Faunal turnover in the Azraq Basin, eastern Jordan 28,000 to 9,000 cal BP, signalling climate change and human impact

Louise Martin\textsuperscript{a,b,c}, Yvonne H. Edwards\textsuperscript{a}, Joe Roe\textsuperscript{a}, Andrew Garrard\textsuperscript{a}
\textsuperscript{a}Institute of Archaeology, University College London, Gordon Square London WC1H 0PY:
\textsuperscript{b}corresponding author: \texttt{louise.martin@ucl.ac.uk}

Abstract
Recent zooarchaeological analyses of game exploitation in the Epipalaeolithic of the Southern Levant identify a decline in large game in the Natufian, with corresponding increase in small prey, interpreted as hunting pressure driven by population expansion. To date, studies focus on the Mediterranean zone. This paper adopts similar approaches to examine Epipalaeolithic to Neolithic faunal data from 16 sites in the steppic Jordanian Azraq Basin. Results here reveal very different trends. Large game, mainly equids, fluctuate throughout the Epipalaeolithic, due to climatic conditions and available water/vegetation. Cattle thrive in the Azraq oasis, showing no decline in the Late Epipalaeolithic. Gazelle exploitation is predominant and sustainable throughout the Epipalaeolithic, even at Kharaneh IV and Wadi Jilat 6 ‘megasites’. However, PPNB assemblages from the limestone steppe show intensive game exploitation resulting from longer-stay settlement. The focused gazelle-hunting camp at Dhuweila in the Basalt desert also shows pressure from indiscriminate culling impacting herd demography, interpreted as providing meat for onwards exchange. Human impacts on steppe fauna appear both local and in many cases short-term, unlike the large-game suppression reported from west of the Rift Valley. Resource pressures and game over-kill, whether population-driven or otherwise, are not currently apparent east of the Jordan River.

Keywords:
Southern Levant; Epipalaeolithic; PPNB; Prey exploitation; Hunting pressure; Palaeoenvironment; Climate change
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INTRODUCTION

In recent decades, the southern Levant (modern day Jordan, southern Syria and Lebanon, Palestine territories and Israel) has been the focus of attempts to understand diachronic changes in the patterning of animal remains found at archaeological sites through the late Pleistocene and early Holocene. This area has yielded rich faunal datasets for the Epipalaeolithic and early Neolithic periods (24,000-9,000 cal BP), encouraging research agendas aimed at documenting and explaining zooarchaeological trends up to the appearance of agriculture and domestic livestock at approximately 10,500 cal BP. The paramount theme examines the broadening exploitation of animal prey by hunter-gatherer-foragers across this period with attendant questions related to animal use intensification.

Zooarchaeological studies in the southern Levant have long noted an increase in smaller game, either in the Natufian (later Epipalaeolithic, c. 14,700-12,000 cal BP) or Pre-Pottery Neolithic A (PPNA, earliest Neolithic, c.12,000-10,900 cal BP) (e.g. Davis, 1985; Tchernov, 1991) attributed to longer-term occupation of settlement sites, and the construction of an ‘anthropogenic’ environment less favourable to larger mammals (Tchernov, 1994; but see Edwards, 1989 and Henry, 1989 for alternative explanations). Longer time-depth studies over the past 15 years have refined the picture of a broadening animal food spectrum in the Natufian, showing an increased representation of fast-moving game birds and hares on sites (Stiner et al., 1999; Stiner, Munro and Surovell, 2000; Stiner, 2001; Stiner and Munro, 2002; Munro, 2003, 2004) along with a decline in larger game animals (Stutz, Munro and Bar-Oz, 2009), and intensive hunting of the dominant small ungulate,
gazelle (Munro, 2009). These trends are widely accepted as resulting from expanding human populations exerting pressure on large game animals by over-hunting, which increasingly forced the exploitation of lower ranked small game animals and birds. In this paradigm, small game usage is interpreted as reflecting a ‘demographic pulse’ (Stiner, Munro and Surovell, 2000), an idea that has found widespread acceptance in the archaeological literature.

Zeder’s (2012) questioning of these interpretations of ‘broad spectrum’ patterns is a relatively lone voice, casting uncertainty on the general applicability of the framework. Drawing on case-studies where broad-spectrum expectations are not borne out, and developing an alternative view of optimal foraging based on niche construction by humans (NCT), she argues that apparent ‘resource depression’ need not be driven by population pressure or over-hunting. Rather it may have been a feature of resource rich environments, where ranges of habitats and seasonally predictable plant and animal resources could have encouraged longer term stay of human groups and stimulated different means of procuring smaller prey, with little impact on large mammals. She looks beyond core Levantine areas, for example to eastern Turkey, to find large game surviving well into the Holocene. Indeed even in the southern Levantine Jordan Valley the current authors find no evidence of resource pressure in one Natufian case-study (Edwards and Martin, 2013; P. Edwards et al., 2013).

The aim of this paper is to look beyond the lush Mediterranean woodland/parkland zones of the southern Levant to examine a sequence of Late Pleistocene/early Holocene faunal assemblages from the Azraq Basin of eastern Jordan. The basin encompasses a variety of environmental niches and has been intensively researched over the past 35 years; the archaeological sequence has gaps but nevertheless faunal data can be used to explore whether observed trends are similar to those in the Mediterranean zones. In brief, our research questions are: Is an increase in small game witnessed through the Epipalaeolithic in the Azraq Basin? Is there a corresponding decline in larger game? Is there evidence for hunting pressure? It should be borne in mind that the eastern Jordanian steppe and desert sites are likely to have been occupied only seasonally and populations may have been
relatively sparse through some stages of the Epipalaeolithic and early Neolithic, although year-round
settlement might have been possible (Byrd et al., 2015). Some favoured locales appear to have been
occupied longer-term or more intensively but the overall low density of sites does not suggest
demographic ‘packing’; thus, the suggested ‘cause’ of broad spectrum economies elsewhere should
not be applicable here. The eastern Jordan sequence can therefore, in some respects, serve as a ‘test’
of factors involved in faunal spectrum change.

An associated aim of this study is to unravel whether changes in faunal spectra represent
variable availability of wildlife, human pressures on wildlife, or selective hunting practices. The role
of climate change, while acknowledged as a prime driver in cultural change through the
Epipalaeolithic and Neolithic of the southern Levant (e.g. Bar-Yosef and Belfer-Cohen, 1989; Henry,
1989; Byrd and Garrard, 1990; Goring-Morris and Belfer-Cohen, 1998; Byrd, 2005) tends to be
underplayed in recent studies of faunal turnover (Stiner and Munro, 2002; Stutz, Munro and Bar-Oz,
2009) where humans are given primacy as catalysts of change. We assume that relatively arid zones
are sensitive to pressures arising from regional climate changes, which may lead to fluctuations in
animal communities, and recognise that ecological pressures should be separated from human
impacts where possible.

The Azraq Basin – present climate, water and vegetation

The Azraq Basin is an inland drainage system covering c. 12,000 km² of the eastern Jordanian
plateau, with the Azraq oases at its centre (Figure 1). The area embraces a diversity of geological
contexts and ecosystems with varied elevation from 500m in the basin centre to 1,800m at the
northern periphery (Figure 2). The west and southern parts of the drainage system are typified by
limestone, chalk and marl hills, cut through by wadis which feed into the low-lying central basin and
eventually into the central playa at Qa el-Azraq. To the north and north-east the basin is covered by
basaltic hills surfaced by extensive boulder fields (Figures 1 and 2). Although basalt is impermeable
it contains joints and fissures which allow rain to replenish the underlying water-table, supplying seasonal springs at the basalt fringes and eventually feeding the copious perennial springs at Azraq.

Small seasonal pools can form in wadi systems in both the basalt and limestone areas after winter storms although rarely for more than a few weeks.

The Azraq Basin has a smaller seasonal and diurnal temperature range than the Arabian or North African deserts and the general climate is less arid but characterised by hot dry summers and by cold winters with occasional storms (Nelson, 1973; Garrard and Byrd, 2013, 10-17). Rain falls sporadically across the basin in winter and early spring, with average mean levels varying from c.200m, in the north and western margins, to less than 50mm in the south and east. The temperature ranges between minus 4°C and 42°C. The area currently falls within the Irano-Turanian vegetation zone, with Sudanian elements penetrating to the south. Vegetation is generally wet-steppe, becoming more arid and desertic to the south and east. Along with abundant grasses, it includes a variety of chenopods such as Atriplex and Salsola, woody shrubs such as the Retama (Broom) and Halozyx which provide some shade, and occasional Pistacia trees which provide both shade and fat-rich nuts.

The Basalt desert has some additional specific shrubs such as the heat resistant Lycium depressum and Capparis spinosa, the caper bush. At the centre of the basin, the Qa el-Azraq is an area that floods after heavy winter storms although the standing water currently usually evaporates by the end of spring. Large permanent wetland areas also occupy the oasis, fed by copious perennial springs and surrounded by marshy vegetation dominated by bullrushes, giant reeds and Tamarix shrubs.

Wildlife in the basin has been greatly impacted by hunting with firearms from vehicles during the 20th century, so that large game such as gazelles and onagers are locally extinct. Shaumarai wildlife reserve at Azraq hosts reintroduced herds of Arabian oryx and gazelles, but otherwise the area serves as seasonal grazing lands for large sheep and goat flocks, with farming around Azraq, and some opportunistic rain-fed crop-sowing in some wadis (see France 2010, 85-116; Garrard and Byrd, 2013). This is a very different picture to the prehistoric (and perhaps more recent) past when
numerous archaeological sites attested to wildlife-rich landscapes which underpinned hunter-gatherer use of the area.

