

# The role of foxes in the Natufian economy: a view from Mount Carmel, Israel

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## Reuven Yeshurun

Zinman Institute of Archaeology, University of Haifa, Mount Carmel, 31905 Haifa, Israel  
ryeshuru@study.haifa.ac.il

## Guy Bar-Oz

Zinman Institute of Archaeology, University of Haifa, Mount Carmel, 31905 Haifa, Israel  
guybar@research.haifa.ac.il

## Mina Weinstein-Evron

Zinman Institute of Archaeology, University of Haifa, Mount Carmel, 31905 Haifa, Israel  
evron@research.haifa.ac.il

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## Abstract

The Natufian culture of the Levant represents a sedentary, terminal Pleistocene hunter-gatherer society. Excavations of Natufian hamlets yield rich faunal assemblages in which a significant rise in small carnivore frequencies is noted (mainly red fox, *Vulpes vulpes*). Fox frequencies remain high in the succeeding Pre-Pottery Neolithic A (PPNA). We use Late Natufian fox remains from the site of el-Wad Terrace (Mount Carmel, Israel) as a case-study to discern the depositional history and exploitation of foxes in the Natufian. Our analysis shows that it is likely that foxes were consumed for food and thus should be considered in analyses of Natufian diets. Moreover, it seems that foxes were not captured by the same methods nor using similar foraging opportunities as other fast small game species (eg, hares). We hypothesise that foxes were captured close to the sites which they approached for food. Thus, the constant rise in fox abundance from the early Epipalaeolithic to the PPNA could potentially reflect a parallel rise in site occupation intensity.

## 1 Introduction

Trends in intensification of animal exploitation have recently been well-documented for terminal Pleistocene hunter-gatherer societies around the Mediterranean basin. Among these trends is the broadening of the spectrum of the animal resource base to include lower-ranked prey species such as agile, small mammals and birds, which tend to provide small quantities of edible material for a high capture cost. This diversification of prey types has provoked a considerable research interest, because of its significance in the formation of complex hunter-gatherer societies and the Neolithisation process (eg, Bar-Oz 2004; Davis 1983, 1991, 2005; Hayden 1990; Hockett & Haws 2002; Kuhn & Stiner 2006; Munro 2004; Munro & Bar-Oz 2005; Stiner 2003; Stiner et al

1999, 2000; Stutz et al 2009; Tchernov 1991, 1993). It has been predicted that the traits of more complex societies – settling down in permanent or semi-permanent hamlets, food storage, population increase and technological innovations – would often lead to (or alternatively be made possible by) a broad-spectrum economy (eg, Flannery 1969). Thus, human demographic pulses, social organisation and occupation intensity may all be reflected in the remains of small animals from archaeological sites (eg, Munro 2004; Stiner 2001; Tortosa et al 2002).

In the Southern Levant, research relating to the economic role of small game has concentrated primarily on the Natufian culture, because of its temporal location just before the Neolithic Revolution and



**Figure 1** Location map showing Epipalaeolithic and Neolithic sites mentioned in the text

the indications it provides for a transition to a more complex hunter-gatherer society (eg, Bar-Yosef 1998; Henry 1995; Valla 1995). The Natufian culture is  $^{14}\text{C}$ -dated to ca 15k-13k cal BP (Early Natufian) and to ca 13k-11.7k cal BP (Late and Final Natufian) (Stutz 2004 and references therein). The richest Natufian sites are found within the Mediterranean environments of the southern Levant: the 'Core Area' of this culture (figure 1). Core Area sites are characterised by dwellings and installations built in stone; a variety of flint, bone and stone tools; art and decorative objects; numerous graves; and a relatively large area, high density of finds and thickness of habitation sediments. Moreover, remains of commensal animals, such as house mouse (*Mus musculus*), rat (*Rattus rattus*) and house sparrow (*Passer domesticus*) are common, signifying that humans unintentionally created new ecological niches for species which feed on human

rubbish or find shelter in human hamlets (Auffray et al 1988; Tchernov 1984, 1991). Most scholars interpret these findings as evidence of the sedentary and complex nature of the Natufian, which existed on the threshold of the Neolithic revolution (eg, Bar-Yosef 1998; Bar-Yosef & Belfer-Cohen 1989; Belfer-Cohen & Bar-Yosef 2000; Henry 1991; Valla 1995).

Human-animal relations during the Natufian are characterised by commensalism of the above-mentioned animals, along with the probable domestication of the dog (Davis & Valla 1978; Dayan 1994a; Tchernov & Valla 1997) and intensive gazelle and small game exploitation (eg, Bar-Oz 2004; Bar-Oz & Munro 2007; Campana & Crabtree 1990; Davis 1983; Davis et al 1994; Munro 2001, 2004; Munro & Bar-Oz 2005; Rabinovich 1998; Tchernov 1993; and see papers in Bar-Yosef & Valla 1991; Delage 2004). These human-animal interactions have been the focus of

detailed research. However, the role of small carnivores during the Natufian was somewhat neglected. Despite the fact that they appear in considerable numbers in Natufian bone assemblages, small carnivores are usually not incorporated into analyses of Natufian diet and subsistence (but see Bar-Oz 2004:50; Crabtree et al 1991; Davis 1989, 2005). Among the small carnivores, red fox (*Vulpes vulpes*) is especially abundant. Here we focus on the role of foxes in the Natufian economy and its implications for understanding past human-animal relations. First we present the relative frequency of foxes in the course of time, and then we examine a Late Natufian case-study to understand the origin of fox remains and the way foxes were exploited.

