



“After 20 Years”: A Taphonomic Re-evaluation of Nahal Hadera V, an Epipalaeolithic Site on the Israeli Coastal Plain

Guy Bar-Oz and Tamar Dayan

Department of Zoology, Tel-Aviv University, Tel-Aviv 69978, Israel

(Received 29 September 2000, revised manuscript accepted 27 February 2001)

We carried out a detailed taphonomic study of the faunal remains from Nahal Hadera V (NHV), a large Kebaran open-air site on the northern coastal plain, Israel. Faunal remains were previously identified to bone element and species (Saxon, Martin & Bar-Yosef, 1978). However, NISP and MNI values were calculated based on teeth and epiphyses only. In this study we identified the maximum number of skeletal elements, including head fragments, vertebrae, ribs, carpals/tarsals, and shaft fragments. Further analyses included search for various bone surface modifications and the study of mode of bone fragmentation. We found minor loss of bones caused by various diagenetic processes, and no signs of carnivore activity. These results suggest that most of the bone destruction was caused during time of occupation, probably for marrow consumption, as indicated by mode of bone fragmentation. Absence of selective transport for gazelle (*Gazella gazella*) and fallow deer (*Dama mesopotamica*), the major prey species (with 70% and 20%, respectively), is supported by homogeneous representation of head-limb-toe elements. However, the carcasses may have been processed before transport to the site. Thus, a taphonomic analysis from NHV helps to illuminate the economy of NHV inhabitants and fine-tunes our understanding of the depositional history of the site. However, it does not overthrow results of earlier research using classical methods.

© 2002 Elsevier Science Ltd.

Keywords: BONE FRAGMENTATION, EPIPALAEOLITHIC, FALLOW DEER, FAUNAL ANALYSIS, GAZELLE, KEBARAN, LEVANT, SKELETAL PART REPRESENTATION, SURFACE MODIFICATION, TAPHONOMY.

Introduction

The use of taphonomic tools to interpret zooarchaeological remains has developed and advanced dramatically during the last two decades. Taphonomic research has yielded a growing body of literature documenting sources of attrition that may affect zooarchaeological samples either before or after their deposition (see Lyman, 1994, for an extensive review of the history of taphonomic research and a wide range of analytical approaches). Zooarchaeologists largely recognize the significance of taphonomic research for detecting potential biases in the zooarchaeological record (e.g., Gifford, 1981; Bonnicksen, 1989; Koch, 1989; Behrensmeier, 1991; Stiner, 1991; Lyman, 1994; Martin, 1999). Clearly many scientists are confident that taphonomy holds the key to fine-tuning our understanding of ancient human economies.

Recently Marean & Kim (1998) suggested that detailed taphonomic investigation may actually overthrow the results of previous research. In a challenging study they suggested, based on careful identification

and refitting of shaft fragments in Kobeh cave (Middle Paleolithic) of Iran, a totally different depositional scenario for the remains. Their results imply a different economy of the early hominids than previously inferred. Their analysis, which included the mid-shaft fragments of long bones, produced a skeletal element profile dominated by limb bones of the highest meat utility. Removing these mid-shaft fragments creates a profile dominated by head and foot, previously interpreted as reflecting human scavenging. Marean & Kim (1998) suggested that this perceived pattern is a methodological artefact resulting from ignoring the shaft fragments, and that the actual scenario to be reconstructed is of active hunting by humans. This study triggered an ongoing debate regarding both research methods and the conclusions to be drawn from the evidence (see Bertram & Marean, 1999; Klein, Cruz-Urbe & Milo, 1999).

Marean & Kim's (1998) conclusions have far-reaching implications. If studies that do not incorporate fine taphonomic detail may be totally overthrown, the conclusions drawn from a wide volume of literature on prehistoric economies may be questionable. Although Marean & Kim's study deals with cave assemblages, their results may also be applied to open-air sites of other periods (Blumenschine, 1998).

Tel.: 972-3-6409024. Fax: 972-3-6409403. E-mail: dayant@post.tau.ac.il

Marean & Kim's (1998) results have raised debates concerning the time, effort, and budget required to apply their analysis of shaft fragments (Stiner, 1998; Klein *et al.*, 1999). In larger samples, typical of later sites, such a study would require an unacceptable time investment (Greenfield, 1998). Obviously, in most studies epiphyses tend to be chosen because they provide more information concerning taxon, age, sex, and size, in less time than do long bone shaft fragments. These limitations are of particular relevance for rescue excavations.

We carried out a detailed taphonomic study of the faunal remains from Nahal Hadera V (NHV) in order to improve our knowledge about the economic structure and the depositional history of the site. The terminal Pleistocene cultures of the Levant have been the focus of intensive research, results of which have been published as numerous site reports. Reconstructing the subsistence economy of prehistoric people is often key to understanding the evolution and development of their cultures. Faunal remains from this period have been studied using classical zooarchaeological methods (e.g., Legge in Noy *et al.*, 1973; Davis, 1974; Clutton-Brock, 1979; Saxon *et al.*, 1978; Dayan *et al.*, 1986; Tchernov in Valla *et al.*, 1986; Horwitz in Hovers *et al.*, 1988). Taphonomic research in the Levant is still limited; few studies in recent years have employed taphonomic techniques (e.g., Rabinovich, 1998; Rabinovich & Tchernov, 1995; Speth in Bar-Yosef *et al.*, 1992; Speth & Tchernov, 1998).

In a zooarchaeological research continuum spanning the past century, should a line be drawn between earlier studies and those using taphonomic techniques? Can studies using taphonomic techniques be viewed as a fine-tuning of earlier research or as revolutionizing our reading of the data? How much trust can we place in earlier studies?

The faunal remains from NHV, a large Kebaran open-air site on the coastal plain, had been identified to bone element and species when previously published within a site report that encompassed pedology, the faunal remains and the lithic assemblage (Saxon, Martin & Bar-Yosef, 1978). The zooarchaeological report was limited to species identifications based on teeth and epiphyses only. NISP and MNI values obtained were calculated based on select anatomical elements, without identification of shaft fragments and less identifiable body parts (head fragments, vertebrae, ribs, and carpals/tarsals). Surface modification was not studied, and age distribution was based only on unfused metapodials.

The Kebaran site of NHV is a key site for understanding the economic structure of the Epipalaeolithic sequence of the coastal plain. The site is one of the few Kebaran open-air sites located in the core of the Mediterranean region. It comprises thick cultural deposits and high densities of faunal remains. The Epipalaeolithic cultures (Kebaran–Geometric–Kebaran–Natufian, in the Mediterranean region)

evolved during the Last Glacial Maximum (~20/18–10 ka) from nomadic hunter-gatherers (Kebaran) to complex communities with large-scale permanent settlements (Natufian) (e.g., Bar-Yosef & Belfer-Cohen, 1989, 1992; Henry, 1989; Kaufman, 1992; Fellner, 1995; Goring-Morris & Belfer-Cohen, 1998). It has been suggested that during the Natufian we witness an increasing reliance on a broad spectrum economy featuring an increased number of small game species (e.g., Henry, Leroi-Gourhan & Davis, 1981; Tchernov, 1992; but see Bar-Oz, Dayan & Kaufman, 1999) and an increase in the percentage of gazelle (*Gazella gazella*) exploited (e.g., Legge, 1972; Davis, 1982, 1983; Henry, 1989; Tchernov, 1992; Martin, 2000). The roots of these subsistence strategy changes may lie in the preceding Kebaran culture. Only a very limited number of pre-Natufian Epipalaeolithic excavations have yielded good faunal collections, and many of these have been published mainly as faunal lists, as was done for NHV (Saxon *et al.*, 1978).