**MATERIALS**

Since the late 1970’s the Azraq Basin has been the focus of several survey and excavation projects (Baird et al., 1992; Betts, 1985, 1986, 1991, 1998; Betts et al., 2013; Byrd, 1988; Copeland and Hours, 1989; Garrard, 1998; Garrard et al., 1994a, 1994b, 1996; Garrard and Byrd, 1992, 2013; Muheisen, 1988; Muheisen and Wada, 1995; Rollefson et al., 2001; Richter et al., 2009, 2013, 2014; Maher et al., 2012). We consider sixteen sites in the Azraq catchment that have produced faunal assemblages, spanning a timeframe from the Late Upper Palaeolithic c.30 ka to the end of the Late PPNB c.9.0 ka cal BP. For the analyses that follow, it is important to note the variation in site types and environmental contexts. These are summarised in Figures 1 and 2 which show site locations, and Table 1 which presents site size, position and references. Ascribed occupation periods, radiocarbon dates and chronotypological assignations are given in Table 2. Sites fall into three broad environmental contexts: the oasis and springs in the central basin; valleys draining the rolling hills of the limestone steppe; wadis and playas cutting through or fringing the basalt steppe and desert. All sites can be assumed to have been occupied by mobile hunter-gatherers; Neolithic faunal assemblages with domestic livestock are not included here since pasturing would have affected wild animal procurement. Of the 16 sites, some exhibit signs of repeated or longer-term visits, while others seem to have been shorter-term camps. An estimate of these different occupation patterns is shown in Table 3 (developed from Byrd, 1988, based on lithic analyses and densities, bone densities, artefact distributions and thickness of deposits). Complex factors such as resource base, site function and social links are likely to have affected length of stay. Several sites exhibit multiple occupation levels representing distinct reoccupations of the same locale in different time-periods, often with a hiatus between them. In such cases faunal assemblages from these are considered separately (e.g.
Kharaneh IV, Wadi Jilat 6, Wadi Jilat 22; Dhuweila). Sites with different re-building phases within the same time-period, however, have their assemblages combined, e.g. Wadi Jilat 7 Middle PPNB assemblages. The total number of faunal assemblages used in the current study is 31 (Table 2).

Since the aim of the study is to trace faunal change through time, we assume that each assemblage ‘samples’ the available fauna in the area. There is a notable absence of faunal data from the Latest Epipalaeolithic/Late Natufian period, reflecting the sparsity of known and excavated sites from this time-frame in the Jordanian steppe and desert until recently (Richter et al., 2014). The PPNA is currently unknown from this region (Byrd, 1992).

Faunal assemblages were originally recorded by various zooarchaeologists and many by the current authors (Table 1). The Numbers of Identified Specimens (NISP) for each assemblage are given in Table 4, alongside the relative proportions (NISP %) of taxa. All identified mammalian taxa are included, plus tortoise and bird remains.

METHODS

We follow methods devised by Stutz, Munro and Bar-Oz (2009) who explored changes in large to small prey through the Epipalaeolithic in the western Galilee/Mount Carmel region. Stutz and colleagues used the numbers of gazelle (often the most common species) as a reference index against which the relative abundance of other sized prey could be assessed, diachronically. They grouped other prey animals by body weight and their ‘escape speed’, e.g. either fast or slow (following approaches of Stiner, Munro and Surovell, 2000; Stiner, 2001; Stiner and Munro, 2002).

This approach is used for the Azraq Basin assemblages and Figure 3 shows the resulting taxa groups. There is some variation in prey types between Galilee/Mount Carmel and Azraq Basin regions, however, which reflect different vegetation and ecological conditions. Deer, for example, are common in the Galilee/Mount Carmel sequence, where woodland abounds, whereas deer are absent altogether from Azraq Basin assemblages where equids and cattle constitute the main large game.
Medium-large game, such as boar and ostrich, are also relatively scarce in the Azraq Basin, but have been included in order to record this weight/size category.

Stutz and colleagues omitted counts of foxes, canid and martens from their Galilee/Mount Carmel study (Stutz et al., 2009; Munro, 2004) presumably being unsure of their status as prey animals. We include these taxa, along with larger birds, in the small game category for the Azraq sites, since there is no evidence to suggest they are not part of the prey assemblage. They are found amongst bones of larger prey showing similar treatment and condition and are clearly within the cultural assemblage. While the Galilee/Mount Carmel study encompassed the Epipalaeolithic, from earlier to late phases, our study looks back to the Late Upper Palaeolithic and forward to the PPNB, providing an extended view of prey change over time.

Following the approach described by Stutz and colleagues (2009), NISP count indices were used to define the relative abundance of four grouped prey types with categories divided by size and speed; fast small game (fsg; hare, fox, canids and medium/large birds); slow small game (ssg; tortoise, hedgehog, porcupine); medium-big game (mbg; ostrich, boar); large-big game (lbg; equid, cattle). While the taxa amongst these prey types often have different habitats, feeding ecologies and defence behaviours it is primarily their relative size and speed which are of interest here. This approach allows us to draw out regional comparisons with the Galilee/Mount Carmel area. Small-big game (sbg) largely gazelle, cf Gazella subgutturosa, with very occasional wild sheep/goat, were used as a reference index against which the relative abundance of large and small game were assessed [e.g. relative abundance index (RAI) = NISP lbg/(NISP lbg + NISP sbg)]. This strategy avoids the false identification of abundance change in other prey types.

Sample size analysis
Sample sizes vary widely across the faunal assemblages shown in Table 4, with some NISPs in the thousands and others less than a hundred. It is well known that taxonomic abundances in an assemblage can be affected by sample size (Grayson, 1984, 116–129), so in order to screen for inadequate sampling we plotted the relationship between sample size and the relative abundance indexes (RAIs) of our four prey type groups (Figure 4). With the exception of mbg, none of the RAIs showed a significant correlation with sample size, validating our assumption that variation in these indexes is not simply a function of variation in sample size, and can be interpreted archaeologically.

The RAI of medium big game did, however, show a strong and highly significant correlation with sample size \((r_s=0.613, p<0.001)\), probably because the taxa making up this group—ostrich and boar—occur extremely infrequently in our sample (Total NISP=51). Therefore mbg was excluded from the rest of the analysis.

**Mantel tests and regression**

Following Stutz and colleagues (Stutz et al., 2009), Mantel tests were used to confirm that there were statistically significant trends in taxonomic abundance over time. The Mantel test is a permutation-based (nonparametric) test of the correlation between two matrices of dissimilarity or distance (Mantel, 1967; Sokal, 1979) and is widely used in ecology and genetics (Legendre and Fortin, 2010). Essentially, the Mantel test is an extension of conventional measures of correlation, such as Pearson’s \(r\), Spearman’s \(rho\) or Kendall’s \(tau\), from comparing two sets of variables directly, to comparing the pairwise dissimilarity between the observations of two sets of variables (which is mathematically equivalent to comparing similarity, its inverse). It has two main advantages over straightforward correlation tests (Guillot and Rousset, 2013): dissimilarity metrics can summarise multivariate data for use in a single test (as in this case, where variation in the abundance of multiple taxonomic groups is combined); and it can be used to detect and account for the correlation of a
variable with itself due to proximity of observations (e.g. in space or time), a phenomenon known as autocorrelation, which otherwise violates the assumption of independence of most parametric statistical tests. The statistical tests were performed in the R statistical environment (R Core Team, 2016), using the vegan package for Mantel tests (Dixon, 2003; Oksanen et al., 2016).

Mantel tests were performed to detect temporal autocorrelation in taxonomic composition data—that is, to test if assemblages that were distantly separated in time also tended to have very different compositions, and vice versa—which would statistically validate the assumption that variation in taxonomic abundance is structured by time. First, a matrix of temporal dissimilarity was computed by calculating the absolute difference between the midpoints of the radiocarbon or chronotypological age ranges (Table 2) of each possible combination of assemblages. The difference in taxonomic composition between each of these pairs was summarised using a Morisita–Horn dissimilarity index (Morisita, 1959; Horn, 1966), which is independent of sample size (Wolda, 1981), comparing both the NISP of individual taxon and the RAI of our prey type groups. Finally, the Mantel tests were performed by calculating the Pearson correlation coefficient of these matrices, and computing a p-value by comparing this result to that of 1000 randomly shuffled permutations of the same matrices.

In the second stage of the analysis, trends in our prey types (excluding mbg) were investigated individually. Two approaches were taken to interrogating the data. In the first, data from assemblages of the same period were combined, thereby providing a broad view of prey type changes over time and balancing out the ‘noise’ of variability unrelated to changes through time, e.g. specialist hunting/trapping locales. In the second approach, the prey type indexes of individual assemblages were plotted against the median age of the assemblage, to examine trends in more detail. Because these trends were contained in a single variable and turned out to be relatively linear, a regression analysis was used to quantify and assess them, rather than further Mantel tests (cf. Stutz...
et al., 2009). In both cases Stutz et al.’s data from eight Kebaran–Natufian sites in western
Galilee/Mount Carmel were used as a comparison.

RESULTS

Mantel tests of temporal distance against dissimilarity in taxonomic composition (Morisita–Horn
indexes) revealed a significant correlation, which was substantially stronger when prey type RAIs
were compared ($r=0.402$, $p=0.00099$) rather than individual taxa ($r=0.191$, $p=0.01898$). We drew two
conclusions from these results. First, that significant proportion of the variation in the relative
abundance of taxa can be explained by changes through time; justifying the more detailed
investigation of individual temporal trends carried out in the next stage of our analysis. Second, that
trends in the exploitation of broad prey types are more significant than variation in individual taxa;
validating the use of RAIs.

Relative prey abundance (RAI) through time

Large game

Figure 5a shows the relative abundance of large big game (lgb) for the eastern Jordan sites to have a
significant, strong correlation with the calendar age of the assemblage ($r_s=0.500$, $p=0.00307$) (note:
E. Jordan mbg was not tested due to the above finding that it has inadequate sample size; mbg,
however, is shown for western Galilee sites in Figure 5a, where this size category constitutes the
main big game).