## 2 Materials and methods

The red fox is represented in Levantine faunas since the Lower Palaeolithic, usually in very small numbers (Davis 1977; Dayan 1994b; Kurtén 1965). Fluctuations in the relative frequency of foxes are examined here by focusing on the relevant chronological sequence for understanding the Natufian remains, ie, the Epipalaeolithic period (ending with the Natufian culture) and the Pre-Pottery Neolithic Period (the PPNA, immediately succeeding the Natufian, and the subsequent PPNB) (table 1). Fully developed agricultural societies with domesticated livestock appear in the late PPNB and especially from the PPNC onwards and therefore PPNC and later assemblages were not included in this study. Given the considerable variation of southern Levantine landscapes, we limited our examination to sites in the Mediterranean zone of present-

day Israel and Jordan, and to more marginal adjacent regions such as the Jordan Valley (figure 1). We did this in order to keep the broad environmental background of the assemblages as constant as possible (naturally we concur that microenvironmental variation still occurs between sites such as el-Wad, located at the foothills of the western cliff of Mount Carmel, and Salibiya I, located at the lower Jordan Valley).

Our sample consists of 31 assemblages dating to the terminal Upper Palaeolithic or Earlier Epipalaeolithic (EPI) (Kebaran and Geometric Kebaran cultures; hence EPI), the Early Natufian (EN), the Late Natufian (LN), the Pre-Pottery Neolithic A period (PPNA) and the Pre-Pottery Neolithic B period (PPNB) (tables 1, 2). All assemblages, with the exception of Jericho, were collected using rigorous recovery methods including sieving with fine meshes and picking all faunal fragments, thereby excluding the bias of differential recovery of large and small elements or species. The relative abundance of selected taxonomic groups: ungulates; foxes and other carnivores; and hares is presented in table 2. In order to measure the relative abundance of foxes we employed the ratio of fox to ungulates, following Tchernov (1994), using the Number of Identified Specimens (NISP). The fox / ungulates ratio was employed because of the variability in counting NISP. Different researchers include different taxa within the NISP counts but ungulate counts are relatively standard. Statistical comparison of fox frequencies between periods was performed using the Mann-Whitney *U*-test (Sokal & Rohlf 1995).

A clarification relating to the NISP counts is in or-

Table 1 The sites discussed in this study and their cultural chronology

Period	Culture	Date (ka BP uncalibrated)	Sites in this study
Early Upper Palaeolithic		20-19	Meged Rockshelter, Ohalo II
Epipalaeolithic	Kebaran and Geometric Kebaran	19-13	Nahal Hadera V, Urkan e-Rub IIa, Ein Gev I, Hezibah 7-18, Neve David
	Early Natufian	13-11	El-Wad, Hayonim, Wadi Hammeh 27
	Late Natufian	11-10.2	Salibiya I, Hayonim, Hilazon Tachtit, el-Wad, Einan, Raqefet, Hatoula, Iraq ed-Dubb
Pre-Pottery Neolithic A		10.2-9	Jericho, Hatoula, Iraq ed-Dubb, Netiv Hagdud, Gesher
Pre-Pottery Neolithic B		9-7.5	Jericho, Motza, Kfar Hahores, Abu Ghosh, Yiftahel, Ain Ghazal

**Table 2** Zooarchaeological data for the faunal assemblages used in this study. Abbreviations: EPI = Terminal Upper Palaeolithic or Earlier Epipalaeolithic; EN = Early Natufian; LN = Late/Final Natufian; PPNA = Pre-Pottery Neolithic A; and PPNB = Pre-Pottery Neolithic B. Remarks: Numbers in parentheses are NISPs based on dentitions only; an asterisk denotes unsieved assemblages

Site	Culture/ period	Fox	Other carnivores	Hare	Ungulates (total)	Ungulates (identified to species level)	Reference
Meged Rockshelter	EPI	8	7	25	1645	749	Kuhn et al 2004
Ohalo II	EPI	118	20	77	7203	2508	Rabinovich & Nadel 2005
Nahal Hadera V	EPI	190 (67)	23	474	18266	n/a (2380)	Bar-Oz & Dayan 2002
Ein-Gev I	EPI	140	15	198	5296	2372	Marom & Bar-Oz 2008
Urkan E-Rub IIa	EPI	6	0	17		648	Hovers et al 1988
Hefzibah 7-18	EPI	105 (56)	8	239	8085	n/a (1232)	Bar-Oz & Dayan 2003
Neve David	EPI	41 (10)	14	39	2382	n/a (305)	Bar-Oz et al 1999
el-Wad Cave	EN	32	25	536	1,448	817	Munro 2004, Rabinovich 1998
Hayonim Cave	EN	116	110	1,559	2,804	1,677	Munro 2004
Wadi Hammeh 27	EN	8	5	12		214	Edwards 1991
Salibiya I	LN	27	2	18		320	Crabtree et al 1991
Hayonim Terrace	LN	153	86	630	4,962	4462	Munro 2004
Hilazon Tachtit	LN	54	39	93	1,086	692	Grosman & Munro 2007
el-Wad Terrace	LN	197 (71)	19	185	2172	n/a (237)	Bar-Oz et al 2004
Einan	LN	29	8	102	914	343	Valla et al 2004
Raqefet	LN	(2)	(1)	(0)		(27)	Nadel et al 2008
Hayonim Cave	LN	153	104	417	1,645	983	Munro 2004
Hatoula	LN	(7)	(5)	(7)		(68)	Davis et al 1994
Iraq ed-Dubb	LN	23	1	13	74	45	Edwards & Martin 2007
Iraq ed-Dubb	PPNA	15	2	16	90	40	Edwards & Martin 2007
Hatoula	PPNA	(28)	(27)	(48)		(46)	Davis et al 1994
Jericho*	PPNA	128	15	n/a		379	Clutton-Brock 1979
Netiv Hagdud	PPNA	152	16	84		133	Tchemov 1994
Gesher	PPNA	2	0	2	69	61	Horwitz & Ashkenazi 2006
Jericho*	PPNB	64	16	n/a		715	Clutton-Brock 1979
Motza EPPNB	PPNB	561	181	181	5048	3545	Sapir-Hen et al 2009
Motza MPPNB	PPNB	54	28	7	611	464	Sapir-Hen et al 2009
Kfar Hahoresh	PPNB	35	0	25	479	394	Goring-Morris et al 1994/5
Abu Gosh	PPNB	81	7	n/a		2522	Horwitz 2003a
Yiftahel	PPNB	100	32	46	1482	1431	Horwitz 2003b
Ain Ghazal	PPNB	83	59	20		15029	Driesch & Wodtke 1997

