

Desert Kites: Were They Used For Hunting Or For Herding? A Review of the Recent Academic Literature

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ABSTRACT

Since the discovery of desert kites during the 1920s in southwestern Asia (where they are widely distributed) their possible functions have received much attention from archaeologists. Two main functions have been hypothesized, namely, kites primarily used either as game traps or as structures used for livestock husbandry. Two papers published in the 1990s expressed opposing views about the relevance of these different uses. During the last two decades much information has been gathered on kites as a result of archaeological excavations and satellite imaging. However the function or functions of desert kites remains uncertain. Starting from the 1990s debate, we revisit this controversial issue by reviewing the academic literature published since then. On the basis of this literature and other considerations, we conclude that although some (or all) may have been used for hunting, their main use was for the mustering of livestock. This favors the hypothesis of Echallier and Braemer (1995). In addition, it seems likely that kites were used for a third function, namely the capture of some wild or feral species of animals, particularly goats.

Keywords: Desert Kites, Drive Structures, Early Bronze Age, Ethology, Hunting Strategies, Livestock Domestication, Southwest Asia, Tended Facilities, Wild Ungulates, Zooarchaeology.

INTRODUCTION

Desert kites (or simply "kites") are archaeological large stone structures widespread in most regions of southwest Asia. They are usually made of two low and long walls converging to a large enclosure surrounded by adjacent small cells. Since their discovery in the 1920s by British Royal Air Force pilots flying over the Syrian desert they have attracted the attention of archeologists. Archaeologists have rapidly tried to interpret what these structures were used for, and have suggested various purposes such as for fortifications, water management, game traps and animal husbandry (Maitland, 1927; Rees, 1929; Kirkbride, 1946). After these pioneering interpretations, subsequent publications have favored two possible functions of kites, namely their uses as hunting or herding structures. These possibilities were explored in the 1990s in *Paléorient* by Echallier and Braemer (1995) and by Rosen and Perevolotsky (1998). The former did not reject the use of kites for hunting but considered that their main use was for livestock husbandry (1995: 61) while the latter clearly rejects the

herding function of kites (1998: 110). Since the end of the 1990s, there have been important academic additions to the literature on kites. Most academic publications focus on kites located in a given region of South-West Asia, such as in the Syrian desert (Abu-Azizeh and Tarawneh 2015, Bar-Oz, Nadel, *et al.* 2011, Bar-Oz, Zeder, *et al.* 2011, Betts and Burke 2015, Bonacossi 2014, Bonacossi and Iamoni 2012, Echallier and Braemer 1995, Helms and Betts 1987, Kempe and Al-Malabeh 2010, 2013, Legge and Rowley-Conwy 1987, Zeder *et al.* 2013), the Negev and the Sinai (Holzer *et al.* 2010, Nadel *et al.* 2010, Nadel *et al.* 2013), Yemen and the Arabian peninsula (Brunner 2008, 2015, Kennedy *et al.* 2015, Skorupka 2010), the Caucasus¹ and the Asian central steppe²(Barge *et al.* 2016, Betts and Yagodin 2000, Brochier *et al.* 2014, Chahoud *et al.* 2016, Gasparyan *et al.* 2013).

Some publications also provide comparative studies of kites across southwestern Asian

¹Armenia.

² Kazakhstan and western Uzbekistan.

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regions (Barge, Brochier and Crassard 2015, Barge, Brochier, Régagnon, *et al.* 2015, Crassard *et al.* 2015). Given this literature, it is the aim of the present paper to revisit this debate about the function of kites.

Even though kites have attracted the attention of archaeologists for a long time (e.g. Betts 1982, Legge and Rowley-Conwy 1987), archaeological excavations coupled with the recent use of satellite images provided by Google Earth and Windows Live Satellite have 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 2017) in South-West Asia, from the Arabic peninsula, to the Levant, the Syrian desert,³ the Caucasus, and up to the vast steppe of central Asia.

The exhaustive inventory by country provided by the Globalkites Project (2017) was, on September 01, 2016 the following⁴: 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. These numbers are much larger than those available during the mid-1990s.

For instance Echallier and Braemer (1995: 36) estimated that at least 700 to 800 kites were in the Near-East and the Middle-East. Nevertheless, despite numerous publications devoted to kites during the last two decades, their function remains an open question. While 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.

From a review of the academic literature, we assess the arguments provided either by Echallier and Braemer (E&B) or by Rosen and Perevolotsky (R&P) against or for the herding or the hunting function. This leads us to identify four groups of arguments. Indeed, thanks to the recent academic literature, some arguments provided by E&B or R&P have been strengthened

or weakened, some are inconclusive, while others lead to qualify and extend the vision these authors had about the function of kites.

THE DEBATE IN THE 1990S ABOUT WHETHER KITES ARE HUNTING OR HERDING STRUCTURES: ECHALLIER AND BRAEMER (1995) VS ROSEN AND PEREVOLOTSKY (1998).

Even though the functions of kites were considered in the academic literature before the 1990s (e.g. Helms and Betts 1987), it was only during the 1990s that two papers, one by E&B and the other by R&P, concentrated significantly on this issue.

