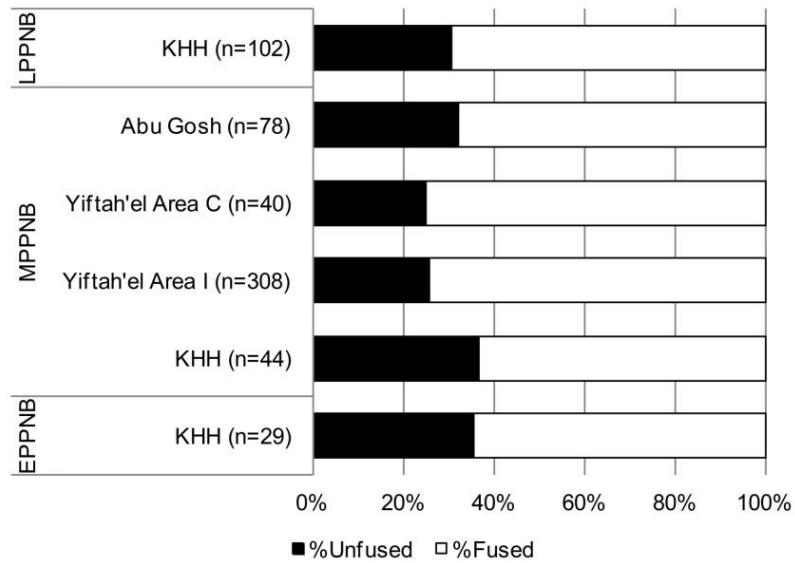


Figure 5.5. The proportion of juvenile gazelles at KHH and other sites in the Mediterranean Hills including Motza (Sapir-Hen *et al.* 2009), Yiftah'el (Horwitz 2003; Sapir-Hen, *et al.* 2016) and Abu Gosh (Ducos and Horwitz 2003) based on the percentage of unfused elements that fuse at or around 18 months of age (proximal humerus and tibia, distal radius and ulna).

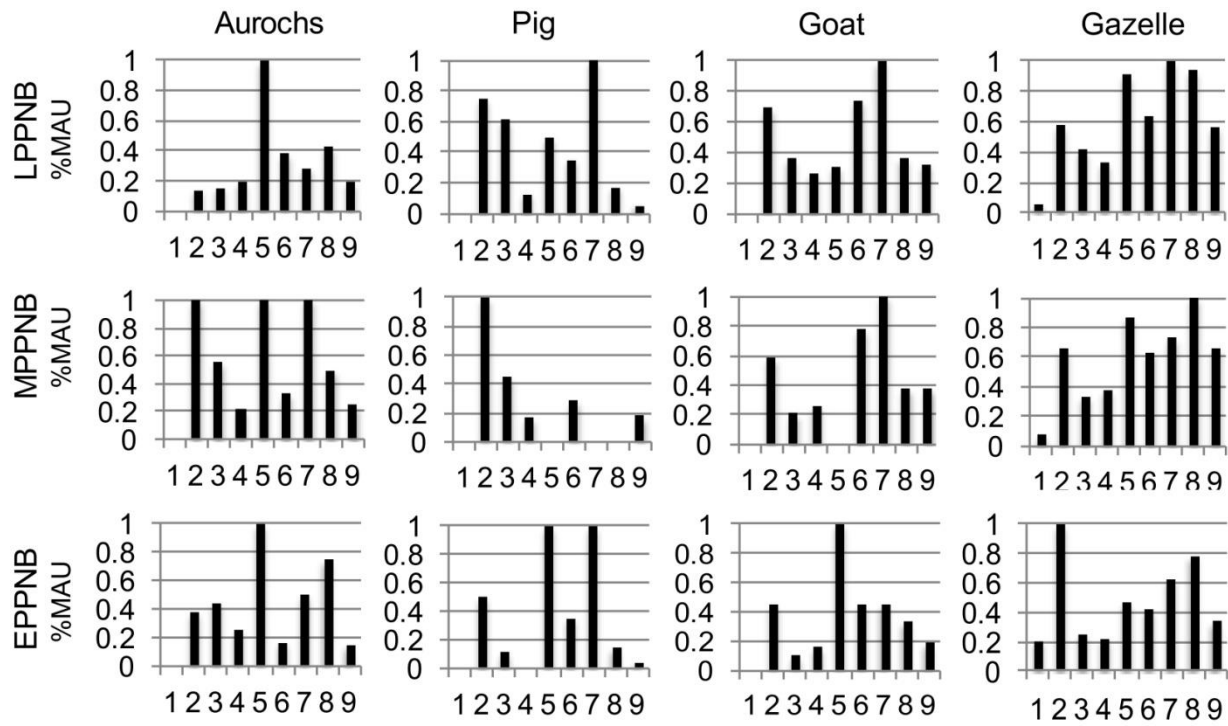


Figure 5.6. Body-part representation (%MAU) of gazelle, cattle, goat and pig at KHH over time.

Stiner's (1991, p. 460) anatomical regions represented on x-axis: 1. Horn; 2. Head; 3. Neck; 4.

Axial; 5. Upper Front; 6. Lower Front; 7. Upper Hind; 8. Lower Hind; 9. Feet.

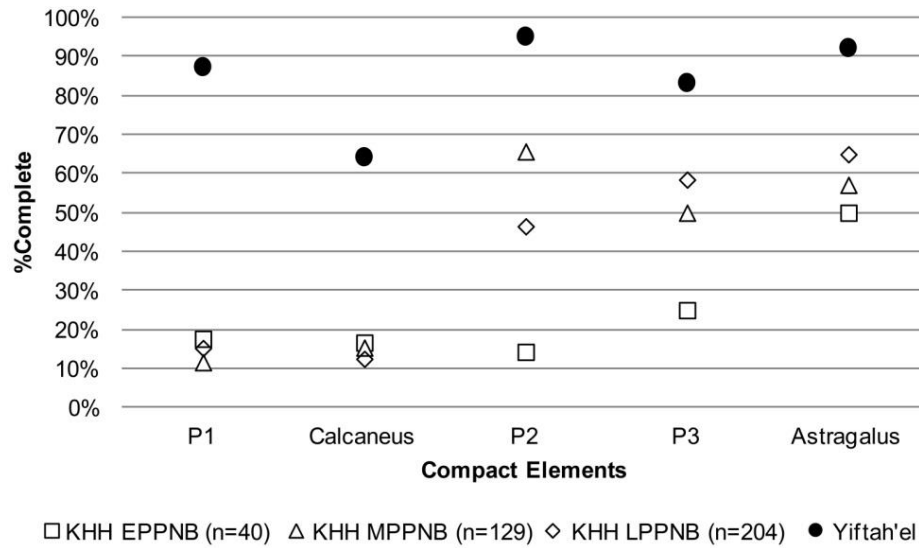


Figure 5.7. % Completeness of small compact gazelle bones from KHH and MPPNB Yiftah'el (Area G and I Yiftah'el; Sapir-Hen et al. 2016). Elements are organized in decreasing order of marrow yield. P1= First Phalanx; P2= Second Phalanx; P3= Third Phalanx.

