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Were Desert Kites Used Exclusively as Driven Hunting Structures ? Unresolved Issues and Alternative Interpretations of the Evidence – Socio-economic and Biological Considerations (A Draft)

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Were Desert Kites Used Exclusively as Drive Hunting Structures? Unresolved Issues and Alternative Interpretations of the Evidence – Socio-economic and Biological Considerations (A Draft)

Abstract

Although much information has been gathered during the last decade (as a result of archaeological excavations and satellite imaging) many unresolved issues remain about desert kites. These include the precise function of these huge archaeological stone structures which are widely distributed throughout southwestern Asia. According to the common vision, kites were hunting structures used to drive and to mass-kill large herds of wild ungulates. We qualify this view by analyzing the morphology of kites, the behavior of the targeted prey, and the logistical constraints associated with the mass-killing of ungulates. This leads us to conclude that as hunting structures, kites could also have been used for passively trapping animals. We believe it to be likely that kites were used (individually or collectively) for multiple purposes, which may have altered with the passage of time. An important use (at one stage in the existence of many kites) may have been for the mustering of livestock (especially sheep and goats), and for the capture of some wild or feral species of animals suitable for domestication. Some kites may also have been utilized for religious purposes or for cultural ceremonies.

Keywords: desert kites, drive structure, Early Bronze Age, ethology, hunting strategies, livestock domestication, southwest Asia, tended facilities, wild ungulates, zooarchaeology.

JELClassification: Z13

Were Desert Kites Used Exclusively as Drive Hunting Structures? Unresolved Issues and Alternative Interpretations of the Evidence – Socio-economic and Biological Considerations (A Draft)

1. Introduction

Desert kites are large stone structures. They were detected and labelled in the 1920s by aircraft pilots flying over Near-Eastern desert areas. In most cases, desert kites (simply 'kites' hereafter) usually consist of two arms which end in a large enclosure (Barge, 2014). The arms (also called walls, wings or antennae) consist of a low wall (usually about half a meter) of superposed dry stones. Their length varies from less than 100 meters to more than one kilometre. Both arms form a V-shape, with at one side a large entrance opening to the landscape and at the other side, a narrow and funneled entrance leading into an enclosure. The enclosure (also called the corral, the head or the apex) is also made of dry stones superposed but walls are higher (about one meter and a half high). The area of the enclosure is variable, ranging from hundreds of square meters to several hectares. In most cases, small cells (also called "blinds") made of stone are built along the external wall of the enclosure. Besides these common features (arms, enclosures, cells),kites are also characterized by the diversity of their shape, size, location, the direction of the entrance, and number of cells (Barge et al., 2015a, 2015b).

This diversity, as well as their shape, have attracted archaeologists' attention for a long time (e.g. Betts, 1982; Legge and Rowley-Conwy, 1987). The recent use of satellite images provided by Google Earth and Windows Live Satellite has yielded new information about these structures (Barge et al., 2013). Satellite images have shown that kites are much more numerous than what was initially thought (Betts and Burke, 2015). Indeed, on September 1, 2016, 5210 kites were inventoried (Globalkites Project, 2016) in South-West Asia, from the Arabic peninsula, to the Levant, the Syrian desert,[1]the Caucasus, and up to the vast steppe of central Asia. The exhaustive inventory by country provided by the Globalkites Project (2016) was, on September

[1] The Syrian desert is part of the Al-Hamad, i.e. is an arid land of south-western Asia, extending from the northern Arabian Peninsula to eastern Jordan, southern Syria, and western Iraq.

01, 2016 the following[2]: Armenia: 194, Egypt: 5, Iraq: 52, Israel: 20, Jordan: 1174, Kazakhstan: 499, Lebanon: 3, Saudi Arabia: 761, Syria: 2200, Turkey: 236, Uzbekistan: 51, Yemen: 15.

Most academic publications focus on kites located in a given region of South-West Asia, such as the Syrian desert (Helms and Betts, 1987; Legge and Rowley-Conwy 1987; Echallier and Braemer, 1995; Kempe and Al-Malabeh, 2010, 2013; Bar-Oz et al, 2011a, 2011b; Morandi Bonacossi and Iamoni, 2012; Zeder et al., 2013; MorandiBonacossi,2014; Betts and Burke, 2015; Abu-Azizeh and Tarawneh, 2015), the Negev and the Sinai (Holzer et al., 2010; Nadel et al., 2010, 2013), Yemen and the Arabian peninsula (Brunner, 2008, 2015; Skorupka, 2010), the Caucasus[3] and the Asian central steppe[4] (Betts and Yagodin, 2000, Gasparyan et al., 2013; Brochier et al., 2014; Barge et al., 2016; Chahoud et al., 2016). Some publications provide comparative studies of kites across southwestern Asian regions (Crassard et al., 2014; Barge et al., 2015a, 2015b).

Even though some disagreement still exists about their function (Legge and Rowley-Conwy, 1987; Helms and Betts, 1987; Echallier and Braemer, 1995; Rosen and Perevolotsky, 1998) and dating (Zeder et al., 2013; Betts, 2014; Zeder and Bar-Oz, 2014; Morandi Bonacossi, 2014; Betts and Burke, 2015), the most recent publications about kites have resulted in a common vision about their function and dating. Indeed, it seems commonly agreed that the main(if not the unique) function of kites was for hunting. Moreover, recent archaeological excavations indicate that these structures were built during the post-Neolithic period, i.e. mainly during the Chalcolithic-EBA (3rd to 4th Millennium BC) (Zeder et al., 2013: 116, Table 1). In other words, this general vision (Helms and Betts, 1987; Legge and Rowley-Conwy 1987; Rosen and Perevolotsky, 1998; Bar-Oz et al, 2011a, 2011b; Zeder et al., 2013; Abu-Azizeh and Tarawneh, 2015; Holzer et al., 2010; Nadel et al., 2010, 2013) can be stated as follows: Kites are stone structures built in southwestern Asia from the Chalcolithic-EBA and used mainly as hunting structures. Motivated by socio-cultural concerns, hunters have used these facilities to capture and mass-kill large herds of wild ungulates, especially migratory species such as the goitered gazelle, and this has contributed to the extirpation of some of these species.

Despite the considerable amount of information about the features of kites now provided by fieldwork, archaeological excavations, and satellite images, little is known about them from an archaeological point of view. Indeed, despite the large number of currently inventoried kites,

[2] A regularly updated interactive mapping of kite structures is available at http://www.globalkites.fr
[3]Armenia.
[4] Kazakhstan and western Uzbekistan.

archaeological excavations within these structures (or in their vicinity) have yielded few results. Although it is certain that these structures were human-built, very few organic artifacts such as charcoal or animal bone remains have been found within and around kites.