Marean & Kim (1998) focussed their study on shaft fragments and bone surface modification. However, there are other aspects of taphonomic research, which may be important for understanding site formation processes, but which have little to do with Marean & Kim's arguments (e.g., ratio of unidentified bone fragment size categories, bone weathering, degree of bone fragmentation, etc.). Moreover, in the past two decades zooarchaeological research methods have developed significantly also in such aspects as studying the age structure of the hunted population (based on tooth wear).

We carried out a detailed taphonomic and zooarchaeological analysis in order to gain insight into the Kebaran economy. In particular we wished to define the depositional history of the bone assemblage so as to gain insight into human subsistence patterns (food transport and food processing). In addition, we analyzed the age structure of the hunted population, based on continuous distinction (tooth wear) and juvenile-adult distinction (epiphyseal closure) (e.g., Davis, 1987).

We tested the contribution of carrying out detailed taphonomic research to our understanding of the economy of the Epipalaeolithic hunters-gatherers of NHV. Specifically, we asked whether our detailed taphonomic study bolsters previous hypotheses and fine-tunes our understanding of the depositional history of the site, or whether it overthrows the results of previous research.

The Site and its Settings

The site of NHV is situated on the central coastal plain, on top of the first sandstone ("Kurkar") ridge overlooking the Hadera river, about 1 km south-east of its outlet to the sea. The coastal plain is a flat land strip with parallel sandstone ridges, following the contours

of the sea shore, which during the Kebaran was some 10–13 km wider than today (Weinstein-Evron, 1998). The Hadera River flows westward from the mountainous zone, obstructed by the sandstone ridges and forming, until recently, swamps and ponds at the vicinity of the site. NHV is a large lowland site, comprising deep and rich cultural deposits and a high density of artefacts, much the same as the nearby Geometric-Kebaran sites of Hefzibah a few hundred metres away (Ronen *et al.*, 1975; Zackheim & Bar-Oz, 1998) and Neve-David at the foothill of Mount Carmel near Haifa (Kaufman, 1989, 1992).

The excavation by E. Saxon in 1973 was carried out in a 3 m by 2 m pit on the highest area of the hilltop. All matrix was dry-sieved (0.2 cm) and then wet-sieved, sorted, and stored at the Institute of Archaeology, the Hebrew University, Jerusalem. E. Saxon identified the faunal material. The majority of the Kebaran finds were preserved stratified and were restricted to a layer of a very dark brown Hamra soil, 0.2–0.6 m below the surface (Saxon *et al.*, 1978). There are no radiometric dates from NHV. Chronologically the lithic assemblage (group C and D, Bar-Yosef, 1981) places the site within the time frame of the Kebaran complex *c.* 20/18–15/14.5 ka (Bar-Yosef & Vogel, 1987).

The bone assemblage was found to be dominated by mountain gazelle (*Gazella gazella*, 70%) and fallow deer (*Dama mesopotamica*, 20%). Other large mammals from the coastal plain (equids [Equus spp.] and hartebeest [*Alcelaphus buselaphus*]) and from the wooded area (aurochs [*Bos primigenius*] and roe deer [*Capreolus capreolus*]) are represented by small proportions. Small game are represented by the fox (*Vulpes vulpes*), hare (*Lepus capensis*), and tortoise (*Testudo graeca*) (see below). The prehistoric environment reconstructed by Saxon points to a majority of species associated with dry sandy soils with sparse vegetation, predominantly grass and scrub. The aurochs and cervids indicate the availability of a permanent water source nearby, while gazelles, hartebeests, and equids indicate that wet marshy areas must have been minimal or non-existent (Saxon *et al.*, 1978).

Faunal Analysis Procedures

We carried out the following faunal (including taphonomic) analysis procedures:

- (1) After sorting the identifiable elements, the unidentified material was sieved through two meshes (1 cm and 0.5 cm; note also that the entire site was dry sieved using 0.2 cm mesh). The remains of each size group (i.e., 0.2–0.5 cm, 0.5–1, larger than 1 cm) were weighed. Fragments larger than 1 cm were also counted. This procedure enabled us to compare the ratio of each of the bone size categories in the assemblage to those of other sites (Gifford-Gonzalez, 1989).
- (2) Skeletal elements were identified to the closest possible taxonomic unit, including elements not

previously identified by Saxon: head fragments, vertebrae, ribs, carpals/tarsals (only astragali and calcanei were previously identified), and shaft fragments. The latter were identified to size class only. The hartebeest remains are rare and therefore we assume that their share in the medium-large size class is negligible, and we view the entire class as representing fallow deer. The same is true for gazelles and the extremely rare bones of roe deer in the small-medium size class. A growing number of studies has shown that these elements (head fragments, vertebrae, ribs, carpals/tarsals, and shaft fragments) are important for extrapolating modes of preservation in relation to bone density (Lyman, 1984, 1994), food transport (i.e., Food Utility Index, Metcalfe & Jones, 1988), and body part representation (e.g., Marean & Kim, 1998). Moreover, recording the degree of fragmentation of each identified bone element (i.e., percent of preservation) enables us to compute the Completeness Index (Marean, 1991). The ratio of cranial bones to teeth was used to estimate bone preservation (after Stiner, 1994).

- (3) All identifiable fragments were immersed in acetic acid (5%) for *c.* 24 h, then transferred to sodium bicarbonate in order to buffer the acid, and washed and dried slowly. This procedure enabled us to observe various surface modifications by using a 10 × -magnifying lamp. We searched for modifications indicating post-depositional agents (i.e., bone weathering [Behrensmeyer, 1978], trampling [Fiorillo, 1989], root marks [Lyman, 1994], abrasion [Shipman & Rose, 1988]), as well as cut marks (Binford, 1981), percussion marks (Blumenschine & Selvaggio, 1988), and signs of animal activity (Fisher, 1995).
- (4) Mode of bone fragmentation was analysed for all epiphyses and near-epiphysis shaft fragments. Fracture angle and outline were assessed in order to determine the stage at which the bones were broken (Villa & Mahieu, 1991), as well as the bone circumference preservation index in order to discern carnivore activity (Bunn, 1983).
- (5) Age structure of the major hunted species (gazelle and fallow deer) was analysed based on epiphyseal closure (Davis, 1980). Gazelle age structure was also analyzed on the basis of tooth wear (rate of tooth wear of recent gazelle was determined using individuals of known age in the Tel-Aviv University Zoological Museum).

The Faunal Assemblage

The site yielded 5444 complete and fragmentary bones, larger than 1 cm in maximum dimension, weighing a total of 20,403 g. The rest of the bone assemblage comprised 0.5–1.0 cm (7483 g), and 0.2–0.5 cm (4198 g) unidentified bone fragments. Of the 5444 2654 bones

were identified to taxon and body part. Similar ratios of identifiable to non-identifiable elements are known from African hunter-gatherer sites (see Gifford-Gonzalez, 1989).