der here. Normally we compared the number of fox remains which were identified to species (not the 'small carnivore' or 'small mammal' group) with the total number of identified ungulate bones, whether they were identified to species (ie, gazelle) or to size class (ie, gazelle-size). Unidentified elements were not included even when it was possible to group them within a certain ungulate size-class. Some reports do not provide NISPs for ungulate size-classes, only for bones identified to species level; some reports provide species and size-class combined; and some count species in other ways, eg, by teeth (table 2). These different counting and reporting methods may introduce some bias to our comparison. However, it is important to stress that when comparing different counting methods from the sites which were published fully enough, no remarkable differences emerged (see table 2 for data). Thus we assume that the methodological 'background noise' is not significant, even though we fully acknowledge that the most reliable comparison would be made between assemblages that originate in the same region and were collected systematically, analysed and published by

the same person using similar methods. Unfortunately, limiting ourselves to the few such published cases would severely reduce the number of assemblages available to us, and would not allow us to discuss the wider picture.

Having put the Natufian fox remains in their broader chronological context, we then analyse the fox remains from the Late Natufian sample of el-Wad Terrace, Mount Carmel (Weinstein-Evron et al 2007) as a case-study to discern the exploitation patterns of fox remains in Natufian times. El-Wad is a large site in Mount Carmel, within the Natufian 'Core Area' (figure 1), displaying a long and rich Early to Late/Final Natufian sequence. It is well-known from the 1929–1934 excavation campaign of Dorothy Garrod (Garrod & Bate 1937; see also Weinstein-Evron 2009). The site was later excavated by Valla and Bar-Yosef (Valla et al 1986), by Weinstein-Evron (1998) and by Weinstein-Evron and Kaufman (Weinstein-Evron et al 2007). We present data from the latter, and continuing, excavation. The excavation of the Late Natufian layers uncovered a rich and meticulously collected faunal assemblage, composed mainly of gazelles and

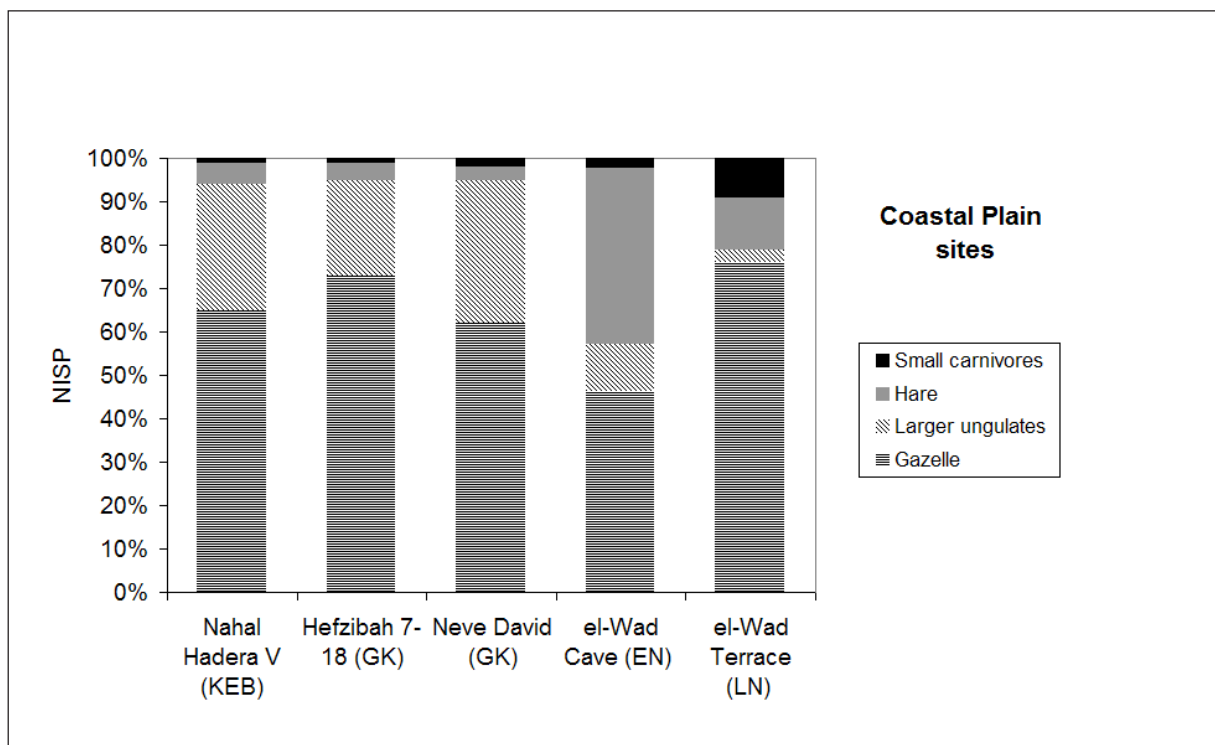
small game species, including fox remains (NISP = 180). Late Natufian meat subsistence at el-Wad focused primarily on mountain gazelle (*Gazella gazella*, 72% of NISP). Carnivores (7%) are represented by red fox (*Vulpes vulpes*), wolf (*Canis* sp), jungle cat (*Felis chaus*), beech marten (*Martes foina*), and Eurasian badger (*Meles meles*). The most abundant of these is the fox, comprising more than 90% of the carnivores. Herbivorous small game (7%) is represented by hare (*Lepus capensis*), tortoise (*Testudo graeca*), and partridge (*Alectoris chukar*). Traces of carnivore activities such as gnawing and digestion are rare, suggesting that carnivores did not play a major role in biasing the el-Wad Terrace bone assemblage. Traces of human activities such as butchery, marrow extraction and burning are abundant, and, coupled with the provenience of the bones from rich human occupational layers, they suggest that the faunas of el-Wad Terrace represent the discard of butchered game animals by the late Natufian inhabitants of the site (for a detailed account of faunal-analysis procedures and results see Bar-Oz 2004; Bar-Oz et al 2004).

