

# Role of mass-kill hunting strategies in the extirpation of Persian gazelle (*Gazella subgutturosa*) in the northern Levant

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**Continuous and intensive exploitation of wildlife resources by early agricultural societies had major ecological consequences in the ancient Near East. In particular, hunting strategies of post-Neolithic societies involving the mass killing of wild ungulates contributed to the eventual extirpation of a number of wild species. A remarkable deposit of bones of Persian gazelle (*Gazella subgutturosa*) from fourth millennium BCE levels at Tell Kuran in northeastern Syria provides insight into the unsustainable hunting practices that disrupted gazelle migratory patterns and helped set the course for the virtual extinction of this species and possibly other steppe species in the Levant. The social context of mass kills conducted during periods when people relied primarily on domestic livestock for animal resources sets them apart from the more targeted and sustainable practices of earlier periods, when wild animals were the major or sole source of animal protein.**

Once one of the most common wild ungulates in the Levant, gazelle (*Gazella* sp.) now persist only as remnant populations in protected areas. Prehistorically, three species of this small ungulate could be found in large numbers throughout southwest Asia: the mountain gazelle (*G. gazella*), an animal that prefers low altitude, open woodlands, and richer grasslands from the Arabian Peninsula to Syria (1); the dorcas gazelle (*G. dorcas*), a small desert-adapted animal once found in more southern parts of the Levant, the Arabian peninsula, and North Africa (2); and the Persian or goitered gazelle (*G. subgutturosa*), a larger steppic migratory species that had a wide distribution, ranging from southern Arabia to eastern Turkey, Iran, and Central Asia (3). Today all three species are listed on the International Union for Conservation of Nature and Natural Resources Red List as threatened, vulnerable species at high risk for extinction in the wild (4).

Indiscriminate hunting of gazelle with modern firearms in the nineteenth and early twentieth centuries, along with accelerated habitat loss, is known to have had a major impact on populations of all three species of gazelle in southwest Asia (5). However, it is unclear whether these more recent developments are the primary drivers of gazelle extirpation or simply represent the final coup de grâce in a much more extended process. Archaeozoological demonstrations of ungulate mass kills are commonly associated with local extirpation from uncontrolled hunting and depletion of herds. The history of hunting of American pronghorn (*Antilocapra americana*) provides a parallel example of a long-distance migratory ungulate whose decline was due in large part to hunting and habitat fragmentation, here in the proto-historic and early historic periods across western North America (6, 7).

Gazelle were the dominant prey species of foraging groups in the Levant from the final days of the Last Glacial Maximum (ca. 20,000 cal BP), until they were replaced as major sources of animal protein by domestic animals some 10,000 y later (8). In the southern Levant, this period saw continuous intensification in the exploitation of the mountain gazelle, as evidenced by their increasing importance in the spectrum of exploited species, an increase in the proportion of juveniles in prey assemblages, and

heavy processing of gazelle carcasses for marrow and grease (9–12). Yet thousands of years of sustained targeted hunting of prime-age individuals did not drive this species to extinction. On the contrary, human harvesting actually might have contributed to the general health of gazelle herds by maintaining population levels below the region's carrying capacity (11). In the Early Holocene, as domestic species were added to the diet, the importance of gazelle in the southern Levant declined. Given gazelle's evident ability to withstand many thousands of years of intensive hunting before the introduction of domestic animals in the Levant, it seems likely that the increasing reliance on domestics during the Early Holocene was not due to the lack of availability of gazelle, but was instead an economic decision based on the fact that domesticates offered greater security and a wider range of resource options.