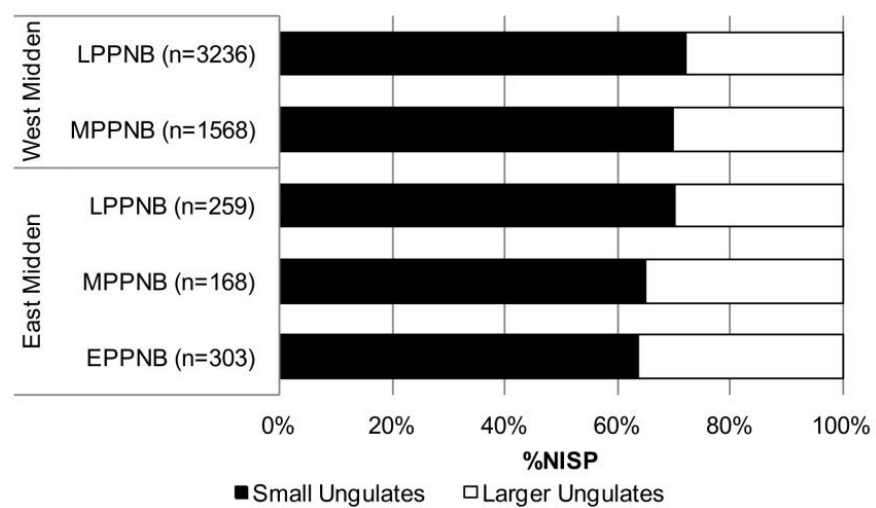


Figure 5.8. Relative taxonomic abundance of ungulates in KHH midden contexts over time (% NISP).

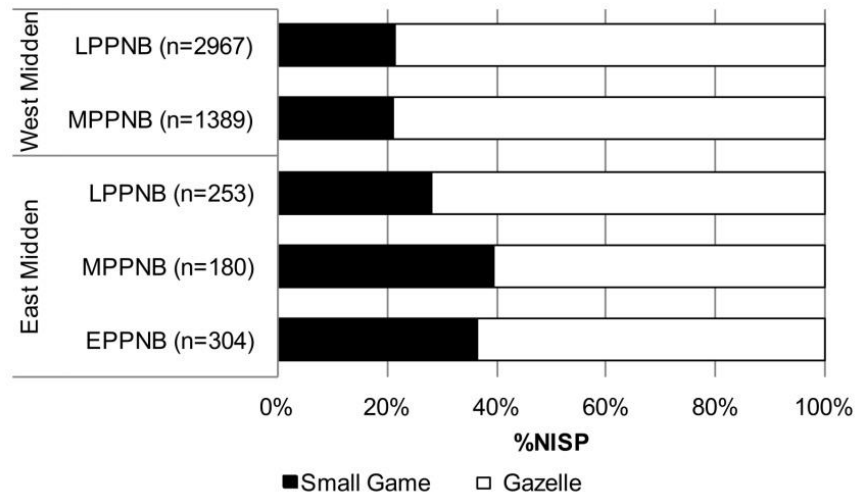


Figure 5.9. Relative taxonomic abundance of smaller taxa (small ungulates and small game) in KHH midden contexts over time (%NISP).

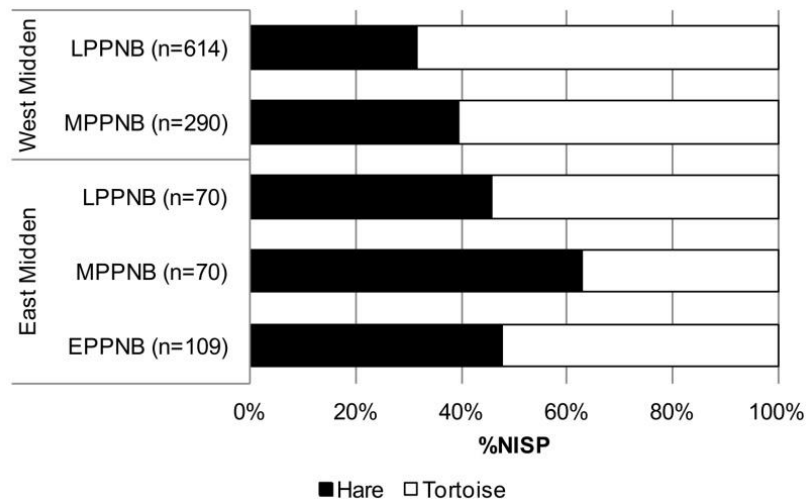


Figure 5.10. Relative taxonomic abundance of fast and slow small game in KHH midden contexts over time (%NISP).

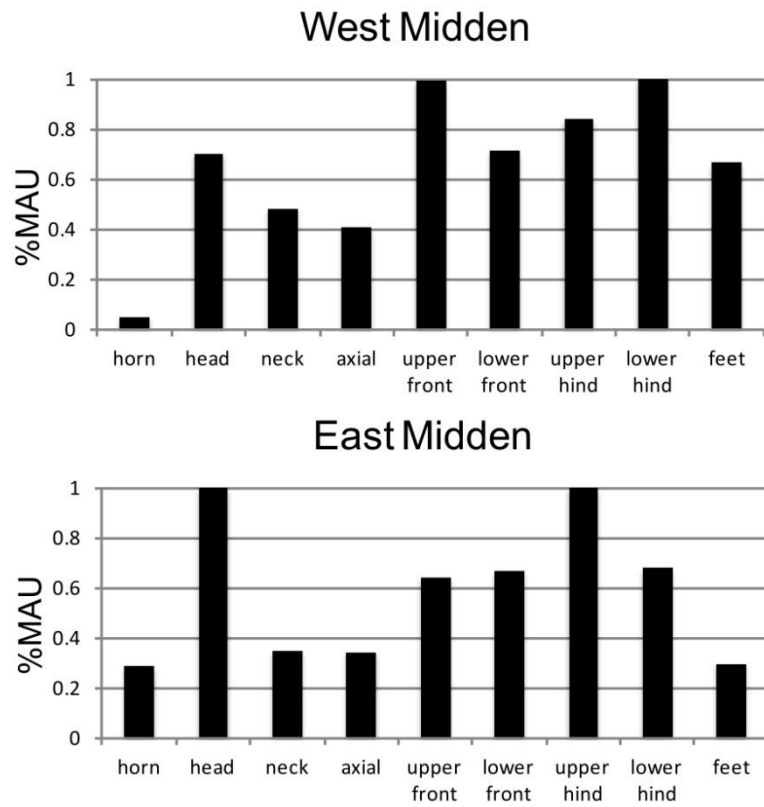


Figure 5.11. Representation of gazelle anatomical regions (%MAU) in the east and west middens at KHH.

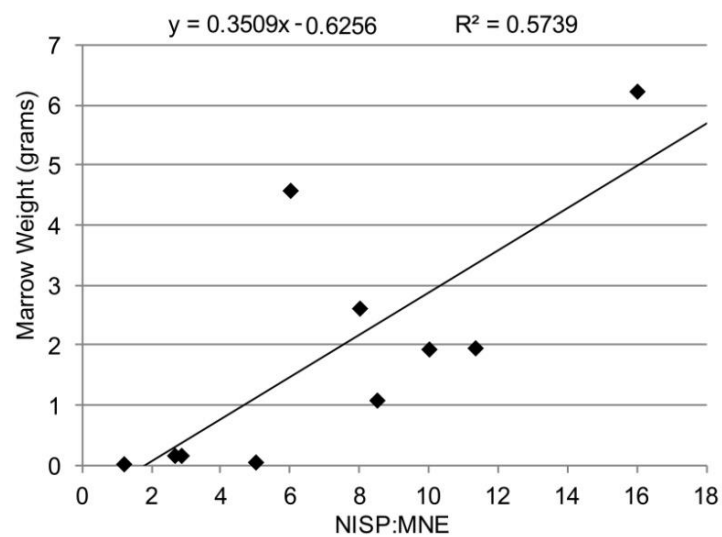


Figure 5.12. Gazelle fragmentation (NISP:MNE) vs. marrow weight in grams for marrow-bearing limb bones (Bar-Oz and Munro 2007). A significant positive relationship was detected ( $p < .01$ ).

