HUNTING AND HERDING IN A SEMI-ARID REGION

AN ARCHAEOZOOLOGICAL AND ETHOLOGICAL ANALYSIS OF THE FAUNAL REMAINS FROM THE EPIPALAEOLITHIC AND NEOLITHIC OF THE EASTERN JORDANIAN STEPPE

Volume one

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SUMMARY

Hunting and herding in a semi-arid region: an archaeozoological and ethological analysis of the faunal remains from the Epipalaeolithic and Neolithic of the eastern Jordanian steppe

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This thesis focuses on the faunal remains from a sequence of 11 Epipalaeolithic and ten Neolithic sites in the eastern Jordanian steppe, with the aim of investigating the subsistence practices of hunters and herders between 20,000bp and 7,500bp, and their temporal and geographic variability within the study region.

The first section outlines the archaeological and palaeoenvironmental background of the southern Levant; reviews subsistence evidence and models for the periods concerned; and describes the study area and sites.

The second section concerns methodological approaches. A model of gazelle ethology for prehistoric eastern Jordan is presented, since this taxon is dominant in many of the study assemblages. Eleven modern case studies are used to predict population structure, demography and mobility, drawing on the principles of behavioural ecology. The archaeozoological methodologies used in the thesis are explained.

The third section presents the results of the analyses. Taxonomic identification, quantification and faunal diversity are described and discussed for each assemblage, and broad temporal and geographical trends highlighted.

Whether the assemblage compositions reflect the environmental changes discussed earlier is considered. It is demonstrated that the size diminution observed in both gazelle and hare between the late Pleistocene and early Holocene is probably attributable to climatic change. The question of selectivity in the taxa killed by prehistoric hunters is investigated. This is approached through ecological modelling and it is concluded that no strong selective biasses are observed. The nature of gazelle hunting is then further explored; the age profiles and sex ratios of the animal culls are compared to the model of gazelle social composition, and seasonal hunting times are proposed. The results suggest that none of the Epipalaeolithic assemblages shows signs of selective culling. Two Neolithic assemblages contain high proportions of juveniles, and interpretations relating to herd management practices, intensive hunting, and the targetting of vulnerable animals are discussed.

The treatment of carcasses of the hunted animals is investigated. Body part representation, butchery and processing evidence, and taphonomic factors are considered, in order to present a picture of the activities undertaken at each site.

The appearance of domestic caprines in eastern Jordan is considered. An assessment is made of their wild/domestic status, the management of herds and of carcass treatment.

The results of the faunal remains analysed are integrated with other forms of archaeological evidence to discuss issues of mobility, contact and exchange, and to consider the changing and varied use of this area in prehistory.

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CONTENTS

VOLUME ONE

VOLUME TWO

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

This study focuses on the faunal remains from a series of late Pleistocene and early Holocene sites on the Jordanian Plateau, in order to address certain issues concerning subsistence practices and other human activities. The sites date from c. 20,000bp to c. 7,000bp, and are Epipalaeolithic and Neolithic in character. The study area and sites are described in Chapter 3; the area is henceforth termed eastern Jordan.

Eastern Jordan is today considered climatically and vegetationally arid, or semi-arid, relative to the better-watered regions of the Near East to the west and north-west. Archaeological investigation of arid Levantine regions is a relatively recent phenomenon; prior to the last two decades, most survey and excavation work was done in the more fertile areas. Extensive research has now taken place in the Negev and Sinai Deserts and on the Syrian Plateau, as well as in the eastern Jordanian study area, which redresses the imbalance somewhat. It is notable, however, that in neither of these other areas are there very complete sequences of occupation through the late Pleistocene/early Holocene. Also, in terms of subsistence studies, the Negev and Sinai have suffered from poor preservation of organics, particularly in the Epipalaeolithic. The importance of the present study, therefore, is that the eastern Jordanian sites cover a long time sequence, several different areas have been investigated, and sites have relatively good preservation of animal bone. The data are germane for both inter- and intra-regional comparisons.

My approach to the data has deliberately been to work from the bones outwards, and to explore variability rather than 'change' as far as possible, and this is for two main reasons. Firstly, although there is a relatively good chronological sequence of sites in some parts of the study area, the record is nevertheless discontinuous: the faunal assemblages serve rather as 'samples' of different time periods and potentially different kinds of occupation, and any linking process should not be assumed (although there **is** more evidence for continuity in the Neolithic record). Secondly, a tendency in work on Near Eastern prehistoric subsistence has been to create overarching models for explaining an 'outcome' (e.g. the origins of agriculture, or the appearance of domesticated animals). My interest is in explaining variation within and between regions and time periods, rather than in creating an all-encompassing explanation of the process. The data are examined in relation to proposed models at the end of this work, but an independent analysis is attempted in the main body of the thesis.

Chapter 1 describes the different topographic, climatic and vegetational areas of the southern Levant, outlines the archaeological chronologies and reviews palaeoenvironmental data, firstly to provide a setting for the study area, and secondly because these neighbouring Levantine areas serve as the closest comparisons for eastern Jordan.

In Chapter 2, I review subsistence data from all southern Levantine areas, focusing on the animal bone evidence; interpretations are critically discussed. Three broad themes tend to dominate (animal-related) subsistence studies. Firstly, most overviews of pre-agricultural periods suggest that there is some form of 'intensification' or increased 'specialization' of both animal and plant use through the late Pleistocene, particularly in the late Epipaleolithic (Henry 1989). Secondly, much research has been directed at establishing the timing of, and proposing explanations for, the appearance of domesticated animals in the region. Thirdly, there is interest in the beginnings of pastoral economies.

I have drawn heavily on archaeozoological work in the Levant, and on these themes, in developing the issues to be independently explored in the eastern Jordan study area. These issues are seen as means of exploring the animal bone variability which is described in Chapter 6.

The division between 'hunting' and 'herding' has been maintained for convenience of discussion, **not** because these are viewed either as necessarily accurate terms, discrete activities or the only alternatives (cf. Higgs and Jarman 1972; Ingold 1980). That caprines were herded in the area in the Neolithic is strongly suggested by their sudden appearance in an area where they were previously virtually absent. Hunting, however, is not assumed to have a simple meaning, and part of this project aims to define the forms of relationship likely to have existed between 'hunters' and morphologically wild animals (i.e. gazelles).

Nevertheless, it was deemed justifiable to separate 'hunting' questions (Chapter 7 and 8) from 'herding' questions (Chapter 9) since different issues are addressed in each, not because they are seen as unproblematic categories. The specific areas of interest are as follows:

Hunting

i) Do the faunal assemblages reflect environmental change? The nature of late Pleistocene/early Holocene environmental changes in the Levant is fairly well accepted; the palaeoenvironmental data for the region in general, and the study area specifically, are discussed in Chapters 1 and 3 respectively. Chapter 7.1 then addresses the question of whether these changes are visible in the faunal assemblages. Many Near Eastern mammals have been argued to show temperature-related size change (Davis 1981), and metrical analyses are used to explore this in the study assemblages. Other means of approaching the question are more problematic: small mammals are potentially intrusive; most of the larger mammals seen in assemblages have a fairly broad range of habitats and tolerances and few bones are identifiable to **species** as opposed to **genus**.

ii) Do hunters show selectivity in taxa? Early post-glacial hunters in the Levant are often assumed to have been opportunistic foragers, with faunal assemblages and their relative distributions of taxa viewed as direct reflections of the animals living around sites (Davis 1982; Bar-Yosef and Belfer-Cohen 1989). For the later postglacial period (Natufian c. 12,500-10,000bp), many interpret faunal assemblages to show selective hunting, particularly towards gazelle, since this taxon dominates samples from a range of environments (Henry 1975; Garrard 1982; Cope 1991; Tchernov 1993). Environmental reconstructions and expectations are required to explore this idea, and these are given in Chapter 3 and Chapter 7.2, and discussed in the latter.

iii) Is gazelle hunting specialized? The various interpretations of gazelle dominated assemblages are discussed in Chapter 2. A divide exists between those who believe that this animal was hunted randomly (Davis 1983) and those who identify biases in culls towards particular age or sex groups, which they believe to diverge from those **expected** in herds (Legge 1972; Saxon 1974; Cope 1991). The latter have led to arguments for management practices such as loose herding with selective cropping being in operation, particularly in the late Epipalaeolithic. Alternative explanations for 'specialized' gazelle hunting involve ideas of mass-kills and animal drives (Legge and Rowley-Conwy 1987; Campana and Crabtree 1991). Chapter 7.3 examines the gazelle cull patterns from the study assemblages for signs of either selective or non-selective hunting, or for evidence for particular hunting techniques.

iv) What kind of activities are witnessed at sites? Chapter 8 presents skeletal part representation, butchery marks and processing evidence for the hunted taxa. These data allow interpretation both of the activities taking place at sites and of the nature of the site in general (e.g. kill-site, butchery location, multiple activity site).

Herding

i) When do herded animals - in this case sheep and goats - first appear in eastern Jordan? Zoogeographic arguments strongly suggest that eastern Jordan is not an area where caprine domestication took place (Garrard *et al.* 1988; 1993; 1994; Baird *et al.* 1992). Rather, it appears that sheep and goats were introduced to the area and therefore presumably herded. Chapter 9.1 aims to document the presence of sheep and goats in the study area.

ii) Do the caprine remains belong to morphologically domesticated or wild populations? In the absence of morphological criteria, metrical analyses are used to explore this issue in Chapter 9.2.

iii) How were caprines managed in eastern Jordan? From the few assemblages where data are sufficient, cull patterns are examined in order to infer management practices (Chapter

9.3). The issue of **how** caprines were being kept feeds into the question of why and how they may have been originally introduced.

iv) Caprine carcass treatment. The skeletal element representation for sheep and goats is presented in Chapter 9.4.

Chapter 9 broaches the question of how and why caprines may have been introduced to the eastern Jordanian steppe. The suggestion that hunter-gatherer groups integrated domesticated animals into their economies and activities (Byrd 1992) is considered in relation to both faunal patterns over time and the evidence of material culture.

The animal bone assemblages used to address these issues derive from excavations as part of the Azraq Basin Project (directed by Andrew Garrard) and the Black Desert Survey (directed by Alison Betts), with material from Kharaneh 4 (excavated by Mujahed Muheisen) also. These projects have produced a total of 39 faunal assemblages, which do not equate to the number of sites excavated, since a site may yield more than one chronologically/typologically distinct 'assemblage'.

Two main limitations were encountered in the use of these faunal assemblages: firstly, sample sizes are sometimes small, precluding any detailed analysis; secondly, the high degree of bone and particularly tooth fragmentation is obstructive, in that age and sex assessment are difficult, and measurements permitted are few.

The approach used in this project has been to follow standard archaeozoological methodologies, in terms of identification, quantification, and age and sex determination (Chapter 5).

A major interpretative tool used has been to apply details of the ecology and ethology of the commonly occurring taxa, since any understanding of taxonomic representation, relative abundances of taxa, and age and sex patterns relies heavily on knowledge of animal behaviour (e.g. Simmonds and Ilany 1977; Clutton-Brock 1978; Garrard 1984; Legge and Rowley-Conwy 1987). For most animals, this information derives from extant literature; for the gazelle, however, predictions of behaviour pattens for gazelle in prehistoric eastern Jordan were modelled using the principles of behavioural ecology (Chapter 4).

Throughout this study, although prime concern lies with the faunal remains, an attempt has been made to integrate results with other specialist studies in order to produce more contextualised interpretations. This is particularly relevant in exploring issues such as mobility, contact and group activities. Full integration of data however, for example with archaeobotanical results (Colledge pers. comm.), is a future project.

CONVENTIONS

Dates

All dates referred to are radiocarbon years **bp** (before present).

Periods

In discussion, the oldest site/period is always referred to first, the youngest last. In tables, the oldest site/period is always at the bottom, the youngest at the top.

Neolithic	NEO
late Late Neolithic	LLN
early Late Neolithic	ELN
Late Neolithic	LN
Pre-pottery Neolithic C	PPNC
Pre-pottery Neolithic B	PPNB
Pre-pottery Neolithic A	PPNA
Pre-pottery Neolithic	PPN
Epipalaeolithic	EPAL
late Epipalaeolithic	L EPAL
middle Epipalaeolithic	M EPAL
early Epipalaeolithic	E EPAL
late Upper Palaeolithic	L UPAL
Upper Palaeolithic	U PAL

Study area codes

Wadi el-Jilat	WJ
Kharaneh	KH
Azraq	AZ
Wadi el-Uwaynid	UW

Study site codes

When a study area code is followed by a number **without** a gap, this refers to a site (e.g. WJ32 is site 32 in the Wadi el-Jilat).

When a study site code is followed by a number/letter **with** a gap, this refers to a phase of a site (e.g. WJ22 B is phase B of site WJ22; WJ7 3 is phase 3 of site WJ7; DH 2 is phase 2 of DH).

WJ sites/phases (assemblages):

WJ7 1, WJ7 2, WJ7 3, WJ7 4, WJ7 5, WJ8, WJ9, WJ10, WJ13 1, WJ13 2, WJ13 3, WJ22 B, WJ22 C, WJ22 E, WJ25, WJ26, WJ32

KH sites/phases (assemblages):

KH4 A, KH4 B, KH4 C, KH4 D

AZ sites/phases (assemblages):

AZ17, AZ18, AZ31

UW sites:

UW14, UW18

Black Desert sites:

Khallat Anaza, DH 1, DH 2, Ibn el-Ghazzi, Jebel Naja, B27 1, B27 2, B27 3

Levant area codes

EU	Euphrates region
DB	Damascus Basin
JV	Jordan Valley
CP	Central Palestine (including Galilee)
PC	Palestine Coast
MC	Mount Carmel
JH	Jordan Highlands
EJ	Eastern Jordan
SJ	Southern Jordan
N	Negev
S	Sinai

Other

above sea level	asl
below sea level	bsl

NISP	number of identified specimens
MNE	minimum number of ends

CHAPTER ONE

THE ENVIRONMENTAL SETTING AND ARCHAEOLOGICAL BACKGROUND

This chapter aims to provide a setting into which the study area - eastern Jordan - can be placed, both in terms of modern and palaeo-environments and archaeological sequences; subsistence practices are reviewed in Chapter 2. The period of interest in this project is that from 20,000bp to 7,500bp.

Firstly, the physiographic regions of the Levant are described, with their present climates and vegetation; next, palaeoclimatic and palaeoenvironmental reconstructions for late Pleistocene/early Holocene are reviewed; lastly, issues of subsistence are considered.

The Levant, as a bridge between Africa, Asia and Europe, encompasses a variety of landscapes and is a complex mosaic of environmental settings. Levantine landforms are a result of tectonics and volcanism. A metamorphic Pre-Cambrian 'basement' underlies the ubiquitous Cretaceous limestones, which together with Nubian sandstones, are the parent rocks for most soils (Bender 1974). The highlands were formed largely in the Miocene and the Basalt Desert was produced by volcanic eruptions in the Miocene-Pleistocene. These landforms give rise to the six topographic regions described below (figure 1.0). In general, the major features tend to be longitudinal belts paralleling the Mediterranean coast (Zohary 1973):

The coastal plain is low land bordering the Mediterranean, stretching from the foot of the Lebanon mountains in the north, where it is fairly narrow, to the northern Sinai in the south. Soils are light, and fertile alluvial ground predominates.

The hill and mountain range consists of limestone forms, stretching from Lebanon and merging into the Sinai plateau. Average altitude is 600m asl with peaks at 1,200m. The western face tends to gently slope and support a Mediterranean vegetation, while the eastern escarpments facing the Jordan Valley are mainly steppic or desertic.

The Negev and Sinai. The Negev plateau, south of the highlands, is an almost unsown desert. The Sinai peninsula is a plateau tilting upwards towards the south, giving rise to high mountains (Gebel Katherina 2,640m asl), with deep ravines. The northern part is mainly limestone with *reg* and *hammada* dominating.[1]

The Jordan-Arava rift valley is a low depression reaching 396m bsl at the Dead Sea Basin, and is part of the great African Rift.

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[1] *Reg* describes a desert region with exposed pebble surface; *hammada* exposed bedrock.

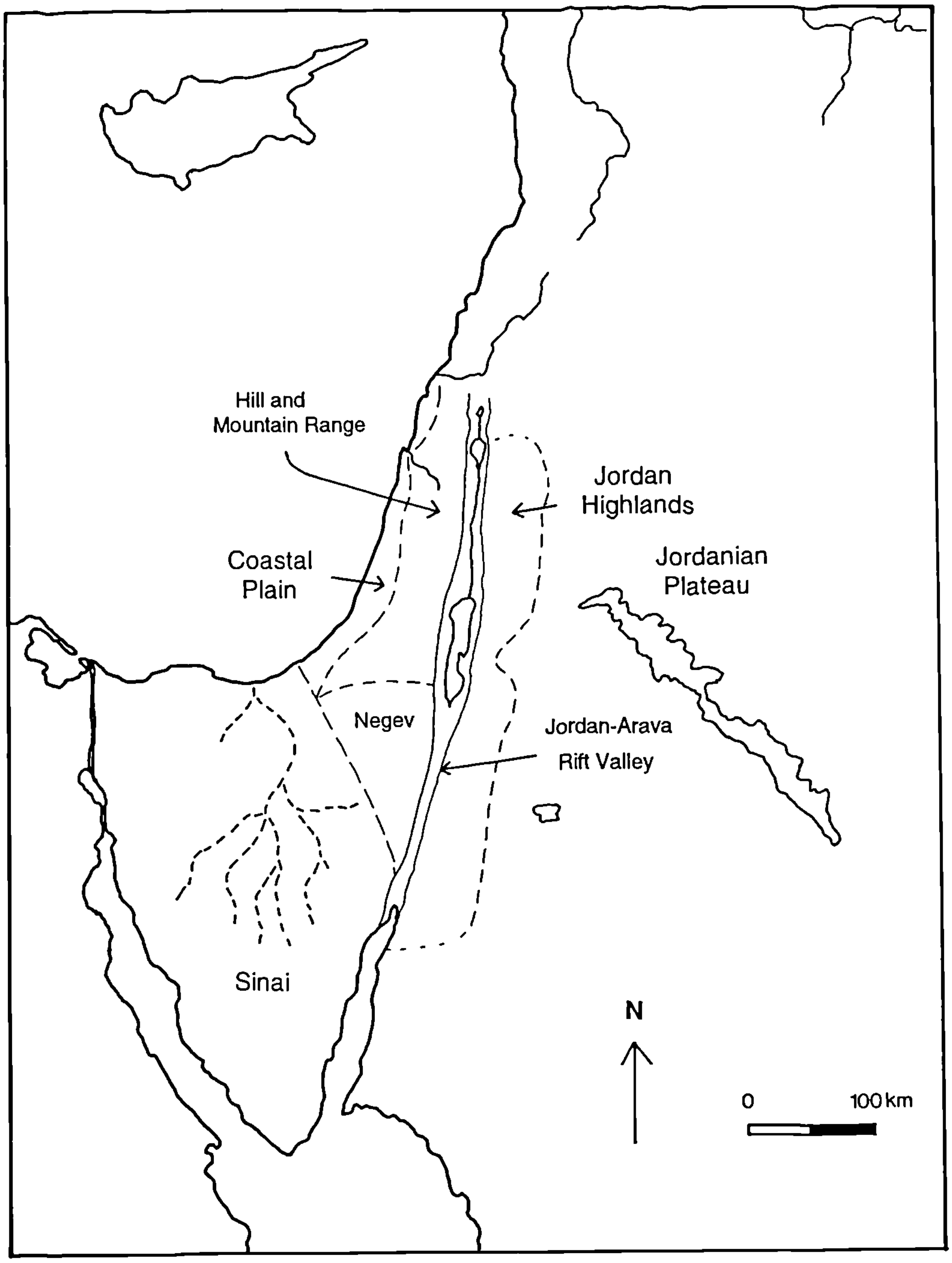


Figure 1.0. The major topographic regions of the southern Levant.

The Jordan highlands are formed mainly of limestone, with granite rocks and sandstones, and reach heights of 1,720m asl in the south. The western escarpments have a Mediterranean climate and vegetation.

The Jordanian plateau: the eastern deserts. To the east of the Jordan highlands is a calcareous *hammada*, forming the limestone steppe/desert. The Syrian desert to the east of this is lava sheet, with basalt boulders and dead volcano cones, also referred to as the *harra*. The eastern deserts, both the *hammada* and *harra*, are the geographical focus of the present project.

The present environment - climate and vegetation

Factors affecting the climate are partly global, partly regional, and partly related to the local topography. The Levant experiences a seasonal climate, with winter rainfall predominant, although part of the area may not see rain for one or several consecutive years. In general, annual precipitation decreases from north to south, and from west to east, with the obvious disturbance of the Jordan rift valley (figure 1.1).

Vegetation is limited by moisture, whilst temperature, air humidity, soil qualities and rainfall influence phytogeographic distribution. The southern Levant has great diversity in plant life, resulting from its position at the meeting place of four plant-geographical regions: the Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian. Delineation of these regions has been through assessment of areas of similar vegetal diversity which have the same dominants (see Zohary 1973). The four different elements are often found intermingled with each other (figure 1.2):

1) **Mediterranean** environment is characterised by short, mild, wet winters, with dry, moderately hot summers. Rainfall ranges between 350mm-1000mm/year, with a more regular distribution than other variants. The climate allows for year round plant growth, and the vegetation is strongly influenced by adjacent Irano-Turanian areas; for example, in Palestine and Jordan Mediterranean vegetation is being gradually impoverished at the expense of steppe and desert plants. Characteristic Mediterranean vegetation is evergreen forest and maquis which only thrive, however, in areas receiving 400mm rainfall/year or more. Lowland and upland areas have quite distinct variants.

Generally, the Tabor oak (*Quercus ithaburensis*) dominates the well watered lowland areas below 300m, for example on parts of the coastal plain and interior valleys. The drier lowlands see carob trees (*Ceratonia siliqua*) dominant, and areas receiving less than 400mm

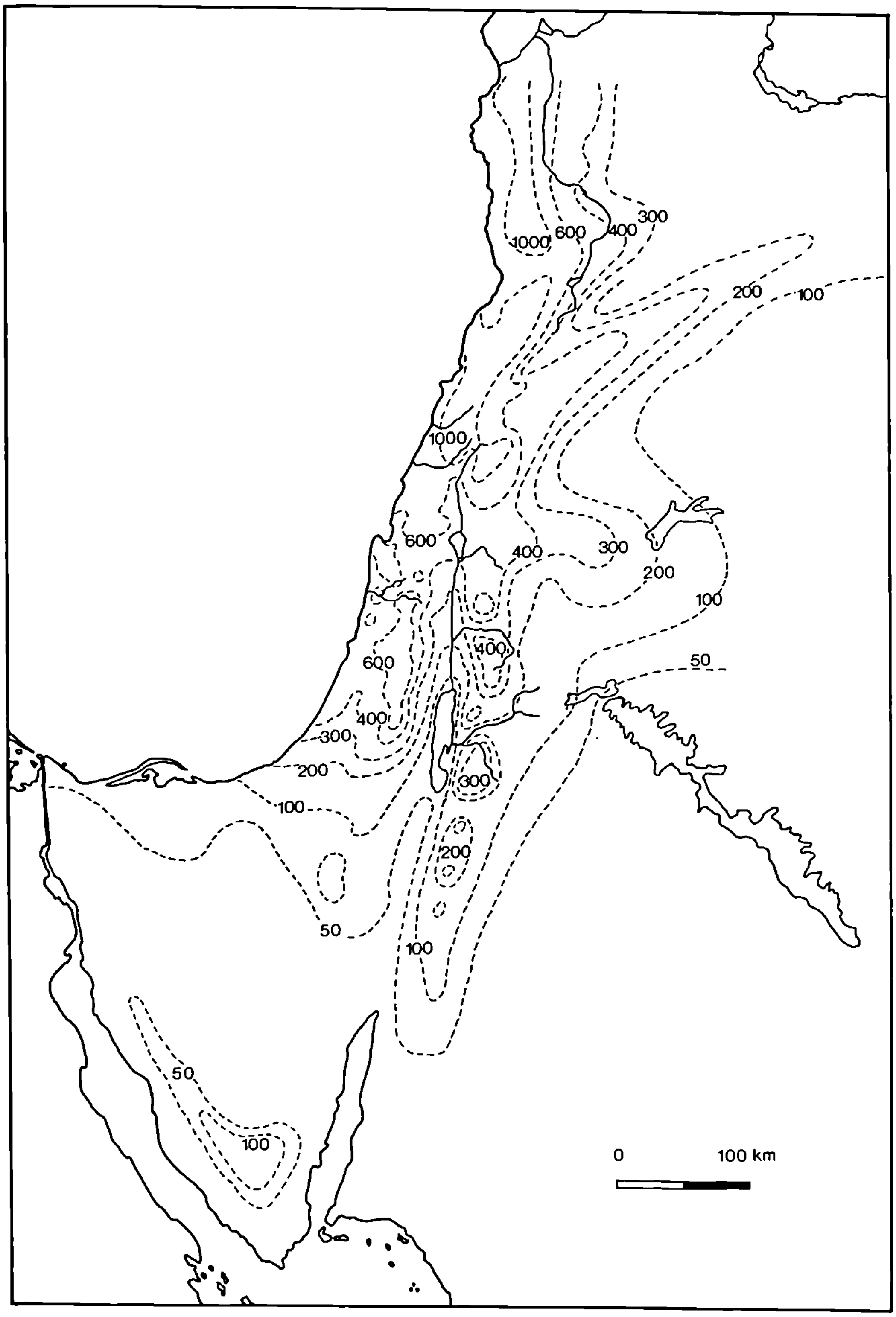


Figure 1.1. Rainfall (mm) map for the southern Levant.

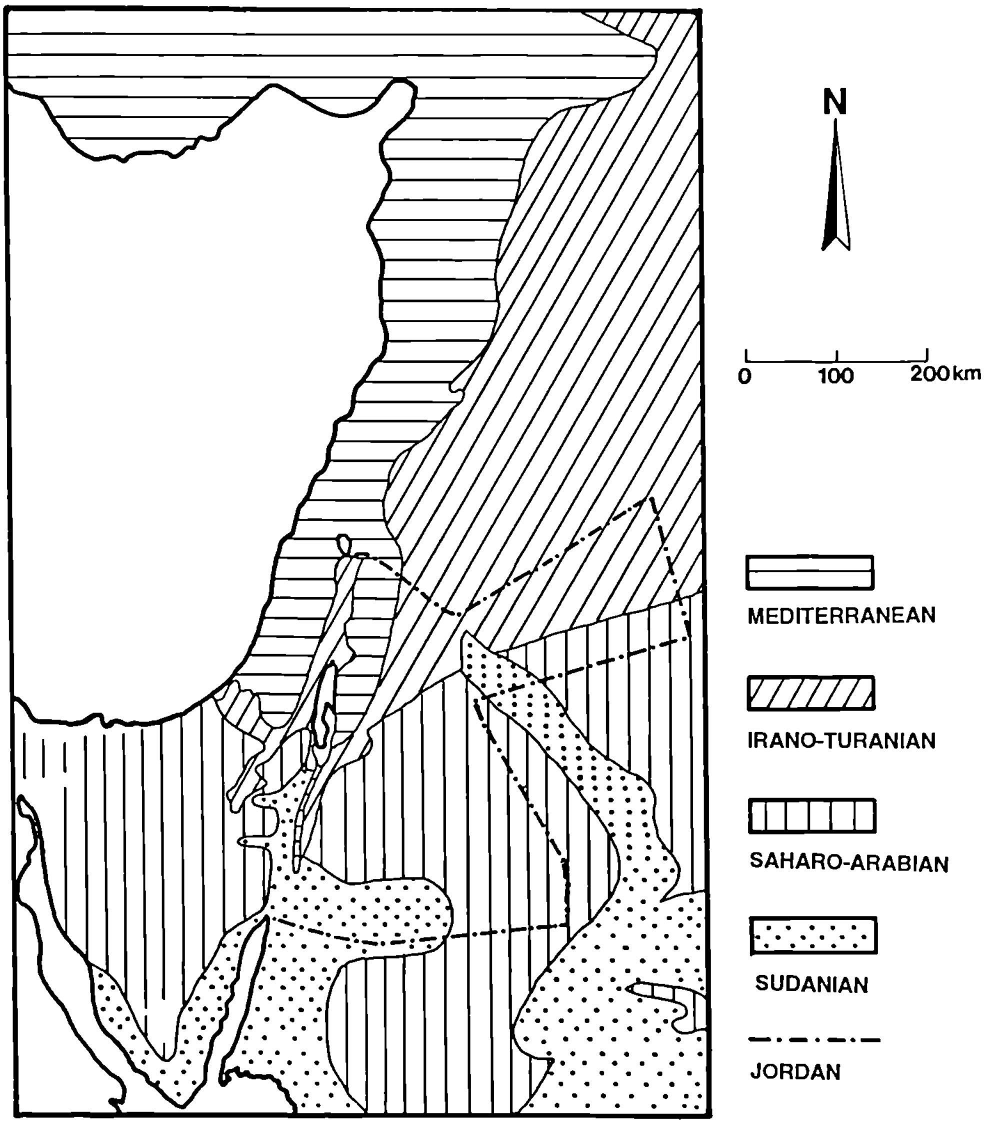


Figure 1.2. The four main vegetation zones of the southern Levant: Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian (adapted from M. Zohary 1973). The dotted line defines Jordan.

rainfall/year support evergreen shrub and dwarf shrub vegetation (such as *Ziziphus spina-christi*) and grasses.

Above 300m in the uplands, the evergreen Palestinian oak (*Quercus calliprinos*) is found in associations with Palestinian terebinth (*Pistacia palaestina*), juniper (*Juniperus phoenicea*), Aleppo pine (*Pinus halepensis*), laurel (*Laurus nobilis*), Judas tree (*Cercis siliquastrum*), Syrian maple (*Acer syriacum*) and cedar (*Cedrus libani*). The Atlantic terebinth (*Pistacia atlantica*) is often found in zones into which Irano-Turanian vegetation is irradiating.

2) The **Irano-Turanian** environment sees between 200mm and 350mm rainfall/year, experiences less mild winters than the Mediterranean zone, and drier hotter summers. This climatic zone embraces the eastern Jordanian deserts, the eastern side of the Palestine highlands, the southern Jordanian highlands and the northern Negev. Vegetation sees two periods of arrested growth annually due to temperature extremes.

The most characteristic plant of this steppic zone is sagebrush (*Artemisia herba-alba*), with associated communities of other low brush or dwarf shrubs. Exposed ground surface is common, except where the steppe meets Mediterranean vegetation, where grasses and herbs are dense. The most commonly-found tree in the Irano-Turanian zone is the Atlantic terebinth (*Pistacia atlantica*), but this only survives at higher, wetter altitudes.

3) The **Saharo-Arabian** environment receives less than 100mm rainfall/year, and often as little as 25mm-50mm. Although a seasonal climate prevails, the winters are mild and short, and summers long and dry with high temperatures. Rains are sporadic and torrential with irregular distributions. Transpiro-evaporation rates are extremely high, making this a marginal area regarding plant life.

The presence of *hammadas* leads to a sparse distribution and low diversity of vegetation. *Wadi* beds, however, can see a denser and more diverse flora with low shrubs and some desert-adapted trees such as thorny acacias. The most characteristic plants are low shrubs, e.g. the bean caper (*Zygophyllum dumosi*) and *Anabasis articulata*. The southern Negev and the southern part of the Jordanian highlands fall into the Saharo-Arabian zone.

4) The **Sudanian** variant is dependent on a tropical climate, with warm winters and very hot summers. Temperature is decisive for this vegetation; plant moisture requirements are often met by underground water rather than rainfall. Rainfall is the same as in the Saharan zone.

The southern part of the Jordan rift valley harbours a series of Sudanian and other Afro-Asian tropical plants, found at altitudes between 400m bsl and just above sea level, indicating a remnant Pliocene vegetation (e.g. *Hammada salicornica*). This area and the coastal plain, which also has a Sudanian element, support characteristic acacias (*Acacia albida*) and other shrubs (e.g. *Ziziphus spina-christi*).

Palaeoenvironmental reconstructions

The data which form the basis for palaeoclimatic and palaeovegetational reconstructions derive from disparate sources and Wright (1992) identifies the following problems with their use:

> 1. Distinguishing regional from local events.
> 2. Distinguishing local or regional events from **climatic** events.
> 3. Comparing diverse kinds of data.
> 4. Chronological 'resolution': dating events within relatively brief time spans.
> 5. Correlating local sequences from diverse and widely separated places.
> 6. Distinguishing natural from cultural effects (especially with respect to faunal, macrobotanical and pollen samples).
> 7. Distinguishing effects of particular climatic variables from each other (e.g. temperature vs. precipitation).
> 8. Accounting for short-term fluctuations otherwise uncharacteristic of the period under observation.
> 9. Comparing periods of different length.
> 10. Necessity of assuming certain constants in interpreting data (e.g. assuming constant rates of sedimentation in pollen accumulation on lakeshores).
> 11. Controlling for the possibility that ancient climates or environments may have no modern parallels and thus may have left 'signatures' which cannot be interpreted correctly.
>
> (Wright 1992:6)

A further problem is the use of value-laden terms such as 'amelioration' and 'deterioration', and relative terms such as 'humidity' and 'aridity'.

Pollen cores

A general scarcity of pollen-bearing sediments has been noted for the Near East (Van Zeist and Bottema 1982). Only two areas have produced pollen-rich lake bottom deposits: the Ghab in north-west Syria and the Huleh Basin in northern Palestine.

The Ghab I sequence (Niklewski and van Zeist 1970) which covers the late Pleistocene/early Holocene, shows arboreal pollen (AP) as high as 50% between 25,000bp and 20,000bp. A fluctuation (20-45%) in AP follows until 14,000bp, with *Artemisia* and Chenopodiaceae also in high proportions. An extreme decline in AP (10%) is observed between 14,000bp and 11,000bp, after which AP rises again with *Quercus*, *Pistacia*, *Olea* and *Ostrya/Carpinus orientalis* dominant. Baruch and Bottema (1991) interpret the diagram as showing steppe-desert vegetation dominant in the Pleniglacial, reflecting cold and dry conditions, but with significant tree growth. They see the Late Glacial forest contraction (14,000-11,000bp) as resulting from high evaporation and temperature depression. The subsequent re-growth of trees after 11,000bp reflects an increase in humidity, and also in temperature and precipitation, and they note the greatest expansion of forest from 10,000bp to 8,000bp.

The Huleh Basin sequence (based on Tsukudas diagram only) has been described by Van Zeist and Bottema (1982). Before 24,000bp open forest is seen in northern Palestine. From 24,000bp to 14,000bp steppe-forest vegetation is dominant, confirming that cold, dry conditions were similar to those in the Ghab. After 14,000bp, however, the Huleh diagram shows an expansion of the oak forest, reaching a peak at c. 10,000bp.

From 14,000-10,000bp, it appears that northwest Syria and northern Palestine show almost opposite trends; also, between 10,000bp and 8,000bp the former experiences rich forests and the latter more open vegetation. Van Zeist and Bottema explain this as resulting from differences in precipitation and therefore humidity between the areas, although temperatures rise and fall at roughly the same time since they reflect the world-wide trends (i.e. temperature increase during the European Allerod from c. 12,000bp to c. 11,000bp and temperature decrease after this during the younger Dryas) (Van Zeist and Bottema 1982).

A new pollen diagram from Huleh has recently been described by Baruch and Bottema (1991) which, in places, conflicts with the earlier Huleh core described above. This new diagram is arguably more reliable since it is based on a single 16m core which is well dated, rather than shorter joined cores. Baruch and Bottema see an expansion of forest starting at c. 15,000bp, which accelerates after 13,000bp to reach a maximum extent of forest at c. 11,500bp. They interpret this as being the product of increasing humidity, presumably because global temperatures are assumed to rise through the Late Glacial period. In contrast to the earlier diagram, forests are seen to contract between 11,500bp and 10,000bp, from which they interpret a climatic deterioration with decreased temperature. Unlike any of the other pollen diagrams, the new Huleh core shows harsh conditions immediately preceding the Holocene. In the early Holocene (10,000-9,000bp), Baruch and Bottema see re-expansion of forests, implying an increase in precipitation, assuming higher global temperatures.

Many (e.g. Bar-Yosef and Valla 1991:2-3) see the recent Huleh pollen core as giving a picture more consistent with world-wide climate models, such as that produced by COHMAP (1988). This model predicts firstly that the effects of decreased temperatures during the Younger Dryas (11,500-10,000bp) were global, and secondly, that the early Holocene was relatively wet, if changes in the orientation of the earth are viewed alongside atmospheric circulation patterns. Since the recent Huleh core appears to have more accord with the emerging combined data sources, is more reliable in nature than the others from the Levant, and is probably more applicable to a **southern** Levantine study, this diagram will be the one drawn upon most heavily in this thesis for palaeoenvironmental modelling.

Pollen samples from sites

Pollen samples from terrestrial sediments are highly subject to interpretational problems, including questions of how pollen arrived on sites, and their relationship to human action. Combined studies from late glacial deposits in Palestine and Jordan, however, support an argument for aridity up until c. 13,000bp with forest increasing at c. 12,000bp, after which arid-adapted chenopods increase (Leroi-Gourhan 1982, Leroi-Gourhan and Darmon 1991). Site pollen samples from the lower Jordan Valley, (Salibiya I, IX, XII and Fazael IV and VIII, see Darmon 1984 and Darmon 1987), also indicate moist conditions at about 12,000bp, followed by a progressive drying out which peaks around 10,000bp.

Deep-sea cores

Pollen cores from the Mediterranean, Red Sea and Persian Gulf basins all show an increase in the freshwater input at c. 8,000bp and significant temperature rise from the peak of the last glaciation to the present. Luz (1982) advises great caution in using these studies for regional environmental reconstruction because deep-sea cores also reflect global climatic events. The above-mentioned increase in freshwater, for example, could be interpreted either as an increase in rainfall, or as the result of glacial melt-water.

Lake levels

Roberts (1982) uses the combined data from all Near Eastern lake basins to monitor the surface water balance and hence the climate. From 22,000bp to 19,000bp he notes high lake levels, which contradicts all other palaeoenvironmental evidence. Between 15,000bp and 11,000bp lake levels are low, explained by a cold and arid climate, which also contradicts the picture presented by Baruch and Bottema's Huleh pollen diagram (1991). The Holocene desiccation is reflected in low lake levels in the southern Levant between 9,000bp and 6,000bp.

Geomorphological studies

Goldberg's geomorphological studies in the Negev (1976), Sinai (1977) and Jordan Valley (Bar Yosef et al. 1974) form the basis of his overview of a climatic reconstruction from 20,000bp to 9,000bp (Goldberg 1981, table 1). He sees three climatic phases:

1) 20,000-16,000bp: a 'dry' interval
2) 16,000-12,000bp: a 'moist' interval
3) 12,000-10,000bp: a 'drier' interval

Slightly wetter conditions are also noted from 10,000-9,000bp. The reconstruction is based mainly on the nature of the sediments within which dated sites are found. The earlier sites (Kebaran and Geometric Kebaran/Mushabian) are from the Sinai and Negev, however, and later localities (13,000-10,000bp) are principally in the lower Jordan Valley; as Henry points out (1989:76), it is sometimes unclear whether observations reflect localised events (including human action) or more widespread developments.

Archaeobotanical remains

Moore and Hillman have attempted to use macroscopic plant remains as an indicator of vegetational and environmental change (Moore and Hillman 1982). Charred seeds and fruits, recovered by flotation from Tell Abu Hureyra in northern Syria, show changes over the period 11,500bp to 10,000bp., which the authors interpret as a reflection of the cooling impact of the Younger Dryas.

Botanical samples from the earliest deposits at Abu Hureyra (11,500-11,000bp) show exploitation of flora from steppic and forest-steppe environments, as well as from the Euphrates flood plain. Changes are noted in the subsequent period (11,000-10,400bp), when some plants from forests or forest fringes are no longer represented, and representation of wild cereals and grasses in samples increase. The suggestion is that aridification prevented fruit formation on trees in forest fringes, the areas nearest the site. The decline of herbaceous plants from the forest fringes is marked in the period from 10,400-10,000bp, and a reduction in the use of wadi bottom plants (needing floodwaters?) is also noted.

The argument presented seems inherently flawed by the underlying assumption that variation in the plants represented at the site reflects their varying availability, rather than differences in human selection.

> We argue that the most economical explanation of such a series of shifts in the pattern of plant collecting is an alteration in the composition of plant communities in the Abu Hureyra catchment brought about by climatic change.
>
> (Moore and Hillman 1992:488)

As with pollen samples from archaeological deposits, and faunal assemblages, insurmountable problems exist in using macroscopic plant remains as an environmental indicator. The presence of species can indicate a particular vegetation (but not necessarily a local one), but an absence of species represented cannot be used to infer their unavailability in the environment.

Fauna

Fauna is particularly difficult to use to gauge environmental change because animal life does not have an immediate reaction to it; populations vary in their flexibility and adaptability and extinctions only take place under conditions of swift and extreme climatic change (Tchernov 1982). In addition, many of the non-rodent faunal remains retrieved from sites are likely to be the result of human selection. Archaeozoological samples have, however, been taken to reflect the environment in the following ways:

Faunal turnover: Tchernov (1982) notes that only two species of medium-sized ungulate became extinct at the end of the glacial - the steppe rhinoceros (*Rhinoceros hemitoechus*) during the Kebaran, and *Equus hydruntinus* in the Neolithic, with other similar sized species (e.g. deer and large carnivores) being eliminated much later during historical times. "Most of the ungulates and the larger carnivores withstood the swift climatic deterioration of the postglacial period" (Tchernov 1982:110), indicating that species diversity alone is too general a gauge for the climatic fluctuations under examination.

Intra-specific size changes: according to Bergmann's Rule, races from cooler climates tend to be larger (in species of 'warm blooded' vertebrates) than races of the same species living in warmer climates. Consequently, it is possible to infer palaeotemperatures of a certain region and period through animal (bone) size, bearing in mind that inter-species competition and artificial selection also affect the size of a population (Tchernov 1982).

Postglacial dwarfing has been recognized for many species in the southern Levant. Kurten (1965) found most carnivores in Palestine and Lebanon to undergo considerable size reduction at the end of the Pleistocene; Tchernov (1968, 1982) notes the same phenomenon for two rodent species (*Spalax ehrenbergi* and *Microtus guentheri*); and Davis (1977) finds a 1mm decrease in the length of the mandibular first molar for fox (*Vulpes vulpes*) from the Kebaran to the Pre-Pottery Neolithic. From this he infers a temperature increase of 8-9°C at about 12,000-11,000bp in Palestine (Davis 1977:350). Davis also finds gazelle to undergo dwarfism in the Natufian (12,000-10,000bp), followed by boar, goat and aurochs; he favours temperature change (estimated at 15°C elevation) as an explanation (Davis 1981).

Rodents are believed to arrive on sites mostly via their accumulation by Strigiforms (owls). Since they are not assumed to result from human action, micromammal samples can reflect their natural distributions in a site's surrounding area.

Simple relative proportions of rodent species have been used to indicate the local environment around a site, such as the study of Natufian microfauna from Hayonim Cave, which showed 58% of clearance forms, 21% of typical woodland species and some bare rock dwellers (Bar-Yosef and Tchernov 1966).

Concerning a longer sequence, Tchernov uses the relative proportions of three genera, *Sciurus*, *Apodemus* (arboreal) and *Microtus* (open-land), to trace local conditions from the

Aurignacian to the Neolithic. Briefly, the patterns indicate open-land (interpreted as cool) conditions in the early Epipalaeolithic, with arboreal elements (implying higher precipitation and temperatures) increasing in the Natufian, only to decline (with some extinctions of arboreal rodents) in the Neolithic (Tchernov 1968, 1982).

Relict faunal elements are animal species with preferred habitats different from those in which they now live. Many species (e.g. insects and rodents) exist in certain 'refuge' areas of the Levant, such as in the highlands of the southern Sinai, but their main distributions are in environments 5°C cooler, and receiving 200mm more rainfall than today. They are hence seen as being relics of Pleniglacial conditions.

Discussion

Most data discussed above point to a general cold, arid period from 22,000bp to about 14,000bp, with local fluctuations. The subsequent period from 14,000bp to 12,000bp sees rising arboreal pollen in the southern Levant (Van Zeist and Bottema 1982 [Tsukadas diagram], Baruch and Bottema 1991), but decreasing forests reflected in the Ghab diagram for the northern Levant (Van Zeist and Bottema 1982). This has been explained in two ways. Firstly, Butzer (1978) finds a difference in climatic-environmental successions between the north and south Levant unsurprising since the areas are affected differently by atmospheric circulation and precipitation patterns. Secondly, Bar-Yosef and Valla (1991:2) suggest that differences observed between the Huleh and Ghab diagrams may be caused by a chronological discorrelation, resulting from a lack of dates from the Ghab.

The period from 12,000-10,000bp shows conflicting evidence for the southern Levant alone. One interpretation sees this time as being one of increasing oak forest, reflecting increased temperatures and increased precipitation until the drying out in the Holocene (Van Zeist and Bottema 1982). Another theory holds that this was a period of continuous aridification, which became more pronounced towards 10,000bp (Bar-Yosef and Belfer-Cohen 1989). This finds support in geological sequences (particularly from Fazael-Salibiya. Goldberg 1981) and faunal changes (Davis 1981; Tchernov 1982).

The Huleh pollen core described by Baruch and Bottema (1991), however, has been interpreted as showing more varied climatic events. They argue that the types of arboreal pollen found at 12,000-11,000bp indicate a moister, more humid phase reflecting the world-wide temperature increase associated with the Allerod, which peaked with maximum forest vegetation at around 11,500bp. The subsequent shrinking of forests noted until the early Holocene (10,000bp) is associated with rapid cooling and aridification, representing the global 'Younger Dryas' phenomenon.

As has been argued above, this last scenario is based on a more reliable pollen core and fits the global data better than the other models. Supportive evidence is found in site pollen studies from the lower Jordan Valley (Darmon 1987), and geomorphological reconstructions from the same area (Goldberg 1981).

The COHMAP (1988) global climate model predicts certain details which the forms of evidence reviewed above cannot provide. The model sees the changes in orientation of the earth's axis during the last 18,000 years as causing increased insolation and a gradual warming of the northern hemisphere. By drawing on atmospheric circulation patterns and surface boundary conditions, the model suggests a 'climatic optimum' from 12,000-6,000bp, resulting in more extreme seasonality than at any time before. Predictions state that summer temperatures would be 2-4°C higher than today, and winter temperatures correspondingly lower.

These details, in conjunction with the recent Huleh core, are used as the basis for palaeoenvironmental modelling for the study area (Chapter 3).

ARCHAEOLOGICAL COMPLEXES AND CHRONOLOGY
20,000-7,500bp

The main recognized archaeological divisions of the Epipalaeolithic and Neolithic are the Kebaran Complex, the Geometric Kebaran Complex, the Mushabian Complex, the early and late Natufian, the Harifian, Khiamian, Sultanian/PPNA and the PPNB/PPNC complexes (table 1.0). These are not chronologically or geographically discrete - most have overlapping dates - and some definitions are under dispute.

Problems in definition arise because:

1) different workers have used different classificatory systems to describe observed variability.

2) as more sites are excavated/surveyed, newly observed variability can either produce new definitions, or a broadening of the old ones.

3) classification depends on the interpretation of variability.

Classifications

In 1981 Bar-Yosef proposed a new taxonomical-chronological framework for the Levant to incorporate new results from the Sinai, Negev and Jordan Valley, which did not comfortably fit the existing assemblage labels used for the Mediterranean or Coastal zones. He explained his approach:

> An archaeological entity is defined on the basis of lithic assemblages analysed with respect to their techno-typological traits and taking into account variability which might reflect seasonal activity, intra-site activity areas, etc. But in order to build a more complete system, additional aspects, such as site location, site size and geographical distribution of sites are considered (Joachim 1976).
>
> (Bar-Yosef 1981a:390)

Thus, lithics are analysed in terms of techniques of knapping, tool modification, tool types and relative frequencies within an assemblage. Metrical frequencies also categorize assemblages. Henry (1989) explains how all general lithic types (i.e. scrapers, burins, notches-denticulates, backed bladelets and geometric microliths) appear to some extent in all Epipalaeolithic assemblages, making the use of 'type fossils' impossible.