At the Azraq sites equid and cattle were dominant in assemblages, while in Galilee/Mount
Carmel sites fallow deer are most common. Trends in abundance appear to differ significantly over
time at Azraq Basin sites, with moderate levels of equid/cattle (RAI = c.0.28) from c.28,000 cal BP
(Late Upper Palaeolithic and Initial Epipalaeolithic), an apparent decline in the Early Epipalaeolithic
(c. 20,000 cal BP) but followed by an upward surge (RAI 0.3-0.4) towards 15,000 cal BP. during the
Middle and early Late Epipalaeolithic. These changes contrast dramatically with the steady decline of Galilee/Mount Carmel fallow deer (mbg) between 19-13,000 cal BP (ie. Early to Late Epipalaeolithic (RAI c.0.45 to c.0.07-0.08). A data gap coincident with the Late Natufian and PPNA obscures the final decline of Azraq cattle/equid, which occurred sometime between 13-10,000 cal BP (see Yizhaq et al., 2005). Thereafter, c.10-9,000 cal BP (Early to Late PPNB) these large game animals virtually disappear: they either decline in the vicinity or are not the objects of hunting. It is interesting to note that in the Galilee/Mount Carmel assemblages, alongside the marked decline of mbg - fallow deer, boar and hartebeest – cattle and equids occurred only in very low proportions throughout the period examined here.

Small game

The relative abundance of fast small game shows a significant, strong correlation with the calendar age of the assemblage ($r_s=-0.549$, $p=0.00094$). However, the relative abundance of slow small game showed no correlation with calendar age ($r_s=-0.083$, $p=0.64691$), and thus only $fsg$ is displayed in Figure 5b.

Fast small game – including fast birds, carnivores and lagomorphs - seem not to have been important resources in Azraq Basin assemblages until they rise gradually in relative abundance at c.15,000 cal BP (from the Middle and into the Late Epipalaeolithic). These periods are associated with climate warming in the post Last Glacial Maximum period, and particularly during the Bølling Allerød phases. They tend to be marked by increasing abundance of small game, hare, fox and birds, relative to gazelle. In the Galilee/Mount Carmel assemblages, small game use was insubstantial until the early Late Epipalaeolithic (c.15,000 cal BP) when the abundance of fast small game increased dramatically (Figure 5b, following Stutz et al., 2009). Thereafter, the latest Epipalaeolithic/Late Natufian was marked by a decline in fast small game, and as Stutz and colleagues show, accompanied by an upward surge in tortoise. From c. 10,900 cal BP (Early and Middle PPNB)
Figure 5b shows fast small game reaching high relative abundance levels (RAI >c.0.5) in some assemblages, before declining at c.9,000 cal BP. It is evident from these analyses that faunal patterns differ greatly between eastern Jordan and Galilee/Mount Carmel. Summarizing Figures 5a and b, we see Azraq Basin trends showing sustained, if not increased, use of large game (cattle and equids) into the Middle and Late Epipaleolithic, before a complete decline in the PPNB. There is also a slight rise in fast small game earlier (Middle Epipalaeolithic) than seen in Galilee/Mount Carmel (where it is Late Epipalaeolithic), but without the high spike. Thereafter high but variable levels of fast small game are seen in the Azraq Basin Early and Middle PPNB. Acknowledging that Azraq Basin assemblages derive from varied environmental locations with diverse water and vegetation resources, we next explore whether these patterns are retained at the individual sites/assemblage level.

Site specific relative prey abundance

Large game When Azraq Basin assemblages are considered individually (Figure 6, plotted by archaeological period rather than calendar age), variation in large game abundance is apparent across the Epipalaeolithic. In the Initial Epipalaeolithic and first stages of the Early Epipalaeolithic large-big game, mainly equid are relatively common at Uwaynid 18 (RAI c.0.17) sited near to a spring, but even more abundant at Wadi Jilat 6 Middle (RAI c.0.35) near an at least seasonally well watered wadi in the limestone steppe (although note the small sample-size). In the later assemblages of the Early Epipalaeolithic, however, equid/cattle abundance becomes very low, notably at both of the large aggregation sites of Wadi Jilat 6 Upper 1-3 levels, and Kharaneh IV (levels B-D). The Middle Epipalaeolithic sees moderately high but variable equid/cattle abundance at Wadi Jilat 22. A high peak of large game is seen at Azraq 18, located at the oasis in the centre of the basin. However during all phases of the PPNB it is evident that cattle/equid were more or less absent from both Wadi
Jilat 7 and the site of Dhuweila in the basalt margins. Figure 6 clearly shows the effects of site location, variation in localized environments, water availability and habitats within the Azraq Basin.

Fast and slow small game  Figure 7 shows patterns for small prey also on an individual site/assemblage basis. Slow-moving prey, largely tortoise, are uncommon (< RAI 0.05) at most sites apart from Mid-Late Epipalaeolithic Wadi Jilat 22 (RAI c.0.3) and Mid PPNB Wadi Jilat 32 (c.0.67) where they appear as a notable presence, but for other PPNB assemblages they have low representation, and as already established, relative abundance variation over time is not statistically sound. Fast moving prey were numerous in Wadi Jilat 22, Early and Mid PPNB Wadi Jilat 7 (RAI max.0.4-0.6) and in Mid PPNB Wadi Jilat 32 where relative numbers peak. These findings contrast with those from El-Wad Cave and Hayonim Cave where Stutz and colleagues (2009) show small prey reaching high numbers only in the Late Epipalaeolithic, apparently associated with a decreasing abundance of gazelle. Tortoises also outnumber fast small prey at Late Epipalaeolithic Hayonim Terrace and Hilazon Tachtit, but notably never do so at any of the Azraq Basin locations.

Gazelle  The one taxon not elucidated by the above analyses is gazelle - the most common steppic/desertic mammal in most assemblages - since it serves as a reference index for assessing variation in other taxa size classes. Figure 8 remedies this by showing how gazelle relative proportions shift through time, from being the dominant prey throughout the Epipalaeolithic, appearing in lower relative proportions in the Middle and Late Epipalaeolithic, and being only the third most common taxon at Late Epipalaeolithic Azraq 18 in the oasis. Gazelle are the major, small-big game animal but representation is varied in the PPNB, when it is sometimes equalled or exceeded by hares. Dhuweila in the basalt margins is an exception in showing an assemblage comprising almost exclusively gazelle.
A similar diachronic spectrum through the Epipalaeolithic for Galilee/Mount Carmel faunal assemblages (Figure 9) shows a more unidirectional trend, with gazelle and fallow deer declining in the Late Epipalaeolithic, with a corresponding increase in small prey, especially tortoises, partridges and hare. This picture contrasts with Stiner’s (2001) diet breadth study which used assemblages from more inland Galilee sites (in the Wadi Meged) and found tortoise steadily declining between c.30,000-10,000 cal. BP. Otherwise, trends were similar. The Azraq Basin picture (e.g. Figure 8) does show ‘directional’ trends, but far more fluctuating, perhaps reflecting the larger area and more varied environmental contexts incorporated in this study (12,000km²) compared to that of Stutz et al., (2009) (c.3,000km²).

Summary of data patterning

In the Azraq Basin, small game increases within assemblages in the Middle and Late Epipalaeolithic, at least a millennium earlier than seen in the Galilee/Mount Carmel. But closer inspection shows this pattern derives from the sequential occupations of one site, Wadi Jilat 22, where high proportions of bird and tortoise are seen. Fast small game, especially hare, increases sharply within PPNB assemblages, while tortoise bones remain relatively low in abundance. For large game, Figure 8 shows that cattle did not made a significant contribution to any of the Epipalaeolithic assemblages except the oasis site Azraq 18 where they dominate; subsequently in the Holocene cattle virtually disappear. Equid representation is more varied, being at its highest in the Initial Epipalaeolithic, declining in the Early Epipalaeolithic, increasing again in Middle and Later Epipalaeolithic assemblages, but becoming rare in the PPNB. How much this patterning reflects climatic shifts in the Late Pleistocene/early Holocene and attendant ecological changes, or changes in the ways that hunter-gatherer groups interacted with their prey and impacted wildlife, are explored in the following section.
In order to unravel the main influences on the faunal changes documented above, we discuss trends in the light of three factors: climatic shifts through the time-frame; evidence for hunting pressure on individual game species; and small game ratios which might reflect site occupation intensity. Our aim is to examine the combination of climatic and human occupation influences that could have guided prey choice across the time sequence.

Climatic conditions and shifts 30,000 cal BP to 9,000 cal BP

Animal distribution and density in the Azraq Basin – especially for herd ungulates – will have been influenced by climatic variability, impacting water supply and vegetation, as well as complex factors relating to soil type, topography and forage. The more regional-scale evidence for climate changes from the Late Upper Palaeolithic to Late PPNB in the southern Levant is summarized in Table 5, with data deriving from the Soreq Cave speleothem δ^{13}O and δ^{18}C isotope analyses, and investigations of Lake Lisan levels (Bar-Matthews, Ayalon and Kaufman, 1997, 1999; Bartov et al., 2002; Robinson et al., 2006). The right hand columns of Table 5 summarize studies of plant growth and geomorphology specific to the Azraq Basin (Colledge, Conolly and Shennan, 2004; Jones and Richter, 2011; Hunt and Garrard, 2013), and it is notable that these eastern Jordan signatures occasionally deviate from the regional picture.