The relative abundances of the 14 taxa found (including *Felis chaus* and *Agama stellio*, previously unidentified by Saxon) were quantified using the number of identified specimens (NISP) for each taxon together with the minimum numbers of individuals (MNI) from which the remains originated (as in Klein & Cruz-Urbe, 1984). Table 1 summarizes Saxon's results and ours. The main difference between the results is sample size, mainly caused by the addition of the bones identified to size class. Since bone fragments constitute the overwhelming majority of identified elements, we documented the bone fragments as a fraction of the bone by its part and by its side. For example, a long-bone epiphysis was documented by its percent of the proximal or distal end, and whether it is a lateral or medial fragment. All identified elements were then summed to number of complete bones. By this method MNI values do not depend on the degree of fragmentation (Klein & Cruz-Urbe, 1984). This fact may account for the lower MNI found by us in comparison to Saxon. The discrepancy between Saxon's and our MNI values could also be explained by his attributing certain bone elements to different strata within the Kebaran layer. In our analysis we refer to the Kebaran assemblage as one unit, as we found it stored.

Although our identified element count is more than double that previously identified, our results do not differ significantly in the relative abundance of each taxon from those of Saxon (based on NISP; R^2C test of independence; Sokal & Rohlf, 1995; Gadj=25.09; $P<0.001$; Figure 1). This result shows that our laborious method of identification, which included the size classes of bones and shaft fragments, did not change species abundance distributions. Evenness of the two samples (based on Shannon-Weaver indices; Krebs, 1989) reveals no major differences between the earlier analysis and ours. The contribution of the evenness to the diversity of an assemblage is $J=H'/H_{max}$ (Zar, 1996). The evenness calculated for each of the assemblages (0.024 and 0.028 for Saxon and us) suggests that use of size category bones did not affect equitability.

The major prey species at NHV (based on NISP) are gazelle (72.3%) and fallow deer (23.4%). Similar proportions of these species were also found in other Epipalaeolithic sites in the area (Bar-Oz *et al.*, 1999). The small-game/ungulate index for NHV is 0.08 (calculated as in Stiner, Munro & Surovell, 2000). A high ratio is suggested by Stiner *et al.* (2000) to reflect food stress and rising human population densities during Late Palaeolithic. The ratio at NHV is lower than those found by Stiner *et al.* (2000) in the Kebaran assemblages of Hayonim cave and Meged rock-shelter (0.17 and 0.37, respectively; small game in

both consisted mainly of tortoises, partridges, and hares).

Dental wear of gazelles was analysed based on dental age classes through comparison to rate of tooth wear of recent gazelle skulls in the Tel-Aviv Zoological Museum, whose age at death was recorded (following Deniz & Payne, 1982 for goats). The percentage of young individuals, under the age of 18 months, according to dental wear stage, is 38%. For comparison, the percentage of young individuals (under 18 months of age) in a recent herd is estimated at approximately 35% (Baharav, 1974). This result suggests a hunting pattern that is not age-related. However, we note that these results are merely suggestive, since not only do the percentages of young in the field vary considerably from year to year in natural herds, but the effect of time averaging on the "fossil herd" may be significant as well. The percentage of young individuals based on gazelle epiphyseal fusion (Davis, 1980) of several skeletal elements (i.e., radii, metapodia, femora, tibiae, calcanea) whose fusion ages range between approximately 10 and 15 months of age (method developed by Davis, 1983) is 41.1%. The percentage of young individuals based on epiphyseal fusion of distal metapodia reported by Saxon *et al.* (1978) is 35.2% (and 36.1% in our analysis). Thus the gazelle epiphyseal age profile resembles the dental profile quite closely.

We used the method developed by Davis (1983) for calculating the percentage of young gazelles in the herd also for fallow deer, and arrived at 25%. The percentage of young individuals based on epiphyseal fusion of distal metapodia reported by Saxon is 41.6% (and 44.4% in our analysis). Both results for ageing the fallow deer are problematic owing to small sample size ($N=4$ out of 9 measurable bones in Saxon's analysis, and $N=7$ out of 28 in ours). Nevertheless, the percentages of young gazelle and fallow deer found in NHV are similar to those found in other Epipalaeolithic sites from the area (Davis, 1983; and see Bar-Oz *et al.*, 1999 for discussion).

Taphonomic Analyses

The relationship of bone preservation to bone density (e.g., Lyman, 1984, 1994) enables us to assess the relative strength of taphonomic disturbances caused by pre- and post depositional processes, which reduce our ability to interpret human subsistence patterns and palaeoecological conditions (Klein & Cruz-Urbe, 1984). The probability that skeletal parts will survive various taphonomic processes is at least partially a function of their structural density (e.g., Lyman, 1994).

We found a positive and significant relationship ($R^2=0.452$; $P<0.01$) between gazelle bone survivorship (based on proportional frequency of elements observed in NHV [%MNI]) and bone density (based on domestic sheep bone densities [Lyman, 1984]), which accounts for 45% of the observed variance. A positive

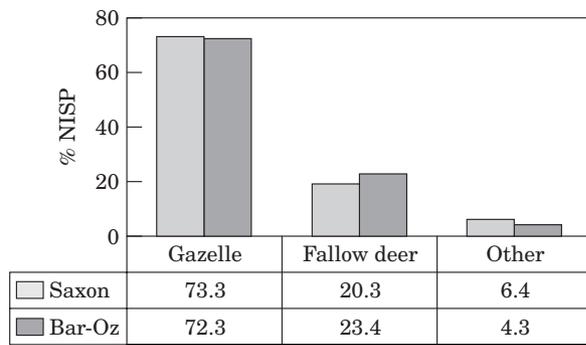


Figure 1. Relative frequencies of the main hunted species from NHV found by Saxon and in the present study.

relationship ($R^2=0.57$; $P<0.001$) was also found between fallow deer bone survivorship (based on proportional frequency of elements observed in NHV [%MNI] and bone density (based on *Odocoileus* spp. [Lyman, 1984]), which accounts for 57% of the observed variance. The regression line obtained for gazelles ($MNI=0.965*(\text{bulk density})-0.12$) does not differ significantly from that for fallow deer ($MNI=0.927*(\text{bulk density})-0.125$) (ANCOVA; $F=0.619$; $P<0.001$). These results suggest a similar rate of differential loss of gazelle and fallow deer bone elements relative to their density, owing perhaps to taphonomic disturbances. Human grease rendering could lead to a similar result (Speth & Spielman, 1983; Speth, 1989).

The relationship of bone preservation to food utility index (FUI) (Metcalf & Jones, 1988) shows the opposite pattern to that found for bone density. This method accounts for the economic utility of animal body parts found at the site (based on minimum number of animal units [MAU] observed in NHV) and FUI (based on the weight of useable tissue associated with caribou [*Rangifer tarandus*] body parts). The relationships between the variables enable us to assess the relative strength of selective transport. Selective transport is suggested when there is a significant positive relationship between abundance and food utility, together with a lack of relationship between abundance and bone density (Klein, 1989). However, bone frequency of gazelle and fallow deer in relation to their estimated food value shows no relationship between the variables ($MAU=-0.025*(\text{food utility index})+14.05$, $R^2=0.036$, $P=0.448$; $MAU=-0.02*(\text{food utility index})+5.74$, $R^2=0.110$, $P=0.177$, for gazelle and fallow deer respectively). These results suggest that bone frequency was affected by selective destruction (density) alone and was not affected by selective transport (food value) (see Klein, 1989 for discussion). The absence of selective transport decisions is supported by the skeletal part representation (see below).