## Chapter 6. Conclusion

This dissertation revealed multiple new aspects of human-animal relationships at the ceremonial site of Kfar HaHoresh (KHH). The four journal articles that comprise this volume present faunal evidence for domestication, subsistence strategies, scales of ritual practice, and depositional histories from the Early, Middle and Late Pre-Pottery Neolithic B (EPPNB, MPPNB, LPPNB) (10,600–8,700 cal. BP). Although evidence for each of these changes at KHH fits regional trends, differentiation from the norm distinguishes this ceremonial site from other sites in the region.

Research on the fauna recovered from the 2010–2012 excavation seasons at KHH contributes to current narratives surrounding the role of KHH and the greater region. The new data better illuminate the pace and form of economic and ritual change in the Mediterranean Hills region. New methods were also developed to reconstruct faunal depositional histories to reassess the diverse activities that define the function of KHH.

### **The beginning of animal management in the Mediterranean Hills**

#### *New PPNB subsistence evidence from KHH*

The Early, Middle, and Late PPNB faunal data from KHH improves the resolution of the current picture of subsistence change around the time when goat management first began in the Mediterranean Hills region. The new faunal data from KHH evidences narrowing dietary breadth across the PPNB. The KHH data reveals high hunting efficiency, especially by the MPPNB when large-bodied adult ungulates were more commonly hunted. Although evidence from KHH

differs in some ways from nearby sites, it largely supports regional trends of alleviated hunting pressure during the PPNB.

Analysis of ungulate demographic profiles and body size at KHH also reveals new insight into the degree of human control over herd animals in the Mediterranean Hills during the PPNB. Demographic evidence from KHH suggests an increase in human control over goat populations in the MPPNB as both female and juvenile goats increase in frequency. This supports regional evidence that goat management began by the MPPNB in the Mediterranean Hills (Horwitz 2003; Martin and Edwards 2013; Sapir-Hen, *et al.* 2016).

#### *Novel LPPNB subsistence data from KHH*

KHH is the only site with a sizeable LPPNB faunal assemblage in the Mediterranean Hills region and thus represents a novel data point for subsistence analysis. Dietary breadth continued to narrow in the LPPNB at KHH, extending a regional subsistence trend (Meier, *et al.* 2016). Additionally, low hunting pressure on young gazelles and small game indicate that hunting efficiency continued to rise into the LPPNB at KHH.

By the LPPNB, goat mortality profiles from KHH begin to fit expectations for modeled culling of caprine populations that were managed for meat (Payne 1973). This data is most similar to the goat populations from MPPNB Abu Gosh and Final LPPNB/PPNC Yiftah'el that were interpreted as managed herds (Ducos and Horwitz 2003; Horwitz 2003). Still, the evidence from LPPNB KHH is not as convincing as other Southwest Asian sites that have high abundances of neonates or evidence of animal penning that points to more fully managed caprine populations (Zeder and Hesse 2000; Stiner, *et al.* 2014).

## **Ritual practice at PPNB KHH**

The fauna from KHH highlights new regional trends in ritual practice across the PPNB. Evidence of an aurochs feasting event was documented at KHH and was similar to other feasting deposits at the site that featured multiple aurochs individuals in structured deposits from the EPPNB. Similar published evidence from other sites in the southern Levant was compiled to detect continuity between these and earlier ritual practices with aurochs in the region (Meier, *et al.* In press). Repeated formal deposition of ceremonial trash (Walker 1995) from aurochs feasts may have served to reiterate and construct social memory across the southern Levant (i.e. Hodder and Cessford 2004; Kuijt 2008).

This research also pinpointed a change in the scale of aurochs deposition from the MPPNB onward. After the EPPNB, aurochs feasting deposits became rare, except at LPPNB Basta (Becker 2002), which differs in form from earlier deposits. Instead, smaller, more idiosyncratic aurochs deposits are typical of this time. These are interpreted as remains of smaller-scale practices that reflect changing social interactions in the southern Levant from the MPPNB onward (Meier, *et al.* In press). Interestingly, this shift corresponds with changing human-animal relationships as goat management begins in the southern Levant.

## **Depositional practices at KHH**

Reconstruction of faunal depositional histories in different contexts revealed new evidence of behaviors related to the organization and use of space at KHH (Meier *et al.* *Under review*). To do this, methods were developed by building upon current multivariate taphonomic methods to illustrate the speed of deposition and burial of faunal remains in different contexts (Bar-Oz and Munro 2004; Yeshurun, *et al.* 2014a; Grosman and Munro 2016). Notably, a new

technique for the detection of evidence of minimal bone movement was also developed for this research that utilized GIS.

These methods were used to detect multiple cleaning episodes on the monumental platform at KHH, which began in the EPPNB and intensified through the MPPNB. In the middens, faunal remains yielded evidence of systematic deposition as primary and secondary refuse from the Early to Late PPNB (Meier *et al. Under review*). More structured deposition was evident in the west midden and for the feasting remains in the *Bos* concentration. Faunal remains from the graves examined in this study were likely deposited and buried as intrusive fill. Finally, evidence of the disturbance of the aurochs feasting deposit, pits and wall contexts at KHH, or tertiary refuse, also suggests a greater reworking of the site that differentiates its use from earlier sites with no tertiary refuse (Yeshurun, *et al.* 2014a).

Together, this evidence for diverse refuse, some with notably structured placement, suggests that space was first organized by some of the earliest visitors to the site in the EPPNB. The repeated use of the middens for subsistence refuse deposition also reflects a practice of site maintenance that was sustained by visitors to KHH over time. The organization of space at KHH may also demonstrate changing social norms of site use by the PPNB (Hardy-Smith and Edwards 2004). This study documents an earlier start to changes in regional site use that extended to non-habitation sites.

## **New insights from KHH**

### ***Animal domestication***

Animal management evidence from KHH provides a unique opportunity to re-assess models for domestication in the Mediterranean Hills, including models of autochthonous goat

domestication in the region (Horwitz, *et al.* 1999; Horwitz 2003) versus models of importation of managed animals from the northern Levant. Managed animals do not increase in abundance at KHH as quickly as they do at other Mediterranean Hills sites by the MPPNB period (Horwitz, *et al.* 1999; Martin and Edwards 2013). In fact, in the EPPNB at KHH goat and aurochs are more abundant than in the MPPNB and LPPNB and similar in frequency to those from MPPNB Motza and Yiftah'el, but not MPPNB Abu Gosh (Ducos and Horwitz 2003; Sapir-Hen *et al.* 2009; Sapir-Hen, *et al.* 2016). Nevertheless, aurochs representation was likely inflated at EPPNB KHH due to their abundance in feasting deposits. By contrast, goat remains were more evenly distributed across site contexts.