Several authors have suggested that the mass harvesting of Persian gazelle using “desert kites” might have played a role in their extirpation (13–15). These enigmatic stone structures can be found in large numbers from Arabia to southeastern Turkey along a proposed former migratory route for this species. Some of these structures may date to as early as 8000–7000 BCE (13), and evidence for seasonal culling of gazelle in Abu Hureyra has been used to argue for the practice of mass-kill strategies as early as 13,000 cal BCE (14, 15). Recent evidence from across the region, however, suggests that the use of desert kites was particularly common and widespread from 4000 to 1000 BCE (16–19). Yet it has been difficult to accurately assess how these structures were used over this long period, which species they targeted, and what role they may have played in the long-term decline of gazelle in the region. Animal remains have rarely been found in direct association with kites. Gazelle and other wild species compose a small percentage of faunal assemblages recovered from settlements of the period 4000–1000 BCE that might have been associated with kites (but see ref. 20), and previous research has focused on reconstructing the management of domesticated livestock.

The recovery of a large, well-preserved deposit of Persian gazelle bones from the site of Tell Kuran in the Khabur River Basin of northeastern Syria provides direct evidence of the use of kites for hunting gazelle in post-Neolithic times. We use the analysis of this remarkable assemblage to demonstrate how this advance in hunting technology may have substantially altered the impact of human predation on this species. Dating to somewhere between 3500 and 3100 BCE and situated in close proximity to

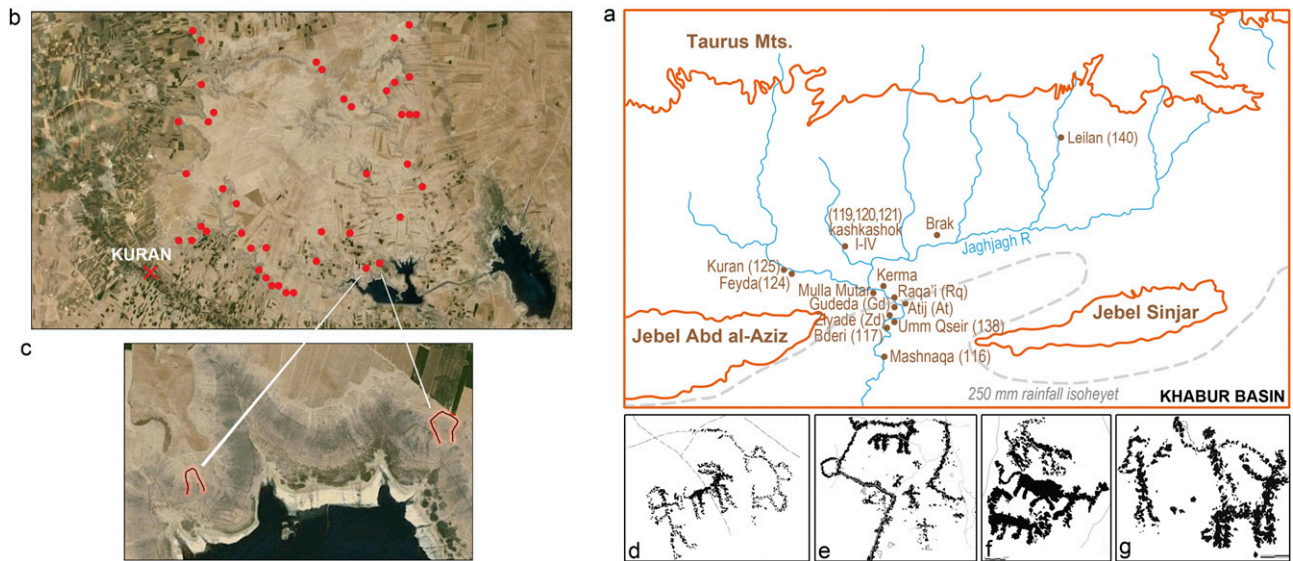
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**Fig. 1.** The Khabur Basin. (A) Archaeological sites. (B) Location of desert kites in the Hemma Plateau (source: Google Earth). (C) Images of two desert kites (source: Google Earth). (D–G) Rock art images in the Hemma Plateau. Source: ref. 21.

a number of desert kites (19, 21) Tell Kuran contained a lens of densely packed gazelle bones (22), whose shallowness and limited horizontal extent suggests that all of the elements were deposited in a single butchery event of animals killed at one time (*SI Materials and Methods*).