Surface modifications observed on all epiphyses and near-epiphysis shafts fragments suggest that major loss by decay is not likely. The bone assemblage contains

few signs related to diagenetic processes (which affect bones in relation to their size, volume, and density, as well as external factors, such as pH, and sediment composition, among others [e.g., Lyman, 1994]). Chemical decomposition, however, was not studied during the excavation so we cannot attempt to quantify its role in the taphonomy of the site. Burial, physical, chemical, and biological processes in the soil may destroy bones but leave teeth relatively untouched. However, ratios of (based on MNI) cranial bones to teeth (21.5/24 for gazelle and 8.5/14 for fallow deer) suggest minor loss of identifiable bones caused by fragmentation or decomposition processes (after Stiner, 1994). Similar results were obtained by using Marean's (1991) method for measuring the impact of post-depositional destruction. The Completeness Index for NHV calculated for the navicular-cuboid (70.3%) and astragalus (72.35%), which show the greatest difference among other carpals and tarsals, are similar to those from Marean's (1991) non-destructive site, suggesting that the NHV bone assemblage did not suffer significantly from post-depositional destruction. The long bone assemblage contained minor signs of surface weathering (stages 0–2, according to Behrensmeier, 1978), suggesting that weathering was also insignificant. We found no typical signs of surface modifications (as in Fiorillo, 1989) indicating pre-depositional bone trampling. Among all the identifiable elements, we have found 27 (8.7%) with root marks (Lyman, 1994) on the surface of the bones, suggesting that root activity was also minor in biasing the bone assemblage. None of the bone edges displayed rounding and/or smoothing of break surface (e.g., Shipman & Rose, 1988), suggesting that abrasion caused by physical erosion was insignificant as well. In addition, adequate representation of bone elements according to their surface-volume ratio (after Shipman, 1981) suggest that loss of bones owing to fluvial transport is not very likely.

Signs of animal activity, chewing, gnawing and scratch marks of carnivores and rodents (see Fisher, 1995 for description and references) are totally absent from all identifiable elements. In addition, the non-identifiable elements (examined on all fragments larger than 4 cm) that comprise mainly mid-shaft fragments contained no carnivore tooth marks and no digestion signs (e.g., Horwitz, 1990). Lack of carnivore signs was also found in the nearby Geometric-Kebaran site of Neve-David (Bar-Oz *et al.*, 1999). According to Blumenschine (1988), defleshed bones discarded in the Serengeti are typically scavenged by hyenas and jackals within a day. Moreover, carnivores regularly scavenge bones discarded at the San (Bertram, Kroll & Bunn, 1991) and Hadza (Lupo, 1995) hunter-gatherers camps. Alternative hypotheses may be related to cooking processes which would make the remains less attractive to carnivores (Lupo, 1995) or to length of occupation, which may affect the availability of the remains to carnivores (Yellen, 1991; Bunn, 1993). The lack of carnivore activity owing to intensive processing

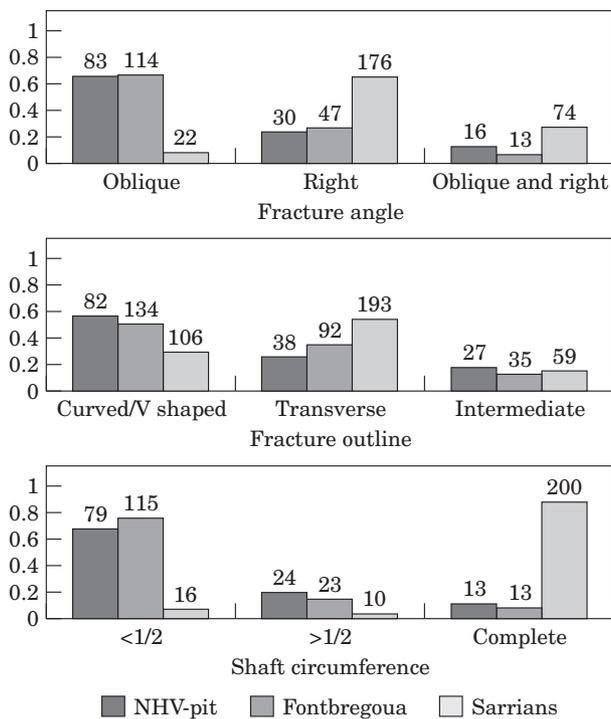


Figure 2. Relative frequencies of fracture angle, fracture outline, and shaft circumference from NHV compared to Fontbregoua and Sarriens (after Villa & Mahieu, 1991).

is supported by modes of bone fracture (see below). Once the shafts are detached from the spongy epiphyses, and bone marrow extracted, they no longer retain nutritional value for carnivores. Intense bone fragmentation to facilitate extraction of grease (see Speth & Spielman, 1983) would have further reduced its attractiveness. Our results accord with those of Blumenschine's (1988) natural experiments and Marean & Spencer's (1991) and Marean *et al.*'s (1992) experiments with captive spotted hyenas; they found few carnivore tooth marks on human-processed assemblages.

Fracture angle, fracture outline and shaft circumference of the NHV bone assemblage were studied in search of evidence for "green" (fresh) bone fracture and/or dry bone fractures (see Villa & Mahieu, 1991 for description of fractures). We examined these characteristics on all epiphyses and compared them to those of bones from two Neolithic sites in southern France, in which the taphonomic history has been established, based on other characteristics. Fontbregoua is characterized by high proportions of green bone fractures, while Sarriens is characterized by high proportions of dry bone fractures (Villa & Mahieu, 1991). NHV and Fontbregoua are similar within all the typological fractures studied (Figure 2). Comparison between NHV and Fontbregoua shows no significant differences between the two sites (fracture angle: $\chi^2=0.23$, $P=0.63$; fracture outline: $\chi^2=2.73$, $P=0.1$; shaft circumference: $\chi^2=0.5$, $P=0.48$). The opposite pattern

was found when we compared NHV to Sarriens (fracture angle: $\chi^2=125.02$, $P<0.001$; fracture outline: $\chi^2=37.43$, $P<0.001$; shaft circumference: $\chi^2=194.92$, $P<0.001$). These results suggest that mode of bone fracture found in NHV shows relatively few dry bone fractures resulting from bone trampling, as observed in Sarriens, and indicate that fractures were made on fresh bones, probably for marrow extraction, as was found in the site of Fontbregoua.

Thus we suggest that bone fractures at NHV reflect human activities during occupation, an action that produced a large number of fragments with green bone fractures. Similar ratios of fresh bone fractures were obtained from the nearby site of Neve-David (Bar-Oz *et al.*, 1999). Comparison between NHV and Neve David shows no significant differences between these two sites ($\chi^2=1.09$, $P=0.3$; $\chi^2=0.14$, $P=0.7$, for fracture angle and fracture outline respectively), suggesting that both assemblages suffered bone breakage for marrow extraction, which resulted in high numbers of percussion fractures.