Echallier and Braemer (1995): The Herding Function of Kites

E&B (1995) surveyed an area of roughly 500km² in the central and southern Syrian Desert and found more than 500 kites. In most of their paper (1995: 36-56), these authors describe the morphology, orientation and location of kites, and as a result provide a typology of kites. The function of kites is discussed at the end of their paper (1995: 56-62). Mostly these authors provide reasons why kites were not used for hunting. They point out the lack of wild animal bone remains in the vicinity of kites as well as the absence of flint arrowheads or spear points within or close to kites. They consider the location of kites as well as their morphology to be inappropriate for hunting. They argue that indirect evidence provided by archaeological petroglyphs as well as by travelers' accounts (from the nineteenth century onwards) do not support the idea that kites were used as game traps but rather favors their use for herding. In addition, they believe that if kites were used for hunting, there should be much more evidence of a hunting culture in regions where kites are present.

This latter point has some connections with the second controversial issue found in the academic literature about kites, namely their dating. Most authors consider that, except in the Sinai and the Negev, the dating of kites is unclear (Barge, Brochier and Crassard 2015: 159, Brochier *et al.* 2014: 49). From archaeological excavations within or around kites in the Syrian desert, some authors contend that some kites could have been built before the Early Bronze Age (EBA). They claim that some kites were constructed during, either the early sixth millennium BC (Bonacossi 2014), or in the

³ 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.

⁴ A regularly updated interactive mapping of kite structures is available at <http://www.globalkites.fr>

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seventh millennium BC (Helms and Betts 1987), and even during the early Epipaleolithic and Neolithic periods (Legge and Rowley-Conwy 1987). However, the most frequent view nowadays is that kites are a post-Neolithic phenomenon. According to Zeder *et al.* (2013: 116), "*the most intensive use of kites across the entire Levant was in the 4th through the 3rd millennium BCE*", i.e. during a time spanning the Chalcolithic and the EBA. In 1995, E&B's view about the dating of kites accorded with the current dominant one. They considered (1995: 55) that kites could have existed in the Neolithic period but there is only firm evidence of their existence from the Chalcolithic onward. In other words, they believe that kites were mainly built and used after the Neolithic era, i.e. during a period in which much of the human diet was provided by agro-pastoralism. As contended by Zeder *et al.*, (2013: 116) "*It is for perhaps this reason that Echallier and Braemer proposed the unlikely hypothesis that 'kites were erected by pastoralists in order to capture and eventually corral herds of possibly semi-domesticated animals'*".

In fact, in their conclusion E&B (1995: 60-62) provided a qualified vision of the functions of kites, i.e. they contended that the function of kites evolved with the passage of time. They considered that some kites could have been used for hunting (e.g. gazelles) but that this was not their main function.

They believe that during an 'initial period' associated with the animal domestication process, kites were used for the capture of wild animals suitable for domestication.

According to Ducos (1993), there would have been goats and cattle in the southern Levant. Later, i.e. during a 'second period', they are of the view that kites were used mainly for the management of free-ranging domesticated livestock (that is translating "*semi-liberté*" as semi-free or partially free; see below).

Rosen and Perevolotsky (1998): Kites as Game Traps

In 1998, R&P published a short paper⁵ (five pages) the purpose of which was to reject the view of E&B (1995) that desert kites were used for capturing wild animals suitable for domestication and for animal husbandry. They provide two main arguments.

⁵ In which, curiously, there is only one heading, namely "Introduction".

The first (1998: 107-108) is that from the Palaeolithic onwards, humans have used a variety of tools and devices for hunting wild game, especially to reduce the striking distance between them and hunted animals. For such a purpose they have used natural traps for driving and corralling wild animals, and subsequently they have built such traps. Desert kites should, therefore, be considered as an example of such human-built traps.

Their second argument is about the animal domestication process (1998: 108-111), and it includes zoological and anthropological reasons. They point out that the wild ungulates (gazelles, oryx) found in areas where kites are also present have never been domesticated. The four species which were initially domesticated are sheep, goats, cattle and pigs. Moreover, even though domestic caprines were reared in the arid regions of the Near-East from the Neolithic period, their wild progenitor (the mouflon and the bezoar) had been first domesticated before (at the turn of the Neolithic period) and far away, in mountainous regions (the Taurus Mountains and Zagros Mountains) in the northern part of the fertile crescent. They also added that the domestication process requires a long-term close relationship between wild animals and humans. Thus, the latter would have been settled by farmers rather than by nomadic hunters (e.g. the Solubba) who were living in the areas where kites exist.

"Semi-domesticated Animals": Rough Translation Leading to Misunderstanding

In their rebuttal, R&P pay particular attention to the wording "semi-domesticated animals" used by E&B. However, it should be noted that this wording has only been used by E&B in the English version of their abstract. Moreover, in the French version of the abstract, "semi-domesticated animals" is correctly translated by "*animaux semi-domestiqués*". In the main text, written in French, they use twice (on page 61) the wording "*semi-liberté*". R&P (1998: 108) have wrongly considered that "*semi-liberté*" should be translated by "semi-domesticated". Indeed, they state that (1995: 108) "*It is now proposed by Echallier and Braemer that, at some point in history, some of the 'desert kites' were also used for handling 'semi-domesticated' ('semi-liberté') animals.*"

Thus the French to English translation could have led R&P to underestimate the argument developed by E&B. Indeed, "*semi-liberté*"

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simply means that animals, being domesticated or not (i.e. whatever "the stage" they have reached along the domestication process), can be corralled part of the day (e.g. in the kites) and left in the pastures during the remaining part of the day. In fact, "semi-liberté" should be translated by "free range", the latter denoting a method of farming husbandry where the animals, for at least part of the day, can roam freely outdoors (but in some cases with shepherds), rather than being confined in an enclosure for 24 hours each day. It should be noted that "free range" animal husbandry was likely widespread during prehistory (and even beyond).