Small changes to the structure of goat populations are also evident in the limited demographic data from EPPNB KHH that reveal moderately high culling of younger individuals (Meier, *et al.* 2016). This evidence hints that the utilization of goats began to change in the region by as early as the EPPNB. However, even in combination with the high goat abundance, evidence from EPPNB KHH is still too equivocal to support early control. It does hint that site visitors at least had knowledge of goat management by this early date, possibly via visitors to ceremonial events from more distant locales where management had begun. In combination with the high goat abundance in the EPPNB, this could point to an earlier start to human manipulation of goat herds accessed by KHH, possible for ceremonial provisioning of feasts or special occasions with controlled animals (see Hayden 2003).

The more convincing evidence for greater control over goat populations by the LPPNB at KHH highlights increased human control over goats over time. This hints at increasing manipulation of goat populations over several PPNB periods, rather than a short-term local experiment in management. Together, the new data from KHH may support either the

autochthonous domestication scenario or more long-term access to imported goats through trade networks that KHH uniquely accessed as a ceremonial center. Based on evidence for a continuous process over time, I speculate that even if controlled goats initially reached the area through importation in the Early–Middle PPNB, local processes likely took over and continued into the LPPNB.

### ***The role of a ceremonial site***

The more than 20 years of research at KHH, have built a strong case for KHH's primary function as a ceremonial center for periodic funerary and communal activities for visitors from the surrounding region (Goring-Morris 2000; Goring-Morris, *et al.* 2008). Supporting evidence includes two caches of naviform flint blades near isolated human skulls (Goring-Morris 2005; Barzilai and Goring-Morris 2010), the unusual location of KHH (Birkenfeld and Goring-Morris 2015), and the abundant burials (85+) that support the reuse of the site over time by people from the same kin group (Alt, *et al.* 2015). The food choices at KHH further highlight its ceremonial function as they deviate from those in the greater region.

The continuation of intensive hunting into the LPPNB at KHH, to a point beyond what is typical in the larger southern Levantine region, reflects the symbolic nature of food selection at this ritual site. The focus on gazelle likely inverted the norms of efficient food selection, which is a common feature of ritual meals (Bell 1997; Rappaport 1999). This reflects a long-term tradition of food use that may have served to reinforce social memories of site visitors over time (Kuijt 1996).

The primary cultic function of KHH is also supported by evidence for formalized site maintenance, potentially in an effort to maintain the sacred setting. Cleaning was likely

associated with PPNB ritual behavior as similar evidence for clean ritual plastered areas was found at Beidha and 'Ain Ghazal (Kirkbride 1966; Rollefson 2005). Additionally, organized site use over time reflects sustained cooperative behavior by visitors from the wider region spanning several generations.

### ***PPNB ritual practice***

The ceremonial use of KHH has been associated with ritual mechanisms that increased social regulation (Goring-Morris 2000), possibly through ritual elaboration that paralleled changes in animal husbandry over time (Goring-Morris 2000; Goring-Morris 2005). The new faunal evidence indicates that ritual aurochs deposits became more elaborate in form, but less practiced once goat management began (Meier, *et al.* In press). Thus, changes in ritual regulatory mechanisms coincide with the start of ungulate management in the region, but likely reflect a transition to more small-scale means of social regulation.

Importantly, newly refined results on the fauna from the middens can be used to re-evaluate Goring-Morris' hypothesis that the middens reflect ceremonial feasting much like the *Bos* pits (Goring-Morris 2005). Interestingly, the two middens included in this study contain the refuse generated by different activities, with complex cleaning and subsistence refuse in the east midden and more atypical food refuse in the west midden. The depositional histories clarify that the middens are not feasting deposits. In all, the subsistence refuse in different contexts at KHH represent a spectrum of food practices (i.e. Twiss 2007), ranging from more mundane meals, to special small consumption events, and larger feasts—all of which differ from the more efficient subsistence choices made at other sites in the region.

## **KHH and early social complexity**

In the Mediterranean Hills region, KHH is exceptional in many ways and offers further insight into the development of social complexity during the transition to agriculture.

Importantly, faunal evidence at KHH stands apart from that of neighboring sites and supports hypotheses that it functioned as a ceremonial center. This reflects more diversified site use, pointing to greater complexity in the social function of PPNB sites.

Changes in the access to goats create a potential avenue for greater economic inequality among communities at a time when greater social complexity began to develop in the region (Rollefson 2000; Barzilai 2010; Pearson, *et al.* 2013; Wright 2014). The shift away from more public ritual practice arose concurrently with the increased control over herd animals. Both the shifts away from communal feasting and monumental platform use reflect a change in public practices at KHH in the MPPNB, likely reflecting the use of the site by smaller groups of visitors. This is supported by the subsistence evidence for decreased site use intensity in the LPPNB (see Chapter 5). The shift away from large-scale public ritual practices at KHH also hints that other mechanisms of social memory construction (Kuijt 2001; Hodder and Cessford 2004) were utilized from the MPPNB and onward.

Therefore, based on the new faunal evidence it is reasonable to hypothesize that community integration was no longer a primary role of ritual practices at KHH from the MPPNB onward. This contrasts with interpretations of human burial evidence across the region that appears less differentiated in the MPPNB, highlighting the action of ritual mechanisms that minimized social differences within communities (Kuijt 1996; Goring-Morris 2000). Rather, the shift in aurochs deposits illuminates less standardized ritual mechanisms (Kuijt and Goring-Morris 2002) that begin to diversify in the MPPNB. Still, persistent traditions of food use at

KHH, namely gazelle selection, and site maintenance practices may have continued to promote group solidarity, but among smaller-sized groups that visited the site through the LPPNB.

Nonetheless, the evidence of some shifts to more diverse ritual practices by the MPPNB could indicate movement away from socially equalizing mechanisms. Rather, diverse practices may have served to reinforce more pronounced social inequality by the time that goat management began in the Mediterranean Hills. This emphasizes the need for more focused comparative studies of intra-site faunal use to simultaneously track economic and ritual change within single regions. Still, the new findings from KHH begin to clarify how diverse ritual practices with animals changed as their roles shifted with the start of animal management and the related expansion of social inequality.