In brief, high stands of Lake Lisan during the cold period preceding and during the early stages of the Late Glacial Maximum (LGM) have been identified, which are the consequence of major increases in rainfall coupled with less evaporation associated with the drop in temperature (Bartov et al., 2002; Hazan et al., 2005; Robinson et al., 2006; Enzel et al., 2008). The cold conditions of this period featured on both sides of the Jordan Valley rift during the Upper Palaeolithic and Early Epipaleolithic. Geological sections indicated the presence here of a likely perennial lake in the Azraq Oasis during this period (Garrard et al., 1988a; Jones and Richter, 2011;
Hunt and Garrard, 2013) while sediment profiles at Wadi Jilat 6, Kharaneh IV and Uwaynid 14 and 18, demonstrate that locally available standing water was present at diverse locations through the LGM and post LGM warming phase prior to the Heinrich 1 event (Hunt and Garrard, 2013; Richter et al., 2013). This picture of a well-watered landscape was corroborated by archaeobotanical studies which provide evidence that the broad drainage wadis would have been lined with perennial shrubs, sedge, grassland and scattered trees (Garrard et al., 1988b; Colledge, 2001). More recently, geoarchaeological work at Kharaneh IV has confirmed the presence of a relatively lush habitat with rich vegetation along the adjacent wadi (Maher et al., 2012) while sedimentary successions at Ayn Qasiyya in the Azraq oasis point to the presence of permanent water and marshland from the Early to Middle Epipalaeolithic (Richter et al., 2009).

Long-term or repeated occupation sites such as Wadi Jilat 6, Ayn Qasiyya and Kharaneh IV had declined by the end of the post LGM warming phase when water availability may have become limiting (Bar-Matthews et al., 1999; Robinson et al., 2006; Jones and Richter, 2011; Hunt and Garrard, 2013). It is notable that Kharaneh IV was established in a late phase of the LGM, and overlapped with the final phase of occupation of Wadi Jilat 6 which lies 30km to the south. Both sites are exceptionally large, intensively occupied hunter-gatherer aggregation centres, and have been called ‘megasites’ (a term more commonly applied to PPN village settlements) and seem underpinned by an environment of relative lushness (Garrard and Byrd, 1992; Richter et al., 2013).

Both were abandoned during a drier phase following the LGM. In the warm up period following the Heinrich 1 event there is evidence of localised seasonal marshland in parts of the Wadi Jilat (Hunt and Garrard, 2013, 74-78) and reoccupation of sites in that area and at Azraq (Wadi Jilat 22, 10 and 8; Azraq 17). Occupation at some of these sites continued into the warmer, moist Bølling Allerød, however the ensuing cold arid period of the Younger Dryas seems to have led to the disbanding of communities into small, mobile groups, not easily detected by archaeological survey.
There is evidence from other areas of the southern Levant (e.g. the Wadi Faynan in south-west Jordan: Hunt et al., 2004; Finlayson and Mithen, 2007) for moister conditions during the Early Neolithic, but the environmental (particularly the geological) record from eastern Jordan is more ambiguous. There is certainly evidence for an expansion of settlement through the PPNB although the sites appear to have been occupied by seasonally mobile groups (e.g. Wadi Jilat 7, 26 and 32) (Byrd, 1992; Garrard et al., 1994b; Garrard and Byrd, 2013). There are traces of small-scale cultivation which may have been opportunistic and limited to seasonally damp alluvial areas or relating to slightly moister conditions (Colledge, 2001). By c.9000 cal BP Late PPNB sites began to appear in the Basalt desert fringes at locations such as Dhuweila and Ibn el-Ghazzi (Betts, 1998).

Understanding how these local climatic changes through the Late Pleistocene and Early Holocene may have affected large game availability is clearly complex but we might, for example, consider differences in water-dependency for the three main taxa: gazelle, equids and cattle. All Arabian gazelle species (Gazella subgutturosa, G. gazella, G. dorcas) are adaptable grazers and browsers, independent of standing water, and fairly drought tolerant (Ostrowski, Mésochina and Williams, 2006), so it is very likely that gazelle herds met both their forage and water requirements in the Azraq Basin throughout the sequence. Only G. subgutturosa has been identified from Azraq Basin assemblages to date, on the basis of horn-core morphology, from both Early Epipaleolithic and Neolithic assemblages (e.g. Kharaneh IV, Uwaynid 18, Dhuweila). This steppic species is independent of standing water, and fairly drought tolerant, so we can assume that fluctuations in water availability would not have a severe impact on their presence.

Equids have different requirements. From the Azraq Basin assemblages, there are hints of two sizes of equids, probably representing the larger E. caballus and smaller E. hemionus, with the latter being identified from dentition at Early Epipalaeolithic Wadi Jilat 6, Late Epipalaeolithic Azraq 18, and Neolithic Dhuweila (Martin, 1994, 1998); the former identified at Ayn Qasiyya (Edwards, unpublished data), while intense fragmentation renders most postcranial specimens unidentifiable to
equid size class. *E hemionus* in particular is characteristic of steppe and desert environments and finds its forage there. They are both able to obtain their water requirements from vegetation in wet seasons, but need to drink from standing water every few days in drier seasons (Klingel 1977; Roses and Moehlman, 2002), and will always stay close to standing water. With this in mind, it is notable that the fluctuations in the proportions of equids in assemblages (Figure 8) tend to coincide with wetter and drier phases of the Epipalaeolithic. For example, their consistent presence in the Initial Epipalaeolithic and early part of the Early Epipalaeolithic marks a time when the Azraq Basin is evidenced as well-watered. Equids declined in the upper phases of Wadi Jilat 6 and Kharaneh IV occupation, when water availability seemed to decrease. The Middle Epipalaeolithic witnessed locally moister conditions and was marked by higher equid proportions in assemblages. Thus increased equid presence can be linked to the availability of drinking water, although other factors such as site location and seasonality may also have been causal. It is harder to explain the virtual disappearance of equids in the PPNB assemblages, if there was increased wetness across the Azraq Basin. This is explored further below.

Turning finally to cattle (*Bos primigenius*), these obligate drinkers require drinking water every 2-3 days, whether in wet or dry seasons. Wild cattle, and by implication aurochsen, have a strong adherence to standing water, and will not graze further than a day's walk from water sources and a favoured location would be open areas with grass and marshland around lakes (Garrard, 1980 Table 3B; van Vuure, 2005). It is therefore not surprising that cattle are seen only at Ain Qasiyya and Azraq 18, both sites within the oasis. While other areas may have had standing water or seasonal wadis, these did not offer contiguous permanent water sources that allowed wild cattle to thrive.

In sum, the effects of the changing climate through the Epipalaeolithic and PPNB in the Azraq Basin is most likely to have impacted on the presence of equids, since they are occasional drinkers, being neither independent of standing water (like gazelles), nor obligate drinkers with a strong adherence to water sources (like cattle). Variation in their relative abundance can be
interpreted as environmentally-linked, rather than the result of human impact, at least until the early Holocene when their disappearance requires further explanation.

Evidence for predation pressure

For the Mediterranean vegetation zones of the southern Levant, many authors have argued for an intensification in gazelle hunting during the Epipalaeolithic. In an important early study, Davis (1983) found an increase in the proportion of juvenile gazelles within assemblages between the Mousterian and Natufian which he attributed to year-round hunting pushing down the demographic profile of gazelle herds. In later broader-scale analyses, Munro also noted increases in juvenile gazelles between Early/Middle Epipalaeolithic assemblages (Kebaran and Geometric Kebaran) where juveniles made up less than 30% of gazelles culled, compared to Late Epipalaeolithic (Natufian) assemblages where they rose above 30% (Munro, 2004). Refining the juvenile fraction further, Munro (2009) also found that the targeting of ‘fawns’ also increased through the Epipalaeolithic, even between the early and late Natufian. This was interpreted as Natufian hunters actively hunting all available gazelle age classes as part of a broader shift in resource intensification which also included smaller game. This, in turn, was seen as a response to occupation intensity and resource stress, ultimately driven by population pressure (see Stiner, Munro and Surovell, 2000; Stiner and Munro, 2002; Munro, 2009; Stutz, Munro and Bar-Oz, 2009). While there are other factors that play into an ‘increase’ in juvenile animals observed in assemblages - such as site seasonality and variability in hunting strategies (see Simmons and Ilany, 1975-77 and Davis, 1983 for excellent considerations of these factors) - there is wide acceptance in southern Levantine prehistory that predation pressure on gazelles is reflected in the demography of cull profiles.

With this in mind we might predict for the Azraq Basin that an increase in the proportion of juvenile gazelles, alongside evidence for targeting fawns, indicates hunting pressure. This prediction is considered in the following section. It should be noted that Munro’s (2004) threshold of 30%
juveniles stems only from internal observation of her study site data. One of us (Martin, 2000, 25, Table 12) found, in a review of modern single-birthing gazelle populations, records of juveniles making up 39% of herds in normal years under no conditions of hunting pressure. In our examination of gazelle cull data below, we therefore use this higher figure (39%) as a threshold below which we do not assume pressure on gazelle herds.

From the Azraq Basin assemblages, there is sufficient epiphyseal fusion data for an examination of gazelle cull profiles, while only brief comment can be made concerning the sparse equids data and there are insufficient data to address hunting pressure on cattle.

**Gazelle**

Table 6 shows gazelle fusion data from selected Azraq Basin assemblages (the number of elements with fusion data is shown in the right hand column; note some are too small to be reliable). The left column shows the number of indeterminate longbones of gazelle size which are of neonate size (assumed to be gazelle, since there is no similar sized ungulate present). Data are also given for the percentage of unfused elements that fuse between birth and 7 months, those that fuse between 3 and 7 months, and those that fuse by c18 months (following Munro, Bar-Oz and Stutz, 2009). Unless otherwise noted, we assume a spring birth peak for gazelles in the Azraq Basin (Martin, 2000, 19-20).

Early Epipalaeolithic assemblages in the limestone steppe, e.g. Kharaneh IV and Wadi Jilat 6, show overall juvenile cull percentages of 25-35%, which lie well within the range of single birthing gazelle populations in most Middle Eastern and indeed east African habitats (Martin, 2000, 25-6, Table 12). There are also low numbers of very young animals/neonates represented in these assemblages, particularly animals of less than 7 months old (represented by unfused proximal radii and phalanges, distal humeri and scapula glenoid). These large-scale repeated occupations therefore do not show any evidence for hunting pressure, despite clearly having a strong focus on gazelle...
hunting. The data rather seem to show sustainable hunting practices, which did not target newborn calves, or females in late gestation period, or even a particularly high proportion of juveniles and sub-adults.