The lengths of the fresh fractures of the proximal and distal ends of the lower limb (metacarpal and metatarsal) point to a consistent process of bone breakage. Out of 213 proximal and distal metapodials of gazelle, 72% were in the range of 1.5–3 cm, and mean size of all metapodial fragments is 2.6 cm (s.d.=0.99). In addition, we found a small number of percussion marks, close to the fracture edges, which also could have been possibly made during marrow processing (see Blumenschine & Selvaggio, 1988). Percussion fractures on some carapace and plastron fragments indicate that tortoise shells were split open, possibly by placing them on an anvil and striking along the opposing margin with a hard hammer (Stiner & Tchernov, 1998; Munro, 1999).

Cut marks were found on gazelle and fallow deer remains. Their remains bore a small number of cut marks, examined on all epiphyses and near-epiphysis shafts (Table 2). All cut marks were made during the process of dismemberment of the carcass (after Binford, 1981). Dismemberment cut marks are often deeper and more pronounced than skinning and filleting cut marks (Noe-Nygaard, 1989). The low frequencies of cut marks found in NHV contrast with the frequencies found at the Kebaran site of Hayonim cave (Rabinovich, Bar-Yosef & Tchernov, 1996), but probably the latter site is an exception from other Epipalaeolithic sites (Rabinovich, pers. comm.). It could be that the low frequency of cut-marks found at NHV is due to high fragmentation of the bone assemblage, possibly because of intensive bone processing. In this case bone fragments would be less likely to retain marks. Moreover, the basic assumption when discussing butchery patterns is that butchery marks are an incidental result of butchery, and that not all butchered bones bear these marks (e.g., Lyman, 1992). This observation is compatible with Shipman's (1981) experiments, which showed that it is possible

Table 2. Sum of cut marks on gazelle and fallow deer bones and their related activities (after Binford, 1981)

	Bone	Cut mark	Activity	N
<i>Gazella gazella</i>	Humerus dis	HD-2	Dismemberment	2
	Scapula neck	S-1	Dismemberment	1
	Astragalus	TA-1	Dismemberment	3
	Metatarsus dis	MTD-1	Dismemberment	2
<i>Dama mesopotamica</i>	metatarsus prox	MTP-1	Dismemberment	1
SUM				9

Table 3. Skeletal parts representation of gazelle and fallow deer pooled into 4 carcass

	Head*	Body†	Limb‡	Toes§	Total
Gazelle					
Obs.	32	22	82	108	244
Exp.	104	988	312	416	1820
Obs./Exp	0.31	0.02	0.26	0.26	0.13
Deer					
Obs.	5	6	14	16	41
Exp.	26	247	78	104	455
Obs./Exp	0.19	0.02	0.18	0.15	0.09

*Petrosium.

†Thoracic and lumbar vertebrae.

‡Humerus, radius, scapula, ulna.

§Phalanx I and II.

to skin an animal without leaving any marks on bones.

Skeletal Part Representation

The distribution of various skeletal parts was studied in order to discern which parts of gazelle and fallow deer were present at the site. In order to examine representation of skeletal parts, we grouped gazelle (small-medium) and fallow deer (large-medium) bones of similar densities into five parts of the carcass. These are: head, represented by the skull (petrosium); trunk, represented by the thoracic and lumbar vertebrae; fore and hind limbs, represented by long bones; and toes, represented by phalanx I and II. In order to factor out the preservation bias related to bone density, only post-cranial bones with similar density values (in the range of 0.21–0.3 g/cc) were used in this analysis (fallow deer bone densities based on *Odocoileus spp.*, and gazelle bone densities based on *Ovis aries* [Lyman, 1994]). Unfortunately, there are no published density values for cranial elements. Since we did not want to ignore them altogether we added the commonly retrieved and well-preserved petrosium bone to our analysis.

The skeletal part distribution of gazelle and fallow deer reveals a significantly different representation from that expected (Table 3) ($\chi^2=177.36$, $P<0.001$; $\chi^2=24.05$, $P<0.001$ for gazelle and fallow deer, respectively). The expected values were calculated based on

MNI values (i.e., the expected number of head parts based on the petrosium bone for the 52 gazelles found is 104 parts). The ratio of the observed to the expected value reveals low representation of vertebrae, on the one hand, and high and similar counts of heads, limbs, and toes, on the other, both for gazelle and fallow deer. However, this result should be interpreted with caution, because there are many problems associated with the analysis of vertebrae from archaeological sites (Stiner, 1994). Moreover, scarcity of vertebrae is common in many assemblages (e.g., Brain, 1981). It could be that the low frequency of vertebrae is due to heavy processing of axial parts of both species for rendering bone grease (Speth & Spielman, 1983; Speth, 1989; Hanson, 1998). However, axial parts are attached to high amounts of meat and therefore are not likely to be abandoned, unless their carcasses were processed in the field. According to Monahan (1998), the most frequently transported skeletal elements among the Hadza are always post-cranial axial units (and specially the vertebrae), with less complete transport of limbs. In addition, we found a relatively high proportion of scapulae and pelvis for both gazelle and fallow deer, suggesting that certain axial elements were present at the site.

Comparison of skeletal part distribution without the axial parts reveals a homogeneous representation of head parts, limbs (both upper and lower) and phalanges for both species ($\chi^2=0.58$, $P=0.75$; $\chi^2=0.24$, $P=0.88$, for gazelle and fallow deer respectively). This result is in accord with Bertram's observation among

the Kua hunter-gatherers (Bertram & Marean, 1999 and reference therein) for class 2 and class 3 bovids, which are equivalent in their size to gazelle and fallow deer. Class 2 was transported virtually whole, while class 3 was transported either by carrying the entire carcass in “minimally disarticulated units” or by carrying extensively processed carcass parts. Therefore, transporting intensively processed carcasses can be another reason for the low abundance of vertebrae at the site. Comparison between gazelle and fallow deer skeletal part elements shows no significant difference in their body part distribution ($\chi^2=0.13$, $P=0.93$) in spite of their significant size differences (gazelle weigh c. 20–25 kg while fallow deer weigh c. 80–100 kg, Mendelsohn & Yom-Tov, 1999). This comparison suggests that both species were subjected to similar treatment. Therefore it could be that both species required extensive field butchery before importation to the site.

Discussion

The Kebaran inhabitants of NHV subsisted mainly on mountain gazelle (70%) and fallow deer (20%). Other mammals from the coastal plain (equids, hartebeest, aurochs, and roe deer) were not hunted to the same degree. Small game (fox, hare, and tortoise) are also found in small proportions. A hunting pattern focusing on gazelle and fallow deer is similar to that found in the nearby Geometric-Kebaran sites of Neve-David and Hefzibah and appears to characterize the Epipalaeolithic (Bar-Oz *et al.*, 1999).

The age structure of the hunted population suggests random hunting of gazelles. NHV with 38% immature gazelles does not differ from the general Epipalaeolithic sequence (Bar-Oz *et al.*, 1999). This finding should be bolstered by a larger sample size, which will enable aging the fallow deer population with more certainty and will allow sexing of the hunted populations.

Taphonomic re-evaluation of the NHV bone assemblage provides further insight into the Kebaran economy, in terms of body part representation and the depositional history of the site. The taphonomic analysis suggests minor loss of bones because of various diagenetic processes and indicates that most of the bone destruction occurred during time of occupation, probably as a result of exploiting bones for marrow consumption, an action that produced large numbers of fragments, most of which exhibited green bone fractures. The absence of selective transport together with the low rate of axial units could suggest that gazelle and fallow deer required extensive field butchery before importing to the site (e.g., Bertram & Marean, 1999). Alternatively, it could be that the low abundance of vertebrae is due to intensive activities such as rendering bone grease (Speth & Spielman, 1983; Speth, 1989). However, we lack

further evidence (i.e., fire-cracked stones) for this explanation.