In spite of the common view previously stated, many basic (but fundamental) questions about kites remain unanswered. For instance, which wild animals were actually hunted by utilizing kites? Were these species hunted seasonally, e.g. during their migration, or throughout the year? How were the prey hunted given the diversity of presumed hunted species, the behavioral variation of targeted species, of their habitats, and the diversity of ecosystems where kites have been built? What was the exact function of cells? If, as is commonly assumed, kites were used for the mass-killing of wild ungulates, why has only a single gazelle-bone assemblage consistent with mass-killing been found to date, namely in Northern Syria (Bar-Oz et al., 2011a; Zeder et al., 2013)?

We believe that if so many important issues are still unresolved, it is because the common view does not allow for the probable diversity of function(s) and use(s) of kites. More precisely, we believe that even though kites are considered to be hunting structures, their presence is consistent with diverse hunting methods. Such diversity is implied by natural (e.g. animal migration) as well as cultural (e.g. herders mobility) changes which occur in the short-term, in relation to seasonal and inter-annual variations. This short-term diversity contributes to strengthen the possible diversity of kites' function which could be used as hunting and/or herding structures, contemporaneously or successively. This second diversity is also implied by natural (e.g. climate change) as well as cultural changes (the shift towards complex societies), but it is now relevant in the *longue durée*. Thus, in order to improve our understanding of kites it seems useful on the one hand to take into account the influence of the passage of time and, on the other hand, to distinguish several levels of time as suggested by Braudel's analysis of historical times (1996).

2. The Common Vision about the Function of Kites

As stated by Barge et al. (2015a: 164), a stone structure can be considered to be a kite if it has three characteristics. First, if it has (at least one, two in most cases, and sometimes more than two) long converging walls, or at least stone alignments which can be discontinuous. Second, at the convergent extremity of these walls is an enclosed space. In some cases, a funneled

entrance connects the converging walls and the enclosure. Third, one or several cells, i.e. small enclosed and walled spaces, are located on the external periphery of the enclosure.

As stated previously, the usual view about kites is that their main function (if not the unique one) was for hunting. This view is supported by several arguments which we now outline.

Kites as Drive Hunting Structures

Such an explanation of the use of kites is plausible since in all continents, Pleistocene as well as Holocene hunters have used similar structures (made either of stone, brush or wood) to drive, to trap and to kill wild game (Bar-Oz and Nadel, 2013; Smith, 2013).[5] As exemplified by the drives found in the Great Basin and in most Northern America regions (Frison, 1998, 2004; Hockett et al., 2013; O'Shea et al., 2013), these structures were mainly used to hunt large herds of migratory species (bison, pronghorn, reindeer). We may even add that similar structures, i.e. walls or fences converging to an enclosure, were built in aquatic environments (rivers, river estuaries, marshes) and used to trap aquatic animals. Such structures were mainly used to harvest anadromous fish (e.g. salmon, trout, eel), for instance by Mesolithic hunter-gatherers of Northern Europe/Southern Scandinavia (Ertebølle culture) and by several cultures of the American North-West coast, from the Archaic period to the modern era (until the nineteenth century AD). It was thus logical to assume that kites (i.e. southwestern Asian driving structures) were also used for hunting, especially of medium-sized wild herbivores, such as gazelles that were abundant in the Near East during the prehistoric period.

Kites are suitable for hunting wild animals that behave in particular ways. These animals are mostly gregarious, live in herds, tend to run in the same direction when threatened, follow regular trails and have a valuable meat or raw material of benefit to hunters. The southwestern Asian ungulates[6] likely to be trapped using a kite were most probably *Ovis* sp. (sheep), *Capra* sp., *Gazelle* sp., *Cervus* sp., *Equus* sp., *Bos* sp., and *Bison* sp. In addition to wild species, feral goat and sheep could also have been hunted with kites. Given their large number as well as their often impressive size, such as the chained star-shaped kites found in East Jordan and that run over dozens of kilometer (Betts and Burke, 2015; Barge et al., 2015b: 147), it was also assumed

[5] See for instance the special issue n°297 of *Quaternary International* published on May 29, 2013 and devoted to "Worldwide large-scale trapping and hunting of ungulates in past societies".
http://www.sciencedirect.com/science/journal/10406182/297
See also the special issue "Desert kites - old structures, new research" published in volume 26 issue 2, November 2015, of the *Arabian Archaeology and Epigraphy*. http://onlinelibrary.wiley.com/doi/10.1111/aae.2015.26.issue-2/issuetoc

[6] It also seems (but it is disputed) that ostriches may have been hunted with kites.

that kites were used for wild game mass-killing (Legge and Rowley-Conwy, 1987), an assumption which has been recently supported by archaeological excavations in the Syrian desert (Bar-Oz et al., 2011a; Zeder et al., 2013) as well as in the southern Levant (Bar-Oz et al., 2011b).

The Orientation of Kites and Gazelle Seasonal Mobility

A large number of kites (for instance most kites located in East Jordan) are oriented to the east (Barge et al., 2015b: 147; Barge et al., 2015a: 167; Betts and Burke, 2015: 83-86). Such orientation is in fact consistent with the presumed migratory route of some wild ungulates, especially the goitered gazelle, even though these species are now extinct in the Near East. Following influential publications about Near-Eastern kites (Legge & Rowley-Conwy, 1987; Zeder et al., 2013), there is now a tendency to believe that kites were used for targeted mass-kill of ungulates. This vision leads us to ask two important questions: which species congregated in sufficiently large herds (of hundreds animals) and when, i.e. in which season did such congregation occur.

Concerning the various species, let us focus on gazelle because they seem more likely to congregate in large herds compared to wild asses and oryx. It should be noted that three gazelle species were present in the Near East, namely the goitered gazelle (*Gazella subgutturosa*), the mountain gazelle (*Gazella gazella*) and the *Gazella dorcas*. Even though they belong to the same genus, they usually do not occur in the same habitats (Kingswood and Blank, 1996: 5) and do not have the same mobility pattern. As with other forms of behavior, gazelle mobility patterns are varied: some populations are sedentary, others nomadic, and others perform seasonal migrations (Martin, 2000: 22).