### 3 Foxes in the Epipalaeolithic and the Early Neolithic periods

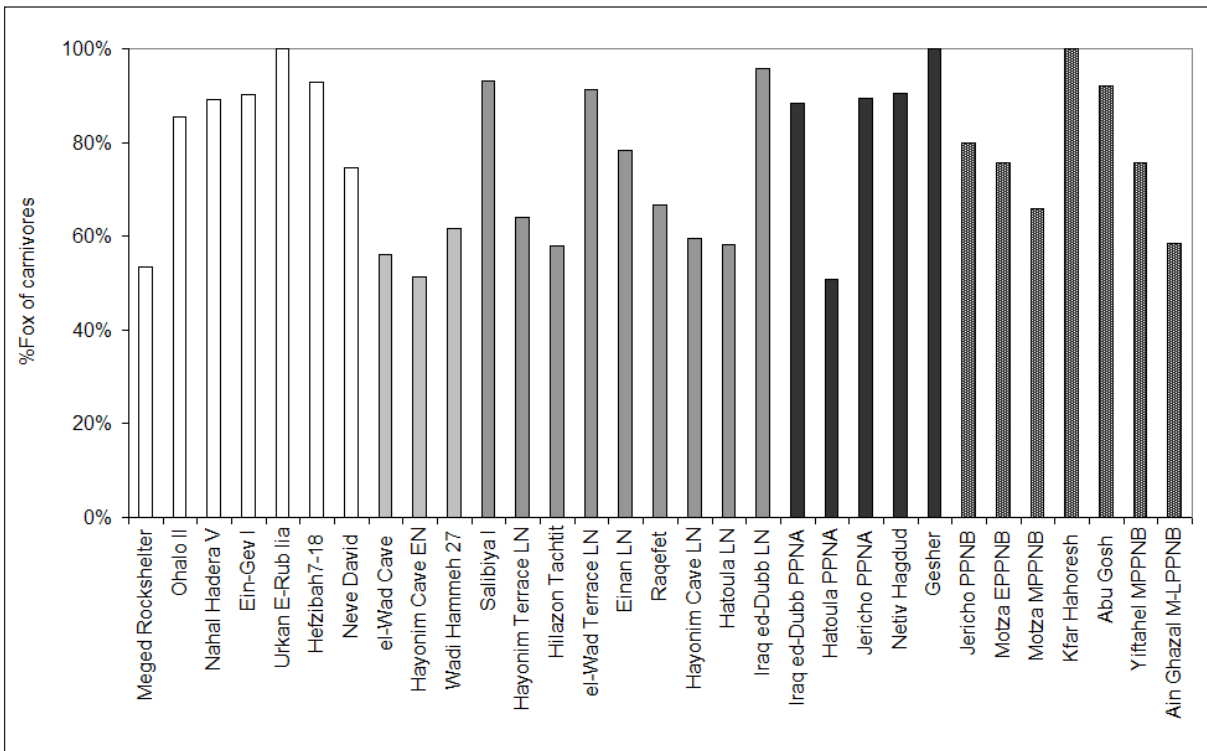
Examining the Epipalaeolithic faunas of five assem-

blages from the central Coastal Plain of Israel, all located in similar landscape and ecological setting, clarifies the trends of Natufian animal exploitation (figure 2). Natufian hunters primarily acquired mountain gazelle (*Gazella gazella*) while larger ungulates (such as fallow deer and aurochs) had become scarce compared to the earlier Epipalaeolithic. Bar-Oz (2004) showed that gazelle frequencies during the Late Natufian of el-Wad Terrace were unchanged compared to the Earlier Epipalaeolithic of the Coastal Plain and that larger ungulates were replaced by small game species, namely hares, tortoises and partridges (see also Davis 1989, 1991; Davis et al 1994). Small carnivores are also quite abundant in Natufian faunas (figure 2), but their role in the Natufian economy is not as clear. Among the carnivores, red fox (*Vulpes vulpes*) is the most common taxon in Epipalaeolithic (including Natufian) and Early Neolithic sites; its frequencies exceed that of every other carnivore (figure 3). We note that in faunal assemblages from the periods under discussion large carnivores are extremely rare. Apart from foxes, the assemblages occasionally include wolf (*Canis* sp), golden jackal (*Canis aureus*), jungle cat (*Felis chaus*), beech marten (*Martes foina*), marbled polecat (*Vormela peregusna*) and Eurasian badger (*Meles meles*).

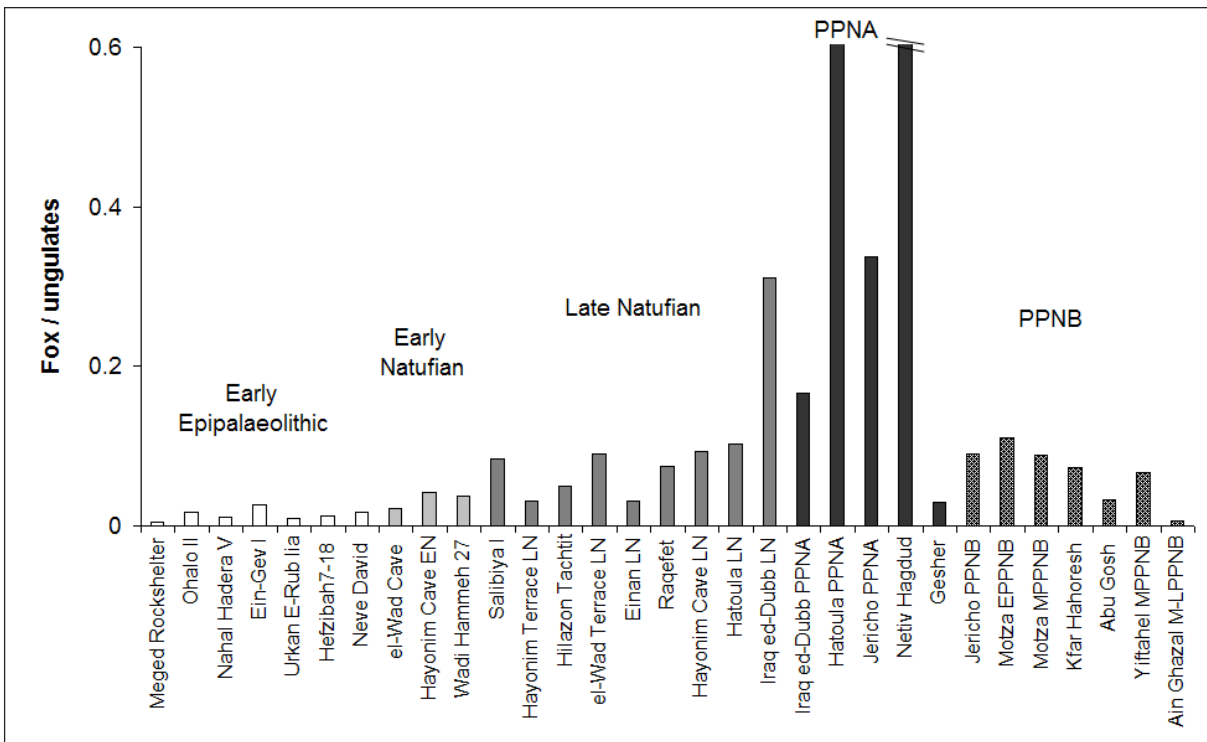
We used the ratio of fox to ungulates to measure



