



New perspectives on the use of kites in mass-kills of Levantine gazelle: A view from northeastern Syria

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ABSTRACT

A deposit of gazelle bones at Tell Kuran in the Khabur Basin of northeastern Syria provides evidence for the use of desert kites in the mass-slaughter of steppic game. The deposit's late 4th millennium BCE date, long after livestock had replaced game as primary meat sources, suggests that this practice was directed toward social rather than economic ends. Evidence for the use of kites in the mass killing of steppe animals in the Khabur Basin is examined and the possibility that not only gazelle, but also onagers and possibly other steppe animals' were hunted in this way is explored. The role of such socially driven practices in the local extirpation of steppe species is discussed.

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1. Introduction

World War I pilots were the first to record the presence of mysterious stone structures found in large numbers across the desert and steppe regions from the Arabian Peninsula to northeastern Syria (Legge and Rowley-Conwy, 1987, pp. 91). Though varied in form (Helms and Betts, 1987; Kennedy, 2011, 2012), these structures are generally constructed of low stone walls that define a semi-enclosed round or oblong structure with an opening on one side from which two long walls lead outward in a funnel-like shape (Fig. 1). Called “kites” because of their resemblance to the child's toy when viewed from the air (Rees, 1929), there have been multiple hypotheses proposed for their function – as fortresses built for the protection of herders and their livestock (Maitland, 1927; Rees, 1929; Kirkbride, 1946), as corrals used in the process of managing “semi-domesticated” animals (Echallier and Braemer, 1995), as structures used in water control (Helms, 1976), and even as having cultic functions (Eddy and Wendorf, 1999).

The most likely, and the most widely accepted, function for these structures is that they were used for the entrapment of wild game animals (e.g. Helms and Betts, 1987; Legge and Rowley-Conwy, 1987; Betts and Yagodin, 2000; Van Berg et al., 2004; Nadel et al., 2010; Bar-Oz et al., 2011a; Kennedy, 2011, 2012). Early traveler's accounts dating as far back as the 17th century document the use of these and other similar structures in game drives by local Bedouin tribes (Teixeira, 1604; Burckhardt, 1831; Barker, 1876;

Wright, 1895; Musil, 1928; Aharoni, 1946; see discussion in Legge and Rowley-Conwy, 2000, pp. 442–447). While a number of different game animals are mentioned in connection with the use of kites in mass-kills, including oryx and ostriches (Field, 1954), the most common target was gazelle, with reports of large migrating herds being driven into kites or kite-like enclosures and killed in the hundreds (Burckhardt, 1831, pp. 200–221; Aharoni, 1946, pp. 31–33, translated from the Hebrew by Meshel, 2000).

Today, gazelle persist in the region only as remnant populations, with all three species of Levantine gazelle listed on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List as threatened species at high risk of extinction. Once, however, these animals were ubiquitous, found in large numbers across the entire region – the mountain gazelle (*Gazella gazella*) in the low altitude, open woodlands and richer grasslands from Arabia to Syria (Mendelssohn et al., 1995), the smaller bodied, desert adapted Dorcas gazelle (*Gazella dorcas*) in the southern parts of the Arabian peninsula and North Africa (Yom-Tov et al., 1995), and the larger Persian or goitered gazelle (*Gazella subgutturosa*) thought to have once migrated across more steppic parts of the region from southern Arabia to eastern Turkey, and into Iran (Zhevnerov, 1984; Kingswood and Blank, 1996).

Prehistorically, from the Late Pleistocene up to the widespread adoption of domesticates in the Early Holocene, gazelle were the primary prey species of Levantine hunter-gatherers. Mountain gazelle were intensively hunted in the more humid parts of the southern Levant (Bar-Oz, 2004; Munro, 2004), and the Persian gazelle was the dominant prey animals in the more arid steppe from the eastern Jordan up through the middle Euphrates (Legge

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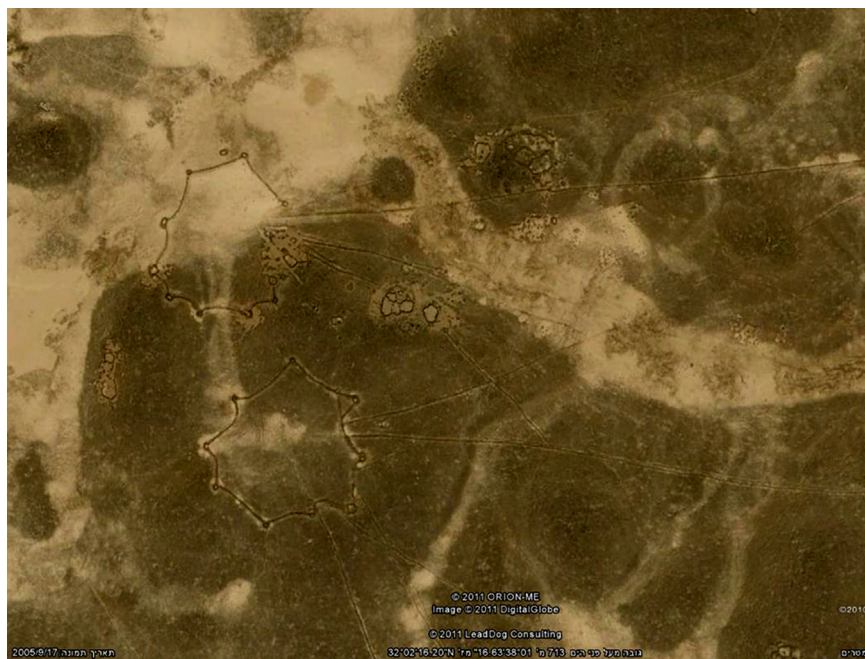


Fig. 1. Star-shaped kites in eastern Jordan. Photo Credit: Google Earth.

and Rowley-Conwy, 1987). The indiscriminant use of modern firearms in hunting gazelle, coupled with accelerated habitat loss, is often credited with delivering the final *coup de grâce* that pushed these, and other indigenous species, to (and in some cases over) the brink of extinction (Mendelssohn and Yom-Tov, 1999; Dolev and Perevolotsky, 2004; Tsahar et al., 2009). It is unclear, however, whether these more recent developments (especially the use of firearms) were the primary drivers of the extirpation of gazelle and other wild species in the Levant, raising the question of whether this was a more extended process that reaches back into ancient times. More specifically, one might ask what role did the use of desert kites (which number in the thousands across the entire range of these species) play in this process?

Answers to these questions have remained elusive for a number of reasons. First of all, dating the construction and use of kites (either by absolute methods or relative ones) has proven extremely difficult, making it hard to determine the dates, the duration, or the intensity of this practice. Perhaps even more of an impediment has been that, aside from ethno-historic descriptions of the use of kites in gazelle hunting in the recent past, there has been, until now, no firm archaeological evidence for a mass-kill of gazelle that can be tied to the use of kites. Here we offer such evidence that comes from the small fourth millennium BCE site of Tell Kuran on the banks of the Khabur River in northeastern Syria (Figs. 2 and 3). The fortuitous discovery of a deposit of gazelle bones at this site can be confidently attributed to a single mass-kill event that can itself be linked to the contemporary construction and use of nearby kites (Fig. 4). This single find, put in the context of the emerging picture of the construction and use of such structures across the region, provides special insight into the scope and the cultural parameters of mass-hunting in ancient times, as well as providing new insight into the role of mass-kill strategies using kites in the eventual extirpation of gazelle, and other steppe animals, in the Levant.

2. Previous studies

Researchers who have written about Levantine kites and their use in the mass-kill of gazelle can be grouped into two camps – 1) those who argue that the initial and most frequent use of these

strategies was coeval with periods in which gazelle were the predominant prey species in the Late Pleistocene and Early Holocene (c. 21,000–8000 years ago), and 2) those who argue that the widespread use of kites in the region occurred much later, from the 4th through the 1st millennium BCE (c. 6000–1000 years ago), well after domestic livestock had replaced gazelle as the primary source of animal protein. With one notable exception, those arguing for the early-use scenario base their case on patterning in archaeofaunal data held to be indicative of mass-kill strategies. The second, later-use camp, in contrast, relies entirely on the growing body of dates for kite construction obtained using a range of relative and, more recently, absolute methods.

2.1. The case for the use of kites in the Epipaleolithic and Neolithic Levant

As noted above, gazelle (especially mountain gazelle in more humid regions and Persian gazelle in the more arid steppe) were the primary prey species in the Levant throughout the Epipaleolithic (c. 21,000–11,500 cal BCE, Bar-Oz, 2004; Munro, 2004) up through their eventual replacement by domestic sheep and goats beginning in the region about 8000 cal BCE in the Jordan Valley and extending throughout the Levant by the Late Neolithic some 2000 years later (Martin, 1998; Horwitz et al., 1999; Munro, 2009; Sapir-Hen et al., 2009; Zeder, 2011). It is only logical, then, that early efforts at assessing the use of desert kites in the mass-kill of gazelle focused on these early Epipaleolithic through Neolithic periods when gazelle were the primary source of animal protein for foragers and transitional agriculturalists in the region.

In 1987, Anthony Legge and Peter Rowley-Conwy published an influential paper in *Scientific American* that argued for the use of desert kites in the mass-kill of gazelle near the settlement of Abu Hureyra in the Middle Euphrates Valley (Legge and Rowley-Conwy, 1987) (Fig. 2). Gazelle, likely predominately if not solely Persian gazelle, were the dominant prey species at this site during its initial occupation in the Late Natufian (c. 11,000–9500 cal BCE) and during the initial phases of the site's reoccupation in the early Middle Pre-pottery Neolithic B (PPNB, c. 7600 cal BCE). In their 1987 article and in a more extended treatment of the topic in 2000 Legge and

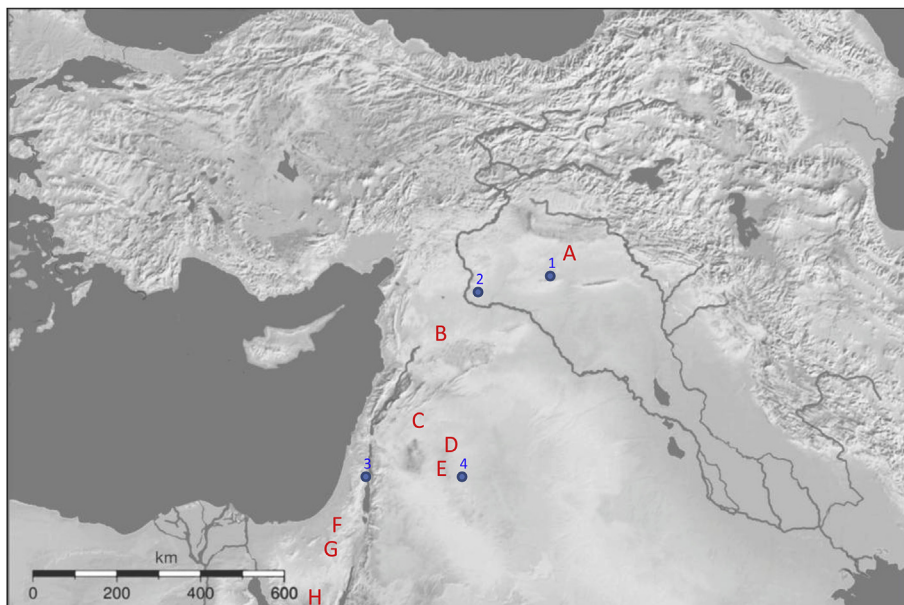


Fig. 2. Map of kite systems and archaeological sites mentioned in the text. A. Hemma Plateau, Van Berg et al., 2004; B. Central Syria, Echallier and Braemer, 1995; C. Southern Syria, Echallier and Braemer, 1995; D. Jawa, eastern Jordan, Helms and Betts, 1987; E. Azraq, eastern Jordan, Helms and Betts, 1987; F. Negev, Holzer et al., 2010; Nadel et al., 2010; G and H. Sinai, Eddy and Wendorf, 1999, Meshel, 2000; 1. Tell Kuran, Hole, 2001; 2. Abu Hureyra, Legge and Rowley-Conwy, 1987, 2000; 3. Salibiya I, Campana and Crabtree, 1990; 4. Dhuweila, Betts, 1998.