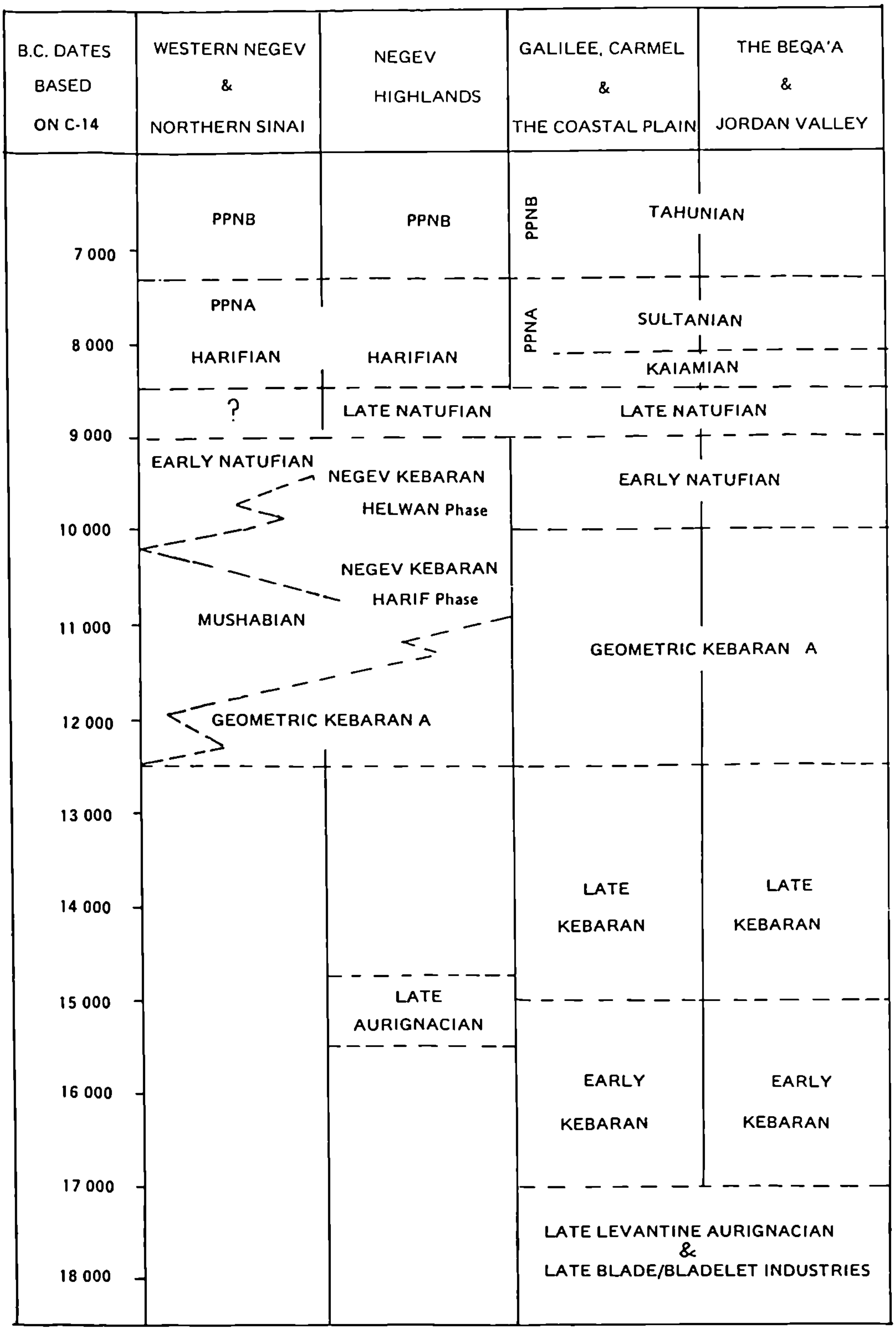
For the Neolithic, Bar-Yosef recommended using a simplified typology of arrowheads, since they tend to exist in all Levantine assemblages (Bar-Yosef 1981b).

The overall classificatory system, however, is heavily dependent on radiometric dating, stratigraphic sequences and a full consideration of the broad 'archaeological assemblage'.

In recognition of the confusion over whether terms related to a 'culture', spatial-temporal assemblages or specific technology, Henry (1989:79-83) proposes a hierarchical classification system for lithics. This identifies a 'complex', 'industry', 'phase/facies' and 'assemblage', and also lays down a framework for correlating socio-economic data with lithic classifications. In general, though, his broad lithic classifications are similar to those of Bar-Yosef.

Moore (1985) has made different divisions. He defines stages: Epipalaeolithic 1 and 2, Archaic Neolithic 1 and 2, and Developed Neolithic 3 and 4, with "the principal criterion for this division being differences in the nature of their subsistence economies" (Moore 1985:14). These rather broad labels will not be used here; their main value is in comparing economic developments across different areas of the Near East, but the nature by which they are defined does not provide a neutral chronological framework for subsistence studies.

The following review uses generally accepted 'complex' labels. For each, the brief description includes the following data (where available): dates, lithic industries, other aspects of material culture, site sizes, settlement patterns, and a discussion on how the archaeological record has been interpreted, including consideration of the possible derivation of each complex. **Subsistence evidence is not included here**, but in Chapter 2. Heavy use has been made of overviews by Bar-Yosef (1980;1981a;1981b;1982), Bar-Yosef and Belfer-Cohen (1989), Byrd (1989), Henry (1989), Goring-Morris (1989) and Baird (1993).



B.C. DATES BASED ON C-14	WESTERN NEGEV & NORTHERN SINAI	NEGEV HIGHLANDS	GALILEE, CARMEL & THE COASTAL PLAIN	THE BEQA'A & JORDAN VALLEY
7 000	PPNB	PPNB	PPNB TAHUNIAN	
8 000	PPNA HARIFIAN	HARIFIAN	PPNA SULTANIAN KAIAMIAN	
	?	LATE NATUFIAN	LATE NATUFIAN	
9 000	EARLY NATUFIAN	NEGEV KEBARAN HELWAN Phase	EARLY NATUFIAN	
10 000		NEGEV KEBARAN HARIF Phase	GEOMETRIC KEBARAN A	
11 000	MUSHABIAN			
12 000	GEOMETRIC KEBARAN A			
13 000			LATE KEBARAN	LATE KEBARAN
14 000				
15 000		LATE AURIGNACIAN	EARLY KEBARAN	EARLY KEBARAN
16 000				
17 000			LATE LEVANTINE AURIGNACIAN & LATE BLADE/BLADELET INDUSTRIES	
18 000				

Table 1.0. Chronological table of the late Pleistocene/early Holocene cultural complexes in the southern Levant (after Bar-Yosef 1981). Note that dates are BC.

The Epipalaeolithic

The Kebaran

Dated from approximately 20,000-14,500bp, Kebaran assemblages are dominated by narrow bladelets, the width frequencies of which fall into four clusters: A, B, C, D. Of these, A and B are probably earlier (with A maybe representing a regional expression), with C and D probably ordered chronologically. Generally, early and late phases are discernible, with the latter characterized by the obliquely truncated backed bladelet. Artifacts include few bone tools (an engraved point was found at Jaiita II in the Lebanon) and ground stone items such as basalt bowls, pestles and mortars.

Small excavation areas and erosion tend to make Kebaran site size difficult to evaluate, but most appear to cover areas of 15-25m², with fewer reaching 100-150m², and one as large as 350m². Sites have a strong adherence to the Mediterranean vegetation zone (figure 1.3), are mainly in the lowlands and near *wadis* (Ein Gev I, Urkan e-Rubb, Fazael III-4 & VII, Nahal Oren, Wadi Madamagh), at altitudes of 150-200m asl, although some small highland sites have also been found, and desert areas see a few isolated sites, e.g. Kharaneh 4 (one of the study sites) in eastern Jordan and Nahal Zin in the western Negev. Only Ein Gev I in the Jordan Valley sees architectural remains, and very few sites have yielded burials.

Bar-Yosef and Belfer-Cohen (1989) interpret the lowland and upland sites as winter and summer hunting encampments respectively, a pattern they see as resulting from the cool arid climatic conditions. Sites are believed to show high levels of material culture continuity from the late Upper Palaeolithic in the region (Goring-Morris 1987:15).

The Geometric Kebaran

This entity dates from roughly 14,500bp to 13,000-12,500bp. Bar-Yosef's initial classification (1970) distinguished between two Geometric Kebaran industries - A and B - although the latter has since ceased to be recognized (Henry 1989:153) and much of the variation has been absorbed by the newer classification of 'Mushabian' (see below). Divisions are now seen within the 'A' industry (Bar-Yosef 1981a): Group I has a dominance of trapeze-rectangles, with triangles also present, whilst Group II assemblages constitute **only** trapeze-rectangles, made on wider bladelets than those of Group I. Henry (1989) notes a further two Geometric Kebaran industries, III and IV; the former shows a greater balance in tool classes than other groups, whilst IV sees a high frequency of lunates.

Group I industries are found mainly in the Mediterranean zone, but also extend into the steppe/desert areas. Group II assemblages are restricted entirely to the steppe/desert, extending from the Sinai

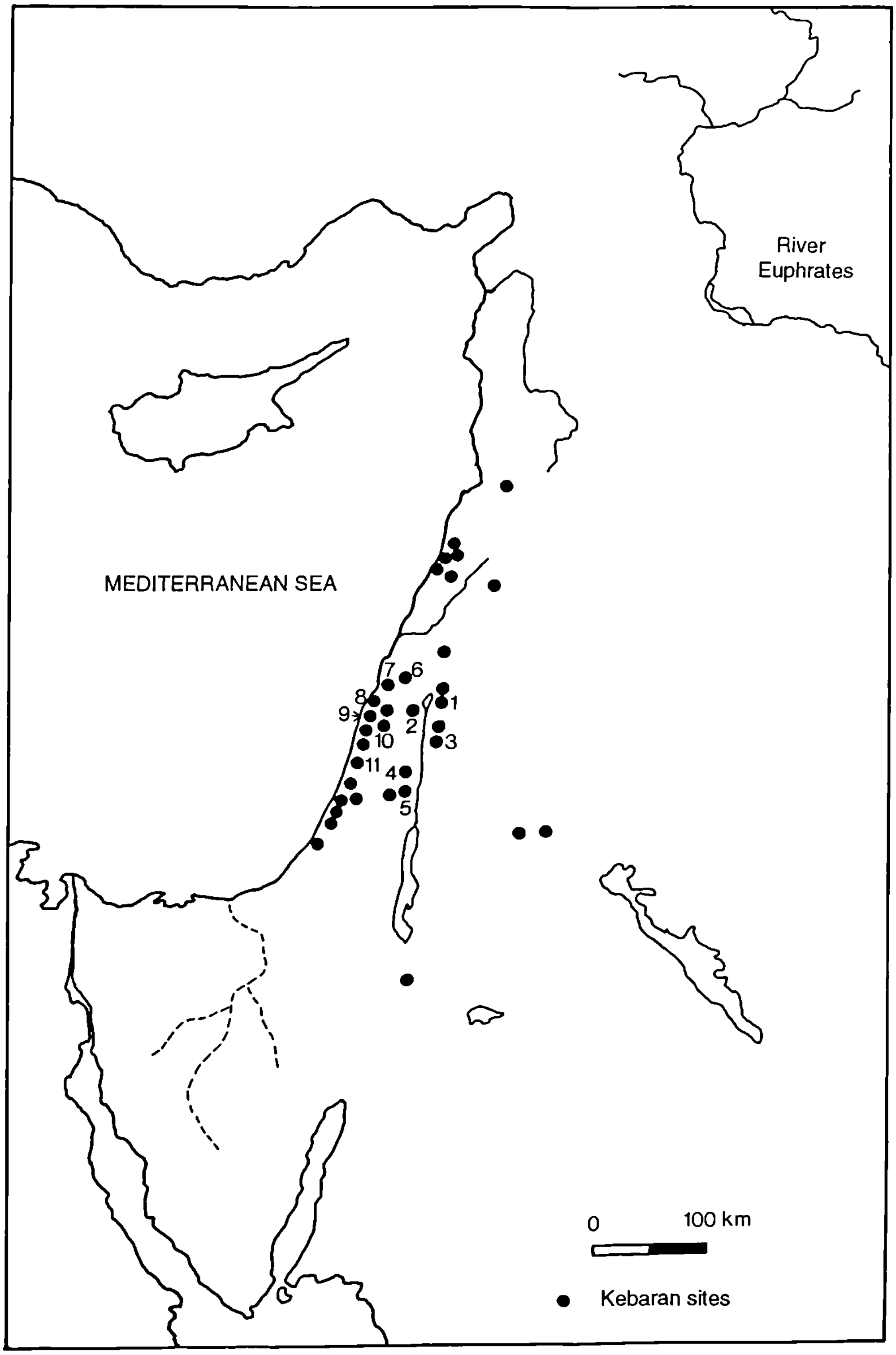


Figure 1.3. The distribution of Kebaran sites (after Bar-Yosef and Belfer-Cohen 1989). The numbered/named sites are those with faunal remains, discussed in Chapter 2: 1=Ein Gev I; 2=Ohalo II; 3=Wadi Hammeh 26; 4=Urkan e-Rubb IIa; 5=Fazael IIIa and VII; 6=Hayonim Cave; 7=Iraq e-Zigan; 8=Kebara Cave; 9=Nahal Oren; 10=Rakefet; 11=Nahal Hadera V.

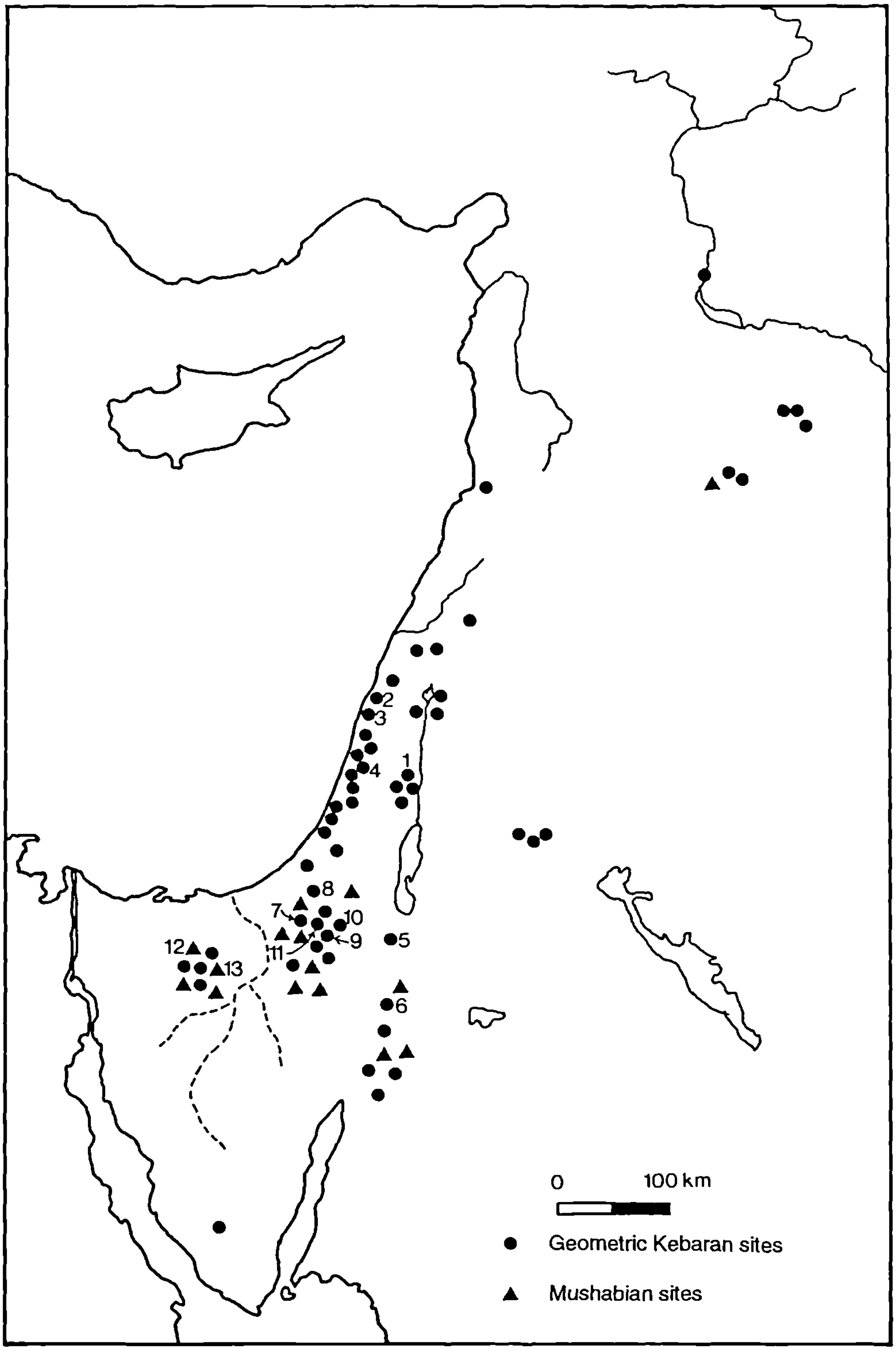


Figure 1.4. The distribution of Geometric Kebaran and Mushabian sites (after Bar-Yosef and Belfer-Cohen 1989). 1=Fazael VIII; 2=Neve David; 3=Nahal Oren; 4=Hefsibah; 5=Wadi Madamagh; 6=Tor Hamar; 7=Hamifgash I; 8=Nahal Inbal; 9=Azariq XVI; 10=Nahal Sekher 22; 11=Shunera III; 12=Lagama North VIII; 13=Mushabi V.

and Negev to the Jordanian and Syrian deserts in the northeast. Group III industries are known from only three sites in northern Palestine, between Lake Tiberias and the Mediterranean coast. The Group IV industry (also known as Hamran) is known from an area from the Dead Sea southwards, and eastward to the edge of the Syrian desert.

Other items of material culture include small numbers of bone tools, but quite a wide variety of ground basalt and limestone items, e.g. from Hefsibah. Marine molluscs from the Mediterranean are also noted. Evidence of architecture is rare; the best examples are seen at Neve David, where two small oval limestone-slab structures were found.

Site sizes range from 15-25m^2 to 300-400m^2. They are widespread, found in both lowlands and highlands (e.g. Naba'a el Maghara in the Lebanese mountains), although Goring-Morris notes that in the Negev and Sinai, sites cluster in the lowlands (exceptions being Maaleh Ziq and Wadi Sayakh). General distribution differs from the preceding Kebaran in the presence of sites in more desertic areas and at higher elevations (figure 1.4); both Bar-Yosef and Henry (1989) see this as an effect of moister climatic conditions. There is general agreement that the Geometric Kebaran developed directly from the Kebaran.

The Mushabian

Dating from c. 14,000bp to c. 11,700bp, the Mushabian temporally overlaps both the Geometric Kebaran and the early Natufian. The industry was first noted in the Gebel Maghara area of northeastern Sinai, and has since been identified in the Negev and southern Jordan, suggesting an arid zone distribution (figure 1.4). Three divisions are observed in the lithics industry, which follow these three geographical areas. Broadly, however, the Mushabian is characterised by the microburin technique, the appearance of La Mouillah Points and a dominance of arched backed bladelets.

Sinai and Negev Mushabian industries see scrapers and notches-denticulates as dominant, with backed bladelets and backed tools common in the geometric classes. The Negev Mushabian is divided into two phases, the Harif (before 12,500bp), and the Helwan (12,500-11,000bp), on the basis of stylistic and technological attributes. Likewise, the Sinai Mushabian has early and late phases with roughly similar time divisions. The southern Jordan Mushabian, termed Madamaghan (Henry and Garrard 1988:23), parallels trends observed in the other two areas. The sequence is best observed at the site of Tor Hamar, where close affinity with the Sinai Mushabian is seen.

Goring-Morris (1987; 1989) views the Negev and Sinai highland zones as having specific settlement patterns and a more diverse tool kit during the Mushabian. He termed some of these higher elevation sites 'Ramonian', arguing that their subsistence practices there would have differed from other areas. Bar-Yosef (1981a) also uses the term Negev Kebaran for the Negev Mushabian.

Mushabian material culture is characterized by worked bone, groundstone and ornamental shell, in particular dentalium beads. Architecture is scarce, but hearths and artifact scatters, such as at Mushabi V and Mushabi XIV in the Sinai, define occupation areas.

Site size varies between high inland areas (e.g. Gebel Mughara, the Negev Highlands and southern Jordan) where sites range from 30m² to 200m², and coastal sites, which cover areas of 900m² and 1000m² (e.g. Nahal Hadera I and II). Some interpret this as a seasonal settlement pattern, with summer occupation at upland sites, winter near the coast (Henry 1989:144); this model is founded on assumptions of resource availability, and is not corroborated by archaeological evidence.

Similarities between the Mushabian and some north African industries have been widely noted; in addition, that the Mushabian lacks affinity with the Geometric Kebaran has encouraged suggestions that Mushabian sites represent a penetration of Nile Delta hunter-gatherers into the southern Levant (Bar-Yosef 1981a; Goring-Morris 1989).

The Natufian

This richest and best known of the Levantine Epipalaeolithic complexes is hard to characterize due to the great variability exhibited. The Natufian dates from c. 12,500bp to c. 10,000bp, a period within which some recognize three phases (Valla 1984, 1987a, quoted in Byrd 1989), but most accept only two - early and late - with the division between them at c. 11,000bp.

Historically, Natufian assemblages have been classified using the simplest common denominator - the present of lunates - as 'type fossils'. Consequently, very varied and often geographically disparate sites have been classed together. Recent research in the Negev, Sinai, Jordan and Syria has called into question the use of the single term 'Natufian' for the diversity of subsistence and settlement remains observed (Byrd 1989; Belfer-Cohen 1989; Olszewski 1986).

A new definition for the Natufian (proposed by Bar-Yosef 1981a, based on 1970) basically limited the term to 'base camp' sites (e.g. those with architecture, diverse cultural material, burials) in the Galilee, Jordan Valley, Mount Carmel and Judean Desert. Some other smaller 'seasonal camps' were also incorporated, as long as they lay within a radius of 50kms from 'base camps', since these were interpreted as part of the same 'cultural entity' '(Bar-Yosef and Belfer-Cohen 1989:456). Variation between these settlement types was seen to represent an annual occupation cycle of sedentary 'base camps' with 'transitory camps' located around it in a radiating distribution. Byrd critiques this scenario concluding that the pigeon-holing of sites into these two types is not useful (Byrd 1989; 1991:260). Firstly, he questions whether site size should be the primary criterion for classification. Secondly, he challenges the underlying assumption that only one settlement in the annual cycle will have the characteristics of large size, thick deposits, architecture, burials etc. Thirdly, he notes that within the model, no sites have been related to each other in a working regional seasonal system (Byrd 1989:174). Bar-Yosef and Belfer-Cohen have, in addition, not explained their assumptions about what constitutes a territory, and they have introduced the concept of 'culture' when the classification system (see above) attempts only to describe archaeological variation. Despite these problems, the general accepted characteristics of the Natufian complex will be outlined here.

Natufian lithics industries are generally characterized by microliths made on quite broad bladelets (Henry 1989). The geometric microlith component is always dominated by lunates. Other tools which appear in roughly equal numbers are backed bladelets, burins, scrapers and notches-denticulates, and a few 'massive tools' are often present. Sickle blades are consistent but in very small numbers.

Henry (1989:190-191) notes that geometric microliths form a proportionately greater part of the tool-kits in drier settings, and argues that these tools reflect hunting, which is highly correlated with more open drier vegetation areas. He also finds geometrics to increase proportionally through time at some Mediterranean zone Natufian sites (e.g. Hayonim Cave and Terrace and Ain Mallaha); this is read as evidence for more intensive hunting, resulting from a climatic deterioration.

Byrd's (1989) detailed analysis of Natufian chipped stone assemblages identifies three tool-kit clusters: cluster 1 has a high percentage of non-geometric backed tools and correlates with sites in forest and coastal areas; cluster 2 sees a high percentage of notches and denticulates, scrapers and simple retouched pieces; cluster 3 has higher frequencies of geometrics and lower percentages of burins. The latter two appear at steppe-desert sites, with cluster 2 appearing to represent a broader range of activities than 3.

Other aspects of Natufian material culture show a great increase in richness and quantity compared to previous periods. Worked bone points, barbed points or 'harpoons' (e.g. from Hayonim Terrace), awls, borers and sickle hafts are often decorated with parallel lines or net patterns. Bone sickle hafts from Kebara and El-Wad are sculpted into animal forms. A functional interpretation of worked bone production (Bar-Yosef and Tchernov 1970) sees the tools as representing hunting, sewing and weaving activities, which would have emerged in response to Natufian subsistence security. Henry suggests that it may be 'indirectly tied to ranking and prestige, which, in turn, fuelled intensified foraging and the development of surpluses' (Henry 1989:197).

The ground stone assemblages consist of mortars, pestles, bowls, cup marks, querns, slabs and grooved stones, some in primary and others in secondary locations (such as in graves or incorporated into walls). The great increase in worked stone has commonly been seen to reflect increased dependence on cereals in particular, as well as other resources such as nuts. On this subject, Wright comments:

> There is no reason to assume *a priori* that mortars, pestles, grinding slabs and handstones reflect cereal processing alone ... The reason for the presence of large numbers of pounding tools in the Early Natufian may have been diverse and variable from one site to the next and may have had more to do with group size than with specific resources.
>
> (Wright 1991:35)

Ornamental objects such as pendants and beads, made of greenstone, malachite, bone, teeth and many kinds of marine shell (especially dentalium) from both the Mediterranean and the Red Sea, are commonly found in Natufian deposits. Statuettes and figurines, both anthropomorphic and zoomorphic, have been recovered, and the depiction of sexual organs is fairly common, as seen in the phallic objects from El Wad and Rosh Zin.

Architecture is best known from Ain Mallaha, Hayonim Cave and Rosh Zin, and more limited at sites such as El Wad, Hayonim Terrace, Wadi el-Hammeh 27, Abu Hureyra and Mureybet. Structures tend to be semi-subterranean, circular or curvilinear, built of unmodified stones and either in clusters or lines. In northern Syria, timber and clay were also used in building. Other architectural features include storage pits, terrace walls, stone pavements and a unique feature at Rosh Zin of a monolithic phallic-shaped limestone column inside the structure wall, with associated grooved stones and polished limestone disc. Burials are common on some sites, with a very broad pattern of group burials in the early Natufian and individual interments in the late Natufian. The wealth of skeletons, grave goods, grave furniture etc. has led to much discussion on mortuary practices and social organization (see summary in Henry 1989:206-211).

Sites fall into three size groups: smaller ones range from between 15-100m^2, medium sized sites are 400-500m^2 and larger 'base camps' tend to exceed 1000m^2. Henry (1981;1989) and Bar-Yosef (1983) see a number of the Natufian 'base camps' as sedentary settlements, and the presence (Tchernov 1984) and frequency (Tchernov 1991a, 1991b) of certain rodent species on these sites has been used as supporting evidence. Others remain sceptical that frequencies of commensal animals can identify sedentism (Tangri and Wyncoll 1989; Byrd 1989:183-4; Edwards 1989:28-31), or indeed that the Natufian has **any** unequivocal markers of sedentism (Edwards 1989).

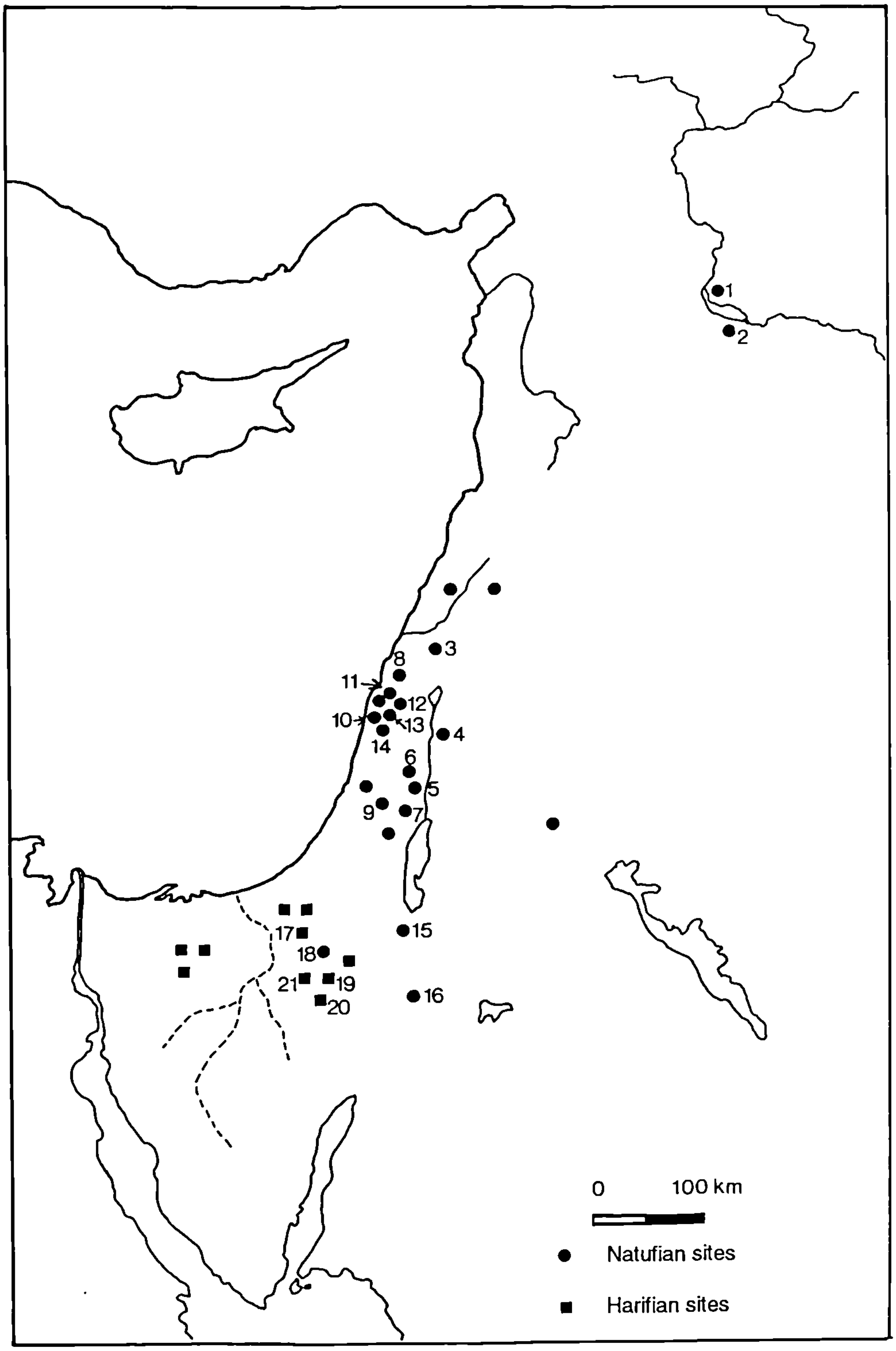


Figure 1.5. The distribution of Natufian and Harifian sites (after Bar-Yosef and Belfer-Cohen 1989). 1=Mureybet; 2=Abu Hureyra; 3=Ain Mallaha; 4=Wadi Hammeh 27; 5=Salibiya I; 6=Fazael VI and IV; 7=Jericho; 8=Hayonim Cave and Terrace; 9=Hatoula; 10=Nahal Oren; 11=Abu Usba Cave; 12=el Wad; 13=Rakefet; 14=Kebara Cave; 15=Beidha; 16=Wadi Judayid; 17=Rosh Horesha; 18=Abu Salem; 19=Ramat Harif; 20=Rosh Zin; 21=Shlulat Harif.

Natufian assemblages tend to be found in the Mediterranean and Irano-Turanian vegetation belts (figure 1.5), and sites are both open-air and situated in caves or rock-shelters. The derivation of the Natufian is disputed. Henry suggests that the complex may have developed on the Jordan plateau; he places the transition from the Kebaran in the framework of climatic changes, arguing that newly available resources stimulated groups to intensify and become more sedentary (Henry 1989). Bar-Yosef and Belfer-Cohen (1989) also see climatic changes observed at c. 13,000bp as being instrumental in Natufian developments; but in their case they see pressure on resources as being causal. Kaufmann (1992) rejects ideas of a stimulus of environmental change, arguing instead that the roots of Natufian developments could be firmly placed in Kebaran and Geometric Kebaran traditions. He sees these as being more complex than has often been assumed, and that patterns of increased social organization and contacts between groups had been gradual throughout the Epipalaeolithic. In this context, the emergence of Natufian traits is seen as a gradual intensification of social relationships and production, and change primarily comes from within (Kaufmann 1992:192).

The Harifian

Harifian sites are commonly considered to be a late Natufian development restricted to the Negev Highlands, western Negev and northern Sinai (figure 1.5). The complex is poorly dated but believed to last from c. 10,700bp to c. 10,000bp.

The industry is characterized by an arrowhead - the Harif Point - but otherwise assemblages show similarities to the Natufian with an abundance of small lunates and triangle microliths. Worked bone is limited; ground stone artifacts are confined to upland sites, as are the remains of stone-built oval dwellings and storage structures (e.g. Abu Salem). Marine shells are frequently found, two-thirds of which come from the Red Sea.

Larger Harifian settlements, over 1000m², are found in the highlands (e.g. on the Harif Plateau and its surroundings). These have been interpreted as 'summer aggregation base camps' (Bar-Yosef and Belfer-Cohen 1989:475). Smaller sites ranging from 50-200m² occupy the sandy lowlands of the western Negev and northern Sinai, and are generally viewed as transitory winter camps. These seasonal settlement models are based solely on reconstructions of available resources.

The interpretation of Harifian settlement patterns (outlined by Bar-Yosef and Belfer-Cohen 1989:475 and Henry 1989:224), which appears to go unchallenged, holds that increasing aridity led to declining resources and forced late Natufian populations from the Mediterranean woodlands south into the Negev. These groups produced the Harifian assemblages, which supposedly accounts for its similarities with Natufian assemblages.

The Neolithic

The Pre-Pottery Neolithic A (PPNA)

Two distinct industries are included within the PPNA: the Khiamian and the Sultanian. They show considerable overlap, but the former appears slightly earlier.

The Khiamian industry

The Khiamian remains rather ill-defined; it is identified from a restricted area in the Mediterranean woodland zone, and appears to cover a short time span (c. 10,500-10,300/10,100bp). Most Khiamian levels overlie, and are considered a development of, late Natufian occupations. The Khiamian is broadly coeval with the Harifian in the arid zone.

Characteristic of the lithic industry are the Khiamian point, a lower frequency of microliths than the Natufian, sickle blades and some large heavy-duty implements. Ground stone artifacts continue in the Natufian tradition and sculpted figurines (e.g. from Salibiya IX, Nahal Oren, El Khiam and Mureybet) share strong similarities with those from the Natufian.

Site sizes range from c. 1000m² to over 3000m²; most are at fairly low elevations (El Khiam being the highest at 430m asl) and near permanent water sources (figure 1.6). Architectural remains are, as yet, fairly scarce.

The Sultanian Industry

This industry dates between 10,300/10,100bp and 9,300/9,200bp, and associated subsistence remains provide evidence for the intensive collection or cultivation of cereals and legumes. The Sultanian is best known from levels at Jericho, Nahal Oren, Gilgal I, Netiv Hagdud and Hatoula - all in the Mediterranean belt.

The lithic industry is based on blade production and bifacial flaking, with a low microlithic component. Khiamian points are present in low percentages, perforator tools are well represented and heavy-duty implements like picks, tranchets axes and adzes are found in fairly high proportions. The earliest observations of the use of heat treatment in lithic technology are from this period. Anatolian obsidian is seen for the first time in tool production, but ground stone artifacts tend to show similarity to Natufian types.

Assemblages from Mureybet III and Tell Aswad IA, sites in Syria, tend to be included in the Sultanian industry. They show regional differences in certain lithic types, including the *herminette* (adze made on a thick flake), perforators, a relatively high frequency of scrapers, and Khiamian points which decrease at the expense of Helwan points (Bar-Yosef and Belfer-Cohen 1992).

Concerning architecture, some sites have rounded or oval semi-subterranean stone foundations, but unlike Natufian buildings, these have mud-brick superstructures. The huge stone walls and tower of Jericho are attributed to this phase, and have been interpreted as defensive by Kenyon, although Bar-Yosef suggests the walls acted as protection against floods. The Nahal Oren structures are of roughly equal sizes and clustered together, whilst at Netiv Hagdud they vary in size and have open spaces between them.

Burials are often single without grave goods, and skeletons characteristically show the lower jaw in place but skull removed. Crushed skulls were found on a house floor at Netiv Hagdud.

A few stone-carved figurines belong to the Sultanian, and these together with some baked clay female figurines from Netiv Hagdud, show a difference in artistic representations from the preceding Natufian.

Sites show a great increase in size during this period. Some small settlements exist (1000-2000m^2) but most cover 1-3 hectares. Locations favour lower elevations and proximity to water sources, although the site of Iraq ed-Dhubb on the western Jordanian plateau shows that higher cave sites were also occupied during this period (Kuijt *et al.* 1991).

The Sultanian has been interpreted as representing groups of 'incipient cereal cultivators'. Some see these sites as the first agricultural settlements, located on the modern boundary between the Mediterranean and the Irano-Turanian zone (figure 1.6). This zone has been referred to as the 'Levantine Corridor' (Bar-Yosef and Belfer-Cohen 1992:38), a belt running from the middle Euphrates through the Jordan Valley and into southern Jordan. To the west, south and east of this 'corridor', evidence points to a continuation of hunting and gathering (Bar-Yosef and Belfer-Cohen 1989), but a lack of excavation in contemporaneous steppe/desert sites to the south and east, resulting in a lack of subsistence data, has made it so far impossible to suggest what the relations between the different areas might have been (Byrd 1992:50).

The Pre-Pottery Neolithic B (PPNB)

This period, dating c. 9,600-7,500bp, is chronologically divided into early, middle, late and final/PPNC phases (after Cauvin 1987, quoted in Rollefson 1989). Sites from the fertile areas of the Levant, including the northeast (Syria), show that people were familiar with cultivated plants at this time, whilst herded animals probably appeared during the PPNB sequence. The arid southern areas, however, so far exhibit very limited reliance on cultivated plants, and

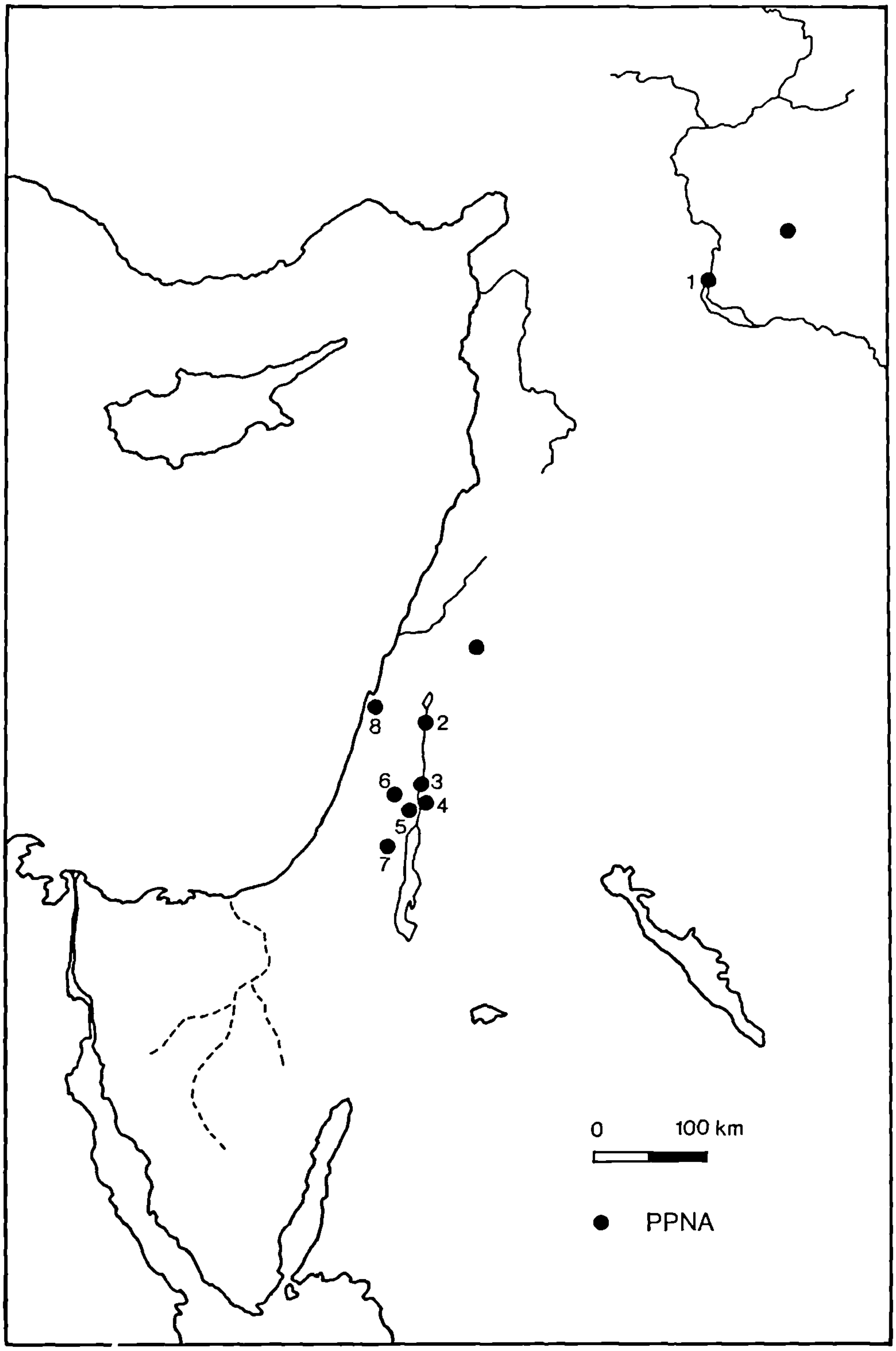


Figure 1.6. The distribution of PPNA sites. 1=Mureybet; 2=Gesher; 3=Gilgal; 4=Netiv Hagdud; 5=Jericho; 6=Hatoula; 7=el Khiam; 8=Nahal Oren.

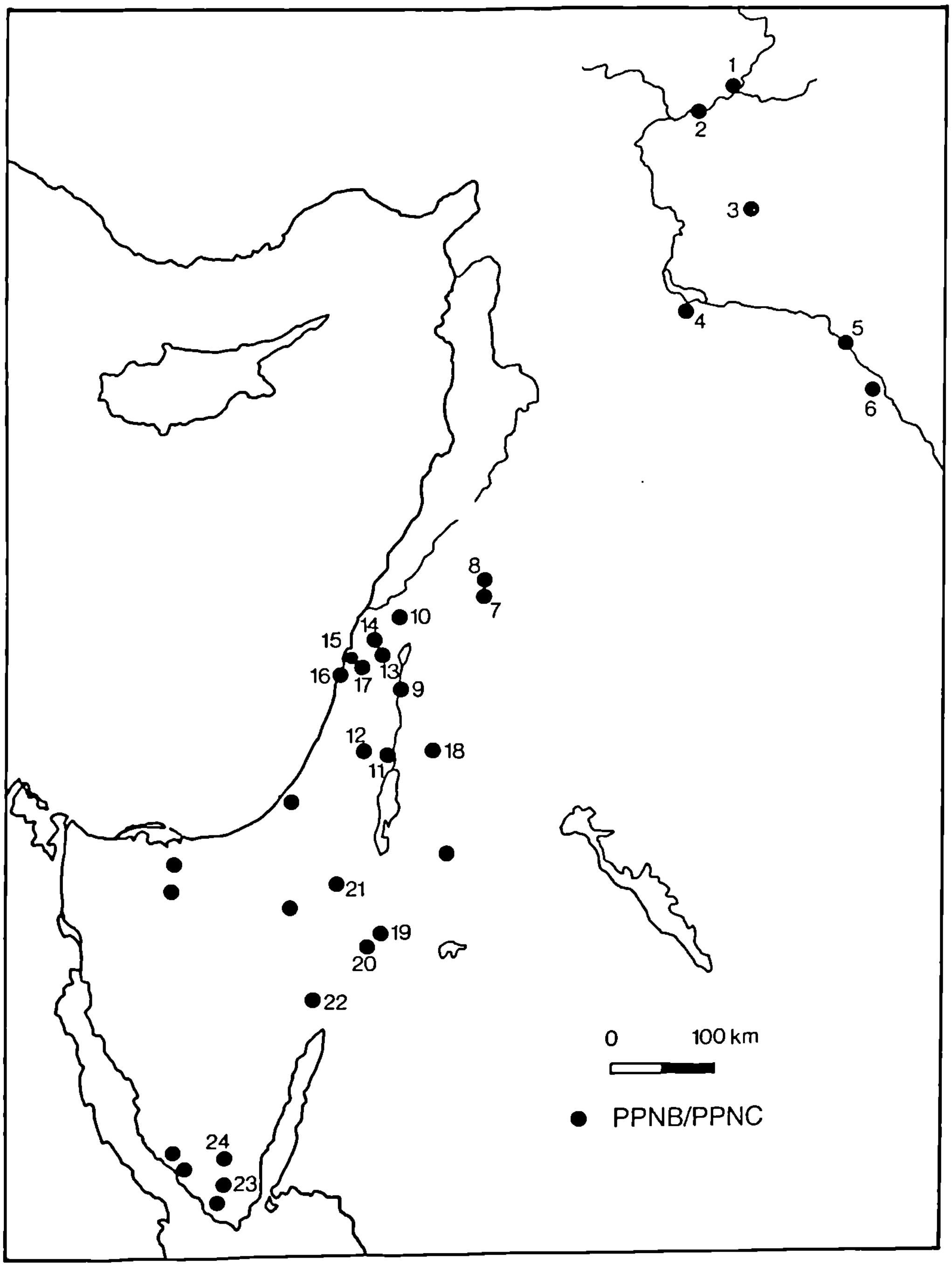


Figure 1.7. The distribution of PPNB sites. 1=Gritille; 2=Hayaz Höyük; 3=Assouad-Djezireh; 4=Abu Hureyra; 5=Tell es-Sinn; 6=Bouqras; 7=Aswad; 8=Ghoraife; 9=Munhatta; 10=Beisamoun; 11=Jericho; 12=Abou Gosh; 13=Yiftahel; 14=Kfar Hahoresh; 15=Nahal Oren; 16=Atlit; 17=Rakefet; 18=Ain Ghazal; 19=Beidha; 20=Basta; 21=Nahal Divshon; 22=Nahal Issaron; 23=Ujrat el-Mehed; 24=Wadi Tbeik.

perhaps even no dependence on herd animals by the end of this period (Byrd 1992:52) (see figure 1.7 for site distributions).

The PPNB generally shows an increasing degree of complexity in all spheres (Bar-Yosef and Belfer-Cohen 1991), such as architecture, burial practices, ritual, contacts and exchange and subsistence activities, although change from the preceding period appears more pronounced in the Levantine Corridor than in the east, west or southern areas. Sites in this corridor tend to be much larger than contemporaneous ones elsewhere: Abu Hureyra, Ain Ghazal, Basta and Beisamoun reach 12 hectares during the PPNB. Caches of human statues have been excavated at Ain Ghazal in Jordan; plaster and asphalt modelled skulls have been found at Ramad, Beisamoun, Ain Ghazal, Jericho and Nahal Hemar Cave - commonly interpreted as a cult of the ancestors; clay (and sometimes bone and limestone) female and animal figurines are also common.

In terms of architecture, rectangular buildings are seen to replace round structures at the larger sites. Byrd and Banning (1988) have described how the southern Levantine 'pier houses' of Ain Ghazal, Jericho, Beisamoun and Yiftahel, and probably also the 'corridor buildings' of Beidha, represent a different building tradition from the multi-cellular rectangular structures of the northern Levant (e.g. Abu Hureyra). Curvilinear stuctures characterize the arid and semi-arid zones.

As with the Epipalaeolithic complexes, PPNB subsistence patterns will be discussed separately below. Here, a simple framework for the PPNB is given, which is extremely selective due to the wealth of data available.

The early PPNB

This phase from c. 9,600-9,200bp is much discussed, both in terms of subsistence activities, and also as to its exact distribution. The southern Levant certainly has early PPNB remains (e.g. Nahal Oren, Abou Gosh), and finds are clearly present in the northern Levant (Mureybet II, Tell Aswad Ia). There are also indications of early PPNB material in eastern Jordan at Wadi Jilat 7 (one of the study sites).

The lithic industry is characterized by bipolar cores, Byblos points, both long and short Helwan points, long sickle blades, tranchet axes and the widespread appearance of heat-treated blades.

The middle PPNB

Lasting from c. 9,200-8,500bp, this phase is often considered the 'Classic PPNB', represented at sites such as Munhatta, Abu Gosh, Jericho and Beidha. It was during this phase that numerous sites were established in the central Levant, such as Ain Ghazal on the Jordanian Plateau.

Lithics are dominated by long, inversely retouched sickle blades, and a high frequency of Jericho and Byblos points, with fewer Amuq points. Amygdaloid and oval axes replace tranchet axes, and bipolar core reduction and heat treatment are common technologies.

The large sites in the Mediterranean zone have been termed the first 'permanent PPNB agricultural villages' (Rollefson 1989:169), whilst smaller outlying occupations in the steppe/desert area are believed to be seasonal, and hunting and gathering continue to be important.

The late PPNB

From c. 8,500bp to c. 8,000bp great disturbances were seen in the settlement patterns in the southern Levant. Many sites such as Jericho, Beidha and Munhatta were abandoned and other sites were founded in previously unoccupied areas.

New sites such as Beisamoun, Wadi Shu'eib and Basta are often very large (Basta in Jordan covers about 12 hectares, and previously-established Ain Ghazal reaches 9.5 hectares in this period). Northern Levantine sites such as Tell Abu Hureyra and Bouqras also seem to have undergone size growth. The desert/steppe areas continue to see occupation (e.g. Azraq 31, Wadi Tbeik, Ujrat el-Mehed, Nahal Issaron) but settlements are much smaller.

Two main arguments have been forwarded in explanation of the abandonment of so many late PPNB settlements. One view holds that climatic deterioration, in the form of increased aridity, destroyed the agricultural support base upon which village sites were founded (de Contenson 1982). The other is that sedentism, overgrazing, and an increasing dependence on agriculture led to environmental degradation around permanent water sources in the Mediterranean zone, resulting in the abandonment of such locations (Kohler-Rollefson 1988; Rollefson and Kohler-Rollefson 1989). This second view draws on recent palaeoclimatic evidence contradicting earlier assumptions of climatic 'drying-out' at this time.