A different picture is seen at Early Epipalaeolithic Ayn Qasiyya at the centre of the drainage basin, which has far higher juvenile proportions (48% and 39% respectively for A and B, Edwards, unpublished data). These proportions are equal to or above the expectations of representative hunting of single-birthing gazelle populations and various explanations should be considered: 1) hunting pressure, driving up the proportions of juveniles; 2) double-birthing of gazelle in the lusher oasis environment; 3) selective hunting of juvenile animals.

As noted above, the expectation for hunting pressure is that alongside high juvenile counts, the killing of younger classes of fawns should also be seen, as evidence of all age-classes being targeted. At Ain Qasiyya there are very few remains of calves up to 7 months. Could this be due to wet/marshy burial environments potentially degrading and selectively eliminating young unfused bone (see Gordon and Buikstra, 1981; Mays, 2010, for human bone)? This possibility cannot be dismissed, but considering that other Azraq Basin sites in wetlands and marsh environments include sometimes high numbers of these very young age classes (Table 6, WJ22 Mid, AZ18) it is difficult to argue that Ain Qasiyya alone suffered taphonomic loss of this age-class of bone. Rather, it is parsimonious to assume that bones of gazelle fawns were not present at Ain Qasiyya in perceptible numbers.

The possibility of gazelle herds ‘double birthing’ in the wetter oasis locale also needs consideration, since it would result in the presence of higher relative proportions of juvenile animals to adults. While *Gazella subgutturosa* normally give birth once a year (Martin, 2000), they can birth twice a year in environments with permanent water, food and shade, where the lack of seasonal stress can produce two fawning periods (Habibi, 1991; Kingswood and Blank, 1996; Dunham, 1997), one in spring and another in autumn. A current programme of gazelle dental isotope analyses will inform
on animal birth seasons in future. Until then, there is no firm evidence to support or dismiss the idea.

If gazelle were double-birthing, there would be higher proportions of juvenile animals in the environment during each season (see Baharav, 1983; Martin, 2000, 26) and certainly far higher than a 39% expectation. In such a scenario there would be no need to invoke hunting pressure arguments to explain ‘high’ proportions of juveniles in cull patterns.

Regardless of the possibility of double-birthing, Table 6 shows that the ‘high’ proportions of juvenile gazelle deaths at Ain Qasiyya do not include fawns under the age of c.7 months. The avoidance of fawns might well be expected in a hunting practice where nursery herds, including young animals with their mothers, are not the target of hunts but left to grow larger in body size (or to reproduce in the case of mothers). There is therefore some evidence for selective avoidance of animal groups during hunting, whether intentional or not, while there is with no direct evidence for hunting pressure at Ain Qasiyya.

At Middle Epipalaeolithic Wadi Jilat 22, both levels show overall juvenile counts (at 7-18 months) in the 30% range (32% and 36%), higher than seen at earlier sites in the limestone steppe (Table 6), but still within expectations of ‘representative’ culling scenarios of single birthing populations. There are, however, increased numbers of fawns culled within the first 7 months of life and notable lower percentages of gazelles hunted overall at Wadi Jilat 22 (Figure 8). While the expectations for hunting pressure are not met, the high fawn count needs consideration. We have argued elsewhere (Martin, Edwards and Garrard, 2013) that Wadi Jilat 22 is a seasonal hunting locale in a wetland setting, focused on trapping birds of prey - particularly eagles - while on their spring or autumn passage. The presence of newborn gazelles indicates a spring or early summer occupation, and the targeting of nursery herds, or inexperienced young game around the local marsh seems best explained as an opportunistic strategy while waiting for birds of prey. Wadi Jilat 22 occupations are likely to have been highly seasonally restricted, and considering the specialised nature of the site (Garrard and Byrd, 1992, 2013) where gazelle hunting was not the main focus of
activity, the gazelle cull evidence seems to reflect seasonality, rather than human pressure on wildlife. Late Epipalaeolithic Azraq 18 has a very small sample of gazelle fusion data and is not discussed further.

Early and Middle PPNB occupations at the seasonal village of Wadi Jilat 7 see relatively high culling of fawns up to 7 months old, and a higher overall juvenile cull (40 and 42% respectively), where gazelle proportions are again low and hare exploitation high (Figure 8). Spring occupation is likely, and since Colledge (2001) has reported small-scale experimentation with crop planting at this site, residence may have extended into late spring/early summer for harvesting (Garrard et al., 1996). The evidence for culling fawns perhaps reflects the targeting of nursery herds, while hunters seem to have been equally engaged in trapping local small game, predominantly hare, as gazelle hunting (Figure 8). Within this more human-impacted ‘anthropogenic’ environment, gazelle cull patterns provide good evidence for pressure on herds, with hunting hitting young age classes. Whether this reflects more widespread steppic pressure on game animals is difficult to gauge since PPNB sites and assemblages in the steppe are sparse. The stone-built structural footings characteristic of steppe sites in this period - for example the upright limestone slab foundations which may have had brush/hide/cloth roofs at Wadi Jilat 7, 26, 32 (Baird et al., 1992; Garrard et al., 1994b) - attest to repeated seasonal visits. Sites are very different from large permanently occupied PPNB village settlements seen in the Mediterranean zone to the west. It is hard to imagine small seasonally mobile steppe groups impacting game herds on a wide-scale in this period, but the faunal patterns from WJ7 do suggest local pressure on game, where herds may have been deterred from the immediate vicinity of settlements and there is evidence of indiscriminate culling of young gazelles.

Late PPNB Dhuweila in the basalt desert shows a significant cull of animals in each of the young and sub-adult age classes, with an overall very high proportion of juveniles in the assemblage (55%), seemingly indicative of indiscriminate hunting. The assemblage includes over 90% gazelle, with evidence for intensive carcass processing (Martin, 1998). Dhuweila is a short-term, repeatedly
visited, seasonal hunting camp (Betts, 1998) situated on a highpoint, overlooking seasonally flooded mud flats, and appears to have been a dedicated gazelle hunting camp. Betts (1998) suggested that the Late PPNB phase of the site was built into a long basalt guide-wall, perhaps part of a kite (hunting structure), and while this is not unanimously accepted (Zeder, 2012), it is easy to imagine hunters preparing trackways or guiding walls to divert gazelle herds in their direction. The demographic profile evidence showing the culling of large numbers of fawns, alongside an overall 55% juveniles, which exceeds all expectations for single-birthing herds (see Martin, 2000 Table 12), and meets expectations for hunting pressure. The data indicate that hunting in this locale was impacting the demographic profile of gazelle herds in the Late PPNB.

In sum, throughout the Early Epipalaeolithic, hunter-gatherers seemed to practice sustainable exploitation of gazelle as their main prey, with no apparent hunting pressure. We also find no evidence of gazelle hunting pressure in Middle Epipalaeolithic assemblages, where lower gazelle proportions and cull patterns are best explained in other ways. It is only in the Early and Middle PPNB in the limestone steppe that there is clear evidence for some human impact on gazelle herds. We propose some displacement of gazelle herds, maybe only seasonally, an effect that likely increased with the later Neolithic introduction of domestic caprines to the steppe (Garrard, College and Martin, 1996; Martin, 1999). Significant hunting pressure on gazelles is first witnessed at Late PPNB Dhuweila; whether this was achieved with hunting traps or guide-walls will no doubt continue to be debated (Helms and Betts, 1987) but there is clear evidence of intensive hunting.

While we argue above for intensive gazelle hunting by the Late PPNB, there is no evidence for the decimation of herds. The repeated later Neolithic occupations at Dhuweila, for example, continue to show intensive gazelle hunting (>90% of assemblages), indicating large numbers of animals were present in the basalt desert during this period. While hunting methods exerted pressure on herds, they did not, as some have previously suggested (Legge and Rowley-Conwy 1987; 2000) drive gazelle to extinction in prehistory in the Jordan steppes/deserts.
Equids are the second most common large game animals in the Azraq Basin after gazelle, and as suggested above may have been subject to changing environmental pressures, particularly fluctuations in water availability. This could explain variations in their representation in the limestone steppe and at the central oasis, and through wetter and drier phases of the Epipalaeolithic. Was hunting pressure also a factor affecting equid numbers at the end of the Pleistocene and into the early Holocene? Assessment of pressure on equids is complicated by our poor understanding of the species represented at sites, which are often not identifiable beyond genus level due to high fragmentation of bones and teeth. In the Levant, particularly in late Pleistocene/early Holocene steppe-grasslands, we might expect the presence of smaller equids including the now extinct Syrian wild ass (Equus hemionus hemippus) or the Persian onager (E. hemionus onager). The wild horse (E. caballus ferus) is also likely to have been present and possibly the wild ass (E. africanus) whose distribution ranged from north African into the Levant in the early Holocene (Uerpmann, 1987). Another possible resident equid was the European wild ass (Equus hydruntinus). Some reservation concerning identification is necessary since aDNA work shows that hemiones and hydruntines share similar genomes. Comparisons of mitochondrial DNA show the same 28-29 base pair deletion which might indicate that they are not true separate species (Orlando et al., 2006, 2009). In addition the DNA hypervariable regions (Geigl and Grange, 2012) demonstrate that hydruntines and hemiones are closely linked, but comparisons of grouped haplotype sequences find a significant genetic distance that points to distinct speciation, although it is impossible currently to be confident that they are different species. For now, we question our prior identification of hydruntines in the Azraq Basin (e.g. Azraq 18: Garrard, 1991; Martin, 1994).