Rowley-Conwy relied primarily on indicators of strong seasonality in gazelle slaughter (as indicated by wear patterns and crown heights of deciduous teeth and by the fusion and thickening of the calcaneus) to argue for a targeted mass-kill of gazelle in the late spring (late April and early May) (Legge and Rowley-Conwy, 2000). This, they maintain, was the time of the year when large herds of Persian gazelle would be giving birth in the northern-most part of a hypothesized migration route that began in fall and winter breeding grounds far to the south in eastern Jordan and northern Saudi Arabia. Although they do not present a breakdown of the Abu Hureyra gazelle age profile (other than to say that the assemblage was comprised of 20–28% “infantile” gazelle, Legge and Rowley-

Conwy, 2000, pp. 452), Legge and Rowley-Conwy further argued that the representation of “every age group”, young and old, among the Abu Hureyra gazelle assemblage suggests a mass-kill strategy involving whole herds of animals, and not a targeted strategy focusing on individual, high yield animals (Legge and Rowley-Conwy, 1987, pp. 91). In addition, the even representation of all skeletal elements in the assemblage (mediated only by bone density) further suggests that the processing of whole carcasses took place at the site (Legge and Rowley-Conwy, 2000, pp. 453). Although no kite structures had been found near the site, they posited that the combined patterns of strong seasonality in the killing of whole herds of gazelle whose carcasses were processed

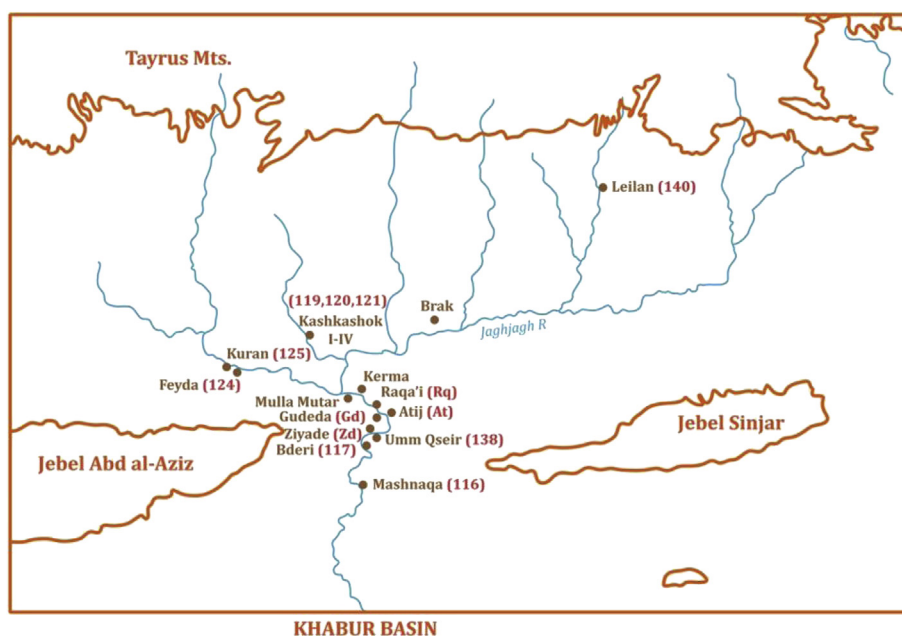


Fig. 3. Map of the Khabur Basin showing sites mentioned in text, see Table S1 for full names of sites.

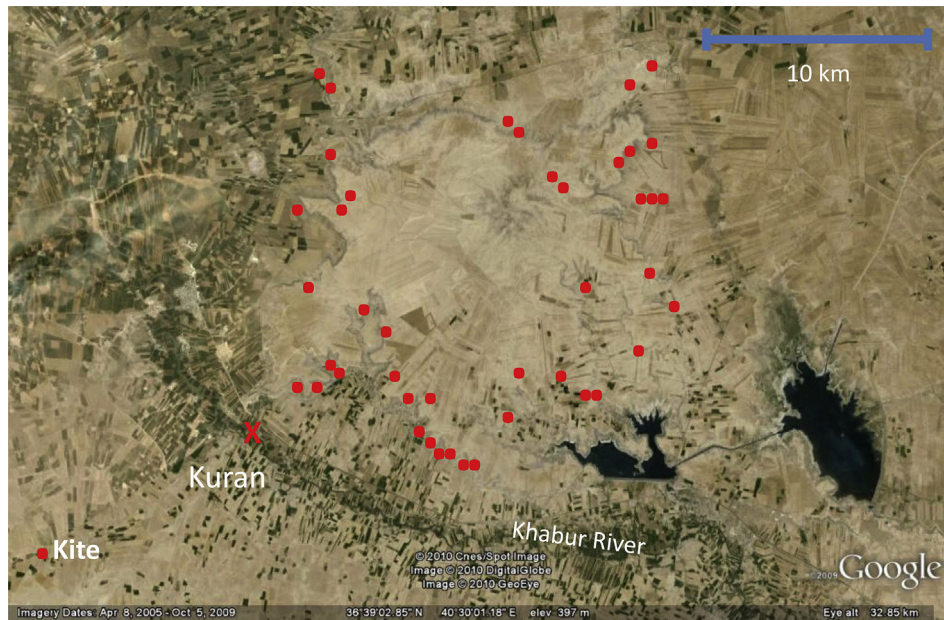


Fig. 4. Map showing location of Tell Kuran and Hemma Plateau kites, source Google Earth, Van Berg et al., 2008.

on-site all pointed to the use of nearby kites in the mass-kill of gazelle newly arrived in their spring/summer pastures.

In 1990 Douglas Campana and Pam Crabtree published an article that argued for the use of mass-kill strategies, this time focused on mountain gazelle, at the Late Natufian site of Salibiya I in the Jordan Valley (Campana and Crabtree, 1990). As in Legge and Rowley-Conwy's earlier study, their case for communal drives was based on patterning in archaeofaunal remains. Here the fact that gazelle comprised almost 90% of the large mammal assemblage from the site, along with the high proportion of juveniles (nearly 50% – though once again no finer breakdown of the age profile was given) were used to argue for the use of communal mass-kill strategies at Salibiya I, and, by extension, at other Natufian sites with similar archaeofaunal signatures in their faunal assemblages. Since no kites were found in the region, the authors proposed (following Henry, 1989, pp. 214) that Natufian hunters used nets in communal game drives that snared not only gazelle in great numbers, but also a diverse array of other species (hares, birds, tortoises, lizards, and foxes) (Campana and Crabtree, 1990, pp. 233).

In contrast, Helms and Betts (1987) based their argument for the early use of desert kites in gazelle mass-kills on the association of the remains of what they interpret as the guiding walls of a 'kite' [original quotation marks] incorporated into Late PPNB (c. 6500 cal BCE) structures at the site of Dhuweila in eastern Jordan – a site that lies on a line of chained star-shaped kites (Helms and Betts, 1987, pp. 47, Figs. 5 and 6). Another nearby Late PPNB site is also said to have structures that are built into the guiding walls of kites in the same kite system. The recovery of Beidha and Byblos type projectile points (common in later PPN contexts in the Levant) along with other point types found in Late PPNB through 5th millennium contexts from an unspecified number of star-shaped kites (type D in their typology) is also marshaled as support of a Late PPNB date for this ubiquitous type of kite. Found in large numbers in all three areas included in their ambitious survey of the 'panhandle' region of eastern Jordan (the Dhuweila, Jawa, and the Azraq regions), star-shaped kites are frequently arrayed in "chains" of linked and overlapping kites oriented in a single direction along topographic features that might be used as an aid in the ambush and driving of gazelle. The ubiquity of these type D kites in eastern Jordan, and in other parts of the desert steppe from Saudi Arabia into Syria, led Helms and Betts to suggest

that the Late Neolithic represents a kind of apogee in the use of these structures in the mass-kill of Persian gazelle. Based on the architectural associations between these temporally anchored type D star-shaped kites and other types of kites in their typology, Helms and Betts present a hypothetical chronology that puts the construction and use of their types A–C from about 10,000 years ago to about 7500 BCE, their type D from about 7500 BCE to circa 4500 BCE. Types E through I (which are often found oriented in different directions isolated from one another) are thought to represent later use of these structures in mass-kills, based once again on architectural associations with dated settlements, from the 4th millennium BCE to the Roman era (Helms and Betts, 1987, pp. 54).

Louise Martin's analysis of the animal remains from Dhuweila finds that gazelle (most likely Persian gazelle) comprise nearly 90% of the faunal assemblages from both the earlier Middle PPNB levels at the site (c. 7900 cal BCE), as well as the Late PPNB levels (c. 6500 cal BCE) that are said to have been built over and into the walls of pre-existing kites (Martin, 1998). Juvenile animals less than 18 months old are well represented in both earlier and later levels at the site, rising from 38% of the ageable gazelle in earlier levels to more than 50% of those from Late PPNB levels. Seventeen percent of the Late PPNB gazelles were culled before they reached two months of age, compared to 12% in the earlier levels. Proportions of males and females, determined by metric analysis of astragali, are roughly equal in both levels. Based on the low numbers of phalanges recovered relative to other skeletal elements, Martin suggests that lower legs of gazelle may have been removed from the site, perhaps during the skinning process, with the rest of the carcass processed at the site of consumption rather than the kill site (Martin, 1998, pp. 170). These are generally the same patterns that Legge and Rowley-Conwy, as well as Campana and Crabtree, interpreted as evidence for mass-kill strategies using kites or other communal hunting techniques.