The final PPNB/PPNC/early Late Neolithic

The period from c. 8,000-7,500bp is referred to as the final PPNB in the northern Levant, the PPNC at some southern Levantine sites, and the early Late Neolithic in the arid areas of the southern Levant. This confusing scenario might be explained by differences in the archaeological record at this time, although a paucity of information from the south Levant should be mentioned. Continued trends from the late PPNB are seen in the north, whilst central and southern sites show increasingly divergent characteristics. At Ain Ghazal for example, architecture, burial practices and subsistence evidence change markedly. Also, some southern Levantine lithic assemblages have a higher flake to blade ratio and a more specialized industry than most other PPNB industries. The southern Levant also differs from the north in that little evidence of ceramics has been found before c. 7,500bp, whilst it is common in the final PPNB in the north (Rollefson 1989). The term 'early Late Neolithic' is used for coeval sites in eastern Jordan (Garrard *et al.* 1994), which are aceramic.

Summary

This chapter briefly describes the archaeological, environmental and palaeoenvironmental characteristics of southern Levantine areas, since some of these provide the closest parallels and comparisons for eastern Jordan. This study area is defined in full detail in Chapter 3.

An attempt has been made to highlight the regional diversity of the southern Levant, in terms both of material culture traditions and chronologies, and topography and phytogeography.

As shown in Chapter 3, contact between eastern Jordan and other areas of the southern Levant is evidenced in most periods, and changes here appear very broadly to reflect those elsewhere. The study area, however, is seen to have strong regional traditions, and variability within the area, despite the obvious close ties with the areas further west. Eastern Jordan clearly has different constraints to other Levantine areas: it is considered semi-arid/arid like the Negev and Sinai, but compared to these it is relatively flat, meaning that the limitations of settlement, mobility and subsistence may well differ.

The palaeoenvironmental evidence presented here is drawn on frequently in Chapter 3 due to the dearth of data from the study area. The archaeological complexes are referred to throughout, for example in the subsistence review in Chapter 2 and in discussions, although as will be seen, they are not all applicable to the eastern Jordanian record.

CHAPTER TWO

SUBSISTENCE IN THE LEVANT 20,000-7,500bp

Here, evidence for subsistence activities is superimposed onto the chronological and archaeological framework described in Chapter 1. The review primarily concerns faunal remains and their interpretation, but includes mention of plants. The aim is to highlight issues of relevance to the eastern Jordan study area.

The plant and animal resources

The resources which have either been evidenced archaeologically or are expected to have been available in prehistory are fully reviewed in Appendix 1. The ecology and ethology of selected mammalian taxa are also outlined there.

Generally, Levantine vegetation is characterized by seasonality. Cereals tend to ripen in late spring/early summer and, if to be used, must be collected soon after ripening as they disperse soon after (Byrd 1989:173). Legumes tend also to ripen in the same season, but the perennials, the nut, oil and fruit plants, are more varied in their seasons of production. Fruits, however, would be most abundant from September to November (Schmida *et al.* 1986 quoted in Bar-Yosef and Belfer-Cohen 1989:450); and acorns ripen in the autumn months. Actual densities and distributions of plants are extremely difficult to predict due firstly to the inadequacy of palaeoenvironmental data, and secondly because of the restrictions on using modern analogues.

Complex factors (above general environmental conditions) influence the distribution of animal taxa, including vegetation density and distribution, predator-prey interaction, commensal relationships as well as the internal dynamics of animal populations. With the possible exception of some equids, little suggests that any Levantine herd animals would have migrated; rather, most would make small-scale seasonal movements. Populations may have moved in and out of areas if they could no longer be supported, but unless this is regular and seasonal it does not constitute 'migration'. Animal availability, therefore, is not predicted to have been seasonally determined in most Levantine areas; herd composition, social groupings and animal condition, however, will be highly correlated with the seasonality of forage. Migratory birds are clearly only available at certain times of the year.

Limitations of subsistence data

1) Many more, and generally larger, faunal and botanical samples derive from late Epipalaeolithic and early Neolithic contexts than early Epipalaeolithic ones. This results partly from the nature of deposition at earlier sites (i.e. shorter occupations; less recognizable

activity areas); partly from preservational factors, and partly from research bias. The effect is that subsistence for the Natufian and Neolithic is better investigated than for earlier periods.

2) Preservational biases exist not only chronologically but geographically; for example, organic remains tend not to survive in the sandy areas of the Negev and Sinai.

3) Early animal bone reports (and some more recent) tend to describe fauna solely as climatic/environmental indicators, rather than as a source of subsistence information (e.g. Bate 1937; Haas 1952; Bar-Yosef and Tchernov 1966; Tchernov 1976; Noy, Schuldenrein and Tchernov 1980). In such cases, quantitative data are often not available, but only species presence. These reports make a very limited contribution to discussions of subsistence.

4) Colledge (1991) notes a bias in Near Eastern archaeobotany towards looking for domestic or wild grain; this is reinforced by the fact that seeds survive better than other plant parts under conditions of charring, rendering them both more retrievable and identifiable.

> There has been a tendency, therefore, to emphasise the importance of the contribution of seeds in the early diet which, depending on the local availability of certain species in an area, may or may not have been a dominant source of plant foods.
>
> (Colledge 1991:396)

5) Hillman discusses how archaeological plant remains bias the reconstruction of actual 'diet', and introduces the concept of 'missing foods':

> Any realistic assessment of the original extent of dietary diversity at the site must take account of possible gaps in the archaeological record. Plant remains inevitably provide an incomplete picture of past diet, and this is especially true when preservation is by charring, as foods eaten raw or cooked by boiling are unlikely to come into contact with fire, and even of the foods which do, many fail to survive in identifiable form ... The problem is compounded on hunter-gatherer sites where preservation subsequent to deposition is generally much poorer ... Clearly, then, reconstructions of past diet which fail to take explicit account of these gaps in the record are potentially misleading.
>
> (Hillman 1989:218)

The implication of a recent investigation into vegetative material (Hather 1988) is that recognition of plant parts other than seeds is possible.

Review of subsistence data

Plant and animal remains are reviewed for each major time period; the discussion of fauna is restricted to mammals of hare size and above. The area covered is the southern Levant, although parts of the northern Levant are included in the overviews of the Natufian, PPNA and PPNB/PPNC, where they are considered relevant. The sites which have produced faunal remains are plotted in figures 1.3-1.7.

The Kebaran

c. 20,000-14,500bp

Plant remains

Only two sites have provided botanical remains from this period: Ohalo II and Nahal Oren/Wadi Fellah in Palestine; Wadi Kubbaniya in Egypt, although outside the area, is also informative.

Ohalo II on the south-western shore of the Sea of Galilee, dated to c. 19,000bp, has produced abundant *in situ* organic remains (Nadel 1991; Nadel and Hershkovitz 1991). Plant remains include large quantities of wild barley seeds, wild specimens of emmer wheat, almond, olive, pistachio and grape, and a variety of small-seeded grasses, acorns and wild pear seeds (Kislev *et al.* 1992). They all represent plant resources local to the site, and their seasons of availability fall into two periods of the year - April-May and July-October (Hansen 1991:166).

Nahal Oren's Kebaran levels yielded wild vetch, fig and unidentified grasses (Noy *et al.* 1973). The domestic emmer wheat described in the original report has been shown to be intrusive (Legge 1986:15-19).

Wadi Kubbaniya near Aswan in Upper Egypt, although not Kebaran, dates to an equivalent period (c. 18,000-17,000bp). Original identifications of domesticated cereals have been dismissed, since grains are probably intrusive (Hillman 1989:213). Plant remains include charred fragments of soft vegetable matter mostly from tubers of the wild nut-grass, but also of club-rush, dom palm and other fruits and nuts (Hillman 1989:209). They are all locally available wild plants growing along the river's edge, and Hillman concludes that 'root' foods probably played a pre-eminent role in the diet.

The general paucity of archaeobotanical remains from this period makes assessment of plant use difficult. Comment has tended to rely on indirect evidence, for example Bar-Yosef and Belfer-Cohen suggest the processing of wild seeds of legumes and cereals, and also of acorns, on the basis of the presence of pounding tools (1989:462) (but see Wright

1991). Henry sees the narrow range of processing tools, however, to reflect a non-intensive use of plants in the Kebaran (Henry 1989:17). New approaches for identifying plants other than cereals (such as those used at Wadi Kubbaniya) may provide more direct evidence for plant use.

Animal remains (table 2.0, figure 1.3)

Kebaran sites tend to show high frequencies of gazelle remains, ranging between 77% of the main species at Nahal Oren and 41% at Ein Gev. Fallow deer is usually the next most common species, with lower proportions of equids, wild boar, aurochs, red and roe deer, wild goat and hartebeest being found. Most faunal assemblages derive from sites in the Mediterranean belt; sites in the steppe/desert areas, e.g. Nahal Zin in the Negev, have produced few faunal remains, which underlies the importance of the early Epipalaeolithic assemblages included in the present study.

Fauna from Kebaran samples is all 'wild', and all likely to have been available fairly near to sites. From what is known of their modern ecology, species reflect a mixture of open parkland and woodland vegetation (e.g. *Gazella gazella, Equus caballus, Equus hemionus/asinus, Equus hydruntinus* - one fragment from Ein Gev I, *Sus scrofa, Bos primigenius, Alcelaphus buselaphus, Capra aegagrus, Dama dama mesopotamica, Cervus elaphus, Capreolus capreolus*).

Both sites on the Mediterranean coastal plain, Nahal Oren and Nahal Hadera V, have very high frequencies of gazelle, and a 'high' proportion of juveniles has been noted for the former, which introduced questions of whether selective cropping was practiced (Legge 1972). Fallow deer represent 15% and 20% of the main food animals at these sites respectively. This pattern is also seen at Kebara Cave in the Carmel Mountains, where Saxon observes an increase in the frequency of gazelle in the Kebaran in relation to the preceding Aurignacian period, and proposes some form of management of gazelle (Saxon 1974) (see section on gazelle below).

The only assemblage from the upper Jordan Valley - Ein Gev I - differs from this trend in that gazelle are less frequent (41%) and goat make up 18% of the assemblage (Davis 1974). Wild goats are present, but in smaller proportions, at Fazael IIIA, Fazael VI and Urkan e-Rub in the Lower Jordan Valley, where gazelle again reaches very high frequencies (e.g. 73% and 95%).

In their regional overview, Bar-Yosef and Belfer-Cohen (1989) argue that

> ... the Kebaran continued the tradition of Upper Palaeolithic hunters and hunted the abundant ungulates of the local environment
> (Bar-Yosef & Belfer-Cohen 1989:462)

Kebaran fauna (%)

site	equ	bos	sus	gaz	alc	cpr	ovi	cer	dam	cap	lep	can	vul	ss
JV														
E Gev	1	3	3	41	-	18	-	7	26	3	-	-	-	793
Ohalo	-	-	-	x	-	-	-	?	?	?	x	-	x	-
WH 26	-	-	4	50	-	*8	-	-	-	-	4	-	36	28
FZ III	-	<1	2	73	-	5	-	-	18	2	x	-	-	117
FZ VII	-	x	-	x	-	x	-	-	x	-	-	-	-	12
U Rub	-	-	1	92	-	<1	-	-	3	<1	3	-	1	671
CP														
Hay C	-	x	-	x	-	-	-	x	-	-	x	-	-	-
PC														
N Had	<1	4	<1	72	1	-	-	-	20	1	1	-	-	1347
N Oren	-	4	1	74	-	1	-	1	20	1	-	-	-	159
MC														
Keb C	5	5	-	65	2	-	-	-	23	2	-	-	-	-
I Zig	x	x	x	x	-	-	-	-	x	-	-	-	x	-
Rakef	-	x	7	77	-	2	-	-	9	-	1	-	4	91

Table 2.0. Kebaran faunal remains: selected taxa shown as % of NISP. ss=sample size; x=presence only.

equ=equids; bos=cattle; sus=boar; alc=hartebeest; cpr=goat; ovi=sheep; cer=red deer; dam=fallow; cap=roe; lep=hare; can=canid; vul=fox.
* denotes goat/sheep.

Areas:
JV=Jordan Valley; CP=Central Palestine; PC=Palestine Coast; MC=Mount Carmel.

Site codes/refs:
E Gev (Ein Gev I): Davis 1974
Ohalo (Ohalo II): Nadel 1991
WH 26 (Wadi Hammeh 26): Edwards *et al.* 1988
FZ III & VII (Fazael IIIA & VII): Goring-Morris 1980
U Rub (Urkan e-Rub IIA): Hovers *et al.* 1988
Hay C (Hayonim Cave): Bar-Yosef and Tchernov 1966
N Had (Nahal Hadera V): Saxon, Martin and Bar-Yosef 1978
N Oren (Nahal Oren VIII): Legge 1973
Keb C (Kebara Cave): Saxon 1974
I Zig (Iraq e-Zigan): Heller 1978
Rakef (Rakefet): Garrard 1980

The Geometric Kebaran and Mushabian
c. 14,500-11,700bp

Although together these complexes are geographically more widespread than the Kebaran, with numerous sites in the Negev and Sinai (Mushabian), there is no corresponding increase in subsistence data. This is due, in part, to poor preservation of organic material from the desertic regions.

Plant remains

Apart from wood charcoal, no plant remains have been retrieved from Geometric Kebaran or Mushabian deposits.

Animal remains (table 2.1, figure 1.4)

The range of fauna is similar to that at Kebaran sites, with gazelle being most frequent where information is available. At Neve David and Hefsibah on the coastal plain, for example, gazelle constitute c. 50% of each assemblage (less than in Kebaran samples), with fallow deer the next most common (43% at Neve David). Other taxa which occur in much smaller proportions are aurochs, wild boar and roe deer.

A single site in the Jordan Valley - Fazael VIII - has produced faunal remains, which are poor compared to Kebaran data from here; the few bones mentioned (deriving from an eroded section) are from fallow deer and gazelle.

Two sites in southern Jordan show contrasting pictures of animal exploitation: Wadi Madamagh near Petra has 83% wild goat (of a sample of 110 bones), whilst Tor Hamar further south has 64% gazelle and 33% caprines (probably all wild goat). Garrard explains this difference as being due to the extremely rugged habitat around Wadi Madamagh, which wild goats favour, whilst Tor Hamar is on the edge of a more steppic plateau (Henry and Garrard 1988).

As mentioned above, Mushabian sites tend not to yield organic remains: apart from a few probable gazelle bones from Lagama N VIII, and ostrich shell fragments from Mushabi Basin sites, there is a total absence of faunal remains.

Despite the relative paucity of data for the Geometric Kebaran, a fairly detailed model of resource use has been proposed by Henry (1989:138-142,166-170). He suggests that groups followed a mobile foraging strategy with episodes of seasonal aggregation and dispersal and that vertical nomadism or transhumance would have overcome seasonal food shortages. He identifies two kinds of sites: the first, which are large with deep deposits and high densities of artifacts, are found at lower elevations; the second are smaller with thin cultural deposits and low artifact densities, and are found at high elevations. Henry argues that upland sites are spring/summer occupations, whilst lowland sites are visited in autumn and winter. In support of this proposed cycle, he states that upland occupation

> would also have coincided with the period of new plant growth, resulting in the most extensive and diverse season for plant resources ... These resources would have been important foodstuffs in their own right in conjunction with attracting game animals to the higher elevations.
>
> (Henry 1989:169-170)

The model is intended for both central and northern Palestine (e.g. with Hefsibah and Neve David as lowland sites and Hayonim Terrace acting as an 'upland counterpart'), and for Mushabian sites in the Negev and Sinai. Goring-Morris also hints at seasonal use for the upland and lowland sites in the Negev and Sinai peninsula (Goring-Morris 1989), but his general interpretation differs significantly from Henry's. Firstly, he presumably sees some larger higher elevation sites as a separate entity since he terms them 'Ramonian'; in this case a transhumance model may not hold. Secondly, he sees no evidence for seasonality in the choice of Geometric Kebaran site locations in the Mediterranean belt.

Geometric Kebaran/Mushabian fauna (%)

site	equ	bos	sus	gaz	alc	cpr	ovi	cer	dam	cap	lep	can	vul	ss
JV														
FZVIII	-	-	-	x	-	-	-	-	x	-	-	-	-	6
PC														
Hefsib	-	27	-	40	4	-	-	-	27	2	-	-	-	123
N Oren	-	4	3	77	-	-	-	1	14	<1	-	-	-	968
MC														
N Dav	-	1	1	54	-	-	-	-	44	-	x	1	-	177
SJ														
T Ham	2	<1	-	65	-	33	-	-	-	-	<1	-	-	544
W Mad	x	x	x	x	-	x	-	-	-	-	x	x	-	110
N														
Hamif	-	x	-	x	x	-	-	-	-	-	-	-	-	-
N Inb	x	x	-	x	-	-	-	-	-	-	-	-	-	-
Azariq	-	-	-	x	-	-	-	-	-	-	-	-	-	-
N Sekh	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Shuner	-	-	-	x	-	-	-	-	-	-	-	-	-	-
S														
Lag N	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Mushab	-	-	-	x	-	-	-	-	-	-	x	-	-	-

Table 2.1. Geometric Kebaran/Mushabian faunal remains: selected taxa shown as % of NISP. ss=sample size; x=presence only.

equ=equids; bos=cattle; sus=boar; alc=hartebeest; cpr=goat; ovi=sheep; cer=red deer; dam=fallow; cap=roe; lep=hare; can=canid; vul=fox.

Areas:
JV=Jordan Valley; PC=Palestine Coast; MC=Mount Carmel; SJ=Southern Jordan; N=Negev; S=Sinai.

Site codes/refs:
FZVIII (Fazael VIII): Goring-Morris 1980
Hefsib (Hefsibah): Saxon, Martin and Bar-Yosef 1978
N Oren (Nahal Oren VI and VII): Legge 1973
N Dav (Neve David): Kaufman 1989
T Ham (Tor Hamar): Henry and Garrard 1988
W Mad (Wadi Madamagh): Perkins 1966
Hamif (Hamifgash I): Goring-Morris 1987:140
N Inb (Nahal Inbal): Davis 1982
Azariq (Azariq XVI): Goring-Morris 1987:140
N Sekh (Nahal Sekher 22): Goring-Morris 1987:140
Shuner (Shunera III): Goring-Morris 1987:140
Lag N (Lagama North VIII): Bar-Yosef and Goring-Morris 1977
Mushab (Mushabi V): Phillips and Mintz 1977

The Natufian and Harifian

c. 12,500-10,000bp

As in preceding periods, less subsistence data derive from the desert/steppe regions than from the Mediterranean belt. The Harifian (or desert Natufian) is under-represented in this discussion, despite the large number of sites explored in the last 20 years.

Plant remains

Four sites have yielded botanical remains: Nahal Oren and Hayonim Cave in Palestine, Wadi Hammeh 27 in the Jordan Valley, and Tell Abu Hureyra on the Euphrates in northern Syria.

Wadi Hammeh 27, an early Natufian site situated on the edge of forests, produced small quantities of wild barley (*Hordeum spontaneum*), along with a variety of legumes including lentil (*Lens* sp.) and chick pea (*Cicer* sp.), acorns and grasses (Edwards *et al.* 1988; Colledge pers. comm.). Colledge has suggested that some of the other "small round seeds" retrieved, for example of dodder (*Cuscuta* sp.), may have been gathered incidentally in the collection of other plants (Edwards *et al.* 1988:552).

Hayonim Cave, also early Natufian, has provided evidence for wild barley, wild almond nuts and legumes, particularly lupins (Hopf and Bar-Yosef 1987, quoted in Hansen 1991). The small sample from Nahal Oren yielded seeds of *Vicia* sp., including those of broad bean, and grape (*Vitis* sp.), along with grasses (Noy *et al.* 1973:92).

The most abundant and best-studied plant remains from this period are from Tell Abu Hureyra in Syria. The assemblage dates to the late Natufian, and Hillman and Colledge have identified over 150 species of potentially edible seeds and fruits which grow in a diverse range of habitats (Hillman, Colledge and Harris 1989). Amongst the grasses recovered from the site were wild einkorn, rye and oats; in response to the specific question of whether these wild-type cereals could have been cultivated, the authors conclude that there is no evidence to support this, and it is more likely that they would have been harvested from wild stands close to the site (1989:264). Wild legumes represented include lentils and vetch. Many fruits and nuts, shrubs, herbaceous plants and tubers are also in evidence. This study shows how, in this area at least, Natufian gatherers exploited an extensive range of wild plants during a minimum of two periods through the year: spring/early summer and autumn (Hillman, Colledge and Harris 1989:263).

Animal remains (table 2.2, figure 1.5)

In his review of Natufian faunal remains, Byrd (1989) observes no distinct temporal patterns between early and late Natufian settlements, but finds considerable variation between broad environmental zones. Gazelle remains dominate assemblages from the forest and coastal zones, with fallow deer and cattle as the next most frequent; wild boar, roe deer and red deer show a limited representation. Steppic and desert sites see caprines occurring much more frequently (Byrd 1989:176).

Indeed, this pattern is seen clearly in table 2.2: Nahal Oren on the coastal plain has 83% gazelle, as does Hayonim Terrace in western Galilee. Hatoula 4 and 5 in central Palestine show gazelle predominant, as do El Wad B and Kebara Cave on Mount Carmel. Likewise, in the Jordan Valley, gazelle make up between 47% at Ain Mallaha and 89% of the assemblage at Salibiya I. In contrast, two settlements in the Negev - Rosh Horesha and Abu Salem - whilst again showing gazelle predominant (58% and 52% respectively), have relatively high proportions of wild goat (36% and 44% respectively). Only at Beidha in southern Jordan (70% goat/ibex), in an extremely rocky and craggy location, and at Khallat Anaza in the eastern Jordanian desert (67% caprines), are wild caprines seen to dominate. The Natufian assemblage at Tell Abu Hureyra in northern Syria can be added to this picture; here, at the junction of the steppe and foothills, gazelle constitutes 71% of food animals exploited, with caprines making up 12% and equids 16%.

The faunal assemblages therefore seem to be specific to regions, vegetation and especially to local topography. Bar-Yosef's (1982) view is that the 'Natufian hunting strategy' was to take the available game, the mammals within immediate territories of sites. Others believe, however, that some groups had a more complex treatment of gazelles, and that this relationship reflects more than simple hunting of 'available' animals (e.g. Saxon 1974; Legge 1972; Garrard 1982; Bouchud 1987); these suggestions are considered below.

Davis has argued, using three main lines of evidence, that some Natufian sites have domestic dog present. Firstly, *Canis* sp. carnassial tooth measurements show diminution at this time, beyond that expected to result from climate or temperature change (Davis 1981), and skeletal size reduction is a characteristic often seen to accompany domestication. Secondly, an articulated puppy skeleton found with a human burial at Ain Mallaha has led to interpretations of close cultural links between humans and wolves/dogs (Davis and Valla 1978). Thirdly, Davis found high numbers of corroded small bones from Natufian levels at Hatoula, which he interpreted as being partially digested by carnivores (Davis 1987:148). The absence of such corroded specimens from earlier assemblages he studied led Davis to propose the arrival of canids on sites during the Natufian. The possibility that wild canids could produce the same results, however, should be kept in mind.

Natufian/Harifian fauna (%)														
site	equ	bos	sus	gaz	alc	cpr	ovi	cer	dam	cap	lep	can	vul	ss
EU														
Abu H	15	-	-	65	-	11*	-	-	-	-	9	-	-	154
Murey	24	3	<1	51	-	-	2	-	1	-	11	<1	8	1526
JV														
Mall e	-	5	6	64	x	6	-	4	7	8	x	x	x	687
Mall l	-	5	15	47	x	4	-	9	9	11	x	x	x	905
WH 27	1	<1	5	76	-	*7	-	<1	<1	1	5	1	3	243
Salib	-	1	5	78	-	1	-	-	2	-	5	-	7	365
FZ VI	-	3	10	73	-	10	-	-	3	-	-	-	-	30
FZ IV	-	-	5	90	-	-	-	-	5	-	-	-	-	20
Jerich	-	-	-	x	-	-	-	-	-	-	-	-	-	4
CP														
Hayo C	-	x	-	x	-	x	-	x	-	-	x	-	x	-
Hayo T	-	<1	1	83	x	<1	-	<1	14	1	-	-	-	4522
Hatoul	-	1	1	97	1	-	<1	-	-	-	<1	-	<1	2353
PC														
N Oren	-	9	4	83	-	<1	-	<1	3	1	-	-	-	1846
MC														
A Usba	x	x	x	x	-	x	-	-	x	x	x	x	x	-
El Wad	x	x	x	x	?	x	-	?	x	?	x	x	x	-
Kebara	4	14	11	48	11	-	-	4	7	2	-	-	-	-
Rakef	-	1	4	82	-	1	-	3	6	1	1	<1	2	983
SJ														
Beidha	2	6	-	22	-	70	-	-	-	-	-	-	-	129
W Jud	16	10	-	32	-	19	22	-	-	-	1	-	-	125
N														
R Hor	2	<1	-	60	-	37	-	-	-	-	1	-	<1	989
A Sal	1	-	-	53	-	45	-	-	-	-	1	-	<1	1156
R Har	x	x	-	-	-	x	x	-	-	-	-	x	-	-
R Zin	x	-	-	x	-	x	-	-	x	-	-	-	-	-
S Har	-	-	-	x	-	-	-	-	-	-	-	-	-	-

Table 2.2. Natufian/Harifian faunal remains: selected taxa shown as % of NISP. ss=sample size; x=presence only.

equ=equids; bos=cattle; sus=boar; alc=hartebeest; cpr=goat; ovi=sheep; cer=red deer; dam=fallow; cap=roe; lep=hare; can=canid; vul=fox.
* denotes goat/sheep.

Areas:
EU=Euphrates; JV=Jordan Valley; CP=Central Palestine; PC=Palestine Coast; MC=Mount Carmel; SJ=Southern Jordan; N=Negev.

Site codes/refs:
Abu H (Abu Hureyra): Legge 1975
Murey (Mureybet Ia): Helmer 1991
Mall e and l (Mallaha early levels II, III, IV; late level I): Bouchud 1987; I have amalagamated Ducos' (1968) results with Bouchuds, given in Bouchud 1987:17 table II.
WH 27 (Wadi Hammeh 27): Edwards *et al.* 1988
Salib (Salibiya I): Crabtree *et al.* 1991
FZ VI, IV (Fazael VI, IV): Goring-Morris 1980
Jerich (Jericho): Clutton-Brock 1979
Hayo C (Hayonim Cave): Bar-Yosef and Tchernov 1966
Hayo T (Hayonim Terrace): Henry *et al.* 1981
Hatoul (Hatoula 4 + 5): Davis 1985
N Oren (Nahal Oren): Legge 1973
A Usba (Abu Usba Cave): Stekelis and Haas 1952
El Wad (El Wad B): Bate 1937
Kebara (Kebara Cave): Saxon 1974
Rakef (Rakefet): Garrard 1980
Beidha (Beidha): Hecker 1989
W Jud (Wadi Judayid): Henry and Turnbull 1985
R Hor (Rosh Horesha): Butler *et al.* 1977
A Sal (Abu Salem): Butler *et al.* 1977
R Har (Ramat Harif): Goring-Morris 1987:365
R Zin (Rosh Zin): Tchernov 1976
S Har (Shluhat Harif): Goring-Morris 1987:329

The PPNA
c. 10,500-9,200bp

Plant remains

It is from this period that the earliest evidence available for domesticated, and therefore cultivated plants comes. Tell Aswad in Syria (Damascus Basin) has domesticated emmer wheat and two-row hulled barley, as probably do certain sites in the Jordan Valley and coastal Palestine (Netiv Hagdud, Jericho, Nahal Oren) (from review by Hansen 1991). Jericho also has einkorn. Mureybet on the Euphrates continues to see the collection of wild einkorn and barley (Hansen 1991), although this is described as 'intensive' (Bar-Yosef and Belfer-Cohen 1989). Wild fruits and seeds are also evidenced.

Animal remains (table 2.3, figure 1.6)

The late Pleistocene trend of faunal remains varying on a regional/environment basis continues in the PPNA. In the Euphrates region, equids are represented (at Mureybet) in higher proportions than seen previously in the Levant. They were also present here in higher percentages than elsewhere in the preceding Natufian (e.g. at Abu Hureyra and Mureybet).

In the Jordan Valley, where quantified data are available, gazelle continues to dominate assemblages. In the woodland and coastal zones of Palestine, gazelle representation is also high, as in preceding periods. At Nahal Oren, Legge observes 'high' proportions of juvenile gazelle, as he does in Kebaran and Natufian levels from the site, and similarly he infers selective culling in the PPNA. At Hatoula, Davis (1985) finds no evidence of selective gazelle culling, and observes what he considers a 'normal' percentage of juveniles culled (32%). The site of El Khiam has a very high percentage of goat bones; this is more similar to some of the Epipalaeolithic assemblages from southern Jordan and the Negev, and probably reflects the rocky craggy location of the site. All *Capra* sp. and *Ovis* sp. bones found are believed to be from wild animals.

A trend which Davis has observed in the PPNA of Hatoula is notable (1985; 1991): he found higher proportions of smaller animals in the PPNA than he did in the Natufian levels at this site, and notes also the high frequencies of bird and fish. Davis sees this as a culmination of a late Pleistocene trend from large ungulates to small mammals, and this is discussed below.

PPNA fauna (%)														
site	equ	bos	sus	gaz	alc	cpr	ovi	cer	dam	cap	lep	can	vul	ss
EU														
Mur Kh	46	5	3	39	-	-	6	-	2	-	-	-	-	-
Mur M	62	9	2	25	-	-	<1	-	3	-	-	-	-	-
JV														
Gesher	-	-	3	91	-	-	-	-	-	-	3	-	3	65
Gilgal	-	x	x	x	-	-	-	-	x	-	x	x	x	-
N Hag	-	-	x	x	x	x	-	-	x	-	x	x	x	-
Jer	<1	6	10	53	-	*2	1	-	<1	<1	-	x	23	554
CP														
Hat	-	2	1	92	?1	-	?1	-	-	-	3	-	2	279
Khiam	1	1	<1	14	-	83	-	-	-	-	-	-	<1	326
PC														
N Oren	-	2	4	88	-	3	-	<1	3	1	-	-	-	516

Table 2.3. PPNA (Khiamian/Sultanian) faunal remains: selected taxa shown as % of NISP. ss=sample size; x=presence only.

equ=equids; bos=cattle; sus=boar; alc=hartebeest; cpr=goat; ovi=sheep; cer=red deer; dam=fallow; cap=roe; lep=hare; can=canid; vul=fox.
* Jer (Jericho) also has a category of goat/sheep constituting 1%.

Areas:
EU=Euphrates; JV=Jordan Valley; CP=Central Palestine; PC=Palestine Coast; SJ=Southern Jordan.

Site codes/refs:
Mur Kh (Mureybet I=VIII, Khiamian): Ducos *et al.* 1978
Mur M (Mureybet X-XVII, Mureybetian): Ducos *et al.* 1978
Gesher (Gesher): Horwitz and Garfinkel 1991
Gilgal (Gilgal I-IV): Noy, Schuldenrein and Tchernov 1980
N Hag (Netiv Hagdud): Bar-Yosef, Gopher, Tchernov and Kislev 1991
Jer (Jericho): Clutton-Brock 1979
Hat (Hatoula 2 and 3): Davis 1985
Khiam (El Khiam): Ducos 1966
N Oren (Nahal Oren): Legge 1973

The PPNB/PPNC
c. 9,600-7,500bp

Plant remains

This period witnesses an expansion in the variety of cultivated plants: einkorn, emmer, and bread wheat, two-row and six-row barley, and a range of legumes, including chickpeas, broad bean and bitter vetch are evidenced (Hansen 1991).

Animal remains (table 2.4, figure 1.7)

Table 2.4 shows faunal remains from all phases of the PPNB/PPNC together which obscures temporal trends, particularly the appearance of caprines (sheep and goat) at some sites. This much debated issue, however, is dealt with separately below and only broad patterns are mentioned here.

Sites in the Euphrates area of northern Syria/eastern Turkey tend to have much higher frequencies of caprines than previously noted for the area, and a corresponding decrease in gazelle. This switch is best seen in the two phases of Abu Hureyra where caprines replace gazelles as the most common animals. The low proportion of equids compared to earlier periods is also notable.

Preliminary reports from Damascus Basin sites (Aswad and Ghoraife) show caprines making up at least 40% of each assemblage, and the Ghoraife sequence shows sheep replacing goat as the dominant taxon in the later phase (II).

Jordan Valley sites also see an increase in caprines and decline in gazelle compared to earlier periods, whilst the Mediterranean zone (central and coastal Palestine) has more variation: some sites have high gazelle counts (Rakefet), and others have significant numbers of caprines (Abou Gosh, Atlit). The two phases of Ain Ghazal on the Jordanian plateau show the proportion of caprines to increase through time.

Beidha in southern Jordan continues to see goats dominating the assemblage as they did in the Natufian levels. Neighbouring Basta, however, has high numbers of both sheep and goat, and is one of the earliest sites to show both these animals morphologically domestic. The goats at Negev and Sinai sites are believed to be wild (usually ibex). Bar-Yosef (1984) has proposed a seasonal mobility model for hunter-gatherers in the southern Sinai during the late PPNB: he suggests winter sites will be in sheltered depressions, whilst open valleys would be occupied during summers. The very high relative proportion of hare bones at Wadi Tbeik is notable since no other sites, contemporaneous or earlier, have this pattern.

PPNB/PPNC fauna (%)

site	equ	bos	sus	gaz	c/o	cpr	ovi	cer	dam	cap	lep	can	vul	ss
EU														
Grit	-	3	17	x	71	-	-	-	x	x	x	x	-	-
Hayaz	-	12	21	<1	59	2	3	*1	-	<1	1	<1	<1	2213
Asouad	1	12	10	21	-	32	23	-	<1	-	-	<1	-	615
AbuH e	6	4	1	82	6	-	-	-	1	-	1	<1	<1	1500
AbuH l	1	8	1	19	71	-	-	-	-	-	1	-	1	504
T Sinn	1	5	-	1	79	4	8	-	-	-	-	<1	<1	590
Bouqr	-	43	1	6	-	20	27	-	2	-	<1	-	<1	1074
DB														
Aswad	-	x	x	x	x	40	-	-	-	-	-	-	-	-
GhorI	-	-	-	x	x	30	10	-	-	-	-	-	-	-
GhorII	-	-	-	x	x	10	40	-	-	-	-	-	-	-
JV														
Munhat	-	13	23	27	21	12	-	-	-	4	-	-	1	565
Beis	3	1	27	14	-	53	-	-	1	-	-	-	-	77
Jer	1	12	15	14	4	44	2	-	-	-	-	x	8	773
CP														
Abou G	-	18	13	13	-	56	-	-	<1	-	-	-	-	3618
Yift	-	x	x	x	-	15	-	-	x	x	-	-	x	-
Kfar H	-	x	x	x	-	x	-	-	x	-	x	-	x	-
PC														
N Oren	-	2	5	76	-	14	-	-	1	2	-	-	-	570
Atlit	-	47	13	1	-	38	-	-	?1	-	-	-	-	145
MC														
Rakef	-	1	5	83	-	<1	-	1	5	<1	1	-	3	715
JH														
AG 1	-	13	7	15	24	33	1	-	-	-	2	<1	5	2753
AG 2	1	6	13	10	26	8	36	-	-	-	<1	<1	<1	791
SJ														
Beidha	-	2	<1	7	-	90	-	-	-	-	-	-	-	3041
Basta	4	4	<1	10	-	49	33	-	<1	-	-	<1	-	36534
N														
N Div	-	x	-	x	-	x	-	-	x	-	-	-	-	-
N Iss	x	-	-	x	-	x	-	-	-	x	-	-	-	-
S														
Ujrat	<1	<1	-	1	-	92	-	-	-	-	6	-	1	2478
Tbeik	2	<1	-	9	-	25	-	-	-	-	65	-	x	933

Table 2.4. PPNB (early, middle, late, final/PPNC) faunal remains: selected taxa shown as % of NISP. ss=sample size; x=presence only.

equ=equids; bos=cattle; sus=boar; c/o=goat/sheep; cpr=goat; ovi=sheep; cer=red deer; dam=fallow; cap=roe; lep=hare; can=canid; vul=fox.

*=red or fallow deer.

Areas:

EU=Euphrates; DB=Damascus Basin; JV=Jordan Valley; CP=Central Palestine; PC=Palestine Coast; MC=Mount Carmel; JH=Jordan Highlands; SJ=Southern Jordan; N=Negev; S=Sinai.

Site codes/refs:

Grit (Gritille Höyük): Stein 1986
Hayaz (Hayaz Höyük): Buitenhuis 1988:82-98)
Asouad (Asouad-Djezireh): Helmer 1985a
AbuH e and l (Abu Hureyra early and later PPNB): Legge 1975
T Sinn (Tell es Sinn): Clason 1980
Bouqr (Bouqras): Buitenhuis 1988:41-88
Aswad (Aswad I and II): Ducos 1993
Ghor I and II (Ghoraife I and II): Ducos 1993
Munhat (Munhatta): Ducos 1968; the 21% goat/sheep originally identified as *Ovis orientalis*, but I assume this is under question since later publications (e.g. Ducos 1993) do not mention them.
Beis (Beisamoun): Davis 1978
Jer (Jericho): Clutton-Brock 1979
Abou G (Abou Gosh): Ducos 1978; the rel. freq. of small ruminants is based on a sample of 340
Yift (Yiftahel): Horwitz 1987
Kfar H (Kfar Hahoresh): Goring-Morris 1991
N Oren (Nahal Oren): Legge 1973
Atlit (Atlit): Horwitz and Tchernov 1987
Rakef (Rakefet): Garrard 1980
AG 1 and 2 (Ain Ghazal PPNB and PPNC): Köhler-Rollefson *et al.* 1988; Wasse pers.comm.; the percentages of goat and sheep are based on Wasse's recent study of caprine samples (256 bones from PPNB, 97 from PPNC); I have divided the original caprine category identified by Köhler-Rollefson according to Wasse's percentages.
Beidha (Beidha II-III): Hecker 1975
Basta (Basta): Becker 1991
N Div (Nahal Divshon D1): Tchernov 1976
N Iss (Nahal Issaron): Goring-Morris and Gopher 1983:157-8
Ujrat (Ujrat el-Mehed): Dayan *et al.* 1986
Tbeik (Wadi Tbeik): Tchernov and Bar-Yosef 1982

Discussion of selected taxa

The main taxa represented at the study sites in eastern Jordan are gazelle, equids, hare and caprines, as seen below in Chapter 6. The archaeozoological interpretation of these taxa in the Levant is discussed here in further detail.

Gazelle

All gazelle species have been treated together in tables 2.0-2.4. Those which have been identified from the Levant are *Gazella gazella*, whose finds derive mainly from lusher areas (although Tchernov *et al.* 1986/87 have recently identified it from the southern Sinai), *Gazella dorcas*, which appears to have had a more arid zone distribution, and *Gazella subgutturosa*, predominantly a steppe inhabitant.

The dominance of gazelle bones at numerous Epipalaeolithic and Neolithic sites in the Levant has stimulated, and continues to stimulate, great interest. Their high counts have been considered relevant in three main spheres of research: 1) palaeoenvironmental reconstructions, 2) as signs of hunter-gatherers' intensification of food production, and 3) as indications of seasonal occupation and hunting. Debate on the relationship between prehistoric groups and this taxon is very much alive.

Garrod and Bate's hugely influential work on the Mount Carmel Caves (1937) was one of the first to note the high proportions of gazelle from certain prehistoric levels. They interpreted fluctuations between the two dominant taxa - fallow deer and gazelle - as reflections of moist and arid climatic periods, therefore disregarding potential preference on the part of hunters.

Garrard's (1980; 1982) re-examination of the Mount Carmel fauna in the light of newer palaeoenvironmental evidence (derived from multiple sources) concluded that the high proportions of gazelles from the Natufian levels defied expectations. (Incidentally, the argument remains unchanged in the light of more recent palaeoenvironmental reconstructions - see Chapter 1). Palaeoenvironmental data suggested a woodland Natufian-period landscape, whilst the fauna from the Mount Carmel Natufian levels was actually representative of open country. Garrard saw two possible interpretations of this contradiction: firstly, fire clearance of woodlands may have been taking place in the Natufian, although unevidenced, which may have altered faunal distributions. Secondly, groups could have developed a loose herding relationship with gazelle during the Natufian, which accounted for the high frequency of this taxon. This contribution provided a convincing argument that some Natufian-period hunter-gatherers were directly or indirectly shaping access to, or distribution of, their resources.

Similar conclusions, of a Natufian-period bias towards gazelle, had been drawn by Henry (1975). He found gazelle remains dominant at sites across varied phytogeographic zones (from modern woodland areas to steppe/desert; from areas today receiving 800mm to 200/100mm rainfall), leading him to suggest a human 'cultural filter' was in operation, regardless of local environment. Henry proposed that hunter-gatherers chose gazelle-rich hunting territories, and also that effective drive-hunting techniques produced the high proportions of these animals, an idea which has been developed over the last twenty years. More recent data in table 2.2 show that there **are** Natufian faunal assemblages which are not gazelle-dominant (Beidha, Wadi Judayid); this suggests that hunting practices were not so uniform across general time periods as Henry described.

Assemblages with high gazelle counts lent themselves to the new ideas of the Higgs palaeoeconomy school in the 1970's - ideas which challenged the traditional fixed categories of 'domestic' and 'wild' animals, and argued that a wide range of 'man-animal relationships' existed (cf. Higgs and Jarman 1972). Another Higgsian line was that there is "no reason for making the assumption that husbandry is an exclusively Postglacial phenomenon" (Higgs and Jarman 1972:12). Such concepts had particular applicability to the Levantine Epipalaeolithic, especially the Natufian, which was often viewed as the precursor, culturally and economically as well as temporally, to the period witnessing the earliest cereal cultivation and animal domestication (e.g. Mellaart 1965).

In his review of prehistoric gazelle exploitation in Palestine, Legge argued that the particular relationship existing between human groups and gazelle at Nahal Oren was equivalent, in principle, to domestication where animals are managed for the maximum reproductive potential of the herd (Legge 1972:123). This is primarily based on the observations of "the very high frequency of immature gazelle at Nahal Oren" (54%, 55% and 50% for the Kebaran, Natufian and PPN repectively), which Legge interpreted as selective cropping for herd maintenance. The implication is that Legge saw selective culling for the whole time sequence (Kebaran to Neolithic). He argues that gazelle **could** be tamed, and their present wild status does not mean they were never domesticated.

Legge's proposal was challenged on two main counts. Firstly, several authors argued that the territorial behaviour of gazelle, their wide-ranging feeding habits, and their need for inter-individual distance, would not have permitted even loose herding, yet alone a form of domestication (Clutton-Brock 1978:50; Simmons and Ilany 1977; Garrard 1984). Secondly, others questioned whether the proportions of juveniles which were claimed to be 'high' were in fact higher than expected in unmanaged herds. Collier and White (1976) reviewed population structure data of several herd ungulates, actually in response to claims of caprine domestication rather than gazelles, although they inspired critiques of the latter; they found proportions of juveniles within herds to vary greatly both through the year, and between populations. Subsequently Simmons and Ilany (1977) and Henry and Garrard (1988) drew on population structure data from modern gazelle herds in Israel to conclude that Legge's 'high' juvenile percentages could be expected in herds in the wild at certain times of the year. These works stressed the importance of animal behaviour studies in the interpretation of cull patterns, and found that gazelle hunting could produce the same results as the patterns interpreted by Legge as herding.

Saxon's (1974) proposal of a mobile gazelle herding economy, based on the fauna from Kebara cave, was subject to similar criticism. He argued for selective culling of male animals, with the intention of extracting large returns with the least impact on the herds' breeding capacity. The data were not particularly convincing (he used horncores - likely to be subject to many biases - to produce a sex ratio of 26 males to 7 females); but theoretically, as Simmons and Ilany (1977) pointed out, hunting primarily of male bachelor groups, whether intentionally selective or not, would produce the same results as Saxon's 'herding' pattern.

More recently, the theory that gazelles underwent a form of 'proto-domestication' has been revived by Cope (1991), who uses metrical analyses of gazelle bones from late Pleistocene/early Holocene sites (Hayonim Cave, Kebara Cave and Terrace, Mallaha, Hatoula) to explore the issue. In brief, Cope finds the gazelle astragalus to exhibit sexual dimorphism (Horwitz, Cope and Tchernov 1990) and since it survives well, she bases sex ratios on this bone. From her seven assemblages, the two which precede the Natufian have roughly equal male:female ratios, as does the Natufian/PPNA sample; whilst the four Natufian samples show male biases ranging between 80:20 and 60:40 (Cope 1991:346 table 2). These are interpreted as showing intentional Natufian sex selection.

The second part of Cope's study involves a comparison of the size of bone elements, and size ranges, over time. She finds the diminution in gazelle bone size between the Palaeolithic and end of the Epipalaeolithic, which has been identified by Davis for this taxon and many others, and interpreted convincingly as a response to temperature change (Davis 1981). She also finds an **increase** in size variation of certain gazelle bones in the Natufian, compared to previous periods, and a synchronous dwarfing of some elements more than others. This pattern is interpreted in the following way: the overhunting of male animals in the Natufian reduced the gene pool of gazelle populations and restricted female choice; this resulted in a release of stored genetic variability producing greater size variation, with a decrease in size of some elements only (Cope 1991:356-7). This scenario is not immediately convincing since, as Cope herself admits, under circumstances of known domestication, the size variation of animals **decreases** rather than increases. Also, she does not adequately explore other reasons for the uneven dwarfing of skeletal elements: for example, would temperature-related body size diminution affect all elements equally? These issues need fuller consideration before Cope's argument would have credence.

Returning to juvenile gazelle counts, Davis found an explanation for variation which avoided any idea of selective hunting (Davis 1983). In brief, when he plotted the juvenile percentages from a series of sites ranging from the Mousterian to Natufian, he found an increase in the Natufian, from c. 27% to c. 33% (he did not include Legge's results from Nahal Oren, which have a much higher pre-Natufian juvenile count). Davis' preferred explanation for this increase was that assemblages with lower proportions of juveniles reflected winter hunting, when there are fewer young animals in nature, and the higher Natufian count represented year-round hunting and the higher mean annual proportion of juveniles in herds. He also finds a wider range of gazelle tooth (m_3) crown height measurements at the Natufian site than at earlier sites, which supports an interpretation of summer **and** winter occupation, as opposed to winter occupation alone earlier (Davis 1983:61). This contribution to the gazelle debate was extremely important since it actually applied modern gazelle population data to the archaeological record, and showed how much variation in the juvenile count **could** be explained by seasonality alone. Davis' conclusions feed into questions of changing mobility and settlement patterns, and the specific issue of Natufian sedentism.

The seasonality theme has been taken up by Liebermann (Lieberman *et al.* 1990; Lieberman 1991; 1993), who has examined cementum increments on gazelle teeth from a host of late Pleistocene Levantine sites as a means of exploring seasons of occupation. His results support arguments, including Davis', for longer-term occupation, or sedentism, at some Natufian sites, whilst earlier Epipalaeolithic sites show hunting during only one or two seasons (e.g. winter/spring) by this method (Lieberman 1993:607 table 1).

In the last decade, the idea that gazelles were hunted using drives and surrounds has become more popular, perhaps partly resulting from studies in the eastern Jordanian desert and the Negev which document the extent and nature of 'kite' structures, believed to have been for taking gazelle (Helms 1981; Betts 1983; 1984; Betts and Helms 1986; Helms and Betts 1987; Meshel 1974; 1976).

In the Natufian levels of Abu Hureyra in northern Syria, Legge and Rowley-Conwy (1987) found strong signs of (spring) seasonal culling from gazelle tooth crown-height measurements and bone measurements. In addition, age profiles showed animals of every age group were culled, including the very young and the very old. Legge and Rowley-Conwy argued "[t]his pattern undoubtedly resulted from a killing technique in which an entire herd was taken at once" (1987:91), and proposed that the occupants of Abu Hureyra were mass-killing gazelles on a seasonal basis using kite structures. They predicted the gazelle herds to have been migratory, and therefore only seasonally available; gazelle migration routes were suggested, based on sightings of early European travellers, and they speculated that the southerly point of the migration was eastern Jordan (the study area) or northwestern Saudi Arabia (Legge and Rowley-Conwy 1987:91).

Campana and Crabtree (1990) also argue for whole herd gazelle hunting at Natufian Salibiya I in the Jordan Valley on the basis of an "overall age profile of the gazelle bones ...

[which] closely resembles that recorded by Baharav for modern mountain gazelles" (ibid:230). They interpret this as 'communal hunting' and draw on ethnographic accounts of techniques to suggest that nets could have been used for hunting in the Natufian.

Mortality profiles are notoriously ambiguous, and as Edwards (1991) points out, in criticism of Campana and Crabtree's theory, the time resolution of Natufian deposits does not allow interpretation of assemblages as if they were discrete events; 'catastrophic' mortality profiles, i.e. those which theoretically result from mass kills, could equally result from the culling of different age groups over time (Davis 1983:55). Problems also arise with the identification of whole herd kills because, as mentioned above, the complexity of gazelle social organization means that the 'whole herd' is a variable entity, both seasonally and between populations. However, when one animal is clearly the object of hunting, as gazelles are at both Abu Hureyra and Salibiya I, it would not be implausible for groups to have practised mass killing and driving (cf. Driver 1990); and animals which are predictable in their behaviour and location at certain times of the year are frequently seen to be the focus of organized hunting tactics (cf. Davis and Reeves 1990). Nevertheless, arguments for gazelle mass capture techniques in the Natufian remain an inference from ethographic and historical sources, rather than from faunal assemblages, or even from the existence of drive structures.