First, we consider the mobility and congregation of *Gazella gazella* and *Dorcas gazelle*. *G. gazella* displays limited seasonal movements between lower elevations in winter/spring and higher grasslands in the summer while *G. dorcas* is sedentary.[7] In other words, even though they are gregarious and have some mobility, they do not engage in long distance movements, as some migratory species do, and therefore usually occur in small groups. Both species, *G. gazella* and *G. dorcas* are unlikely to have been targeted for the presumed mass-killing of ungulates. Despite the previous conclusion, it does not mean that both species were not hunted. In fact, during the Epipalaeolithic and early Neolithic cultures (prior to the domestication of the

[7] See Martin (2000: 22, Table 8) for a complete presentation of gazelle mobility according to species and sub-species.

main livestock animals) the dominant prey species throughout the Mediterranean region of the southern Levant was the mountain gazelle (*Gazella gazella*) (Sapir-Hen et al., 2009). Both species, *G. gazella* and *G. dorcas* were present later, i.e. during the Neolithic period and beyond, in the southern Levant, especially in the Negev and the Sinai.

In both regions desert kites have been found and studied intensively (Holzer et al., 2010; Nadel et al., 2010, 2013). However, according to the inventory (by country) provided by the Globalkites Project (2016), on September 01, 2016, only 25 kites have been recorded in Egypt and Israel. Moreover, and as pointed out by Barge et al. (2015a: 164), these kites should be excluded from the 'definition' of kites because they do not present the required characteristics.[8] Indeed, they are structures with neither enclosure, nor adjacent cells. In fact, the long walls converge into a pit. Thus the smaller and isolated Negev and Sinai kites were probably built to trap small numbers of non-migratory local herbivores that grazed in small herds (e.g. *Gazella dorcas*, onager (*Equus hemionus*) and Arabian oryx (*Oryx leucoryx*)) (Nadel et al., 2010: 977). The previous observation confirms that species and herd size may have determined the location and dimensions of the traps.

Second, we consider the mobility and congregation of *Gazella subgutturosa.* Four subspecies of goitered gazelle (*Gazella subgutturosa*) have been identified (Kingswood and Blank, 1996; Cichon et al., 2011), but only two are present in the Near Eastern region, namely the Persian Gazelle (*Gazella subgutturosa subgutturosa*) and the Arabian sand gazelle (*Gazella subgutturosa marica*). Both subspecies are seen to roam widely, moving long distances in search of food, but the extent to which they are migratory is unclear. However, in Arabia, historical sources suggest that they may have been migratory in some areas of the steppe in the past (Martin, 2000: 22). Recent studies in Kazakhstan confirm that the Persian gazelle is migratory (Blank et al., 2012), i.e. Persian gazelles gather into large groups of several tens of individuals and move in continuous waves consisting of several hundred gazelles. In other words, among all gazelle species and subspecies, the Persian gazelle and the Arabian sand gazelle seem to be the perfect candidates for the use of kites in order to organize mass killing. Thus, the analysis of gazelle mobility favors the conclusion reached by Legge and Rowley-Conwy (1987) as well as by Zeder et al. (2013), that kites were used to capture whole herds of animals, most likely the Persian gazelle and the Arabian sand gazelle.

[8]It should be noted that in spite of their low number and special characteristics, the Negev and Sinai kites have been extensively studied in the academic literature, and thus may have contributed to an erroneous vision of what the other kites actually are.

It has also been observed that for the Persian gazelle, large congregations occur for the Spring migration (from the end of March to early April) and Autumn migration (in October) and mixed-sex groups (i.e. including male and female) are most numerous during migrations (Blank et al., 2012: 317). Female groups are smallest and solitary females are the most numerous during parturition in May and these groups are largest during the rutting season in November–December. In contrast, male groups are smallest and solitary males are the most numerous during the rutting period. Furthermore, during the rutting season, adult males stop their daily movements between night pastures and resting areas, and establish a net of fixed, demarcated individual territories. Therefore, it is only during the spring and/or autumn migration that the large kites could have been used for the mass-killing of Persian gazelles.

Rock Art and Epigraphic Evidence

Petroglyphs representing kites have been found sometimes in close proximity to some large-scale traps in the Near East. What they seem to suggest is that kites were used for ungulate hunting (Betts, 1987; Kennedy, 2012; Bar-Oz and Nadel, 2013: 3; Smith, 2013: 11). Of significance are the rock drawings of kites which have been discovered in Jordan. Some of these drawings have been found in association with Safaitic inscriptions (Maraqten, 2015). One of the best preserved rock drawings of kites is the well-known Cairn of Hani, associated with a Safaitic inscription (Kennedy, 2012). The Cairn of Hani is located near the center of four adjacent map sheets which collectively have one of the highest concentration of kites in the Jordanian part of Harrat ash-Sham. Two hunting scenes are depicted in the drawing. The first represents a scene in which a flock of gazelles is being trapped in a kite, possibly with the aid of dogs; the gazelles are captured by three hunters waving their arms. In the second, the hunted animals appear to be addax antelopes: three hunters appear, one of them holding a bow and arrow. The drawing associated with the Safaitic inscription clearly indicates that the hunted animals were driven into an enclosure.

It should be noted that the date implied by the drawing and Safaitic text (1st century BC to 4th century AD) is much later (perhaps by several thousand years) than when kites are thought to have been first constructed. As such, it represents crucial evidence for their continued (if not continuous use) over a long period.

Travelers' Accounts

Finally, a number of travelers' accounts from the sixteenth to as late as the twentieth century described kites as structures used for hunting, and none of these mentioned their use for herding (some of these accounts are reported in Bar-Oz and Nadel, 2013: 5-6). Some of these accounts (during the first half of the nineteenth century; Simpson, 1994), are about the Solubba. The Solubba (or Sleb or the Ṣulayb) were a Hutaymi tribal group (or a caste) from the Arabian desert of non-pastoral nomads who lived a different lifestyle from the Bedouin, with whom they lived in a kind of symbiosis, until the Second World War. All across the Arabian Peninsula, spreading as far north as Palmyra, the Solubba, hunter-gatherer traders, tinkers and musicians, persisted until as late as World War II (Betts 1989, Simpson, 1994). They were reputed to 'not look like' Bedouins and to have a deep knowledge of the desert. They have been identified with the Selappayu of the Akkadian records. One of the links with the foraging past was their presumed use of 'desert kites' (Helms & Betts 1987), some of which were still in use in the twentieth century. According to Simpson (1994), in addition to large-scale gazelle hunting, and because the latter is seasonal by nature, the Solubba economy also included the collection of salt from local salines in the southern Jazira. Salt was probably marketed but was also important for salting gazelle meat and hides.

Thus, we have two important pieces of information about the Solubba. First, travelers' accounts confirmed that the Solubba were using kites for hunting gazelle in the nineteenth century. Second, according to the Akkadian records, the Solubba were identified in the third millennium BC. Since the Solubba were known as gazelle hunters, it is possible that the Solubba built some of these kites, and were among the first users of these hunting structures.