Martin, however, takes a more cautious approach. In her 1998 report on the Dhuweila faunal remains, and in a later paper on the behavioral ecology of gazelle (Martin, 2000), she maintains that while mass-kill strategies using nearby kites might have been employed at Dhuweila, the patterning in her data does not unequivocally support a mass-kill hypothesis. Instead, she suggests that the age and sex patterns she observed in this assemblage might be better interpreted as a palimpsest of different encounters with

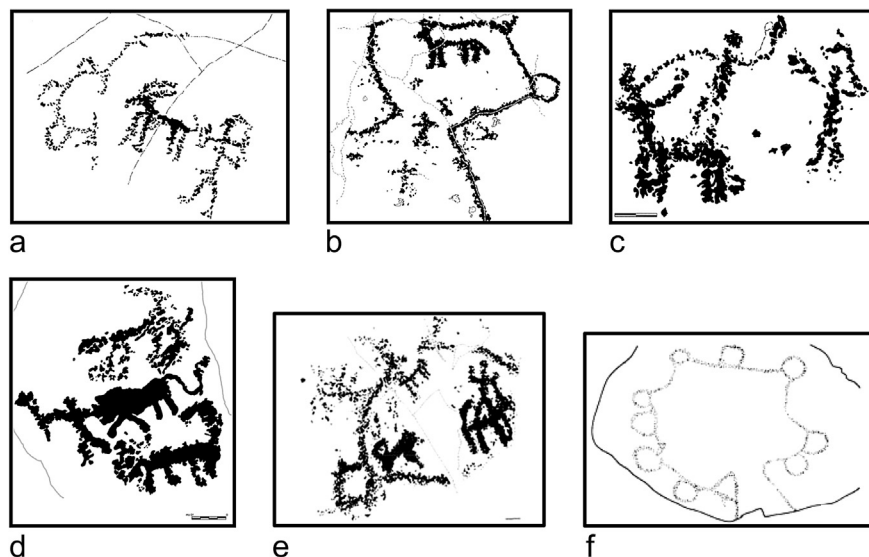


Fig. 5. Petroglyphs of desert kites. a) bird(?)—headed man driving Persian gazelle into a kite, Hemma Plateau, Van Berg et al., 2004; b) possible onager in a kite, Hemma Plateau, Van Berg et al., 2004; c) human with mace (?) riding bull, Hemma Plateau, Van Berg et al., 2004; d) human with mace capturing a lion, Hemma Plateau, LeMaitre and Van Berg, 2008; e) human with mace riding a quadruped (canid?) with a dog, Hemma Plateau, Van Berg et al., 2004; f) star-shaped kite identical to kites representation in Hemma Plateau, Jawa, eastern Jordan, Betts and Helms, 1986.

gazelles over many seasons. Mixed herds comprised of all ages and sexes would have been encountered in the winter, young males from bachelor herds in winter and spring, while females and new-borns would have been abundant in the spring/early summer. The

resulting prey profile would resemble the composition of a living herd in the complete absence of mass-kill strategies. She goes on to question Campana and Crabtree's argument for mass-kill of mountain gazelle in the Natufian on similar grounds, maintaining that this pattern might instead reflect the fluid nature of gazelle herd demographics that vary throughout the year. Based on her understanding of gazelle behavior (drawn from an impressive compilation of the zoological literature on all three species of gazelle found in the Levant), she suggests that gazelle under presumably "lush" vegetation conditions of the Natufian would have been too widely dispersed to have been driven into nets in large numbers. It is important to note here, however, that, based on more recent paleo-environmental data, the Late Natufian period to which this site belongs may have seen a decline in forage availability due to the Younger Dryas climatic downturn (Munro, 2004; Stutz et al., 2009). Martin also questions Legge and Rowley-Conwy's hypothesis that the gazelle at Abu Hureyra migrated over long distances, leaving fall/winter breeding grounds in areas like the Dhuweila region to travel several thousand kilometers to the Middle Euphrates where they give birth in the late spring/early summer. Based on her review of the literature on modern gazelle behavioral ecology, she concludes that small bodied gazelle, like those found at Dhuweila, are unlikely to engage in long distance migrations. She also questions why, following Legge and Rowley-Conwy's migration hypothesis, gazelle would leave the Middle Euphrates during the hot and dry summer months for even more arid areas to the south (Martin, 2000, pp. 28).

2.2. The case for the use of kites in later periods

While acknowledging the possibility that use of these structures began in the Neolithic, other, more recent, studies of Levantine kites are finding mounting evidence that the construction and use of kites in the region occurred considerably later. This work has focused on kites in Syria that can be seen as an extension of the kite system documented by Helms and Betts (1987) in eastern Jordan, as well as another system of kites found in the southern Negev desert and the Sinai.

2.2.1. Syrian kites

Echallier and Braemer's survey of roughly 500 km² in the central and southern Syrian Desert found more than 500 kites,

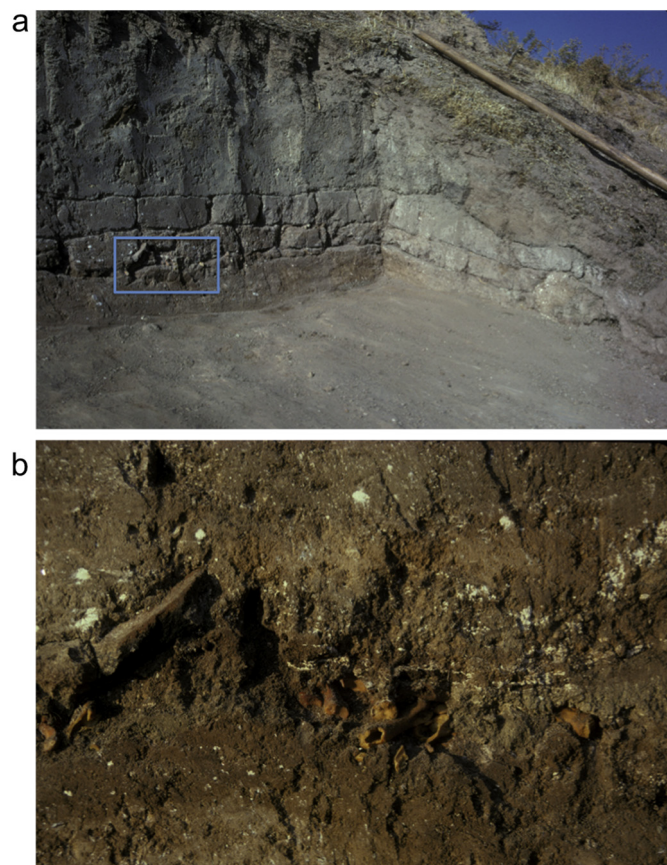


Fig. 6. Tell Kuran Gazelle Deposit. a) cut into south face of Kuran showing location of gazelle deposit under 4th millennium building, rectangle shows location of close up in b; b) close up of Gazelle Deposit showing phalanges extending into unexcavated area, Photo Credit: Frank Hole.

both isolated and in conjoined chains, similar in density and types to those found by Helms and Betts some 400 km to the south in eastern Jordan (Echallier and Braemer, 1995). As in the earlier Helms and Betts study, star-shaped kites (often in chains) were the most common type encountered, but Echallier and Braemer also found the full range of trapezoidal, circular, arrow shaped, and other types similar to those found in large numbers to the south (Echallier and Braemer, 1995, pp. 42–47). As in Jordan and northern Saudi Arabia, the kites in Syria were also built in strategic locations that took maximum advantage of the typography, with guide walls opening toward wadis and depressions that would facilitate taking herds of pasturing animals by surprise and driving them into enclosures.

Datable material associated with kites across the region (either architectural relationships to dated structures or the presence of distinctive lithics or ceramics) uniformly point to the end of the 4th millennium BCE or the Chalcolithic period (6000 years ago) up through the 3rd millennium BCE Early Bronze Age as the primary (if not sole) periods represented. These researchers found no evidence for more ancient kite use stretching back into the Neolithic, although they do not deny that this may be the case (Echallier and Braemer, 1995, pp. 55). They do, however, question the dating of the Dhuweila 'kites' arguing that both the interpretation of these structures as kites and their relationship to the Late Neolithic structures at the site is open to question (Echallier and Braemer, 1995, pp. 54). They also note that their later chronology for the use of kites in this region agrees with Helms and Betts' dates for kites in the Jawa region which, by architectural associations, are dated to the 4th millennium BCE (Helms and Betts, 1987, pp. 50).

Farther to the north, in a survey of the basaltic Hemma plateau in the Khabur Basin of northeastern Syria, a team from the Free University of Brussels, Belgium found more than 50 large, "monumental", kites. The kites on the Hemma Plateau had enclosures of various different shapes, both polygonal and round, though none were arrayed in chains like those found in southern Syria and eastern Jordan (Van Berg et al., 2004, 2008) (Fig. 4). Datable materials were not recovered from any of these structures, although the use of stones from kites for the construction of buildings dating to the Neo-Assyrian period (1st millennium BCE) is cited as a *terminus ante quem* for their use (Van Berg et al., 2004, pp. 91).

Evidence for the dating of these kites comes instead from their association with over 3000 rock art carvings found in surveys of the northern, western, and southwestern edges of the plateau (Fig. 5) (LeMaître and Van Berg, 2008). Many of these carvings show what can only be interpreted animals being driven by humans (sometimes assisted by dogs) through the long guiding wall arms of the kite into round or rectangular enclosures ringed with small circular niches or blinds. At least one of these carvings clearly shows a Persian gazelle with its lyre-shaped horns being driven into a kite by a bird(?)—headed man holding a weapon (Fig. 5a). Others show larger quadrupeds that, based on their long ears and strait tails, might be best identified as onager (Fig. 5b, interpreted by Van Berg et al. (2004) as a cow, pp. 94).

The bird-headed man is not the only mythical creature depicted in these carvings. Several of these kite scenes are associated with figures with clear parallels to "well-known Mesopotamian iconography" (Fig. 5c–e). These include human figures holding objects resembling maces riding on the backs or holding of animals (bulls, lions, and possibly dogs). These animals, in turn, can be associated with the attribute animals of various Mesopotamian gods – the bull related to the storm god Adad, the lion with Ishtar or Ningirsu, and the dog with the goddess Gula (Van Berg et al., 2004, pp. 96). These figures, the authors argue, find direct parallels with Mesopotamian glyptic art and ceramic decoration dating to the 3rd millennium

BCE (LeMaître and Van Berg, 2008, pp. 11), leading them to conclude that the rock art, and the kites that they depict, are best dated to the 4th through the 3rd millennium BCE (Van Berg et al., 2004, pp. 97).

Van Berg et al. (2004) also find parallels between the rock art depictions of kites on the Hemma Plateau with those recorded by Betts and Helms in the Azraq Basin part of the Jordan survey (Betts and Helms, 1986). Numerous rock carvings from this region depict kites of the same form seen in the Hemma carvings (Fig. 5f), interpreted by Betts and Helms as depictions of their star-shaped kites. One of these kite carvings shows three ostriches (an animal attested in 4th millennium faunal assemblages from Jawa) being driven into the kite, with one ostrich inside the enclosure and two in its neck (Betts and Helms, 1986, pp. 71; Betts, 1989). The close similarity between the rock art carvings in the Hemma Plateau of northeastern Syria, and the Azraq Basin of eastern Jordan, lead Van Berg et al. to suggest that these carvings (and the kites they depict) are contemporary, made, perhaps, by the same nomadic population (Van Berg et al., 2004, pp. 97).