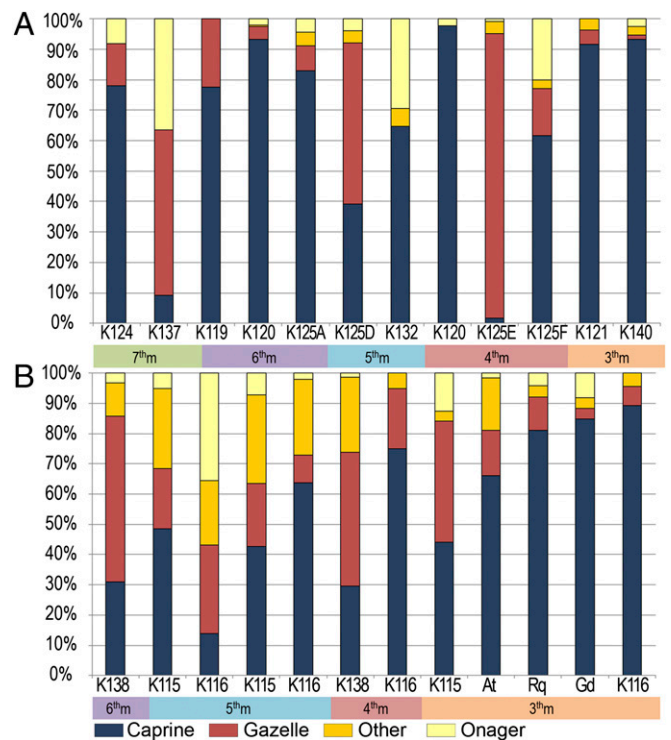
In the present study, we examined the taphonomy and composition of this unusual deposit, as well as evidence of butchery marks on these bones, to determine the history of the deposit and the methods used for processing animals contained within it. We also examined evidence of the age and sex distribution of the animals in this deposit to reconstruct the demographic composition of the slaughtered herd. (*SI Materials and Methods* provides details on our zooarchaeological procedures.) This analysis provides a window into post-Neolithic hunting strategies for gazelle, along with the potential impact of desert kites in the extirpation of gazelle and possibly other steppe species in the Levant.

The Khabur River Basin in northeastern Syria is a large catchment basin that in the well-watered north is drained by the Khabur River and a number of smaller rivers and streams (Fig. 1). In the south, which has significantly less annual precipitation, the Khabur Basin is deeply incised, and rain-fed agriculture is risky, if not impossible. First occupied in ca. 7000 BCE, the Khabur Basin has supported a mix of agricultural and more specialized settlements in both its northern and southern reaches. A fully developed network of urban centers and subsidiary settlements arose at ca. 2600 BCE (23, 24).

Analyses of more than 20 faunal assemblages spanning 6000 y from sites across this environmentally varied region have revealed a distinctive pattern (22, 25, 26). Domestic species consistently dominate in assemblages from sites north of the current-day 250-mm rainfall isohyet, the lower limit for viable rain-fed agriculture (Fig. 2A and Table S1). South of this limit, wild species, especially Persian gazelle and onager (*Equus hemionus*), played a significant and sometimes dominant role in the subsistence economy (Fig. 2B). Although not as important as in the south, the continued utilization of these steppe species in northern sites indicates that these animals were still present in this more densely occupied part of the region for at least 3000 y after the establishment of agricultural economies. This is especially apparent in the Kuran E (K125E) assemblage, comprised almost entirely of Persian gazelle. Gazelle and onager progressively decreased in importance

in southern sites throughout the first half of the third millennium. They essentially disappeared altogether in both northern and southern assemblages in the mid-third millennium, when urban economies crystallized across the region.