Lack of signs of carnivore activity suggests that bones were not available to carnivores at the time of the site's occupation (Bunn, 1993). Ethnographic evidence from Hadza sites (Bunn, 1991, 1993) shows that in short term occupation sites (maintained only for few days) bones are left while still fresh and are thus available to carnivores, which arrive at the site soon after its abandonment. In long-term occupation sites (maintained for weeks to months) the rate of exposure to carnivore is low and insignificant. Thus, lack of carnivore activity provides support for the hypothesis that NHV was occupied for long periods of time during the year.

Unlike Marean & Kim's (1998) results from Kobeh cave, and Bertram & Marean (1999) results for size 4 bovids from Die Kelders cave, our results, which included careful identification of shaft fragments and size class bones, as well as a host of other taphonomic techniques do not differ from results of previous research. Comparison with Saxon *et al.*'s (1978) classical study suggests no major differences in taxonomic composition. In addition, a comparison with Saxon's results shows similar proportions for most body parts (Table 1), except body and head parts that were not studied by Saxon. The only major difference found was for tortoises, caused by the addition of carapace and plastron fragments to the analysis. In spite of our great efforts to identify the maximum number of skeletal elements, we do not see major differences between Saxon's results and ours in the frequency of the long bones relative to other body parts.

We conclude that taphonomic analysis fine-tunes our understanding of the depositional history of the site and helps illuminate the economic structure of the site. However, these results do not overthrow earlier classical research. Our results are from one site only, but we feel that they are certainly of relevance also to other open-air sites. Of course, all researchers must bear in mind that the great global variability in site type, in ecological settings, in human ancient practices, and in depositional histories, may limit our ability to generalize. More research is required to clarify this issue.

Blumenschine (1998) suggested that detailed taphonomic research should also be applied to open-air sites. For NHV we found no major post-depositional alterations. However, since every site has its specific taphonomic history, it is important to record the potential attrition biases before drawing intersite comparisons. The marked differences in preservation between the upper strata of Hefzibah (10–50 cm, below surface; Bar-Oz, unpubl. data) and the nearby site of NHV can serve as an example to the potential of taphonomic biases. In Hefzibah we find at the higher strata a high rate of weathering (stages 5–6; Behrensmeier, 1978) and the assemblage is dominated by high-density bones (over 0.4 g/cc in Hefzibah, and 0.1–0.6 in NHV;

Lyman, 1994). The assemblage comprises mainly teeth, phalanges, and diaphysis shaft fragments, and is dominated by aurochs and, to a lesser extent, fallow deer and gazelle with almost no small game. Without taphonomic analysis a comparison between the two strata would suggest different economic structures for the nearby sites. We recommend that future faunal analyses include multivariate taphonomic analyses (e.g., Behrensmeyer, 1991). Surely, this inclusion will enable a more reliable comparison between sites and assemblages and eventually lead to more meaningful conclusions concerning human subsistence patterns.

In sum, taphonomy is an important contribution to zooarchaeological analysis, but studies that have been carried out without using taphonomic methods are valuable, too. While some researchers view taphonomy as a revolutionizing step in reading data, we see the use of taphonomic tools as an upgrade of data acquisition and interpreting prehistoric subsistence patterns.

Our results contribute to the ongoing debate regarding research methods and the conclusions to be drawn. This debate has many aspects, including the time and effort that must be invested in applying the shaft fragments assemblage. In this study we applied these approaches to revisit the faunal assemblage of NHV. For larger assemblages typical of later sites, such a study would require an unacceptable time investment.

We conclude that, unlike O'Henry's (1904) characters, who met after 20 years and found that their lives had taken diametrically opposite turns, taphonomic studies and those using time-honored classical methods have similar scientific trajectories, leading to similar ends, but at different levels of detail.

Acknowledgements

We thank O. Bar-Yosef for making the NHV faunal assemblage available to us, N. Munro for her help in identifying the tortoise carapace and plastron, J. Speth for discussion and encouragement throughout the development of this research, T. Shariv of the Tel-Aviv University Zoological Museum for her help, and O. Bar-Yosef, A. Gopher, M. Weinstein-Evron, D. Kaufman, D. Simberloff, C. Marean and J. Speth for their comments on earlier drafts of this manuscript. This research was supported by the Irene Levi Sala CARE Archaeological Foundation.

References

- Baharav, D. (1974). Notes on the population structure and biomass of the mountain gazelle, *Gazella gazella gazella*. *Israel Journal of Zoology* **23**, 39–44.
- Bar-Oz, G., Dayan, T. & Kaufman, D. (1999). The Epipalaeolithic faunal sequence in Israel: a view from Neve-David. *Journal of Archaeological Science* **26**, 67–82.
- Bar-Yosef, O. (1981). The Epipalaeolithic complexes in the southern Levant. In (J. Cauvin & P. Sanlaville, Eds) *Prehistoire du Levant*. Paris: CNRS, pp. 389–408.
- Bar-Yosef, O. & Belfer-Cohen, A. (1989). The origins of sedentism and farming communities in the Levant. *Journal of World Prehistory* **3**, 447–498.
- Bar-Yosef, O. & Belfer-Cohen, A. (1992). From foraging to farming in the Mediterranean Levant. In (A. B. Gebauer & T. D. Price, Eds) *Transitions to Agriculture in Prehistory*. Madison, Wisconsin: Prehistory Press, pp. 21–48.
- Bar-Yosef, O., Vandermeersch, B., Arensburg, B., Belfer-Cohen, A., Goldberg, P., Laville, H., Meignen, Y., Rak, Y., Speth, J. D., Tchernov, E., Tillier, A. M. & Weiner, S. (1992). The excavations in Kebara Cave, Mt. Carmel. *Current Anthropology* **33**, 497–550.
- Bar-Yosef, O. & Vogel, J. C. (1987). Relative and absolute chronology of the Epipalaeolithic in the southern Levant. In (J. Evin & F. Hours, Eds) *Chronologies in the Near East*. Oxford: British Archaeological Reports, pp. 219–246.
- Behrensmeyer, A. K. (1978). Taphonomic & ecological information from bone weathering. *Paleobiology* **4**, 150–162.
- Behrensmeyer, A. K. (1991). Terrestrial vertebrate accumulations. In (P. A. Allison & D. E. G. Briggs, Eds) *Taphonomy: Releasing the Data Locked in the Fossil Record*. Topics in Geobiology Vol. 9. New York: Plenum, pp. 291–335.
- Bertram, L. E., Kroll, E. M. & Bunn, H. T. (1991). Variability in camp structure and bone food refuse patterning at Kua San camps. In (E. M. Kroll & T. D. Price, Eds) *The Interpretation of Archaeological Spatial Patterning*. New York: Plenum, pp. 77–148.
- Bertram, L. E. & Marean, C. W. (1999). Explaining the “Klasies Pattern”: Kua ethnoarchaeology, the Die Kelders Middle Stone Age archaeofauna, long bone fragmentation and carnivore ravaging. *Journal of Archaeological Science* **26**, 9–20.
- Binford, L. R. (1981). *Bones: Ancient Men and Modern Myths*. New York: Academic Press.
- Blumenschine, R. J. (1988). An experimental model of the timing of hominid & carnivore influence on archaeological bone assemblages. *Journal of Archaeological Science* **15**, 483–502.
- Blumenschine, R. J. (1998). Comment on “Mousterian large mammal remains from Kobeh cave”. *Current Anthropology* **39**, S92–S93.
- Blumenschine, R. J. & Selvaggio, M. (1988). Percussion marks on bone surface as a new diagnostic of human behavior. *Nature* **333**, 763–765.
- Bonnichsen, R. (1989). An introduction to taphonomy with an archaeological focus. In (R. Bonnichsen & M. H. Sorg, Eds) *Bone Modification*. Orono: University of Maine Center for the Study of the First Americans, pp. 1–5.
- Brain, C. K. (1981). *The hunters or the hunted? An introduction to African cave Taphonomy*. Chicago: University of Chicago Press.
- Bunn, H. T. (1983). Evidence on the diet & subsistence patterns of Plio-Pleistocene hominids at Koobi Fora, Kenya, & Olduvai Gorge, Tanzania. In (J. Clutton-Brock & C. Grigson, Eds) *Animals & archaeology: 1. hunters & their prey*. Oxford: British Archaeological Report, pp. 21–30.
- Bunn, H. T. (1991). A taphonomic perspective on the archaeology of human origins. *Annual Review of Anthropology* **20**, 433–467.
- Bunn, H. T. (1993). Bone assemblages at base camps: A further consideration of carcass transport and bone destruction by the Hadza. In (J. Hudson, Ed.) *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*. Carbondale, IL: Center for archaeological investigations, pp. 156–168.
- Clutton-Brock, J. (1979). The mammalian remains from the Jericho Tell. *Proceedings of the Prehistoric Society* **45**, 135–157.
- Davis, S. J. M. (1974). Animals remains from the Kebaran site of Ein-Gev I: Jordan valley, Israel. *Paléorient* **2**, 453–462.
- Davis, S. J. M. (1980). A note on the dental and skeletal ontogeny of *Gazella*. *Israel Journal of Zoology* **29**, 129–134.
- Davis, S. J. M. (1982). Climatic change and the advent of domestication; the successions of ruminant artiodactyles in late Pleistocene-Holocene in the Israel region. *Paléorient* **8**, 5–15.
- Davis, S. J. M. (1983). The age profiles of gazelles predated by ancient man in Israel: possible evidence for a shift from seasonality to sedentism in the Natufian. *Paléorient* **9**, 55–62.