These main interpretations of gazelle exploitation in the Levant show a range of approaches and conceptual frameworks. Some see gazelles in certain areas as being under human control in the Natufian, or earlier, with high degrees of hunting selection and herd management practised (Legge 1972; Saxon 1974; Cope 1991; Tchernov 1993); others find explanations of opportunistic hunting preferable (Davis 1983); whilst some specify certain hunting techniques (Henry 1975; Legge and Rowley-Conwy 1987; Campana and Crabtree 1990), but no selective practices within these. None specify that these are exclusive strategies, and variability of practice between areas and sites is accepted (e.g. Butler *et al.* 1977 for Negev sites).

All studies draw to some extent on gazelle behaviour. Many use modern data on herd structure, distribution and mobility fairly directly, although Hovers *et al.* (1988), in their interpretation of the cull patterns at Urkan e-Rubb, caution against straightforward analogy. There is a tendency also to assume that certain species of gazelle have fixed behaviour patterns, for example *Gazella gazella* will not have pronounced birth peaking, whilst *G. dorcas* will (Simmons and Ilany 1977), and to apply this to prehistoric periods; this approach is challenged in Chapter 4. Legge and Rowley-Conwy (1987) have been most concerned with behavioural **reconstructions**, i.e. seeing animal behaviour as adaptive to ecological conditions, although still seeing particular aspects of behaviour as being species-specific. They draw firstly on the ecology of the Persian gazelle (*G. subgutturosa*), the species identified at Abu Hureyra, and secondly on historic accounts of gazelle movements to model prehistoric gazelle migrations in a region where this animal is now extinct. They predict the formation of large herds which move long distances in search of forage and moisture, but which break up into small groups in summers (Legge and Rowley-Conwy 1987:92-93). The behavioural ecological approach is explored in Chapter 4.

Equids

All equids have been treated together in the above tables, which obscures whether representation includes the large wild horse (*Equus caballus/ferus*) or the smaller asses (*Equus asinus/hemionus, Equus hydruntinus, Equus africanus*). Most evidence, however, points to a disappearance of the wild horse during the late Pleistocene, with a continued presence of the more arid-adapted asses through the Neolithic (Clutton-Brock 1991; Uerpmann 1982; 1987).

Tables 2.0 to 2.1 show very low frequencies of equids in the Kebaran and Geometric Kebaran/Mushabian, and in the Natufian and PPNA a higher representation is seen only at Abu Hureyra and Mureybet on the Euphrates and at Wadi Judayid in southern Jordan. This may reflect the locations of these sites - at edges of open plains/steppes - which is preferred equid habitat. By far the majority of excavated sites are in woodland zones, or rugged terrain (e.g. Negev and Sinai) where wild equids would not be expected in large numbers.

The widespread decline in equid representation in the PPNB is not explicable by site location alone: Ain Ghazal, for example, on the edge of the Jordanian steppe, has very low proportions, as does Abu Hureyra. Köhler-Rollefson questions whether this is due to the increasing aridification of the early Holocene, or changes in hunting practices (Köhler-Rollefson 1990). Other ideas (drawn from Clutton-Brock 1992) include overhunting, or a suggestion that changes in the ways human groups used the landscape during this period interfered with equid grazing land and migration routes, and hence pushed out herds. Aridification seems a poor explanation, since the wild ass/onager is believed to tolerate arid conditions (Garrard 1980); ideas of hunting practice (including overhunting) and disruption of equid herds will be considered in relation to the declining frequency of these animals in the eastern Jordanian sequence.

Hare

Hare bones are possibly more subject to biases in preservation, retrieval and reporting (because they are not considered major food animals) than the larger mammals discussed here, and therefore the hare data should be treated cautiously. The species represented in tables 2.0-2.4 potentially include *Lepus capensis* and *Lepus europaeus*.

Kebaran and Geometric Kebaran assemblages have low percentages of hare bones, the highest being 3% from Urkan e-Rub in the Jordan Valley (disregarding the tiny sample from WH 26). Two Natufian sites in the Euphrates region see higher frequencies (9% and 11%); others in the Jordan Valley have 5%, whilst elsewhere they are in very low proportions. In the PPNA, two sites have 3% hare, and following table 2.4, these rough proportions continue in the PPNB, except in the Sinai where hare bones dominate the assemblage from Wadi Tbeik (65%).

Tchernov (1991; 1993) sees a slightly different pattern, drawing on unspecified assemblages which are presumably not yet published. He observes hare to undergo a "... conspicuous increase in its exploitation in the Natufian ..." in the southern Levant (Tchernov 1991:330), which is not particularly evident in table 2.2 if the Euphrates data (i.e. northern Levant) are removed. Tchernov sees the increase to continue in the PPNA and PPNB (Tchernov 1991:331 figure 7; 1993:26 figure 1), again a pattern which is not apparent from available data used to compile tables 2.3 and 2.4 (except for the single case of Wadi Tbeik). Considering the overall low hare representations shown in tables 2.3 and 2.4, it appears likely that Tchernov based his conclusions on selected PPNA and PPNB sites only. Nevertheless, he explains the increase in hare representation from the Natufian onwards as part of a widening of the range of food resources used (a broadening of the species spectrum), resulting from an overuse of the traditional sources of larger game animals, ultimately relating to longer-term occupation of sites:

> ... sedentary humans populations were forced, through specialized hunting techniques, to rely on much less energetically (in terms of amount of meat per catch) rewarding animals (like *Lepus* and *Alectoris*), and many small species became newly and highly represented in all Natufian layers.
> (Tchernov 1993:13)

Problems with interpretations of a broadening of the food spectrum are discussed below.

Tchernov interprets the extremely high percentage of hare at Wadi Tbeik in the Sinai differently however. The architecture at this PPNB site does not suggest long-term occupation, but rather seasonal use. In explanation of the faunal pattern, he argues "during this period these regions were still much more mesic and allowed intensive hunting" (Tchernov 1993:16). This does not in itself seem adequately to explain the high representation of hare, since Natufian/Harifian hunting sites in the Negev, presumably in equally or more 'mesic' environments, have very low counts of hare (table 2.2). Tchernov may be implying that intensive hunting had depleted the larger mammals, forcing groups to catch more hare, although this is not stated. Whatever, it would seem that the dominance of hare at Wadi Tbeik relates to different use of the local area from earlier occupation, whether in terms of mobility, hunting practices or season of occupation. These issues will be considered in relation to the increase in hare representation seen at some of the Neolithic study sites in eastern Jordan.

Caprines

The prime interest in the presence of caprines in the early Holocene Levant has been in their emergence as major early domesticates, although wild goat (*Capra aegagrus*) and ibex (*Capra ibex*), and the occassional wild sheep (*Ovis orientalis*) were hunted in certain locales throughout the late Pleistocene.

Discussion of domestication is fraught with confusion, firstly due to varied definitions of the word itself, and secondly because different criteria have been used to identify domesticates archaeozoologically. It is for these reasons that the broad genus names (*Ovis* sp., *Capra* sp.) are used in the tables in this chapter. Here, the problems of recognizing the changing human relations with sheep and goat are explored, and the evidence reviewed.

Definitions of domestication

There is a tension between the use of the word 'domesticate' to describe both a state and a process. Following Meadow (1989:81), I use 'domestication' to refer to the process, and 'domestic animals' or 'domesticates' as the end results of this process. Problems arise with attempts to describe animals at early stages of the process (e.g. caprines in the Neolithic of the Near East), if, indeed that is what it was (see below).

Many agree on a simple definition of a domestic animal - "... one whose breeding is largely controlled by humans" (Davis 1987:126), or one bred in captivity, generally implying that breeding stock has been separated from wild populations. Some describe the **process** as representing a change in the focus of human-animal relationships towards the living animal and its progeny, rather than the products of carcasses (Meadow 1984), or where living animals are integrated as alienable objects into the socio-economic organization of human groups (Ducos 1978; 1989). Bokonyi stands alone in attributing both the initial "... capture and taming by man of animals of a species ...", along with a second stage involving breeding, to one intentional process of domestication (Bokonyi 1969:219). Most others remove intentionality from the discussion, preferring to concentrate on identifying the relationship between people and animals.

Higgs and Jarman (1972), and Jarman and Wilkinson (1972) identified both theoretical and methodological problems with using the term 'domesticate' (in both contexts) in archaeozoology. They found it inappropriate to focus on a single dichotomy between domesticates or non-domesticates when a whole range of relationships obviously exist between humans and animals which do not necessarily correlate with animals being morphologically domestic or wild (see also Ingold 1980, who sees the productive relations between humans and animals as being of prime importance). They also questioned whether the isolation of animal populations - the stage after which most archaeozoologists aim to identify domesticates - is a useful conceptual dividing line, for two reasons. Firstly, the assumption that population isolation actually occured in early economies is not well founded. Secondly, even had population isolation occurred, there is no inherent reason to believe that morphological changes would result. Any changes, in size or morphology, would be due to selective pressures.

Many archaeozoologists responded to Jarman and Wilkinson's (1972) call, and explored human-animal relationships around the time of assumed domestication through animals' cull patterns (e.g. Hecker 1975 proposed 'cultural control' of wild goats; Ducos 1978 and 1993 sees 'proto-élevage' of cattle and caprines; Horwitz 1989 models a phase of 'incipient domestication' for caprines; Cope 1991 argues for the 'proto-domestication' of gazelle). That many of these new terms imply that they occurred **before** domestication suggests that there is still a search for markers for a state of true domesticates, and that the term 'domestication' has some currency as defining a fixed relationship between humans and animals.

The above suggests that the term domestication should properly be put aside when dealing with late Pleistocene/early Holocene human-animal relationships. Use of the term tends to breed unilineal models in which the end result is pre-ordained, rather than exploring the spectrum of possible human-animal relationships (cf. Higgs and Jarman 1969). An attempt should be made to assess relationships, appreciating potential regional and temporal variability, and avoiding the tendency to force them into unilineal models which typically result in domesticates. I will, however, retain use of the term domesticate in the following discussion of caprines, to refer to animals with which people have **already** established extremely close physical contact, which people breed from, and do not hunt, which they probably herd or keep penned for most of the time, and which they manage in some way.

Evidence used to recognize caprine domesticates

A vast literature exists on the methods and problems of identifying domesticated animals from faunal assemblages (see recent comprehensive and critical reviews by Meadow (1989) and Horwitz (1989)). In brief, six criteria are commonly applied to sheep and goat remains:

1) **Zoogeographic evidence**: the presence of animals outside their natural wild range is one of the most reliable indicators of human importation. Heavy reliance is placed upon knowledge of past animal distributions; other causes, such as fluctuating distributions or sudden irruptions of animals into new areas, need to be dismissed. Wild goats are known from many late Pleistocene sites in the southern and northern Levant. The traditional view of the southern Levant being outside the range of wild sheep, making humans responsible for their presence there in the Neolithic, has been challenged in the last decade by occasional late Pleistocene finds in the Damascus Basin, Jordan Highlands and Negev (table 2.5).

2) **Changes in animal frequency**: as with 1), changes observed in the relative proportions of animals at sites can be attributable to other factors, such as changing environmental conditions, animal movements or hunters' changing prey preferences, as well as to the introduction of domesticates. Another problem of using sudden species spectrum change as an indicator of the appearance of domesticates (whether locally derived or imported) is that few sites have the multiple time sequences required to identify 'change'. Comparisons of sites within the same areas suffer from problems of time resolution (are they contemporaneous?), and from the potential for variation in subsistence practices at neighbouring sites, even when coeval.

3) **Age and sex structures of culls**: this approach relies on the identification of age and sex ratios different from those believed to characterize wild populations of the taxon. The method has received criticism on many grounds. Firstly, it assumes normal demographic structures exist for wild populations, when in fact wide variation is likely both between populations and within populations at different times of year, and under changing conditions (e.g. Chapter 4; Collier and White 1976; Simmons and Ilany 1975-77). Secondly, particular cull patterns are not unique to fixed human-animal relationships: hunters can potentially selectively cull; domesticates may be subject to a variety of management practices resulting in different animals being culled; or as Meadow (1989) points out, both hunters and herders may have social reasons for killing, or not killing, certain animal classes, or conversely, they may have no choice in what is killed at all.

4) **Morphological evidence**: for caprines, horncores are often considered morphologically different between wild and domestic populations. Morphological variation in the wild, however, is not well understood which warns against rigid use of this criterion. Even should the difference hold, the reasons behind it (intentional selection or relaxed natural selection pressure) need to be understood, as does the amount of time needed for such selection to occur, for use in periods of early domestication.

5) **Size change**: many taxa exhibit a decrease in body size at the time of their assumed domestication, which has led the first to be treated as a product of the latter in the zooarchaeological literature. The reasons for size change in this instance are not well understood, whether it results from intentional selection, or selection due to changed living conditions of animals, including lower levels of nutrition. Meadow (1989) quotes Widdowson (1980) as suggesting that growth rates of early domesticates may have been slow, and body size may have been set at levels appropriate to available nutrition. A major problem in the assessment of size change is that large samples of measurements are required, preferably from sites with multiples phases, and these are few and far between (but see Hesse 1978; Meadow 1984). For this reason, size variation has been explored within broad time periods and across wide geographic areas, using methods whereby small samples can be combined for comparison against a standard baseline (Uerpmann 1979 for the 'standard animal' method and his case study of sheep; Grigson 1989 for cattle). In all cases, attention must be paid to other potential sources of size variation, such as regional differences, temperature related size change (Davis 1981), and variations in sex distributions.

6) **Pathology**: a high incidence of pathology, interpreted as resulting from animals living in unnatural conditions, and additionally with human protection, has been used as corroborative evidence for the domestic status of goat herds at PPNB Ain Ghazal (Köhler-Rollefson 1986). Horwitz notes the problem in attributing pathologies to particular causes since many diseases leave similar marks (1989:163).

In summary, morphological and metrical criteria may be of limited value in identifying early stages of domestication; cull data are often ambiguous, as is pathological evidence, which has the additional drawback of being rare. Zoogeographical observations, and changes in the frequencies of animals at sites or in regions, can produce plausible arguments for the appearance of domesticates, although both suffer from equifinality.

Claims for the presence of domesticates at sites are more convincing if they draw on more than one line of evidence. Meadow advises the examination of all criteria together, with trends observed over space and time, and crucially, he calls for interpretations of human-animal relationships to be considered with respect to the complete archaeological record - an integrated approach (Meadow 1989:87).

The evidence for domestic caprines in the Levant

This section does not aim to explain the appearance of caprine domesticates in the Levant, but only to review the evidence in order to set a backdrop for changes seen in eastern Jordan (Chapter 9). Geographically, discussion is limited to the southern Levant and northern

Levant/Euphrates region; no attempt has been made to cover the extensive work in the Zagros, Sinjar or Taurus, or central Anatolia. Sheep and goat are considered separately. Periods preceding the PPNB are treated separately from the PPNB, since this is when the evidence apparently becomes more complex.

Sheep

sheep remains pre-PPNB Levant

period/site	area	% sheep id	sample size	source
PPNA				
Mureybet (Kh)	EU	5.8%	?	Ducos *et al.* 1978
Mureybet (M)	EU	0.3%	?	Ducos *et al.* 1978
Jericho	JV	0.4%	531	Clutton-Brock & Uerpmann 1974; Clutton-Brock 1979
Hatoula 3	CP	?1.0%	143	Davis 1985
late Natufian				
Abu Hureyra	EU	c.6.0%	?	Legge 1993
Mureybet 1a/2	EU	2.8%	1012	Helmer 1991
Mureybet 1a/3	EU	1.6%	552	Helmer 1991
Hatoula 4	CP	0.3%	2081	Davis 1985
Hatoula 5	CP	0.4%	246	Davis 1985
Rosh Horesha	N	0.3%	1109	Davis *et al.* 1982
Harifian				
Abu Salem	N	0.4%	1179	Davis *et al.* 1982
Ramat Harif	N	(7 bones)	?	Davis *et al.* 1982
early Natufian				
Wadi Judayid	JH	14%	?202	Henry & Turnbull 1985

Table 2.5. The percentage of sheep remains from Epipalaeolithic and PPNA sites in the Levant. Areas: EU=Euphrates; CP=central Palestine; JV=Jordan Valley; JH=Jordan Highlands; N=Negev.

All pre-PPNB sheep bones shown in table 2.5 are assumed to be from wild animals, sometimes on the basis of their large size (Helmer 1991; Clutton-Brock and Uerpmann 1974), in one case on the identification of an *Ovis orientalis* horncore (Henry and Turnbull 1985), but mainly because of the wide-held belief that domesticates do not exist in these periods.

The identification of sheep in the Negev, Jordan Highlands, Jordan Valley and Mediterranean zone of Palestine in the late Pleistocene, although in fairly small numbers (but see Wadi Judayid), has altered opinions on the wild distribution of the taxon. Accordingly, their later (Neolithic) presence in the southern Levant in larger numbers should not necessarily be viewed as introductions (Horwitz 1989:173).

sheep remains in the PPNB Levant				
period/site	area	% sheep id	sample size	source
final PPNB/C				
Ain Ghazal	JH	*56.0%	803	Wasse p.c.; Köhler-Rollefson *et al.* 1988
late PPNB				
Cafer Hoyuk C	EU	24.6%	104	Helmer 1985b, 1988
Hayaz Hoyuk	EU	0.6%	9138	Buitenhuis 1988
Tell es-Sinn	EU	8.0%	619	Clason 1980
Assouad	EU	35.0%	616	Helmer 1985a
Abu Hureyra	EU	c.30.0%	?	Legge & Rowley-Conwy 1986; Legge 1993
Ghoraife II	DB	40.0%	?	Ducos 1993a
Basta	SJ	c.30.0%	37280	Becker 1991
middle PPNB				
Cafer Hoyuk A	EU	9.0%	705	Helmer 1985b, 1988
Abu Hureyra	EU	c.12.0%	?	Legge & Rowley-Conwy 1986; Legge 1993
Ghoraife I	DB	10.0%	?	Ducos 1993a
Aswad	DB	2 bones	?	Ducos 1993a
Jericho	JV	1.6%	773	Clutton-Brock & Uerpmann 1974
Ain Ghazal	JH	*2.0%	2998	Wasse p.c.; Köhler-Rollefson *et al.* 1988

Table 2.6. The percentage of sheep remains from PPNB sites (early, middle, late and final/PPNC) in the Levant. Areas: EU=Euphrates; DB=Damascus Basin; JV=Jordan Valley; CP=central Palestine; JH=Jordan Highlands; N=Negev. *The Ain Ghazal percentages are based on a recent study by Wasse (pers. comm.) who examined caprine samples only; 256 bones for middle PPNB, 97 for PPNC; I have divided the original caprine category identified by Köhler-Rollefson *et al.* (1988) according to Wasse's percentages.

There are no sheep remains from the Levantine early PPNB. In the middle PPNB, there has been a suggestion of domestic populations in the Euphrates area. At Abu Hureyra, despite the percentage of sheep being relatively low, Legge's (1993) metrical analysis finds the sample to have a similar size range to later sheep from the site. Legge proposes that if the later sheep are domestic, which he argues they are, then the middle PPNB sheep may be also.

Since wild sheep are known from the area (table 2.5), however, the sample should be subject to more criteria before such statements are accepted.

In late PPNB deposits, many sites see much higher percentages of sheep. For Abu Hureyra, there is a marked increase in the proportion of caprines, half of which are said to be sheep (Legge & Rowley-Conwy 1986; 1987), which together with the size of the animals discussed above, might suggest that they are domesticates. At Cafer Hoyuk, however, there is also an increase in the proportion of sheep, though Helmer (1985b; 1988) finds them indistinguishable in size from wild populations, and interprets their age curve as being 'non-selective'. At Assouad, also on the Euphrates, Helmer (1985b) again identifies wild size sheep, but by their co-variance in representation with other taxa through the sequence, concludes that they are domestic.

In the Damascus Basin, sheep from Ghoraife II show similar evidence to Abu Hureyra: a sharp increase in their proportion is observed and they are smaller than animals from the area which are considered wild; additionally, a high proportion were culled in their first year of life (c. 50%) (Ducos 1993a).

Finally, Becker has identified domestic sheep from the late PPNB site of Basta in southern Jordan using morphological criteria (Becker 1991); and the switch from goat (see below) to predominantly sheep in the final PPNB/PPNC at Ain Ghazal on the Jordanian plateau (Wasse pers. comm) is also suggestive of close animal control. In short, various criteria (sharp increases in representation, size diminution, morphology, species frequency changes and age profiles) have been used to suggest the presence of domestic sheep at certain Levantine sites by the late PPNB (8,500-8,000bp); unpublished data would permit closer scrutiny of this issue. These sites tend to be in the 'Levantine Corridor' (from the middle-Euphrates through the Jordan Rift Valley).

Goats

goat remains from Kebaran Levant				
period/site	area	% goat id	sample size	source
Kebaran				
Ein Gev 1	JV	c.15.5%	>293	Davis 1974
Urkan e-Rub	JV	0.1%	>650	Hovers *et al.* 1988
Fazael IIIA	JV	5.2%	116	Goring-Morris 1980
Fazael VII	JV	25.0%	12	Goring-Morris 1980
Nahal Oren	PC	0.1%	1342	Legge 1973
Rakefet	MC	2.0%	92	Garrard 1980
Tor Hamar	JH	32.5%	551	Henry & Garrard 1988
Wadi Madamagh	SJ	82.7%	110	Perkins 1966

Table 2.7. The percentage of goat remains from Kebaran sites in the Levant. Areas: JV=Jordan Valley; PC=Palestine coast; MC=Mount Carmel; JH=Jordan Highlands; SJ=Southern Jordan.

Goat remains from all pre-PPNB deposits in the Levant (Kebaran, Natufian, Harifian and PPNA - see tables 2.7 to 2.9) are assumed to be from wild animals, either *Capra aegagrus* (the wild goat/mouflon) or *Capra ibex* (ibex). The former - believed to be the ancestor of the domestic goat - apparently had a more northerly distribution; the latter probably more southerly, although the two overlap. Many workers describe goat finds simply as *Capra* sp., showing the difficulty of making species identifications. In other cases it is clear that bones have been allocated to either wild goat or ibex on assumptions about habitat preferences. It is widely accepted that domestic goats did not exist before the PPNB.

The Negev (N), Sinai (S), and areas of southern Jordan (SJ) are believed to be ibex territory (Uerpmann 1987), and throughout the late Pleistocene and early Holocene, goat bones from here have been assigned to this species, despite few positive identifications of horncores (e.g. small numbers from Ramat Harif, Beidha, Madamagh).

Prior to the PPNB, goat remains are found in all areas of the Levant. They are present in low frequencies in central and coastal Palestine (CP, PC, MC), although having higher percentages in the occasional craggy area (e.g. the small sample from El Khiam, table 2.9). Sites in the Jordan Valley and Jordan Highlands (JV, JH) see varying frequencies (*C. aegagrus* horncores have been identified from Ein Gev I and Tor Hamar); goat is known from the Basalt area of eastern Jordan; and high proportions are recorded from sites in southern Jordan (SJ), where *C. aegagrus* and *C. ibex* have been identified from the same sites.

The goats identified by Ducos (1993a) from the PPNA levels at Aswad Ia (also confusingly known as the northern Levantine early PPNB), are said to be morphologically wild, but subject to conditions of 'proto-élevage' (proto-herding). This interpretation is based on the age curves, described as showing controlled exploitation of the goats (Ducos 1993b:164), and is the earliest claim for such a practice in the Levant.

goat remains from Natufian/Harifian Levant

period/site	area	% goat id	sample size	source
Harifian				
Abu Salem	N	44.4%	1179	Butler *et al.* 1977
Ramat Harif	N	?	?	Goring-Morris 1987
late Natufian				
Mallaha 1	JV	4.0%	553	Bouchud 1987
Salibiya 1	JV	1.6%	320	Crabtree *et al.* 1991
Hayonim T - B	CP	0.5%	4522	Henry *et al.* 1981
Nahal Oren V	PC	0.2%	1846	Legge 1973
Rakefet	MC	0.8%	1002	Garrard 1980
Khallat Anaza	EJ	5.9%	34	Garrard 1985
Rosh Horesha	N	36.0%	1019	Butler *et al.* 1977
early/late Natufian				
El Wad B1,2	MC	0.2%	1530	Garrard 1980: table 5D
Abu Usba Cave	MC	?	?	Stekelis & Haas 1952
Rosh Zin	N	(MNI=7)	?	Tchernov 1976
early Natufian				
Wadi Hammeh 27	JV	0.4%	281	Edwards *et al.* 1988; Garrard pers. comm.
Mallaha 2,3,4	JV	5.0%	1039	Bouchud 1987
Fazael VI	JV	10.0%	30	Goring-Morris 1980
Hayonim Cave	CP	3.6%	357	Bar-Yosef & Tchernov 1966; Byrd 1989:176
Wadi Judayid 2	JH	12.0%	184	Henry & Turnbull 1985
Beidha	SJ	69.8%	129	Hecker 1989

Table 2.8. The percentage of goat remains from Natufian and Harifian sites in the Levant. Areas: JV=Jordan Valley; CP=central Palestine; PC=Palestine coast; MC=Mount Carmel; JH=Jordan Highlands; EJ=Eastern Jordan; SJ=Southern Jordan; N=Negev.

goat remains from PPNA Levant

period/site	area	% goat id	sample size	source
Aswad Ia	DB	c.40.0%	?	Ducos 1993a
Jericho	JV	1.9%	531	Clutton-Brock 1989
Netiv Hagdud	JV	low freqs	?	Bar-Yosef *et al.* 1991
El Khiam	CP	69.0%	42	Ducos 1966
Nahal Oren	PC	3.1%	516	Legge 1973

Table 2.9. The percentage of goat remains from PPNA sites in the Levant. Areas: DB=Damascus Basin; JV=Jordan Valley; CP=Central Palestine; PC=Palestine coast.

goat remains from early PPNB Levant

period/site	area	% goat id	sample size	source
Aswad Ib	DB	c.40.0%	?	Ducos 1993a
Nahal Oren	PC	13.9%	570	Legge 1973

Table 2.10. The percentage of goat remains from early PPNB sites in the Levant. Areas: DB=Damascus Basin; PC=Palestine coast.

goat remains from middle PPNB Levant

period/site	area	% goat id	sample size	source
Abu Hureyra	EU	?	?	Legge & Rowley-Conwy 1986
Aswad II	DB	c.40.0%	?	Ducos 1993a
Ghoraife I	DB	30.0%	?	Ducos 1993a
Munhatta	JV	11.9%	566	Ducos 1968
Jericho	JV	44.0%	773	Clutton-Brock 1979
Abou Gosh	CP	39.0%	3618	Ducos 1978
Yiftahel	CP	<15.0%	?	Horwitz 1987
Kfar Hahoresh	CP	common	?	Goring-Morris 1991
Ain Ghazal	JH	*51.0%	2998	Wasse p.c.; Köhler-Rollefson *et al.* 1988
Beidha II-III	SJ	90.0%	3041	Hecker 1975
Nahal Divshon	N	sev frags	?	Tchernov 1976

Table 2.11. The percentage of goat remains from PPNB sites in the Levant. Areas: EU=Euphrates; DB=Damascus Basin; JV=Jordan Valley; CP=Central Palestine; JH=Jordan Highlands; SJ=Southern Jordan; N=Negev. *The Ain Ghazal percentages are based on a recent study by Wasse (pers. comm.) who examined caprine samples only; 256 bones for middle PPNB, 97 for PPNC; I have divided the original caprine category identified by Köhler-Rollefson *et al.* (1988) according to Wasse's percentages.

For the middle PPNB period, suggestions of the selective culling of goats become common. Ducos proposes that Aswad II continues to see 'proto-élevage', based on cull patterns again, as does the site of Abou Gosh in the Judean Hills (Ducos 1978; 1993a). In both cases the goats are morphologically inseparable from wild examples. At Ain Ghazal on the Jordanian plateau, Köhler-Rollefson finds 50% of the goats to be juveniles, she identifies a 2:1 ratio of females to males and also notes a high frequency of pathological phalanges in the sample (Köhler-Rollefson 1985; 1989). The combined evidence leads her to conclude that the goats are "well on their way to domestication" (1989:145), despite being morphologically wild. At Beidha also, the selective culling of wild goats has been proposed by Hecker (1975), who uses age profiles as the basis of his argument. Additionally, the sharp increase in the percentages of *Capra* sp. between PPNA (1.9%) and middle PPNB (44%) levels at Jericho suggests a change in their exploitation. It is notable that most sites identified as having selective goat culls in this period are situated in the 'Levantine Corridor' (as are those argued to see the earliest domestic sheep in the late PPNB).

goat remains from late PPNB Levant				
period/site	area	% goat id	sample size	source
Abu Hureyra	EU	c.30.0%	?	Legge & Rowley-Conwy 1986; 1987
Ghoraife II	DB	10.0%	?	Ducos 1993a
Beisamoun	JV	52.5%	78	Davis 1978
Atlit	PC	38.0%	145	Horwitz & Tchernov 1987
Basta	SJ	46.0%	37280	Becker 1991
Nahal Issaron	N	dominant?	?	Goring-Morris & Gopher 1983
Ujrat el-Mehed	S	70.0%	3257	Dayan *et al.* 1986
Wadi Tbeik	S	21.0%	1077	Tchernov & Bar-Yosef 1982

Table 2.12. The percentage of goat remains from late PPNB sites in the Levant. Areas: EU=Euphrates; DB=Damascus Basin; JV=Jordan Valley; PC=Palestine coast; N=Negev; S=Sinai.

The evidence for goats in the late PPNB highlights regional variability. At Ghoraife in the Damascus Basin, the relative proportion of (morphologically wild) goats declines, in favour of sheep (see above), considered domestic (Ducos 1993a). A high percentage of apparently wild goats (Horwitz 1989) is seen in the very small sample from Beisamoun. Coastal Atlit shows a higher relative proportion of goats than any earlier site in the locale; Horwitz and Tchernov (1987) interpret this as resulting from 'intensive hunting'. At Basta in southern Jordan, Becker claims high percentages of domestic goats, identified on the basis of morphology (Becker 1991). In the arid regions of the Negev and Sinai, the high proportions of goat are taken to reflect hunted ibex.

The final PPNB/PPNC at Ain Ghazal appears to mirror developments in the Damascus Basin in the late PPNB, where sheep replace goats as the dominant taxon. The Damascus Basin sheep (Ghoraife II) are called domestic; those from Ain Ghazal have not been commented upon so far. In each case, the goats which they replace are not considered morphologically domestic, although selective culling has been proposed. The only claims for morphologically domestic goats, therefore, are from late PPNB Basta in southern Jordan.

goat remains from final PPNB/PPNC Levant				
period/site	area	% goat id	sample size	source
Ain Ghazal	JH	*12.0%	2998	Wasse p.c.; Köhler-Rollefson *et al.* 1988

Table 2.13. The percentage of goat remains from final PPNB/PPNC sites in the Levant. Areas: JH=Jordan Highlands. *The Ain Ghazal percentages are based on a recent study by Wasse (pers. comm.) who examined caprine samples only; 256 bones for middle PPNB, 97 for PPNC; I have divided the original caprine category identified by Köhler-Rollefson *et al.* (1988) according to Wasse's percentages.

Discussion

Selective culling evidence appears to suggest that morphologically wild goats were under some form of cultural control at some Levantine sites by the middle PPNB (Aswad II, Abou Gosh, Ain Ghazal, Beidha). In the late PPNB, there is certainly evidence for some morphologically domestic goats at Basta. Domestic sheep are first claimed in the late PPNB (Ghoraife II, Basta), and probably also in the case of final PPNB/PPNC Ain Ghazal.

Variability in the fauna across the Levant must be stressed: many sites have very few caprines throughout the PPNB sequence; some have extremely high proportions of (usually) goat; others have no caprines; some apparently have only hunted ibex; and PPNB sites in the Mediterranean woodland zone of Palestine have no sheep.

Horwitz has suggested that the pattern of caprine representation at southern Levantine PPNB sites correlates well with time, i.e. caprines increase throughout the sequence across different areas (Horwitz 1993). She has, however, treated sheep and goats together, which rather blurs the differences outlined above. Secondly, she prefers to fit the data into her four stage model (Horwitz 1989), where, for example, middle PPNB sites would show 'intensive hunting' of caprines - thereby rejecting the arguments for cultural control/mangement/proto-élevage reviewed above because "... the caprines found at these sites have not all been assessed as morphometrically domestic" (Horwitz 1993:30).

When sheep and goat are considered separately, however, a different picture emerges of regional, temporal and inter-site variability. Additionally, if a sharp increase in a taxon's representation is seen as significant, and cull patterns viewed as potentially significant in assessing human-animal relationships, it becomes difficult to accept a unilineal model for caprine domestication which is applicable to most areas of the southern Levant. Rather, the evidence leans more towards Bar-Yosef and Belfer-Cohen's (1989) proposal of managed caprines, or the concept of domestication, entering the region via the 'Levantine Corridor'. An alternative view of the evidence might be that some middle PPNB show close control of local goats (e.g. Beidha), and this need not have been an introduced concept. The data for sheep, however, seem more clearly to suggest introduction.

Themes in interpretation

At the risk of over-simplification, this chapter describes several chronological trends in subsistence data from 18,000bp to 7,500bp. Firstly, cultivated cereal crops are first seen in the PPNA; secondly, caprines become dominant in some areas during the PPNB; thirdly, the importance of gazelle declines in the PPNB relative to their previous primacy at most sites; fourthly, there is a tendency for a decreased representation of equids in the PPNB in areas where they were common earlier (e.g. Euphrates region); and fifthly, there is some suggestion of an increased reliance on hare, possibly from the Natufian, at some sites. Despite these gross patterns, variability between regions is clear.

Explanations for subsistence change will neither be described in detail here nor evaluated, since this is not the prime concern of this work. The main trends in interpretation, however, are highlighted, and the inter-related themes which dominate subsistence studies in Levantine prehistory are described. These themes are the search for agricultural origins, climatic change, demographic change, increasing complexity, intensification, specialization and the broadening of the resource base.

The origins of agriculture

A vast amount of literature deals with agricultural origins in the Near East (see reviews of G. Wright 1971; Moore 1985), and no attempt will be made here at recapitulation. In brief, available evidence might suggest that cereal cultivation had a southern Levantine origin (van Zeist 1988:56-58) and domesticated crops are evident in southwest Syria and the Jordan Valley in the PPNA. Caprine domestication is harder to pinpoint; some see central Anatolia as the centre of sheep domestication (Ducos and Helmer 1981); others propose that goat domestication was centred in the Zagros (Hole 1984), whilst the Levantine evidence for cultural control of goats in the PPNB is much debated. Most seem now to agree that the beginnings of plant cultivation and animal herding were independent but related phenomena, with domestic cereals appearing at least 1,000 years before domestic caprines.

The various models proposed for agricultural origins fall into two broad categories:

1) Firstly, **'disequilibrium' models** have invoked an imbalance between population and resources to explain 'change'. Frequent interpretations see either a late Pleistocene increase in population, or climatic change as leading to resource depletion (Childe 1952:25; Boserup 1965; Binford 1968; Flannery 1969; Cohen 1977). These models variously see 'migration' to 'tension zones' as triggering experimentation (Binford 1968); or 'restricted mobility' leading to 'packing zones' or 'nuclear zones' as producing a context for innovation (Binford 1983:211; Braidwood 1960; Braidwood and Howe 1960).

Several recent studies continue to draw heavily on 'stress' models, but accentuate different variables: Bar-Yosef and Belfer-Cohen see "abrupt climatic fluctuations in a marginal environment" as a force for technological and social change, emphasising the importance of 'pre-adaptive traits' such as semi-sedentism and the exploitation of relatively small territories (Bar-Yosef and Belfer-Cohen 1989). [Flannery earlier saw ground-stone technology and storage facilities as 'pre-adaptations' (Flannery 1969)]. Moore argues that population pressure and an **'increased** abundance' of plant and animal resources were instrumental in changing social organization, which led to the new kinds of food production (Moore 1985). Henry concludes that agriculture grew out of an intensive specialized exploitation of plants and animals (1989:236), with population increase and sedentism serving as prime causal factors.

'Availability' models should also be included here. Both Wright (1977) and McCorriston and Hole (1991) argue that the early Holocene change from a continental to Mediterranean climate with extreme seasonality served to regenerate the Mediterranean flora, perhaps leading to speciation of some new taxa. McCorriston and Hole suggest annual plants would have out-competed many perennial species under these conditions, resulting in a previously unencountered richness of cereals. They see "seasonal shortages of critical resources" as the incentive to use and store cereals (1991:59).

Legge and Rowley-Conwy's model of Natufian gazelle hunting at Abu Hureyra includes elements of a disequilibrium model, where a new technique (drive hunting) creates imbalance: they argue that the success of mass-killing using kite structures may have depleted gazelle populations and that "the reduced availability of gazelles, in turn, could have forced the community back on husbandry of sheep and goats" (1987:95). Davis (1991) and Tchernov (1993) also use the idea of overhunting of large game to explain the increased frequency of small mammal bones from some Natufian/PPNA sites.

2) Attention was drawn to **social factors** by Bender, who considered that processualists had placed too much importance on technology and demography (Bender 1978). She emphasised instead how reciprocal social relations of gatherer-hunter bands could have created increased demand, surpluses, sedentism and ultimately subsistence change, and suggested that control (and knowledge) of production would have played an integral part in change. Her main point is that "demography and technology are products of social structure rather than independent variables" (Bender 1978:214).

Similarly, Cauvin and Cauvin (1983) see environmental stress as commonplace, and demography as socially controllable, forcing them to reject disequilibrium models. Instead they propose a near reversal of processualist explanations: with reference to their excavations at Mureybet in Syria, they suggest social change (more permanent settlements, regrouping) occurred **prior** to changes in food-procurement, and that domestication was used as a means of conveying new social practice:

> L'agriculture, la chasse organisée, le protoélevage qui lui succède vers 7500bc à Mureybet nous ont paru être avant tout des facons de mettre en oeuvre **à travers** les activities alimentaires une nouvelle pratique sociale qui se manifeste aussi dans les constructions 'monumentales', donc collectives, de Jéricho PPNA.
>
> (Cauvin and Cauvin 1983:49-50)

Hodder builds on these ideas in a study primarily concerned with the adoption of agriculture in Europe, but also proposing that the initial taming of animals in the Near East served as a metaphor for social changes that were taking place in societies (Hodder 1990).

Intensification and specialization

The focus on the beginnings of agriculture has tended to produce post-hoc interpretations of subsistence which describe a process towards agriculture; for example, late Epipalaeolithic subsistence evidence has been read as reflecting 'pre-adaptions' to, or 'experiments' in Neolithic developments (e.g. Henry 1989; Cope 1991; Tchernov 1993). Henry (1989) describes late Natufian foragers being "pulled towards new resources that demanded intensified exploitation" (ibid:3), referring to cereal exploitation. In his model favourable ecological conditions and the existence of milling technology allow these developments (Henry 1989:231).

In interpretations of animal remains, Cope actually links Natufian gazelle exploitation with later caprine domestication by terming the cull patterns she observed 'proto-domestication' (Cope 1991). Her proposal of selectivity, specialized (i.e. focused) gazelle hunting, with the intention of herd maintenance had been forwarded by others too (Legge 1972; Saxon 1974; Garrard 1982).

Arguments for gazelle driving appear to envisage non-selective culls (Legge and Rowley-Conwy 1987; Campana and Crabtree 1990), but they imply a **change** in practice in the Natufian, constituting either more control over animals, or more animals hunted - all serving as forerunners of animal domestication.

I have several reservations in accepting that Natufian gazelle hunting was more specialized, or more intensive than in other periods. Firstly, relative proportions of gazelle are similarly 'high' in the Kebaran as they are in the Natufian. Tchernov's claim that "gazelle remains in Natufian beds [deposits] always significantly outnumber all other ungulates" (1993:12) is generally true (but see Beidha, table 2.2), but this also holds for the Kebaran (table 2.0).

Secondly, there are problems of inconsistency in the interpretation of cull patterns: a bias noted towards male gazelle in the Natufian is taken to imply selective culling and cultural control (Cope 1991:357), whilst male bias from an admittedly small sample from the Kebaran assemblage of Urkan e-Rubb is taken to "reflect seasonal exploitation patterns" in hunting (Hovers *et al.* 1988:45). It appears likely that pre-conceived ideas are in operation, probably aided by the existence of more, and larger, Natufian assemblages which could potentially show more patterning than other earlier periods.

Thirdly, there continues to be a tendency to interpret any kind of cull bias (whether towards males or juveniles) as being intentional and aimed as conserving the breeding stock. This seems to be a strong case of interpretation in view of events of c. 2,000 years later. The problems of identifying any selectivity in relation to normal herd structures have been well aired (e.g. Collier and White 1976; Simmons and Ilany 1977); however, when cull patterns **are** interpreted as selective, most see this as being aimed at controlled cropping and herd maintenance. There has been little consideration of other reasons why certain age or sex groups may be better represented than others, for example whether products (meat, hides, horns) of some animal classes are more desired than others, or even whether some animals may be easier to catch (but see Meadow 1989). It appears that interpretations have been narrowly channelled to link late Epipalaeolithic hunting with domestication.

The broad spectrum revolution

Flannery's (1969) 'broad spectrum revolution' model proposed an Upper Palaeolithic broadening of the subsistence base to include greater amounts of marine resources, molluscs and birds; he also suggested that the 'broad spectrum' collecting pattern was a pre-condition for the first domestication, along with other 'pre-adaptations' such as ground-stone technology and storage facilities (Flannery 1969:77 (Wright 1991:39 questions the link with ground-stone)). The model has recently been re-evaluated on many separate accounts.

Edwards (1989) comprehensively reviews the published fauna from the southern Levant, to conclude that

> no significant increase in species diversity is evident in archaeological faunas from the period between 50,000 and 10,000 years ago, nor that shifts in emphasis in the frequencies of prey hunted can account for significant changes in settlement pattern and the rise of domestication economies in Southwest Asia at the end of the Pleistocene.
>
> (Edwards 1989:225)

He argues instead that the wide variety of plants and animals which is evident in assemblages 12,000 years ago had been used since the Mousterian. The greatest taxonomic diversity, however, is seen in the Natufian. This is primarily an increase in avian and molluscan taxa (with no corresponding decline in the relative frequency of large animals) which Edwards qualifies as being often incorporated in sites by non-human agencies, or being ornamental rather than food items (Edwards 1989:231). Also, he suggests that the larger volumes of fauna produced by Natufian sites would have led to increased species diversity.

Henry's (1989) review takes a smaller sample of sites than Edwards, but concludes similarly that the notion of a gradual broadening of the subsistence base during the late Pleistocene cannot be supported. He **does** see small species better represented in Natufian deposits, but calculates that they could not have made a significant contribution to the overall diet (Henry 1989:18).

Edwards also questions the role of 'broad spectrum' subsistence patterns in the origins of food production. A brief review of some ethnographies of modern foragers with such subsistence economies leads him to conclude that 'broad spectrum' resource use is neither a precondition for agriculture, nor does it require "high[er] levels of socioeconomic integration" (Edwards 1989:242).

There is evidence, however, that within specific site or regional sequences, assemblages **do** show an increased reliance on a wider range of taxa through time, and that these could represent food animals. Davis notes a significant increase in small mammal representation between the Natufian and PPNA levels at Hatoula (Davis 1991:385 figure 2), which he sees as resulting from hunting pressure. Tchernov (1991:330) finds a drastic augmentation of the range of animal species exploited in the Natufian, which he relates to longer-term occupation of certain sites. Others (e.g. Campana and Crabtree 1990:233 and Hovers *et al.* 1988:45) tend to invoke the term 'broad spectrum' simply to describe assemblages with a wide range of vertebrates.

Conclusions

This chapter highlights some of the main issues to be considered in the study of eastern Jordanian faunal remains, and the data and interpretations presented here are drawn on heavily in later discussions. My aim, however, is to attempt assessment of faunal variability in the study area **without** the pre-conceived frameworks which clearly exist in many of the above interpretations. Finally, in Chapter 10, data from eastern Jordan will be discussed in relation to this broader Levantine subsistence picture to see if comment can be added, or support lent or not, to any interpretations outlined here.

CHAPTER THREE

THE STUDY AREA: EASTERN JORDAN
22,000-7,500bp

The geographical focus of this project is an area of the present-day arid and semi-arid zones of north-eastern Jordan, including sectors of both the limestone and basalt 'deserts'. Archaeological investigations have been concentrated in the following four regions (see figure 3.0); the first area is in the limestone; the second and third border the basalt desert:

- Wadi el-Jilat (including Wadi el-Kharaneh)
- Azraq Central Basin
- Wadi el-Uwaynid
- Basalt Desert

In the last 20 years, these areas have seen several survey and excavation projects. All areas fall within the same broad steppe/desert zone, but cover a range of environmental/ecological variability, which makes them germane to both inter- and intra-regional comparison in terms of settlement patterns and subsistence practices.

This chapter firstly summarizes the geology and present climate, vegetation, fauna and landuse of eastern Jordan. Next the history of archaeological research is reviewed, and each area is described, firstly in terms of archaeological settlement patterns, and secondly of palaeoenvironmental evidence. A reconstruction of climate and vegetation patterns from 20,000bp to 7,500bp. is offered. Finally, the sites used in this study are described, and general trends discussed.

Geology (figure 3.1)

The Transjordanian Plateau is a vast tract of limestone and basalt desert, ranging from 500-1000m asl, extending for several hundred kilometres into Syria, Iraq and Saudi Arabia. The sector which falls into the eastern 'pan-handle' of Jordan consists largely of Cretaceous limestone and chalk hills covered with coarse flint and chert debris, known as the *hammada*. This is interrupted in the central strip by a volcanic basalt boulder landscape running from north to south (Bender 1974). This Basalt Desert (*harra*) covers 45,000 km^2, extending from Jebel Druze, south-east of Damascus, to the northern fringes of the Nefud Desert in Saudi Arabia, and is thought to be of mainly Miocene-Pleistocene date, but with some basalt of Holocene origin. The plateau dips gently to the east-north-east, and has two significant depressions - the Azraq Basin and the Wadi Sirhan - into which most *wadis* lead. The greater Azraq Basin has a catchment of 12,000 km^2, including areas of both the limestone and basalt. At its centre the basin

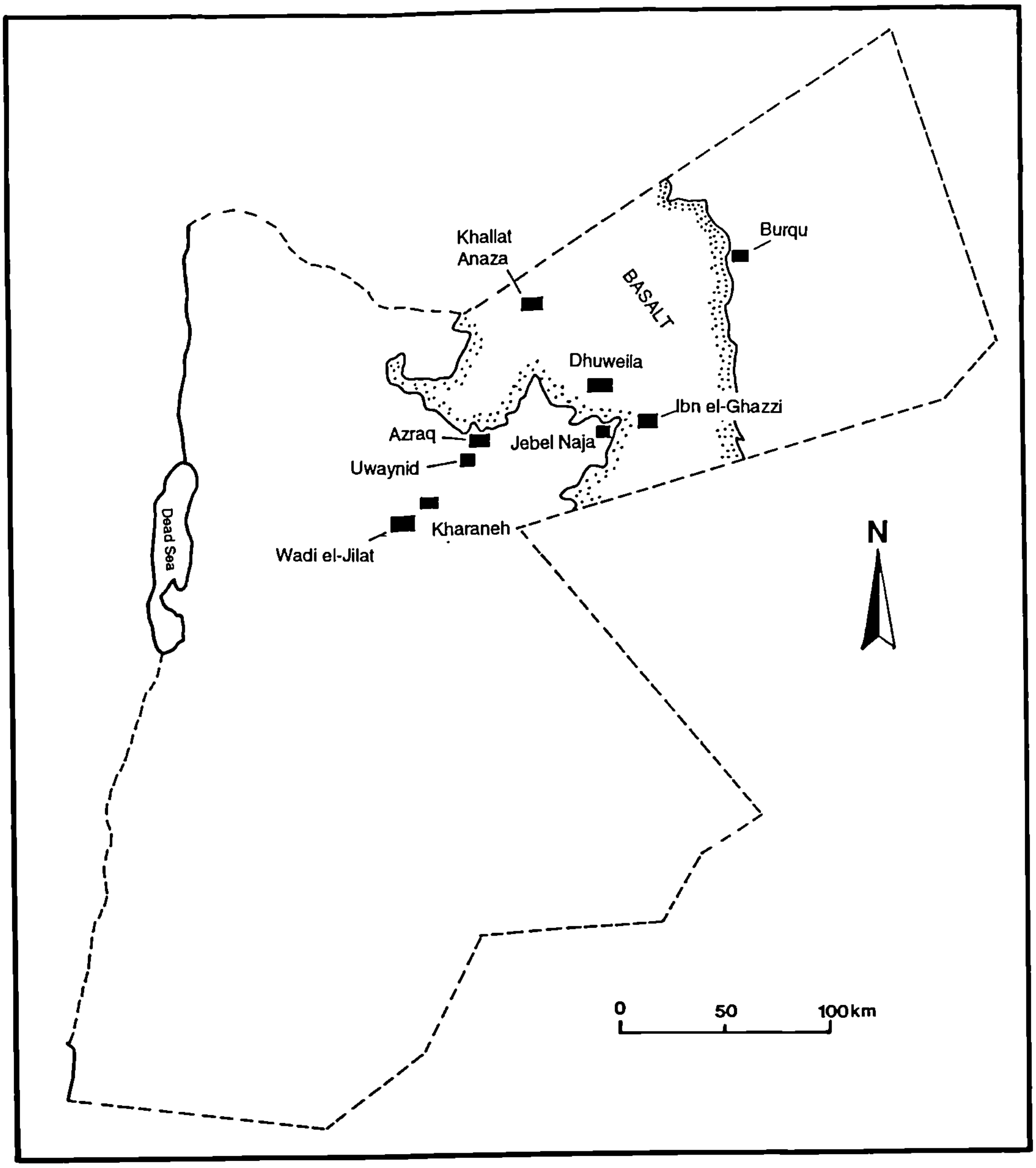


Figure 3.0. Areas of archaeological investigation in eastern Jordan.