Tell Kuran is small site (ca. 0.25 ha) on the right bank of the Khabur River, in the northern, better watered part of the basin (Fig. 1A). During an archaeological sampling project in 1990–1991 (23), several small cuts were made into the mound where



**Fig. 2.** Faunal assemblages in the Khabur Basin over time. (A) Northern Khabur Basin. (B) Southern Khabur Basin. The names and periods of the site are listed in Table S1.



ash layers could be seen. Whereas the lower part of the site has well-preserved Ubaid architecture (ca. 4700–4600 BCE), the upper layers are Late Uruk (ca. 3300 BCE).

Excavations of Uruk levels (Kuran E) into the north side of the mound exposed a dense layer (~5–10 cm thick) of gazelle bones on a compact surface (*SI Materials and Methods*). This Kuran E bone layer was continuous over at least 2 of the 3 m<sup>2</sup> excavated, and its southern terminus was not encountered. The deposit was covered with a layer of red mud brick. Levels contemporary with this deposit have yielded two radiocarbon dates of 4710 ± 60 (3631–3353 cal BCE) and 4625 ± 70 (3101 cal BCE) (24).

## Results

The Tell Kuran bone deposit is composed almost exclusively of the remains of Persian gazelles, with 2,631 skeletal elements representing a minimum of 93 individuals (Fig. 3 and Table S2). Most skeletal elements are complete, and the degree of bone fragmentation is low. Remains of other animals are scarce and include only few isolated bones of cattle [*Bos taurus*; number of identified specimens (NISP) = 2], sheep/goat (NISP = 10), pig (*Sus* sp.; NISP = 4), and equid (*Equus* sp.; NISP = 2), which might be intrusive from a matrix above or below this densely packed bone deposit. The prominence of gazelle in this assemblage stands in strong contrast to other fourth millennium assemblages from the northern Khabur Basin that are dominated by the fragmented remains of domestic livestock (mostly sheep and goat) (Fig. 24). Clearly this is not a typical midden deposit composed of an amalgam of bones discarded after butchery and consumption. The assemblage is the only documented occurrence of a deposit dominated by a wild ungulate species in a post-Neolithic site in the Levant.

The excellent preservation of most skeletal elements, the presence of porous and low-density skeletal parts of both immature and adult animals, and the high frequency of green bone fractures with oblique or V-shaped and jagged fractures indicate the minimal role of in situ bone attrition (Table S3). Analysis of surface modifications suggests that major loss of bones by decay did not affect the assemblage. Gazelle long-bone shafts exhibit minor signs of surface weathering; the majority of bones bear no signs of surface cracking or exfoliation. In addition, destruction of skeletal elements by carnivores appears to have been minimal. The low percentage of carnivore tooth marks (all of which were made by dogs) strengthens the impression that although dogs had some access to discarded bones after the butchery, they were not a major agent in removing the bones from their location where initially discarded. All of these factors indicate that the bones were quickly covered after deposition and sustained only minimal postdepositional disturbance and in situ bone attrition.

The vast majority of the gazelle bones are nonmeaty lower foot elements (first, second, and third phalanges) (Fig. 3 and Table S2). The only high-meat yield element found in any frequency is the scapula. Other skeletal elements are represented in much lower ratios. This includes axial parts (vertebrae, rib, pelvis) and cranial elements, particularly skull portions, which are

expected in high numbers in discard piles of butchery deposits. The occurrence of these different elements, even in low numbers, argues against this being a deposit of gazelle skins with the lower foot bones and hoofs still attached. Instead, such an anatomical representation of carcasses indicates that this deposit represents an initial stage of the butchery of a large number of gazelle carcasses in which animals were skinned and partially dismembered, and the low-utility elements were discarded in one location. Higher-utility elements were removed for further processing and consumption elsewhere. The absence of cranial elements in this deposit may indicate that skulls and mandibles were removed at the kill site or, perhaps more likely, they were included with other higher-utility parts taken from the initial butchery site for further processing. This pattern differs significantly from the skeletal element profile of gazelles at Abu Hureyra, where skeletal elements from all body parts were discarded (15). Such a pattern is more indicative of a midden deposit accumulated over time comprising refuse generated by the butchery and the consumption of animals. In contrast, the Kuran assemblage is consistent with an initial stage in the butchery that, given the shallowness and compactness of the deposit, likely represents a single butchery episode.