Indeed, the generally poor understanding of nutrition and diseases made it difficult to raise many livestock species without giving them access to a varied diet. Moreover, the labor of keeping livestock in confinement and carrying all their feed and water to them can be prohibitive except for high-profit animals such as dairy cattle.

Thus, by focusing their attention on "semi-domesticated animals", R&P could have thought that E&B were not aware of what animal domestication actually is, while E&B were talking about a method of farming husbandry.

ARGUMENTS FAVORING THE HYPOTHESES OF ROSEN AND PEREVOLOTSKY (1998) THAT KITES WERE ONLY USED FOR HUNTING

In the first part of their paper, R&P (1998: 107-108) provide arguments supporting the hunting function of kites. They stress the similarity of kites with other drive-hunting structures found elsewhere in the world. They also identify various species which are (or were) present in the areas where kites exist and have noted that many of these species are gregarious, and their behavior makes them very suitable for hunting using kites.

Recent academic literature strengthens this part of R&P's argumentation, i.e. reinforces the view that kites were used as game traps.

The Similarity of Kites with Other Drive-Hunting Structures

R&P (1998: 108) have pointed out that trapping systems are ubiquitous among hunters and that due to their similarity with other drive hunting structures, kites would also have been used as game traps. This similarity has been highlighted in more recent publications and adds to the

plausibility of the use of kites for drive-hunting. Indeed, 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).⁶ 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 utilized 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 employed to trap aquatic animals. By analogy, it might be appropriate 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. However, argument by analogy is not a foolproof scientific method.

Species with Suited Behavior for Being Hunted with Kites

According to R&P (1998: 108), the principal targets when hunting with kites were "*several species of gazelles, onagers, oryxes, ostriches and, perhaps, wild camels,*" but no direct evidence of this assertion is provided. Subsequent publications have given support to this view by demonstrating that 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. In addition to the species mentioned by R&P, the southwestern Asian ungulates⁷ likely to be trapped using a kite were most probably *Ovis* sp. (sheep), *Capra* sp., *Cervus* sp., *Equus* sp., *Bos* sp., and *Bison* sp. Besides wild species, feral goats and sheep

⁶ 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>

⁷ It also seems (but it is disputed) that ostriches may have been hunted with kites.

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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 running over dozens of kilometers (Barge, Brochier and Crassard 2015: 147, Betts and Burke 2015), it was also assumed 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, Zeder, *et al.* 2011, Zeder *et al.* 2013) as well as in the southern Levant (Bar-Oz, Nadel, *et al.* 2011).

Many kites (for instance most kites located in East Jordan) are oriented to the east (Barge, Brochier and Crassard 2015: 147, Barge, Brochier, Régagnon, *et al.* 2015: 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 and Rowley-Conwy 1987, Zeder *et al.* 2013), there is now a tendency to believe that kites were used for the targeted mass-killing of ungulates. This vision leads us to ask two important questions: which species congregated in sufficiently large herds (of hundreds animals) and when (in which season) did such congregation occur.

Mobility and Congregation of Gazelles Species

Concerning the various species, let us focus on gazelle because they seem more likely to congregate in large herds compared to wild asses or the 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, 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.⁸ 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 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, Nadel *et al.* 2013). However, according to the inventory (by country) provided by the Globalkites Project (2017), on September 01, 2016, only 25 kites have been recorded in Egypt and Israel. Moreover, and as pointed out by Barge, Brochier, Régagnon *et al.* (2015: 164), these kites should be excluded from the 'definition' of kites because they do not present the required characteristics.⁹ Indeed, they are structures with neither an enclosure, nor adjacent cells. In fact, their 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, let us examine the mobility and congregation of *Gazella subgutturosa*. Four subspecies of goitered gazelle (*Gazella subgutturosa*) have been identified (Cichon *et al.* 2011, Kingswood and Blank 1996), but only two (were) are present in the Near Eastern

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

⁹ 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.

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region, namely the Persian Gazelle (*Gazella subgutturosa subgutturosa*) and the Arabian sand gazelle (*Gazella subgutturosa marica*). Both subspecies roam widely and move 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 killings. 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.

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.

WHETHER KITES WERE EMPLOYED FOR THE ACTIVE OR PASSIVE ENTRAPMENT OF GAME?

R&P did not address in detail how the hunts with kites were organized. However, they implicitly agreed with the prevalent vision about the hunting method associated with kites. According to the latter, 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 a view implies the 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. E&B (1995: 58-60) had already noticed that several features associated with the morphology and location of kites did not support their use as game traps. These observations led these authors to favor the herding function of kites (see section 5 of the present paper). However, it seems more likely that these features lead to a qualification of the use of kites for hunting. As explained below, several morphological features of kites and behavior of prey support the view that kites were used for a passive form of hunting (Betts and Burke 2015: 83) rather than an active one. Rather than being driven towards kites, wandering game may have unintentionally entered the guiding walls of kites and subsequently, became trapped at their apex. Consider this aspect.