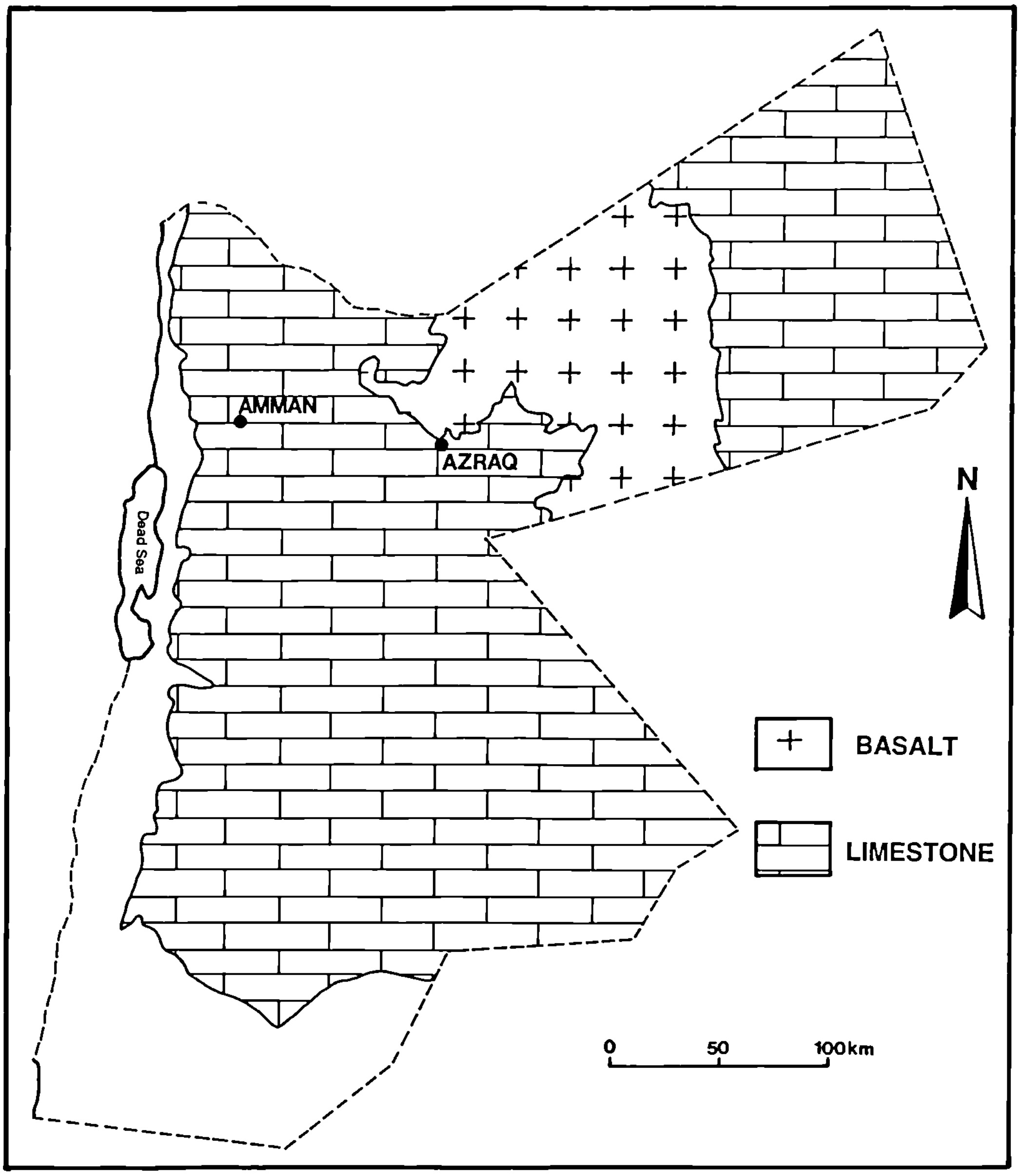


Figure 3.1. The geology of the Jordanian Plateau.

is 500m asl; in the west it reaches 900m asl, and in the south and east elevations range from 600-900m asl.

Present climate

Rainfall decreases from north-west to south-east across eastern Jordan, producing both steppe and steppe/desert environments (see Chapter 1, figure 1.1). Westerly areas, which meet the well-watered grasslands of the western plateau, receive c. 200mm of rainfall a year, whereas the south-east receives less than 50mm and desertic conditions predominate. Only areas receiving in excess of 100mm rainfall/year generally support typical steppic vegetation. The Wadi el-Jilat, for example, in the limestone region, receives c. 100mm, making it transitional between steppe and steppe/desert.

Eastern Jordan has an extreme seasonal climate. Most rain falls between November and March in erratic, unevenly distributed storms. Rain is unpredictable, generally localised and variable from year to year (Shehadeh 1985:30-31).

The two bodies of permanent standing water which exist today are Azraq Central Basin, which has a complex of springs and freshwater pools, and Lake Burqu on the eastern edge of the basalt. The latter oasis is currently enhanced by damming, obscuring estimates of the volume of water it may previously have retained year-round. Stream beds tend to fill only in the wet season, although in places, deep rockpools can remain water-filled into the dry months. Playas (*Qa'as*) are frequent on the plateau and collect run-off in wet seasons, which evaporates over several months. In both limestone and basalt deserts, man-made or artificially enhanced water catchment systems are found in natural collection points. Betts and Helms (1989) suggest the earliest date for some of these is the Early Bronze Age.

Temperatures are known only for the Azraq Central Basin. In recent history, Azraq village has experienced temperatures ranging between 45°C and -10°C, with a July average of 36°C (Shehadeh 1985). Generally, the study area climate can be described as 'Saharan-Mediterranean' (Eisawi 1985) due to its low rainfall (but less arid than the Arabian and Saharan deserts) and extreme temperatures (but with smaller seasonal/diurnal temperature ranges than true deserts).

Soils

Guest (1966) describes two soil types for the study area - 'grey desert soils' and 'light brownish grey desert soils', which roughly adhere to the steppe and steppe/desert zones respectively. The former are calcareous surface soils, very low in organic matter (less than 1%), and usually present to a depth of less than 20cm. 'Light brownish grey desert soils' have an even lower organic content (less than 0.5%), are highly calcareous, and often gypsiferous. They are found to depths of a few centimetres, often wind eroded.

Local topographic features have influenced soil formation to create a complex mosaic of soils, and hence vegetational micro-environments, within the above polarized picture.

Present vegetation (see Chapter 1, figure 1.2)

Two main plant associations reflect these variations in climate and soils: the Irano-Turanian and the Saharan-Arabian (M. Zohary 1973). The former covers the more north-westerly areas, in the cooler steppe receiving over 100mm rainfall, and the latter adheres to the drier eastern area receiving below 100mm rainfall. Additionally, Sudanian vegetation (characteristic of hot deserts) is known from a narrow strip in the Basalt Desert where it extends up from Saudi Arabia.

Irano-Turanian vegetation is characteristically a mixture of steppe grasses and dwarf shrubs, with an absence of trees and large shrubs (except for some *Pistacia* sp. trees in the Wadi Butm). A wealth of species, many endemic, would probably exist if not for modern overgrazing. A rather uniform thin carpet of grasses such as *Poa bulbosa* might be expected, with many shrubby chenopods. Perennial shrubs such as *Artemisia herba-alba* are well known from the steppe, as are developments of *Astragalus* spp.. This kind of vegetation is fairly lush in the west of the plateau and around Azraq oasis in spring, but in summer months it is confined to *wadi* bottoms and water-collecting depressions.

The Saharo-Arabian vegetation of steppe/desert regions is poorer in the number of species present. Scattered perennial shrublets are common whilst ground vegetation such as *Stipa capensis* signals degraded conditions. A relatively uniform plant cover exists in spring but becomes very sparse in summers.

The desert Sudanian vegetation, which M. Zohary (1973) notes for a limited area east of Azraq, includes a dominant association of Hammadetea salicornici intermixed with Acacietea tortilis.

Following Zohary (1950) Guest divides vegetational events into three seasons: 1) cold, wet winters when plant growth is arrested; 2) a mild spring growing period; 3) hot, dry summers when plant growth is again arrested. In the 5-6 months of summer, moisture available to plants is minimal, even from dew.

Recent fauna

Medium and large-sized wild animals have been greatly reduced by modern over-hunting, but according to Nelson (1973) eastern Jordan was probably quite rich in wild ass *(Equus hemionus)*, oryx *(Oryx leucoryx)*, goitred gazelle *(Gazella subgutturosa)* and Dorcas gazelle *(Gazella dorcas)* until this century. The goitred gazelle survives today in extremely small numbers in the north-east area of basalt desert. *Struthio camelus* (the ostrich) is also believed to have been common.

Until the 19th century, the range of carnivores is believed to have included the Asiatic lion (*Panthera leo*), leopard (*Panthera pardus*), caracal (*Caracal caracal*) and cheetah (*Acinomyx jubatus*) (Nelson 1973). The striped hyaena (*Hyaena hyaena*), wolf (*Canis lupus*), jackal (*Canis aureus*) and fox (*Vulpes vulpes/Vulpes rupelli*) all survive today, as do hare (*Lepus* sp.) and wild cat (*Felis sylvestris/libyca*), although probably in much lower numbers than in earlier times.

Nelson suggests that wild boar (*Sus scrofa*) and a wide range of spring and autumn migrant birds (e.g. large raptors, storks, herons and cranes) could have been found around the Azraq marshes until recently. Some are still evident, but the gradual draining of the marshes for domestic water has greatly reduced the amount of standing water and hence vegetation which would attract visiting birds.

Present landuse

Non-irrigation cultivation is presently only possible on the western edge of the plateau, in the wetter steppe. Small-scale opportunistic planting of barley is practised in drier areas (although mainly in stream-beds or on the margins of playas), but the success of these ventures is not known.

Permanent settlements exist only on the western border of the plateau, in Azraq oasis, and along the major trade routes with Iraq and Saudi Arabia.

Most of the *hammada* and *harra* is used by Bedouin for herding sheep and goats. Lancaster and Lancaster (1991:131) describe these animals thriving here in winter months, finding graze and browse well into the early summer. Summer forage, though, is more problematic and neither sheep nor goat would survive today without supplementary transported water and fodder. Lancaster and Lancaster stress that all users of the area have both access to other areas and also very diverse social and economic networks which allow survival in eastern Jordan.

Camel herders also use the area in the rainy months, but penetrate further into the desert as far as Iraq (i.e. they cover greater distances, for greater quantity of feed).

History of archaeological research

Until 1975, numerous sites, ranging from the Lower Palaeolithic to the Neolithic, had been observed in eastern Jordan (Lancaster-Harding 1958; Field 1960; Van Liere 1960-61;

Zeuner *et al.* 1958; Rees 1929; Maitland 1927), but very few excavated (e.g. Waechter's Wadi Dhobai/Jilat excavations, Waechter and Seton-Williams 1938).

The Azraq Basin Project began in 1975 under the directorship of A. Garrard and aimed to examine the environmental history, settlement patterns and subsistence in the arid and semi-arid lands of eastern Jordan. Specifically, the Azraq Basin was a 'marginal' zone within which to test then-prevalent models for the beginnings of animal and plant husbandry. The project was also part of a broader move to correct the imbalance of work which had concentrated in the fertile areas. Investigations centred on three areas which varied environmentally: Wadi el-Jilat, Azraq Central Basin and Wadi el-Uwaynid. The sources which will be continually drawn on throughout this discussion are Garrard *et al.* 1977; 1985; 1986; 1987; 1988a; 1988b; Garrard and Byrd 1992; Baird *et al.* 1992; Garrard *et al.* 1993; 1994.

The Black Desert Project began in 1982 under the directorship of A. Betts, who surveyed large tracts of the terrain, and excavated selected prehistoric sites. The sources referred to throughout are Betts 1982a; 1982b; 1983; 1984; 1985; 1986; 1987a; 1988a; 1988b; 1989; Betts *et al.* 1990; McCartney 1992.

The four areas of investigation

Wadi el-Jilat (figure 3.2)

This 11km long tributary of the Wadi Dhobai leads into the south-west corner of the Azraq playa, and lies 55 km to the south-west of Azraq itself. The Wadi el-Jilat is between 755m asl and 810m asl, although surrounding hills reach 976m asl. It lies in lightly rolling limestone and flint hills, and is on the present steppe/steppe-desert boundary. A gorge cuts the *wadi* floor, in places to a depth of 10m, and is a natural water collection point.

The earliest archaeology is represented by some Middle Palaeolithic Levallois points collected from a wadi terrace, but no sites of this period have been located. A sequence of sites from the late Upper Palaeolithic to the PPNC/ELN have been excavated.

The **Wadi el-Kharaneh** (figure 3.3), 25 km north of Wadi el-Jilat, is included here because it is in a very similar environmental zone, also on the present-day border between the steppe and steppe/desert. The *wadi* is very broad - roughly 11 km wide - and rises between 625m asl and 650m asl. Numerous sites ranging between the late Acheulian and the Chalcolithic have been recorded (Zeuner *et al.* 1958; Muheisen 1983; Garrard and Stanley-Price 1977; Besançon and Hours 1985), but only the Epipalaeolithic site of Kharaneh 4 has been excavated (Muheisen 1985; 1988)

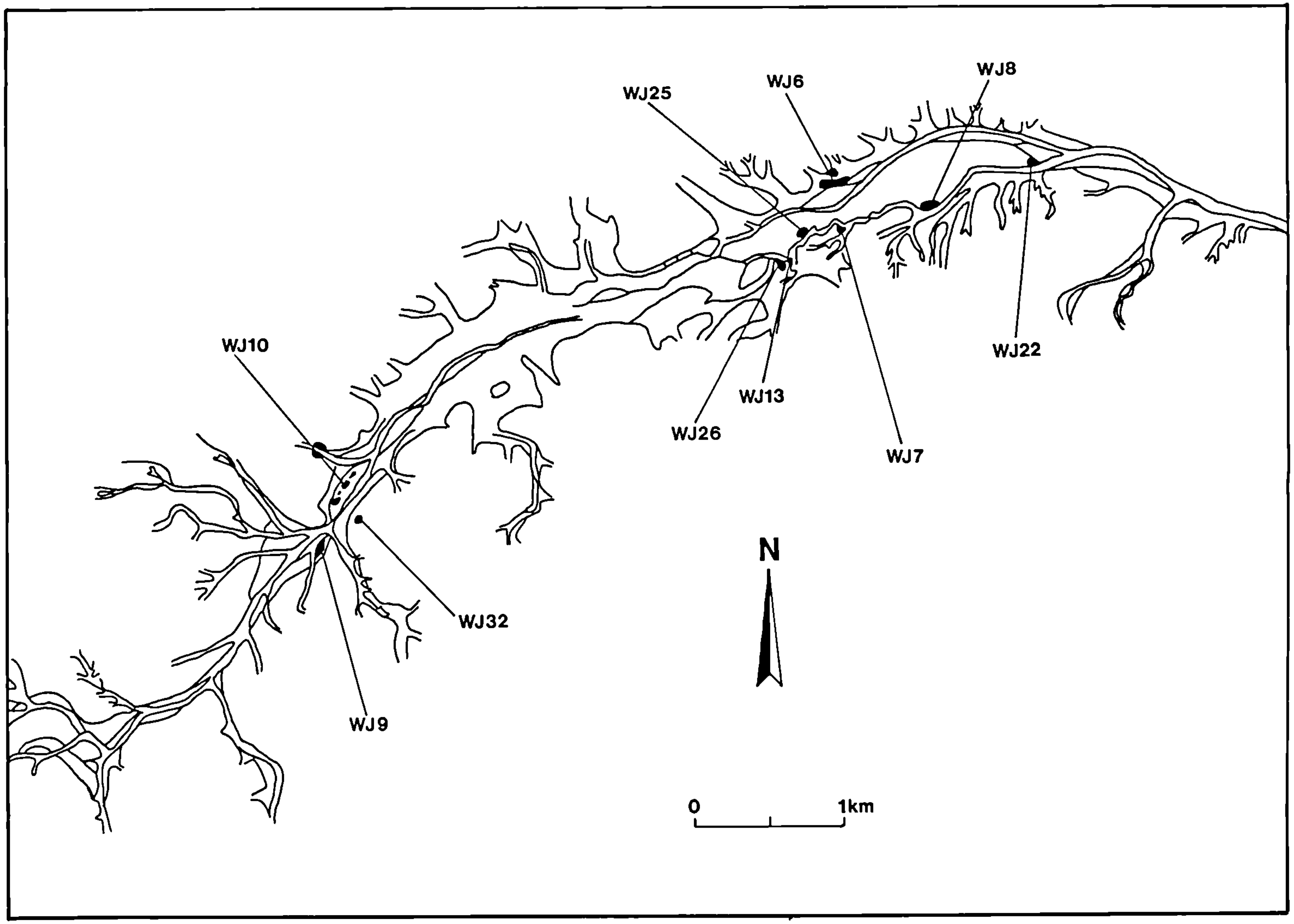


Figure 3.2. The Wadi el-Jilat, showing location of study sites.

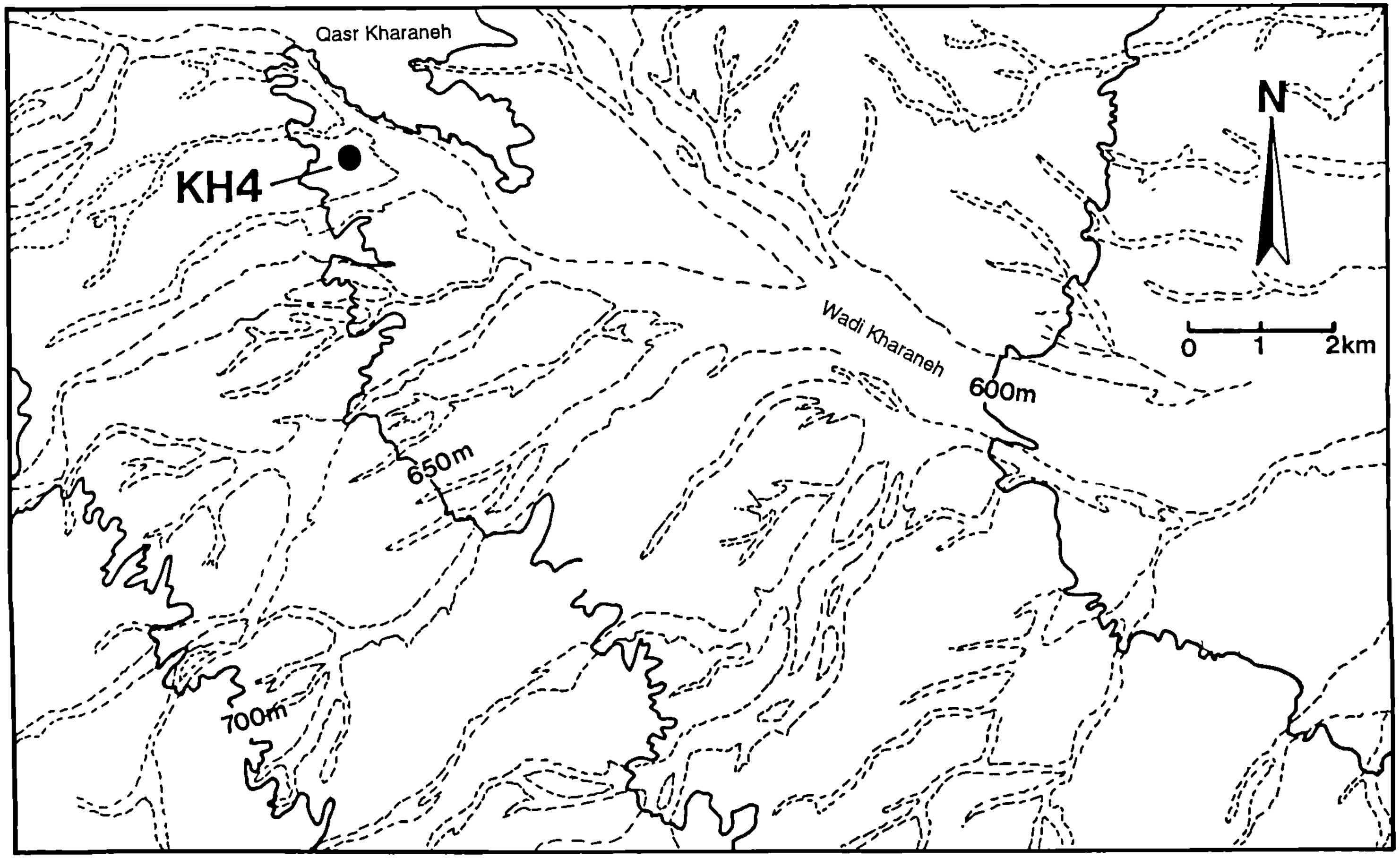


Figure 3.3. The Wadi el-Kharaneh, showing location of Kharaneh 4 (KH4).

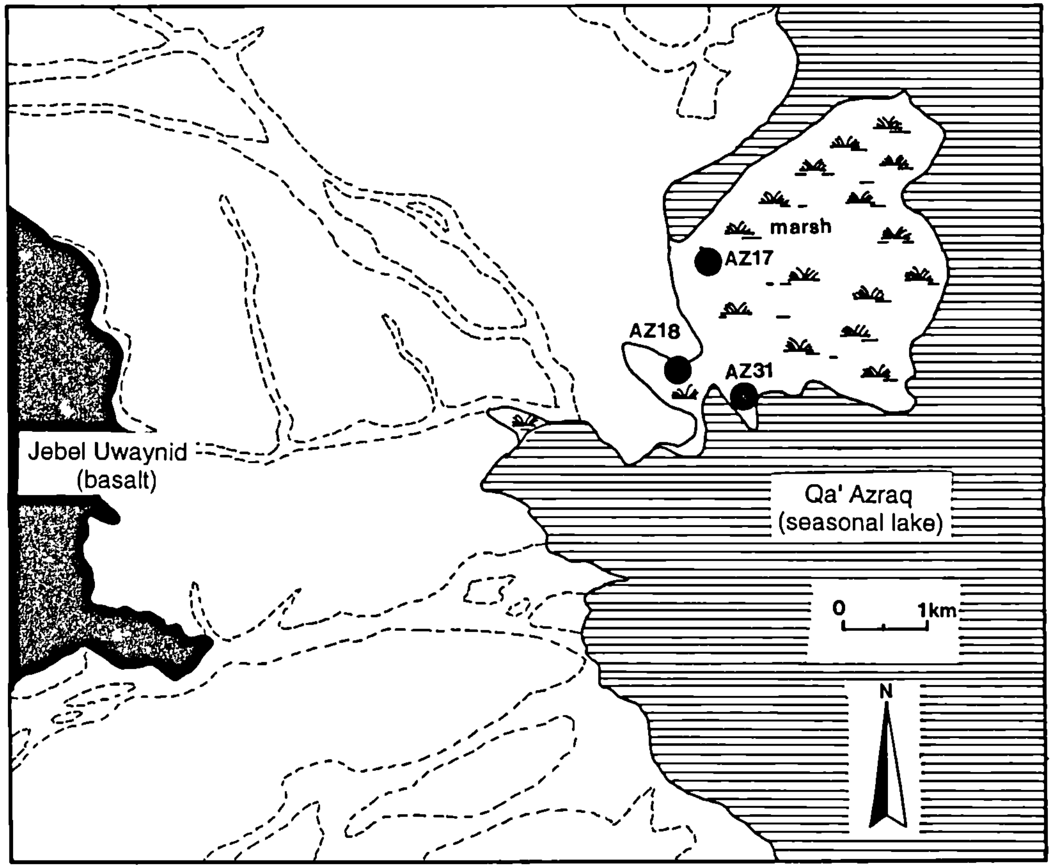


Figure 3.4. Azraq Central Basin, showing location of Azraq 17 (AZ17) and Azraq 18 (AZ18).

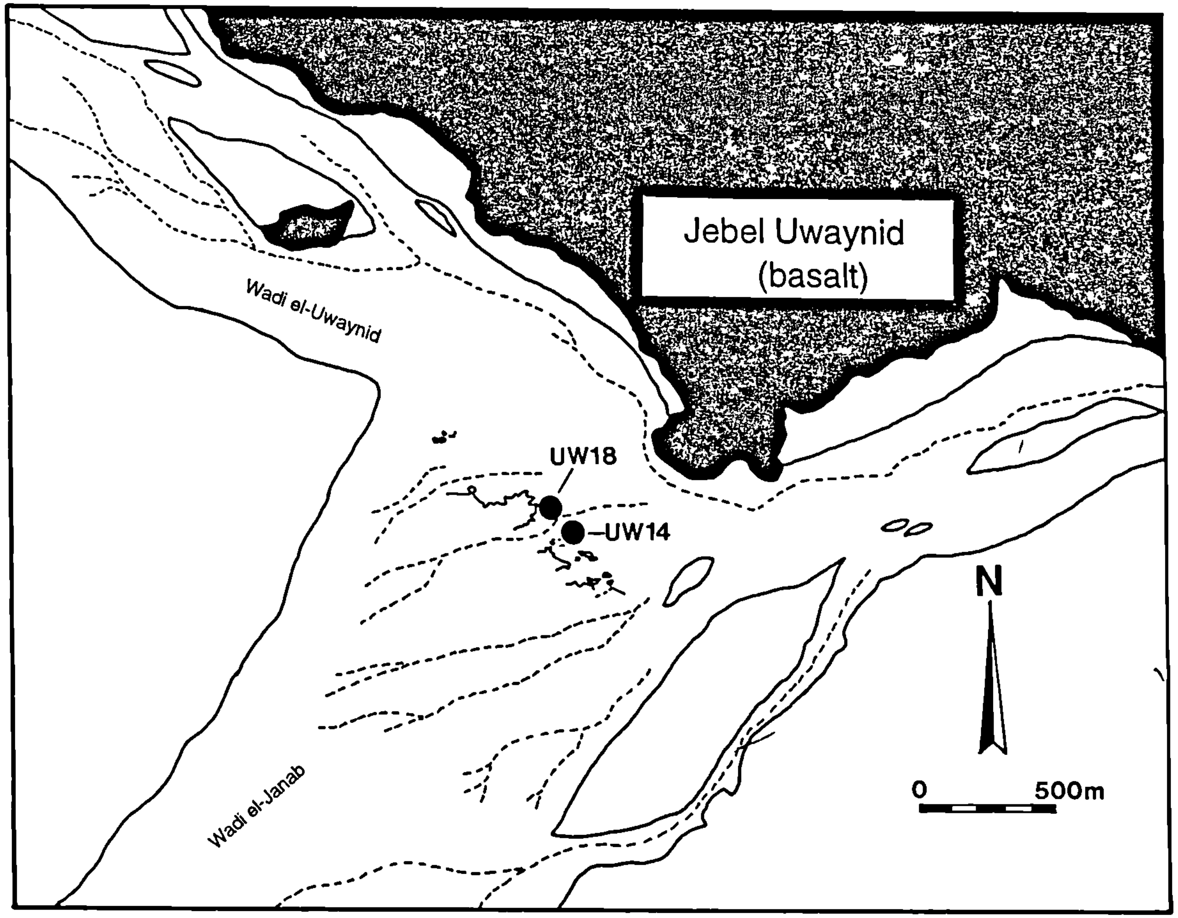


Figure 3.5. Wadi el-Uwaynid, showing location of Uwaynid 14 (UW14) and Uwaynid 18 (UW18).

Azraq Central Basin (figure 3.4)

This oasis lies in a shallow depression, constituting a complex of springs, pools, marshland and a large playa - Qa'a al-Azraq. A Pleistocene lake is evidenced by a thin layer of lacustrine deposits covering the depression. Today, the playa can flood to a depth of 2m in the wet season when it covers c. 50 km²; floods can remain throughout the summer months, but are very variable.

All sites are found adjacent to the springs and marshes south-west of south Azraq (Shishan). Late Acheulian and Middle Palaeolithic assemblages have been found (Copeland and Hours 1988) and the later sequence includes middle Epipalaeolithic, Natufian, PPNB and PPNC/ELN sites.

Wadi el-Uwaynid (figure 3.5)

This *wadi* is 10km south-east of Azraq and runs along the south side of the Jebel Uwaynid, an isolated basalt outcrop. The *wadi* carries much of the runoff water from the central-western side of the Azraq Basin into the playa. Only two sites yielded datable material, both late Upper Palaeolithic/early Epipalaeolithic.

Basalt Desert

Diverse areas of the basalt desert have been investigated (see figure 3.0), including relatively inaccessible central areas, those bordering the limestone *hammada*, wadis, mudflats and upland regions. Systematic survey has taken place in Qa'a Mejalla, Burqu/Ruweishid, Jawa/Shubeiqa, Jebel Qurma, Qa'a Dhuweila, and the lower Wadi Rajil.

There is scant evidence for Palaeolithic occupation - just a few Levallois core surface finds from the Jebel Qurma area - and no early or middle Epipalaeolithic. A few late Natufian sites are known (Khallat Anaza, Jebel es-Subhi and Mugharat el-Jawa) and another (Abu el-Husain) is reported only as Natufian (Betts 1991). Two PPNB sites have been excavated - Dhuweila and Ibn el-Ghazzi, and another (2402 Jebel Qurma) is known from surface finds only (Betts 1989:147). Later PPNB sites in the steppe/desert areas are referred to as 'burin' sites, due to their high proportions of concave truncation burins; they are seen as regional variant of the later PPNB/ELN found in more fertile areas. They are believed to represent specialized economic activity rather than cultural markers. Steppic Late Neolithic sites are abundant, such as the concentration around the lake at Burqu (Betts *et al.* 1990).

Other commonly-found surface features in the Basalt Desert are **kites** and corrals, most of which are difficult to date and are likely to have seen frequent reuse. The term kite describes a structure made from dry-stone walling, enclosed at one end with trailing walls leading into it. They are found in various forms in the Negev and Sinai (Meshel 1974; 1976) and Saudi Arabia, but by far the greatest concentration has been recorded from the Jordanian and Syrian Basalt Desert (although the Syrian section has not been surveyed), where they often form extensive chains over the terrain. Kites have long been recorded and their possible dates and functions discussed (see Helms and Betts 1987). In their review of the evidence, Helms and Betts agree with earlier suggestions that kites represent animal traps, and that the targetted game animal was the gazelle. This is based on ethno-historical accounts, rock-carvings, and archaeological evidence. This last category includes observations that the structures contain no occupation debris; that impact-fractured arrowheads have been found in the enclosures; and in a single case, a kite wall is incorporated into a Late Neolithic site structure (Dhuweila - one of the study sites), which yielded a faunal assemblage dominated by gazelle bones (Helms and Betts 1987; Betts *et al.* nd). The association with this dated site is the only direct evidence that kites may be prehistoric, and as yet it is not known to which other periods this tradition may belong.

Simple circular stone **corrals** are also noted in great numbers, often stretching in loose chains along hillsides or mud-flat margins. They generally yield no dating evidence and are undiagnostic in style, but Betts (1982) suggests they are animal enclosures associated with pastoralists.

Other undated forms are 'jellyfish' structures (also termed 'wheel enclosures', Riley 1982) which generally consist of large circles of low-lying walls with smaller hut-circles incorporated into their outside walls. Their function remains unknown, but the suggestion is that they relate to herding (Betts 1982; 1983).

Settlement patterns

Despite these recent investigations, knowledge of settlement patterns in eastern Jordan remains relatively limited. As yet, observed variation, both between the limestone, oasis and basalt areas, and between eastern Jordan as a whole and the more fertile areas to the west, is difficult to evaluate. For example, it is not clear whether gaps in archaeological sequences reflect gaps in occupation, sampling bias, or whether local assemblages are so different from their well-known Palestinian counterparts that certain periods of occupation (e.g. 10,500-9,500bp) are not yet recognized. Research is still in its infancy, but some points can tentatively be made.

The limestone area evidences almost continuous use through the late Pleistocene and early Holocene, with the exception of the mid 11th millennium bp to the early 10th millennium bp. This gap is contemporary with the PPNA complexes in Palestine, and is a time when other arid areas such as the Negev and northern Sinai show a peak of settlement (Garrard *et al.* 1993). A further observation is that, although there is one Natufian site in

Azraq Central Basin, there are no Natufian finds in the Wadi el-Jilat where a plethora of earlier Epipalaeolithic occupations exist.

The Basalt Desert exhibits the same PPNA-period gap, and also has no assemblages dated to the early or middle PPNB. This area also lacks sites dating to the early or middle Epipalaeolithic; in fact the only pre-Holocene *in situ* sites are late Natufian. Betts (1991:231) notes that this pattern conforms to that in some other Levantine areas, where site distribution expands into the semi-arid areas in the later Natufian.

Late Upper Palaeolithic and Epipalaeolithic sites in the limestone region tend to be large: two sites (Wadi Jilat 6, Kharaneh 4) covering c. 20,000m^2 each are much greater in extent than coeval Levantine sites. Although they are partially deflated and likely to result from smaller-scale palimpsests of occupation, these multiple-phase sites provide evidence for the re-use of certain exact localities over long periods, possibly millennia. It is notable that all sites are adjacent to water sources in an area where water is scarce.

Late Epipalaeolithic sites in the Basalt Desert tend to be smaller (e.g. Khallat Anaza has a surface area of c. 2,000m^2); sites again are adjacent to water sources.

Early PPNB sites appear to be in better-watered areas and open country (e.g. Wadi el-Jilat), whereas later PPNB sites spread further over the steppe and are found in the Basalt Desert (Betts 1989). All PPNB sites are smaller than contemporaneous ones in the moist steppe or Mediterranean zone (e.g. Ain Ghazal and Basta).

Late Neolithic sites are found in both the limestone and basalt areas. They tend to be larger than PPNB sites (e.g. Wadi Jilat 13 and 25), and have been linked to herding (Baird *et al.* 1992:27), although variation is seen, for example at the hunting camp of Dhuweila in the Basalt Desert.

Throughout this sequence, occupation is believed to have been temporary or seasonal in nature, due to the resource limitations of the environment, whether for hunting, herding or mixed-economy groups. What has not been established, however, is whether eastern Jordan served as a year-round territory for groups making seasonal movements within it, or whether the whole area was only used at certain times of the year. As Betts states for the PPNB:

> One other aspect which has not yet been determined is the relationship between steppic groups and those in the Mediterranean zone. Exchange items show that contacts existed but the nature of the relationship between 'steppe' and 'woodland' groups - if indeed there were two such distinct populations - is as yet unclear.
>
> (Betts 1989:147)

This question of how eastern Jordan was used, whether on a year-round basis or seasonally, refers equally to all other periods under discussion here, from the late Upper Palaeolithic to the Late Neolithic.

Palaeoenvironmental evidence

Palaeoenvironmental investigations have been confined to those sites and areas covered by the Azraq Basin Project (see Garrard *et al.* 1988b and 1993 for preliminary results); no evidence derives from the Basalt Desert. Pollen survival is very poor in the area due to calcareous soils, and diatom and mollusc data have not been used due to the limited knowledge of the tolerances of many of the Middle Eastern species.

The palaeoenvironmental evidence available is of two kinds: sedimentary analysis and the geomorphological context of the sites. This is often difficult to interpret since sediments can reflect both broadscale and localized activities. A single pollen sample taken from a terrace in the Wadi el-Jilat provides other data, although unfortunately it is undated. The evidence, although scant, is reviewed firstly for the Late Pleistocene, and secondly, the Early Holocene and table 3.0 provides a summary of interpretations. The sites referred to are described in detail below; those prefixed with WJ are in Wadi el-Jilat, AZ are in Azraq, and UW in Wadi Uwaynid.

Late Pleistocene

Two **late Upper Palaeolithic** sites yield evidence: WJ9 (21,150±400bp) and UW18 (23,200±400bp; 19,500±250bp). WJ9 was found eroding from levels of a fluvial deposit (aggradation unit B), interpreted as having accumulated during a drying out phase when soil erosion was more intense in the valley. In contrast, UW18 is contained in soils suggestive of a higher water table and more vegetation than present-day conditions. Whether this resulted from a general increase in moisture or local spring activity is ambiguous.

The **early Epipalaeolithic** is evidenced at WJ6, where the lowest level (C, estimated at 20,000-18,500bp) sees pedogenic activity suggesting formation under wetter conditions than present. It is assumed that more vegetation than present in the *wadi* today would have been needed to anchor these soils. Such pedogenic activity is also found in WJ6 level B, also early Epipalaeolithic.

Two of the early Epipalaeolithic phases of Kharaneh 4 (A and B, estimated to date to 20,000-16,000bp) are contained within alluvial clays, which reflect formation under moister conditions than present (Muheisen 1988b:175). UW14 (18,400±250bp) is contained in deposits which, as described above for UW18, suggest a higher water table and more vegetation than present, although again, this might reflect very localized activity.

A more arid regime may have characterized the later part of the early Epipalaeolithic, evidenced in sediments of the upper levels of WJ6 and Kharaneh 4. WJ6 A (16,700±140bp; 15,470±130bp) was contained in a sandy matrix, and Kharaneh 4 C and D (the latter dated to

15,200±450bp and 15,700±160bp) were found in aeolian sandy silts (Muheisen 1988b:175), both more indicative of aridity than the sediments of the earlier levels of these sites.

Earlier early Epipalaeolithic sites, therefore, provide evidence for moist local conditions in the Wadi el-Jilat, Wadi el-Kharaneh and Wadi el-Uwaynid. The later early Epipalaeolithic, however, has indications of relatively more aridity.

By comparison, the **middle Epipalaeolithic** (c. 14,500-12,500bp) shows rather contradictory evidence for Wadi el-Jilat alone. WJ22 phases E and C (dated 13,540±120bp and 12,840±140bp) are both contained within marsh sediments (evidenced by *Phragmites* spp. stems), suggesting local spring activity or possibly even artificial damming of the valley. It is equally possible, though, that the marsh reflects a more generalized widespread wetter episode. The site of AZ17 (13,260±200bp) also has occupation horizons which are in part within marsh deposits, again containing casts of *Phragmites* spp. in growth position.

In contrast, the occupation horizon at WJ8 (13,310±120bp - therefore maybe coeval with WJ22) was found in dune silts, suggesting formation under dry conditions (Garrard *et al.* 1988:321). This rather contradicts the general picture.

The single **late Epipalaeolithic** site - AZ18 (estimated to date to 12,500bp-10,000bp) - is contained within aeolian silts, suggesting relative aridity.

On a more regional scale, all Epipalaeolithic occupations in Wadi el-Jilat, with the exception of WJ8 as noted above, are contained in loessic silts. Garrard *et al.* (1993:36) argue that, in contrast to the present-day soil erosion in the area, the loess accumulation evidenced between 20,000bp and 13,000bp is likely to reflect moister conditions and a greater coverage of vegetation. This is consistent with the late Glacial being generally moister than today.

All Wadi el-Jilat Epipalaeolithic sites overlie a lithified aggradation complex (aggradation D), and from the upper part of this a sparse but well preserved **pollen sample** was collected. The sample consisted of 72.5% herbaceous pollen, mainly representing steppic taxa, 14% shrub pollen and 8% arboreal pollen. The arboreal pollen, from heavy pollen producers such as *Pinus* spp., *Abies* spp., *Betula* spp. and *Alnus* spp., implies fairly cool, pluvial conditions to the area further west. The context of this sample, however, is not dated.

Early Holocene

Most of the Neolithic sites in the area (e.g. WJ7, WJ13, WJ23,WJ24, WJ25, WJ26, AZ31) are found within shallow silty-sandy sediments which are awaiting analysis. This kind of deposit, however, is still collecting today, and may reflect drier conditions. By contrast, PPNB WJ32 is contained in colluvium, although this might be explained by its hillslope position as opposed to the *wadi* floor location of the other Neolithic sites.

TIME BP	WADI EL-JILAT	AZRAQ CENTRAL BASIN	WADI EL-UWAYNID
8,000	WJ7,13,23,24,25 26 in silt-sand =DRY	AZ31 in silty sand=DRY	
9,000			
10,000			
11,000			
12,000		AZ18 in aeolian silts=DRY	
	WJ22C=MARSH		
13,000	WJ8 dune=DRY	AZ17=MARSH	
	WJ22E=MARSH		
14,000			
15,000			
	KH4D sandy=DRY		
16,000	KH4C sandy=DRY		
	WJ6A sandy=DRY		
17,000			
18,000			
			UW14 high water
19,000	WJ6C=MOIST		table=MOIST
	KH4Bclays=MOIST		
20,000	KH4Aclays=MOIST		
			UW18 high water
21,000	WJ9 erosion=DRY		table=MOIST

Table 3.0. The implications of the sedimentological analyses for sites in the three areas covered by the Azraq Basin Project (after Garrard 1988b and 1993). (Note that Kharaneh 4 - KH4 - is included in the Wadi el-Jilat area).

In brief, there is neither sufficient evidence or time resolution to assess properly whether palaeoenvironmental patterns are consistent within time periods between areas (Wadi el-Jilat, Azraq Central Basin, Wadi el-Uwaynid) or within an area. Two periods, however, show contradictions. First, late Upper Palaeolithic WJ9 has evidence for aridity whilst UW18 is interpreted as being more moist. Second, the middle Epipalaeolithic aridity suggested by the sedimentary context of WJ8 contradicts evidence for marsh at the broadly coeval phases at WJ22 and AZ17. Explanations for these variations could include differences in local conditions, or maybe environmental fluctuations over time which are imperceptible given the dating methods.

Discussion

How does this picture compare with palaeoclimatic and palaeoenvironmental data from the rest of Jordan, and from the rest of the southern Levant?

Henry's (1986) overview of the palaeoenvironments of Jordan characterizes the period from 20,000bp to 11,000bp as one of alternating moist and dry cycles (note that the late Glacial is, on the whole, assumed to be cooler and wetter than the present and all terms used are relative). His conclusions generally accord with recent evidence from the southern Levant, discussed in Chapter 1, of an increase in humidity in the early Natufian (12,500-11,000bp) followed by cold, dry conditions in the late Natufian until the beginnings of the Holocene (10,000bp). His scenario, however, differs in two respects. Firstly, pollen diagrams for the southern Levant basins witness favourable conditions for tree growth from c. 14,000bp, whereas Henry interprets the period from 15,000-13,000bp as dry. Secondly, the period from 10,000-9,000bp is interpreted as one of increasing humidity and vegetation growth in the southern Levant basins, whilst Henry argues that Jordan continues to experience dry conditions. These two divergences could be explained by local differences, and/or the fact that Henry generally draws on data from Jordanian sites in semi-arid settings.

Henry uses the evidence from Wadi Hammeh 26 on the edge of the Jordan Valley, and Kharaneh 4 (phase A), to suggest a moist episode at around 20,000-19,000bp. The evidence for local wetter conditions in the basal level at WJ6, KH4 A and B and UW18 is in accordance with this, although the Levantine pollen evidence implies that this period is dry. Between 19,000bp and 15,000bp Henry suggests a drier period, which finds support in eastern Jordan from WJ6A, KH4 C and D. At c. 15,000bp, Henry sees a much wetter climate evidenced by a pollen sample from the Wadi Judayid in southern Jordan; eastern Jordan has only one occupation level - KH4 D - which could possibly overlap this date, and this implies relative aridity rather than moisture, therefore adhering more to the combined Levantine models than to Henry's. Accumulated data led him to suggest that areas presently receiving less than 100mm rainfall would have perhaps seen 200-300mm of rain in this period (Henry 1986:11).

Pollen spectra and sediments from Wadi Judayid-Wadi Hisma, and the sedimentology of KH4 C and D form the basis of Henry's argument for a drier episode after 15,000bp and until about 13,000bp (but these two phases of KH4 have since been dated to pre-15,000bp, Muheisen pers. comm.). Evidence from eastern Jordan does not generally support this suggestion: the marsh deposits at WJ22 and AZ17 provide unequivocal evidence for a locally moister regime than present dating between 13,540bp and 12,840bp, although WJ8 presents a conflicting picture. The picture gained from eastern Jordan during this period is more in accordance with the rise in moisture and humidity noted for the rest of the southern Levant post-14,000bp than it is with Henry's model.

After 13,000bp, Henry identifies a moist interval in the sediments of Wadi Hammeh 27 and in the pollen record from Wadi Judayid 2. The related assemblages are both early Natufian (12,500-11,000bp) and, consistent with other evidence from the broader Levant, the moist phase is believed to have continued to c. 11,000bp.. The only site of this period in eastern Jordan to have provided any palaeoenvironmental evidence is AZ18 (typologically early-mid Natufian). Here sediments imply relative aridity, which is at odds with most recent models for the Levant.

Henry sees the period after 11,000bp as predominantly arid, with brief moist episodes. The later Natufian horizons at Beidha and Wadi Judayid (c. 11,000-10,000bp) are both contained in soils indicative of dry conditions, and the pollen record from the latter site confirms a return to desert vegetation. Eastern Jordan has no palaeoenvironmental evidence dating to this period.

A brief moist interval is suggested for the period 9,000-8,500bp, based on geomorphological and palaeobotanical evidence from PPNB Beidha, but again there is no evidence from other Jordanian sites for either this period or the subsequent Late Neolithic.

Modelling the late Pleistocene/early Holocene environment of eastern Jordan

Table 3.1 summarizes the above evidence, creating a very coarse relative palaeoenvironmental sequence for eastern Jordan from 20,000-8,000bp. The sequence combines local evidence from the limestone region, and from the southern Levant.

approx. years bp	**Relative climate**
8,000-	similar to present
9,000- 8,000	increase in aridity and temperature
10,000- 9,000	? arid
11,000-10,000	arid and cold (Younger Dryas)
13,500-11,000	moist and warm
14,000-13,500	increase in temperature and precipitation
19,000-14,000	arid and cold
20,000-19,000	local moisture and cold
-20,000	arid and cold

Table 3.1.

Two trends observed by the COHMAP Members (1988), and highlighted for the Levant by McCorriston and Hole (1991:52-53), add detail to this coarse picture. Firstly, temperatures for the region at 18,000bp are predicted to be 6-8°C cooler than today, whereas by 12,000bp July temperatures are estimated to have been 2-4°C higher, with winter temperatures correspondingly lower. This relates to the second trend: an increase in seasonality, assumed to have been most extreme between 12,000bp and 6,000bp, which led to a predominantly Mediterranean climate over much of the Near East (i.e. greater contrast between summer and winter temperatures, and lengthened summer aridity).

Such data clearly preclude any detailed modelling of the prehistoric environment of eastern Jordan. The aim, rather, is to make broad **relative** comparisons between the study areas over the period of interest as a basis for predicting faunal distribution, animal ecology and behaviour.

The lack of detail on ancient vegetation is problematic. Botanical samples show steppic shrubs and grasses in the Epipalaeolithic and Neolithic in the Wadi el-Jilat, and also in the Neolithic of the Basalt Desert. In addition, Wadi el-Jilat Neolithic samples produced evidence of arboreal vegetation. Such samples, however, are the product of human selection and cannot be used to infer vegetation patterns. Use of modern vegetation is hazardous due to the effects of long-term over-grazing and human interference, as well as those of climatic change. Consequently, the approach here is to assume that prehistoric eastern Jordan had a broadly steppic vegetation cover. Concern does not lie with the **types** of vegetation, but rather with suggestions of density or patchiness of plant cover, times of arrested growth and times of vegetation flushes. Discussion relates only to those periods for which occupation in areas is attested.

Wadi el-Jilat and Wadi el-Kharaneh

Topographically, these areas are both wide *wadis* in rolling limestone and flint hills. Rainfall received would be higher than further east. Throughout the late Pleistocene and early Holocene, the seasonality of rainfall and temperatures would probably mean that vegetation growth was arrested in winters and summers, with the main flush of growth in spring.

In late Upper Palaeolithic (c. 20,000bp) in Wadi el-Jilat, cold dry conditions would probably lead to fairly even vegetation cover with concentrations in *wadis*.

The Early Epipalaeolithic has two patterns: firstly, at c. 20,000-19,000bp, local moisture is evidenced, which might have led to denser vegetation in the *wadis* and surrounding areas. The evidence from sites dating to c. 19,000-14,000bp shows drier conditions again, and vegetation may have been correspondingly sparser. A fairly even cover, however, could be expected throughout.

Middle Epipalaeolithic conditions (c. 14,000-12,500bp) are believed to have been moister and warmer than those preceding them. Vegetation was probably much lusher and denser at this time, and standing water available, witnessed by the marsh plants at WJ22. The vegetation growth period may have extended longer into summers, although with seasonality also increasing, this cannot necessarily be assumed.

Occupation is next seen in the PPNB (c. 9,000-8,000bp) and Late Neolithic (c. 8,000-7,000bp) in Wadi el-Jilat only. The rise in temperatures and aridity would probably have led to an increasing tendency for vegetation to adhere to *wadi* bottoms and depressions, where runoff would collect, especially into the summers. Plant cover would probably have been both more sparse and concentrated than in the late Pleistocene.

Wadi el-Uwaynid

Topographically, this is a large *wadi* bordering a basalt outcrop, and would probably have received similar amounts of rainfall to the Wadi el-Jilat area. Evidence from the late Upper Palaeolithic, however, suggests more local moisture than in Wadi el-Jilat, and hence vegetation would probably be quite dense; seasonality of growth would probably be similar to the Jilat area. The early Epipalaeolithic (c. 20,000-18,000bp) shows similar conditions, and fairly concentrated vegetation patches might be expected.