3. Were the Drive Hunting Methods Supporting Kites Active or Passive?

The prevalent vision about the hunting method associated with kites can be summarized as follows. Kites were used for communal hunting in which two groups of hunters are involved. The first group consists of beaters. They locate animals in the wider landscape, for instance when animals are resting in a shaded area. Then, they frighten the animals and try to drive them towards the wings of a kite. The second group of hunters is located close to the kite, most likely in a concealed position (e.g. behind the enclosure wall) and when the animals are trapped in the enclosure, these hunters kill them. Such view implies active driving of the prey (Betts and Burke, 2015: 83) since animals are driven towards the kite.

Several arguments, based either on morphology of kites and/or the behavior of potential prey throw doubt on this common vision. As explained below, it seems more likely that the kites were used for a passive form of hunting (Betts and Burke, 2015: 83). In other words, rather than being driven towards the kites, the wandering animals may have unintentionally entered the guiding walls of kites and subsequently became trapped at their apex.

The Morphology and Location of Kites

First, kites usually have long arms. For instance, and based on a sample of kites from the eastern Jordan (Barge et al., 2015b: 148), their median length is 497 m and their maximum length is 4.7 km. Moreover, most kites have two arms and 44% have even more than two arms. These features (number of arms and their length) can be explained if the arms are considered as a terrestrial "fix or a gill net". The longer the arms and the more numerous they are, the more likely they are to catch a larger number of animals.

Second, some kites located in East Jordan are connected through their arms and therefore form a chain of kites stretching over several kilometers. The presence of such chains is more consistent with a passive form of drive. Indeed, why would so many interconnected kites have been built if hunters were able to drive the wild animals within any of them?

Third, except kites located in the south Levant, most kites have an enclosure which usually has a large surface (on average it is approximately equal to 1 ha). As pointed out by Betts and Burke (2015: 86), large enclosures are associated with more passive forms of hunting since if the enclosure was smaller, the animals would have been able to sense a trap.

Fourth, meandering walls have often been built (probably before the kites) in the close vicinity of kites. It seems that their function was to restrict animals mobility - e.g. by closing dells between lava hills - i.e. to force them to go towards the closest kites (Kempe and al-Malabeh, 2010: 53). This also is consistent with a passive form of driving.

Fifth, most kites are located in places were wild ungulates are usually wandering. On the one hand, and as previously explained, some kites (located in East Jordan) are oriented in the direction of the (presumed) migratory route of some wild species, especially the goitered gazelle and possibly the onager. On the other hand, some kites, e.g. those present in the Negev and the Sinai; (Holzer et al., 2010; Nadel et al., 2011, 2013), have either one of their arms intersecting a trail used by ungulates, or both arms encompass a wadi.

Animals' Reaction to Entrapment

First, if the active form of driving was adopted, animals may have had to be driven a long distance, from the place where they were located to the closest kite. However, driving a herd of wild animals for a long distance can be costly and risky. Indeed, we have to recall that EBA hunters were pedestrians and thus any ungulate was able to run faster than hunters. A successful drive would have required a large number of hunters. In fact, in an active form of drive, hunters would have faced two main problem. On the one hand, when they had located the targeted animal, they had to surround them. Such task is difficult given the flight distances of many species of wild animals, especially in a steppe environment where visibility is high. For instance, the flight distances of goitered gazelle varies from 2 km to 200m (Kingswood and Blank, 1996: 518). Similarly, it is believed that kites could have been used to hunt ostriches (for their meat, fat and feathers). However hunting ostrich is very difficult given their flight distance, and thus is unlikely to have happened, as suggested for instance by the universal absence of ostrich bones in faunal inventories from excavations in the Arabian peninsula (Potts, 2001: 188). On the other hand, even though hunters were able to surround the herd, the drive towards the kite remained a difficult task. For instance, when pursued, goitered gazelles pack closely together like a herd of goats, running a straight course or crossing back and forth in front of the pursuer (Kingswood and Blank, 1996: 518).Likewise, Asiatic wild asses (*Equus hemionus*) are difficult to catch when using a corral mass-capture device. The main problem is that wild-ass groups when disturbed or chased in the daytime tend to split up quickly. Therefore, as illustrated by a recent corral mass-capture for translocation of Asiatic wild asses organized in Kazakhstan, round-ups of Asiatic wild asses were done at night by use of cars and strong lights to reduce the speed of fleeing asses by impeding their ability to see the terrain (Levanov et al., 2013).

Second, a behavioral trait of some ungulates (antelope, gazelle, reindeer) is that when confronted by fences and walls, instead of leaping over them, they prefer to either crawl under or through them, or to run along the barrier until it ends. Antelopes (e.g. pronghorn; Arkush, 1986) in general tend to run alongside low walls until they find an opening to avoid jumping over the fence. Gazelle, furthermore, memorize fences by adopting the same behavior even when only parts of the walls are present (Chahoud et al., 2016: 150). Nowadays, the Convention on Migratory Species (UNEP/CMS, 2014: 22) recognizes that for open steppe ungulates, fences are an especially challenging intrusion. Even though many of these species are capable of

jumping over low fences, they prefer to walk through or under to the other side. Thus, in a landscape otherwise devoid of obstacles, fences act like a dry-land version of a gill net.

Therefore, given this type of animal behavior it is likely that meandering walls found close to kites as well as their guiding walls were sufficient structures to trap some species of wild ungulates. In other words, the presence of hunters was not required to drive herds towards the enclosure. The behavior of some ungulates (antelope and gazelle) is therefore consistent with a passive form of drive since hunters did not have either to be present along the guiding walls or to construct tall barriers or utilize exceptionally strong materials for such devices.

Behavioral Adaptation of Ungulates to Heat and Water Shortages: Their Shift to Nocturnal and Crepuscular Activity

The activity pattern of every species is a result of interaction between internal factors, (physiological state, behavioral ontogeny, body mass) and external ones (group size, natural cycle of day and night, environmental conditions). Four factors influence ungulate activity budgets: seasonal changes of a pasture's biomass and quality, temperature variations throughout daytime hours and seasons; yearly life-cycles (growth and reproduction), and livestock movements and human activity (Xia et al., 2011). In desert and semi-desert environments, such as the ones inhabited by gazelle (especially in the Near East) temperature is an important influence on the activities of ungulates. Several physiological and behavioral adaptations buffer species against the effects of hotter environments.

First, morphological and physiological adaptations of ungulates exposed to high ambient temperatures, or in situations of water or energy limitations, are quite numerous. These include changes in pelt color and selective brain cooling. Among these adaptations, it has been shown that ungulates may store the heat that otherwise would have been lost by evaporation during the day. This results in wide fluctuations in daily body temperature (called heterothermy) and has been demonstrated for the oryx and the sand gazelle (Hetem et al., 2012). Let us now turn to behavioral adaptations.