**Figure 2** Taxonomic composition of the Epipalaeolithic faunas of the Central Coastal Plain (data from Bar-Oz 2004, Munro 2004, Rabinovich 1998). KEB and GK refer to the Kebaran and Geometric Kebaran cultures, respectively

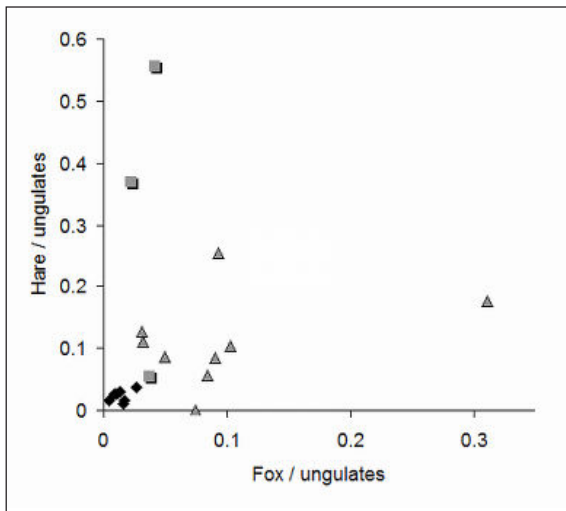


**Figure 3** Relative abundance of foxes within the carnivore sub-assemblages during the Epipalaeolithic and the Early Neolithic. See table 2 for data and references. Bars are shaded according to period



**Figure 4** The frequency of foxes during the Epipalaeolithic and the Early Neolithic of the Mediterranean Southern Levant (shown as the ratio of fox NISP to ungulate NISP per assemblage). See table 1 for the chronology and table 2 for data and references





**Figure 5** Relationship between fox frequency (fox / ungulates) and hare frequency (hare / ungulates) for the Earlier Epipalaeolithic (black diamonds), Early Natufian (gray squares) and Late Natufian (gray triangles). See table 2 for data and references

the frequency of foxes throughout the Epipalaeolithic and the Neolithic of the Mediterranean Southern Levant (table 2, figure 4). The frequency of foxes is low during the Earlier Epipalaeolithic but rises significantly by EN times (Mann-Whitney  $U = 1, p = 0.04$ ). An even more pronounced peak is evident in Late Natufian assemblages, compared to the Earlier Epipalaeolithic and the Early Natufian assemblages from the Mediterranean zone ( $U = 4, p < 0.01$ ). Fox frequencies remain high though very variable during the PPNA. The trend toward greater exploitation of foxes in this period is clear at sites such as Hatoula, Jericho, and especially Netiv Hagdud, where foxes actually outnumber ungulates. The frequency of foxes in the Pre-Pottery Neolithic B (PPNB) generally returns to Late Natufian proportions (LN vs PPNB:  $U = 26, p = 0.60$ ) (figures 4–5).

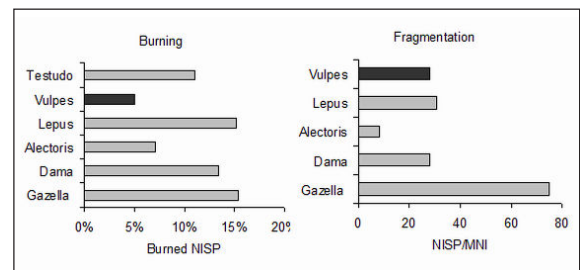
The rising frequency of fox in Natufian assemblages compared to the Earlier Epipalaeolithic partly coincides with the rise in abundance of other small mammals, especially hare. Examining fox abundance in relation to hare may thus yield some important insights. Foxes might have been captured in a similar manner to hares in the Epipalaeolithic, because the two animals are similar in size, share similar habitats and are nocturnal. In order to examine whether fox / hare frequencies are correlated for the assemblages *within each time period* we plotted the frequency of fox (fox / ungulates) against the frequency of hare (hare / ungulates) for the earlier Epipalaeolithic, the Early Natufian and the Late Natufian (figure 5). No significant trend exists for these variables in the EPI,

the EN and LN, which display insignificant positive correlations (EPI: Spearman's  $r = 0.29, p = 0.535$ ; EN:  $r = 0.50, p = 0.667$ ; LN:  $r = 0.22, p = 0.576$ ). It appears that while the proportion of fox and hare acquired in the Natufian rises sharply compared to the EPI, the acquisition of these similar-sized, agile mammals within each period was not linked (see below).

#### 4 Fox taphonomy: a Late Natufian case-study

The significant rise in the abundance of fox remains in the Natufian, especially the Late Natufian, can be further elucidated by looking at their taphonomic and mortality characteristics in relation to other taxa in the assemblages. These observations could determine how fox remains became incorporated in the Natufian habitation layers, how they were modified by the actions of humans and other agents and what role this animal played in Natufian subsistence. The following case-study focuses on the Late Natufian faunal assemblage of el-Wad Terrace.