Azraq Central Basin

This oasis at the centre of a large water catchment area has year-round pools, springs and marshlands. The vegetation supported would probably differ greatly from the other areas, and would be much lusher and denser. The middle Epipalaeolithic (c. 13,000bp) and late Epipalaeolithic (c.12,500-11,000bp) occupations would probably have experienced more year-round availability of vegetation than other areas.

Basalt Desert

Throughout the time sequence, the basalt area is likely to have received less rainfall than any of the above areas. Soils are also probably less favourable for vegetation development. Topographically, the area generally consists of basalt boulder hills and ridges with wide wadis and mud-flats serving as water collection points.

The earliest sites in the Basalt Desert date to the late Epipalaeolithic (c. 11,000-10,000bp), which is believed to be arid. For both this period and the PPNB (c. 9,000-8,000bp) and Late Neolithic (c. 8,000-7,000bp) - times of increasing temperature and aridity - vegetation could probably be expected to be fairly sparse and patchy, even in wet seasons. In summers, particularly with the increased seasonality of these times, there would probably have been little growth at all. A flush of vegetation would have been seen in the spring, but may have been fairly short-lived and concentrated around areas of water collection, such as *wadis* and mud-flats.

The study sites

Most limestone and basalt desert sites which have yielded faunal remains are used in the present study. The sites are described more fully in published preliminary reports. The aim here is to present a brief summary of features, finds and dating evidence of each site. Descriptions follow areas, and the oldest sites are presented first. Dates given are C^{14} uncalibrated. Where no dates are available, sites are assigned to periods on typological grounds. Site names are coded, and these codes used henceforth.

Wadi el-Jilat (figure 3.2)

Wadi Jilat 9 (WJ9) is a late Upper Palaeolithic single period site, dated 21,150±400bp, with a deflated surface area of 6,750m². The lithics are basically non-microlithic, and the assemblage dominated by endscrapers, notches/denticulates and non-standardised retouched pieces. (Refs: Garrard *et al.* 1985:11-13; 1986:7-9; 1988b:46-47; 1993; Byrd 1988a).

Wadi Jilat 6 (WJ6) is a large double mound with a deflated surface area of 19,175m²- one of the largest Epipalaeolithic sites known in the Levant. Three levels of early Epipalaeolithic occupation were excavated. They all contain marine shells (mainly *Dentalium* spp.), bone points, beads and fragments of worked basalt and limestone. (Refs: Garrard *et al.* 1985:15-17; 1986:12-17; 1988b:44-47; 1993; Garrard and Byrd 1992; Byrd 1988a).

WJ6 C is the earliest cultural horizon. Lithics from here are mainly non-geometric microliths (81% of the retouched tools), dominated by arched-backed pieces. The assemblage is virtually indistinguishable from the upper phase at UW18 and the middle phase of UW14, which would date it to c. 18,400-19,800bp.

WJ6 B, the middle occupation, also has a high proportion of microliths (75% of the retouched tools), again non-geometric, among which La Mouillah points dominate. Other forms include double-truncated backed bladelets and Qalkhan points. The non-microlith class includes frequent notches/denticulates, and non-standardised retouched pieces. The assemblage has close affinities with the upper phase of UW14 (18,900±250bp).

WJ6 A, the uppermost occupation, is a dense artifact horizon, the lower part of which is characteristic of compressed and trampled occupational surfaces. At the base, two thin horizontal ochre-pigmented plaster surfaces were found, which had lipped-up edges and appeared to be floors of structures. The lithic assemblage is unique in the southern Levant. It contains a geometric backed-bladelet industry dominated by asymmetric and symmetric triangles, whilst lunates are also present. Non-geometric microliths include microgravette points and curved, pointed, arched backed pieces, whilst the non-microlithic tool component is made up mainly of end-scrapers and burins. A concentration of six C^{14} determinations date this phase to between 15,470±130bp and 16,700±140bp, which is earlier than most known small triangle industries.

Wadi Jilat 8 (WJ8) is a single phase middle Epipalaeolithic site with a surface artifact spread of 6,300m². Basalt artifacts and shell beads were found, but no structural remains. Of the lithics, microliths make up 73% of the retouched tool class, and backed bladelet fragments dominate. Forms include trapeze-rectangles, La Mouillah points, and curved, pointed, arched backed pieces. Of the non-microlithic tools, most are end-scrapers. The occupation is dated to 13,310±120bp. (Refs: Garrard *et al.* 1985:10-11; 1986:9-12; 1988b:46-47; 1993; Byrd 1988a).

Wadi Jilat 10 (WJ10) is also middle Epipalaeolithic with a single phase; the original extent of the site is unknown due to erosion. Of the retouched chipped stone tools, 17% are microliths, of which most are backed bladelet fragments. Non-microlithic tools are principally end-scrapers, burins, truncations and non-standardised retouched pieces. Three C^{14} dates place this occupation between 14,790±200bp and 12,700±300bp. The contrast between this and the assemblage from WJ8 is notable. (Refs: Garrard *et al.* 1985:13-15; 1986:9; 1988b:46-47; 1993; Byrd 1988a).

Wadi Jilat 22 (WJ22) is a middle Epipalaeolithic site with deflated surface covering at least 3,500m²(the site is cut by a stream channel). Of six identified phases, only three contain cultural material. No structural remains were found. Marine shell beads were present throughout the sequence, particularly *Dentalium* spp., *Columbella* spp. and *Cerithium* spp.. (Refs: Garrard *et al.* 1985:17; Garrard and Byrd 1992).

WJ22 E is the earliest horizon, with two dates: 13,490±110bp and 13,540±120bp. The matrix within which artifacts and bone were contained was an extremely hard calcrete and difficult to excavate, making the samples retrieved not reliable in terms of quantification. Lithics, however, appeared similar to WJ22 C.

WJ22 C contained a high density of artifacts dated to 12,840±140bp and 13,040±180bp. The lithics showed a high proportion of cores for blade/bladelet production. Of the retouched tools, microliths formed only 7%, and are primarily backed. 51% of the total retouched class are 'Jilat Knives' - tools made on blades, usually backed and tanged, but not serving as projectiles (since they have edge wear; hence the term 'knives'). These forms are unique in the southern Levant. Other retouched pieces include burins and notches/denticulates.

WJ22 B is the latest horizon, dated to 11,920±180bp. The lithic assemblage has a high frequency of both geometric and non-geometric microliths, with backed examples including trapeze-rectangles, La Mouillah points, triangles and lunates. The non-microlithic tool component includes notches/denticulates, scrapers and burins. Flake cores are common, as are microburins to a lesser degree. This phase contains a number of 'Jilat Knives', probably deriving from WJ22 C.

Wadi Jilat 7 (**WJ7**) is an early, middle and middle/late PPNB site. The deflated surface shows an artifact spread of 2,250m², and structures were visible on the surface. (Refs: Garrard *et al.* 1985:17-18; 1986:17-23; 1988b:44-48; 1993).

WJ7 1 is early PPNB occupation (in areas A and C) showing structures and features cut into bedrock. Finds include basalt grinding slabs, shaft-straighteners, stone vessels and a few stone and shell beads. The lithic assemblage consists of single platform cores, blade/bladelet cores, opposed platform cores, naviform cores, and a specialized core reduction strategy adapted for use with tabular flint (common in the Wadi el-Jilat). The industry generally uses blades and bladelets; Khiam and Helwan points are represented (and one Byblos point), as are Hagdud truncations. By comparison with the lithics typology for the southern Levant, this phase would be dated to c. 9,500-9,000bp.

WJ7 3 is middle PPNB occupation in the same areas as WJ7 1 (A and C), where new stone alignments and walls were erected. The lithic tool kit is similar to that in WJ7 1, but Jericho points suggest its slightly later date.

WJ7 2 refers to squares 1-8, where a complex of structural walls of upright slabs and thick ashy occupation deposits were found. The lithic assemblage includes Byblos, Jericho and Amuq points, burins, scrapers, sickles and borers and is consistent with the two dates (8,810±110bp and 8,520±110bp) in suggesting middle PPNB occupation.

WJ7 4 - also middle PPNB - shows a curvilinear subterranean structure in area B built of limestone slabs placed in the upright position. The structure has a diameter of 3.6m, it has internal partitions and probably supported an organic superstructure. Worked basalt and limestone objects include vessels, shaft-straighteners, pestles, grinding slabs, handstones and incised grooved and perforated stones. Stone and shell beads and bone tools were also found. The lithic assemblage comprises opposed platform blade/bladelet cores, a high proportion of classic naviform cores, the specialized tabular flint reduction strategy, Byblos and occasional Jericho points, a range of piercers and burins. The two dates from this phase are 8,810±110bp and 8,520±110bp.

WJ7 5 represents middle/late PPNB occupation, found in the upper levels of the curvilinear structures established in WJ7 4. Core types are similar to those in the middle PPNB, and Byblos points are present, along with piercers, drill bits and burins. The horizon is undated, but by analogy with lithics from other Levantine sites, probably belongs to the second half of the 9th millennium bp.

Wadi Jilat 26 (WJ26) is a middle PPNB semi-circle of c. 20 buildings, clearly evident at the modern ground surface, with an artifact spread of 7,850m². Most of the structures are circular/oval, but two are rectangular. The lithic assemblage includes opposed platform blade/bladelet cores, naviform cores and tabular adapted opposed platform cores, Byblos and Amuq points, burins and bifacials. Ground stone artifacts and beads are rare. Three main areas were excavated:

WJ26 A covers one of the rectangular structures. This was found to be 5m x 4m in size, cut into bedrock in places, and built of upright slabs, coursed walling and paving. The building has internal 'pier' structures, and a later annex was added.

WJ26 C is a circular semi-subterranean structure built of upright limestone slabs with an internal diameter of 3.5m. Two dates were obtained from the occupation: 8,720±100bp and 8,690±110bp.

WJ26 E describes an area of (external?) stone-lined hearths and bedrock mortars, which appears to be a processing area. A date of 8,740±110bp was obtained from one of the hearths.

Wadi Jilat 32 (WJ32) is a middle or possibly late PPNB site which, in contrast to most others, is situated on a hillslope in the *wadi*. An oval structure built from upright slabs was found cut into the hill, with internal measurements of 1.5m x 3.6m. Basalt handstones, a mortar and a pestle were found. The lithic industry showed similarities with the middle PPNB at WJ7 with opposed platform blade/bladelet cores, classic naviform cores, tabular flint adapted cores, Byblos points and a few burins and inversely retouched blade/bladelets. The site is not independently dated. (Refs: Baird *et al.* 1992)

Wadi Jilat 25 (WJ25) is a single phase site of PPNC/ELN date (8,020±80bp), which has a deflated surface covering 3,200m². An oval structure (measuring 7m x 4.5m) was located, which was built using the same techniques as those seen in the *wadi* in the PPNB. Excavations produced a large number of Dabba 'marble' beads, in various stages of production; a few shell beads were found, and stone tools included basalt handstones, shaft-straighteners and vessels. The lithics show that, in contrast to PPNB sites, flakes become more important than blades. Cores include single platform, change of orientation and opposed platform types. Point types represented are Nizzanim, Herziliya, Amuq and Byblos, and other tools include angle burins, drill-bits on burin spalls and bifacials. (Refs: Garrard *et al.* 1993).

Wadi Jilat 13 (WJ13) is essentially a PPNC/ELN site with two structural phases and a middle levelling phase, although a small number of isolated residual PPNB artifacts was also found. The site has a deflated artifact spread of 800m². The main oval structure measures 10m x 6m and was built in the same tradition as those seen at Jilat PPNB sites; it was modified in its later phase of use by the addition of an internal pavement. WJ13 yielded relatively few grinding and pounding tools, but decorative and 'art' objects were frequent. These included figurines, engraved slabs, perforated stones, dressed pillars, Dabba 'marble' beads in various stages of manufacture, shell beads, mother-of-pearl, and bone beads and tools. Although the two phases of structural use are dated very closely, their lithic assemblages show different affinities. (Garrard *et al.* 1993; in prep.).

WJ13 1 has two dates, 7,920±80bp and 7,870±100bp. Cores include opposed platform blade/bladelet types, classic naviform, and tabular adapted opposed platform types. Blades/bladelets are more important than flakes. Points include Amuq, Nizzanim, Byblos and Herziliya forms. Angle burins, drill-bits on burin spalls, bifacials and end-scrapers are also present.

WJ13 2 refers to a middle phase of occupation during which part of the structure was sealed off, and isolated architectural features, pits and hearths were added elsewhere.

In the later phase, **WJ13 3**, use of the structure is dated to 7,900±80bp and 7,829±89bp. Core types, dominant point types and other tool types are similar to those described for WJ13 1, but the assemblage has the addition of Haparsah points and transverse arrowheads. This phase also includes large transversely-retouched blades, suggestive of Canaanean blades (usually Early Bronze Age), but securely stratified to the Late Neolithic.

Wadi el-Kharaneh (figure 3.3)

Kharaneh 4 (KH4) is an early Epipalaeolithic site, located c. 1km south-west of Qasr Kharaneh. The deflated surface shows artifacts covering an area of 21,672m², which, like WJ6, is likely to represent multiple reoccupations, but nevertheless is the largest known Levantine Epipalaeolithic site. Four cultural horizons were identified which, through comparative lithic typologies and dating, have been correlated with the Kebaran/early Epipalaeolithic. (Refs: Muheisen 1985; 1988a; 1988b; Rolston 1982).

KH4 A has a living floor with associated hearths, a basalt mortar and other worked stone objects. The lithics comprise mainly microliths, with retouched bladelets forming the most common category. These included microgravettes with bipolar retouch. Microburins are also present, as are end-scrapers, with less frequent burins, and notches/denticulates. The assemblage is suggestive of an Ancient Kebaran industry (usually dated to c. 20,000-17,000bp).

KH4 B also consisted of a living floor with hearth and associated artifact and bone concentration. Two skeletons were found buried beneath the floor: one complete, belonging to a male, is extended on its back with the head in an upright position with two large stones covering the head, and another two over the legs. The other skeleton which lay alongside the first is also male and in a very fragmentary condition. Gazelle horncores had been placed either side of the head of this individual (Rolston 1982). The lithic assemblage comprised mainly microliths, with non-geometric forms such as obliquely truncated backed bladelets and narrow pointed bladelets predominating. End-scrapers, burins and truncated blades were also found, as were notches/denticulates and multi-functional tools. Crested bladelet cores are characteristic of this phase, and the total assemblage implies a Classic Kebaran dating (c. 17,000-14,500bp, Henry 1989).

KH4 C had another living floor and a rectangular hearth. Non-geometric microliths dominate the chipped stone assemblage, with forms such as backed and truncated bladelets. End-scrapers are numerous, burins rare, and truncated blades, awls and retouched blades and flakes also present. This phase has not produced satisfactory dates, but stratigraphic positionioning suggests a date between c. 17,000bp and 15,000bp.

KH4 D is the uppermost level, including a living floor with many hearths, a pit and a dense concentration of occupation deposit. A series of postholes forming an arc is possibly the remains of a structure. Marine shells and several pieces of ochre were found on the floor surface. The assemblage is primarily blade/bladelet orientated. It is dominated by geometric microliths, of which trapezes are the most common form. Obliquely truncated bladelets, micro-awls, end-scrapers on blades, truncated blades and notches/denticulates are also present. This phase produced three radiocarbon determinations: 15,700±160bp, 15,200±450bp and 14,570±350bp (Muheisen pers. comm.)

Azraq Central Basin (figure 3.4)

Azraq 17 (AZ17) is middle Epipalaeolithic, located on an island in the present south Azraq marshes. The deflated surface shows an artifact spread of 3,100m^2. Two different lithic assemblages were manifest in the two trenches excavated, although their relative stratigraphic positioning is not clear. (Refs: Garrard *et al.* 1987:18-19; 1988b:46-47; 1993).

The chipped stone from **AZ17 1** (squares 1-6) is predominantly microlithic (83% of retouched tools), consisting mainly of broken backed bladelets, many of which exhibit truncations. A small number of lunates and triangles are also present, whilst the non-microlithic tools are mainly non-standardized retouched pieces.

AZ17 2 (squares 7-15) gave a date of 13,260±200bp, which the excavator sees as being too late for the assemblage. This has a lower proportion of microliths than AZ17 1

(55% of the retouched class), although the types represented are the same. The most common microliths here are very thin bladelets with retouch. Non-microlithic tools are mainly end-scrapers, burins and non-standardised retouched pieces.

Azraq 18 (**AZ18**) is a single phase late Epipalaeolithic/Natufian site, located close to a spring in the south Azraq marshes. The artifact spread covers 1,400m², although the site surface is deflated. Ten pieces of worked basalt and sandstone were found, and shell beads also present. A depression underlying the main occupation held the crushed skulls and disarticulated postcranial bones of up to 11 human individuals. The lithic assemblage is typically Natufian: 84% of retouched tools are microliths, mainly lunates, retouched by Helwan, bipolar and abrupt techniques. Non-microlithic tools are generally non-standardized pieces and truncations. These characteristics suggest the site is early-middle Natufian (12,500-11,000bp). In his analysis of Natufian assemblages, Byrd (1989) places AZ18 in his group 3 cluster which he sees as characteristic of steppe/desert sites, showing a narrow range of activities and a special emphasis on hunting. (Refs: Byrd 1989; Garrard *et al.* 1987:20-21; 1988b:46-47; Garrard 1991).

Azraq 31 (**AZ31**) is a late PPNB and Late Neolithic site, situated between the Azraq playa and marshes. The site is not included in the present work since analysis of the faunal remains is incomplete. It is mentioned here, however, because it is referred to in some later dicussions. (Refs: Garrard *et al.* 1985:17-19; 1987:21-23; 1988b:44-48; Baird *et al.* 1992).

AZ31 late PPNB levels contain hearths and ashy deposits, and a cobbled platform, from which many stone, shell and bone beads came. The horizon has been dated to 8,350±120bp. The lithic assemblage shows cores of opposed platform blade/bladelet type, classic naviform type and those using the tabular-adapted, opposed platform strategy. Blades/bladelets are more important than flakes. Byblos points are present, as are piercers, burins, large blade tools and sickles.

The **AZ31 PPNC/ELN** levels see the remains of structures, which were built using the same upright slab technique as seen in the Jilat Neolithic. Pits and midden deposits were found in the adjacent areas. Finds include a basalt handstone, perforated stones, a shaft straightener, pebble mortars, bone beads and points, shell beads, and Dabba 'marble' beads in various stages of production. The lithics assemblage includes the same core types as the PPNB phase, Amuq, Nizzanim, Herziliya and Byblos points and also angle burins, drill bits on burin spalls, bifacials and sickles.

Wadi el-Uwaynid (figure 3.5)

Uwaynid 18 (UW18) is a two phase late Upper Palaeolithic and early Epipalaeolithic site, situated in a terrace on the south side of the wadi. The surface artifact spread, which is eroded, covers at least 875m². (Refs: Garrard *et al.* 1987:9-15; 1988b:46-47; 1993; Byrd 1988a).

UW18 lower phase consisted only of a hearth with burnt basalt pebbles. The associated lithics assemblage was sparse and indistinct. A date of 23,200±400bp was obtained from the hearth, placing the horizon within the late Upper Palaeolithic.

UW18 upper phase saw a dense horizon of occupational material, including worked basalt pieces and shell beads (*Dentalium* sp.), and all the faunal remains derive from here. The chipped stone assemblage is predominantly microlithic (89% of retouched tools), and narrow, pointed, arched backed pieces are most frequent. Two dates, 19,800±350bp and 19,500±250bp, secure the horizon to the early Epipalaeolithic, and the lithics would not appear to contradict this.

Uwaynid 14 (UW14) is early Epipalaeolithic with three phases. The original extent of the site is uncertain due to erosion. (Refs: Garrard *et al.* 1985:15; 1987:8-15; 1988b:46-47; 1993).

UW14 lower phase consisted of a very thin artifact scatter, and sparse lithic assemblage. It is undated, and its chronological position is unknown.

UW14 middle phase is represented by a dense concentration of artifacts. Microliths dominate (making up 95% of retouched tools) and are predominantly narrow, arched backed pieces, making this assemblage very similar to UW18 upper phase and WJ6 C. The lithic typology is slightly inconsistent with the radiocarbon date of 18,400±250bp; from regional similarities with dated assemblages, the horizon may possibly be earlier.

UW14 upper phase has a date of 18,900±250bp. The lithics again show microliths dominating the retouched tool class (86%); La Mouillah points and double truncated backed bladelets are most frequent.

Basalt Desert (figure 3.0)

Khallat Anaza is a late Natufian site located on the southern bank of the Wadi Rajil, a few kilometres downstream from Jawa. The site is on a small bedrock outcrop, near a deep pool in the wadi, suggesting possible water availability for much of the year. The surface artifact spread covers c. 2,000m^{2}and occupation deposits are thin. Structural remains include a stone wall enclosure, with bedrock mortars and a small flat-stone pavement. Basalt hammerstones, a mortar and beads of shell and Dabba 'marble' are amongst the finds. Within the chipped stone assemblage, cores are for blade/bladelet production, with opposed or crossed platforms. Notches/denticulates and non-geometric microliths are common. The specific tool types, however, are lunates and borers; the lunates being occasionally of Helwan type, but more often showing abrupt or bipolar retouch. The ratio of lunate types suggests a late Natufian date for the site, and following Byrd's typological characterization (1989), the assemblage falls in cluster 2, interpreted as reflecting a focus on processing animal carcasses. (Refs: Betts 1985:30-32; 1991).

Ibn el-Ghazzi is a late PPNB site located in the south-western sector of the Basalt Desert, situated on a hilltop, overlooking a small mudflat. The site consists of groups of structures and concentrations of flint scatters, although the structures appear to have seen much reuse. A preliminary investigation into the lithics shows burins to be common, with bipolar cores and some scrapers, borers and sickle-blades. On typological grounds, the assemblage is similar to that from the late PPNB horizon at Dhuweila. (Refs: Betts 1985:34-36).

Dhuweila (DH) is a late PPNB and Late Neolithic site located on the south-west side of the Jordanian sector of the Basalt Desert, just north of the modern Trans-Arabian Pipeline track. It is situated on a low basalt ridge, overlooking a series of mudflats. (Refs: Betts 1985:33-34; 1988; in press).

DH 1 (PPNB) includes five identified phases of activity (1-5; 1 being earliest), centred on a roughly oval structure with irregular passageway, hearths and pits, some of which are plaster lined. Two of the basalt stones used in construction had carvings on them. The lithic industry is blade based, with blanks struck predominantly from bipolar cores, some of naviform type. A high incidence of core-trimming elements show that some knapping was carried out on site. Arrowheads (Beidha and Byblos type) and burins are characteristic of the tools, and scrapers, borers and bifacial tools occur in small numbers. The burin class includes both dihedral and truncation forms.

Phase 1 saw a series of pits and scoops into the natural ground surface, which contained ashy occupational deposits. The scoops may represent living hollows. A date of 8,350±100bp was obtained. Phase 2 sees a series of thin low walls built against the downslope of the hill. Phase 3 is a major building phase, using techniques of dry-stone coursing, upright slabs and internal partitions in the structure. Several pits are associated with this phase, and a date of 8,190±60bp was given. Phase 4 witnesses the building of further small irregular walls, and Phase 5 sees the heavy buildup of occupation levels in external areas, and the setting of a pavement within the structure. The faunal remains from these five phases are treated together in this project.

DH 2 (Late Neolithic) includes four phases of activity (6-9), all reusing the DH 1 structure. The lithic assemblage is less heavily blade based than in DH 1. Cores are irregular and both blade and flake blanks are smaller; blade cores tend to have single platforms. Arrowheads are common amongst the tools. They are mainly bifacially pressure-flaked forms, some tanged, some leafshaped and others transverse arrowheads. Other tools include tabular scrapers, pressure-flaked knives, burins, borers and a few sickle blades.

Phase 6 represents a partial clearing of the structure, and the laying of new paving over DH 1 occupation deposits. A circular grinding stone was set into this pavement. There are two dates: 7,450±90bp and 7,140±90bp. Phase 7 witnesses a build-up of occupation deposits above the pavement and a high proportion of flint tools and worked basalt was retrieved from here. Phase 8 sees the laying of a second pavement in one section of the structure, and the construction of a semi-circular platform. A sample from this horizon gave a date of 7,030±90bp. Phase 9 sees the build-up of more occupational debris, so that the main structure is mostly filled by this time. The faunal remians from phases 6-9 are treated together.

Jebel Naja is a single period Late Neolithic site in the western Basalt Desert, on a steep slope in the mouth of the Wadi Quattafi. The site is centred around a cluster of corrals, which have probably seen much reuse. Occupation deposits are very thin and many of the finds derived from the surface. A small structure was excavated which contained three fire pits, ashy deposits, and traces of bead making on green and pink stone (Dabba 'marble'?). A preliminary analysis of the lithics shows drills and burin spalls, concave truncation burins and chunks of very roughly worked flint. The site produced a date of 7,430±100bp, which appears consistent with the lithic assemblage. (Refs: Betts 1985:36-39; Betts *et al.* 1990:19).

Burqu 27 (B27) is a Late Neolithic site 0.5km west of the modern lake at Qasr Burqu, which would probably have provided water for much of the year in prehistoric times. This area is at the eastern edge of the basalt, where it meets the limestone. Five phases of activity were identified; only 2 and 3 (referred to here as **B27 2**) produced sufficient faunal remains for use in this project. The lithic assemblage is dominated by burins, scrapers, and retouched blanks, but arrowheads, truncations and perforators are also important. The presence of Byblos points in the earliest levels (phase 1) suggests that occupation began at the PPN/Late Neolithic transition, and, based on typology, the upper levels (4 and 5) may represent the late end of the Late Neolithic, or possibly early Chalcolithic. It is worth noting that the chipped stone is of a very different character to that of other steppic Late Neolithic sites such as DH 2 and Jebel Naja. Other artifacts include stone, shell and chalk beads, shell pendants, two sherds from Phase 4, and an array of groundstone objects. (Ref: McCartney 1992).

Phase 1 represents the earliest occupation and includes pit and hearth features cut into bedrock. Two dates were obtained, 7,350±80bp and 7,930±80bp, which are broadly consistent with the timing of the PPN/Late Neolithic transition in the area. Phase 2 represents a rubble oval structure, with hearths and a paving, and a rich occupation deposit which gave a date of 7,270±80bp. Phase 3 witnesses the building of a second structure, ovoid in plan. Phase 4 has an additional construction, using the upright slab technique. Phase 5 sees paving covering much of the earlier structures, and a large basalt quern set into it. This phase is deflated and disturbed by later activity.

Discussion of general trends

An attempt is made here to draw out patterns and variability within the area of eastern Jordan, for both the general Epipalaeolithic and Neolithic periods. The nature of occupations and material culture is outlined, and temporal and regional trends are highlighted.

Epipalaeolithic

Architecture

By far the majority of Epipalaeolithic sites have no structural features. Most sites consist of artifact horizons of varying depths, which are sometimes interpreted as 'surfaces' or 'living floors', but more often not.

The only three sites/phases which have yielded further information are WJ6 A and KH4 D in the limestone area, and Khallat Anaza in the Basalt Desert. At WJ6 A, the two ochre-pigmented plaster surfaces can probably be seen as 'internal' floors of a structure, but the small area excavated did not uncover any other features. The arc of postholes found at KH4 D has been interpreted as probably structural. At Khallat Anaza, a stone wall enclosure made from basalt boulders, dates to the late Epipalaeolithic.

In situ hearths are seen at some occupations; pits (filled with ash) are only recorded from KH4 C and D; storage features have not been identified.

In other areas of the Levant, architecture is rare in the early Epipalaeolithic, as it is in the study area. The later Epipalaeolithic (Natufian, Harifian), though, sees clusters of structures at Mediterranean zone sites and in the Negev - something which is not mirrored at the two sites of this period in eastern Jordan.

Lithics

From his lithics analysis, Byrd (1988) suggests that there are two types of Epipalaeolithic site in the Azraq Basin: short term sites, and longer term sites or those seeing repeated occupation. These are defined on the density of artifacts, thickness of deposit and range of tool types (indicating range of activities), as well as from other material culture evidence. Table 3.2 shows how the Azraq Basin sites divide into these two categories.

period	short term occupation	longer-term or repeated occupation
L EPAL		AZ18
M EPAL		WJ8 WJ10 AZ17 WJ22 B WJ22 C WJ22 E
E EPAL	UW14 WJ6 C WJ6 B	UW18 WJ6 A
Late UPAL		WJ9

Table 3.2. The two types of occupation observed at Azraq Basin Epipalaeolithic sites, following Byrd (1988).

Of the Epipalaeolithic sites which were not studied by Byrd, all phases of KH4 (A, B, C and D) are probably longer-term/repeated occupations, as is Khallat Anaza in the Basalt desert.

Most of the Epipalaeolithic assemblages have a predominance of blade/bladelet cores, and consist primarily of microliths; flake cores are only prevalent at WJ22 B and AZ18. Other tool types include end scrapers, notches/denticulates, burins and truncations. Microliths show the same trends as elsewhere in the Levant, in that they are mainly non-geometric earlier (e.g. at most early Epipalaeolithic sites) and replaced by geometric types later (at WJ6 A, KH4 D). Many retouched tool categories resemble those from contemporaneous sites elsewhere, but distinctive regional traditions are seen, e.g. in the pointed arched-backed microliths found at UW18, UW14 and WJ6 C, and the early triangle industry from WJ6 A.

Byrd finds the intensive production of microlithics to be the primary activity at Azraq Basin Epipaleolithic sites, and presumes they were used as hunting projectiles (Byrd 1988a:260). A greater diversity of tool types in Middle Epipalaeolithic assemblages (and WJ6 A), however, may reflect a wider range of tasks.

Ground stone

As in the rest of the Levant, ground stone is scarce in early Epipalaeolithic sites in eastern Jordan, and consists mainly of handstones and perforated pieces (Wright 1991). In the late Epipalaeolithic (Natufian), the frequency of ground stone artifacts increases at Mediterranean zone sites, a trend that had been associated with ideas of the intensification of plant processing and sedentism (see Wright 1991; 1993). It is interesting to note that Natufian AZ18 has a relatively high number of ground stone pieces.

Plant remains

The only deposit to yield charred seeds is WJ6 A, and the sample is small. Colledge's analysis found that seeds could be identified only to family or genus level, and most belonged to Chenopodiaceae, Compositae, Cruciferae, Cyperaceae, Gramineae and Scrophulariaceae (Colledge in Garrard *et al.* 1988). Chenopods are widespread in the steppe, flower in both spring and autumn, and their seeds are potentially edible and storable resources. The grasses in the sample compare to *Stipa* spp. and *Aleuropus* spp. and could also have been used as food.

Other

Marine shell beads, which attest to contact/exchange, have been found at several Epipalaeolithic sites. These are made particularly on *Dentalium* sp. (e.g. UW18, WJ6, WJ22), although some are also on other kinds (*Columbella* sp., *Cerithium* sp.).

Worked bone is not common and is represented mainly by bone points (e.g. at WJ6, AZ18) and a few beads; the drilled *Bos primigenius* horncore from AZ18 is noteworthy.

The only occurrences of burials - from KH4 B and AZ18 - show no similarities. The two from early Epipalaeolithic KH4 B are articulated and extended, although one is very fragmentary, and they contrast with the crushed skulls and disarticulated postcranial remains from late Epipalaeolithic AZ18.

Discussion

The eastern Jordanian steppe sees a variety of occupation types in the Epipalaeolithic; some are very large with structures, burials and a seeming diversity of activities; others are apparently short term and relatively specialized, whilst others fall in between.

It is notoriously difficult to interpret the 'function' of stone tools (e.g. Jensen 1988). The predominance of microliths at all sites, however, suggests that hunting was a major activity. At sites with less specialized tool-kits, a wider range of activities might be assumed.

WJ6 and KH4 are two of the largest Epipalaeolithic sites known in the Levant. Their overall sizes of 19,000m^2 and 21,000m^2 respectively by far exceed contemporaneous occupations from the Mediterranean zone or other areas. The issue of these 'mega-sites' has been discussed by Garrard and Byrd (1992), who conclude that whilst deflation and lateral movement of artifacts may have added somewhat to site size, artifacts are generally *in situ* and represent palimpsests of occupation. The sites, in short, document the repeated use of certain specific open areas. Reuse of particular locales may relate, in part, to the presence of resources (e.g. water, flint) within hunter-gatherer territories, or may be because the sites represent, or mark, areas of special significance.

All sites are considered to reflect seasonal occupation, in part because of the nature of the finds, in part due to presumed environmental constraints. Contacts with areas further west are attested both by the similarities in stone tools types and technology, and by the presence of marine shell beads in deposits. Distinct lithic traditions, however, can be seen, e.g. at WJ6 A.

Neolithic

Architecture

Throughout the Azraq Basin Neolithic sequence (PPNB, ELN/PPNC), methods of construction are similar, with structures being rather ephemeral, often semi-subterranean, and walls made of upright limestone slabs or courses of unmodified stone. Internal partitioning and paving are common. These characteristic low walls have been interpreted as sub-structures onto which tent-like superstructures (perhaps made of skins and wood) might have been fixed (Garrard 1994:82).

What does change between the PPNB and ELN/PPNC is the size of buildings: PPNB oval/circular structures are small, usually measuring less than 4m in diameter (e.g. WJ32, WJ26 C, WJ7 4) whilst the few rectangular ones are a little larger in area (e.g. WJ26 A). ELN/PPNC structures are larger, measuring 4.5x7.0m (WJ25) and 6.5x10.0m (WJ13), leading Garrard to suggest that larger groups, or groups and livestock, could have inhabited them. He also finds the two items of potential statuary in the large WJ13 structure to suggest a role "beyond the pure domestic" (Garrard in Garrard *et al.* 1994:85).

The rectangular 'pier' structure at WJ26 A is of interest because of its strong parallels with forms from sites further west, such as Beidha, Jericho and 'Ain Ghazal (Banning and Byrd 1988).

The LLN/PPNC sites in the Wadi el-Jilat do not appear to reuse earlier PPNB structures, although they are often nearby. A further observation is that PPNB structures are grouped in clusters, whilst those from the ELN/PPNC tend to be singular.

Temporal trends in the basalt area are difficult to assess since the number of structures known is few. PPNB and LLN structures all constitute low roughly made walls, of unmodified basalt boulders. Internal divisions and paving are common. Structures from PPNB Ibn el-Ghazi and LLN B27 2 are both oval in plan; that at DH 1 is larger and more irregular, and interestingly, the later phase of the site, DH2, reuses the earlier walls.

Generally, steppic Neolithic architecture tends to be flimsy, perhaps indicating seasonal occupation. Contemporaneous buildings at Levantine moist-steppe or woodland sites are much more substantial, whilst eastern Jordanian structures compare better with those from southern Sinai (Garrard 1994:82), except for the 'pier' house at WJ26 A.

Hearths are commonplace within structures, and WJ26 also has an area of external hearths/bins. Pits tend to characterise sites in the Basalt Desert, although several are recorded from WJ13. Storage areas have not been positively identified, but many features (e.g. bins) could have served this purpose.

Lithics

Baird's analysis of the Azraq Basin Neolithic chipped stone tool assemblages has firstly provided a high resolution chronology for the sites, based on point types; secondly identified chronological changes in assemblage composition through the sequence; and thirdly, suggested that styles of lithic reduction could represent social or cultural groupings (Baird 1993; n.d.a; n.d.b.).

Major changes in tool assemblage composition are seen between the early/middle PPNB and the late PPNB/ELN/PPNC: angle burins predominate earlier, whilst truncation burins occur in high numbers later; burin spall drills are only found in the later deposits, as are bifaces. It is unclear whether the change in burin type represents any change in function, but the appearance of burin spall drills and bifaces (robust cutting tools) might plausibly represent new and different activities.

During the PPNB the lithic reduction strategies (i.e. the broad approach to the material) seen in the Azraq Basin are indistinguishable from those in other areas of the southern Levant. Although slightly more diversity in strategy is seen in the middle/later PPNB onwards than earlier, Baird generally finds that "communities using Jilat were participating in developments in chipped stone technology common to the southern Levant" (Baird n.d.a).

Analysis of 'technique' - the actual preparation of platforms and removal of chips - has allowed Baird to suggest the presence of different communities more clearly than has reduction strategy. The techniques used in eastern Jordan show strong continuity throughout the Neolithic period. Baird sees this as reflecting local tradition, maybe in part a response to available raw material, and a certain amount of autonomy of communities using the area. They also appear to be separated from other areas of the Levant to some degree. Within eastern Jordan, however, he finds two discrete traditions of lithic reduction technique: one in the Wadi el-Jilat and the other in Azraq.

At Basalt Desert occupations, DH 1 and DH 2 show similar ranges of tools (arrowheads, burins, scrapers, borers, bifacials), although shapes and technology change between the two phases. The toolkit from B27 2 is generally much the same; although McCartney notes clear differences in technology between this site, DH 2 and Jebel Naja, she attributes this, in great part, to the different raw material used.

Ground stone

Wright describes a range of ground stone tools, vessels and bedrock mortars from Neolithic sites in eastern Jordan (Wright 1993; in Garrard *et al.* 1994), many more than from Epipalaeolithic deposits. Many of the tools are interpreted as grinding and pounding equipment; shaft straighteners are common, and vessels and more enigmatic grooved pieces also occur. Variation exists between assemblages, both in terms of the number and types of artifacts found, and also in the raw material used. WJ7, for example, has a wide range of seemingly 'household' artifacts, made predominantly on basalt (not local), with evidence of on-site modification. By contrast, the assemblage from WJ13 contains few domestic items, and limestone is the preferred material. Sites in the basalt area show a similar range of ground stone artifacts. Variation appears probably more site-specific than temporal. In general, ground stone pieces from the study area can be characterized as small and lightweight, and therefore probably portable. Pounding and grinding tools are fewer, and less substantial than those in contemporary settlement in the west. In terms of function, Wright does not necessarily link grinding equipment with cereal or seed processing (Wright 1991).

Plant remains

Several Neolithic sites produced botanical samples, which are undergoing study by S. Colledge. The early/middle PPNB horizons of WJ7 1 and 3 contained wild and cultivated type wheat and barley, large seeded *Vicia* spp. and lentils, wild pistachio nuts and fragments of parenchymatous tissue possibly deriving from sedge rhizomes (Garrard *et al.* 1993). Late Neolithic WJ13 has yielded samples with a similar component of plant remains. Colledge has found remains of both the grain and chaff of cereals, possibly indicating that the final processing of wheat and barley was undertaken locally.

From PPNB DH 1 (Colledge in press), Colledge found small quantities of wild einkorn (*Triticum boeoticum* type) and wild barley (*Hordeum spontaneum* type). Deposits from both DH 1 and Late Neolithic DH 2 showed a presence of steppe grasses (*Stipa* spp.), small and large legumes, and fragments of charred root/tuber, amongst other plant remains. Colledge states that all of the plant species represented would have been found in the vicinity of the site, and the wild cereals could potentially have been used as food.

The finds of domestic type cereals from the limestone area in the PPNB, PPNC and LN, and the lack of domestic crops from equivalent period sites in the basalt area, is noteworthy.

Other

Marine shells from most Azraq Basin Neolithic sites show modification for use as beads or ornaments. Both Mediterranean and Red Sea shells have been found; a temporal trend shows *Dentalium* sp. present in PPNB sites (as in the Epipalaeolithic), but absent in the Late Neolithic, when *Conus* sp. and mother-of-pearl shell become common (Garrard *et al.* 1994:96). Marine shells have also been reported from B27 2 (McCartney 1992).

Worked bone assemblages from the Azraq Basin have more diversity than those from Epipalaeolithic contexts. The few pieces from the PPNB (WJ7) include points and a bead by-product. By far the most are known from PPNC/ELN WJ13, where beads predominate, with smaller numbers of bead by-products, points and needles. The presence of bead by-products suggests on-site bead manufacture (Martin in Garrard *et al.* 1994). Bone beads have not been mentioned from Basalt Desert sites.

Stone bead production is another activity which flourishes in the Neolithic in eastern Jordan. From Wadi el-Jilat PPNB and PPNC/ELN sites (WJ7, WJ25, WJ13) large numbers of beads made from Dabba 'marble' (a green/red/black apatitic limestone) were found. The source of this material is 10-15km west of the Wadi el-Jilat, and the frequent presence of unfinished bead blanks at the sites implies on-site working (Wright in Garrard *et al.* 1994). Dabba 'marble' beads have been found at many Levantine Neolithic sites, including those in the Basalt Desert (DH 1 and 2) but evidence of their production is unique to sites in Wadi el-Jilat and Azraq. Other stone used for bead manufacture includes flint, quarzite and calcite.

Other noteworthy aspects of the material culture from the Neolithic sites are figurines, pillars and rock art. From PPNB WJ7 several flat flaked-stone plaques (or figurines) were found. The PPNC/ELN site of WJ13 yielded 21 stone figurines, or pseudofigurines. The former category includes anthropomorphic, zoomorphic and phallic shapes; the latter are unmodified flint nodules which seem to have been selected and cached. At WJ13 three large modified limestone pillars were also uncovered; one was grooved, the others pecked (Wright in Garrard *et al.* 1994). The PPNB levels at DH 1 yielded eight carved basalt cobbles or slabs, most of which depicted horned animals (probably gazelles), although one shows a row of human figures pecked into the stone (Betts 1988).

Finds of red ochre are fairly common from Neolithic sites. Pottery is absent, as are burials.

Discussion

In the Wadi el-Jilat continuity between the PPNB and PPNC/ELN is observed in the settlement patterns, lithic assemblages, the presence of cultivated cereals, architecture and other finds. The changes which do occur are in structure size, and maybe also in a shift from clustered to isolated buildings. The main discontinuity seen in the stone tools is actually mid-way through the PPNB, and is therefore not synchronous with architectural changes. Variation between sites of similar period are most obvious in the ELN, when WJ13 stands out as having many cult objects, whilst WJ25 appears more domestic.

Temporal variation within the Neolithic is less well understood in the Basalt Desert because excavated sites are fewer. The PPNB and LLN phases of DH (1 and 2) show many similarities in material culture, and the later occupation reuses the earlier structure, suggesting strong continuity. Betts interprets the site as a hunting camp, during both phases of use (Betts 1988; in press), and in this respect it is interesting to note an absence of cultivated crops, in contrast to Wadi el-Jilat sites of similar date. B27 2 belongs to the same broad tradition of 'burin sites' as DH 1 and 2, where these enigmatic tools dominate assemblages.

In short, regional traditions (or possibly functional differences?) are observed in the Wadi el-Jilat area, at Azraq and in the Basalt desert. Strong ties, however, are seen in the occurrence of Dabba 'marble' at Basalt Desert sites and at Azraq (at the latter it is worked on site, therefore arriving as raw material); they are also suggested by the presence of basalt objects in the Wadi el-Jilat (at least 50kms from basalt country), although this could also be from sources further west.

Long distance contact/exchange is witnessed by the presence of obsidian at WJ13, AZ31 and B27; the WJ13 material is most similar to obsidian from Nemrut Dag in eastern Turkey (Baird *et al.* 1992:17). Mediterranean and Red Sea shells attest to exchange networks, as do finds of Dabba 'marble' outside the Jordanian steppe/desert. Also, the WJ26 'pier structure' shows contact of some sort with sites further west.

Excavators interpret all Neolithic sites in the region as seeing seasonal occupation, partly because of the flimsy nature of the architecture and partly because of the presumed constraints of the environment and resources. Detailed models of expected patterns of mobility, however, have not been forwarded.

Most sites have similar ranges of tools, including arrowheads, burins, scrapers, perforators and drills, although in varying relative proportions; it is difficult to associate tool types with particular activities, although the link between points and hunting can probably be safely inferred, and the presence of drills correlates with beads at Wadi el-Jilat sites. Adzes, which are common on moister zone sites, are rare and this might be explicable by the lack of wood or trees in the steppe/desert (Baird in Garrard *et al.* 1994). Tools with sickle gloss are rare, both at sites where cultivated crops are present and at those where they are absent.

Aims of the present study

A general aim of this thesis is to document and explore the variability of the eastern Jordanian faunal assemblages, and to explore how groups inhabiting the area used animals over the period 20,000-7,500bp. Chapter 6 presents the raw data, and **describes** chronological, regional and inter-site variation in the composition of the animal bone samples.

The issues addressed in the subsequent three chapters (7, 8, 9) are more specific; they have been developed from data and ideas, both from the southern Levant in general and from the eastern Jordanian study area, which are discussed in the first three chapters (1, 2, 3).

One aim of this work is to assess the impact of the environmental setting of sites on the faunal assemblages produced; to explore both the variation in assemblages, and whether the documented long-term environmental change (Chapters 1 and 3) may be reflected in those subsistence practices involving animals. As seen in Chapter 2, themes of environmental change promoting subsistence change are influential in the Near East, and in this project such ideas (e.g. of resource pressure) will be considered alongside others.

An additional approach is to ask whether the faunal assemblages reflect either the changes or continuity observed in other spheres of the archaeological record, either for eastern Jordan (Chapter 3) or the southern Levant as a whole (Chapter 1). Although social relationships are very difficult to assess, contacts between areas appear to increase through the period of interest, and faunal assemblages will also be considered in this light. The introduction of herded caprines into the area clearly requires analysis of neighbouring practices and relationships between groups.

Ideas (based on other Levantine areas) of increasing 'specialization' in treatment of animals, or increasingly selective practices will be examined. In particular, the question of whether groups had control over, or management of gazelles will be addressed, since this animal dominates most Epipalaeolithic and many early Neolithic assemblages. The problems of identifying selective practices are detailed in Chapter 2; Garrard sums them up as follows:

> Studies have been made of the age and sex proportions in the culled populations of gazelle from Epipalaeolithic and Neolithic sites in this area, to see if they might provide any further evidence concerning the nature of the relationship ... Unfortunately the results of these are difficult to interpret, because gazelle, in common with other gregarious species, varies in herd composition during the year ... and it is probable that different sex and age groups vary in their reaction and thus exposure to predation ...
>
> (Garrard 1982:180)

In light of such problems, and following the example set by many previous workers, my aim here has been to to create a detailed ecological model of gazelle behaviour for eastern Jordan, in order to predict the social composition of herds, and hence to identify when cull practices may diverge from expectations and to be considered **selective**. The behavioural ecology of the gazelle and a model of gazelle ethology for prehistoric eastern Jordan is forwarded in Chapter 4.

Issues of seasonality and mobility will also be addressed, since a major concern is to establish whether eastern Jordan was used year-round as hunter-gatherer or herder territory, or whether it served as an area seeing seasonal use only.

On a more site-specific level, animal bones will be used to explore the range and kinds of activities taking place on sites, and to suggest the nature of occupation at each.

CHAPTER FOUR

GAZELLE BEHAVIOURAL ECOLOGY

> ... to understand how behaviour helps an individual to survive by avoiding predators and exploiting critical resources, or to enhance its reproductive success we must understand the individual's ecology. In particular, we must know what food an animal eats, what enemies it must avoid, what are its breeding requirements and what other members of its population are doing.
>
> (Rubenstein 1989:145)

Behavioural ecology is used by zoologists and sociobiologists as a means of exploring the adaptive variability of animals. Based on principles of evolutionary ecology, whereby natural selection maximizes 'fitness' of behavioural characteristics in different conditions, the underlying assumption is that an animal's reproductive cycle, group size, density and composition, and movements are adaptations to the available food and water resources, predators and commensals, and the requirements and tolerances of the animal itself (Clutton-Brock and Harvey 1978; Krebs 1978; Krebs and Davies 1984; Rubenstein 1989). The method lends itself to predictions of animal behaviour if the constraining variables are known.

Modelling animal behaviour rests on the belief that animals optimize propagation of their genes, and other activities which subserve this function (Krebs 1978:2), whilst minimizing energy loss. That there are both different strategies for optimization, and variation within strategies should be anticipated (cf. Maynard Smith's evolutionary stable strategies).

Concern does not lie with the genetic make-up of a species:

> The behavioural ecologist, though, does not usually know the genetics underlying the character he studies. While he would be interested to know this genetic system, it is not of primary importance to him. His main aim is to uncover the selective forces that shape the character. The behavioural ecologist has hope in his ignorance that his method will work almost regardless of which particular genetic system underlies the character (Lloyd 1977).
>
> (Grafen 1984:63)

The morphological and physiological traits of a species are also not of primary interest; rather, questions aim to understand how the animal's behaviour is organized within physical constraints (Krebs and McCleery 1984:92).

Constructing a model

Clutton-Brock and Harvey (1984:13-15) suggest one method of investigating behavioural adaptation is to compare a number of phylogenetically similar species in different ecological habitats. Rubenstein (1989) also advises the study of variation in traits across species for exploring adaptation. Such methods can suffer from the fact that species in similar habitats may differ greatly in their behaviour (and vice-versa), but if ecological details are adequate for proposing reasons for variation, then results can be very informative.