Second, desert ungulates use body orientation to reduce heat load in hot conditions. They also use shade-seeking, i.e. they select cool microclimates to avoid high environmental heat loads. It has been demonstrated that above a threshold temperature of 28°C, oryx and sand gazelle select cooler microclimates (Hetem et al., 2012).

Third, extremely high midday temperatures in summer possibly force ungulates to rest more during the day instead of feeding to avoid thermal stress. Ruminant species decrease their activity considerably around midday because of high temperatures. This behavior is typical for small body-sized species, such as the gazelle. Therefore, these ungulates display bimodal peaks of feeding. In hot weather, they graze for longer in the early morning and in the late afternoon than during midday. Such behavior has been observed for different ungulate species living in various climates. For instance, it has been observed in a harsh continental climates (namely, in the Kalamaili Reserve) which is situated closer to the Altai Mountains (China). In this reserve(which has an elevation of 600–1470 m above sea level, with an average of 1000 m), the average temperature in July is +20.5°C, with an absolute maximum of 38.4°C. Bimodal feeding activity has been observed for gazelle (*Gazella s. yarkandensis*) (Xia et al., 2011) as well as for the wild Asiatic ass (*Equus hemonius*) (Xia et al., 2013). Current weather records for Jordan (Amman) show that, from June to August, the average maximum temperature is higher than 30°C. As a result of such high temperatures during summer in Jordan (and, broadly speaking, in all the Near East), we may expect that the bimodal feeding activity of ungulates would be exacerbated. Indeed, such behavior has been observed for several ungulates living in the Near eastern desert areas (Fuller et al., 2014), particularly for the Arabian oryx (*Oryx leucoryx*) and the smaller Arabian sand gazelle (*Gazella subgutturosa marica*) (Hetem et al., 2012).

Fourth, feeding activity of ungulates alters seasonally. It is different in the warm-wet period (April-May) in the Levant to that in the hot-dry period (June-August)(Hetem et al., 2012).Ungulates (such as the oryx and the sand gazelle) shift from a pattern of daytime continuous activity (with crepuscular peaks at sunrise and sunset) during the warm-wet period to nocturnal activity during the hot-dry period. Both species become inactive three hours after sunrise and remain inactive in the daytime until an hour before sunset. As stated previously, inactivity during the hot period is accompanied by increased shade-seeking behavior. Environmental conditions, especially heat and aridity therefore change the timing of activity of these species (a phenomenon called 'cathemerality'). There is a shift to crepuscular peaks and even to nocturnal activity. It should be noted that gazelle and oryx are not obligate drinkers of surface water, i.e. they can extract water from the plants they browse without having to drink. Thus feeding at night and early morning is an optimal strategy for them because plants contain the most moisture at this time.

Fifth, the behavior of ungulates is also influenced by predator activity (including hunting by humans) and this leads to the same type of adaptation as their response to high temperature, i.e. to nocturnal bimodal feeding activity becomes more pronounced. Indeed, as pointed out by Kingswood and Blank (1996: 7), "*Goitered gazelles actively feed during early morning and late afternoon, but where they are heavily hunted they become partly nocturnal (...). They move from night pastures and watering areas to rest areas during the morning and return in evening, a distance of 10-15 km.*"

Sixth, the previous five relationships seem to have several implications for hunters. As previously demonstrated, in desert and semi-desert environment characterized by heat, aridity, food and water scarcity, ungulates adapt their behavior. Among these adaptations there is in the warm-wet season, a progressive shift to bimodal feeding activity during crepuscular peaks. Crepuscular animals are active during twilight, the latter being the illumination of the earth's lower atmosphere when the sun itself is not directly visible. In other words, they are matutinal (active between dawn and sunrise) and vespertine (active between dusk and sunset). During the hot-dry season there is an additional shift to nocturnal activity. Such observations mean that for desert ungulates the adjustments of diurnal activity do not lead to lethargy. Indeed they are accompanied, as defined by cathemerality, by an increase in nocturnal activity.

Therefore, it would have been particularly difficult for hunters to locate ungulates and then chase them during crepuscular periods since crepuscular prey require little light to easily spot and avoid predators. Moreover, it would have been impossible for hunters to locate ungulates during the night. Therefore, the only possibility for Near-Eastern hunters to capture ungulates from April to August might have been to develop "quasi-untended" strategies for the use of kites.

Kites as "Quasi-Untended" Facilities

All the arguments previously presented in this section tend to favor an alternative view of the method of hunting relying on kites. While the common view assumes that the use of kites involved in an active form of drive, it seems more likely that they were used as a passive form of drive. In fact, kites are usually considered as an example of tended facilities (Reitz and Wing, 2008: 267). According to the definition provided by Oswalt (1976), tended facilities[9] require the presence of at least one person while untended facilities[10] do not require people to be present

[9]E.g. hunting blinds, fish dams and game surrounds.
[10] E.g. most traps and snares.

since they hold game until the hunters arrive. Of course, as for most tended facilities, the kites always necessitate the presence of some hunters in order to close the entrance of the enclosure when the targeted animals are trapped inside. However, when kites are used in a passive form of drive, the number of required hunters is minimal since closing the entrance is the only task hunters have to do before killing the prey. Moreover kites present several features of untended facilities: they take advantage of the routine habits of targeted species and they reduce search time for game. Thus, kites can be considered as "quasi-untended" facilities rather than as tended facilities.

4. The Culling Schedule: On the Spot or Delayed?

According to the frequent vision, once animals were trapped in the enclosure of a kite, they were killed on the spot. Hidden hunters located in the cells surrounding the enclosure were assumed to throw spears or to use bow-and-arrows to do this. Once the animals were killed, their carcasses were carried to the processing site located far from the kites. For instance, the gazelle bones assemblage found at Tell Kuran in northeastern Syria (Bar-Oz et al., 2011a; Zeder et al., 2013) - which represents a primary butchery deposit (Bar-Oz et al., 2011a: 7347) - and which is associated with hunting utilizing kites, is located at a distance of 3 to 5 km from the closest kite (Zeder et al., 2013: 13, Figure 4). The fact that carcasses are transported and not processed on the spot seems to be logical. Indeed, if the processing site was located close to the kite, human activity would have frightened the herds of animals coming towards the kite, especially if the passive form of drive was used. Moreover the refuse of the butchery sites would have attracted scavengers (vultures, wolves, foxes...) which are also predators of wild ungulates. The latter, being frightened by the presence of some of their predators, would try to avoid the kites.

Despite the prevailing view about the purpose of desert kites and the logic of arguments in support of it, it can be challenged.