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, Brochier and Crassard 2015: 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 "fixed 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 into any of them?

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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 existence of kites) in the close vicinity of kites. It seems that their function was to restrict the mobility of game – 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 is consistent with a passive form of driving.

Fifth, most kites are located in places where wild ungulates usually wandered. 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.*, 2010, Nadel *et al.*, 2013) or in Saudi Arabia (Kennedy *et al.* 2015), have either one of their arms intersecting a trail used by ungulates, or both arms encompassing 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 need to remember 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 problems.

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 it is unlikely to have happened, as supported 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. This was done to impede the ability of the asses 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 a 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 Secretariat 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 these. Thus, in a landscape otherwise devoid of obstacles, fences act like a dryland 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. This is because 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 their heat load in hot conditions. They also rely on shade, i.e. they select cool microclimates to avoid high environmental heat loads. 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. 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 hemionus*) (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. 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, the 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 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 the 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.

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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. 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 have several implications for hunting gazelles. As previously demonstrated, in desert and semi-desert environment characterized by heat, aridity, food and water scarcity, gazelles 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 gazelles 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 targeted ungulates during the night. Therefore, the only possibility for Near-Eastern hunters to capture ungulates in the period 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 entrapment. In fact, kites might be tended facilities (Reitz and Wing 2008: 267). According to the definition provided by Oswalt

(1976), tended facilities¹⁰ require the presence of at least one person while untended facilities¹¹ do not require people to be present 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 could be "quasi-untended" facilities rather than as tended facilities.

DEDUCING THE FUNCTION OF KITES BY ANALYZING THEIR MORPHOLOGY IS INCONCLUSIVE

As stated by Barge, Brochier, Régagnon *et al.* (2015: 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.

E&B (1995: 44) have provided a very similar definition of kites based on their morphology. However, they identify several features of kites (1995: 58-60) which would make them unsuitable for hunting purposes. Their analysis of the morphology of kites, plus an analogy with the wood and net structure currently used by Finnish reindeer herdsman, led them to support the herding function of kites (1995: 58). Let us turn to the review (taking into account recent literature) arguments for and against the use of kites for various critics of the hunting function of kites based on the analysis of kites' and their morphology.

The Lack of Pits

Some kites do not have an enclosure since both guiding walls converge to a pit, which is often

¹⁰E.g. hunting blinds, fish dams and game surrounds.

¹¹ E.g. most traps and snares.

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hidden behind a ramp, and in which caught animals were slaughtered (Holzer *et al.* 2010, Nadel *et al.* 2010, Nadel *et al.* 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 (2017). 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: 59), the lack of a 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). While Betts and Burke (2015: 86) agree that the issue of the lack of pits remains problematic, they point out that caught animals could be killed by hunters located around the enclosures by throwing spears and arrows. The latter vision is quite common in the academic literature (Helms 1981), i.e. the lack of pits in most kites is not considered to be an obstacle to their hunting function.

Very Large Enclosures

Most kites do have a very large enclosure. For instance, Barge, Brochier and Crassard (2015: 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.

E&B (1995: 58-59) have stressed that it would have been difficult in such large enclosures for hunters located along their external wall to kill trapped animals by throwing spears and arrows. However Betts and Burke (2015: 86) have provided evidence that even large enclosures could be effectively used for hunting, and might be most effective for passive hunting (see section 4 of the present paper).

The Lack of Converging Walls

Despite various attempts to define a typology of kites (Bar-Oz and Nadel 2013: 4, Betts and Burke 2015), two broad types of kites exist, namely, one with arms and one without these, as is pointed out by E&B (1995: 59). In the latter case, 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).

The Escape of Trapped Animals

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, as E&B (1995: 59) did, 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 argue with this previous view 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, it could be contended that wild ungulates have slightly different behaviors as regards obstacles and fences (Chahoud *et al.*, 2016: 150).

Thereby it is possible that some species were unable to escape, namely the onager (*Equus hemionus*) and the goitered gazelle (*Gazella subgutturosa*), since the latter do not leap or bound like other Asian gazelles (Kingswood and Blank, 1996: 518), a feature also highlighted by R&P (1998: 109).

EVIDENCE FROM PETROGLYPHS AND TRAVELERS' ACCOUNTS THAT THE USE OF KITES IS INCONCLUSIVE

As some authors did before them (e.g., Helms and Betts 1987), E&B (1995: 56-58) studied

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indirect evidence related to the use of kites, i.e. petroglyphs and travelers' accounts, in order to assess the functions of kites.

However, as explained below, it seems to be impossible to support either the hunting or the herding function of kites on such indirect evidence because they are consistent with multiple (and even opposite) interpretations.