2.2.2. Southern Negev and Sinai kites

Though far less numerous than in the Trans-Jordanian and Syrian deserts to the east, kites have also been found in both the Negev desert and Sinai Peninsula (Meshel, 1974, 2000; Eddy and Wendorf, 1999; Holzer et al., 2010; Nadel et al., 2010; Bar-Oz et al., 2011a). More dispersed over the landscape, kites in these regions consist of long (usually more than 100 m) guiding walls that lead to comparatively smaller rounded enclosures (c. 10–15 m wide) or traps. In some kites ramps were built leading up to the mouths of these traps "to enhance the enclosure's depth and to hide the head of the trap from the eyes of the driven game" (Nadel et al., 2010, pp. 6). As in Jordan and Syria, kites in this region are also constructed to take advantage of the landscape, built in wadis or natural depressions with arms opening into areas that would have served as pasture areas for wild herd animals (Bar-Oz et al., 2011a).

The smaller size of the kite enclosures in the Negev and Sinai, their more dispersed locations, and the lack of the large chained kite systems can all be tied to the kinds of wild herd animals likely to have been hunted in this region. Gazelle species native to the Negev and the Sinai include the mountain gazelle (at least until the early Holocene, Tchernov et al., 1987) and the desert-adapted Dorcas gazelle found in the region today. Neither species is known to have migrated any great distances, as Persian gazelle have been hypothesized to do. Both species also tend to form much smaller groups, typically comprised into small herds of females, their young, and a single male, and equally small herds of bachelor males (Mendelssohn and Yom-Tov, 1999; Martin, 2000). Persian gazelle, in contrast, have been reported to congregate in mixed herds of over 1000 animals in certain seasons of the year (Zhevnerov, 1984, cited in Martin, 2000, pp. 24). Other indigenous species that may have been susceptible to such hunting techniques include the Arabian oryx (*Oryx leucoryx*), the bubal hartebeest (*Alcelaphus bucelaphus*), onagers (*Equus hemionus*), and ostriches (*Struthio camelus*). Most of these species are no longer found in the region today, but their presence in the Negev and Sinai until the arrival of firearms at the end of the 19th century is attested in rock art, in faunal assemblages, and in travelers accounts (Tsahar et al., 2009; Holzer et al., 2010, pp. 813–815).

Significant progress has been made in fixing the chronology of the Negev and Sinai kites using both relative and absolute dating techniques. Excavations by two different teams have found that the initial construction and use of two nearby kites in the southern Negev, the Samar East and West kites, both date to about 3000 cal BCE. Both teams also obtained radiocarbon dates of about 2500 cal BCE for structures overlaying the kites, thus marking the time when

these structures fell out of use. IRSL (infrared stimulated luminescence) dates of fill around and under stones forming the pit of one of these kites obtained by the [Holzer et al. \(2010\)](#) are consistent with a 3000–2500 cal BCE time span for the use of this kite. These

were the primary source of meat protein for foragers and early agriculturalists in this region. Both direct and relative dating of the kites themselves, however, provide little evidence of an early date for the use of kites at this time.

Table 1
Compilation of Dates of Levantine Kites.

Kite system	Location	Date	Context	Dating method	Source
Dhuweila	Eastern Jordan	7th mill. BCE	In use	Association with architecture	Helms and Betts, 1987
Dhuweila	Eastern Jordan	7th–5 th mill. BCE	In use	Lithics	Helms and Betts, 1987
Jawa	Eastern Jordan	Mid-4th mill. BCE	End of use	Association with architecture	Helms and Betts, 1987
K3	Southern Syria	Beginning 2nd mill. BCE	End of use	Association with architecture	Echallier and Braemer, 1995
K9	Southern Syria	End of 4th mill.–beginning of 3rd mill. BCE	In use	Association with architecture and Lithics	Echallier and Braemer, 1995
Hemma Plateau	Northeastern Syria	4th–3rd mill. BCE	In use	Iconography of rock art	Ven Van Berg et al., 2004
Negev	Southern Negev, Israel	4th mill. BCE	In use	Lithics	Avner et al., 1994
Samar East	Southern Negev, Israel	4th–3rd mill. BCE	In use to end of use	Radiocarbon, IRSL, Lithics	Holzer et al., 2010
Samar West A	Southern Negev, Israel	Early 3rd mill. BCE	End of use	Radiocarbon	Nadel et al., 2010
Samar West A	Southern Negev, Israel	5th–3rd mill. BCE	In use	Lithics	Nadel et al., 2010
Samar West B	Southern Negev, Israel	Early 3rd mill. BCE	End of use	Radiocarbon	Nadel et al., 2010
Samar West B	Southern Negev, Israel	5th–3rd mill. BCE	In use	Lithics	Nadel et al., 2010
Har Shahmon	Southern Negev, Israel	2nd mill. BCE	End of use	Radiocarbon & IRSL	Holzer et al., 2010
Har Shahmon	Southern Negev, Israel	4th mill. BCE	In use	Artifacts – lithics	Holzer et al., 2010
Jebel Hamra	Northeastern Sinai, Egypt	4th mill. BCE	In use	Radiocarbon	Eddy and Wendorf, 1999
Sinai	Sinai, Egypt	4th mill. BCE	In use	Ceramics and Lithics	Rothenberg, 1979
Aralo-Caspian	Central Asia	Mid-1st mill. BCE–14th cent. CE	In use	Ceramics	Betts and Yagodin, 2000

dates are also in line with relative dates based on artifacts recovered within and around the kites. Lunates are found in association with both Samar kite pits. Although these tools first appear in the Late Epipaleolithic and Neolithic, they are well documented in other desert sites dating from the 5th to the 3rd millennium BCE ([Rosen, 1997](#) cited in [Holzer et al., 2010](#), pp. 813; [Nadel et al., 2010](#), pp. 9). In addition, pottery and a copper awl recovered from the overlaying structure in one of these kites can be dated to the 5th through the 3rd millennium BCE, once again consistent with the radiocarbon dates from this structure ([Holzer et al., 2010](#)). Radiocarbon and IRSL dates for another kite in the southern Negev obtain by [Holzer et al.](#) point to a somewhat later date of about 1700 cal BCE for its construction and use, although ceramics from within the pit just above bedrock that date to the 4th millennium BCE. The final date for the use of this kite is set by radiocarbon dates from two intrusive burials of about 1500 cal BCE ([Holzer et al., 2010](#), pp. 813). Three radiocarbon dates from a kite in the northeastern Sinai obtained by [Eddy and Wendorf \(1999, pp. 176–177, 278–281](#) cited in [Holzer et al., 2010](#), pp. 813) put its use at about 3200 to 3100 cal BCE. All of these studies agree, then, that the Negev and north-eastern Sinai kites were likely first established in the 4th, and perhaps the 5th millennia BCE “with the most intensive use during the 3rd millennium BCE, followed by ...cessation in their use toward the late 3rd millennium BCE” ([Holzer et al., 2010](#), pp. 813).

Based on these dates, [Holzer et al. \(2010, pp. 813\)](#) go on to conclude that the “Negev–Sinai desert kites ...were a relatively late and probably short-lived phenomenon”. And yet, when all the various dates (absolute and relative) for kites across the Levant are compiled together ([Table 1](#)), it becomes quickly apparent that the dates obtained for Negev–Sinai kites are in agreement with the majority of dates given for kites from the Syrian and Jordanian desert/steppe regions. In fact, the only kites dated to earlier periods are those from the Dhuweila region studied by [Helms and Betts \(1987\)](#), dates that are based on (contested) architectural associations with two Late Neolithic sites, as well as the association of Late PPNB projectile points with an unspecified number of kites. It remains entirely possible that the use of kites and mass-kill strategies stretches back into the Neolithic or earlier, periods when gazelle

Evidence for mass-kills based on gazelle assemblages from these early sites, moreover, may not be as clear-cut as earlier researchers had argued. Assemblages from Abu Hureyra and Salibiya I, for which mass-kill arguments have been made, represent the accumulation of many hunting forays over hundreds of years. So it is hard to say whether demographic signatures resembling a catastrophic kill of a herd generated by such assemblages truly represent the use of mass-kill strategies or, as [Martin \(2000\)](#) has argued, many different hunting forays reflecting the variable herd structures of gazelles over the course of a year. Moreover, the large numbers of juveniles that some researchers have interpreted as an indicator of the capture of entire herds of animals in certain seasons of the year, is interpreted by others as a signal of demographic shifts in herd composition due to intensive hunting ([Munro, 2004](#)). Seasonality signals may simply mean that animals were targeted in certain seasons of the year, without saying much about whether they were taken in communal drives or more targeted hunting forays.

Instead of the apogee of kite use coming in the Neolithic as might be expected, the preponderance of evidence now indicates that the most intensive use of kites across the entire Levant – from the Sinai to northeastern Syria – was in the 4th through the 3rd millennium BCE. There is, then, a disjunction between the period of greatest gazelle predation (Epipaleolithic through Neolithic) and the most intensive period of kite construction and use (4th through 3rd millennium BCE) – periods when people relied primarily on domestic livestock and hunting seems to have been only a supplementary source of animal protein. It is for perhaps this reason that [Echallier and Braemer](#) proposed the unlikely hypothesis that “kites were erected by pastoralists in order to capture and eventually corral herds of possibly semi-domesticated animals” (translated from the French, [Echallier and Braemer, 1995](#), pp. 35; see [Rosen and Prevolotsky, 1998](#) for a counter argument). But without a clear linkage between these kites and contemporary faunal data that can be clearly shown to be the result of mass-kill strategies using kites, it has proven hard to understand how these kites were truly used and how they figured into the pre- and early-urban societies that were developing in the region at this time. The gazelle bone deposit from Tell Kuran in the Khabur Basin sheds important new light on the role

of kites in the mass-kill of gazelle and their role in the extirpation of gazelle, and perhaps other steppe species, in the Levant.

3. Tell Kuran Gazelle deposit

Located on the banks of the Khabur River, this small quarter hectare site was excavated by Frank Hole in the early 1990s as part of a project that sampled midden deposits from a wide range of sites in the Khabur Basin to document changes in subsistence and environment in the region over time (Fig. 3; Hole, 2001). Several small cuts were made into the mound where ash layers could be seen (Fig. 6a). Excavation of an area of some 2 m² over a depth of 10–15 cm revealed a dense mass of gazelle bones (Fig. 6b). This deposit lay on a compact, essentially flat surface and was sealed above by a layer of mud bricks of a subsequent phase of building construction, which occurred, according to the condition of the bones, shortly after the bones were deposited. No attempt was made to dig beyond the small area where the bones were first encountered, and it is likely that this deposit extends further into the mound. It is also probable that at least some of the deposit had eroded down the slope and into the river. Neither the nature of the surface on which the gazelle remains were deposited (indoor vs. outdoor) nor the function of building erected on top of the deposit could not be discerned given the small scale of the excavations at the site.