For our study sites equid dentition has allowed identification of hemiones at Wadi Jilat 6 (Upper), Ayn Qasiyya, Azraq 18 and Dhuweila Late PPNB, while identification of sub-species has
not been possible. Hemiones would be well adapted to the steppe grasslands, semi-desert and desert plains of the Azraq Basin. Recent studies of *E. hemionus* in central Asia and reintroduced populations in the southern Levant show they graze in lush seasons turning to browse in drier seasons. Males hold territories throughout the year with females entering them during the mating season (Klingel, 1977; Reading et al., 2001; Rubenstein et al., 2007). The less frequent presence of wild horse is also attested from a single tooth at Ayn Qasiyya (Edwards, unpublished data).

The decline of equids in the Azraq Basin during the Holocene needs consideration since *E. hemionus* in particular should have found sufficient forage and water. In the Neolithic, equids are present at Late PPNB Dhuweila (see Table 4) and the Later Neolithic phase at Dhuweila (Martin, 1998 Table 8.2, 161-2); they also appear at later prehistoric sites in the Burqu’ area (Betts et al., 2013) but always in low numbers. Their low proportions are curious since onagers are known from historical periods to be common steppe inhabitants, and Syrian wild asses found refuge into the 20th century in areas of the Azraq Basin (Harper, 1945; Nelson, 1973, 160), only to be driven to extinction by regular hunting with firearms.

Small sample sizes render it impossible to assess hunting pressure on equids (Table 7), and fusion data show only that both adults and juveniles were present throughout the Epipalaeolithic with no equivalent data for Neolithic assemblages. While there is therefore no direct evidence for hunting pressure, we suggest that a combination of fluctuating water availability alongside continued hunting of equids impacted their presence in the Azraq Basin. Furthermore, Neolithic occupations, while still seasonal in nature, showed more investment in built structures and were located closer to bodies of water (e.g. wadi beds, lake edges) than in the Epipalaeolithic. Such factors may have displaced water-adhering wild asses and interfered with their territories and habitat use, as documented in recent times in Iran where equid populations were depressed by encroaching human settlement (Tatin et al., 2003). Loss of habitat due to human landscape interference, grazing livestock, and
competition for water and forage is listed among the major threats to *E. hemionus* by the IUCN Red List (http://www.iucnredlist.org/details/7951/0).

Small game ratios and site occupation intensity

Turing to small game animals, Stiner and colleagues (2000, 2002) have proposed that within the overall diet breadth of an assemblage, examination of the small game fraction can indicate levels of site occupation intensity. Following optimal foraging theory predictions, they have demonstrated that hunter-gatherer-collectors would take easy-to-catch slow-moving prey in preference to harder-to-catch fast-moving prey, and that a decline in slow-moving prey accompanied by an increase in fast-moving prey indicated an exhaustion of the former. Stiner and Munro (2002) see the prime reason for this as over-exploitation of food resources in the immediate environment, resulting from intensive site occupation through multiple seasons, or year-round. Application of this logic to southern Levantine faunal assemblages found that tortoises constituted the major slow-moving prey, while hares and birds made up the fast-moving fraction.

For Azraq Basin assemblages, Figure 10 shows the relative proportions of tortoise, hare and birds within the small game category. The overall percentage of the small-game fraction is given below the assemblage labels on the x-axis. It should be noted that raptors are excluded from the ‘bird’ counts, since these analyses focus on animals as food choices, and raptors are most probably captured for non-food purposes. We also stress that tortoise sample sizes are sometimes very small, but note that our quantification method for tortoise remains (see Table 4 caption) already divides scutes by 60, to standardize with mammalian/bird anatomy (unlike some zooarchaologists), thus NISP counts would be far higher. Figure 10 shows that during the Early Epipalaeolithic the percentage of small-game in assemblages was relatively low, always <10% and often far less. Large game always make up most of the diet, especially if considering animal size and weight. Hare generally outnumber tortoise, which are nevertheless always present, and bird representation is
highly variable. There are no strong trends: for example successive phases of occupation at
Kharaneh IV do not see a decline in tortoise representation, which would have indicated exhaustion
of small slow game in this environment. The ratio of tortoise:hare instead seems remarkably
constant at Kharaneh IV showing consistent practices and perhaps underlying resource availability.

From the Middle Epipalaeolithic onwards, assemblages generally show far higher overall
proportions of small game (with the exception of Dhuweila) ranging from 16-65%. The Middle
Epipalaeolithic pattern, however, is different to that seen in the PPNB: at Wadi Jilat 22, tortoises far
outnumber hare and birds, with no decline in tortoise remains between the middle and upper phases
of the site which might be expected if hunters over-impacted local animal resources. This pattern
shows no evidence of intense site occupation; slow-moving tortoises do not become depleted.

PPNB assemblages in the same location (e.g. Wadi Jilat 7) show a very different pattern.
Small game counts overall are even higher than in the Middle Epipalaeolithic, with tortoise
proportions low and hare consistently outnumbering tortoises four/five-fold. We have referred
above to the different nature of occupation during the PPNB in the steppe, with stone-built structures
and evidence for multiple subsistence activities with small-scale cultivation, in addition to hunting
and trapping. Animal procurement activities here favoured hare capture above tortoise use; the
various reasons for this will be discussed below, but one plausible explanation is that the more
intensive nature of these PPNB occupations impacted on the slow-moving and very slow-
reproducing tortoises, while hare populations proved more resilient (Stiner et al., 2002).

Conclusions

This study has examined patterns of wild game exploitation at hunter gatherer sites in the Azraq
Basin of eastern Jordan, following approaches described by Stutz, Munro and Bar-Oz (2009) in
exploration of faunal assemblage change in the Galilee/Mount Carmel area. Stutz and colleagues
showed a steady decline in large game from the Early Epipalaeolithic to the Late Natufian,
accompanied by an increase in small game in the Natufian, interpreted as reflecting demographically driven resource pressure. Their results support earlier proposals (Munro, 2004, 2009a; Stiner, 2001: Stiner et al., 1999) that increased use of small game, particularly resilient fast small game in the Early and Late Natufian, reflects a decline of large game due to over-hunting, associated with increasing site occupation intensity and ultimately driven by population pressure.

Statistically robust diachronic trends for the Azraq Basin across a longer timeframe from the Upper Palaeolithic to the Late PPNB differ from those seen in the Galilee/Mount Carmel area. For example, equids (the main large game in the steppic Azraq Basin) increase in relative abundance in the Middle and Late Epipalaeolithic (at Wadi Jilat 22 and Azraq 18) after low representation in the Early Epipalaeolithic, a fluctuation that convincingly reflects changing water availability rather than human impact. From the PPNB onwards, however, the very low equid representation in assemblages is counter to expectations based on increased moisture/water availability (Table 5). While we cannot rule out the possibility that steppic PPNB hunters had a socio-cultural focus on gazelle hunting rather than equids, we argue above that PPNB settlement types generated an increased local ‘anthropogenic’ impact, and this together with continued hunting would have placed pressure on herds and seasonally and spatially displaced them, sending them into decline. This does not equate to long-term extinction or extirpation, however, since wild equids had a continued presence in the area until recent times.

Wild cattle had a clear adherence to the central oasis of the Azraq Basin. Assemblages analysed from this area are limited to the Epipalaeolithic, so we currently cannot gauge pressures on cattle into the Holocene. However, their high representation at Late Epipalaeolithic Azraq 18, alongside equids, demonstrates that large game thrived locally into the Terminal Pleistocene, a very different scenario to that in the Galilee/Mount Carmel area where Stutz and colleagues (2009) find a diminished large game category by the late Natufian.
Turning to small game, the slight ‘increase’ of small fast game observed at Middle Epipalaeolithic Wadi Jilat 22 cautions against superficial interpretation of temporal trends without paying due attention to the specifics of site function. Middle Epipalaeolithic Wadi Jilat 22 sees a high representation of birds which, as we have argued elsewhere, represents specialized seasonal trapping, providing non-food items such as feathers and talons for onward exchange (Martin, Edwards and Garrard, 2013). This cultural practice was made possible by the development of local seasonal marshland in Wadi Jilat which attended climatic warming (see Table 5). It seems quite different from the small-game increases seen in the Middle to Late Epipalaeolithic of the Mediterranean zone which are interpreted as being food animals.

It is not until the PPNB that the impacts of a more anthropogenic footprint are seen in the form of small game increases in Wadi Jilat assemblages. Wadi Jilat 7 shows a faunal signature consistent with more intensive occupation: here high proportions of small game reflect the displacement, loss of territory and perhaps overhunting of equids, and high hare:tortoise ratios suggest the over-harvesting of the latter, although we note small assemblage sample sizes. While the Wadi Jilat 7 structures are small-scale and seasonal (Baird et al., 1992; Garrard et al., 1994b), lengths of stay are likely to have been influenced not only by animal life, but also by small-scale cultivation of crops. The observed decrease in gazelle at PPNB Wadi Jilat 7 and the hunting of gazelle fawns and calves, hints at range fragmentation and pressure on resources, which are supplemented with small animal trapping and crop cultivation. Our zooarchaeological evidence argues that these observations represent the earliest evidence of increased pressure on resources detected in Azraq Basin environments. Until this point, hunter-gatherer groups seem to have ‘trodden lightly’ in the steppe (a phrase borrowed from Munro et al., 2015).

This is a localized picture however, since the eastern edge of the Azraq Basin supports gazelle herds in abundance during this period at Late PPNB Dhuweila (seen also in the Late Neolithic) (Betts, 1998; Martin, 1998). The apparently indiscriminate hunting tactics of killing
newborns, fawns and juveniles at Dhuweila, impacted the demographic make-up of gazelle populations and reflects a focused targeting of a single species. By this period, mixed agriculture and livestock herding were well-established at village sites in the fertile areas of the southern Levant, with trading and exchange networks well-attested (Bar-Yosef and Belfer-Cohen, 1989; Richter et al., 2011). This raises the possibility that the intensive gazelle hunting observed at Dhuweila could have been a part of a regional network for meat or hide exchange, rather than simply catering for local hunter-gatherer needs.