The Late Natufian fox assemblage of el-Wad Terrace is small but informative. Fox remains (NISP = 180) are scattered throughout the excavated area. No distinct concentrations of fox remains, or articulated bones, were encountered. Fox remains are less fragmented than gazelle, but as fragmented as hare (fragmentation here is measured as the ratio of NISP to MNI per taxon; see Lyman [1994]). Also, the frequency of burned fox elements is lower than other taxa but still amounts to 5% of NISP (figure 6, table 3). These



**Figure 6** Comparison of taphonomic characteristics between foxes and other taxa in Late Natufian el-Wad Terrace

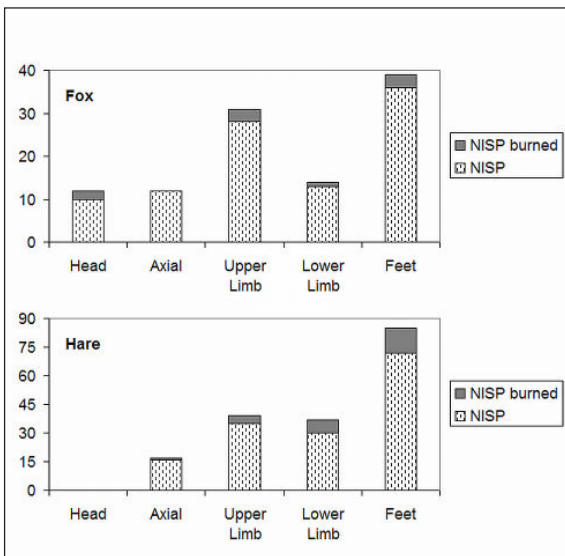
**Table 3** Counts of burned bones per taxon in the el-Wad Terrace assemblage

	NISP	NISP burned n	NISP burned %
Gazella	2055	317	15%
Dama	52	7	13%
Alectoris	42	3	7%
Lepus	172	26	15%
Vulpes	180	9	5%
Testudo	190	21	11%



**Figure 7** Fox 1<sup>st</sup> phalanx with cutmarks from the late Natufian of el-Wad Terrace

dispersal, fragmentation and burning data point to the similarities in fox accumulation processes in comparison with ungulates and other small game



**Figure 8** Number of burned bone fragments per anatomical unit for fox and hare

**Table 4** NISP and MNE counts and burned NISP counts for fox and hare skeletal elements in the el-Wad Terrace assemblage

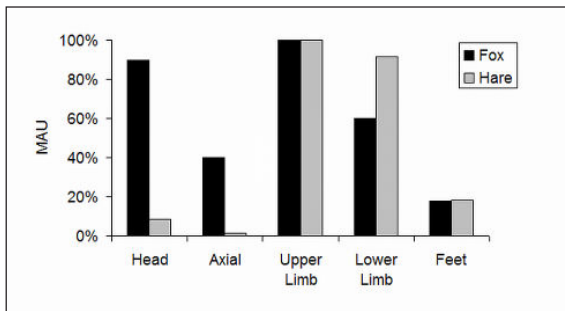
	Fox			Hare		
	NISP	MNE	Burned NISP	NISP	MNE	Burned NISP
teeth	81	9	2	16	1	1
vertebrae	5	4		5	2	
ribs	0	0		3	2	
pelvis	7	2		0	0	
scapula	2	2		7	5	1
humerus	5	2	1	16	12	2
radius	0	0		5	3	1
ulna	2	2	1	1	1	
carpals	0	0		0	0	
femur	18	10	1	15	12	2
patella	5	5	1	4	4	
tibia	4	4		8	3	1
tarsals	7	6		16	11	5
metapod	8	4		21	16	3
palanx1	17	13	2	32	22	7
palanx2	18	18	1	8	7	1
palanx3	1	1		11	11	2
<b>TOTAL</b>	<b>180</b>		<b>9</b>	<b>168</b>		<b>26</b>

such as hares.

One butchery mark was found on a fox bone (a 1<sup>st</sup> phalanx) from the el-Wad Terrace assemblage (figure 7). This cutmark, probably attributable to skinning, as well as some burned bones (NISP = 9), may indicate human butchery and consumption of foxes by the Natufians. However, the skinning mark by itself is ambiguous since it could result from fur-removal activities, not followed by consumption of meat. Additionally, the burning frequency of fox remains is lower than other taxa in the assemblage (figure 6, table 3). However, the variance of burning frequencies observed here amongst different taxa is, among other factors, an artefact of the differential skeletal-element profiles and sample sizes. If the burning frequencies per body parts for fox are compared with that of hare, the picture becomes more similar (figure 8, table 4). Both species display some burned upper and lower limb bones, as well as toes. Foxes also display burned head parts. The burning frequency of the meat-bearing upper limb fragments (represented here mainly by epiphyses) is identical for the two animals, at 11% of NISP. This proportion of fox burning on carcass extremities and epiphyses is probably too high to have resulted from accidental charring, and it is cautiously suggested that it reflects roasting of fox parts for eating.

Further taphonomic observations reveal that the most common parts of the skeleton for the el-Wad Terrace foxes are jaws and upper-limb bones. Conversely, foot bones, the axial skeleton and lower-limb elements are underrepresented (figure 9, table 4). It is unlikely that this pattern is effected by the failure to





**Figure 9** Skeletal element profile of foxes vs hares, presented by %MAU. 'Head' includes the skull and mandible; 'Axial' includes ribs, vertebrae and pelvis; 'Upper Limb' includes humerus, femur and patella; 'Lower Limb' includes the radius and tibia; and 'Feet' include metapodials and phalanges

recover smaller distal limb bones during excavation or while sieving, because of the rigorous recovery methods in the new el-Wad Terrace excavations, which produced numerous small elements of foxes (such as isolated teeth) and other small animals. Fox bone survivorship is not correlated with bone mineral density ( $r^2 = 0.03$ ,  $p = 0.25$ , regression equation is  $y = -0.9166x + 1.6733$ ; BMD values for canidae taken from Novacosky & Popkin [2005]), meaning that this body-part profile is not likely to be a product of density-mediated attrition. Overall, the el-Wad fox remains probably represent complete or nearly complete animals which were brought to the site, and are not confined to heads and toes, as has been claimed for assemblages representing the waste derived from fur-removal activities (eg, Klein 1973). Comparison of the skeletal element profiles of fox and hare in the el-Wad assemblage reveals some differences: head parts are much more abundant for fox, and lower limb parts for hare (figure 9, table 4). Nevertheless, the two species display a complete representation of meaty upper-limb bones.