During excavation, it became clear that this was a unique deposit. Typically, archaeological middens that accumulate as a result of intermittent deposition of refuse (including other midden contexts sampled at Kuran) contain a mix of faunal species and body parts along with bits of pottery, stone tools, plant material, ash, and construction debris. The Kuran bone deposit, in contrast, held nothing but bones. The date of the deposit was established by tracing the stratum for some meters horizontally to where it contained both diagnostic ceramics and charred material, which yielded two radiocarbon dates of 4710 ± 60 (3631–3353 cal BCE) and 4625 ± 70 (3101 cal BCE) (Hole, 2001). Subsequent study of the bones recovered from this special context by one of us (GBO) provided a compelling argument for this being a single episode deposit of the remains of a mass-kill hunting event of a mixed, and likely migrating, herd of Persian gazelle (Bar-Oz et al., 2011b).

3.1. Species composition

The deposit consists of 2649 skeletal elements, 99% (2631 elements) of which are remains of gazelle, identified on the basis of horn morphology as Persian gazelle. Also included in the deposit were a few isolated bones of cattle (*Bos taurus*, 2 elements), pigs (*Sus scrofa*, 4 elements), equids, (most likely *Equus hemionus*, 2 elements), and bones that could only be identified as sheep or goat (*Ovis aries* or *Capra hircus*, 10 elements), all of which may be intrusive from matrix either above or below this densely packed deposit of gazelle bones. Just on species composition alone this deposit stands in sharp contrast to other 4th millennium deposits from the Khabur, including those from Kuran, studied by two of us (MAZ and SJR) which have a much more diverse mix of species, dominated by domesticates (Table S1) (Zeder, 1995, 1998, 2003; Rufolo, 2012).

3.2. Taphonomy

Key taphonomic variables recorded for this assemblage (Table S2) all point to a minimum of *in situ* bone attrition. Preservation of elements in the deposit is excellent, with porous and low-density elements of both immature and adult animals well represented. High frequency of green bone fractures (at 78% of the broken bones from the deposit) also points to minimal post-depositional breakage. Indications of trampling, weathering, and root etching

are very low, with only 3% or less of the bones recovered showing evidence of any of these post-depositional agents of bone destruction. While dogs may have had some access to the discarded bones, the relatively low proportion of bones showing evidence of carnivore gnawing (less than 10%) indicates that carnivores were not a major agent in bone destruction or removal. All of these indicators suggest that the bones were buried soon after deposition and subjected to minimal post-depositional disturbance or attrition.

3.3. Element distribution

The majority of skeletal elements in the assemblage (77%) are from non-meaty lower foot elements (first, second, and third phalanges) with a MNI of 93 individuals represented by 879 first phalanges (Table S3, Fig. 7). Other elements are also represented however, including a number of higher meat yield scapula and some other limb elements, as well as axial and cranial elements. The diversity of elements argues against the possibility that the deposit represents the remnants of a number of gazelle skins with lower foot bones and hooves still attached. Instead, the distribution of skeletal elements strongly suggests that the Kuran Gazelle deposit represents the discard of low-utility elements after an initial stage in the butchery in which the animals were skinned and partially dismembered. Higher utility elements were apparently removed to another location for further processing and consumption. At less than 1%, the low frequency of cranial elements, another relatively low utility element, may mean that these elements were removed with other elements, or perhaps left at the kill site.

This pattern stands in dramatic contrast with the assemblage from Abu Hureyra in which all body parts are reported to be more or less evenly represented (Legge and Rowley-Conwy, 2000, pp. 453–454) – a pattern expected in a midden deposit comprised of an amalgam of butchery and consumption practices accumulated over a long period of time. The Kuran element distribution is also the

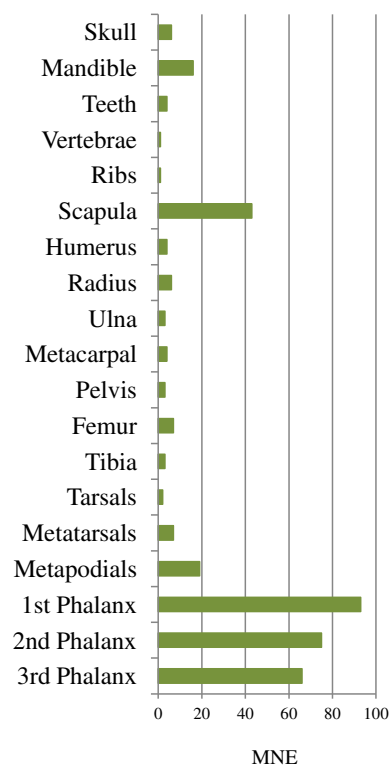


Fig. 7. Distribution of gazelle elements in Kuran Gazelle Deposit, MNE = minimum number of elements, NISP = 2631, see Table S3.

reverse pattern from that reported by Martin (1998, pp. 170) for the Dhuweila gazelles, in which phalanges are poorly represented – a pattern interpreted to as evidence for the removal of lower leg bones during skinning and initial butchery. It is also interesting to note that Loyet (1999) observed a similar carcass-processing pattern in the modern town of Hasseke in the Khabur Basin, which begins with the removal and disposal of lower feet at the slaughter house, followed by the transport of other elements – heads, axial elements, and more meaty limb elements – to market for further processing.

3.4. Butchery techniques

Butchery practices seem to have been relatively standardized, with many of the marks redundantly made in the same location on various elements. Butchery scars associated with skinning are, not surprisingly, the most common, followed by those associated with dismembering (Table S4, Fig. 8). The presence of filleting scars on some of the scapula suggests that meat was stripped off of the blade of this element during initial butchery. The ease with which meat can be removed from the flat blade of the scapula, especially when compared to meat removal from other limb elements, is perhaps why some number of this higher meat yield element (158 NISP, 43 MNI) was discarded with these other low utility bones.

Butchery scars associated with skinning were especially common on first phalanges, often leaving deep and wide scars on the dorsal and plantar surface of these elements in a transverse orientation relative to the axis of the phalanx (Fig. 9). A higher frequency of skinning marks on phalanges rather than on metapodials has been associated with the processing of skins (Binford, 1981). Historically, gazelle skins were highly prized by Bedouin who used them to make clothing and bags to hold water and fermented milk (Betts, 1987). It is likely, then, that along with meat, gazelle skins were also removed from this initial butchery site for further processing.

The depth and the orientation of the marks on the first phalanges also suggest that skinning and initial butchery were



Fig. 9. Butchery scars on plantar surfaces of first phalanges. Photo Credit: Adam Watson.

performed on animals that had undergone some degree of *rigor mortis*. In full *rigor*, the joints of animals become entirely immobile, requiring a great deal of force to remove meat from the bone resulting in more numerous and deeper butchery scars such as seen on the Kuran first phalanges (Lupo, 1994). *Rigor* usually sets in fairly quickly in animals, resolving sometime afterward depending on temperature. The time between a carcass reaching full *rigor* and the resolving of *rigor* is shorter in smaller and younger animals (Saladin, 2010). The depth of the butchery scars on the first phalanges suggests that the Kuran gazelle were butchered sometime after the initial kill (likely three to four hours after death), but before *rigor* had been resolved (probably around 12 h after death). This further implies that the kill-site and the site of initial butchery were some distance apart, but not so far apart that *rigor* would have resolved in the carcasses brought back to the site.

3.5. Demography

Age profiles for the Kuran gazelles were computed on the basis of both long bone fusion and dental eruption and wear following Munro et al. (2009) (Tables S5–S6). Both indices suggest that young animals under seven months of age comprise about 20% of the gazelle in the assemblage, with the rest of the assemblage made up of juvenile and prime-adult animals, along with a smaller proportion of older individuals. Grouping the finer resolution dental ages into categories of young (0–1.5 years), prime adult (1.5–8 years), and old adult (greater than 8 years) animals (Fig. 10, Table S7), we see that the age structure of the Kuran gazelle is dominated by juvenile and prime adult animals (at 41% and 49% respectively), with few old adults (10%). This age profile closely mirrors both a theoretical ungulate living structure model (Lyman, 1987; Stiner, 1990, Table 1), as well as the catastrophic age profile of elk killed in the volcanic eruption at Mt. St. Helen's (Lyman, 1987; Stiner, 1990, Table 1). This pattern is, in contrast, strikingly different from an attritional U-shaped profile from a natural die-off, which would be dominated by very young and very old animals (Stiner, 1990, Table 6). It is also different from a targeted hunting strategy that would focus primarily on prime adult animals (Stiner, 1990, Table 9).

Dental ages of young animals provide an indication of the season of kill. Of the six mandibles belonging to animals under one

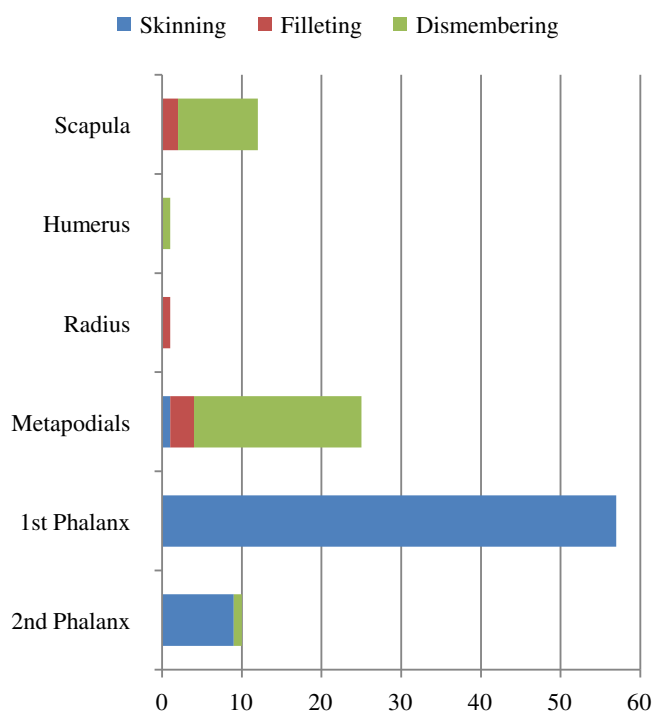


Fig. 8. Number and types of butchery scars by gazelle element in Kuran Gazelle Deposit, NISP = 108, see Table S4.

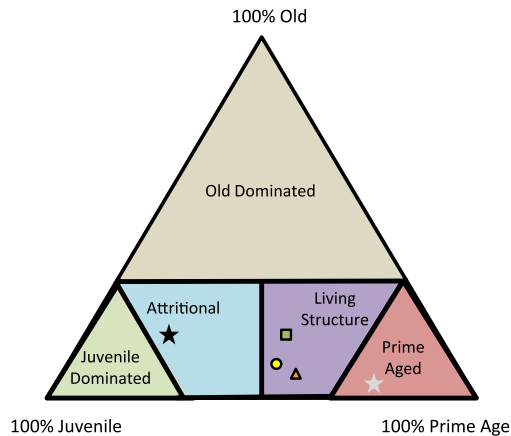


Fig. 10. Triangular plot showing the age profile of Kuran Gazelle Deposit (circle) divided into three age classes (young, prime-age adult, and old adult) compared with a model profile of a living herd (square); a catastrophic profile from St. Helens (triangle); an attritional profile (black star), and a prime adult prey profile (grey star). From Chapman and Chapman (1975); Smith (1975), Lyman (1987) and Stiner (1990). Data in Table S7.

year of age, three fall into the 3 month age category and three into the early parts of the following 3–7 month age category, (c. 3–5 months of age). Assuming a birthing season of April and May, as in gazelle in Iraq today (Habibi et al., 1993), this would indicate that these animals in the sample were killed during mid- to late-summer. If the three youngest animals were born at the end of the birthing season (late May) and the older ones at the beginning of the season (early April), this puts the season of kill in August.