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## Dissertation Appendix

## Chapter 2. Supplementary Figures

**S1 Table. NISP of taxonomic groups represented at KHH by time period. Specimens derive only from well-dated contexts.**

Taxon	EPPNB	MPPNB	LPPNB	Total
<b>UNGULATES</b>				
Aurochs ( <i>Bos primigenius</i> )	112	77	89	278
Aurochs-sized	98	111	152	361
Deer (Cervidae)	1	2	1	4
Fallow deer ( <i>Dama mesopotamica</i> )		2		2
Wild boar ( <i>Sus scrofa</i> )	24	50	157	231
Goat ( <i>Capra</i> sp.)	40	166	219	425
Goat-sized	99	194	265	558
Roe deer ( <i>Capreolus capreolus</i> )	1	1	2	4
Gazelle ( <i>Gazella gazella</i> )	171	568	876	1615
Gazelle-sized	309	831	1237	2377
<b>CARNIVORES</b>				
Fox ( <i>Vulpes vulpes</i> )	89	162	207	458
Wild cat ( <i>Felis silvestris</i> )	18	65	70	153
Indeterminate Canid (Canidae)	1	1	1	3
Marmot ( <i>Marmota marmota</i> )	2	3	6	11
Medium Carnivore-sized	27	123	194	344
Indeterminate Mustelid (Mustelidae)			3	3
Pine Martin ( <i>Martes foina</i> )	1	1	3	5
Polecat ( <i>Vormela peregrusna</i> )	4	5	5	14
Small carnivore-sized	3	4	1	8
<b>SMALL GAME</b>				
Cape hare ( <i>Lepus capensis</i> )	147	225	184	556
Mediterranean spur-thighed tortoise ( <i>Testudo graeca</i> )	172	245	399	816
Turtle ( <i>Mauremys</i> or <i>Emys</i> sp.)	2	13	27	42
Snake (Indeterminate sp.)	15	18	4	37
Agamid lizard ( <i>Agama stellio</i> )	1			1
Lizard (Indeterminate sp.)	7	2		9
Hedgehog ( <i>Erinaceus europaeus</i> )	2	7	1	10
Fish (Indeterminate sp.)	4	3	23	30
Crab		1	7	8
Caucasian Squirrel ( <i>Sciurus anomalus</i> )			1	1
Tiny Rodent	3	2	5	10
Small Rodent	2	2	1	5
Medium Rodent	3			3
Large Rodent	1			1
Murid rodent (Muridae)		3		3
Naked mole rat ( <i>Spalax ehrenbergi</i> )	9		2	11
Vole (Microtinae)	3	1		4
Tiny Bird			1	1
Small Bird		2		2
Medium Bird	12	10	13	35
Partridge ( <i>Alectoris chukar</i> )	2	1	2	5
Duck ( <i>Anas platyrhynchos</i> )		1		1
Common coot ( <i>Fulica atra</i> )			2	2
Rock dove ( <i>Columba livia</i> )		3		3
Shark (Selachimorpha)		1		1
Shell		1	3	4
<b>BIRDS OF PREY</b>				
Buzzard ( <i>Buteo buteo</i> )		4	4	8
Indeterminate Falconiforme (Falconiforme)	2	3	6	11
Golden eagle ( <i>Aquila chysaetos</i> )	1			1
Eurasian eagle owl ( <i>Bubo bubo</i> )			1	1
Indeterminate owl (Strigidae)		2		2
Sparrowhawk ( <i>Accipiter nisus</i> )			3	3
Large Bird ( <i>Buteo</i> or <i>Aquila</i> sized)	7	1	5	13
Huge Bird ( <i>Gyps</i> sp. sized)		3	1	4
<b>Grand Total</b>	<b>1395</b>	<b>2920</b>	<b>4183</b>	<b>8498</b>

S2 Table. MNE of fused and unfused *Gazella* elements used to calculate age stages based on bone fusion (Davis 1980; Munro, *et al.* 2009). Total gazelle MNE by phase: EPPNB n=67, MPPNB n=116, LPPNB n=216.

Age Stage	Elements that Fuse at Stage	EPPNB	EPPNB	MPPNB	MPPNB	LPPNB	LPPNB
		Unfused	Fused	Unfused	Fused	Unfused	Fused
<b>Stage 1</b> <i>0-2 months</i>	Radius-Proximal	0	2	0	3	1	9
<b>Stage 2</b> <i>3-7 months</i>	1st Phalanx-Prox, 2nd Phalanx-Prox, Humerus-Distal, Pelvis-Acetabulum, Scapula-Glenoid	5	24	6	53	11	87
<b>Stage 3</b> <i>8-10 months</i>	Tibia-Distal	3	2	3	2	1	5
<b>Stage 4</b> <i>10-16 months</i>	Femur-Proximal, Calcaneum, Metapodial-Distal, Femur-Distal, Ulna-Proximal	7	15	14	23	17	53
<b>Stage 5</b> <i>12-18 months</i>	Humerus-Proximal, Radius-Distal, Tibia-Proximal, Ulna-Distal	4	5	4	8	12	20

S3 Table. MNE of fused and unfused *Capra* elements used to calculate age stages based on bone fusion (Zeder 2006).

Age Stage	Elements that Fuse at Stage	EPPNB	EPPNB	MPPNB	MPPNB	LPPNB	LPPNB
		Unfused	Fused	Unfused	Fused	Unfused	Fused
<b>I</b> <i>0-6 months</i>	Radius-Proximal					2	4
<b>II</b> <i>6-12 months</i>	Innominate-Acetabulum, Humerus-Distal, Scapula-Glenoid	1	2	3	8	5	5
<b>III</b> <i>12-18 months</i>	1st Phalanx-Prox, 2nd Phalanx-Prox	1	3	2	6	2	10
<b>IV</b> <i>18-30 months</i>	Tibia-Distal, Metapodial-Distal	1	2	1	3	10	6
<b>V</b> <i>30-48 months</i>	Radius-Distal, Femur-Proximal, Femur-Distal, Ulna-Prox, Tibia-Proximal, Calcaneum			2	6	13	6
<b>VI</b> <i>&gt;48 months</i>	Humerus-Proximal						

S4 Table: MNE of fused and unfused *Bos* elements used to calculate age stages based on bone fusion (Grigson 1989).

Age Stage	Elements that Fuse at Stage	EPPNB Unfused	EPPNB Fused	MPPNB Unfused	MPPNB Fused	LPPNB Unfused	LPPNB Fused
<b>I</b> <i>7-18 months</i>	Humerus-Distal, Radius-Prox, 1st Phalanx-Prox, 2nd Phalanx Prox	1	4	1	3	7	9
<b>II</b> <i>24-36 months</i>	Tibia-Distal, Metapodial-Distal					2	3
<b>III</b> <i>36-42 months</i>	Calcaneum						
<b>IV</b> <i>42-48 months</i>	Humerus-Proximal, Radius-Distal, Ulna-Prox, Femur-Proximal, Femur-Distal, Tibia-Proximal	9	2	1	2	5	8

S5 Table. MNE of fused and unfused *Sus* elements used to calculate age stages based on bone fusion (Hongo and Meadow 2000).

Age Stage	Elements	Age for curve (months)	LPPNB Unfused	LPPNB Fused
<b>I</b> <i>0-8 months</i>	Scapula-Glenoid, Pelvis-Acetabulum, Radius-Proximal	4	1	2
<b>II</b> <i>8-18 months</i>	Humerus-Distal, 2nd Phalanx-Proximal	13	4	2
<b>III</b> <i>18-24 months</i>	Tibia-Distal, 1st Phalanx-Proximal,	21	2	1
<b>IV</b> <i>24-36 months</i>	Metapodial Distal, Fibula-Distal	30	2	1
<b>V</b> <i>36-48 months</i>	Calcaneum, Tuber calcis, Femur-Proximal	42	0	0
<b>VI</b> <i>48-60 months</i>	Radius-Distal, Ulna-Proximal & Distal, Femur-Distal, Tibia-Proximal, Fibula-Proximal, Humerus-Proximal	54	8	2

S6 Table. Measurements included in *Capra* LSI for (a) EPPNB, (b) MPPNB, and (c) LPPNB KHH (mm). Measurement abbreviations from (von den Driesch 1976). Unfused bones= \*.