Rock Art and Epigraphic Evidence: Interpretations of the Cairn of Hani

Petroglyphs representing kites have been found sometimes in close proximity to some large-scale traps in the Near East. For most scholars, what they seem to suggest is that kites were used for ungulate hunting (Bar-Oz and Nadel 2013: 3, Betts 1987, Kennedy 2012, 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. E&B (1995: 57-58) studied the Safaitic desert kites rock drawings associated with the Cairn of Hani. 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 scenes are depicted in the drawing. The first represents a scene in which a flock of ungulates is being trapped in a kite, possibly with the aid of dogs; the ungulates are captured by three men 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.

Most interpretations of the drawing associated with the Safaitic inscription consider that it clearly indicates hunted animals being driven into an enclosure (Kennedy 2012). E&B (1995: 57) claim that such interpretation is in fact self-fulfilling. Indeed, the drawn animals of the first scene are usually assumed to be gazelles and therefore it is deduced that the drawing describe a hunting scene. However if the drawn animals are assumed to be goats - which is not a strong assumption since gazelles and goats have a similar morphology - then the interpretation of a herding scene becomes obvious. Moreover in this first scene the three men do not have weapons, while the artist includes weapons in the second scene; thus there is no reason to assume that in the first scene they were hunters.

Consequently E&B (1995: 58) provided an additional argument supporting the herding function of kites. Macdonald (2005: 332-345) discussed the drawings and the inscription where a kite is present and suggested a reading similar to that of E&B. He came to the conclusion that the drawings of the desert kite might relate to the herding of goats. However, taking into account Kennedy (2012), such an interpretation is still controversial (Maraqten 2015: 229).

Therefore, the interpretation of rock art describing "hunting scenes" with kites is ambiguous. As pointed out by Frison (1998: 14578), "*(rock art) violates many rules of intelligent hunting and thus lead to inaccurate and false impressions of predator-prey relationships*". Indeed it is unclear whether rock drawings on the cairn at Hani depict wild or domestic animals and whether they illustrate hunting or herding scenes.

Travelers' Accounts

E&B (1995: 56-57) were aware of the existence of a number of travelers' accounts (e.g. Burckhardt 1831), from the sixteenth to as late as the twentieth century which described kites as structures used for hunting. However, they point out that these travelers' accounts described about the morphology of kites (and about the hunting technique adopted) are inconsistent from the morphology of 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 where they were slaughtered. However, none of the kites inventoried so far have been found to have such "openings".

Nevertheless, as stressed by Bar-Oz and Nadel (2013: 5-6) - who have collected some of these accounts - all travelers' accounts describe kites as structures used for hunting, and none of these mentioned their use for herding. Moreover, some of these accounts (during the first half of the nineteenth century Simpson 1994), are about the Solubba. The Solubba (or Sleb or the Şulayb) were a Hutaymi tribal group (or a caste) from the Arabian desert of non-pastoral nomads who lived a different lifestyle from the Bedouins, with whom they lived in a kind of symbiosis, until the Second World War. All

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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 were identified in the Selappayu of the Akkadian records. One of their links with the foraging past was their presumed use of 'desert kites' (Helms and 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, travelers' accounts confirmed that the Solubba were using kites for hunting gazelle in the nineteenth century and, according to the Akkadian records, the Solubba were already 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 and then only used them as game trap.

CHALLENGING THE ZOOLOGICAL REASONS OF ROSEN AND PEREVOLOTSKY FAVORING THE HUNTING FUNCTION OF KITES

In their rebuttal paper, one of the reasons given by R&P for rejecting the herding function of kites is based on zoological knowledge (1998: 100). However, as shown below (sections 8 and 9), by relying on the conclusions provided by recent publications, their vision of the domestication process, and therefore of the function of kites, can be challenged.

Domestication: the Final Stage vs a Long-Term Process

R&P state that (1998: 108) "animals are domesticated or not" i.e. that the wording "semi-domesticates" as no precise meaning. One may however challenge this binary vision of domestication. Recent developments about the origins of agro-pastoralism focus on the interaction of humans and the environment. At the core of this approach is the debate about initial process of domestication, i.e. how and why it has happened (Smith 2015, Zeder 2015). One definition of domestication defines it - as R&P implicitly did - as the "morphological or genetic changes in plant and animal species" (Price and Bar-Yosef, 2011: s165) even though

it is now well known that the utility of morphological markers as leading-edge indicators of livestock domestication is problematic (Zeder 2011, 2012, 2015). This new focus on initial domestication has shown that domestication is a long-term process. Furthermore, before "complete" domestication can be achieved, there exist several stages or levels of management of wild resources - such as proto-plant agriculture, the cultivation of wild plants, the management of wild herds, the taming of wild animals (Pryor 2004, Smith 2007, 2009, 2011a, 2011b, Price and Bar-Yosef, 2011, Vigne 2011, Zeder 2011, 2012, 2015). Animal domestication must therefore be viewed as the ultimate outcome of an interactive process between humans and their environments. From a theoretical point of view, such a process - the central feature of the Anthropocene - is clearly described by Niche Construction Theory (NCT) (Smith and Zeder, 2013). In other words, in the earliest phases of domestication some animals might have been managed by humans - including by means of the use of kites - even though these animals were not completely domesticated.