- Davis, S. J. M. (1987). *The Archaeology of animals*. Yale University Press.
- Dayan, T., Tchernov, E., Bar-Yosef, O. & Yom-Tov, Y. (1986). Animal exploitation in Ujrat-el-Mehed, a Neolithic site in southern Sinai. *Paléorient* **12**, 105–116.
- Deniz, E. & Payne, S. (1982). Eruption and wear in the mandibular dentition as a guide to aging Turkish angora goats. In (B. Wilson, C. Grigson & S. Payne, Eds) *Aging and Sexing Animal Bones from Archaeological Sites*. Oxford: British Archaeological Reports, pp. 155–205.
- Fellner, R. O. (1995). *Cultural Change and the Epipalaeolithic of Palestine*. Oxford: British Archaeological Reports.
- Fiorillo, A. R. (1989). An experimental study of trampling: implication for the fossil record. In (R. Bonnichsen & M. H. Sorg, Eds) *Bone Modification*. Orono: University of Maine Center for the Study of the First Americans, pp. 61–71.
- Fisher, J. W. (1995). Bone surface modifications in zooarchaeology. *Journal of Archaeological Method and Theory* **2**, 7–68.
- Gifford, D. P. (1981). Taphonomy and paleoecology: a critical review of archaeologist sister disciplines. In (M. B. Schiffer, Ed.) *Advances in Archaeological Method and Theory vol. 4*. New York: Academic Press, pp. 365–438.
- Gifford-Gonzalez, D. P. (1989). Ethnographic analogues for interpreting modified bones: some cases from East Africa. In (R. Bonnichsen & M. H. Sorg, Eds) *Bone modification*. Orono: University of Maine Center for the Study of the First Americans, pp. 179–246.
- Goring-Morris, N. & Belfer-Cohen, A. (1998). The articulation of cultural processes and Late Quaternary environmental changes in Cisjordan. *Paléorient* **23/2**, 71–93.
- Greenfield, H. J. (1988). Comment on “Mousterian large mammal remains from Kobeh cave”. *Current Anthropology* **39**, S95.
- Hanson, D. K. (1998). Comment on “Mousterian large mammal remains from Kobeh cave”. *Current Anthropology* **39**, S95–S96.
- Henry, D. O. (1989). *From Foraging to Agriculture: the Levant at the End of the Ice Age*. Philadelphia: University of Pennsylvania Press.
- Henry, D. O., Leroi-Gourhan, A. & Davis, S. J. M. (1981). The excavation at Hayonim Terrace: an examination of terminal Pleistocene climatic and adaptive changes. *Journal of Archaeological Science* **8**, 33–58.
- Horwitz, L. K. (1990). The origin of partially digested bones recovered from archaeological contexts in Israel. *Paléorient* **16/1**, 97–106.
- Hovers, E., Horwitz, L. K., Bar-Yosef, D. E. & Miyashiro-Cope, C. (1988). The site of Urkan-E-rub IIa: a case study of subsistence and mobility patterns in the Kebaran period in the lower Jordan Valley. *Journal of the Israel Prehistoric Society* **21**, 20–48.
- Kaufman, D. (1989). Observations on the Geometric-Kebaran: a view from Neve David. In (O. Bar-Yosef & B. Vandermeersch, Eds) *Investigations in South Levantine Prehistory*. Oxford: British Archaeological Reports, pp. 275–285.
- Kaufman, D. (1992). Hunter-gatherers of the Levantine Epipalaeolithic: the socioecological origins of sedentism. *Journal of Mediterranean Archaeology* **5**, 165–201.
- Klein, R. G. (1989). Why does skeletal part representation differ between smaller and larger bovids at Klasies River Mouth and other archaeological sites? *Journal of Archaeological Science* **16**, 363–381.
- Klein, R. G. & Cruz-Urbe, K. (1984). *The Analysis of Animal Bones from Archaeological Sites*. Chicago: University Chicago Press.
- Klein, R. G., Cruz-Urbe, K. & Milo, R. G. (1999). Skeletal part representation in archaeofaunas: comments on “explaining the ‘Klasies Pattern’: Kua ethnoarchaeology, the Die Kelders Middle Stone Age archaeofauna, long bone fragmentation and carnivore ravaging” by Bertram & Marean. *Journal of Archaeological Science* **26**, 1225–1234.
- Koch, C. P. (1989). *Taphonomy: A Bibliographic Guide to the Literature*. Orono: University of Maine Center for the Study of the First Americans.
- Krebs, C. J. (1989). *Ecological Methodology*. New-York: Harper Collins Publishers.
- Legge, A. J. (1972). Prehistoric exploitation of the gazelle in Palestine. In (E. S. Higgs, Ed.) *Papers in Economic Prehistory*. Cambridge: Cambridge University Press, pp. 119–124.
- Lupo, K. D. (1995). Hadza bone assemblages and hyena attrition: An ethnographic example of the influence of cooking and mode of discard on the intensity of scavenger ravaging. *Journal of Anthropological Archaeology* **14**, 288–314.
- Lyman, R. L. (1984). Bone density and differential survivorship of fossil classes. *Journal of Anthropological Archaeology* **3**, 259–299.
- Lyman, R. L. (1992). Prehistoric seal and sea-lion butchering on the southern northern coast. *American Antiquity* **57/2**, 246–261.
- Lyman, R. L. (1994). *Vertebrate Taphonomy*. Cambridge: Cambridge University Press.
- Marean, C. W. (1991). Measuring the postpositional destruction of bone in archaeological assemblages. *Journal of Archaeological Science* **18**, 677–694.
- Marean, C. W. & Kim, S. Y. (1998). Mousterian large mammal remains from Kobeh cave: behavioral implications for Neanderthals and Early Modern Human. *Current Anthropology* **39**, S79–S113.
- Marean, C. W. & Spencer, L. M. (1991). Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity* **56**, 645–658.
- Marean, C. W., Spencer, L. M., Blumenshine, R. J. & Capaldo, S. (1992). Captive hyena bone choice and destruction, the schlepp effect, and Olduvai archaeofaunas. *Journal of Archaeological Science* **19**, 101–121.
- Martin, L. (2000). Gazelle (*Gazella spp.*) Behavioral ecology: predicting animal behavior for prehistoric environments in south-west Asia. *Journal of Zoology, London* **250**, 13–30.
- Martin, R. E. (1999). *Taphonomy A Process Approach*. Cambridge University Press.
- Mendelsohn, H. & Yom-Tov, Y. (1999). *Fauna Palestina: Mammalia of Israel*. The Israel Academy of Sciences and Humanities.
- Metcalf, D. & Jones, K. T. (1988). A reconsideration of animal body part utility indices. *American Antiquity* **53**, 486–504.
- Monahan, C. M. (1998). The Hadza carcass transport debate revisited and its archaeological implications. *Journal of Archaeological Science* **25**, 405–424.
- Munro, N. (1999). Small game as indicators of sedentization during the Natufian period at Hayonim cave in Israel. In (J. C. Driver, Ed.) *Zooarchaeology of the Pleistocene/Holocene Boundary*. Oxford: British Archaeological Reports, pp. 37–45.
- Noe-Nygaard, N. (1989). Man made trace fossil on bones. *Human Evolution* **4**, 461–491.
- Noy, T., Legge, A. & Higgs, E. S. (1973). Recent excavations at Nahal Oren. *Proceedings of the Prehistoric Society* **39**, 75–99.
- O’Henry (1904). After 20 years. *New York Sunday World Magazine* **Feb. 14**.
- Rabinovich, R. (1998). *Patterns of animal exploitation and subsistence in Israel, during the Upper Palaeolithic and Epipalaeolithic (40,000–12,500 BP), based upon selected case studies*. Ph.D. Thesis. Hebrew University of Jerusalem, Israel.
- Rabinovich, R. & Tchernov, E. (1995). Chronological, paleoecological and taphonomical aspects of the middle Paleolithic site of Qafzeh, Israel. In (H. Buitenhuis & H. P. Uerpmann, Eds) *Archaeozoology of the Near East II*. Leiden: Backuys Publishers, pp. 5–43.
- Rabinovich, R., Bar-Yosef, O. & Tchernov, E. (1996). How many ways to skin a gazelle: butchery patterns from an Upper Palaeolithic site, Hayonim cave, Israel. *Archaeozoologia* **8**, 11–52.
- Ronen, A., Kaufman, D., Gophna, R., Bakler, N., Smith, P. & Amiel, A. (1975). The Epipalaeolithic site of Hefziba, central coastal plain of Israel. *Quartar* **26**, 54–72.
- Saxon, E. C., Martin, G. & Bar-Yosef, O. (1978). Nahal Hadera V: an open-air site on the Israeli coast. *Paléorient* **4**, 253–266.
- Shipman, P. (1981). *Life History of a Fossil*. Cambridge: Harvard University Press.
- Shipman, P. & Rose, J. (1988). Bone tools: an experimental approach. In (S. L. Olsen, Ed.) *Scanning Electron Microscopy in Archaeology*. Oxford: British Archaeological Reports, pp. 303–335.