A similar carcass-processing pattern characterized by a high ratio of lower foot bones can be found today in slaughterhouses in the nearby town of Hasseke (27). The butchery of sheep and goats begins by removing the feet of the carcass just before skinning. The animal is then dismembered, and the various butchered portions—carcasses, heads, and entrails—are brought to the market for further butchery and distribution. Most importantly, the remains of the initial butchery phase include a high abundance of toe bones and hoofs, along with other butchery waste (inedible organs). The almost complete absence of burnt bone specimens (Table S1) further indicates that the excavated material principally represents a primary butchery deposit, not cooking or consumption refuse.

Butchery marks are especially common on the posterior distal ends of the first phalanges (Fig. S1 and Table S4). Many of these marks are deep and wide, and most are found in a transverse orientation relative to the phalanx axis (Fig. S2). Many of the cuts are irregular with wide grooves and in various shapes, reinforcing the hypothesis that they were made with stone tools (*sensu ref.* 28). The orientation of the marks and the fact that many of them are seen on both the anterior and posterior sides of the phalanges suggest that they occurred during skinning. In addition, many of the marks were redundantly made in the same anatomical location. A high frequency of skinning marks on phalanges, rather than on the distal metapodials, is often associated with thorough processing of skins (29). The importance of gazelle skins in this region today is documented by ethnographic accounts among the Bedouin tribes of northern Syria, who selectively used gazelle hides to make footwear and clothing, as well as bags to hold water and fermented milk (30).

The depth and the orientation of the marks also suggest that the skinning of gazelle resulted from butchering carcasses that had undergone a certain amount of rigor mortis. In full rigor mortis, the joints of the carcass become totally immobile, and the process of butchering requires a great deal of force. In such instances, skinning marks are more numerous, deeper, and much more pronounced (31). The abundance of skinning marks on gazelle phalanges that had undergone rigor mortis suggests a certain delay between the time when the gazelle died and the time when they were butchered at the site. Thus, it seems plausible that Tell Kuran gazelle were killed some distance from the site and then brought to the margin of the site for this initial butchery activity.

Additional dismemberment and filleting butchery marks are mostly associated with disarticulation of long bones (Table S4). It seems that after the primary butchery, which involved skinning

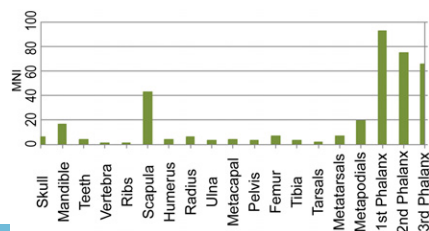


Fig. 3. Minimum number of gazelle individuals in the Kuran E bone deposit.

the gazelle and dismembering the fore limbs, complete limbs excluding the phalanges were transported to another location for further butchery and distribution. The presence of filleting butchery marks on some of the scapulae suggests that meat was stripped off of the shoulder blade during this early butchery phase, and the scapulae were discarded with other low-meat yielding elements.

Age at death of the hunted gazelle population was inferred on the basis of epiphyseal fusion and dental eruption and wear of complete mandibles (Tables S5 and S6). The resulting age profiles resemble the demographic structure of a living herd (Fig. 4). In our analysis, we separated the sample into three broad age groups: juveniles (birth to the age at which the deciduous lower fourth premolar is normally shed), prime-age adults, and old adults (i.e., more than half of the lower third molar crown is worn). These three age cohorts represent major life history transitions typical of many ungulates. Like the age structure of a catastrophic profile and a theoretical living structure, the Kuran gazelle assemblage is dominated by juveniles and prime-age adults, with fewer old adults (Tables S7 and S8) (32; data from ref. 33). This pattern is strikingly different from an attritional mortality profile expected with natural die-off, which consists of large numbers of young and old animals with few prime-age adults. It also differs from the prime-age mortality profile consistent with targeted hunting strategies focusing on the finest animals in a herd.