First, even though animals were killed on the spot, i.e. within the enclosure, it is not sure that hunters used lithic spears and arrows for that purpose. Indeed, although projectile points, which represent a dominant portion of formal lithic tool assemblages from PPNA and PPNB sites in southwest Asia, are typically associated with hunting weapons, no projectile points, simple flakes or their fragments used as projectile points, have been found embedded in animal bones (Müller-Neuhof, 2014). Given the lack of any evidence that wild animals were hunted with a

bow-and-arrow, alternative hunting methods have to be taken into consideration. For instance, trapped animals could have been slaughtered by using a knife, stick or club, as Maraqten (2015: 215) reported for ibex-hunting with kites. Another possibility(explored below) is that trapped animals were not killed on the spot but captured, and killed later, e.g. at a butchery site. It should be noted that the two previous alternative explanations (culling with knife or stick, and delayed culling) are both consistent with the preservation of hides. If ungulates were killed by using lithic projectiles, then their hides would have been damaged. Yet, hides of ungulates (gazelle, and especially oryx) were very valuable, maybe more so than their meat and fat, since they were used to make bags (used to transport liquids, such as water or fermented milk), footwear, clothes and tents (such as the ones used by nomads).

Second, if the caught animals were not killed on the spot but simply captured within the kite enclosure, then they could have been tethered and herded alive to the butchery site. According to such scenario, several intriguing features of kites' use become clearer.[11] On the one hand, it may explain why few animal remains have been found within kites and in their vicinity while kites are assumed to have been used for mass-kill strategies. On the other hand, the capture of animals alive is more consistent with the management of trapped animals. Indeed, if trapped animals were killed on the spot, their meat and hides would have needed to be processed rapidly otherwise they would have rotted, especially given the hot temperature of arid environments. The drying of meat and hides, by either salting or smoking, would have had to be organized near the kite to ensure preservation of the products. Furthermore, from the kite to the butchery site, the transportation of carcasses would have been very costly, especially given the long distance between both sites.

Third, if caught animals were captured and not killed on the spot, then the function of cells or "blinds" becomes more obvious. Except in rare cases (one per cent) cells are present and are always built with care; they are closed and made of high and corbelled walls. However, their precise function remains unknown. Three main interpretations of their function exists. According to the common view, they are "hides" or "blinds" where hunters were concealed and from where they killed the trapped animals. Alternatively, for Kempe and Al-Malabeh (2010: 62-63) these "blinds" could be "traps" into which animals searching for their way out of the enclosure would jump, be caught and killed. One may however argue that if cells were "traps", as claimed by Kempe and al-Malabeh (2010), why did not hunters build more cells around each

[11] This seems feasible for some species such as goat and sheep.

kite? Besides these two explanations, which both support the hunting function of kites, one may assume that the adjacent cells could have been holding pens. While the captured animals (either wild or suitable for domestication)could have escaped "easily" from the enclosure (since its wall was not very high and made of superimposed stones), they were not able to escape from the cells (where the walls are high, their height being sometimes increased by a pit, and the walls are corbelled). Moreover, in the cells, captured animals had a better protection against scavengers and predators. This would be a useful technique if only few hunters were attempting to harvest a large number of ungulates, allowing time to transport a portion of the catch to the butchery site without scavenging animals stealing any dead ungulates or predators killing any trapped ungulates. The penned animals would have been kept there for a while and later transported either to the butchery site (for wild animals) or elsewhere (for animals suitable for domestication).

5. Unresolved Issues about the Function of Kites: Were they Used for Hunting, Herding or Both?

According to the common vision, most authors consider that kites were only utilized for hunting game (Legge and Rowley-Conwy, 1987; Helms and Betts, 1987). In fact, scholars have long argued in favor of this hunting hypothesis and have dismissed the possibility that these structures were used for animal husbandry (Rosen and Perevolotsky, 1998; Holzer et al., 2010; Bar-Oz et al., 2011a; Bar-Oz and Nadel, 2013; Zeder et al., 2013). However, some authors believe that kites may have been used for herding flocks of domesticated animals or wild species suitable for domestication, or for taming 'semi-domesticated' animals (Echallier and Braemer, 1995). Some authors agree that hunting was the main function, but they do not reject the herding function (Brochier et al., 2014; Crassard et al., 2014). In other words, and as stated by Morandi Bonacossi (2014: 36), "*The current state of knowledge, however, does not allow us to exclude the possibility that at least some desert-kites were multifunctional structures, perhaps used – not necessarily contemporarily* (...)." Indeed, after the Neolithic and the time of incipient domestication, livestock husbandry became the main focus of the subsistence economy of prehistoric societies in most southwestern Asian regions since the latter are characterized by poor soils (lava fields, the “harraat”) and low rainfall levels. Thus, nomadic herders may have used kites to park their flocks at night in order to protect them from predators, thieves, or bad weather conditions (e.g. dust storm). Therefore, the large number of kites could be explained by the widespread transhumance and activities related to nomadism, the latter

being widespread in many regions of southwest Asia given the poor quality of pastures. In addition to the previous reason, other arguments challenge the common view that all kites were used exclusively for hunting game.

Intriguing Features of Kites' Morphology

First, some kites do not have an enclosure since both guiding walls converge to a pit, which is often hidden behind a ramp, and in which caught animals were slaughtered (Holzer et al., 2010; Nadel et al., 2011, 2013). However these kites are all located in the South Levant - the Negev and the Sinai - and are very few in number, about 25 according to the inventory provided by the Globalkites project (2016). While the hunting function of these kites seems obvious, all the other kites do not have a pit. As pointed out by Echallier and Braemer (1995), the lack of pit favors a herding function since in all drive structures found in other continents, a (natural or human-made) pit is present (see e.g. the famous "bison jumps" of northern America).

Second, most kites do have a very large enclosure. For instance, Barge et al. (2015b: 146-148) have studied the morphology of 530 kites located in the very heart of the Jordanian Harrat al-Shaam; the median surface of the enclosure is 0.99ha. In such large enclosures, hundreds animals (and even more) could be gathered, an observation which favors the herding function of kites.

Third, despite various attempts to define a typology of kites (Bar-Oz and Nadel, 2013: 4; Betts and Burke, 2015), one may simply consider that two broad types of kites structure exist, one with arms and one without. For the latter, there is no widespread interpretation of their function. For some scholars (e.g. Chahoud et al., 2016: 148), even though arms can be absent – as, for instance, for kites recorded in Armenian highlands (>1000 m altitude) - these kites were nevertheless hunting structures and their specific shape can be explained by the prey targeted. For other scholars, the lack of arms shows that both hunting and animal husbandry functions of kites ought to be considered (Brochier et al., 2014).