While witnessed a few thousand years later, the changes seen in the Wadi Jilat PPNB sites mirror to some extent those seen in the Late Epipalaeolithic in the southern Levantine Mediterranean zones, where small game replace larger game (Stiner et al., 1999, 2000; Stiner, 2001; Stiner and Munro, 2002), while noting the Azraq Basin Late Epipalaeolithic-PPNA data-gap. However, for the Azraq Basin PPNB, demographic pressure arguments do not seem relevant: the Wadi Jilat PPNB sites are relatively small, seasonal and not consistent with large populations. As argued above, these factors may have deterred/disrupted the range used by larger game and encouraged trapping of local smaller game. The Wadi Jilat PPNB sites equally do not fit Zeder’s scenario for diversified prey in which she sees hunter-gatherers moving into resource rich environments with multiple eco-zones, where a wide range of large and small game could be hunted and trapped (Zeder, 2012). A note of caution must be raised when using bone assemblages to trace faunal turnover: it is well-understood that assemblages do not necessarily reflect animal communities living around sites, neither in taxonomic range nor proportion, since they are filtered through human selection. Some Azraq Basin faunal assemblages reveal social preferences or avoidance of particular animals, such as the highly selective raptor trapping at Wadi Jilat 22 or gazelle hunting at Dhuweila. Also, at Ain Qasiyya at the oasis edge, a higher representation of cattle might be expected, but assemblages are dominated by gazelle, hinting at cattle avoidance. Understanding site functions and activities, in addition to
environmental contexts and hunting and trapping patterns, is essential prior to interpretation of
diachronic faunal shifts.

Finally, comparisons made in this paper between the eastern Jordan Azraq Basin and western
Galilee/Mount Carmel sites draw attention to significant differences between both their
environmental settings and archaeological settlement patterns. Azraq Basin sites are all in open-air
locations, ranging from hilly limestone steppes to the west, to marshland and springs in the central
oasis, and basaltic hills to the east (see Figure 2). Scattered trees, perennial shrubs and grassland
would have been features of the Early and Middle Epipalaeolithic landscape with rich vegetation
alongside wadis and in marshland areas. The post-Younger Dryas warming in the Holocene saw
restoration of springs and marshes (Garrard et al., 1988b; Colledge, 2001; Maher et al., 2012) but
throughout the periods under discussion in this study, it is likely that only seasonal occupation could
be sustained.

By contrast, the western Galilee/Mount Carmel sites were located across more verdant,
fertile locations with plentiful open woodland in the hilly Mount Carmel area and open grasslands on
the plain between the hills and the sea (Saxon, Martin and Bar-Yosef, 1978; Kaufman, 1987; Bar-Oz,
Dayan and Kaufman, 1999; Stutz et al., 2009). The faunal trends observed here between the
Geometric Kebaran and Natufian (e.g. Munro, 2009) of intensification of gazelle exploitation, and
the replacement of large game hunting with the collection of tortoises, and trapping of hare and game
birds, are concurrent with apparent human population growth, and increasingly permanently-
occupied aggregated settlements in the area (Bar-Yosef, 2000; Munro, 2004). Large Natufian sites
are interpreted as permanent basecamps (Bar-Yosef and Belfer-Cohen, 1989, 1991) which would
have placed very different pressures on local wildlife to seasonal habitations.

Contrasting patterns of wildlife exploitation seen in the Azraq Basin can, at least in part, be
explained by the very different environmental setting and nature of human occupation seen through
these periods. The Azraq Basin case-study presented here thus cautions against universal broad-scale
explanations of hunting pressure and faunal change, even within relatively small regions such as the southern Levant. We have demonstrated much variation even between the micro-environments of the Azraq Basin itself, so variation is to be expected across the region in general. This study reveals diverse hunter-gatherer use of the wildlife through time and across the different locales examined, but what emerges is that human impacts on steppe and desert fauna through the Epipalaeolithic and PPNB seem both local and in many cases short-term, unlike the large-game suppressed situations reported from west of the Rift Valley. Resource pressures leading to game over-kill, whether population-driven or otherwise, are not currently apparent east of the Jordan River (Edwards and Martin, 2013; Munro et al., 2015).

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List of Tables and Figures: Captions

Tables

1. The sixteen study sites (and site codes) in the Azraq basin and Basalt desert areas with topographic location, approximate site size and excavation areas indicated. Site area and m asl taken from Garrard and Byrd (2013); for further information on sites and faunal assemblages see references given.

2. Radiocarbon dates ka cal BP for Azraq basin/Basalt desert sites with oldest at the base (n=31: Betts, 1998; Garrard et al., 1994a; Garrard and Byrd, 2013). Time-ranges shown for sites without secure radiocarbon dates are based on lithic typologies.

3. Estimates of patterns of occupation at sites in the Azraq basin and Basalt desert from the Late Upper Palaeolithic to the Late PPNB (Pre-Pottery Neolithic B) (based on Byrd, 1988). Source of data indicated by symbols: * Martin (1994); ^Byrd (1988) and Garrard and Byrd (2013); ** Betts (1985, 34-36). *** Betts (1986); ^^ Richter et al. (2009). See Table 1 for site codes, details of region, landscape, site size and occupation.

4. Identified mammals, birds and reptiles from all sites discussed in the text and expressed as NISP%, with NISP totals shown in right hand column. Herb = herbivore; Gt = goat; Sm = small; Lg = large; Mam = mammal. * Tortoise includes total number of scutes divided by 60 plus girdle and long bones.

5. Palaeoenvironment data for eastern Jordan sites. Site codes (see Table 1) are used in the Plant Growth and Geomorphology columns. Data sources: Soreq cave speleothem isotope data, Bar-Matthews et al., 1999; Lake Lisan levels, Bartov et al., 2002; Hazan et al., 2005 with reference to Bar-Matthews et al., 1999 and Robinson et al., 2006. Geomorphological evidence: Hunt and Garrard, 2013; Jones and Richter, 2011; Richter et al., 2013; Plant Growth evidence: Colledge et al., 2001.

6. Gazelle epiphyseal fusion data showing percentages unfused: Dhw 1 – Dhuweila, Betts, 1998; KHIV - Kharaneh IV, Martin, Edwards and Garrard, 2010; AQ – Ayn Qasiyya, Edwards, unpublished data: WJ22 – Wadi Jilat 22, Martin, Edwards and Garrard, 2013; all other sites Martin, 1994. Percentages of newborn are also shown. Age at fusion taken from Munro, Bar-Oz and Stutz, 2009. For site codes see Table 1. Px = proximal; rad = radius; phal 1 = phalanx 1; dist = distal; hum = humerus; scap = scapula.

7. Equid epiphyseal fusion data from Azraq basin sites dating from Earliest (IntEP) to Late (LEP) Epipalaeolithic. Informative elements are >c. 15 months – proximal phalanx 1 and 2; 15-18 months – distal humerus, proximal radius, distal metapodia; 18-24 months – pelvis, distal tibia: 36-42 months proximal humerus, distal radius, proximal tibia, femur, calcaneum. Fusion data for - AZ18, WJ6 and UW18 from Martin (1994); WJ22 Martin, Edwards and Garrard (2013); AQ Edwards (unpublished data). Age at fusion taken from Silver (1969). For site codes see Table 1. div2 = divided by 2; fg = fusing. For other abbreviations see caption to Table 6.
Figures


2. Google Earth Landsat topographic image showing the Azraq drainage basin and distribution of eastern Jordan sites relative to the modern landscape.

3. Major prey classes identified at Azraq basin area sites. Where estimates of body weight are given for two prey types the values are separated by forward slash (/). Indications of escape speed are also given.

4. Relationship between sample size and relative taxonomic abundance of four prey types. Left to right: slow small game (ssg); fast small game (fsg); medium big game (mbg); large big game (lbg) with respective Spearman’s rank correlation coefficients and showing regression lines. Only mbg shows a significant correlation at the 95% confidence level.

5. Relative abundance of big game (a, top) and fast small game (b, bottom) in eastern Jordan (E. Jordan) and western Galilee (W. Galilee) (following Stutz et al., 2009) through time, cal ka BP. Lines illustrate the overall trend using LOESS local regression models (Cleveland and Devlin, 1988) fitted to the individual assemblage data ($\alpha=0.67$, degree=1). Note that neither mbg from E. Jordan nor lbg from W. Galilee show significant trends and are excluded, as is ssg from both regions.

6. Long term trends in NISP relative abundance of large and medium large game at single occupation sites/levels in the Azraq (Az) basin area. Comparisons are made with western Galilee/Carmel site data (NHV – Nahal Hadera V; NVD – Neve David; HFU – Hefsibah; EWC – El-Wad Cave; HCE – Hayonim Cave; HCL – Late Natufian Hayonim Cave; HYT – Hayonim terrace; HZT – Hilazon Tachtit). Values for total NISP are shown in parentheses, sites with NISP <100 are excluded.

7. Long term trends in NISP relative abundance of fast and slow small game at individual occupation sites/levels in the Azraq basin. Comparisons are made with western Galilee/Carmel site data (see Figure 6 caption for site names). NISP values for combined small game are shown in square brackets.

8. Proportions of mammalian taxa plus bird and tortoise (% NISP) from Azraq Basin and Basalt desert assemblages. Total NISP is shown in curved brackets; only sites with NISP >100 are included. Unidentified large and small herbivores are omitted.

9. Proportions of mammalian taxa plus bird and tortoise (% NISP) from western Galilee/Mount Carmel sites/levels. Data from Stutz, Munro and Bar-Oz (2009); total NISPs shown in curved brackets.