The dental wear data attest to the presence of very young individuals, ~3 mo of age (Table S5). Assuming a birthing season of April and May, as seen in gazelle in Iraq today (34), this would indicate that these animals were killed in mid- to late summer.

Several different indices indicate that males and females are approximately evenly represented in the assemblage, with females perhaps slightly better represented than males (Fig. S3 and Table S9). This pattern is consistent with the mixed herd of males and females seen during seasonal migration (3, 34, 35). Based on earlier travelers' accounts, the topography of the region, and the distribution of desert kites, Legge and Rowley-Conwy (14, 15) reconstructed the seasonal migrations of gazelle along a north-south axis. In late spring, the gazelle move north, where the young are born. Once they reach the birthing areas, the herds separate into female nursery herds and bachelor herds. The separate herds spend a few months in their northern territories before aggregating again into mixed herds of males and

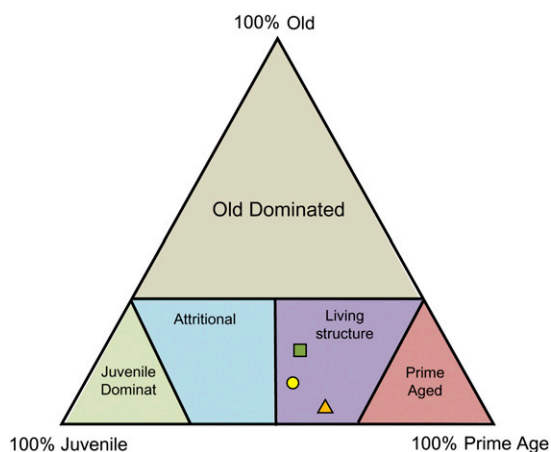
females and migrating to the southern territories in mid- to late summer.

The observed sex distribution and age profile, along with the taphonomy of the bone deposit itself, indicates that the Tell Kuran gazelle deposit resulted from a single hunting episode that occurred during the mid- to late summer seasonal migration cycle. The age and sex profile of the hunted Tell Kuran gazelle resembles a catastrophic demographic structure, indicating that the hunt was targeted at the mass killing of an entire migrating herd, not at culling individual gazelle. This presents firm evidence indicating that mass killing was a hunting strategy in the ancient Near East.