Three different indices were used to compute the proportions of males and females in the assemblage: horn core and scapula morphology, and the measurements of the second phalanx (following Munro et al., 2011) (Table S8). All three indices indicate a roughly even representation of males and females, with the more reliable measures of the three – the scapular morphology and the second phalanx measurements – indicating that females were slightly better represented than males.

Taken together, the demographic data for the Kuran gazelle assemblage points to a catastrophic kill of a mixed herd of males and females of all ages. This pattern is consistent with the demography of Persian gazelle during seasonal migration (Habibi et al., 1993; Kingswood and Blank, 1996; Lhagvasuren and Milner-Gulland, 1997; Martin, 2000). The likely late summer date of this catastrophic kill, following Legge and Rowley-Conwy's (1987, 2000) reconstructed seasonal migration of Persian gazelle, points to the beginning of the fall migration when segregated herds of bachelor males and females with young come together to begin their fall migration to breeding grounds to the south.

As we have seen, Martin has questioned whether Persian gazelle in the Levant engaged in such a long distance migration, wondering why gazelle would leave one hot-dry area for another (Martin, 2000, pp. 22–23). One might as easily question, however, why gazelle capable of migrating long distances, as Persian gazelle have been documented to do, would remain in the southern reaches of their range during the hottest and most arid months of the year. Current weather records for Jordan show increases in temperature and aridity that begin in March and peak in August – temperature extremes that are greater than parallel seasonal increases in temperature and aridity in northern Syria (Woolfenden and Ababneh, 2011). If Persian gazelle once followed the migratory route hypothesized by Legge and Rowley-Conwy, they would arrive in northern Syria for birthing season in early April when the steppe pasture lands of the Syrian Jezirah would be at their most lush and remain there until August-months when Jordan is at its hottest and

driest. The return migration would begin in late August/September, once summer pastures were depleted. This departure date would have them arrive back in their southern breeding zones in October/November during the winter rainy season when temperatures in the region are relatively mild and pasturage more plentiful.

Even though constrained today in their movements by low numbers and anthropogenic barriers to migration, the larger bodied Persian gazelle are still the most likely of the three Levantine gazelle species to engage in migration (Martin, 2000). Gazelle in Central Asia, until recently classified as a sub-species of Persian gazelle, are known to have formed mixed herds of thousands of animals during annual migrations that covered up to 1000 km (Zhevnerov, 1984 cited in Martin, 2000). And while the range of the migration in historic times is not known, Legge and Rowley-Conwy cite travelers' reports of Persian gazelle migrating in large numbers in the Middle Euphrates region (Legge and Rowley-Conwy, 2000, pp. 442–447). Whether or not Persian gazelle were engaged in such long distance migrations in antiquity, there is a strong likelihood that they did migrate between different seasonal pastures forming large groups of mixed herds while they did so.

3.6. Summary

When all of the data on the Kuran gazelle are drawn together the following picture emerges. The Kuran gazelle deposit is the result of a single hunting episode in late summer (probably August) of a mixed herd of migrating gazelle conducted a relatively short distance from the site. While the precise location of the kill can never be known, Kuran is within 10 km of a number of the kites found in Van Berg et al.'s survey of the Hemma plateau that have been dated to the 4th through the 3rd millennium BCE, contemporary with Kuran (Fig. 4). The proximity of these kites to Kuran and their contemporaneity suggest that it is not unlikely that the mass-kill was accomplished using one or more these nearby kites. At least 93 carcasses were brought back to the site, likely many more since the bones recovered are only part of the entire deposit. Initial skinning and dismemberment took place on the riverside margin of the site, with low utility foot bones discarded at this location and the higher utility meaty portions, and the skins, removed elsewhere for further processing and consumption.

This was, then, a communal activity that involved a considerable amount of logistics including: 1) building and maintaining kites in strategic locations; 2) observation of resident gazelle herds and co-ordination of people needed to stampede and kill animals as they were beginning their fall migration; 3) transport of carcasses to butchery sites like Kuran where they were systematically dismembered in a standardized way; 4) further processing and preparation of large quantities of meat, either for immediate consumption or dried for later use; and 5) distribution of meat (dried or fresh) to large numbers of people from Kuran and, likely, other nearby communities. The possible religious overtones of this activity implied by the rock art, adds another element to this large-scale communal activity.

4. Impact of mass-kill hunting in the Khabur Basin

Analysis of faunal assemblages from the Khabur Basin by two of us (MAZ and SJR) (Zeder, 1995, 1998, 2003; Rufolo, 2012) provide some insight into the possible impacts of mass-kill hunting using kites on gazelle and, quite possibly, onagers that were both once found in some numbers in the region. Zeder's analysis of 25 different assemblages from the Khabur Basin has highlighted dramatic shifts in the proportions of wild game exploited over a 5000 year period, from the introduction of domestic livestock in the region in the 7th millennium BCE through the rise and fall of the first urban societies in the 3rd millennium (Fig. 11, Table S1). Assemblages from sites in the better watered and more densely occupied northern

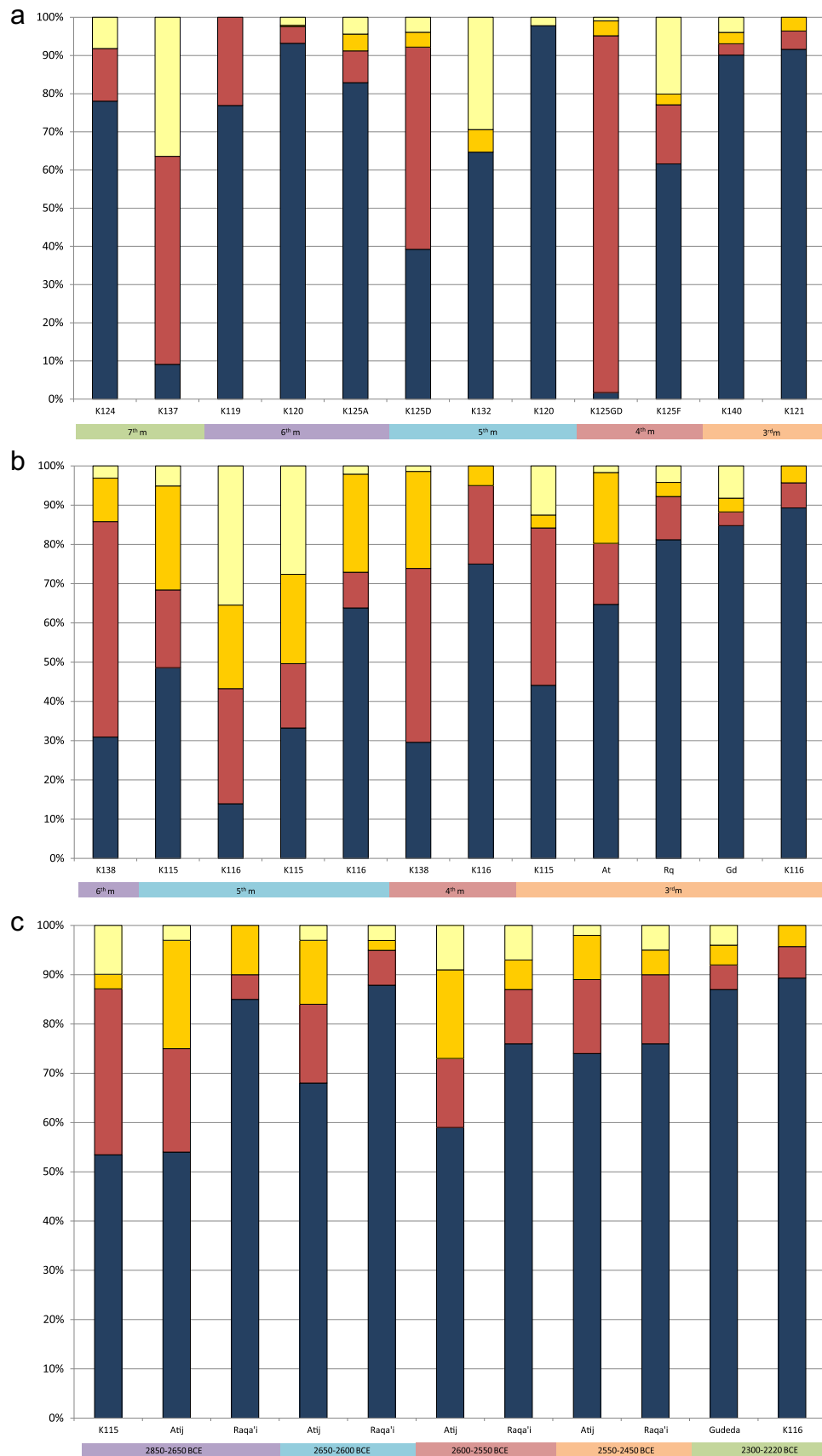


Fig. 11. Khabur Basin Faunal Assemblages, domesticates (sheep, goats, cattle, pig, blue), gazelle (red), onager (orange), other wild species (yellow). a) sites in the northern steppe above the 250 mm rainfall isohyet (see Fig. 5); b) sites in the southern steppe below the 250 mm rainfall isohyet; c) early to mid-third millennium sites in the southern steppe, sources [Rufolo, 2012](#); [Zeder, 1995, 1998, 2003](#).

part of the basin, where rain-fed agriculture is possible, are usually dominated by domesticates — sheep and goats, cattle, and pigs (Fig. 11a). Despite the emphasis on domesticates in this part of the region, up until the mid-3rd millennium gazelle were also hunted in some quantity. This is true not only for Kuran, as demonstrated by the Kuran Gazelle Deposit (K125GD), but also at other sites in the northern steppe (i.e. K137 in the 7th millennium BCE and 5th millennium Ubaid age deposits at Kuran (K125D). Gazelle were much more commonly utilized by residents of the more arid and more sparsely occupied southern steppe (Fig. 11b). Gazelle make up more than half of the faunal remains recovered from the first pioneering occupation of the southern steppe at the 6th millennium Halafian age site of Umm Qseir (K138, Zeder, 1994) and over 40% at 4th millennium levels at the site. They comprise more than 20% at 5th and 4th millennium levels at Masnaq'a (K116), and 40% in early 3rd millennium levels at Ziyadeh (K115).