Fourth, according to the common view, it is believed that after they were driven to the guiding walls, the caught animals were subsequently trapped in the enclosure. In other words, the hunters waited until the animals were within the guiding arms of the trap and then chased them into the enclosure. Near the latter some hunters were waiting in hiding while the beaters attempted to drive the animals into the catch pen. As soon as they managed to do this, those who were waiting in ambush hastened to barricade the entrance of the corral with stones, wood

and brush, and the animals were imprisoned in the pen. Once they were imprisoned, then the animals were slaughtered. One may however wonder why the caught animals, especially because they had been frightened, did not try to escape from the enclosure by jumping over its wall? Indeed, most wild ungulates that are presumed in the literature to have been hunted utilizing kites could jump or climb the enclosure wall easily. These include the red deer (*Cervus elaphus*), the wild goat (*Capra aegagrus*), the wild sheep (*Ovis orientalis*), the roe deer (*Capreolus capreolus*), the Nubian ibex (*Capra nubiana*). However, one may however note that even for these species, pregnant, old or young animals may not be able to jump well or to leap high enough to escape. Moreover, wild ungulates have slightly different behaviors as regards obstacles and fences (Chahoud et al., 2016: 150). It seems possible thatspecies unable to escape could be only the onager (*Equus hemonius*) and the goitered gazelle (*Gazella subgutturosa*), since the latter do not leap or bound like other Asian gazelles (Kingswood and Blank, 1996: 518). For large ungulates, like Aurochs (*Bos primigenius*) and the Caucasian bison (*Bison bonasus caucasicus*), the main problem for the hunters was that the enclosure wall would not be sufficiently solid to resist to their pressure.

Multiple Interpretations of the Indirect Evidence

First, the interpretation of rock art describing hunting scenes with kites is dubious. On the one hand, as pointed out by Frison (1998: 14578), *"(rock art) violate many rules of intelligent hunting and thus lead to inaccurate and false impressions of predator-prey relationships*". Indeed what these petroglyphs really represent often is unclear; more specifically whether it is wild or domestic animals that are depicted, i.e. whether they depict hunting or herding scenes. For instance, a significant study of the Safaitic desert kites rock drawings associated with the Cairn of Hani was accomplished by Macdonald (2005: 332-345). He discussed the drawings and the inscription where a kite is present and suggested a new reading. He came to the conclusion that the drawings of the desert kite might relate to the herding of goats. However such interpretation is still controversial (Maraqten: 2015: 229).

Second, although it is true that travelers' accounts linked kites and hunting, what they described is different from the kites observed and studied nowadays. Indeed, the kites that travelers have described had some "doors or openings" in the enclosure wall. These "openings" led to pits or cells located behind the enclosure wall. Thus, when animals were trapped into the enclosure, they searched for a way to escape and inevitably went through these "doors" and fell into the

pits were they were slaughtered. However, none of the kites inventoried until now have such "openings".

Kites as part of Hunting-Herding Complexes

Pastoralism can entail a wide assortment of subsistence strategies (often called multi-resource nomadism) which can include, but are certainly not limited to, opportunistic cultivation, intensive crop agriculture and hunting and gathering alongside livestock herding (Makarewicz, 2013). For nomadic herders, hunting of game remained an important subsistence strategy and included opportunistic hunting of wild boar, birds and small game in addition to more regular hunting of gazelle. Some arguments favor kites having a double function, namely for hunting and husbandry. Thus, kites could be part of hunting-husbandry complexes.

First, and as a remark, it should be noted that no human settlements have been found in the close vicinity of kites. This is consistent with the idea that kites were built and used by nomadic herders, such as the current Bedouins.

Second, besides the kites, there are also other abundant archaeological evidence of the existence of past communities in regions where kites were built. Thousands of tumuli, stone fences and circles are found in large areas of the Syrian desert, for instance, (Kempe and Al-Malabeh, 2010, 2013). These stone structures include circular ones (or "stone circles" or "wheels") and are sometimes located close to kites (Sparavigna,[12] 2014). The function of these stone circles seems to be unclear. However, what should be noted is that their shape is typical and very different from that of kites. These stone circles look like *mrgari* found currently on the Croatian Islands of Krk and Prvic and which are used for enclosing, dividing and otherwise managing sheep and goats (Morandi Bonacossi and Iamoni, 2012). It is thus possible that kites have been used, for herding domesticated animals that were also managed in the stone circles located in the vicinity of kites.

Third, unlike what was traditionally thought, a growing body of archaeological, genetic, and ethno-historical evidence suggests that long-term gene flow between wild and domestic stocks (including sheep and goat) was much more common than previously assumed, and that selective breeding of females was largely absent during the early phases of animal domestication (Marshall et al., 2014). For instance, six wild bezoar lineages found in domestic goats suggest

[12]Sparavigna also provides a collection of stone circle images at the site https://sites.google.com/site/syriandesertsatelliteimagery/

long-term recruitment of wild females to domestic herds (Naderi et al., 2007). Such admixture between wild and domestic animals of the same species may or may not have been intentional. On the one hand, long-distance pastoral movements of flocks through the Zagros provided continual opportunities for unintentional admixture within the natural range of sheep and goats. On the other hand, any decline in domestic herd size (due to disease, droughts or any other plague) would have provided incentives for wild-capture. It is thus possible that kites were utilized for their capture.

Fourth, in archaeozoological records, caprines dominate faunal assemblages in the Near East, Arabia and Transcaucasia in the Neolithic period. If kites were used for hunting gazelles, it should be expected that there would be a significant frequency of wild game bone in the assemblages. Moreover, we have already noticed that very few animal bones have been found within or near kites. The previous observations seem inconsistent with (according to the common view) the presumed use of kites to mass-kill wild ungulates. As pointed out by Crassard et al. (2014), "*the question arises of whether kites were already in existence, but not used during the Early Bronze Age of this area or whether they were subsequently built*." However these observations are consistent with the herding function of kites. Indeed, in the cases of species suitable for adding to domesticated stocks, no bones would be left at site, especially once domestication became established.

6. Discussion

From the above review, it is clear that there are many different views about the purposes for which desert kites were used. The predominant view is that they were primarily or exclusively used for the mass-killing of ungulates, particularly gazelles. While this may have been so at one stage in the existence of many (and in some cases, may have been their exclusive use), doubts have been raised about the validity of the hypothesis and about whether drives were actually conducted for this purpose. Taking into account the available evidence it seems probable that a predominant use of some desert kites (in at least one stage of their existence) was for the mustering of domesticated livestock, and for the capture of some species of feral or wild animals suitable for domestication. The possibility also cannot be ruled out that some were used for religious purposes or cultural ceremonies. Let us discuss these possibilities further and consider the multifunctional use of kites.