A

Element	Measurement [1]	EPPNB KHH <i>Capra</i> specimen measurements
Calcaneus	GB	20.11
P1	Bp	12.97, 16.47
Scapula	LG	25.16
Tibia	Bd	33.71
Ulna	BPC	22.34

B

Element	Measurement [1]	MPPNB KHH <i>Capra</i> specimen measurements
Astragalus	BC	23.42
Femur	DC	21.3*
P1	Bp	13.76, 15.35,
P1	Bd	12.57, 12.54, 12.72
Radius	Bd	33.11*
Radius	BFp	29.66
Tibia	Bd	24.68*
Ulna	BPC	26.46

C

Element	Measurement [1]	LPPNB KHH <i>Capra</i> specimen measurements
Astragalus	BC	18.79, 19.17, 19.39, 19.39, 21.26
Calcaneus	GB	19.8, 22.2*, 25.77
Femur	Bd	39.87*
Femur	DC	24.72, 25.61*
Humerus	Bd	31.57
Metacarpal	BP	24.81
Metatarsal	Bd	24.72*
Metatarsal	BP	20.1, 21.5,
Metatarsal	Bd	28.81
Phalanx 1	Bd	11.61, 11.93, 12.81, 12.97, 13.02*, 17.01, 14.48, 13.13*, 13.4*, 14.12
Phalanx 1	Bp	12.51
Radius	BFp	28.51, 30.6*, 32.74*, 36.44
Radius	Bd	28.95*, 28.96*, 29.01, 30.36, 33.47*
Tibia	Bd	26.11, 34.99
Ulna	BPC	21.79, 22.33*, 29.08
Tibia	Bd	33.94

1. von den Driesch A. A Guide to the Measurement of Animal Bones from Archaeological Sites. Cambridge, MA: Harvard University Press; 1976.

S7 Table. Measurements included in *Bos* LSI from KHH (mm). Measurement abbreviations from (von den Driesch 1976). Unfused bones marked with \*.

Element	Measurement [1]	KHH specimen measurements
Astragalus	GL	84.39, 84.39
Humerus	Bd	91.11
Metacarpal	Bp	78.79
Metatarsal	Bd	73.4
Nav. cuboid	GB	64.27, 70.55
Phalanx 1	Bp	27.53*, 30.47*, 38.3
Phalanx 2	Bp	30.34, 33.48, 34.1, 35.57, 36.25, 38.1, 38.54
Radius	Bp	85.35

1. von den Driesch A. A Guide to the Measurement of Animal Bones from Archaeological Sites. Cambridge, MA: Harvard University Press; 1976.

## Chapter 5. Supplementary Figures

Supplementary Table 1. Figure 3 diversity values.

Notes by Loci Type	<i>Bos</i> Pit	Burials	West Midden	West Gen. Area	East Gen. Area	East Midden	Platform	Pits	Stone Feature	Wall
Number of Loci	1	3	8	n/a	n/a	4	15	7	21	7
Total NISP	203	64	7151	3155	1259	1167	1893	94	661	80
Shannon Diversity	1.01	1.73	1.79	2.09	1.96	2.06	2.09	2.29	2.10	2.04

Supplementary Table 2. Chi-square analysis of bone fragment size groups by context examined based on adjusted residuals (AR). Raptor sample is small (n<5) and only included in assemblage total. AR value significance marked: \* = p<.05; \*\*\* = p<.001

Tax_type	Max Length		Bos Concentration	Burials	East Midden	East Gen. Area	West Gen. Area	Pits	Platform	Stone Features	Wall	West Midden		Chi- Sq. Value	df	Asymptotic Sig. (2-sided)
GOAT	<3cm	Count	<5	5	40	<5	129	<5	36	26	<5	227	471	9.412	9	0.400
		AR	n<5	1.1	0.6	n<5	0.6	n<5	-0.6	0.7	n<5	-1.0	-			
	>3cm	Count	<5	<5	7	<5	26	<5	10	<5	<5	57	106			
		AR	n<5	n<5	-0.6	n<5	-0.6	n<5	0.6	n<5	n<5	1.0	-			
		Total	<5	5	47	<5	155	<5	46	30	<5	284	577			
CARNIVORES	<3cm	Count	-	<5	38	9	101	9	65	18	-	203	444	3.929	7	0.788
		AR	-	n<5	-0.3	0.4	-1.5	0.4	1.2	0.6	-	0.1	-			
	>3cm	Count	-	<5	<5	<5	<5	<5	<5	<5	-	<5	9			
		AR	-	n<5	n<5	n<5	n<5	n<5	n<5	n<5	-	n<5	-			
		Total	-	<5	39	9	105	9	65	18	-	207	453			
HARE	<3cm	Count	<5	<5	46	12	110	<5	49	27	<5	123	374	4.739	9	0.856
		AR	n<5	n<5	0.5	0.3	-2.2*	n<5	0.5	0.4	n<5	1.0	-			
	>3cm	Count	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5			
		AR	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	-			
		Total	<5	<5	46	12	112	<5	49	27	<5	123	376			
BOS	<3cm	Count	12	<5	15	<5	50	<5	11	24	<5	89	205	21.048	9	0.012
		AR	-1.0	n<5	-1.3	n<5	-1.5	n<5	0.6	3.1*	n<5	0.9	-			
	>3cm	Count	18	<5	24	<5	67	<5	9	8	<5	85	217			
		AR	1.0	n<5	1.3	n<5	1.5	n<5	-0.6	-3.1*	n<5	-0.9	-			
		Total	30	<5	39	<5	117	<5	20	32	<5	174	422			
SMALL TAXA	<3cm	Count	-	<5	9	-	24	<5	17	<5	<5	35	95			
		AR	-	n<5	-	-	-	n<5	-	n<5	n<5	-	-			
	>3cm	Total	-	<5	9	-	24	<5	17	<5	<5	35	95			
GAZELLE	<3cm	Count	7	9	171	37	414	17	191	73	10	1151	2080	16.997	9	0.049
		AR	-0.6	-0.3	2.1*	1.1	1.9	0.3	-0.2	1.6	0.9	-3.4*	-			
	>3cm	Count	<5	<5	6	<5	23	<5	16	<5	<5	114	165			
		AR	n<5	n<5	-2.1*	n<5	-1.9	n<5	0.2	n<5	n<5	3.4*	-			
		Total	8	10	177	38	437	18	207	75	10	1265	2245			
SUS	<3cm	Count			<5	<5	25		<5	<5	<5	49	85	6.577	6	0.362
		AR			n<5	n<5	0.2		n<5	n<5	n<5	-0.4	-			
	>3cm	Count			<5	<5	7		<5	<5	<5	16	26			
		AR			n<5	n<5	-0.2		n<5	n<5	n<5	0.4	-			
TORTOISE	<3cm	Count	<5	<5	36	9	72	<5	75	21	<5	223	447	1.002	9	0.999
		AR	n<5	n<5	0.3	0.1	0.4	n<5	0.4	0.2	n<5	-1.0	-			
	>3cm	Count	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5			
		AR	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	n<5	-			
		Total	<5	<5	36	9	72	<5	75	21	<5	224	448			
Total	<3cm	Count	24	20	361	72	927	37	448	196	22	2106	4213	64.657	9	0.000
		AR	-6.9***	0.3	1.0	2.0*	-1.3	0.7	2.4*	2.1*	-0.1	-1.2	-			
	>3cm	Count	19	<5	38	<5	129	<5	38	14	<5	277	526			
		AR	6.9***	n<5	-1.0	n<5	1.3	n<5	-2.4*	-2.1*	n<5	1.2	-			
		Total	43	22	399	75	1056	40	486	210	25	2383	4739			