The Unsuitability of Local Wild Ungulates for Domestication

R&P stressed (1998: 108) that wild animals that were present in the regions where kites have been built have never been domesticated (all subspecies of gazelles, oryx, onagers) or have been domesticated (ostriches, wild camels) long after the Bronze Age. Therefore, from the Neolithic to the end of the Bronze Age, kites could not have been used for the domestication of these local wild animals. Nevertheless, one may argue that some attempts to domesticate these local wild animals might have existed during the Neolithic and that kites could have been used for such purpose. Probably of greater importance is that flocks or herds of feral species are likely to have established themselves in many regions where kites exist. These are formed by domesticated or semi-domesticated animals escaping to the wild. These most likely included goats.

Location and Timing of the Domestication Processes

R&P state that the wild progenitors of domesticates, i.e. the bezoar and the mouflon, respectively for the goat and the sheep, were found in mountainous regions (the Taurus and Zagros Mountains) located in the northern part

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of the fertile crescent, i.e. far from the regions where kites are numerous (e.g. the Syrian desert). They added that their domestication occurred earlier than the construction of kites and that "*these animals were domesticated outside the area in which "desert kites" are found and introduced to the desert as fully domesticated livestock*" (1998: 108). In other words there was, according to R&P, neither geographical nor chronological reasons for using kites for the domestication of these animals.

R&P's previous argument seems to be confirmed by the most frequent vision about domestication found in the recent academic literature. Indeed, according to the latter, it is admitted that the progenitors of the herbivores that were initially domesticated in the Near East are the bezoar or wild goat (*Capra aegagrus*) and the mouflon or wild sheep (*Ovis orientalis*). Both species are highly social and gregarious but they are not migratory. During the Epipalaeolithic period (from ca. 20,000 to 14,000 calibrated years BP) in the Taurus Mountains both species have been hunted intensively, and then selectively (Atici, 2009). Since they are not migratory species their domestication has been achieved in their natural habitat (Zeder, 2005).

However, several considerations weaken R&P's claims. For most species - animals as well as plants - there was not a unique domestication process in an unique location but several processes that started in different periods and in different regions, some being immediately successful and others only achieving success after several failures (Zeder 2011: S230). This type of diversity is well documented for goats, sheep, cattle and pigs.

Naderi *et al.* (2007) have shown the existence of at least six maternal lineages of wild bezoar. Hiendleder *et al.* (2002) have also demonstrated that the origins of the domestic sheep are unclear but are from diverse sources. Three domestic lineages have been identified, all thought to be derived from different populations of wild sheep (*Ovis orientalis*). The same conclusion has been reached for the origins of domestic taurine cattle and modern domestic swine (for an overview, see Zeder 2011: S230).

Nevertheless, Zeder (2012: 175) claims that the domestication of these four species was not the result of independent 'domestication events' but was achieved by the domestication of different

lineages of wild populations within the same cultural context. In addition to these results based on genetic studies, it should also be noted that according to Shackleton (1997), the wild progenitor of goat and sheep were also present in regions of the fertile crescent other than the Taurus and Zagros Mountains.

It is therefore possible that, at some stage in the domestication of these species, kites could have been used for their capture and their domestication beyond the 'initial' (places of their) domestication.

One may also argue that our current vision about what were the natural habitats of wild goat and wild sheep is biased. Indeed, since these wild animals are currently living in only rocky mountainous regions where access is difficult, one should not surmise that they have always solely lived there, and thus were far away from regions where kites have been built. Some of these species were probably able to live in other valleys and hilly environments, especially goats and wild sheep. Because they might have been excessively hunted in the Neolithic they might have become extinct in these other. When they were roaming more widely in valleys and plains, they could have been captured by means of kites and subsequently domesticated.

STRENGTHENING ECHALLIER AND BRAEMER'S HERDING FUNCTION OF KITES AND ITS EXTENSION TO A THIRD FUNCTION: INDIRECT EVIDENCE OF THE CAPTURE OF WILD ANIMALS KEPT ALIVE

According to the hunting function of kites, 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, Zeder, *et al.* 2011, Zeder *et al.* 2013) - which represents a primary butchery deposit (Bar-Oz, Zeder, *et al.* 2011: 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

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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 its favor, it can be challenged. Three arguments that support the use of kites for the capture of wild animals which were subsequently not slaughtered but kept alive.

The Lack of Lithic Projectile Points

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 2014a). 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 Maraqtan (Maraqtan 2015: 215) reported for ibex-hunting with kites. Another possibility is that trapped animals were not killed on the spot but simply captured by means of kites and not necessarily killed later.

Easier Transportation of Living Animals

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 another place. According to such scenario, several intriguing features of kites' use become clearer.¹² 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.

Cells Used as Pens

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 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 or elsewhere (for animals either wild or suitable for domestication).

¹² This seems feasible for some species such as goat and sheep.

THE POSSIBLE GOALS ASSOCIATED WITH KITES USED FOR THE CAPTURE OF WILD OR FERAL ANIMALS

In R&P's paper, as in most subsequent literature on kites, it is assumed that the human-animal relationship is fully described by predator-prey dynamics. Indeed, hunters' objective was to hunt wild game until it was killed and subsequently consumed. It is however possible to consider, as E&B did, that the goal of kites' users was to hunt wild game but without killing it, and instead to keep wild animals in captivity. In fact the capture of wild or feral animals may be explained by four different goals or purposes. They are presented below, according to their respective chronological relevance.