The el-Wad Terrace fox assemblage is biased in favour of adult animals (about 75%, based on epiphyseal fusion data). The age structure of foxes in nature changes considerably depending on the season. During mating season, foxes in Israel today form monogamous couples and give birth to 3–5 pups. Sometimes they form 'families' with many pups concentrated in one den (Mendelssohn & Yom-Tov 1999). Thus, an age profile dominated by adults could result from intentional culling of larger foxes, and refutes the possibility of natural accumulation of fox remains as a result of denning activities on-site in periods of abandonment by humans.

In sum, similar fragmentation and dispersal characteristics as the 'nutritive' species, the abundance

of adult foxes, the representation of meat-bearing elements rather than skinning waste and the burning on meat-bearing elements, all suggest that foxes had multipurpose roles in the Natufian economy. While it is reasonable to assume that the captured foxes were skinned and their fur used by the Natufians, we have no reason to believe that foxes were not eaten following their probable skinning for furs.

## 5 Discussion

Diachronically foxes become much more important in the Natufian, particularly in the Late Natufian, than before. Our analysis of Late Natufian el-Wad Terrace indicated that fox remains underwent similar taphonomic processes and display similar characteristics of human consumption as the rest of the assemblage, particularly these species that are widely considered to be 'nutritive' (gazelles and hares). Thus it is reasonable to assume that foxes were used as a food source by the Natufians of el-Wad, along with other small-game species such as tortoises, hares, partridges (Bar-Oz et al 2004; Munro 2004; Rabinovich 1998) and perhaps even mole-rats (Weissbrod et al 2005). This, of course, does not contradict the use of foxes for raw materials (pelts, sinew, beads and tools) just like gazelle bones were used for manufacturing pendants, points, spatulas and needles (Garrod & Bate 1937; Weinstein-Evron 1998; Weinstein-Evron et al 2007).

### 5.1 Foxes as food in the Natufian and the Early Neolithic

Foxes probably did not constitute a particularly important source of food for the Natufians, because of their small absolute numbers compared to ungulates (gazelles) and because of their small size. However, their role in the Natufian meat economy, especially in the Late Natufian, was greater than before. Just before the appearance of the Natufian culture, the Geometric Kebaran assemblage of Neve David (Mount Carmel) displays a low frequency of fox remains but one specimen bears a dismemberment cut-mark, perhaps attributable to consumption (Bar-Oz et al 1999). Most studies of Natufian faunal assemblages did not consider the foxes to be part of the meat economy. Davis (1989, 2005) inexplicitly includes small carnivores as 'game species' which broadened the hunting spectrum of terminal Pleistocene-early Holocene inhabitants of the Levant. On the other hand, Crabtree et al (1991) related the fox remains from

Salibiya I in the Jordan Valley to pelt and sinew working, not to food remains. In a detailed taphonomic study of fox remains from Hayonim Cave (Western Galilee) Munro (2001) found that lower (non-meaty) limbs are somewhat better represented than upper (meaty) limbs. A large proportion of fox remains were burned, but this was partly attributed to postdepositional burning based on their location in the cave. Thus, foxes (and other small carnivores, mainly felids and mustelids) were considered to have been hunted by the Natufians of Hayonim for their skins, and not routinely used as food (Munro 2001). Conversely, Some Late Pleistocene – Early Holocene cases of fox-eating were recognised around the Mediterranean Basin and Northwest Europe, based on butchery marks, burning and body-part profiles (eg, Charles 1997 and references therein; Compagnoni et al 1997; Legge & Rowley-Conwy 2000).

If foxes were used for food by some of the Natufian groups, than their role in the small-game diet should be revisited. Munro (2004) pointed out an increase in the abundance of fast small game (hares and partridges) in the Early Natufian, while the Late Natufians exploited more slow small game (tortoises). Munro links this phenomenon to site-occupation intensity being greater in the Early Natufian; the Early Natufians had to capture high-cost small game in order to meet the dietary needs of a larger or more sedentary population. The Late Natufians could settle for the easily-captured slow game (tortoise) presumably because their populations were smaller and more mobile, allowing them not to overexploit the easily captured game (see also Bar-EI & Tchernov 2001; Stiner et al 1999, 2000; Stiner & Munro 2002). In this scheme, foxes were not included since they were not considered a part of the diet. Our analysis demonstrates that it is likely that foxes were consumed for food in Late Natufian el-Wad Terrace. If foxes are considered part of diet, their numbers should perhaps be added to the tally of fast small game species, as a partial substitute for other small agile prey (hare) in the Late Natufian. However, comparing the Early and Late Natufian layers of Hayonim Cave, which were analysed by the same researcher using identical protocol and thus are the most comparable case of intra-Natufian faunal change, the relative frequency of fox in the Late Natufian is lower than the frequency of hares in the Early Natufian (Munro 2004). Therefore fox could not have constituted a full substitute for the

people of this period.