**Supplementary Table 3. AR of gazelle fresh (green) and dry breakage types represented by context.** AR value significance marked: \* =  $p < .05$ ; \*\*\* =  $p < .001$

Type of Break		<i>Bos</i> Concentration	Burials	East Midden	East General Area	West General Area	Pits	Platform	Stone Features	Wall	West Midden	Total
Dry	Count	<5	<5	43	<5	135	<5	38	19	<5	363	613
	AR	n<5	n<5	-0.7	n<5	2.1*	n<5	-2.6*	-0.7	n<5	1.1	
Green	Count	5	8	135	34	307	13	164	63	7	962	1698
	AR	-0.7	0.5	0.7	2.3*	-2.1*	0.3	2.6*	0.7	0.3	-1.1	
Total	Count	8	10	178	38	442	17	202	82	9	1325	2311

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.196 <sup>a</sup>	9	0.046
Likelihood Ratio	18.567	9	0.029
N of Valid Cases	2311		
a. 4 cells (20.0%) have expected count less than 5. The minimum expected count is 2.12.			

Supplementary Table 4. AR proportions of weathered bones by context. Small raptor sample included in assemblage total. AR sig.: \* = p<.05; \*\*\* = p<.001

Taxa Type			<i>Bos</i> Concent.	Burials	East Midden	East Gen. Area	West Gen. Area	Pits	Platform	Stone Features	Wall	West Midden	Sum	Pears. Chi-Sq. value	d f	Sig. (2 sided)
GOAT	Unweathered	Count	8	7	103	<5	300	<5	86	83	7	698	1299	20.998	9	0.013
		AR	-1.9	-2.6*	-1.4	n<5	-1.1	n<5	0.0	-0.6	0.4	2.9*				
	Weathered	Count	5	6	30	<5	75	<5	19	21	<5	128	288			
		AR	1.9	2.6*	1.4	n<5	1.1	n<5	0.0	0.6	n<5	-2.9*				
	Total		13	13	133	7	375	<5	105	104	8	826	1587			
Carnivores	Unweathered	Count	<5	<5	114	15	417	20	163	77	9	747	1566	24.308	9	0.004
		AR	n<5	n<5	-2.0*	-3.6*	1.4	0.1	-1.5	0.7	1.0	1.2				
	Weathered	Count	<5	<5	19	7	35	<5	23	6	<5	70	163			
		AR	n<5	n<5	2.0*	3.6*	-1.4	n<5	1.5	-0.7	n<5	-1.2				
	Total		<5	<5	133	22	452	22	186	83	9	817	1729			
HARE	Unweathered	Count	6	6	115	23	256	8	134	53	<5	289	894	11.895	9	0.219
		AR	0.8	0.8	0.0	0.4	1.3	1.0	0.9	-2.6*	n<5	-1.0				
	Weathered	Count	<5	<5	13	<5	23	<5	12	13	<5	38	102			
		AR	n<5	n<5	0.0	n<5	-1.3	n<5	-0.9	2.6*	n<5	1.0				
	Total		6	6	128	25	279	8	146	66	5	327	996			
BOS	Unweathered	Count	79	<5	62	8	218	5	22	58	5	307	764	77.002	9	0.000
		AR	-6.1***	n<5	-2.9*	-0.6	1.8	1.3	0.1	2.5*	-0.2	3.9*				
	Weathered	Count	66	6	37	<5	59	<5	7	8	<5	69	258			
		AR	6.1***	4.2	2.9*	n<5	-1.8	n<5	-0.1	-2.5*	n<5	-3.9*				
	Total		145	6	99	12	277	5	29	66	7	376	1022			
Small taxa	Unweathered	Count		<5	37	6	101	11	42	16	6	110	333	5.260	8	0.729
		AR		n<5	0.5	-1.3	-1.3	0.7	0.7	0.9	0.5	0.0				
	Weathered	Count		<5	<5	<5	7	<5	<5	<5	<5	5	15			
		AR		n<5	n<5	n<5	1.3	n<5	n<5	n<5	n<5	0.0				
	Total			<5	38	7	108	11	43	16	6	115	348			
GAZELLE	Unweathered	Count	14	26	427	70	1127	22	412	200	29	3343	5670	55.359	9	0.000
		AR	-4.6***	1.3	0.0	-0.8	-3.2*	-2.1*	-0.7	-3.0*	0.9	4.9***				
	Weathered	Count	10	<5	57	12	187	7	60	43	<5	373	752			
		AR	4.6***	n<5	0.0	0.8	3.2*	2.1*	0.7	3.0*	n<5	-4.9***				
	Total		24	27	484	82	1314	29	472	243	31	3716	6422			
Sus	Unweathered	Count			11	<5	80	<5	12	12	<5	204	322	12.882	7	0.075
		AR			-0.7	n<5	-3.3*	n<5	0.1	0.1	n<5	3.1*				
	Weathered	Count			<5	<5	26	<5	<5	<5	<5	23	56			
		AR			n<5	n<5	3.3*	n<5	n<5	n<5	n<5	-3.1*				
	Total				14	<5	106	<5	14	14	<5	227	378			
TORTOISE	Unweathered	Count	9	6	105	15	192	14	127	37	12	578	1095	20.231	9	0.017
		AR	-2.1*	0.7	-2.0*	-0.5	-0.8	0.2	-0.4	-2.3*	1.1	3.1*				
	Weathered	Count	<5	<5	16	<5	21	<5	13	8	<5	37	101			
		AR	n<5	n<5	2.0*	n<5	0.8	n<5	0.4	2.3*	n<5	-3.1*				
	Total		12	6	121	17	213	15	140	45	12	615	1196			
Total	Unweathered	Count	118	51	983	142	2705	84	1001	543	74	6301	12002	210.375	9	0.000
		AR	-12.6***	-1.8	-2.7*	-2.1*	-2.2*	0.6	0.5	-2.4*	1.4	7.5***				
	Weathered	Count	85	13	176	31	433	10	139	101	6	745	1739			
		AR	12.6***	1.8	2.7*	2.1*	2.2*	-0.6	-0.5	2.4*	-1.4	-7.5***				

Supplementary Table 5. Chi-squared comparison of burned and not burned fragments by context with adjusted residual values. \* = p<.05; \*\*\* = p<.001