Onagers were also frequently utilized in the southern steppe of the Khabur Basin, between 20 to 30% of the assemblages from 5th millennium sites (K115 and K116) and 15% of the early 3rd millennium assemblage from Atij (At). Although there are no catastrophic assemblages of onager similar to the Kuran gazelle deposit, rock art from the region suggests that onagers were also hunted using kites and communal killing strategies (Fig. 5b) (Van Berg et al., 2004). Mass-kills of onagers in steppe regions of Iraq are clearly suggested at the sixth millennium site of Umm Dabaghiyeh where onagers comprise nearly 70% of the large faunal assemblage recovered from the site (Bökönyi, 1973, 1978, 1986). Wall paintings discovered at Umm Dabaghiyeh that have been interpreted as showing a drive of onagers using nets (Kirkbride, 1975) add further point to the use of mass-kill strategies in the capture of this steppe species. Similarly, a mural on an Umayyad hunting palace in Jordan that depicts onagers being stampeded by dogs into nets held by hunters attests to the persistence of onager mass-drives into the 8th century CE (Creswell, 1989 cited in Legge and Rowley-Conwy, 2000, pp. 445).

In both the northern and the southern parts of the region the mid- to the late-3rd millennium BCE sees an end to this pattern of relatively high gazelle and onager exploitation, with assemblages across the entire Khabur Basin uniformly dominated by domesticates at 80–90% of mid- to late-3rd millennium sites in both the northern and the southern steppe (Fig. 11a and b).

Rufolo's (2012) fine-grained analysis of assemblages from third millennium sites affords a closer view of this shift (Fig. 11c). Parsed over brief 100–200 year periods, assemblages from the southern steppe show a clear but steady decline in the use of wild taxa, culminating in the late 3rd millennium with the dominance of domesticates in these assemblages. From over 30% of the assemblage from Ziyadeh (K115), dated to the beginning of the 3rd millennium, gazelle decline to 20% of the earliest levels at the multi-component site of Atij, plateauing at little over 10% at successive levels at Atij and nearby Raqa'i, before dropping to less than 5% in mid-3rd millennium levels at the sites of Gudea and Mashnaq'a (K116). Onager utilization falls off more sharply, from 22% in basal Atij to between 15 and 20% in subsequent levels at the site, dropping to less than 5% in final mid-3rd millennium levels at Raqa'i, Gudea, and Mashnaq'a.

The mid-3rd millennium coincides with the crystallization of urban society in the Khabur Basin. Large urban centers of Leilan (K140), Brak, and Mozan in the better-watered northern steppe appear during this period, supported by an increasingly specialized caprine-based pastoral economy centered in the southern steppe (Zeder, 2003; Rufolo, 2012). It is possible that the decline in the utilization of wild game seen across the region during this time of urban formation may, at least in part, be tied to a restructuring of regional economy linked to urban emergence. The loss of grassland habitat associated with the expansion of pastoral economy may have also

contributed to this process. But it is also quite possible, and perhaps likely, that the prolonged and intensive practice of mass-kills of once plentiful herds of gazelle and onager using kites over the course of the 4th and early 3rd millennium had a significant impact on local populations of steppic herd animals that contributed to dramatic decline in assemblages dating to the mid- to late-3rd millennium.

5. Broader implications of the use of kites in the Levant

As we have seen, the Khabur Basin kites are not an isolated phenomenon, but are instead part of a larger system, or systems, of kites that can be found across the entire Levant, from northeastern Syria through central and southern Syria, to eastern Jordan and southern Arabia, with another, smaller system of kites in the southern Negev and across the Sinai. Recently David Kennedy et al. (Kennedy and Bewley, 2009; Kennedy and Bishop, 2011; Kennedy, 2011, 2012) have combined a new aerial reconnaissance program with the study of high resolution Google Earth Satellite imagery that has succeeded in quadrupling the number of identified kites stretching across a vast area from the Sinai and southern Arabia up to Uzbekistan, from the 519 reported in Echallier and Braemer (1995) to a total of 2078 identified kites. They estimate that there a least another 1000 of these structures to be found, with the highest concentration of kites in the "lava fields" that stretch from southern Syria, across the panhandle of Jordan and into northern Saudi Arabia (Kennedy, 2011, pp. 3187). It is important to keep in mind that as extensive as these kite systems seem to have been, the ancient system of kites may have been even larger than is apparent today. The kites that have been located are primarily found on basaltic or other rocky outcrops, with walls and enclosures built of stone. It is quite possible, if not likely, that other kites were built in areas without such rocky substrates, constructed using more ephemeral materials that did not survive to the present (Betts and Yagodin, 2000, pp. 33). Thus the overall system of kites in ancient times may be even larger than the impressive number of surviving kites would lead us to believe.

We have also seen that recent efforts at dating kites uniformly point to the 4th through the 3rd millennium as the apogee of the construction and use of these structures, not only in the Khabur Basin, but across the entire region. This suggests that similar mass-kills of gazelle were taking place on a massive scale during this period across the entire range of all three Levantine gazelle species, with the different densities, sizes, and orientations of kites tailored for the migratory habits and herd structures of these different species. The extensive system in the desert/steppe habitat of the Persian gazelle, in particular, seems tailored to the capture of large migrating herds of gazelle as they moved from breeding grounds to calving grounds.

It is also possible to imagine that Persian gazelle moved across the desert/steppe regions of the Levant in association with other migrating species. A modern day parallel to such a system can be found in East Africa (Bell, 1971), where multiple herbivores of different body sizes (small bodied Thompson gazelles, zebras, and wildebeest) migrate long distances across the Serengeti Plains. Each of these species utilizes a different part of the grasses on these plains; the zebras feed on the upper parts of grasses and herbs, the wildebeest on the middle parts, and the gazelle on the lower parts. The community structure of these herbivores acts as a guild, with earlier migrating animals opening up access to different parts of the resource base to later migrating species. A similar system may also have existed in the Levant in which steppe regions from Arabia to the Khabur Basin were occupied by migrating herds of Persian gazelle and onager that followed seasonal variations in pasture availability across this large region.

It is true that all three species of Levantine gazelle were intensively hunted during the Epipaleolithic and Neolithic. But the

hunting of gazelle in the Levant during these earlier periods seems to have been geared toward meeting the subsistence needs of relatively small groups of foragers and, later, early agriculturalists (Munro, 2004). And while it is possible that communal hunting was practiced during this time, most of the evidence points to a more targeted hunting strategy that focused on prime adult animals—strategies that gazelle, with their high biotic potential, were able to withstand and rebound from (Munro, 2009).

The same may not have been true for the mass-kill practices of the 4th and 3rd millennium BCE when domestic livestock supplied the majority of animal resources utilized by people across the region. Rather than geared toward subsistence, in these later periods mass-kills of large numbers of migratory and resident wild game may well have been motivated by social considerations. As evidenced by the Kuran gazelle deposit, mass-kills using kites was a communal activity of some scope that likely brought together extended networks of people in both the planning and the conduct of the hunt, as well as in the processing, distribution, and consumption of its proceeds. The religious overtones of the rock art associated with kite use in the Khabur Basin further suggest that not only were the kites “very significant for those who built and carved them, but were also integrated into their religious thought” (Van Berg et al., 2004, pp. 97). The social significance of steppic game hunting is further underscored by later third and second millennium texts and glyptic art in which drives of gazelle, onager, and other species like oryx, ibex, ostrich, and the hunting of large carnivores like lions, are associated with both mythic figures (like Enkidu in the Gilgamesh epic) (Heidel, 1949, cited in Helms and Betts, 1987, pp. 41) and late Assyrian kings and princes (Barnett, 1959–60, cited in Helms and Betts, 1987, pp. 59). This implies, then, that not only did game hunting using mass-kill strategies serve a social function in bringing together both sedentary and, possibly, nomadic groups, it also carried an element of social ranking and elevation that found sanction in Mesopotamian ideography (Helms and Betts, 1987, pp. 56). Thus while the demand for game to meet subsistence needs in earlier periods may have been constrained by both the lower human population levels and, perhaps, by a sense of the need for sustainable harvest practices, this may not have been the case for socially motivated hunting of these later periods, when much

larger pre- and post-urban emergence populations were engaged in these practices to cement social networks and elevate social rank.

6. Conclusions

Multiple lines of evidence indicate that mass-kill hunting of wild game by emergent and early urban societies in the region played a role in initiating a process that led to the eventual extirpation of gazelle and other steppic species in the Levant. The record of this practice has been hard to detect in archaeofaunal collections from these periods since heavy dependence on domesticates masks the practice of mass-kill of game in most midden deposits. Recent evidence for the scale of the kite systems across the region during these later periods, the steady decline and eventual virtual disappearance of game animals from faunal assemblages across the region, and the direct evidence for the mass-kill of gazelle at Kuran provided by the lucky find of this unusual deposit, all suggest that this was a wide-spread practice during these periods that had a considerable impact on indigenous game species in the Levant. All three species of Levantine gazelle persisted in the region in some numbers until the use of rifles succeeded in their virtual extirpation. But the large-scale harvesting of whole herds of gazelle using kites now documented for the 4th through 3rd millennia BCE, especially when conducted in breeding and calving territories, is likely to have fragmented populations and disrupted migratory cycles. Onager and other steppic species that may have been captured using kites – hartebeest, Arabian oryx, and ostrich – also persisted, in small numbers, until the early 19th century and the arrival of firearms; but with their larger body size and lower reproductive rate these animals would have been even more susceptible to the impacts of mass-kills on migrating and resident steppic species (Tsahar et al., 2009). The open-ended demand for animals harvested using mass-kill strategies to meet social rather than subsistence goals of emergent and early urban societies in the region can, in light of these multiple lines of evidence, be credited with initiating the long march toward the ultimate extirpation of gazelle and other steppic game animals in the Levant.

Appendix A

Table S1
Faunal assemblages from the Khabur Basin.

Region	Period	Dates	Site name	Site#	Domestic ^a	Gazelle	Equus	Other wild	Total #
North	PPN/PN	7000–6500	Feyda	K124	78.1%	13.8%	0.0%	8.1%	196
	Ceramic Neolithic	6700–6200	Tell Halaf	K137	9.1%	54.5%	0.0%	36.4%	11
	Proto-Hassuna	5800–5500	Kashkashok II	K119	76.9%	23.1%	0.0%	0.0%	13
	Late Halaf	5800–5500	Kashkashok I	K120	93.2%	4.4%	0.3%	2.1%	385
	Ubaid	5200–4500	Kuran A	K125A	82.8%	8.4	4.4	4.4	180
	Post-Ubaid	4900–4500	Kuran D	K125D	39.3%	52.9%	3.9%	3.9%	51
	Post-Ubaid	4500–4300	Tell Brak	K132	64.7%	0.0%	5.9%	29.4%	17
	Early Uruk	3900–3600	Kashkashok I	K120	97.8	0	0	2.2	45
	Late Uruk	3600–3100	Kuran Gazelle	K125GZ	1.8%	96.8%	0.4%	1.0%	3091
	Late Uruk	3600–3100	Kuran F	K125-F	61.6%	15.5%	2.8%	20.1%	284
	Mid III	3000–2800	Leilan IIIb	K140	93.4%	1.3%	3.0%	2.3%	6382
	Nuzi	2000–1800	Kashkashok IV	K121	91.6%	4.8%	3.6%	0.0%	166
South	Halafian	5900–5500	Umm Qseir	K138	30.9%	54.9%	11.1%	3.1%	3511
	Ubaid	5200–4500	Ziyadeh	K115	48.7%	19.8%	26.5%	5.1%	2671
	Ubaid	5200–5000	Mashnaq'a	K116	13.9%	29.4%	21.3%	35.4%	811
	Post-Ubaid	4500–4000	Ziyadeh	K115	42.6%	21.0%	29.2%	7.2%	2315
	Post-Ubaid	4500–4300	Mashnaq'a	K116	63.8%	9.1%	25.0%	2.1%	679
	Late Uruk	3900–3600	Umm Qseir	K138	29.6%	44.3%	24.7%	1.4%	636
	Uruk	3900–3500	Mashnaq'a	K116	75.0%	20.0%	5.0%	0.0%	20
	Ninevite 5	3300–2600	Ziyadeh	K115	44.1%	40.1%	3.3%	12.5%	152
	Ninevite 5	3000–2500	Atij	At	66.2%	14.9%	17.3%	1.6%	1853
	Ninevite 5	3000–2500	Raqai	Rq	81.2%	11.0%	3.6%	4.2%	3131
	Ninevite 5	3000–2500	Gudeda	Gd	84.8%	3.5%	3.5%	8.2%	682
	Ninevite 5	3000–2500	Mashnaq'a	K116	89.4%	6.3%	4.3%	0.0%	78

^a Domestic Species = Sheep, goats, cattle, and pigs.