- Sokal, R. R. & Rohlf, J. F. (1995). *Biometry*. 3rd edition. New York: W. H. Freeman & Company.
- Speth, J. D. (1989). Early hominid hunting and scavenging: the role of meat as an energy source. *Journal of Human Evolution* **18**, 329–343.
- Speth, J. D. & Spielman, K. A. (1983). Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Archaeology* **2**, 1–34.
- Speth, J. D. & Tchernov, E. (1998). The role of hunting and scavenging in Neanderthal procurement strategies: new evidence from Kebara cave (Israel). In (T. Akazawa, K. Aoki & O. Bar-Yosef, Eds) *Neanderthals and Modern Human in Western Asia*. New York: Plenum Press, pp. 223–240.
- Stiner, M. C. (1991). The community ecology perspective and the redemption of “contaminated” faunal records. In (G. A. Clark, Ed.) *Perspectives of the Past: Theoretical Biases in Mediterranean Hunter-Gatherer Research*. University of Pennsylvania Press, pp. 229–242.
- Stiner, M. C. (1994). *Honor Among Thieves*. Princeton University Press.
- Stiner, M. C. (1998). Comment on “Mousterian large mammal remains from Kobeh cave”. *Current Anthropology* **39**, S98–S103.
- Stiner, M. C., Munro, N. D. & Surovell, T. A. (2000). The tortoise and the hare: small game use, the broad spectrum revolution, and Paleolithic demography. *Current Anthropology* **41**, 39–73.
- Stiner, M. C. & Tchernov, E. (1998). Pleistocene species trends at Hayonim cave: changes in climate versus human behavior. In (T. Akazawa, K. Aoki & O. Bar-Yosef, Eds) *Neanderthals and Modern Human in Western Asia*. New York: Plenum Press, pp. 241–262.
- Tchernov, E. (1992). Biological evidence for human sedentism in Southwest Asia during the Natufian. In (O. Bar-Yosef & F. R. Valla, Eds) *The Natufian Culture in the Levant*. International Monographs in Prehistory, Archaeological Series 1. Ann Arbor, pp. 315–340.
- Valla, F. R., Bar-Yosef, O., Smith, P., Desse, J. & Tchernov, E. (1986). Un nouveau sondage sur la terrasse d’El Ouad, Israel (1980–1981). *Paléorient* **12**, 21–38.
- Villa, P. & Mahieu, E. (1991). Breakage patterns of human long bones. *Journal of Human Evolution* **21**, 27–48.
- Weinstein-Evron, M. (1998). *Early Natufian El-Wad Revisited*. ER-AUL 77.
- Yellen, J. E. (1991). Small mammals: post discard patterning of Kung San faunal remains. *Journal of Anthropological Archaeology* **14**, 152–92.
- Zackheim, O. & Bar-Oz, G. (1999). Hefzibah. *Hadashot Arkheologiyot: Excavations and Surveys in Israel* **109**, 45–46.
- Zar, J. H. (1996). *Biostatistical Analysis*, 3rd Edition. Upper Saddle River, NJ: Prentice-Hall.