10. Relative proportions of tortoise, hare and birds (excluding all canids and birds of prey following Stutz et al., 2009) of the total small prey category (NISP) from Azraq Basin assemblages. For each assemblage the percentage of small prey of total prey is shown below the...
assemblage code. Note small prey values range from 1.5% at Dhuweila (Dhw) to 64.9% at Wadi Jilat 7-4 (WJ7 4) and 97.5% at Wadi Jilat 32 (WJ32).
<table>
<thead>
<tr>
<th>Period</th>
<th>Site name &amp; code</th>
<th>Approx site area m²</th>
<th>Excav area m²</th>
<th>m asl</th>
<th>Region</th>
<th>Local position &amp; proximity to water sources</th>
<th>Site reference</th>
<th>Fauna reference</th>
</tr>
</thead>
<tbody>
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<td>LPPNB</td>
<td>Ibn el-Ghazzi</td>
<td>c.1050</td>
<td>c.36</td>
<td>695</td>
<td>basalt desert to east of Azraq</td>
<td>hilltop overlooking wadis &amp; mudflats</td>
<td>Betts 1985</td>
<td>Martin 1994; 1999</td>
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<td>Dhuweila (Dhw)</td>
<td>c. 700</td>
<td>c.240</td>
<td>635</td>
<td>basalt desert to east of Azraq</td>
<td>rocky rising ground overlooking wadis &amp; mudflats</td>
<td>Betts 1998 (p37-50)</td>
<td>Martin 1994; 1998; 1999</td>
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<td>77</td>
<td>785</td>
<td>limestone and flint hills in steppe/ desert transition zone</td>
<td>terrace adjacent to Wadi Jilat gorge; seasonally water filled</td>
<td>Garrard et al.1994b</td>
<td>Martin 1994; 1999</td>
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<td>MPPNB</td>
<td>Wadi Jilat 26 (WJ26)</td>
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<td>terrace adjacent to Wadi Jilat gorge; seasonally water filled</td>
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<td>Martin 1994; 1999</td>
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<td>Wadi Jilat 32 (WJ32)</td>
<td>2,000</td>
<td>5</td>
<td>810</td>
<td>limestone and flint hills in steppe/ desert transition zone</td>
<td>hillside above Wadi Jilat</td>
<td>Baird et al 1992</td>
<td>Martin 1994; 1999</td>
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<td>Late EpiPal</td>
<td>Khallat Anaza</td>
<td>2,000</td>
<td>12</td>
<td>c.1200</td>
<td>basalt region</td>
<td>lower slopes Jebel Druze; basalt out-crop above Wadi Rajil near winter plunge pools</td>
<td>Betts 1998</td>
<td>Martin 1994</td>
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<td>Azraq 18 (Az18)</td>
<td>1,400</td>
<td>6</td>
<td>508</td>
<td>central Azraq basin</td>
<td>close to major springs &amp; playa.</td>
<td>Garrard 1991; Garrard &amp; Byrd 2013</td>
<td>Martin 1994</td>
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<td>Mid-early Late EpiPal</td>
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<td>4</td>
<td>775</td>
<td>limestone and flint hills in steppe/ desert transition zone</td>
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<td>Martin 1994</td>
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<td>Mid &amp; early Late EpiPal</td>
<td>Wadi Jilat 22 (WJ22)</td>
<td>3,500</td>
<td>4</td>
<td>770</td>
<td>limestone and flint hills in steppe/ desert transition zone</td>
<td>terrace above Wadi Jilat gorge</td>
<td>Garrard &amp; Byrd 1992; Garrard &amp; Byrd 2013</td>
<td>Martin 1994; Martin, Edwards &amp; Garrard 2013</td>
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<td>Early-Mid EpiPal</td>
<td>Wadi Jilat 10 (WJ10)</td>
<td>c.450</td>
<td>8</td>
<td>805</td>
<td>limestone and flint hills in steppe/ desert transition zone</td>
<td>terrace above Wadi Jilat gorge</td>
<td>Garrard &amp; Byrd 2013</td>
<td>Martin 1994</td>
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<tr>
<td>Early EpiPal</td>
<td>Kharaneh IV (KHIV)</td>
<td>21,500</td>
<td>16</td>
<td>640</td>
<td>wide valley set between limestone, chalk and flint hills</td>
<td>lower terrace of Wadi al Kharaneh draining eastward to Azraq basin; double mound</td>
<td>Muheisen 1988; Muheisen &amp; Wada 1995; Maher et al. 2012</td>
<td>Martin, Edwards &amp; Garrard 2010</td>
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<tr>
<td>Early EpiPal</td>
<td>Ayn Qasiyya (AQ)</td>
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<td>77</td>
<td>c.500</td>
<td>central Azraq oasis</td>
<td>close to major springs</td>
<td>Richter et al 2009</td>
<td>Edwards (unpublished data)</td>
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<td>Late Up Pal-Initial EpiPal</td>
<td>Uwaynid 18 (UW18)</td>
<td>875</td>
<td>10</td>
<td>525</td>
<td>alluvial plain at margins of basalt outlier and limestone/marls</td>
<td>terrace close to ancient spring &amp; near to confluence of several wadis</td>
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<td>Martin 1994</td>
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<td>6,750</td>
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<td>810</td>
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<td>Azraq 17 (AZ17)</td>
<td>3,100</td>
<td>15</td>
<td>508</td>
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<td>island in marshland close to springs.</td>
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<td>Martin 1994</td>
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Table 1
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<th>Site/assemblage</th>
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<th>Chronotypology based on lithics</th>
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<td></td>
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<td>9.9-9.5</td>
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<td>WJ7 2</td>
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<td>KhAnz</td>
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<td>WJ22 Up</td>
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<td>WJ22 Mid</td>
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<td>WJ10 T2</td>
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<td>19.0-18.7</td>
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<td>KHIV B</td>
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<td>Dhw**</td>
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<td>KhAnz***</td>
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<td>AQ D^^</td>
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| Dhw   | 8,000| 0.7-7ky increased rainfall | Dhw: wild einkorn & barley; grasses; Chenopods e.g. Stipa and saltbush | AQ springs reestablished
| WJ7 5 | 9000 | Short warmer spells | WJ7: domestic einkorn; wild einkorn & barley; grasses; Pistacia lentis & other taxa | Warmer conditions:
| WJ26, WJ7 2-4 | 10,000 | Holocene | WJ26: increased precipitation and evaporation ratios | Med' area increased C3 plants
|  | 11,000 | | | WJ22 more arid enviro A218, WJ22
|  | 12,000 | Younger Dryas sea surface temperature drop c.15.2-11.4ky cold period | Level stabilises c.400mbsl | Levant chenopods & Artemisia high
|  | 13,000 | Balling Allerod | c.14ky warmest period | Increased precipitation and evaporation ratios
| A218 | 14,000 | Pre-Bolling warming | lake levels high | Med' area increased C3 plants
| WJ22 Up | 15,000 | | | WJ22 marshland disappears
| WJ22 Med | 16,000 | Heinrich 1 Event | c.19.14ky gradual temperature increase with short cooler period | Reduced water but marsh develops at AQ
|  | 17,000 | post LGM warming start | C.16.5kyr | Med' area increased C3 & increasing C4 plants
|  | 18,000 | | | Reduced lake levels at Azraq Dunes
| KHIV D | 19,000 | | | Abandonment mega-sites
| KHIV B | 20,000 | Late Glacial Maximum | | AQ 'cool marsh'
| A217 T1: WJ6Up/KHIVA | 21,000 | Late | coldest & driest conditions | AK6 upper level: steppe shrubs, sedge indicates nearby water
| AQ B | 22,000 | | | Increasing aridity at WJ8
| WJ6 Mid | 23,000 | Heinrich 2 Event | Extreme cooling | WJ6 palaeosol formation & UW18 marsh
| AQ A | 24,000 | | | Reduced water but marsh develops at AQ
| UW18 T2 Up; WJ6 Low | 25,000 | | | WU6 & UW18 some loess deposition
| WJ9 11/2 | 26,000 | Very cold dry | Lake Lisan & Kinneret merge | Med' area C3 and C4 plants mixed
| UW18 T2 Low | 27,000 | | | WU9 more arid & aeolian sedimentation
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Abbreviations: px = proximal; dist = distal; rad = radius; phal = phalanx; hum = humerus; scap = scapula.
Table 7.

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<th>equid fusion period</th>
<th>site</th>
<th>px ph1 &amp; ph2 &gt;c.15 months</th>
<th>hum dist/ rad px/ mp dist 15-18 months</th>
<th>pelv &amp; tib distal 18-24 months</th>
<th>hum px/rad d/ulna, femur, tib px/calc 36-42 months</th>
<th>equid NISP %</th>
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Abbreviations: px = proximal; ph1 = phalanx 1; ph2 = phalanx 2; dist (d) = distal; hum = humerus; rad = radius; mp = metapodial; pelv = pelvis; tib = tibia; cal = calcaneum
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<th>Escape speed</th>
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<td>Hare/Fox</td>
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<tr>
<td>Tortoise</td>
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<tr>
<td>Gazelle</td>
<td>15-25</td>
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<td>Boar/Ostrich</td>
<td>60-200/70-145</td>
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<tr>
<td>Equid</td>
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<td>Cattle</td>
<td>700-900</td>
<td>fast</td>
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</tbody>
</table>
Figure

Click here to download Figure: Fig 4 with regression lines.pdf
Figure 5 (a, top; b, bottom)
Figure 7

- hare, fox, canid, bird AZ
- hare, bird W Gal
- tortoise, hedgehog AZ
- tortoise W Gal

NISP relative abundance index

init

Early EpiPal

Mid EpiPal

Late EpiPal

Latest EpiPal

LATE NATUFIAN
Figure 9

% NISP

Tortoise
Partridge/Birds
Hare
Gazelle/Roe deer/Goat
Fallow deer/Other
Cattle/Red deer/Equid

Figure 9 (Click here to download Figure: Fig 9.docx)

Early Epipal 18.5kya
Mid Epipal 17kya
Late Epipal 14.5kya
Late Epipal 13kya