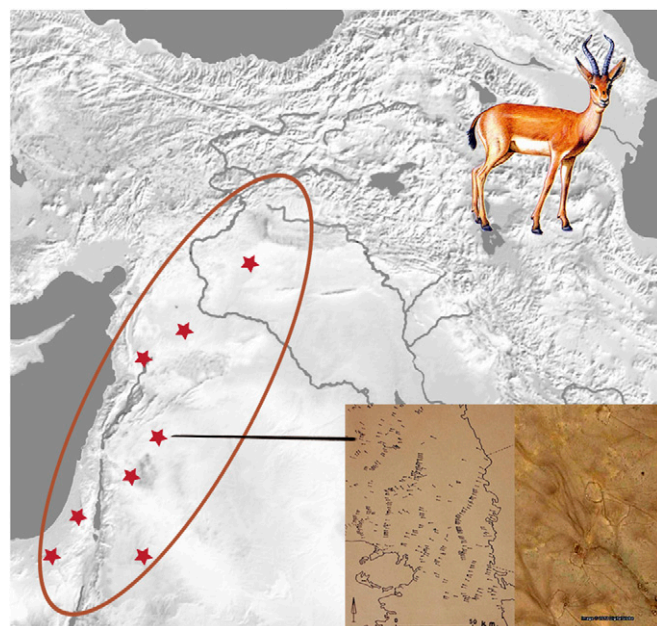
### Discussion

Recent archaeological surveys have located nearly 50 kites on and around the Hemma Plateau in the northwestern Khabur Basin (21, 23), several within 10 km of Tell Kuran (Fig. 1 B and C). Although it is possible that some of these rock constructions were built as corrals for domestic animals, rock art discovered in close proximity to these kites depicts stone traps being used to hunt animals that are clearly Persian gazelles (Fig. 1D). Other animals shown being captured and killed in these kites, sometimes with the aid of dogs, include an equid species, probably an onager (Fig. 1E). Depictions of humans holding maces or clubs tethered to lions and bulls have been interpreted as representations of Mesopotamian divinities, imbuing this communal activity with religious symbolism (Fig. 1 F and G).

Temporal placement of desert kites is difficult, because these structures seldom contain any charcoal or other organic remains needed for radiocarbon dating, or any artifacts (e.g., pottery, stone tools) that could situate them within a cultural chronology. Stylistic comparisons of the rock art with Mesopotamian iconography, however, puts the images portrayed in the Hemma Plateau rock art (and, by inference, use of the associated kites) within the time span of the fifth to the first millennium BCE (21, 23). The incorporation of the walls of several kites into buildings dating to the Neo-Assyrian period of the first millennium BCE provides a *terminus ante quem* for their use (21).



**Fig. 4.** Triangular plot showing the age profile of Kuran E gazelle (yellow circle) divided into three age classes (young, prime-age adult, and old adult) compared with a model profile of a living herd (green square) and a catastrophic profile from St. Helens (orange triangle). Source: ref. 32; data from ref. 33.



**Fig. 5.** Distribution of Persian gazelle in the Levant showing locations where desert kites have been found. (Inset) Chain kites. Source: ref. 13.



These dates correspond well to the Tell Kuran gazelle deposit, which is firmly dated to the later fourth millennium BCE (24). Faunal assemblages from the region demonstrate that gazelle meat was only a supplementary source of protein during this time (Fig. 2 and Table S1), and that the hunting of gazelle did not play a major role in the subsistence economy of the fourth millennium Khabur Basin. The iconography of the rock art associated with the kites used to capture the gazelle in the Tell Kuran deposit, however, indicates that the capture of these animals played an important social role that was imbued with religious overtones. The hunting and processing of these animals (and possibly other game, such as onager) required the coordination of numerous people responsible for building and maintaining kites, driving and killing animals, and transporting them back to habitation sites like Tell Kuran for butchery. The butchery of these animals also appears to have been a coordinated activity in which animals were systematically skinned and at least partially dismembered and discarded in one location. The preparation of the meat of up to 100 or more animals and the distribution of this meat (either fresh or dried) along with its subsequent consumption is also likely to have been a focus of communal activity involving the residents of several nearby settlements.

It is difficult to assess the overall impact of this mass-kill strategy on steppic game animals in the Khabur. Gazelle and onager are virtually absent in Khabur faunal assemblages dating to the mid-third millennium BCE, even in those from the more southern part of the region, where both species had been well represented from the sixth to the early third millennia (Fig. 2). The disappearance of these species from regional faunal assemblages might be a reflection of a restructuring of the subsistence economy as part of an urban emergence in the region and the associated development of an increasingly specialized pastoral economy that supplied meat and other pastoral products, especially wool, to growing urban centers (26). Habitat loss resulting from the growth of settlements and the more intensive use of steppic grasslands for pasturing domestic flocks also might have played a role in the extirpation of wild steppe species. However, the prolonged use of kites in the massive sustained harvesting of wild herds during periods leading up to urban emergence, as evidenced by the many desert kites and associated rock art sites in the region and now documented by the gazelle bone deposit at Tell Kuran, could well have played a major role in the process that led to the eradication of gazelle and perhaps other wild ungulates in the Khabur Basin.