Delayed Slaughtering

When an animal is hunted and killed, its meat must be consumed rapidly (within a few days) - especially in hot or temperate climates - otherwise the meat goes rotten. A solution is to preserve the meat by drying it, by smoking it or by salting it. The problem is that such food processing techniques are costly and risky. The drying process is a long one, it requires scarce inputs such as salt, and a lot of attention to keep the meat away from predators (rodents, birds, carnivores...) during the processing and also when the meat is dried and stored. Moreover, such processes are not well suited for mobile foragers who have to carry on their back all their possessions.¹³ Therefore, another solution to get fresh meat on a regular basis was to hunt almost every day. Such a strategy was costly because it required daily efforts for hunters and, in addition, their hunt was not always successful.

Drying and storing meat as well as hunting every day or so were two costly strategies for pre-Neolithic foragers. It therefore seems quite logical that to overcome such difficulties - and even before the Holocene - hunters tried to capture wild animals and keep them in captivity for a while. In doing so, they were able to have fresh meat for several days since captured, prey could be slaughtered day after day. It should be noted that such situations have nothing to do with any management of wild animals and a fortiori with taming. Indeed, the hunters did not have to take care of the captured animals since their purpose was simply to delay their culling. The unique requirement for hunters was to keep

these wild animals in captivity, by means of tethering or penning them for instance. However, the availability of water and fodder for captured animals limits the scope for this strategy.

Animals Transport and Relocation

Beginning in the early 1990s, a number of sites have been discovered and excavated on Cyprus that have radically transformed our understanding of Neolithic emergence in the Mediterranean Basin. Indeed, as an island - isolated from the mainland - its upper Pleistocene terrestrial mammalian fauna was reduced to only four or five endemic species. Around 10,500–9,000 B.P., pioneers, probably coming from the Northeastern Levant, and traveling by boat, introduced mainland animals into Cyprus (Zeder 2008). These include wild game (fallow deer, fox) and early domesticates fauna (dog, sheep, cattle). In addition to the previous taxa, goats and pigs were also present but all the goats and approximately half of the suids at were wild/feral and therefore were obtained by hunting (Vigne *et al.* 2011).

In fact, such transportation and relocation of domesticated animals is not an isolated event, but it is well documented for Cyprus. For instance, even before the colonization of Cyprus, i.e. shortly after the early PPNB, early domestic ungulates were transported far from their areas of origin - the Taurus mountains - toward the south, to the Damascus region (Vigne 2011). Later, all the coasts and the islands of the Mediterranean basin were colonized in a way similar to that of Cyprus (Zeder 2008). What is more interesting given our aim is that such transportation and relocation also concerned wild animals, or more precisely wild animals that were "managed" and thus before morphological modifications due to their domestication were detected. For instance, Naderi *et al.* (2008) have studied the phylogeographic structure of the bezoar and showed that it is weak compared to other wild ungulates. The authors have concluded - because such mixing of haplotypes is very unusual in natural populations - that the most likely explanation for this mixing in bezoars is that humans translocated many animals in the past. In other words, their study considers the human management of wild flocks to be a possibility. It should be noted that all these transportations - especially when undertaken by boat - necessarily entailed acclimatization of the animals. Humans probably played a role in this.

¹³ Even though Neolithic foragers could be helped by beasts of burden (e.g. donkeys).

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A prerequisite for such control of wild animals is that they were initially captured and some may have been captured using kites.

Milk Exploitation

In the early 1980s, a new concept then called "Secondary Products Revolution" (SPR) was introduced in archaeology (Sherratt, 1983). The main idea was twofold. On the one hand, it was assumed that domestic animals were initially used for their primary products rather than any of their other uses. Primary animal products are defined as those which can be extracted only once in the lifetime of the animal, upon its death, and include meat, hides, blood and bone. This previous mode of animals exploitation was later replaced by a more diversified exploitation for their secondary products,¹⁴ such as milk, wool and textiles, and applications, such as traction power or transport. Thus, Sherratt (1983) argued that exploitation of secondary products appeared long after initial animal domestication, and that it should be considered as a consequence, not a cause, of the domestication. Subsequent researches have systematically used faunal data to test Sherratt's hypothesis about the introduction of secondary products in later phases of the Neolithic. These researches have led to a more balanced vision about the introduction of SPR, especially about milk and dairy products.

First, it has been demonstrated that the strict association of the SPR with the late Neolithic phase was a strong assumption. Indeed, the changes that might be linked with the Secondary Products Revolution are by no means associated with a single century or millennium and emerged in different periods across the Near-East (Marciniak, 2011).

Second, by interpreting slaughtering age profiles which reflect animal management strategies, Helmer and Vigne (2007) provide clear evidence for milk exploitation of sheep and goats as early as the first advances of the Neolithic in the Near East. Since dairy products were already part of the diet at the very beginning of the Neolithic process, it therefore seems likely that they played a role in the earliest Near Eastern domestication processes.

¹⁴ By contrast, secondary animal products can be exploited without slaughtering animals, and the same animal can be repeatedly exploited in the course of its lifetime.