The gazelles

At least seven species belong to the genus Gazella, inhabiting regions from the Middle East and Africa to the Indian Subcontinent. Much controversy surrounds their classification (Groves 1985; Uerpmann 1987), but the present state of knowledge suggests that species and distributions are as follows:

Middle East, north Africa and central Asia
Gazella gazella
Gazella dorcas
Gazella subgutturosa

East Africa
Gazella granti
Gazella thomsoni
Gazella soemmering

Iran, Pakistan and India
Gazelle bennetti

The most intensively studied of these are *G. gazella, G. dorcas, G. granti* and *G. thomsoni*. A single brief study of *G. subgutturosa* has been found; although others apparently exist in Russian, translations are not available. Table 4.0 lists the 11 case studies used in the present exploration of gazelle behavioural ecology, plus the data sources, which are drawn upon in the following discussion; it also gives the location of each gazelle population used and the code by which it is referred to henceforth. The case studies include both Middle Eastern and African gazelle populations in order to achieve a wide intra-genus comparison. It should be noted that most of the animal populations are either protected or enclosed for conservation purposes, and are thus not in truly 'wild' conditions. This does not invalidate the approach; undoubtedly factors such as enclosure, human proximity or supplementary feeding will affect an animal's behaviour (cf. Mendelssohn 1974), but if these influences and the animal's responses are understood, then they need not obstruct exploration of behavioural ecology.

no	species	location	code	source
1	*G. gazella*	Upper Galilee Israel	UG	Baharav (1983a; 1983b)
2	*G. gazella*	Lower Galilee Israel	LG	Baharav (1974a; 1974b; 1981; 1983a; 1983b)
3	*G. dorcas*	Southern Negev Israel	SN	Baharav (1982; 1983b)
4	*G. dorcas*	Southern Negev Israel	HWW HOT	Baharav (1982; 1983b)
5	*G. gazella*	Thummah and Farasan Island Saudi Arabia	KKWRC FI	Habibi *et al.* (1993)
6	*G. subgutturosa*	Thummah Ghurrub and Al-Hurrah Saudi Arabia	KKWRC Gh Al-H	Habibi *et al.* (1993)
7	*G. dorcas*	Kavir Nat Park Turan Protected Area Iran	KNP TPA	O'Regan (1980)
8	*G. granti*	Ngorongoro Crater Tanzania	NC	Estes (1967)
9	*G. granti*	Serengeti Nat Park Tanzania	SNP	Walther (1972)
10	*G. thomsoni*	Ngorongoro Crater Tanzania	NC	Estes (1967)
11	*G. thomsoni*	Tanzania	T	Brooks (1961)

Table 4.0. The 11 case study populations of gazelles include five species inhabiting a range of environments. Some of the studies contrast the behaviour of the same population in different areas, and codes separate these cases.

Details of each case study population, such as habitat, feeding strategy, reproductive strategy, population organization and movements are summarized in Appendix 2.

Exploring behavioural adaptations

Factors which shape the way animals behave divide into two broad categories: constraints and solutions. 'Constraints' are the limits within which an animal lives, and these include its habitat (i.e. the surrounding environment and the available food, water and shelter), predators and commensals. Nutritional requirements can also be classed as constraints. 'Solutions' represent the behaviour the animal uses in responding to constraints, such as breeding patterns or movement. At times, the line between constraints and solutions becomes blurred, for example, an animal's body size acts both as a constraint in that it dictates nutritional requirements, but it can also be a response, i.e. an adaption to resource availability, competition and predators. The interaction of constraints and variables in behavioural ecology is extremely complex; all factors relate to all others, which means that there is no obvious starting point. The availability of food, however, ultimately underlies many aspects of animal behaviour.

Environment

The gazelle populations of the case studies inhabit a wide range of environments, from extreme deserts to steppic regions, woodlands and grasslands. The *G. dorcas* populations of the southern Negev (SN, HWW, HOT) experience the lowest rainfall - an average of 25mm/year, and temperatures up to 34°C; the *G. gazella* and *G. subgutturosa* in Saudi Arabia (KKWRC, FI, Gh, Al-H) inhabit areas receiving 50-100mm rainfall/year with much higher temperatures of 45°C in summers; the *G. dorcas* populations studied in Iran also see c. 100mm rainfall with summer temperatures reaching 38°C; the two populations of *G. gazella* in the Galilee vary in that one (LG) lives in an area receiving 200-350mm rainfall, whilst the other (UG) sees a higher 500-750mm rainfall/year. All of these environments are markedly seasonal with hot summers, cool winters, and rainfall being concentrated in the winter months. Rainfall varies greatly depending on latitude and regional topography; it generally decreases southwards and eastwards from the Mediterranean coast.

The *G. granti* and *G. thomsoni* populations studied in Tanzania (NC, SNP, T) all inhabit areas receiving a much higher rainfall of >760mm/year. Temperatures average 32°C in summers, with the climate ranging from hot humid coasts to hot dry plains. The east African environment is also seasonal, but varies greatly from the Arabian habitats in that there are two rainy seasons: the 'small rains' arrive in November, and the 'long rains' are in April-May.

Vegetation is sparse in the desertic southern Negev, with acacia shrubs being best developed in *wadis* and depressions. In general, vegetation is patchy with low diversity. The same is true of the *G. gazella* and *G. subgutturosa* (KKWRC, FI) habitats in Saudi Arabia and on Farasan Island; sparse desertic vegetation dominates. The habitat of *G. dorcas* (KNP, TPA) in Iran is described as seeing perennial shrubs and spring annuals, and is characteristically steppic.

In the lower Galilee, the *G. gazella* (LG) inhabits an area of dwarf shrub communities and woodland margins, whilst in the upper Galilee, populations range through diverse vegetation zones of woodland, grasslands and steppe. Being strongly seasonal, as described above, all of the vegetation habitats of the Arabian gazelles see a main flush of growth in the spring when the winter rains and rising temperatures combine to produce ideal conditions.

Conversely, the gazelles of equatorial east Africa see two major seasons of vegetation growth per year - after both the small and the long rains. The *G. granti* and *G. thomsoni* NC populations inhabit a predominantly grassland area, whilst the SNP area is described as being more diverse vegetationally with woodlands, bush, clearings and plains grasslands.

Forage requirements

Gazelles are characterized as relatively selective herbivores. Like all ruminants, they cope badly with thick cell walls of plant material and therefore select other parts:

> The strategy of the ruminant ... is based on high efficiency of extraction and utilization of protein at the expense of a high rate of intake and processing of food, with the consequent emphasis on selecting for high-protein plant components.
>
> (Bell 1971:88)

Ruminants spend much of their time in pursuit of desirable, optimal plant food. Diet selection is learnt and it is believed that decisions are made to assess forage quality versus availability (Westoby 1974:229, 294). Amongst large generalist herbivores, food preference has been correlated, in a non-linear way, with the nutrient content of the food (Westoby 1974).

Nutrient requirements of an individual increase with body weight, although not proportionately (Clutton-Brock and Harvey 1978). Table 4.1, therefore, suggests that *G. gazella* requires more forage than *G. dorcas* in a similar habitat (although the *G. dorcas* in Iran are much heavier); *G. subgutturosa* would have similar requirements to the Iranian *G. dorcas*, but greater than the Israeli *G. gazella*; *G. thomsoni* in Tanzania is of a similar size to the larger Arabian gazelles, but its co-habitant, *G. granti*, is more than twice its weight, and therefore would have much greater nutritional needs.

Table 4.1 also shows male gazelles to be heavier than females. Such dimorphism probably leads to different nutritional requirements, although within-sex nutritional needs will vary through the year in response to demands of the reproductive cycle, such as pregnancy, lactation and the rut.

The gazelles in the case study populations are all described as being independent of standing water. Crucial water requirements are often met through selection of high water-content plants or the intake of dew, and animals conserve body water through methods such as shading, restricting movements and feeding at the cooler times of day.

species/population	adult weight	source	
G. gazella LG	f: 18kg m: 25kg	Baharav	(1983a)
G. dorcas	f/m: 14-17kg	Garrard	(1980)
G. dorcas KNP/TPA	f: 20kg m: 30kg	O'Regan	(1980)
G. subgutturosa	f/m: 20-28kg?	Garrard	(1980)
G. granti NC	m: 68-81kg	Estes	(1967)
G. thomsoni NC	f/m: 20-28kg	Estes	(1967)

Table 4.1. Adult weights for gazelle species. f=female; m=male.

Timing of births

Births are generally timed to coincide with the peaks of favourable vegetation conditions, when moisture and temperatures combine to produce new plant growth. Such conditions favour the survival of both fawns and mothers.

In areas of sparse vegetation - the extreme deserts and steppes - gazelle birthing times are synchronized in spring (see *G. dorcas* SN, HWW, HOT, KNP, TPA, *G. subgutturosa* KKWRC, table 4.2). During pregnancy, mothers have access to winter plant foods, ensuring relatively high fat levels, and fawning during the vegetation peak allows them the highest nutrition for lactation. The denser spring forage permits both mothers and fawns to restrict movements, and hence expend less energy; increasing temperatures also aid fawn survival.

The *G. gazella* populations in the lusher Mediterranean zones have different birthing patterns, and demonstrate that strong seasonality breaks down with an increased level of nutrition. The *G. gazella* LG group can breed twice a year and has two birthing peaks, in spring and autumn, which reflects a longer wet season and abundant availability of high quality plant resources (e.g. *Z. lotus*). Births, however, are observed throughout the year, suggesting no real lean season.

case study	timing of births	reason given
G. gazella UG	peak in June but throughout summer	summer irrigation (Baharav 1983b)
G. gazella LG	year-round but peaks in spring and autumn	water available year-round but less in summer (Baharav 1974a)
G. dorcas SN	synchronized in March	water scarce, flush of veg. in spring (Baharav 1983b)
G. dorcas HWW/HOT	synchronized in March	water scarce, flush of veg. in spring (Baharav 1983b)
G. gazella KKWRC	year-round but peaks in spring and autumn	? supplementary feeding/watering (Habibi *et al.* 1993)
G. subgutturosa KKWRC	synchronized in March/April	? supplementary feeding/watering but best food avail. in spring (Habibi *et al.* 1993)
G. dorcas KNP/TPA	synchronized in April/May	best food avail. (O'Regan 1980)
G. granti NC	year-round but peaks in Jan/Feb	flush of veg. aft. small rains (Estes 1967)
G. granti SNP	year-round but peaks in Dec/Feb and Aug/Sept	peaks of veg. when water available (Walther 1972)
G. thomsoni NC	year-round but peaks in Jan/Feb	green pasture aft. small rains (Estes 1967)
G. thomsoni T	year-round but peaks in Jan/Mar and June/July	fresh pasture after both rains + drained ground (Brooks 1961)

Table 4.2. The birth times of gazelles.

G. gazella UG shows a rather anomalous breeding pattern. Females give birth throughout the summer, peaking in June, despite the wet season being from November to April (200-350mm/year rainfall). Baharav (1983b) explains this as an adaption to summer irrigation which allows animals daily access to water from May to November. He does not state whether water predictability alone has altered this population's birthing time (prior to irrigation, peaks were spring/autumn), or whether accompanying vegetation growth is a factor, but he does note that the animals turn from graze to browse in summer. It is likely, therefore, that the summer water availability frees gazelles from selecting high water content food, and allows them to concentrate on forage of nutritionally high quality.

Year-round births, with spring and autumn peaks, are observed for the *G. gazella* KKWRC in Saudi Arabia, which contrasts the strongly seasonal spring fawning seen in the *G. subgutturosa* population inhabiting the same area. Habibi *et al.* (1993:42) suggest that the different patterns are related to differences in social organization; the ways that animals organize socially, however, are themselves responses to constraints and requirements. Rather, it would appear that body size differences between the two species could account for their different breeding patterns, with the smaller *G. gazella* finding sufficient nutrients in a small area to enable year-round breeding (and twice yearly pregnancies), whilst the heavier *G. subgutturosa* reaches the desired nutritional level only in spring.

The African gazelle populations all give birth year-round with peaks between December and March after the small rains, and sometimes also in June to September after the long rains. Thus there is a correlation between fresh grazing and the dropping of fawns, although resource conditions are never detrimental to mother and fawn survival. Brooks also notes that animals give birth on dry ground, which may be an additional explanation for the timing of births after the rains (Brooks 1960). The two species, *G. granti* and *G. thomsoni*, have similar birthing strategies, despite great body size differences (see table 4.1). Differences, instead, are seen between areas: the Ngorongoro Crater (NC) case studies have a single birthing peak, whilst the two from larger areas (SNP and T) have an additional peak after the long rains. No explanation for this is given, but habitat descriptions suggest that NC is a more homogenous open grassland than the other two areas, which firstly might not be suitable as calving ground after the long rains. Secondly, births may be more synchronized (i.e. one peak) in open plains as an anti-predator strategy. Alternatively, there may be climatic or vegetational reasons for a single birth peak in NC populations.

In most case studies, adult females give birth once a year, indicating that their nutritional levels do not allow a quick return to oestrus after birthing. Three populations, however, (*G. gazella* LG, *G. gazella* KKWRC and *G. thomsoni* T) birth twice a year, which suggests that nutritional requirements can be met virtually year-round.

Population density, group size and forage availability

Gazelle population density tends to increase with higher rainfall (table 4.3), although multiple factors cross-cut a simple correlation. The two populations of *G. gazella* in the Galilee oppose the trend, with animals in the lower rainfall zone (LG) having a higher density than those in the higher rainfall zone (UG). This can be explained by comparing types and distributions of vegetation between the areas. Baharav (1983a) describes the UG area as having a diverse range of shrub species upon which the animals feed; in contrast, those in LG feed almost entirely on one shrub, *Ziphus lotus*. They also shade and find concealment under this same shrub. All of their requirements are met by the abundant *Z. lotus* shrubs in the area, resulting in a high population density.

The two populations of *G. dorcas* in the Negev (SN and HOT) demonstrate how density can vary in the same rainfall regime - in this case, according to vegetation and ultimately topography. The animals inhabiting the open terrain (HOT) feed only on isolated shrubs, limiting them to extremely low densities. Those in the acacia tree-bearing *wadis* and alluvial fan area of the desert (SN), have much higher population densities, showing how forage availability is a prime constraining factor.

Few data exist for the African gazelles (NC, SNP and T), maybe due to the difficulty of calculating densities of migratory animals. The *G. thomsoni* T, however, has been recorded in very high densities during times of congregation (Brooks 1961).

case study	population density (individuals/km²)	rainfall (mm)
G. dorcas HOT	0.1	25mm
G. dorcas HWW	-	25mm
G. dorcas SN	5.0	25mm
G. subgutturosa KKWRC	-	50-100mm
G. subgutturosa Gh	0.2	50-100mm
G. gazella KKWRC	-	50-100mm
G. gazella FI	4.0	50-100mm
G. dorcas KNP	1.5	100mm
G. dorcas TPA	0.7	100mm
G. gazella LG	23.0	200-350mm
G. gazella UG	13.0-18.0	500-700mm
G. granti NC	-	>760mm
G. granti SNP	-	>760mm
G. thomsoni NC	54.0	>760mm
G. thomsoni T	-	>760mm

Table 4.3. The population densities of gazelle case study populations, and the amount of rainfall in their habitats.

Density is therefore seen to be integrally related to forage availability and distribution, and hence water resources, climate, soil and topography. Consequently, higher population densities are possible during the wet seasons than dry seasons. Densities, therefore, reflect the number of individuals an area can carry but they do not describe the size of groups which form. Group size is closely tied into the changing social composition of groups, resulting from reproductive activities; although herd sizes will be limited by population density, they are determined by the factors explored in the section on social organization (below).

Rubenstein (1978) also sees group size to be an adaptation to two other factors: predators and competitors or commensals. Groups of animals can often detect an approaching predator sooner than solitary individuals, and group living allows each individual more feeding time by spreading vigilance activity (Pulliam and Caraco 1984:131). Also, tightly aggregated groups may discourage or confuse predators. The gazelle case studies provide little information on the relationship between group size and predators. The Arabian populations are mainly in protected areas, which prohibit conclusions from being drawn. The African gazelles have numerous predators, but documentation of anti-predator behaviour is confined to mothers and fawns, e.g. concentration of births to saturate appetite, the grouping of mothers (Estes 1967), the concealment of fawns after birthing (Brooks 1961; O'Regan 1980), and the cleaning of fawn's scent by mothers. Despite the lack of relevant data, the sizes of herds other than the mother/fawn groups may be an adaptation to predators, although probably always underlain by forage availability.

The presence of other non-predatory animals in an area (competitors or commensals) can either constrain or enhance group size. In the case study from Iran, O'Regan (1980:74) explains the lower density, and hence smaller groups, of the *G. dorcas* population in the TPA region, against that in the similar KNP region, as resulting from the presence of domestic flocks (table 4.3). The habitat could not sustain large numbers of both gazelles and sheep and goats, and gazelle numbers were consequently suppressed.

By contrast, the African gazelles co-exist alongside a host of other herbivores; their success, in fact, depends greatly on these other feeders. Bell (1971) describes the grazing ecosystem of the Serengeti National Park where the selectively feeding Thomson's gazelle follow in the path of larger, more generalist zebras and wildebeest for the grasses they make available:

> The activity of the earlier members of the succession in breaking down and opening up the dense stands of stems and culms by grazing and trampling is therefore of great assistance to the later members of the succession ... [they] prepare the structure of the vegetation for the following members.
>
> (Bell 1971:92)

Bell argues that a reduction in the number of one species could lead to a reduction in the number of another. Thus, gazelle group size and density would be dependent upon those of its commensals.

Finally, human settlement also affects gazelle density: Mendelssohn (1974) notes that, because of new protection laws, gazelle populations increased in Israel after 1948, despite the increase in human populations. Higher densities, however, were only found in areas where human settlement was sparse.

Home range and mobility

The home range is the total area that an animal population covers in a year, and therefore encompasses all kinds of movement. As with other forms of behaviour, gazelle mobility patterns are very varied: some populations are sedentary, others nomadic whilst others perform seasonal migrations. Table 4.4 shows the home range sizes and forms of mobility for the gazelle case study populations, and also gives the size of their enclosures. Unfortunately, home ranges are often not documented.

case study	enclosure	home range	mobility
G. gazella UG	6km^2	2km^2	very limited
G. gazella LG	10km^2	-	sedentary
G. dorcas SN	11km^2	-	very limited
G. dorcas HWW	550km^2	1-2km^2	sedentary
G. dorcas HOT	550km^2	25km^2	nomadic
G. gazella KKWRC	680km^2	-	sedentary
G. subgutturosa KKWRC	680km^2	-	long dist. movements
G. dorcas KNP	-	-	sm. seasonal movements
G. dorcas TPA	-	-	sm. seasonal movements
G. granti NC	311km^2	290km^2	migration
G. granti SNP	-	-	migration
G. thomsoni NC	311km^2	42-143km^2	migration
G. thomsoni T	-	-	migration

Table 4.4. The size of enclosures and home ranges for gazelle case studies, where information is available, and the types of movement they make.

Of the Arabian gazelles, those which are sedentary or have limited seasonal movements exhibit small home ranges, indicating that sufficient forage can be found in a small area for year-round maintenance. *G. gazella* UG, for example, makes small seasonal movements between lower elevations in winter/spring and higher grasslands in the summer, and *G. dorcas* KNP and TPA move either nearer to springs, or nearer to particular browse plants on a seasonal basis. The restricted movement of the gazelles in the Negev desert *(G. dorcas* HWW), however, is attributed to their need to seek shade and conserve energy/water, rather than to sufficient forage availability:

> Any unnecessary movement and exposure to direct solar radiation escalates the rate of water loss, imposing constraints which elevate energy costs.
> (Baharav 1982:333)

Comparisons of the two *G. dorcas* populations inhabiting the same enclosure in the Negev again highlight the effect of different topography and vegetation. The sedentary *G. dorcas* HWW, which feeds on vegetation patches in the *wadi* beds, has a home range of 1-2km². By contrast, G. *dorcas* HOT roams extensively over the sparsely vegetated open plains, covering an area of 25km² a year. This is the only case study population which could be described as nomadic, where animals wander ceaselessly for forage, although Mendelssohn (1974:740) also describes some Israeli gazelles becoming nomadic to evade the wandering flocks of the Bedouin.

There is little firm data for *G. subgutturosa* populations, but historical sources suggest that in some steppic areas they may have been migratory in the past (Aharoni 1946, quoted in Mendelssohn 1974:726; see Legge and Rowley-Conwy 1987). The case study of *G. subgutturosa* KKWRC describes the animals as moving long distances in search of food, but not as migratory, although behaviour has obviously seen much human interference. That these animals are seen to move in search of food, whilst the sympatric *G. gazella* KKWRC are sedentary, is probably best explained by body size differences between the two species: the heavier *G. subgutturosa* would have greater food requirements than *G. gazella* forcing them to search farther afield for forage.

The only gazelles described as undertaking repeated fixed migrations are the populations in east Africa. Both *G. granti* and *G. thomsoni* are seen to make two seasonal long distance seasonal migrations a year, the first at the onset of the 'small rains' in November, and the second with 'long rains' in April/May. Their migrations follow the fresh grazing which the rains stimulate; they also move to find dry refuge areas away from the heavy rains, and females also seek dry fawning grounds. These movements are integrally linked with the migrations of the gazelle's commensals (see previous section), as they also are with the human firing of vegetation cover (Bell 1971; Brooks 1961).

G. granti has a large home range (see table 4.4), covering an average of 290km²/year compared to the 42-65km² (wet season) or 142km² (dry season) over which *G. thomsoni* moves. This difference is probably primarily due to the larger size, and hence greater nutritional needs, of *G. granti* (see table 4.1), which travels long distances and feeds on large quantities of browse plants and long dry grass. Locomotion costs are relatively higher for smaller animals such as *G. thomsoni*, making longer migrations unattractive. This animal instead restricts its movement, and has very particular food preferences, selecting mainly short fresh grass to provide required nutrients.

Another form of gazelle movement which deserves comment is flight distance. Mendelssohn (1974) notes that Israeli *G. gazella* move distances of between 700m and 1,000m when startled, and that hunting pressure increases flight distances. They also react to humans and moving objects at distances of 1km. Lighter animals move at faster speeds. Mendelssohn suggests that gazelle's activity is mainly diurnal due to their poor eyesight in the dark (1974:731).

Social organization

The age and sex composition of groups varies both between gazelle populations, and within populations at different times of the year. Social structure is integrally linked with the reproductive activities of a population, which are in turn limited by critical resources.

All the gazelle case studies except one show sexually active adult males holding territories - the common mating strategy for this size antelope (Jarman 1974). Territoriality reflects sufficient resources for males to control a circumscribed area, for at least the mating season, into which females are attracted. They thus guarantee access to females and mating opportunities. In some cases, males defend territories for short periods during the rut only (e.g. *G. subgutturosa* KKWRC, *G. gazella* LG), whilst in others they are territorial for much of the year (*G. gazella* KKWRC, *G. granti* NC and *G. thomsoni* NC). This ties in to the timing and frequency of birthing (see above), and hence also to forage availability. In short, it appears that territories are generally held for longer in lusher environments than in sparsely vegetated ones, although different strategies are observed within the same environment. *G. gazella* KKWRC males are territorial throughout the year, but their co-habitants, *G. subgutturosa* KKWRC are vigorously territorial only during the rut. This seems best explained by differences in body size and forage requirements between the two species; the former (smaller) species is sedentary whilst the latter moves over long distances to feed. There is also some suggestion that territoriality is related to increased population densities (Mendelssohn 1974:737).

The single case of non-territoriality is seen in *G. dorcas* HOT. Animals in this population roam widely for forage because their habitat is sparsely vegetated. Forage density does not permit males to keep females in a limited area; hence, the observed strategy is one of following, where an adult male wanders with a small group of females in an attempt, it appears, to secure mating.

Harem groups can be the product of both territoriality and the 'following' mating strategy. These consist of several adult females, a single adult male and sometimes also young. Harem herds become established during mating.

In nearly all cases, males which are not involved in mating (i.e. sub-adult or non sexually-active males) form bachelor herds. (They are not seen amongst *G. dorcas* HOT, however, presumably because resource distribution does not lend itself to group formation). Bachelor herds vary greatly in size: herds of 2-5 males are noted for *G. dorcas* HWW; up to 4 for *G. gazella* FI; and up to 300 for *G. thomsoni* T. Bachelor herds appear to form during mating, and hence are probably a constant feature of populations where year-round mating is the norm, but may be temporary aggregations otherwise.

Females tend to become solitary just before birthing, and seek out suitable fawning grounds. For the African gazelles this means a dry refuge area, while for most of the Arabian populations, this means a patch providing lush vegetation, shade and concealment. After birth, some fawns are noted to 'lie out' for about a month in these areas (*G. gazella* LG, *G. dorcas* KNP/TPA), whilst others are integrated into nursery herds - large groups of mothers and fawns (*G. subgutturosa* KKWRC, *G. granti* and *G. thomsoni* NC), which may result from the need to move.

At times when gazelles are not involved in reproductive activity, mixed sex herds can form (e.g. *G. subgutturosa* KKWRC, *G. dorcas* KNP/TPA, G. *gazella* KKWRC, *G. granti* and *G. thomsoni*). The African gazelles also form large mixed herds before migrations. Table 4.5 shows the numbers that types of herd can attain in the case study populations.

case study	herd size harem	bachelor	nursery	mixed
G. gazella UG	-	-	-	-
G. gazella LG	3-6	-	-	-
G. dorcas SN	-	-	-	-
G. dorcas HWW	-	2-5	5-22	-
G. dorcas HOT	2-5	-	-	-
G. gazella FI	-	4	5	-
G. subgutturosa Gh	-	2	<20	<56
G. dorcas KNP	6	-	-	9
G. dorcas TPA	3	-	-	5
G. granti NC	-	-	-	<100
G. granti SNP	30-40	-	-	<428
G. thomsoni	-	-	-	-
G. thomsoni T	5-61	6-300	-	-

Table 4.5. The sizes of gazelle herds in the case study populations. Data taken from Appendix 2.

Population structure

Sex ratio

Data on the ratio of male to female gazelles in the case studies suggest that roughly equal proportions of the two sexes are born (table 4.6, see *G. granti* SNP), but at adulthood there are less males than females in populations. The extent of this phenomenon varies, with *G. granti* SNP showing half the number of adult males to females, whilst *G. dorcas* KNP has only slightly fewer males than females. There are two possible explanations for this trend. Firstly, Walther proposes that the mortality rate is higher in males than females, and that the average lifespan of adult females is longer than that of adult males (Walther 1972:359). Similar observations have been made for red deer, where males appear more vulnerable upon leaving nursery herds (cf. Legge and Rowley-Conwy 1988:43-44). Secondly, the imbalance may result from the limitations the environment places on the number of male territories which can be held; when capacity is reached, males, rather than females, may be forced to move out.

case study	age	male:female ratio
G. gazella UG	adult	6.5:10.0 (average)
	adult	5.4:10.0 (Jan-Jun)
G. gazella LG	adult males, females incl yearlings*	8.1:10 (average)
G. dorcas SN	-	-
G. dorcas HWW	-	-
G. dorcas HOT	-	-
G. gazella KKWRC	-	-
G. subgutturosa KKWRC	-	-
G. dorcas KNP	adult	3.1:3.6 (July)
G. granti NC	-	-
G. granti SNP	neonate	1.3:1.0
	subadult	1.0:1.0
	adult	1.0:2.0
G. thomsoni NC	-	-
G. thomsoni T	-	-

Table 4.6. Sex ratios of gazelles in case study populations. *Baharav (1974a) includes sexually mature yearling females in this count; if they are removed, the ratio becomes 1:1.

Age structure

Only four of the case studies provide details of age structure in gazelle populations. Multiple factors determine age profiles. These include the number of times females birth per year, the number of fawns they produce at each birthing, the number of fawns that survive, the age at which females reach sexual maturity and the composition of the adult population.

This exploration aims primarily to determine the relative proportions of juvenile to adult animals in the case studies, since this is the level of detail required for the archaeological application. Following Davis (1980b:133), adults are taken to mean animals over 18 months old. Proportions have been calculated using the information on age structures given in Appendix 2. Table 4.7 shows the results.

Baharav (1983a) records the *G. gazella* UG population as comprising 6.5 males for every 10 females, and an average of 52 yearlings per 100 mature female. Females give birth once a year, producing single fawns, and they reach sexual maturity at 18 months of age. If the 52 yearlings indicate also that roughly 52 fawns are born each year (although accepting that some will not survive), these figures translate into proportions of c.39% juveniles when both fawns and yearlings overlap (i.e. 165 adults and 104 fawns+yearlings), and c.23% when they do not (165 adults and 52 fawns).

Gazelles in the lower Galilee are much more productive. Some females in this population *(G. gazella* LG) birth twice a year, still having singletons, but reaching sexual maturity at 6 months of age (Baharav 1974b; 1983b). This can lead to proportions of 52% juveniles against 48% adults (based on counts of 81 adult males; 100 'adult' females of which

19 are yearlings; 85 fawns and 74 yearlings; therefore 162 adults and 178 juveniles). The spring birthing alone, however, produces c.20% juveniles between autumn and spring, and c.39% juveniles from spring to autumn, showing that more females give birth at this time than during the second birthing in autumn.

Data on the *G. gazella* KNP show 33% juveniles in the population, although this figure is likely to be deflated since O'Regan notes that the 'adult' count includes both adult and yearling males (1980:116). These animals breed once a year and produce single fawns.

Finally, Walther recorded c.38% juveniles for *G. granti* SNP. This figure should be treated with caution: it may be inflated due to the inclusion of a 'subadult' category comprising animals of 1-2 years of age; on the other hand, it may be deflated by the difficulty of recording neonates and fawns because of their habit of 'lying out' (Walther 1972:357-358, table 2). These gazelles give birth once a year to single fawns.

case study	number births per/yr	number fawns per/b.	age of 1st birth	% juveniles
G. gazella UG	1	1	18 months	23-39%
G. gazella LG	2	1	6 months	52%
	1	1		20-39%
G. gazella KNP	1	1	-	>33%
G. granti SNP	1	1	-	c.38%

Table 4.7. Productivity data and approximate percentages of juveniles for four case study populations.

Other data relevant to the discussion on age structure derive from the groups in the Negev desert. Baharav (1983b) records that the *G. dorcas* SN population produces only one fawn for every three sexually mature females; the HWW groups sees one fawn for every four, and the HOT herds have one fawn for every eight females. Animals which manage pregnancy birth yearly and produce single fawns. Thus it appears that nutritional stress severely affects productivity.

In conclusion, there is some consistency in the proportion of juveniles recorded for different environments. Populations which birth once a year, for example, show relative proportions of 20-39%, whether in east Africa, the Galilee or the Iranian steppe. The range in this percentage is a product of the season of counting: proportions of juveniles are higher between spring and autumn when fawns and yearlings coexist, than from autumn to spring, when the animals in their second year will be recognized as adults. The leap in the percentage of juveniles seen in the *G. gazella* LG population (52%) is due to the ability of many females to birth twice a year in this lush environment. There are no details of age structure for the desert species, but a very low juvenile count may be expected.

Summary

1) **Nutritional requirements**: gazelle forage requirements will increase with larger body size, but not proportionally. Gazelles do not need standing water if they can acquire moisture from forage, but water availability allows them greater forage selectivity.

2) **Timing of births**: births coincide with peaks of favourable vegetation; they range from being highly synchronized in seasonal, marginal environments, to year-round (but with peaks and depressions) in lusher, well-watered areas. Birthing time is also influenced by temperature and moisture, both of which are also integrally linked to vegetal growth.

3) **Mobility**: in areas of sufficient forage, some gazelles become sedentary, making small seasonal movements. In extreme desert conditions, movement is limited to conserve water; in areas of frequent forage patches, sedentism emerges, whilst dispersed patches promote nomadic roaming. Migrations are determined by gazelles search for fresh graze, their need to move with commensals and to find dry refuge areas and calving grounds. Migrations are also tied in with human firing of grasslands. Larger sized animals generally move further in search of forage.

4) **Social organization**: gazelle social groupings are linked to their reproductive cycle, and therefore also to seasons. All populations, except the extreme desert nomadic group, show territorial males and bachelor herds at least during the rut. Harem herds are a feature of all case study populations at mating time. Mothers become solitary when birthing. Some newborn fawns 'lie out', others form nursery herds with mothers. Mixed sex groups form outside times of reproductive activity. The emergence of different groups is determined by the population's breeding strategy.

5) **Group size**: each of the above social groups are limited by the available forage: larger groups are found in lush environments, and group formation is hindered in areas of sparse vegetation. Group size can also be a result of anti-predator behaviour, or the influence of commensals or competitive feeders.

6) **Population density**: this is determined by the type and distribution of vegetation: dispersed resources lead to low densities and concentrated resources can maintain high population densities. Population density varies seasonally in response to forage, mobility and the social organization of animals.

7) **Sex ratio**: some populations show a greater number of females surviving into adulthood than males (up to twice as many); others have a more equal sex balance.

8) **Age structure**: groups in which females birth once a year, and produce a single fawn, have between 20% and 39% juveniles in the population; the lower percentage generally between autumn and spring, and the higher figure between spring and autumn. Females birthing twice a year can result in up to 52% juveniles in a population.

9) **The influence of humans**: all case study populations are protected or enclosed. Effects of this may be that more animals survive due to predator removal/control, or supplementary feeding or watering. Many aspects of behaviour, such as birthing times and mobility, may be altered due to human provision of resources. Human settlement can serve to reduce the density of gazelles in an area, as can the presence of domestic flocks. Both humans and their grazing herds can also cause gazelles to alter mobility patterns. On the other hand, some human behaviour can be beneficial to gazelles, such as firing of grasslands to promote new growth.

In short, complex factors underlie gazelle adaptive behaviour, but forage availability and the nutritional needs of individuals are major determinants.

A model of gazelle behaviour for prehistoric eastern Jordan

Predicting the behaviour of late Pleistocene and early Holocene gazelle populations in eastern Jordan integrates the exploration of gazelle behavioural ecology with the reconstructions of vegetation patterns proposed in Chapter 3. The palaeoenvironmental modelling is very broad, but it is argued that the approach is valid since conditions are only compared relative to each other.

Chapter 3 suggests that four major vegetational patterns might have existed in different areas of eastern Jordan, at various times. These rest on the different topographic, rainfall and run-off, and temperature conditions expected.

1) **Early Epipalaeolithic wide *wadis* in higher rainfall limestone area**. These have fairly even vegetation cover, but concentrations in *wadis* and depressions; seasonal vegetation growth with flush in spring; arrestation in winter and summer. This pattern is predicted for Wadi el-Jilat Upper Palaeolithic and early Epipalaeolithic (late); Wadi el-Kharaneh early Epipalaeolithic (late).

Similar conditions are expected, but with more local moisture, and hence lusher, denser vegetation for Wadi el-Jilat early Epipalaeolithic (early); Wadi el-Kharaneh early Epipalaeolithic (early); Wadi el-Uwaynid Upper Palaeolithic and early Epipalaeolithic (early).

2) **Azraq basin**. The area of pools, springs and marshlands of the central oasis, with standing water and high amounts of run-off, has lusher, denser vegetation than wide *wadis*, and probably more year-round availability. This pattern is expected for the middle Epipalaeolithic and Late Epipalaeolithic occupations in the central basin.

3) **The wide *wadis* in the Neolithic of the limestone area**. Early Holocene conditions of higher temperatures and increased aridity probably saw vegetation adhering to *wadi* bottoms and depressions, and generally being more sparse and concentrated than in 1). Vegetation growth arrested in winters and summers. This pattern is predicted for Wadi el-Jilat PPNB and Late Neolithic.

4) **The Neolithic in the Basalt Desert**. This area is likely to have experienced lower rainfall than the limestone or oasis area, particularly in the Holocene, with higher temperatures and less favourable conditions for vegetation. Vegetation would be sparse and concentrated in *wadi* bottoms and on mud-flats. The spring flush of vegetation would probably have been been fairly short-lived due to more extremely seasonal conditions. This pattern is predicted for the PPNB and Late Neolithic of the Basalt Desert.

The different aspects of gazelle behaviour, summarized above, will be discussed in relation to these four areas/periods.

Nutritional requirements

Gazelle bone measurements (see Chapter 7, figures 7.2, 7.3, 7.5) show the bones of Holocene adult animals to be smaller than those from late Pleistocene sites. Each measurable gazelle bone element (humerus, astragalus, metatarsal) decreases in mean size by approximately 1mm between the Early Epipalaeolithic and Neolithic in eastern Jordan; the larger early Epipalaeolithic animals may have **slightly** greater nutritional requirements than the smaller Neolithic ones, but this is probably negligible.

Timing of births

Each of the four areas/periods are likely to have seen births concentrated in the spring, when the increase in temperatures and the effect of winter rains would cause a flush of new vegetation growth. Prior to March-April, the steppe would probably be too cold for fawn survival; summers would have been too hot and dry. Birthing in autumn, both in late Pleistocene and early Holocene environments, would be firstly hazardous for fawns due to the arrested plant growth in winters, and secondly insecure for mothers who would experience low fat levels during the long summers of sparse vegetation. Births are therefore expected to have been highly synchronized in spring, although stragglers are possible.

Mobility

In the wide *wadis* in the Epipalaeolithic (1) and the Azraq Central Basin (2), where vegetation cover might be fairly even and dense, small seasonal movements of gazelle are predicted. The reconstructions suggest that sufficient forage might be found in relatively small home ranges. In the wetter, lusher periods of the Epipalaeolithic, gazelles could be fairly sedentary, whilst in drier times, animals may be forced to wander small distances for food in summers. It is difficult to put a figure on a predicted home ranges, but case studies of Arabian gazelle populations show animals moving a maximum of 25km^2 in the most sparse vegetation conditions.

The Neolithic gazelle populations (3,4) would have inhabited hotter, drier and more seasonal environments. These animals may have experienced low forage and moisture conditions in summers. By comparison with the gazelles in the present-day Negev, the predictions are that at these times of low resources, they would have restricted movement and sought shade in order to conserve energy and body water. Expectations would be, therefore, for small seasonal mobility and relatively limited home ranges.

The suggestion that prehistoric gazelle populations in Jordan migrated seasonally (Legge and Rowley-Conwy 1987) is rejected through examination of the behaviour of case study animals. Most of the conditions which stimulate long-distance migration by African gazelles do not apply in steppic Jordan. Firstly, African gazelles move between different environments (e.g. bush/clearings and open plains) and follow the rains in search of fresh graze. In eastern Jordan, there is no delineation between vegetation zones, but only gradients of steppe, which all see vegetation growth at roughly the same time (spring). Since the whole region experiences similar seasonality, there seems little benefit in animals moving long distances; rather, they would either wander, or radiate out from an area for forage.

Secondly, gazelles in the African grasslands migrate with a host of commensals who 'open up' high quality graze which they then exploit. It is possible that gazelles in eastern

Jordan fed alongside equids, cattle and other ungulates for parts of the year, but those most likely to migrate - equids - have much greater nutritional needs than gazelles, and would probably have moved much longer distances than viable for the smaller gazelles. As argued above, prehistoric gazelles in eastern Jordan were more likely to have restricted movement as a response to low forage availability, because the costs of locomotion for small animals in areas of sparse forage outweight the benefits. The principle can be seen in a comparison of home range sizes of the 75kg *G. granti* (290km^2) and its co-habitant, 24kg *G. thomsoni* (140km^2), even though theirs is a relatively lush environment.

A third reason for migration appears to be the need of *G. granti* and *G. thomsoni* to find dry refuge areas and fawning grounds. Wet ground is not favourable for fawn survival, and large areas become inhospitable after the rains. In prehistoric eastern Jordan, avoidance of damp ground would not be required.

Fourthly, human firing of the grasslands is seen to be intimately connected to animal migration in east Africa (Brooks 1961; Walther 1972). There have been suggestions of grassland management by fire in the prehistoric Levant (e.g. Garrard 1982; McCorriston 1992), but no evidence for this exists.

To conclude, Legge and Rowley-Conwy's (1987) proposal that late Pleistocene/early Holocene gazelle populations migrated from northern Syria southwards to eastern Jordan, crossing the steppe in hot, dry summers and returning whilst females were pregant in winters, is not supported by the present reconstruction. The conditions which promote migration in east African gazelles are not predicted for prehistoric eastern Jordan. Their model suggests that animals moved distances of 600kms twice yearly - adaptive behaviour which does not appear viable following the above study of gazelle behavioural ecology.

Social organization

The establishment of male territories is predicted to have been the dominant mating strategy in all areas/periods considered. None would have seen such low rainfall, or such sparse vegetation conditions as to preclude the holding of territories, although the high synchronization of births argued for above suggests that males would only become territorial during the rut.

Assuming spring births in eastern Jordan, the mating season would be in the autumn (gestation is c. 6 months). At this time, one would expect to see solitary territorial adult males, 'harem' herds of females wandering through territories, and bachelor herds - the subadult and non sexually-active males. After the rut, in winter, this segregation would break down and mixed herds would form.

In spring, pregnant females would become solitary in locations providing suitable availability of forage, shade and concealment for fawns; such locations may be repeatedly visited fawning grounds. After birth, fawns would probably 'lie out' in these areas for some time. There may be some clustering of mothers and offspring, either for protection, or because suitable forage conditions, plus the inability to move far, concentrates them. In summers, mixed herds consisting of females, young and males are likely to form.

Group size

Larger groups would be expected in the Epipalaeolithic wide *wadis* (1) and at Azraq central basin (2) than in the Neolithic of the limestone area (3). Even smaller groups would form in the Basalt area in the Neolithic (4), due to sparser forage conditions. The groups likely to be affected by forage constraints are mother-offspring groups, bachelor herds and mixed herds. In addition to differences between the areas/periods, group size could be expected to be seasonally variable, with larger mixed herds, for example, forming in winters than in summers. Predators may have been a particular threat around the water pools at Azraq, and group size may have been enhanced by this.

Population density

The case studies show population densities to be determined by the availability, type and distribution of forage. Accordingly, it is predicted that gazelle densities would generally decline from Azraq central basin, to the Epipalaeolithic wide *wadis*, to the Neolithic in those same *wadis*, to being lowest in the Basalt desert in the Neolithic. Within this generalization, densities could be expected to vary with topography, so that higher densities would be found in the wide *wadis* than in their surrounding open plains; and in an area of sparse vegetation, such as the Basalt desert, resources concentrated in run-off locations may lead to higher densities in patches. Seasonal variations, with higher carrying capacities in winter/spring than in summer, should be predicted. It is difficult to suggest actual population densities for each area/period; comparisons with the present day Galilee observations of c. 20/km^2 may be misleading since there is a suggestion that gazelles are more productive on grasslands than in woodland zones (McCorriston 1992:97-98). It is probably safer to argue only that densities would have been much higher in the Epipalaeolithic (1, 2) than Neolithic (3, 4) due to a decline in forage availability, and probably also as a result of changes in human settlement patterns in the later periods.

Sex ratio

By comparison with the case study populations, gazelle herds in prehistoric eastern Jordan are predicted to constitute roughly equal proportions of males and females, although a predominance of adult females might be expected in areas of high competition between male animals (for forage and mating), for example in areas of low resource availability such as the Basalt desert in the Neolithic.

Age structure

Since females are predicted to birth once a year, in spring, producing one fawn, the expectation would be for juveniles to constitute between 20% and 40% of populations. The lower number would be expected between autumn and spring; the higher from spring to autumn. Similar proportions are suggested for each of the four areas/periods.

CHAPTER FIVE

ARCHAEOZOOLOGICAL METHODOLOGY

This chapter describes the basic methodological procedures applied to the eastern Jordanian study sites in order to produce archaeozoological data relevant to the following areas of interest:

Taphonomy

- to attempt to define the factors affecting animal bone survival and condition.
- to allow for taphonomic bias in considering the following data and questions.

Species present

- list of species for zoogeographic interest.
- relative proportions of species, to establish relative economic importance.
- intraspecific variation in morphology, for management/environmental implications.

Age profiles

- to ascertain whether there is selection for particular age groups.
- to infer site occupation at certain times of the year.
- to suggest whether there is management (herding or loose-herding of certain species).

Sex ratios for species

- to suggest selection of certain groups for hunted species.
- to infer management of domesticates.

Body part representation

- to see if patterning suggests certain uses of animal parts and products.
- to reflect possible functions of sites.

Other

- butchery and processing indicators, as aids to the interpretation of body part representation.

Any interpretative models applied to the basic raw data are discussed in the results chapters (6, 7, 8 and 9). This chapter is divided into two sections: the first defines methods used for sorting, counting, recording and quantifying the animal bones; the second describes the criteria employed for identifying the species/taxa occurring at the sites.

The 20 sites described in Chapter 3 form the basis of the present study. Many faunal assemblages have seen previous work, for example by Garrard (1985) and Garrard and Montague (in Garrard *et al.* 1988b), which included the identification and recording of material, and a preliminary stage of analysis. I have re-examined certain aspects of these assemblages for the present project, and undertaken a complete **analysis** for all the sites. It must be stressed, however, that the present project owes much to the original work of Garrard and Montague.

As a result of this situation, different assemblages have been subject to slightly different methodological approaches. Although the final output is broadly comparable across the sites, the material which was specifically studied for this project has had certain additional questions asked of it, and was recorded differently to that studied earlier.

Table 5.0 lists the 20 sites, and shows how the archaeozoological work was divided.

list of sites	original identification & recording	sample size (no. identified bones - NISP)
PPNC/ELN		
B27	Martin	259
Jebel Naja	Garrard	9
DH 2 (1986)	Martin	8418
WJ13	Mylona/Powell*	4151
WJ25	Martin	179
PPNB		
Ibn el-Ghazzi	Garrard	20
DH 1 (1986)	Martin	2786
WJ26	Martin	12
WJ32	Martin	194
WJ7 1 3 4 5	Martin	1108
WJ7 2	Garrard/Montague	715
L EPAL		
Khallat Anaza	Garrard	34
AZ18	Garrard/Montague	295
M EPAL		
AZ17	Garrard/Montague	49
WJ22	Martin	8364
WJ10	Garrard/Montague	67
WJ8	Garrard Montague	92
E EPAL		
UW18	Garrard/Montague	554
UW14	Garrard/Montague	11
KH4 (1981)	Garrard/Martin	3702
KH4 (1985)	Martin	7404
WJ6	Garrard/Montague	2875
L UPAL		
WJ9	Garrard/Montague	102

Table 5.0 shows how the original identification and recording work was undertaken by different archaeozoologists for the sites used in the study. *Powell (1992) and Mylona (1992) studied WJ13 areas B and C respectively under the supervision of, and following the methods of, the author.

The methodology described below is that used by the author on the assemblages studied specifically for this project (i.e. since 1989). Where earlier practice differs, it is mentioned in the appropriate section.

Retrieval and preparation

All deposits from each of the sites were dry-sieved through a 5mm mesh, thus reducing retrieval biases against small bones (Payne 1975). Due to logistical problems of excavating in arid areas, wet-sieving was not possible at any of the sites (although flotation residues were sorted for bone). It is assumed, however, that bones were not obscured in the sieving process, since site sediments are generally fine sandy-silts which tend not to adhere to finds.

Certain animal bone assemblages were washed in the laboratory. Other collections, such as that from WJ22, were covered by a hard calcrete deposit which was removed with a dilute acetic acid solution before identifications could be made. This treatment can destroy bone if applied for too long, and it was avoided where possible. Most bone, however, was identifiable without washing or special cleaning, and needed only occasional dry-brushing for surface examination.

Assemblages studied post-1989 had all the identifiable bones marked with their context number so that material from the whole site could be examined at the same time (see Klein and Cruz-Uribe 1984:21). The bones studied pre-1989 were analysed 'bag by bag' and therefore did not need marking.

Sorting, counting, recording

The animal bone was sorted into identifiable and non-identifiable fragments. What is considered 'identifiable' is obviously subjective and depends, in part, on the level of identification required, the worker's experience, the comparative material available, and also whether the fragment yields sufficient information for it to be considered useful. The ability to identify faunal material also greatly depends on the state of bone fragmentation. For example, the bone from the eastern Jordanian sites is generally very highly fragmented: for medium and large sized animals (gazelles, caprines, equids) the only complete elements found are small compact bones such as carpals, tarsals and phalanges. Long bones are typically only represented by ends and shaft splinters. This tends to give very low identification rates, since many of the smaller fragments of shafts and skull are not diagnostic.

What is 'identifiable'?

In 1979, Watson introduced the concept of 'diagnostic zones' whereby, instead of using the whole bone as the unit of analysis, only certain areas were selected (Watson 1979). He proposed using parts of bones which were species-specific, as commonly preserved as possible and suitable for both fused and unfused material, therefore providing a maximum of information. Watson originally used 88 such zones to standardize recording (Watson 1979:130-131), but the approach has been adapted and taken to an extreme by Davis

(1987:35) who counts only 15 diagnostic zones of the ungulate skeleton, which cover only a very restricted number of skeletal parts.

Although the diagnostic zones approach has been very successful in overcoming the problem of recording and counting the same bone twice (by only recording a zone when more than half of it is present), certain problems remain.

Firstly, the diagnostic zones which have been suggested tend to cover only the articular ends, where long bones are concerned (Watson 1979; Davis 1987). This is done to economize on time, and to use only areas which potentially provide data on species, body part and ageing. Recent research, however, shows that if an assemblage has been subject to carnivore ravaging, the ends of long bones become the most unreliable indicators of original presence (Marean and Spencer 1991). This suggests that if the extent of post-depositional carnivore activity on a site is unknown, long bone shafts should be taken into consideration, otherwise information may be lost.

Secondly, although it is suggested that diagnostic zones can be altered when working on different sites, depending on the character of the assemblage, it is often difficult to gauge which are the most well-preserved zones to 'fix' prior to recording the bones, even after a preliminary sorting. This would also eliminate part of the reason to use zones, namely to standardize recording. This problem is especially apparent with highly fragmented material, such as that from the eastern Jordanian sites. Amongst this material it is a common occurrence to find multiple fragments which could potentially belong to one long bone end. A distal humerus, for example, may often be represented by three fragments which could potentially belong together. If, as has been suggested, the distal humerus is a diagnostic zone, to be counted only if more than half was present, then none of these fragments would represent 'more than half' of the zone, and they would all therefore be discounted.

In conclusion, a more flexible approach was needed for the faunal collections from eastern Jordan, so that highly fragmented material would not be overlooked, and that pre-determined diagnostic zones could not by-pass potentially informative shaft fragments. In addition, a method was needed which would allow direct comparison with the material recorded before 1989, which produced two kinds of data: the number of identifiable specimens (NISP), and the minimum number of bones (MNB).