Hundreds of desert kites, sometimes forming long chains extending across tens of kilometers, have been reported in the Sinai Peninsula and south Arabia, throughout the Jordanian and Syrian deserts, and in the Khabur Basin in northeastern Syria (Fig. 5) (13, 16–19). The distribution of these kites follows what is thought to have been the migratory path of Persian gazelles as they moved in large numbers from breeding grounds in the south to calving grounds in the north (14). Some researchers have questioned whether the migratory path of these animals ever covered this vast territory (36). However, these larger-bodied species of gazelle are historically documented as having been migratory in steppic parts of the Levant in the past (14, 36, 37). A closely related sister species inhabiting parts of central Asia (*Procapra gutturosa*, formerly classified as *G. subgutturosa*) is known to have made long-distance seasonal migrations involving thousands of animals (35). Whether Persian gazelle migrated over many thousands of kilometers or over shorter distances, the number and the placement of these kites, the behavior of remnant populations of these animals today, and ethnohistoric accounts of the use of these structures (14) suggest that they were used to capture migrating animals at some point in their migratory cycle.

It has been argued that the construction and use of these kites dates as far back as 8000–9000 y ago during the Pre-Pottery Neolithic B, when hunted gazelle were still the primary source of

protein for steppic peoples (13). Gazelle remains from the site of Abu Hureyra in the middle Euphrates Valley (14, 15) have yielded demographic data interpreted as evidence for early mass kills using kites or other communal hunting techniques (see also ref. 38, but see ref. 36 for a contrasting interpretation of these data).

Nonetheless, it is becoming increasingly clear that the construction and use of the majority of these structures is a more recent phenomenon. From the Sinai (16) to the Negev (17–19), the western desert of Jordan (13), southern and central Syria (39), and, as we have seen, northeastern Syria (19), various dating methods (both absolute and relative) point to the fourth through the second millennium (4000–1000 BCE) as a period during which the mass killing of gazelle and other steppe species was practiced with considerable intensity across this entire region. Textual and pictorial evidence from historic periods of the third through the first millennium BCE also documents the use of kites in the mass killing of gazelle, often featured as a special prerogative of kings and mythic heroes (Figs. 1–3), further underscoring the social and ritual context of this practice documented in the Khabur.

The mass kill of gazelle and other wild herd animals as a socially driven communal practice with religious connotations appears to have been practiced not only in the Khabur, but also more broadly in steppic regions across the entire the Levant during a period that saw the emergence of socially stratified urban societies in the Near East. This mass-kill strategy diverges dramatically from the hunting tradition of the preceding Epipaleolithic and Neolithic foragers and early farmers in the Levant. Although hunting pressure might have been intensive during periods when gazelle were the dominant prey animal, targeted hunting practices involving the stalking of individual animals appear to have been sustainable and may have even encouraged population growth among predated herds (11). In contrast, the mass-kill strategies of protohistoric and early historic societies, especially when practiced in gazelle breeding and calving areas, is likely to have played a significant role in both decreasing the number of gazelle and inhibiting the potential for population rebound. More importantly, these practices would have disrupted the overall migratory pattern of these animals (whether it encompassed many thousands of miles or a more circumscribed area), leading to the fragmentation of the large migratory populations of Persian gazelle that had once moved relatively unimpeded across this broad territory.

Continued used of kites in the mass killing of gazelle documented in the early twentieth century (37, 40, 41) indicates that the extirpation of gazelle from major portions of the Levant was a prolonged process that might not have been completed until hunting with rifles decimated the remaining fragmented herds in modern times. However, it now seems that the proliferation of mass-killing strategies across the Levant during the fourth through the second millennium BCE marks the beginning of this process, if not a major step in the eventual eradication of this once-common species in the Levant. Other steppe species may have been less able to sustain the mass-kill technology represented by desert kites of emergent urban societies in the Levant. Onagers seem to have been extirpated from the region much earlier than gazelle. Species including the hartebeest (*Alcelaphus buselaphus*), arabian oryx (*Oryx leucoryx*), and even ostrich (*Struthio camelus*), also thought to have been hunted using kites, were extirpated from the southern Levant by the second millennium BCE (5).

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