The Use of Kites for Mustering Livestock

According to Cunliffe (2015: 74) sheep and goats were domesticated in South West Asia between 8,000 to 7,500 BC. It is not clear whether this was done first by hunters (foragers) or farmers, or at about the same time by both. Other species domesticated in the South West Asian region included cattle, donkeys and pigs. The extent to which kites were used to muster these other species will not be considered here but some may have been utilized for this purpose especially if dogs were used in the mustering process and cattle were probably much smaller than most modern cattle breeds.

Herding (using shepherds) was the main way of caring for flocks of sheep and goats in ancient times. Kites probably played a valuable role in the management of these flocks. Some kites may have been used for the following purposes:

- To corral livestock at night (guarded by shepherds);
- To sort out livestock to be killed;
- The cells may have been used to castrate some stock, to pluck wool from sheep, and possibly to milk sheep and goats;
- They may have also been used to select livestock for exchange. Cunliffe (2015) is of the view that the social exchange of livestock was very important in antiquity and led to the geographical diffusion of animal husbandry;
- Another important use of kites may have been to bring herds (flocks) of livestock together for the purpose of transhumance. Breaks in the walls of kites may have been for the purpose of releasing mustered livestock without the necessity of having to circumvent the wings of kites.
- It is not known how the ownership of individual animals in herds was determined. Mustering using kites may have helped identify ownership of individual animals and would have helped in keeping account of the size of flocks and their condition.
- In addition, kites may have been used to capture wild or feral goats or sheep suitable for domestication. In some cases, these may have already attached themselves to domestic herds.

The above uses are consistent with the relative absence of animal bones, for example, of gazelle at the site of kites. The butchery sites for livestock are likely to have been closer to settlements to which selected livestock could be driven for slaughter.

Possible Use of Kites for Religious Purposes and for Cultural Ceremonies

It is conceivable that some kites could have been used for religious or cultural ceremonies. The easterly direction of many of these structures culminating sometimes in a circular enclosure (or the presence of a nearby circular structure) is capable of the following interpretation: The circular enclosure might represent the rising sun and the wings its rays. Groups might have gathered along the arms of the kite to walk to its enclosure and conduct ceremonies there in its cells. This type of use does not rule out other uses of a kite.

Another explanation given in the literature (and mentioned above) is that many kites have an easterly orientation since this was most propitious for trapping of migrating gazelles because the arms would intersect the paths followed by these gazelles. However, if the return migration of gazelles followed the same route, these structures would not be effective in trapping them on their return. Furthermore, if individual herds of gazelle followed set routes, mass-killing of herds would soon decimate their population. Also one should consider the extent to which herds might learn to avoid some traps and change their migratory routes.

Multiple Uses of Kites Either Individually or Collectively

Given the available evidence, it seems likely that many kites were used for multiple purposes, and that the uses of some kites varied with the passage of time. For example, some may have been used at different times of the year for trapping and killing game, for the mustering and husbandry of domesticated livestock (primarily sheep and goats), for the capture of feral and wild animals suitable for domestication and even for religious and cultural ceremonies. The importance of these different uses probably varied with the passage of time. Multiple use would have increased the economic incentive to build such structures. Nevertheless, it is still possible that some of these structures only had a single use which did not alter as time passed.

The type of social groups possessing kites probably varied as economic development occurred and their predominant use is likely to have also altered. For example, hunter-herders and early herding groups may have principally used desert kites for livestock husbandry. With the development of city-states, kites may have been mainly used for recreational hunting, for example the hunting of gazelle by the elite of emerging city-states.

Without a doubt, the ownership of kites would have changed as a result of political and economic developments, and in the long-term these developments most likely altered their uses. Furthermore, existing kites may have been extended or modified and new ones may have been built in order to make them more suitable for their changing purposes. For example, pits may have been added to some to make it easier to capture game. In addition, some desert kites may have been abandoned because they were no longer very effective for catching game because targeted species changed their migratory routes or their populations were much diminished.

7. Conclusion

The diverse function of kites, as hunting and/or herding structures, is influenced by the passage of time. Such influence exists in the long-term, i.e. when social, economic and cultural changes occur. According to this level of time, it can be assumed that the people who have built and used the kites were not sedentary farmers (who were settled on arable lands, and thus far from the kites) but nomads. The latter could be nomadic herders-hunters living all-year round in arid environment where kites are located. In other words, the economy could be dual with sedentary farmers located on arable lands and herders-hunters roaming in steppic environment. Such duality of Near Eastern economies is attested in the academic literature. Indeed, western historical, ethnographic and archaeological accounts have, in general, categorized pastoralist activity within the region using a simple dichotomy of village-based pastoralism (associated with farming) and nomadic pastoralism (Bar-Yosef and Khazanov, 1992). The split between village-based and nomadic pastoralism is thought to have originated in proto-historical times during the Chalcolithic and Early Bronze Age, or perhaps even further back during the Neolithic (Makarewicz, 2013). Of course the transition from the Neolithic society to such duality has not been straightforward, linear and unidirectional. Indeed, it seems that it has been punctuated, with period of rapid changes followed by period of stasis, cyclical evolution and possibly some period of reversion.

The diverse function of kites, as hunting and/or herding structures, is also relevant in the *longue durée*. This level of time, the geographical time, is that of the environment, with its slow, almost imperceptible change, its repetition and cycles. Such change may be slow, but it is irresistible. In the Near East, Eastern Mediterranean and North Africa, Clarke et al. (2016) argue that the period from ~4500 BC to ~3000 BC was one in which climatic changes, some of which were rapid and of high amplitude, had discernable impacts on human groups. These impacts are evident in the archaeological record as changes in modes of subsistence, social organization

and settlement patterns, which manifested themselves differently in different locales. One would expect these changes occurring in the *longue durée* to affect the function of kites.

Our literature review and subsequent discussion suggests that the common hypothesis about kites were primarily used for the capture and mass-killing of game by means of drives, particularly of gazelle, is an inadequate vision of their purpose. Their use seems very likely to have been multifunctional (either individually or collectively) and probably varied with the passage of time. The possibility that desert kites were mainly employed (at least during a part of their life-cycle) to husband domesticated flocks/herds of livestock (particularly sheep and goats) seems to have been given insufficient attention in the available literature. A subsidiary use of kites at one time may have been to capture feral and wild species suitable for domestication. We also speculate that some may have been utilized for religious and cultural ceremonies. Desert kites must have been regarded as valuable structures in antiquity because their construction would have involved considerable skill, effort and resources. It would have been necessary to plan and co-ordinate such an undertaking. An economic surplus of labor and food would have been needed for the building of kites. Their building involved considerable capital investment.[13]

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[13]Questions still remain about when desert kites were build and by whom. Possibly, some foragers who added herding to their means of living constructed early types of desert kites. Cunliffe (2015) claims that some of these groups had a significant labor surplus.

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