Taxa type			Bos Con- centration	Burials	East Midden	East Area	West Area	Pits	Platform	Stone Features	Wall	West Midden	Total	Value	df	Asympt. Sig. (2-sided)
<i>Capra</i>	Unburned	Count	13	11	111	5	286	<5	86	91	5	682	1293	16.352	9	0.060
		AR	1.7	0.3	0.6	-0.7	-3.0*	n<5	0.1	1.6	-1.4	1.2				
	Burned	Count	<5	<5	22	<5	89	<5	19	13	<5	144	294			
		AR	n<5	n<5	-0.6	n<5	3.0*	n<5	-0.1	-1.6	n<5	-1.2				
		Total	13	13	133	7	375	<5	105	104	8	826	1587			
Carnivores	Unburned	Total	<5	<5	124	20	392	17	158	72	9	701	1497	12.090	9	0.208
		AR	n<5	n<5	2.3*	0.6	0.1	-1.3	-0.7	0.0	1.2	-0.9				
	Burned	Count	<5	<5	9	<5	60	5	28	11	<5	116	232			
		AR	n<5	n<5	-2.3*	n<5	-0.1	1.3	0.7	0.0	n<5	0.9				
		Total	<5	<5	133	22	452	22	186	83	9	817	1729			
Hare	Unburned	Count	6	6	111	20	224	6	115	57	<5	281	829	12.035	9	0.211
		AR	1.1	1.1	1.1	-0.4	-1.6	-0.6	-1.6	0.7	n<5	1.6				
	Burned	Count	<5	<5	17	5	55	<5	31	9	<5	46	167			
		AR	n<5	n<5	-1.1	0.4	1.6	n<5	1.6	-0.7	n<5	-1.6				
		Total	6	6	128	25	279	8	146	66	5	327	996			
<i>Bos</i>	Unburned	Count	143	6	91	11	219	<5	21	54	<5	265	818	67.754	9	0.000
		AR	6.0***	1.2	3.1*	1.0	-0.5	n<5	-1.0	0.4	n<5	-5.8***				
	Burned	Count	<5	<5	8	<5	58	<5	8	12	<5	111	204			
		AR	n<5	n<5	-3.1*	n<5	0.5	n<5	1.0	-0.4	n<5	5.8***				
		Total	145	6	99	12	277	5	29	66	7	376	1022			
Raptor	Unburned	Count			8		14		5	7	<5	27	62	6.097	5	0.297
		AR			-2.5*		0.5		0.3	0.4	n<5	0.9				
	Burned	Count			<5		<5		<5	<5	<5	<5	<5			
		AR			n<5		n<5		n<5	n<5	n<5	n<5				
		Total			9		14		5	7	<5	27	63			
Small taxa	Unburned	Count		<5	38	7	102	10	38	16	6	102	323	10.187	8	0.252
		AR		n<5	1.8	0.7	0.8	-0.2	-1.2	1.1	0.7	-2.1*				
	Burned	Count		<5	<5	<5	6	<5	5	<5	<5	13	25			
		AR		n<5	n<5	n<5	-0.8	n<5	1.2	n<5	n<5	2.1*				
		Total		<5	38	7	108	11	43	16	6	115	348			
<i>Gazella</i>	Unburned	Count	21	22	419	62	1065	17	377	209	29	3096	5317	30.737	9	0.000
		AR	0.6	-0.2	2.3*	-1.7	-1.9	-3.5*	-1.7	1.4	1.6	1.3				
	Burned	Count	<5	5	65	20	249	12	95	34	<5	620	1105			
		AR	n<5	0.2	-2.3*	1.7	1.9	3.5*	1.7	-1.4	n<5	-1.3				
		Total	24	27	484	82	1314	29	472	243	31	3716	6422			
<i>Sus</i>	Unburned	Count			9	<5	95	<5	11	13	<5	217	346	43.529	7	0.000
		AR			-3.7*	n<5	-0.8	n<5	-1.8	0.2	n<5	3.5*				
	Burned	Count			5	<5	11	<5	<5	<5	<5	10	32			
		AR			3.7*	n<5	0.8	n<5	n<5	n<5	n<5	-3.5*				
		Total			14	<5	106	<5	14	14	<5	227	378			
Tortoise	Unburned	Count	11	5	107	15	155	10	105	33	8	389	838	41.665	9	0.000
		AR	1.6	0.7	4.7***	1.6	1.0	-0.3	1.4	0.5	-0.3	-5.3***				
	Burned	Count	<5	<5	14	<5	58	5	35	12	<5	226	358			
		AR	n<5	n<5	-4.7***	n<5	-1.0	0.3	-1.4	-0.5	n<5	5.3***				
		Total	12	6	121	17	213	15	140	45	12	615	1196			

Total	Unburned	Count	197	55	1018	140	2552	67	916	552	66	5760	11323	75.201	9	0.000
		AR	5.5***	0.7	5.1***	-0.5	-1.8	-2.8*	-1.9	2.3*	0.0	-2.1*				
	Burned	Count	6	9	141	33	586	27	224	92	14	1286	2418			
		AR	-5.5***	-0.7	-5.1***	0.5	1.8	2.8*	1.9	-2.3*	0.0	2.1*				
		Total	203	64	1159	173	3138	94	1140	644	80	7046	13741			

Supplementary Table 6. AR of weathered bones in the east and west middens over time. AR value significance marked: \* =  $p < .05$ ; \*\*\* =  $p < .001$

Midden	Period		Not Weathered	Weathered	Total	Chi-Square Value	df	Asymptotic Significance (2-sided)
East Midden	EPPNB	Count	418	82	500	19.953	2	0.000
		AR	-1.0	1.0				
	MPPNB	Count			384			
		AR	-3.3*	3.3*				
	LPPNB	Count			275			
		AR	4.1***	-4.1***				
Total		Total	983	176	1159			
West Midden	No Date	Count	413	22	435	44.210	3	0.000
		AR	3.9*	-3.9*				
	E-MPPNB	Count	10	<5	10			
		AR	1.1	n<5				
	MPPNB	Count	1849	297	2146			
		AR	-5.9***	5.9***				
	LPPNB	Count	4029	426	4455			
		AR	1.1	n<5				
		Total		Count	6301	745	7046	

Supplementary Table 7. AR of burned fragments over time in the east and west midden assemblages. AR value significance marked: \* = p<.05; \*\*\* = p<.001

Midden	Period		Not Burned	Burned	Total	Value	df	Asymptotic Significance (2-sided)
East Midden	EPPNB	Count	445	55	500			
		AR	1.1	-1.1				
	MPPNB	Count	207	68	275			
		AR	-7.3	7.3				
	LPPNB	Count	366	18	384			
		AR	5.5	-5.5				
East Midden Total	Total	Count	1018	141	1159	61.341	2	0.000
West Midden	No Date	Count	404	31	435			
		AR	6.2	-6.2				
	E-MPPNB	Count	7	<5	10			
		AR	-1.0	n<5				
	MPPNB	Count	1709	437	2146			
		AR	-3.0	3.0				
	LPPNB	Count	3640	815	4455			
		AR	-0.1	0.1				
West Midden Total		Count	5760	1286	7046	43.430	3	0.000

**Supplementary Table 8. AR of fragments with dry and green fractures over time in the east and west midden assemblages (No fragments with new breaks included).** AR value significance marked: \* =  $p < .05$ ; \*\*\* =  $p < .001$

Midden	PPNB Period		Dry	Green	Total	Value	df	Asymptotic Significance (2-sided)
East Midden	Early	Count	13	64	77			
		AR	-2.0	2.0				
	Late	Count	16	34	50			
		AR	1.5	-1.5				
	Middle	Count	14	37	51			
		AR	0.7	-0.7				
East Midden Total		Count	43	135	178	4.204	2	0.122 (Not Significant)
West Midden	No Date	Count	14	77	91			
		AR	-2.7*	2.7*				
	Late	Count	246	563	809			
		AR	3.1 *	-3.1*				
	Middle	Count	103	322	425			
		AR	-1.8	1.8				
West Midden Total		Count	363	962	1325	12.425	2	0.002