Table S2

Summary of key taphonomic variables for Kuran Gazelle Deposit.

Total NISP	2631
NISP excluding teeth	2606
Abundant of skeletal elements	Toes
Density-mediated attrition	
Correlation Bone mineral density vs. %MAU	MAU = 0.246(BMD) – 0.014
Spearman's <i>r</i>	0.196
<i>P</i> value	0.30
Proximal/Distal humerus MNE	4/8
Proximal/Distal tibia MNE	3/6
% astragali complete	3/3
Total NISP/MNE	1.28
Bone-surface modification	
% Trampling ^a	1.9%
% Root marks ^a	2.5%
% Weathering (≥ 3) ^a	3.2%
% Carnivore gnaw ^a	9.7%
% Rodent gnaw ^a	0.0%
% Cut-marked bones	4.0%
% Percussion marks ^a	0.5%
% Long bone green fractures ^a	78.4%
% Burned	0.2%
Correlation Food Utility Index (FUI) vs. %MAU	MAU = –0.0018(FUI) + 0.024
Spearman's <i>r</i>	= 0.21
<i>P</i> value	= 0.47
Correlation Marrow Index vs. NISP/MNE	Marrow Index = 13.303(NISP/MNE) – 0.6354
Spearman's <i>r</i>	= 0.48
<i>P</i> value	= 0.23

^a Of total long bone ends and mandible fragments (NISP = 370).**Table S3**

Kuran Gazelle Deposit skeletal element frequency.

	NISP	MNE	MNI	%MAU
Head:				
Horn	7	5	3	3.2%
Occipital condyle	4	4	2	2.2%
Petrosum	11	11	6	6.5%
Maxilla	3	3	3	3.2%
Total skull frag.	25	11	6	6.5%
Mandible fragments	43	32	16	17.2%
Mandible ramus condyle	18	18	9	9.7%
Total mandible frag.	61	32	16	17.2%
Isolated mandible teeth	12	12	2	
Isolated maxilla teeth	13	13	2	
Body:				
Axis	1	1	1	1.1%
Cervical ver.	1	1	1	1.1%
Thoracic ver.	4	3	1	1.1%
Lumbar ver.	7	6	1	1.1%
Rib head	8	8	1	1.1%
Rib medial-shaft	16	6	1	1.1%
Rib total	24	8	1	1.1%
Forelimb:				
Scapula glenoid fossa	80	78	43	46.2%
Scapula blade	78	14	7	7.5%
Scapula total	158	78	43	46.2%
Humerus proximal	6	4	2	2.2%
Humerus medial-shaft	8	3	2	2.2%
Humerus distal	8	8	4	4.3%
Humerus total	22	8	4	4.3%
Radius proximal	4	4	2	2.2%
Radius medial-shaft	6	3	2	2.2%
Radius distal	7	7	6	6.5%
Radius total	17	7	6	6.5%
Ulna complete	5	5	3	3.2%
Ulna proximal	2	1	1	1.1%
Ulna total	7	5	3	3.2%
Metacarpus proximal	6	3	2	2.2%
Metacarpus medial-shaft	2	1	1	1.1%
Metacarpus distal	9	8	4	4.3%
Metacarpus total	17	8	4	4.3%

Table S3 (continued)

	NISP	MNE	MNI	%MAU
Hindlimb:				
Pelvic acetabulum complete	2	2	1	1.1%
Pelvic acetabulum ilium	3	3	2	2.2%
Pelvic ilium caudal	2	2	1	1.1%
Pelvic acetabulum ischium	2	2	2	2.2%
Pelvic acetabulum pubis	4	3	2	2.2%
Pelvic total	13	5	3	3.2%
Femur complete	1	1	1	1.1%
Femur proximal	18	12	6	6.5%
Femur medial-shaft	5	2	1	1.1%
Femur distal	7	6	3	3.2%
Femur total	31	13	7	7.5%
Tibia proximal	3	3	2	2.2%
Tibia distal	8	6	3	3.2%
Tibia total	11	6	3	3.2%
Astragalus	3	3	2	2.2%
Calcaneus	2	2	1	1.1%
Metatarsus complete	1	1	1	1.1%
Metatarsus proximal	9	7	4	4.3%
Metatarsus medial-shaft	3	1	1	1.1%
Metatarsus distal	13	11	6	6.5%
Metatarsus total	26	12	7	7.5%
Toes:				
Phalanx 1 complete	511	510	64	68.8%
Phalanx 1 proximal	124	112	14	15.1%
Phalanx 1 distal	244	228	29	31.2%
Phalanx 1 total	879	738	93	100.0%
Phalanx 2 complete	519	519	65	69.9%
Phalanx 2 proximal	27	26	4	4.3%
Phalanx 2 distal	78	76	10	10.8%
Phalanx 2 total	624	595	75	80.6%
Phalanx 3 proximal	2	2	1	1.1%
Phalanx 3 complete	519	513	65	69.9%
Phalanx 3 total	521	515	66	71.0%
Metapod condyle	147	146	19	20.4%
Metapod medial-shaft	5	3	2	2.2%
Metapod total	152	146	19	20.4%
NISP	2631	2077	93	

Table S4

Frequency of butchery marks on gazelle bones and activities with which they may be associated (butchery mark codes are equivalent to Binford's 1981 butchery mark typology).

Element	<i>n</i>	Code	Function
Scapula glenoid cavity	6	S-1	Dismemberment
Scapula glenoid cavity	4	S-2	Dismemberment
Scapula shoulder blade	2	S-3	Filleting
Humerus distal	1	Hd-2	Dismemberment
Radius proximal	1	Rcp-6	Filleting
Metatarsus distal	1	Mtd-2	Skinning
Metatarsus distal	2	Mtd-1	Dismemberment
Metapod condyle	13	Mp-1	Dismemberment
Metapod condyle	8	Mp-3	Dismemberment
Metapod condyle	3	Mp-4	Filleting
Phalanx 1	57	—	Skinning?
Phalanx 2	9	—	Skinning?
Phalanx 2	1	—	Hack
	108		

Table S5

Tooth eruption and wear stages of complete mandibles of Persian gazelle in the Kuran Gazelle Deposit.

Catalog no.	M3	M2	M1	P4	DP4	Age, months
1649	E	E	2	E	8	3
1651	E	E	2	E	7	3
1659	L	L	2	0	6	3
1642	E	E	5	E	11	3–7
1653	L	L	L	0	13	3–7
1658	L	L	L	L	9	3–7
1633	2	5	L	L	L	7–18

(continued on next page)

Table S5 (continued)

Catalog no.	M3	M2	M1	P4	DP4	Age, months
1634	1	3	6	1	—	7–18
1635	1	3	L	L	L	7–18
1645	2	7	L	L	L	7–18
1654	2	6	X	L	L	7–18
1656	2	X	X	L	L	7–18
1637	6	10	12	3	—	18–36
1638	6	10	12	2	—	18–36
1639	5	8	10	2	—	18–36
1640	7	10	12	X	—	18–36
1641	X	10	12	3	—	18–36
1643	6	8	X	X	L	18–36
1646	4	7	8	1	—	18–36
1632	9	10	L	L	—	36–54
1636	9	11	14	4	—	36–54
1647	9	10	L	X	—	36–54
1652	9	X	L	L	—	36–54
1644	10	12	13	4	—	54–96
1650	10	12	13	L	—	54–96
1655	L	L	14	4	—	54–96
1648	11	L	L	L	—	96+
1657	12	X	L	L	—	96+
1660	12	X	L	L	L	96+

The codes for each wear stage are given for dP4, P4, M1, M2, and M3. (X are teeth with broken cusps, E are teeth still erupting, and L are lost or missing teeth.) Tooth eruption and wear codes follow Munro et al. (2009, Fig. 1).

Table S6

Ratio of unfused (UF) bones of gazelle (fusion age data from Munro et al., 2009) in the Kuran Gazelle Deposit assemblage.

	Fusion age (months)	Neonatal	UF	Fusing	Fused	Total	%UF
Radius proximal	3–7	0	0	0	4	4	
Phalanx 2 proximal		0	52	133	356	541	
Phalanx 1 proximal		0	211	26	391	628	
Humerus distal		0	0	3	3	6	
Scapula glenoid-cavity		0	0	8	68	76	21.0
Tibia distal	7–18	0	3	1	4	8	
Femur proximal		0	9	1	5	15	
Calcaneus proximal		0	1	0	1	2	
Metapod distal		0	117	5	39	161	
Femur distal		0	4	1	3	8	
Ulna proximal		0	2	0	5	7	67.7
Humerus proximal	18+	0	4	1	1	6	
Radius distal		0	3	1	2	6	
Tibia proximal		0	0	0	3	3	46.7

Table S7

Kuran gazelle mortality profile divided into three age classes (young, prime-age adult, and old adult) compared with a theoretical living structure model and a catastrophic profile from Mt. St. Helens.

	Young	Prime adult	Old adult	Total
Kuran Gazelle	42%	48%	10%	29
Catastrophic profile in St. Helens ^a	38%	57%	5%	86
Theoretical living structure ^a	34%	45%	21%	55
Attritional demographic profile ^b	68%	15%	18%	—
Prime-adult hunting profile ^c	15%	80%	5%	20

^a Lyman, 1987, in Stiner (1990), Table 1.

^b Chapman and Chapman, 1975, cited in Stiner (1990), Table 6.

^c Smith, 1975, for the Turner Mississippian village site, cited in Stiner (1990), Table 9.

Table S8

Frequency of male vs. female gazelles calculated using different metric and morphological methods from Munro et al. (2011).

Method	Female	Male	Total #
Second phalanx measurements	58%	42%	501
Horn morphology	40%	60%	5
Scapula morphology	56%	44%	41

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