Intentional Admixture of Wild and Domestic Stocks

Unlike what was traditionally thought,¹⁵ 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 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, predation on managed animals or any other factor - would have provided incentives for wild-capture. Herders valued the adaptations of the wild relatives of their domestic animals, manage animals lightly, cull at low levels, and grow herds through capture of more wild animals. Adaptations of wild ancestors to extreme environmental conditions may have contributed to intentional breeding of wild and domestic animals. Because of the unpredictability of animals surviving extreme weather events and disease, ancient herders may have preferred diverse herds, retaining rather than culling deviant individuals thereby maintaining a wide variety of characteristics in their sack. Given the previous explanation, it is thus possible that kites were utilized for the capture of wild or feral animals which could be added to their existing flocks or herds of livestock.

ANTHROPOLOGICAL REASONS FAVORING ECHALLIER AND BRAEMER'S HERDING FUNCTION OF KITES

E&B (1995: 60) have pointed out that if kites were used for hunting, then there should have been, in all of the Near-East, evidence of a culture devoted mainly to hunting. Since such evidence does not exist, they concluded that the

¹⁵ The creation of separate breeding populations of animals, wholly isolated from their wild progenitors, persists as a fundamental assumption of classic speciation-based models.

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use of kites for hunting was marginal. Betts and Burke(2015: 88) have challenged E&B's critics. They state that the kites phenomenon is not homogenous across the geographic range of the Near East and therefore we do not have to identify a single group or culture of hunters who might have built and used them. Moreover, Betts and Burke (2015: 88) added that the people of the desert have provided much archaeological evidence such as graves, cairns, corrals, walls and wheel houses. However they provide no evidence of a strong hunting culture.

R&P have also provided an anthropological reason for the rejection of the herding function of kites (1998: 110). They claimed that "*Hunters who lived at the time of the "kites" establishment in arid environments, operated in small, very mobile groups (nomadic hunters)...The hunting schedule of kite hunters ... forced them to move to a new range every 1-3 months. Such a life style does not provide conditions necessary for any domestication process, which would require a long period of mutual familiarization.*" R&P's view can however be challenged since there exists evidence that a pastoralist culture has emerged from the Late Neolithic in the Near East, even in the arid regions where kites are located.

The Development of Specialized Pastoralism from the Chalcolithic-EBA

As R&P did in 1998, most authors - even before the 1990s - consider that kites were only utilized for hunting game (Helms and Betts 1987, Legge and Rowley-Conwy 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 (Bar-Oz and Nadel 2013, Bar-Oz, Zeder, *et al.* 2011, Holzer *et al.* 2010, Zeder *et al.* 2013). Some authors agree that hunting was the main function, but they do not reject the herding function (Brochier *et al.* 2014, Crassard *et al.* 2015). In other words, and as is 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 for different purposes 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). Moreover, 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. As stated by Müller-Neuhof (2014b: 154), the period that spans the beginning of the Late Neolithic to the end of the EBA is typified by several socio-economic changes and far-reaching innovations that enable people to not only survive, but to live in marginal areas such as the arid regions of Jordan. From the Late Neolithic pastoralism began to be fully developed and became a subsistence strategy that was not as territory-bound in the manner of agriculture.

Kites as Part of Hunting-Herding Complexes

Pastoralism can entail a wide assortment of subsistence strategies (often called multi-resource nomadism). It can include, but are certainly is 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 the use of kites having two purposes, namely for hunting and husbandry. Thus, kites could be part of hunting-husbandry complexes.

First, 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 is 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 2014)¹⁶. The function of these stone circles seems to be unclear. However,

¹⁶Sparavigna also provides a collection of stone circle images at the site <https://sites.google.com/site/syriandesertsatelliteimagery/>

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their shape is similar 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 (Bonacossi and Iamoni 2012). It is thus possible that kites were used for herding domesticated animals that were also managed in the stone circles located in the vicinity of kites.

Third, 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 bones 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 (the common view) of kites being used to mass-kill wild ungulates. As pointed out by Crassard *et al.* (2015), "*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.*" 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.

CONCLUSION

Taking into account the literature reviewed above and our own observations, a major use of most kites (at least, for most of their existence) was for the husbandry of 'free-range' domesticated livestock, especially goats and sheep. Typically, during the day, livestock were able to graze in open areas and have access to water, probably accompanied by shepherds. At night, they would have been corralled in the holding pens of kites for their protection from predators. It is likely also that they were held in these pens in order to obtain secondary products e.g. milk and wool. Livestock may have also been selected for slaughter or for trade (exchange) while penned.

Whether or not kites played a major role in earliest processes of domestication of livestock is unclear. Nevertheless, the available evidence indicates that an important subsidiary use of some kites was for the capture of some species, particularly wild or feral goats, suitable for domestication (as additions to existing stocks) or for slaughter. Feral goats are relatively easy

to muster, particularly using dogs. As well, domesticated flocks can act as decoys.

Only a few kites may have been used for the mass-killing of species such as gazelle. These would include those with pits. These kites would have been unsuitable for husbandry of free-range flocks of livestock. It is also possible that some kites were used in a passive way for capture of some species, such as species of gazelle and their eventual slaughter.

Nevertheless, the view of E&B that kites were mainly used for herding free-range domesticated livestock and in some cases for the capture of wild (or feral) animals suitable for domestication, especially to add these to existing livestock, is difficult to reject.

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