During the Early Neolithic further compelling evidence for the use of foxes as food was published. Clutton-Brock (1969, 1979) was among the first researchers to note the phenomenon of abundant fox remains in this period in her faunal analyses of Tel Jericho. She noticed that in the PPNA and PPNB fox remains are plentiful (even more so considering that her assemblage was unsieved and therefore biased against small animal remains) and did not differ from the remains of food animals in the way they were burned, fragmented and scattered around the site. Sapir-Hen et al (2009) analysed the faunal remains from the Early and Middle PPNB site of Motza in the Judean Hills. Fox remains there are numerous, fragmented and dispersed. Significantly, many specimens that belong to meat-bearing body parts are burned. Considering this, she attributed the Motza foxes to food remains. It seems that Neolithic foxes supplemented hares and gazelles in human diet, before full caprine domestication took place (eg, Clutton-Brock 1969; Henry et al 2003; Sapir-Hen et al 2009). It is interesting to note that foxes become more 'ritually' represented by this period, either through art (eg, Göbekli Tepe; Peters & Schmidt 2004) or by possible intentional burial of their remains (eg, Kfar Hahoreh; Horwitz & Goring-Morris 2004).

### 5.2 Human capture of fox in the Natufian

Human capture of foxes in the Natufian may have been similar to capture methods of hare. Both animals, which are solitary and nocturnal, may be captured by traps and snares (eg, Holliday & Churchill 2006; Winterhalder 1980). Trapping is the likely capture method for a small, nocturnal and agile prey in the Mediterranean *maquis* and open areas surrounding most Natufian sites. If foxes and hares were hunted by trapping, which indiscriminately captures animals of similar size, a parallel trend of the abundance of foxes and hares would be expected. It is predicted that hares would dominate and foxes lag behind, because predators are less frequent in a given territory; and it is expected that capture rates per period (eg, Early Natufian and Late Natufian) would be similar in an intersite comparison. These expectations, however, are not met, as fox and hare frequencies show no correlation in an inter-assemblage comparison among contemporaneous sites. No consistent trend for the relative frequency of the two animals was found for the Earlier Epipaleolithic and Natufian assem-

blages. This might indicate that both in the EN and LN foxes were captured in a manner different from hares.

If foxes were not hunted in the same manner as hares, presumably by trapping, how were they captured? Since the foxes are generalist predators, preferably inhabiting heterogeneous landscapes and fragmented environments (Mendelssohn & Yom-Tov 1999) they are expected to thrive in the vicinity of human settlements, where human activity altered the landscape (eg, accumulating garbage dumps, clearing *maquis* and intensive harvesting of plants). The scale of Natufian human impact on the surrounding environment may have been modest (Lev-Yadun & Weinstein-Evron 2005) but it was on the rise as foragers became less mobile and more sedentary in the Late Epipalaeolithic (Belfer-Cohen & Bar-Yosef 2000; Henry 1991; Kaufman 1992). It is widely accepted that Natufian hamlets, more intensively occupied than before, attracted commensal animals such as the house mouse, house sparrow and rat (Auffray et al 1988; Tchernov 1991). Unlike hares, which avoid human settlements, foxes are known to approach human garbage dumps and refuse areas in search for food (Mendelssohn & Yom-Tov 1999; see also Tchernov 1984). It could be that Natufian hamlets, some of which were large and perhaps occupied year-round, attracted foxes which became commensals. These foxes were easier to capture in the vicinity of the site. If this reasoning is accepted, the documented rise in fox abundance in the Epipalaeolithic-Neolithic transition may hint at a parallel rise of site-occupation intensity. However, most archaeological evidence indicates greater occupation intensity at the Early Natufian, not the Late Natufian in which foxes are more abundant (eg, Belfer-Cohen & Bar-Yosef 2000; Garrod 1957).

The notion of fox commensalism was suggested previously by Kurtén (1965) and also briefly by Tchernov (1991). Kurtén (1965) recognised an increase of fox body size in the terminal Pleistocene, negatively correlated with temperature elevation, and linked it to increased availability of food from human settlements. Conversely, Davis (1977, 1981) emphasised the subsequent reduction of fox body size in the Early Holocene and attributed it to climate warming. Pending exploration of fox commensalism in the el-Wad Terrace is to use larger samples of all Natufian occupational phases, detailed taphonomic analyses,

and body-size analysis.

## 6 Concluding remarks

Foxes are present in the prehistoric sequence of Israel since the Lower Palaeolithic. Their frequencies in the Earlier Epipalaeolithic are low, with a rise in the Early Natufian period (ca 15-13k BP cal BP). Fox numbers rise further during the Late Natufian of the Mediterranean zone (ca 13-11.5k cal BP). In the following PPNA fox numbers reach their peak, in one case (Netiv Hagdud) outnumbering ungulates. During the PPNB period foxes are still abundant, with their frequencies similar to the Late Natufian.

In order to understand the role of foxes in the Natufian economy, we looked at the taphonomy of the Late Natufian assemblage of el-Wad Terrace, Mount Carmel. Patterns of bone dispersal and fragmentation, burning and age-at-death all indicate that the accumulation processes of foxes were no different from gazelles or hares, meaning that they were selectively hunted by the Natufians, transported to the site, butchered and consumed for food, and probably were also used as a source of various raw materials – just like gazelles, for that matter. Considering this, we find no reason to omit the fox from future analyses of Natufian diet.

When frequencies of foxes are compared with hares in the Natufian assemblages no consistent trend emerges. This leads us to suggest that foxes were not hunted using the same methods or foraging opportunities as hares (eg, trapping). It is suggested that foxes were captured close to the sites, to which they approached for food. The Natufians of el-Wad could have taken advantage of the approaching foxes and capture them opportunistically, whereas they had to invest more in order to capture hares (building, setting and attending the traps). Thus, the constant rise in fox abundance from the early Epipalaeolithic to the PPNA could potentially reflect a parallel rise in site occupation intensity. Specifically in the Natufian, the larger sites and refuse accumulations created a new ecological niche for animals, probably including foxes, which are known to be attracted to garbage dumps. This probably caused the Natufians to encounter foxes more frequently, consequently elevating their exploitation.

The assemblage of fox remains presented in this study is small and therefore our conclusions are tentative. With continuing work on the Early and Late

Natufian faunas from the ongoing excavations at el-Wad Terrace, more data and more detailed analyses will be available to investigate the role of small carnivores in the Natufian economy and its implications for Natufian subsistence and social patterns.

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