The 'half-bone' approach

The method of identifying/recording long bones which was adopted for this study is Halstead's 'half-bone' count (Smith and Halstead 1989). Following this, the proximal and distal halves of a bone are recorded separately, as 'zones'. The 'half-bone' can include any combination of end (or end fragment) and shaft (or shaft fragment), since this information is recorded separately from the presence of the zone. In this way, shaft pieces and identifiable small end fragments are not overlooked. For long bones, then, the 'half-bone' has become the unit of analysis.

Instead of only counting the 'zone' when either more than half is present or when particular features are present, as the diagnostic zones approach would suggest, the 'half-bone' method allows all fragments to be recorded. Information is coded in such a way that it can provide both a NISP count and a count of the minimum number of ends (MNE) for each bone. For example, two fragments of distal humerus and one fragment of distal shaft of a humerus, which could all potentially belong to one bone are each recorded, giving a NISP of 3, but two of these fragments will have an additional code discounting them from the MNE count. This makes the results almost fully compatible with those from collections studied before 1989. (It should be noted, however, that the NISP figures for assemblages studied after 1989, being based on a count of zones, are theoretically different from NISP figures given for pre-1989 assemblages, which are based on a count of fragments. This means that a complete longbone would be counted as 2 using the former method, but one using the latter. In reality, however, no longbones survive complete, due to the degree of fragmentation, meaning that this discrepancy can be ignored).

To ensure that fragments which could belong to the same bone are not included in the MNE count more than once, a method of 'joining' is used. This means that all elements from the same archaeological context (i.e. bones that could possibly originate from the same event) are examined together. Judgement of whether fragments could derive from the same bone (using additional criteria such as bone size and state of fusion) is done by eye. The major drawback of this approach is that it is necessary to have the stratigraphic interpretation of the site before studying the faunal collection, so that decisions about how to aggregate the material (i.e. which groups to look for joins within) can be made. Fortunately, stratigraphic information for the eastern Jordanian sites was available prior to this study. With this method, the assemblage cannot be studied bag by bag, but must be marked and strewn as described above.

Other elements

The 'half-bone' approach takes care of the recording/counting of long bones. Of the other anatomical elements, only certain bones or parts of bones were selected for counting. Ribs and vertebrae were not counted, with the exception of the atlas and axis, because they are generally difficult to identify to species, and hard to quantify. For the scapula and pelvis, only the articular parts of each were counted. Due to general poor representation of most cranial parts, the following 'zones' were selected: horn core, occipital condyles, petrous temporal, maxillary cheek dentition, mandibular cheek dentition (including root sockets with teeth missing), and mandibular condyles. All phalanges were counted but were not assigned to fore or hind limb, and the patella was also included. Of the carpals, only the scaphoid, semi-lunaire and capetum-trapezoid were used; of the tarsals, the astragalus, calcaneum and navicular-cuboid were included. Sesamoids and other small bones were omitted from the count. Carapace fragments were counted for tortoise.

For material studied before 1989 the same bones/areas were counted, with the difference being that all carpals, tarsals and sesamoids were included as well. This may inflate counts from these sites slightly, but since the inclusion of these bones was done for all species, it should not bias the relative proportions of species within a site.

For both long bones and other elements, only those fragments identifiable to anatomical element, either for taxon or for a general size category (e.g. large herbivore, medium-sized herbivore) were counted.

Summary of zones/bones counted (for post 1989 material):

Cranium
horn core
petrous temporal
occipital condyle
maxillary dentition
mandibular dentition/root sockets
mandibular condyle

Vertebral column
atlas
axis

Girdle bones
scapula - glenoid and neck
pelvis - acetabulum and adjacent areas of ilium, ischium and pubis

Forelimb
humerus - proximal half
- distal half

radius - proximal half
- distal half

ulna - proximal half
scaphoid
semi-lunaire
capetum-trapezoid
metacarpal - proximal half
- distal half

Hindlimb
femur - proximal half
- distal half

tibia - proximal half
- distal half

astragalus
calcaneum
navicular-cuboid
metatarsal - proximal half
- distal half

Feet
(anterior or posterior)
first phalanx
second phalanx
third phalanx

Recording

The following categories of data are recorded, where applicable, for each bone fragment: context; taxon; state of fusion; whether fragment should be counted for MNE; side of body; state of fragmentation; evidence of burning; presence and type of butchery; carnivore gnawing; rodent gnawing; sex.

Each fragment was recorded using numerical codes, and the data for each site was entered into an SPSS database. A specifically tailored SPSS program written by Glynis Jones (Department of Archaeology & Prehistory, Sheffield University) was run on the data, producing the requested information.

Assemblages studied before 1989 were recorded on forms, and computations were done by hand.

Non-identifiable fragments

For assemblages studied before 1989, the non-identifiable material was simply weighed. After 1989, non-identifiables were both counted and weighed. Since this category tends to form a relatively high proportion of the eastern Jordanian assemblages, more complex methods of classing non-identifiables were originally attempted, for example by sorting into both size categories, and cranial, trunk or limb categories. These methods, however, proved very time-consuming and results had low confidence levels. They were, therefore, abandoned.

Quantification

The two most commonly used means of quantifying relative taxonomic abundance inferred from faunal remains are firstly the number of identified specimens (NISP), and secondly, the minimum number of individuals (MNI). Both have been subject to severe criticisms.

The **NISP** method compares the number of identifiable specimens/fragments attributed to each species, thereby implicitly supposing that each fragment represents a different 'unit'. Problems encountered when using this method include the observations that NISP is affected by butchering, trampling and weathering patterns, that fragmentation may not affect all species and elements equally, and that the total number of elements varies between species (Grayson 1979; 1984; Klein and Cruz-Uribe 1984). This last point can be easily rectified by 'weighting' the skeletal parts of some species, therefore creating a 'standard animal' in terms of numbers of skeletal parts. Grayson (1979) sees the most damaging criticism of NISP as being the potential interdependence of elements in the way they may arrive on site, and partly for this same reason, Klein and Cruz-Uribe suggest that NISP should not be used as a sole index of species abundance (1984:25).

At it's simplest, the MNI is produced by taking a count of the most common element, from either the left or right side of the body, for each species. More complex schemes have been advanced, such as that of Bokonyi (1970), in which age, sex and size of animal are also taken into account. Inherent in this method is the assumption that bones from a site may belong to the same individual.

One problem of using MNI as a measure of taxonomic abundance is that it over-states the importance of rare species, and is likely to understate the representation of more frequently occurring ones. Also, the values produced are not additive, and vary greatly according to different bone aggregation methods (Casteel 1977; Grayson 1973; 1979). This last point means that MNI counts are an unsuitable measure for the eastern Jordan assemblages, since sites recorded before 1989 were studied 'bag by bag', whereas those studied after 1989 used the stratigraphic phase as the unit of aggregation. The different MNI values which would result would be in part a product of the different aggregation methods used. One final point about MNI is that Grayson has found it to be related to, and a mathematical function of, the NISP values of a site. He states

> ... since counts of identified specimens per taxon provide much the same information on ordinal scale abundances as is provided by *minimum* numbers, there would seen little reason to employ minimum numbers analysis unless there is some special reason for doing so.
>
> (Grayson 1979:224)

The only specific reason for using MNI in this study is in the evaluation of body part representation (described below). MNIs are shown for each assemblage (see Chapter 6) and are calculated using both age and side data.

For the purpose of this study the minimum number of ends (MNE) is used for quantifying relative taxonomic abundance, because as has been argued above, it overcomes some of the shortfalls of NISP and MNI. It eliminates the problems caused by potential variations in bone fragmentation, which is a major complaint against the use of NISP. Also, by assessing the MNE for a species, the problems of over- or under-representation, which are a feature of MNI, are avoided. The values which result from MNE are still not additive, but this is irrelevant since contexts needing aggregation were predetermined.

A problem arises when comparing the assemblages studied after 1989 with those recorded before, since the earlier work did not use the 'half-bone' count, and MNEs are not, therefore, calculable. Instead, the data provides either NISP values, or a count expressing the minimum number of individual animals represented by each element of each species. This count is referred to here as **MNB**, and can be used as a rather poor version of MNE. Whereas MNE refers to the number of longbone ends (including left and right, proximal and distal) represented by the fragments of each species, MNB refers only to the number of animals represented by fragments of each element, without accounting for side or end of bone. MNB, therefore, will always be a lower count than MNE would have been, had it been taken, but is useful as a count which eliminates the effects of fragmentation for pre-1989 assemblages nevertheless.

The solution to this problem, therefore, is to use several different methods of presenting relative taxonomic abundance. As seen in Chapter 6, all assemblages have NISP values shown for each taxon, since these are the only directly comparable figures between sites. Collections studied after 1989 also have MNE quantifications, whilst those recorded before 1989 are expressed as MNB. These two measures clearly cannot be compared with each other between sites, since they use different units of analysis. It is possible, however, to compare MNE values (or percentages thereof) between sites where these are given, and likewise with MNB. This situation is not entirely satisfactory, but is an obvious result of using new methodologies, which are believed to be improved, but sometimes provide incompatible data.

Each assemblage also has an **'adjusted MNE/MNB'** count (Chapter 6), which attempts to rectify the problem of different species having different numbers of (some) elements. Equids, for example have half the number of phalanges as gazelles, sheep or goats, whilst carnivores have two and a half times more (and five times more metapodia). These skeletal variations mean that the chance of actually **finding** these elements increases or decreases, depending on the species. For the 'adjusted' count, even-toed ungulates are taken as the 'standard skeleton', and the frequencies of equid, lagomorph and carnivore elements are 'weighted' in the following way:

equid	phalanges	multiply by 2
carnivore	metapodia	divide by 5
carnivore	phalanges	divide by 2.5
lagomorph	metapodia	divide by 5
lagomorph	phalanges	divide by 2.5
mustelid	metapodia	divide by 5
mustelid	phalanges	divide by 2.5

(Although birds do not have a 'standard skeleton', their counts remain unadjusted in this study, partly because variations in the bird skeleton make 'weighting' complex, but also because it seems unnecessary to reduce the count of these bones which have huge survival biases acting against them anyway).

Some archaeozoologists use **meat weights** as an alternative means of quantifying taxonomic abundance (e.g. Hecker 1975; Henry and Garrard 1988). This approach aims to account for the fact that animals of varied sizes are represented in a faunal assemblage, and straightforward bone counts overlook the different potential contributions that each species could make to the diet. Two methods are commonly used for meat weight calculation. The first, the 'Wiegemethode', assumes that a fixed relationship exists between bone weight and meat weight. Casteel, however, has shown that this relationship is actually curvilinear, and that meat weights calculated by this method can be greatly erroneous (Casteel 1978). Another approach uses MNI as the unit for multiplication, but this suffers from the same problems as MNI calculations, and also assumes that whole carcasses (rather than joints of meat) were introduced to sites.

There is, perhaps more importantly, a basic theoretical flaw in using meat weights as a means of animal bone quantification. This is the inherent assumption that all bones which arrive on a site do so as a result of meat procurement activities. The numerous other uses of a carcass, such as for hides, fur, horn, bone and sinews, and the different potentials of meat-use itself, are not seen as being relevant. As Klein and Cruz-Uribe state, this approach "confuses counting with interpretation" (1984:35). Meat weights are not used in this study. The underlying tenet, however, that different sized animals will potentially provide different quantities of meat or any other product, is recognized, and indications of the body size and weight for species are presented in later discussions.

Body part representation

In any analysis of skeletal part representation from a site, attempts must firstly be made to understand the non-cultural factors which could affect the bone. Untangling the effects of weathering and decomposition of bone, elimination through carnivore activity, and actual human use of carcasses, will be discussed in Chapter 8. Here, the method used to produce body part data for this study is described.

The aim is to establish the survival frequency of each element, or body part, for each species (where sample sizes are large enough to be informative). This is done by comparing the **expected** representation of an element/body part with it's **actual** representation. Determination of the expected representation uses the concept of MNI, since this establishes a baseline for exploring the presence of different body parts which is unaffected by fragmentation.

For material studied after 1989, the highest left or right hand MNE/element is taken as the MNI. Material studied before 1989 uses the MNB, since MNE data are not available. Once the MNI is established for any particular aggregation of bones, the **expected** representation is calculated for each element by multiplying the MNI by the number of times the element occurs in the skeleton (e.g. if the MNI for a phase is 24, the expected representation of the distal humerus would be 48 since there are two distal humeri in the skeleton). The actual representation (i.e. the MNE/element) is then divided by the expected representation to give a percentage of frequency for each body part. This is how the graphs in Chapter 8 are arrived at.

Again, there is a problem with the assemblages studied before 1989, since MNE counts were not taken. There are two alternative procedures. Firstly, the whole long bone could be used in body part representation, but this does not take into account either different use, or differential survivorship of the proximal and distal ends of long bones. Secondly, the NISP figure for proximal and distal ends of long bones could be used in place of MNE. Although this second method would give results which are potentially distorted by the (unknown and possibly varied) extent of bone fragmentation, it would give more detailed information for long bone ends, and is therefore cautiously used in this project.

Animal bone identification

The main problem in attempting to identify late Pleistocene/early Holocene animal bones is that the evolution and variability of some taxa/species is not well understood (Uerpmann 1987:10). Identifications tend to rely on three approaches: firstly, modern reference collections may be used; secondly, variation within archaeological material may call for the 'creation' of species; and thirdly, (the least creditable) assumptions are made, based on known distributions and habitat preferences of modern/recent animals.

Use of modern reference material is fairly standard procedure, but the possibility that species/taxa may have undergone considerable morphological change over time must be taken into account. Also, species may have become extinct, either regionally (e.g. fallow deer from the Middle East) or globally (e.g. European wild ass), or moved into an area. In short, when the evolutionary histories of species/taxa are so poorly known, there are always chances of making erroneous identifications. Inadequate modern comparative material is also a frequent problem: Near Eastern wild fauna has rapidly disappeared over the last century (mainly due to hunting), and now that conservation has begun, acquisition of skeletal material, particularly suites of aged and sexed animals, is very limited.

Comparisons with other archaeological material is probably the most useful way of exploring variability, although problems of nomenclature then become an issue. In earlier archaeozoological studies, morphological variation observed within a species, including geographical and temporal variation, tended to be recognized by a different taxonomic label (e.g. Bate 1940), although the actual relationship between different forms was not well understood. Increasingly, archaeozoologists have tended to recognize fewer species and sub-species, and have been more concerned with explaining variation in terms of environmental or anthropogenic influence (e.g. Davis 1981; 1987:68-72; Cope 1991).

In the light of these problems it is perhaps not surprising to find that identifications beyond the taxon level (i.e. to species level) have often been made on the assumptions of present, or recent, known habitats of species, rather than on morphological criteria. As Uerpmann states for gazelles (and is probably equally the case with many other taxa), "In many cases identifications have been based on the present geographical ranges of the respective species" (1987:90). For example, most gazelle remains from the northern and central areas of Palestine are identified as *Gazella gazella*; those from Negev and Sinai are mostly assumed to be *Gazella dorcas*, whilst those from more northerly and easterly parts of the region are usually assigned to *Gazella subgutturosa.* As more studies show variations from this picture, however, (e.g. Dayan *et al.* 1986 who identify *Gazella gazella* from southern Sinai, and Becker 1991 who finds *Gazella subgutturosa* from southern Jordan) the assumption that past species distributions mirror recent ones should be questioned. It is inevitable, though, that expectations of what species/taxa **could** be found are based on animals' known habitats and distributions.

Strictly speaking, identifications should be qualified with the suffix 'type', or the prefix 'cf.'. In practice this would be cumbersome, and instead it is common to make identifications **with the knowledge presently available.**

It is not the concern of the present study to present detailed species identifications or speculations, or to make inter-regional comparisons with other archaeological material: this is the subject of future work. Material has been identified to species level only where morphological criteria allow; otherwise, broader taxon names are used.

For the present project, identifications were made using (in addition to publications referred to below) the animal bone reference collections at the British Institute at Amman for Archaeology and History, the Department of Archaeology and Prehistory at Sheffield University, the Natural History Museum, London, and the personal reference collection of Dr. A. Garrard.

For each taxon/species identified from the study sites, the criteria of taxonomic identification used are described; methods of age and sex determination are given for the most commonly occurring taxa.

Equids

Two methods are used for separating the different species assumed to have inhabited the late Pleistocene/early Holocene Levant (the wild horse, *Equus ferus*, *Equus tabetti* - described by Eisenmann 1992 -, the Asiatic half-ass *Equus hemionus*, the European wild-ass *Equus hydruntinus*, the African wild-ass *Equus africanus*, and the domestic donkey *Equus asinus*). The first uses the dental enamel patterning on the cheek teeth described by Davis

(1980a; 1987:33-34). *Equus ferus* has a caballine 'U' shaped internal fold, as opposed to the 'V' shaped fold found in *E. hemionus*, *E. asinus* and *E. hydruntinus*. Of the asinine equids, *E. hydruntinus* has a diagnostic external fold which separates it from the other two. *E. hemionus* and *E. asinus* are not distinguishable by this method; in fact, separating the bones of wild asses and domestic donkeys is extremely problematic and evidence used for the presence of domestic donkeys in the area in the 4th millennium is usually pictorial or textual (Grigson 1993).

The different equids are also partially separable on osteometric criteria (Davis 1987:35; Eisenmann 1986; Eisenmann and Beckouche 1986; Uerpmann 1982b; 1986). Measurements commonly used are those taken on phalanges and metapodials. Areas of overlap exist, however, especially between the smaller species.

Age/sex determination

The equid teeth and bones from the study sites are generally so few and poorly preserved that ageing methods, e.g. dental eruption and wear sequences, measurement of crown heights (Levine 1982) and use of epiphyseal fusion were not applied. No attempts were made at sex determination since dimorphic canines were not found, and the material did not allow metrical analysis.

Aurochs/Cattle

Cattle remains from the study sites are generally few and fragmentary, precluding species determinations, although *Bos primigenius* has been positively identified on horn core morphology. Cattle bones are mostly referred to simply as aurochs/cattle. Recent tentative identifications of wild water buffalo (*Bubalus* sp.) from Late Neolithic Shams ed-Din on the Euphrates (Uerpmann 1982b:33-34; 1987:78) and bison (*Bison bison*) from PPN Jarmo (Stampfli 1983), however, mean that these species could exist in the study area and the general aurochs/cattle label should potentially include them. Domestic cattle are assumed not to exist until the 6th millennium bc in the Levant (Grigson 1989).

The state of preservation of aurochs/cattle dentition does not allow age determinations; epiphysial fusion is recorded but data are too meagre for the creation of age profiles. Sex determination (apart from on horn core morphology) requires metrical analyses (Degerbol 1963; Degerbol and Fredskild 1970; quoted in Grigson 1989) which the study samples do not permit.

Gazelles

Post-cranial gazelle bones were separated from caprine bones using criteria devised using the available comparative material (Martin n.d.a.). Additional observations were taken from Buitenhuis (1988:28-36).

Separation of the three species generally assumed to inhabit the late Pleistocene/early Holocene Levant (*G. gazella, G. dorcas* and *G. subgutturosa*) is only securely done on horn core morphology. Postcranially the bones are not distinctly different, although today they cover a range of overlapping sizes, with those of *G. subgutturosa* being the most robust, *G. dorcas* the most gracile, and *G. gazella* falling between them (Harrison 1968). Recent distributions (Harrison 1968:364; Mendelssohn 1974; Nelson 1973) show *G. subgutturosa* to be the most commonly found in the Jordanian steppe.

The horn cores of the male *G. subgutturosa* are the only ones to have a lyrate twisting (Uerpmann 1982:27; Compagnoni 1978:119). Also, the lachrymal pit at the base of the horn core is deeper in this species than in either of the others, and the horns are closer together on the skull (Harrison 1968:361). The male *G. gazella* has rather short horns which are wide apart at the base, divergent, and often have the tips hooked forwards and slightly inwards (Harrison 1968:349); and all except the last of these criteria are visible also in the horn cores/frontals. The horn cores of the male *G. dorcas,* by contrast, are longer, not so widely separated at the base and less divergent than *G. gazella.* Although these distinctions are clear in complete horn cores, small fragments, or badly eroded specimens, are often difficult to assign to a single species.

Female horn cores, even when complete, are more problematic to separate. The female *G. dorcas* has long, straight horn cores, whilst both *G. subgutturosa* and *G. gazella* tend to have shorter, rounded bud-like types. The largest collection of female horn cores available - in the Natural History Museum in London - shows these last two types to be almost inseparable in modern material (personal observation).

Both dentition and postcranial gazelle bones are sometimes assigned to species on the basis of size (e.g. Tchernov *et al.* 1986/87; Davis 1974:454; Davis 1977:154; 1985:76; Compagnoni 1978). This method is not without problems, since species size can vary over time and space. Also, identifications are often based on comparisons with very few modern specimens, and some of these modern skeletons are from 'protected' animals which have either been re-bred from small populations or live in changed environments (Mendelssohn 1974). In short, our understanding of the range of size variation which gazelles may have exhibited in the past is poor.

Dental age

Dental eruption sequences have been recorded for samples of modern, zoo-reared *G. gazella* and *G. dorcas*, and wear patterns have been correlated with known age (Davis 1980b). Davis shows that all three molars of these species have erupted by 16-20 months, and also by 20 months the third milk molar is replaced. He states that data for the east African Thompson's gazelle (*G. thompsonii*) shows similar rates of dental development. Garrard's study of modern *G. gazella* skulls, also from Israeli zoo-reared specimens, generally supports these data with the suggestion that the permanent premolars erupt at an age of 15-18 months (Garrard 1980:165). No data were found on the eruption and wear sequences of modern *G. subgutturosa.*

Some studies use dental crown heights to determine age, e.g. Legge and Rowley-Conwy (1987) for Abu Hureyra gazelles and Davis (Davis 1977a; 1983) for a range of Levantine prehistoric gazelle material.

The eastern Jordanian sites yielded very few complete teeth, yet alone tooth rows, due to the very high degree of fragmentation (from weathering, pre- or post-depositional bone treatment?). Consequently it has been impossible to construct age profiles based on dental eruption and wear for most sites. A low-resolution method which has been used is to count teeth root-sockets in the mandible (where the teeth themselves are generally missing), since these can be identified as having held either a deciduous or permanent dentition, and this part of the mandible bone often survives well. The most diagnostic feature is that dP_4 has three roots, compared to the two of P_4, but also all three deciduous teeth tend to have a wider space between their thin roots than seen in the permanent premolars. This is because the permanent teeth develop (and eventually erupt) in this space. Other distinguishing features of the deciduous mandible are the thinness and slenderness of the bone, and the small holes which develop around the root-sockets as the bone becomes more plastic, preparing for the eruption of the permanent teeth. A simple ratio of deciduous:permanent dentitions, therefore, has been used in this study.

Where possible, wear stages of the M_3 have been used, although this tooth is nearly always isolated from the jaw. Since gazelle teeth are very similar in structure to those of sheep and goats, Payne's wear stages (1973; 1987) are easily adaptable for use with the gazelle, and his (1987) codes have been used, e.g. in Chapter 7.

Fusion

Davis has estimated the ages of epiphysial fusion for a collection of *G. gazella* skeletons from the Galilee. The animals were not of known age, but aged according to the dental eruption and wear stages described above (Davis 1980b). The results show all bones to have fused by 12-18 months, with four useful groupings (after Davis 1980b:133):

Bone/epiphysis	**months**
Radius proximal	c.2
Humerus distal	c.2
Coracoid-Scapula	3-6
Phalanx 1 proximal	5-8
Tibia distal	8-10
Metapodia distal	10-16
Calcaneum-tuber calcis	10-16
Femur proximal	10-16
Femur distal	10-18
Humerus proximal	12-18
Tibia proximal	12-18
Ulna proximal	12-18
Radius distal	12-18

Sex determination

Apart from horn core differences (described above), bone measurements have been the main method of separating male and female gazelle bones. They are likely, in fact, to provide a more accurate ratio of sex representation than horn core ratios, since small female horn cores will probably be more prone to destruction than the larger male ones, thus biasing quantification.

The elements commonly taken to exhibit sexual dimorphism in the gazelle are the atlas, axis, scapula, distal humerus, astragalus, distal metacarpal and distal metatarsal (Cope 1991; Davis 1977a; 1987:44; Garrard 1980; Haaker 1986; Horwitz *et al.* 1990). The atlas, axis and scapula, however, often do not survive sufficiently intact for necessary measurements to be taken; and the eastern Jordanian assemblages have not provided enough measurable distal metapodia for these to be useful. The astragalus, therefore remains the most useful, with measurements of greatest length (GLl) and breadth of distal end (Bd) being most common. An area of overlap, however, often quite large, always exists between the sexes (Cope 1991:344; Horwitz *et al.* 1990; Davis pers. comm.). Also, metrical assessment of sex ratios which disregard the possibility of more than one species being represented could be very misleading, since both species and sex are sources of size variation in bones.

Caprines

Sheep and goats were separated using the differences described by Boessneck (1969), Prummel and Frisch (1986) and Payne (1985). This issue is complicated by the potential of both wild and domestic sheep and goat populations being present at the study sites.

Domestic sheep (*Ovis aries*) are apparently separable from the wild sheep inhabiting the area - the Asiatic mouflon *(Ovis orientalis)* - on size (Uerpmann 1978; Uerpmann 1979), although fairly large samples of measurements are needed, and preferably sequences within areas. Horn core criteria have also been used: the mouflon has powerful, ringed, sickle-shaped but curled horns in the male (Clutton-Brock 1981:53) and females are often believed to have always been horned. Following this assumption, Bokonyi sees hornlessness in ewes as a signature of domesticated sheep (Bokonyi 1977:23), but Ducos and Helmer advise caution, arguing that the variability of this trait in wild populations is not well understood (1981:524). Horn cores from the study sites do not survive well enough for assessment.

The two wild goat species (*Capra ibex* and *Capra aegagrus*) are separable on horn core morphology: the ibex tends to have straight scimitar-shaped horns, which are flat and rather rectangular in cross section, whilst the bezoar horn core is compressed laterally on the anterior surface, forming a sharp keel in cross section (Davis 1974a:454-457; 1987:132; Clutton-Brock 1981:58-59). No publications have been found which indicate that the post-cranial elements of these two species are separable.

A reduction in the size of goat bones has been taken to indicate the presence of domestic goats (*Capra hircus*) (e.g. Meadow 1984). Regarding horn cores, those of domestic goats tend to show an anterior keel similar to that seen in the wild bezoar goat (a decisive factor for suggesting ancestry, see Davis 1987:132). Bokonyi has attempted to set-up a simple dichotomy, suggesting that wild goats have non-twisted horn cores whilst domestic goats have twisted ones, with the intermediate examples (e.g. from Tepe Asiab) representing early domesticates (Bokonyi 1977:17-18). Again, although most accept that helically twisted horn cores are the dominant form from the Chalcolithic onwards in the Middle East (e.g. Davis 1987:135), the current lack of understanding about both the mechanisms of morphological change, and the variation in wild populations, cautions against using such criteria (Reed 1983:525-526; Clutton-Brock 1981:61; Meadow 1989; Ducos and Helmer 1981).

Brief mention should be made here of attempts to use histological differences to separate wild and domesticated sheep and goats. The subject was opened by Drew, Perkins and Daly (1971) who claimed that they could identify wild and domesticated caprines through examination of the internal microscopic structure (orientation of apatite crystals and trabecular thickness and shape) of the bones from early Neolithic sites in Anatolia.

Subsequent attempts to duplicate the results of their experiments, however, have failed (Watson 1975; Zeder 1978), although interesting correlations between an animal's ecology, level of activity and bone microstructure and trace-elements have been suggested (Zeder 1978). This kind of methodology has not proved reliable in the identification of domesticated versus wild species, although it has increased understanding of microstructural patterns in bone (Gilbert 1989).

Chapter 2 (section on caprines) discusses the problems associated with the identification of domesticates in the archaeological record. Even if certain morphological criteria are accepted, it is unclear how long these may take to become manifest in a domesticated animal. (Bokonyi (1989) mentions experiments which show measurable changes taking place in 30 generations after domestication (no references given), whilst Meadow (1989) argues that some morphological changes, such as size diminution, may be discernible after only one or two generations.) Depending on which opinion is held, therefore, it may not be possible to identify the earliest stages of domestication on morphological criteria alone. For these reasons, other methods have been used for exploring early domestication/management, such as using the zoogeographical distribution of animals, or age and sex structures, and the incidence of pathology. None of these methods provides clear-cut evidence for domestication, but all have been used to produce valuable insights. These methods are discussed in Chapter 2.

Ageing

Dental eruption and wear was recorded according to the stages described by Payne (1973) and Deniz and Payne (1982), although the dearth of data precluded the construction of age profiles. The age ranges used for epiphysial fusion follow Silver (1969).

Sex Determination

Where possible with the fragmentary material, the pelves have been sexed on morphological grounds (after Boessneck 1969).

Canids

Domestic dog (*Canis familiaris*) is separable from wolf (*Canis lupus*) and jackal (*Canis aureus*) by its smaller size; the most common measurements used are those on the mandibular tooth row, or M_1 (Turnbull and Reed 1974; Davis 1981; 1987:138-139). The intermediate-sized jackal teeth can be separated-out morphologically since the metaconids on their carnassials (M_1) protrude lingually and are more prominent (Davis and Valla 1978:609). Unfortunately, no canid teeth from the study sites were measurable due to their fragmentary state.

Fox

The red fox (*Vulpes vulpes*), Ruppell's sand fox (*Vulpes ruppelli*) and the fennec (*Fennecus zerda*) are apparently separable metrically (Harrison 1968), although size variations due to temperature change should be borne in mind for the periods under consideration (Davis 1977b).

Hare

Hare bones from the study sites are identified only to taxon (*Lepus* sp.) due to the confusion over which species may be represented in the Near East (*Lepus capensis*, *Lepus europaeus*?) (Angermann 1983). The juvenile or adult status of hare bones is not used in this study.

Wild boar

The bones of *Sus scrofa* are so rare from the study sites that assessment of their status is precluded.

Felids

For the small felids potentially represented at the sites (*Felis sylvestris/libyca* and *Felis chaus*) no separating diagnostic criteria were found.

Badger

Badger bones could belong to either *Meles meles* or *Melivora capensis*, the honey badger. No methods were found of separating these two.

Hedgehog

Hedgehog remains from the eastern Jordanian sites could potentially belong to three species: *Erinaceus* sp., *Hemiechinus* sp. or *Paraechinus* sp.. The latter two can be separated from the former on the basis of the dentition (Harrison 1972) and by the presence of a supracondylar foramen in the distal humerus, which *Erinaceus* sp. examples lack (Payne 1983:13).

Rodents

The few fragments of Indian crested porcupine (*Hystrix indica*) were identified using Harrison (1972).

Of the smaller rodents, only the mandibular cheek dentition was identified; maxillary tooth rows tended to be more fragmentary. The occlusal patterns were identified to genus by comparison with drawings in Harrison (1972).

Birds

The bird bones were identified by Barbara West using the Natural History Museum collections at Tring.

Reptiles

Most of the small reptile bones, such as those of lizards and snakes, appear intrusive (from different patination) and have not been identified. Bones and carapace fragments of tortoise (*Testudo gracae*), however, seem well-stratified. Since tortoise carapace fragments by far outnumber their other bones, quantification was based on a minimum number of nuchal scutes, of which there is only one per individual, and they are easily recognizable.

Measurements

Where possible, measurements were taken on all elements of all species. The taking of measurements, however, was frequently hindered by the high degree of bone fragmentation found in most of the assemblages. The aim of taking measurements was to 1) aid the separation of species 2) explore intra-specific variation, including 3) examining sexual dimorphism within species.

Most measurements follow von den Dreisch (1976), and her codes are used in this project (e.g. humerus Bd, BT and astragalus GLl, Bd). Additional measurements follow Davis (1985). Burnt bone was not measured.

CHAPTER SIX

RESULTS

The nature of archaeozoological data is that many and various kinds of evidence can be used to inform on any particular question. Presentation of results is not easily broken down into discrete sections, but frequent cross-reference between them is required.

Results are described and discussed over the next four chapters. Chapter 7 primarily concerns evidence relevant to hunting issues; Chapter 8 deals with carcass treatment of wild animals; and Chapter 9 examines sheep and goat herding in the study area. This chapter contains primary data relating to the faunal assemblages, and extracts overall trends in assemblage composition.

Agents of deposition?

The animal bone samples from the study sites are believed to have a cultural origin, rather than resulting from carnivore activity or natural death accumulations, for the following reasons:

Firstly, all material derives from deposits also containing artifacts, often in high densities.

Secondly, the Neolithic fauna was always in association with structures; some Epipalaeolithic bone derived from living floors, whilst other material showed strong adherence to occupation horizons.

Thirdly, there is no evidence for carnivore lairing at any of the study sites, and, as seen in Chapter 8, very little evidence of carnivore activity at all. In addition, most assemblages contain burnt bone which, though not necessarily reflecting contemporaneous human occupation, does suggest human activity, particularly considering the other contextual information. Animal bone from suspected non-cultural contexts, e.g. from rodent burrows, was isolated in excavation.

The faunal remains are characteristically highly fragmented, which explains the consistently low proportion of identifiable to unidentifiable fragments (see table 6.0). Possible explanations for this degree of fragmentation are offered in Chapter 8. A consequence is that some faunal samples are small, despite the large quantities of material (by volume and weight) often retrieved.

identifiable vs non-identifiable fragments

	counts	(NISP)		weights	(grams)		%	id
assemb	unid	id	tot	unid	id	tot	no	wt
PPNC/ELN								
B27 2	4714	250	4964	3979	1506	5485	5	28
J Naja	-	-	-	-	-	-	-	-
DH 2	39535	8418	47953	23144	10202	33346	18	31
WJ13 3	-	-	-	11888	1809	13697	-	13
WJ13 2	-	-	-	6458	1408	7866	-	18
WJ13 1	-	-	-	14532	3746	18278	-	21
WJ25 1	1096	18	1114	777	23	800	2	3
PPNB								
DH 1	16191	2786	18977	10159	4925	15084	15	33
Ibn G	-	-	-	-	-	-	-	-
WJ32	803	128	931	90	36	126	14	29
WJ26	138	12	150	56	11	67	8	16
WJ7 5	909	94	1003	301	41	342	9	12
WJ7 4	3193	371	3564	725	152	877	10	17
WJ7 3	9528	277	9805	1092	281	1373	3	21
WJ7 2	4099	743	4842	2710	1044	3754	15	28
WJ7 1	5383	381	5764	1545	133	1678	7	8
L EPAL								
Kh An	-	-	-	-	-	-	-	-
AZ18	5997	319	6316	24103	11210	35313	5	32
M EPAL								
AZ17 2	495	27	522	-	-	-	5	-
AZ17 1	238	29	267	-	-	-	11	-
WJ22 E	116	23	139	253	344	597	17	58
WJ22 C	5397	251	5648	3777	1453	5230	4	28
WJ22 B	30304	1116	31420	13961	2716	16677	4	16
WJ10 2	3757	66	3823	2962	221	3183	2	7
WJ10 1	10	1	11	22	28	50	9	56
WJ8	1937	92	2029	665	116	781	5	15
E EPAL								
UW18	4810	612	5422	7621	4264	11885	11	36
UW14 u	117	6	123	81	28	109	5	26
UW14 m	80	5	85	32	2	34	6	6
KH4 D	-	-	-	28528	17258	45786	-	38
KH4 C	-	-	-	-	-	-	-	-
KH4 B	-	-	-	-	-	-	-	-
KH4 A	-	-	-	-	-	-	-	-
WJ6 C	224	8	232	241	6	247	3	2
WJ6 B	2970	122	3092	3496	562	4058	4	14
WJ6 A	34690	3032	37722	28602	7511	36113	8	21
UPAL								
WJ9	1006	103	1109	1531	140	1671	9	8

Table 6.0. The proportions of identifiable and unidentifiable bone fragments per assemblage, by weight and count (NISP), and the percentage of identifiables (right hand column).

The integrity of the samples

The excavation areas of the study sites are often small (table 6.1), especially for some of the Epipalaeolithic sites (e.g. WJ6, KH4). The question arises as to whether animal bone samples are 'representative' of the sites in general, and to answer this, the nature of the deposits must be considered.

As described in Chapter 3, most Epipalaeolithic sites are assumed to result from repeated use of a location over potentially long time periods. The occupation deposits, therefore, are palimpsests of activities, which have been excavated and analysed in broad stratigraphic phases. In most cases it cannot be ascertained whether a phase represents the results of a season's use, or multiple seasonal use, but single 'events' are not identifiable with this level of resolution. It is argued, therefore, that although faunal samples often derive from small areas, they are likely to represent accumulated or mixed activities, and hence are not maybe as narrow as the excavation area may imply. The likelihood of horizontal (and vertical) mixing via deflation processes may also make samples representative of the site as a whole.

The PPNB and Late Neolithic sites are a different case. Here, structural features are usually evident, which probably stabilize occupation deposits and reduce the effects of erosion and mixing. Excavations have tended to centre on structures, with excavation areas being relatively larger than those on Epipalaeolithic sites (table 6.1). Representativeness of samples is therefore considered good.

assemblage	area excavated m²	surface area area of site m²	% excavated
PPNC/LN			
B27	17.00	-	-
Jeb N	1.00	-	-
DH2	9.00	240.00?	4
WJ13	73.50	800.00	9
WJ25	21.00	3,200.00	1
PPNB			
Ibn Gh	3.00	-	-
DH 1	9.00	240.00?	4
WJ26	164.50	7,850.00	2
WJ32	5.00	-	-
WJ7	76.75	2,250.00	3
L EPAL			
Kh An	12.00	-	-
AZ18	6.00	1,400.00	<1
M EPAL			
AZ17	15.00	3,100.00	<1
WJ22	4.00	3,500.00	<1
WJ10	8.00	-	-
WJ8	4.00	6,300.00	<<1
E EPAL			
UW18	10.00	875.00	9
UW14	10.00	-	-
KH4	16.00	21,672.00	<<1
WJ6	4.00	19,175.00	<<1
L UPAL			
WJ9	8.00	6,750.00	<1

Table 6.1. The extent of excavated areas, total surface areas of artifact spreads, and percentages excavated of the eastern Jordanian study sites.

The relative proportions of taxa

The relative frequencies of taxa are shown in tables 6.2-6.40. Information is presented separately for each phase of a site (assemblage), in cases where there is more than one chronologically, or typologically, distinct unit. These divisions are based on lithic typologies, C^{14} dating and stratigraphy (see Chapter 3).

Relative proportions of taxa are shown in four different ways for each assemblage:

1) **NISP** - the number of identifiable specimens.

2) **MNE/MNB** - the minimum number of ends (for assemblages studied after 1989) or the minimum number of bones (for those studied before 1989).

3) **adjusted MNE/MNB** - with taxa 'weighted' according to a standard skeleton.

4) **MNI** - the minimum number of individuals.

Methods of calculation for each of these are described in Chapter 5. Note that counts for assemblages studied before 1989 (i.e. those with MNB) are not directly comparable with those for material studied after 1989 (i.e those with MNE), because recording and counting was done according to different systems. The two methods probably provide comparable data, however, in terms of **relative** proportions of taxa.

Taxa

Tables 6.2-6.40 list the taxa identified in each assemblage. Common names, rather than Latin names, have been used because most material is identifiable only to genus level, and the use of Latin names would have often required strings of alternative species names to cover all possibilities. The ranges of species which general labels such as 'equid', 'sheep' or 'gazelle' could potentially include, are shown in Appendix 1. Any identifications to species level are given below the appropriate table.

Birds are an exception to this rule; bones have generally been identified to species level, and species lists are presented in Appendix 3 (although the bird bone from WJ13, WJ25 and WJ7 1, 3, 4, 5 is not yet identified). For tables 6.2-6.40, all bird bone is counted together.

The count of the small rodent category represents the number of mandibles, since these alone were identified. Since small rodent bones are possibly intrusive, they are included in the NISP and MNE/B columns but have not been used in any further calculations (e.g. for percentages); hereafter they will be ignored.

Sample size

The 39 assemblages used in this study show a great range in sample sizes; for example, DH 2 has a NISP of 8408 whilst UW14 middle phase and B27 lower phase each have only 5 identifiable specimens. The sample size obviously has a great effect on the accuracy of any measure of taxonomic abundance, as well as diversity, and will determine how a sample can be used in any further analysis.

Assessing whether a sample is large enough to be representative of a larger (unknown) population, is not straightforward. Van der Veen and Fieller have discussed how the four variables of total sample size available, proportions of particular taxa, the accuracy or tolerance required and the chance of obtaining that accuracy, are all taken into account when looking for optimum sample sizes for archaeological seeds (van der Veen and Fieller 1982:296). Their examples assume that there is always a larger sample available, and one needs to know how much of that sample should be used for accurate results. This is obviously not the case with the bone samples used in the present study where in all cases (except WJ13 where only two-thirds of the total available sample has been studied), the results shown are based on the complete amount of bone excavated. The idea of increasing the sample size for accuracy is therefore not an option unless further excavation is carried out. It is possible, however, to calculate the accuracy levels of certain sample sizes, and the chances of obtaining those accuracy levels.

Following van der Veen and Fieller (1982:296 table 4) assemblages have been divided into 3 groups. The first group (group 1) includes 11 samples of over 384 MNE/B which have 5% accuracy levels and 95% confidence levels. The second group (2) comprises 10 samples which have a count of between 96 and 384 MNE/B, which have 10% accuracy levels at 95% confidence levels. A third group (3) consists of 18 assemblages with an MNE/B count of less than 96, which are too small to be representative. The list below shows which of these three groups each assemblage falls into.

Group 1 (representative at 5% accuracy levels with 95% chance of obtaining accuracy)

WJ6 A
KH4 A
KH4 B
KH4 D
WJ22 B
WJ7 2
DH 1
DH 2
WJ13 1
WJ13 2
WJ13 3

Group 2 (representative at 10% accuracy levels with 95% chance of obtaining accuracy)

UW18
KH4 C
WJ22 C
AZ18
WJ7 1
WJ7 3
WJ7 4
WJ32
WJ25
B27 2

Group 3 (non-representative assemblages)

- WJ9
- WJ6 B
- WJ6 C
- UW14 upper phase
- UW14 middle phase
- WJ8 A
- WJ10
- WJ22 E
- AZ17 squares 1-6
- AZ17 squares 7-15
- Khallat Anaza
- WJ26
- WJ7 5
- Ibn el-Ghazzi
- WJ25 late phase
- Jebel Naja
- B27 phase 1
- B27 phase 3

In tables 6.2-6.40, counts have been converted into percentages for the 21 assemblages in groups 1 and 2 (and also for WJ6 B and WJ7 5 in group 3, for rough comparison with the assemblages from other levels of the same sites). Assemblages which are in group 3 are considered non-representative and can only be used in a very limited way, for example to confirm the presence of certain taxa in an area.

The difference between NISP and MNE/MNB counts

Depending on the method used for counting, a single faunal assemblage can produce vastly different relative proportions of taxa. In order to see the effects of different counting methods, a comparison of the NISP% and the MNE/B% of taxa within an assemblage can be made, and it can be seen that relative proportions sometimes vary greatly and sometimes very little. The site of WJ22 shows an extreme example, where in phase B, gazelle bones constitute 12% of the assemblage by NISP, but 55% by MNE. In contrast, DH 1 shows gazelle making up 93% of the total whether calculated by NISP or MNE. The differences between the NISP and MNE/B frequencies for each assemblage are seen graphically in figure 6.0. The larger the distance between the two symbols (square and dot) shown for each site, the greater the overall difference between NISP% and MNE/B%.

This difference results from two main factors: fragmentation and non-standard skeletons. When Klein and Cruz-Uribe discuss the relationship between NISP and MNI, they suggest the same two reasons for divergences in their relative proportions (1984:25). Although we are dealing here with MNE/B rather than MNI, their comments are pertinent:

> ... if two species differ markedly in their NISP/MNI ratio, it means either that the bones of one are more highly fragmented than the bones of the other, or that one is represented by a much wider range of skeletal elements than the other.
>
> (Klein and Cruz-Uribe 1984:25)

Firstly, the NISP count does not take into account the effects of fragmentation, whereas the MNE/B count does. This means that if the bones of different sized animals, or different taxa, do not fragment to the same degree, then this will directly affect their NISP counts. For this reason, MNE/B counts are seen to be a more accurate method of comparison between taxa.

The problem of counting non-standard skeletons can also be seen to have an effect on the eastern Jordanian material. There is very obviously one taxon - tortoise - which, due to its anomalous skeleton and hence different treatment, has caused great divergence between the NISP% and MNE/B%. The tortoise carapace appears to fragment easily and is also highly identifiable because of its distinctive structure and texture. An initial decision was made to record all carapace fragments, plus limb bones, for the NISP count. For the MNE/B calculation, though, only the distinctive nuchal scute, plus limbs, was counted, therefore treating the whole shell as an 'element'. The discrepancies which result from these two different counts are seen in table 6.41, and are shown at their most extreme in the case of WJ22, where the NISP% of tortoise in phase B is 81% whilst the MNE% is 13%; in phase C the difference is even larger, with NISP% being 91% and MNE% 12%. The NISP% counts are highly inflated, for the reasons described above, and these high counts have the effect of skewing the relative proportions of the rest of the assemblage. Assemblages which have their NISP% skewed by an over-representation of tortoise are WJ8, UW18, WJ6 A and B, WJ22 B and C, WJ7 1 and 2, and WJ32. The MNE/B counts, which are not influenced by tortoise carapace fragmentation, seem a more useful measure of assemblage composition.

In short, relative proportions of taxa based on MNE/B counts correct for problems of bone fragmentation and counting, and are likely to provide a more accurate means of comparing frequencies of taxa than NISP.

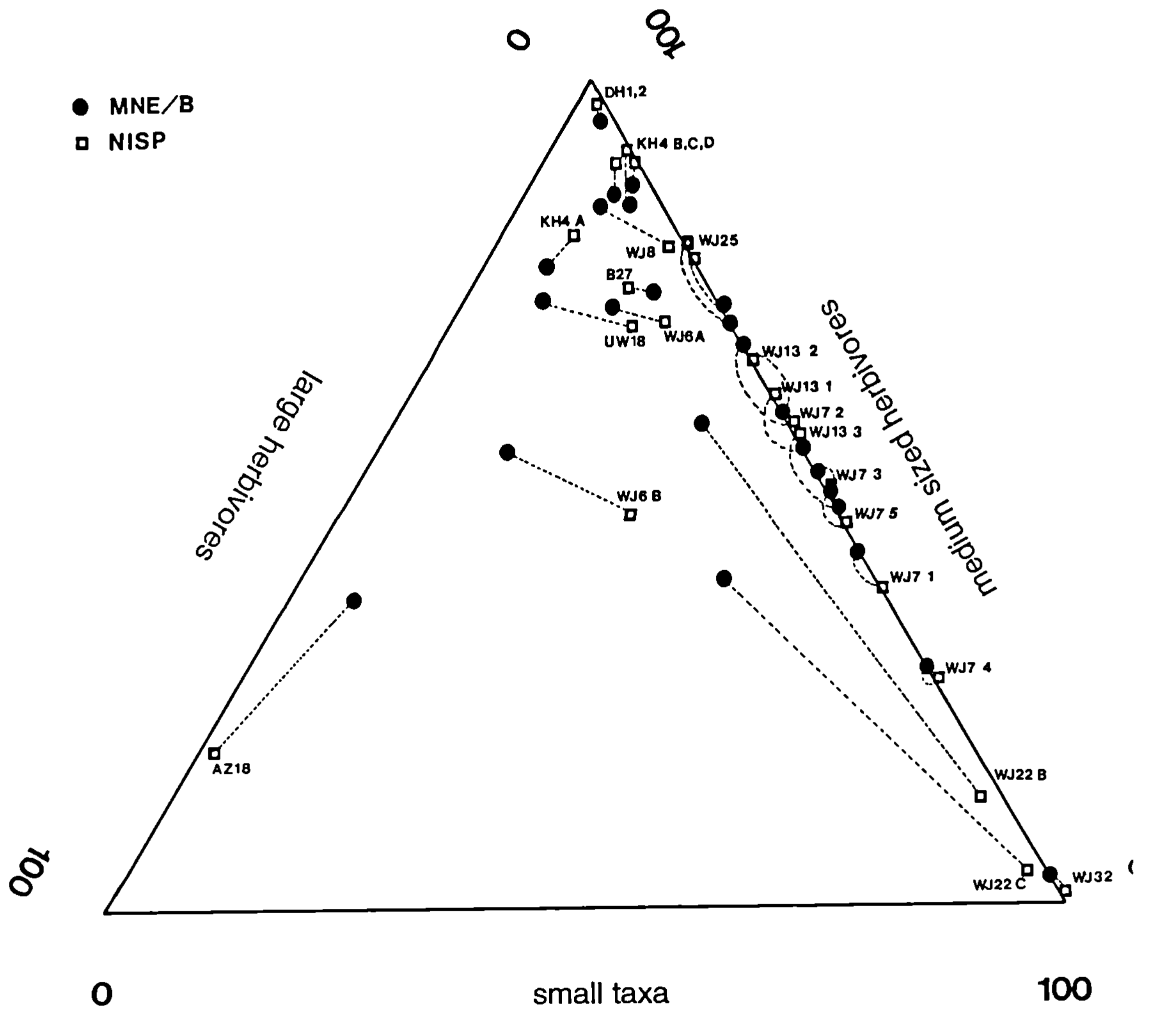


Figure 6.0. The frequencies of large herbivores:medium-sized herbivores:small taxa for group 1 and group 2 assemblages, plotted both as NISP and MNE/B. The greater the distance between the two symbols (square and dot), the greater the difference between NISP% and MNE/B%.

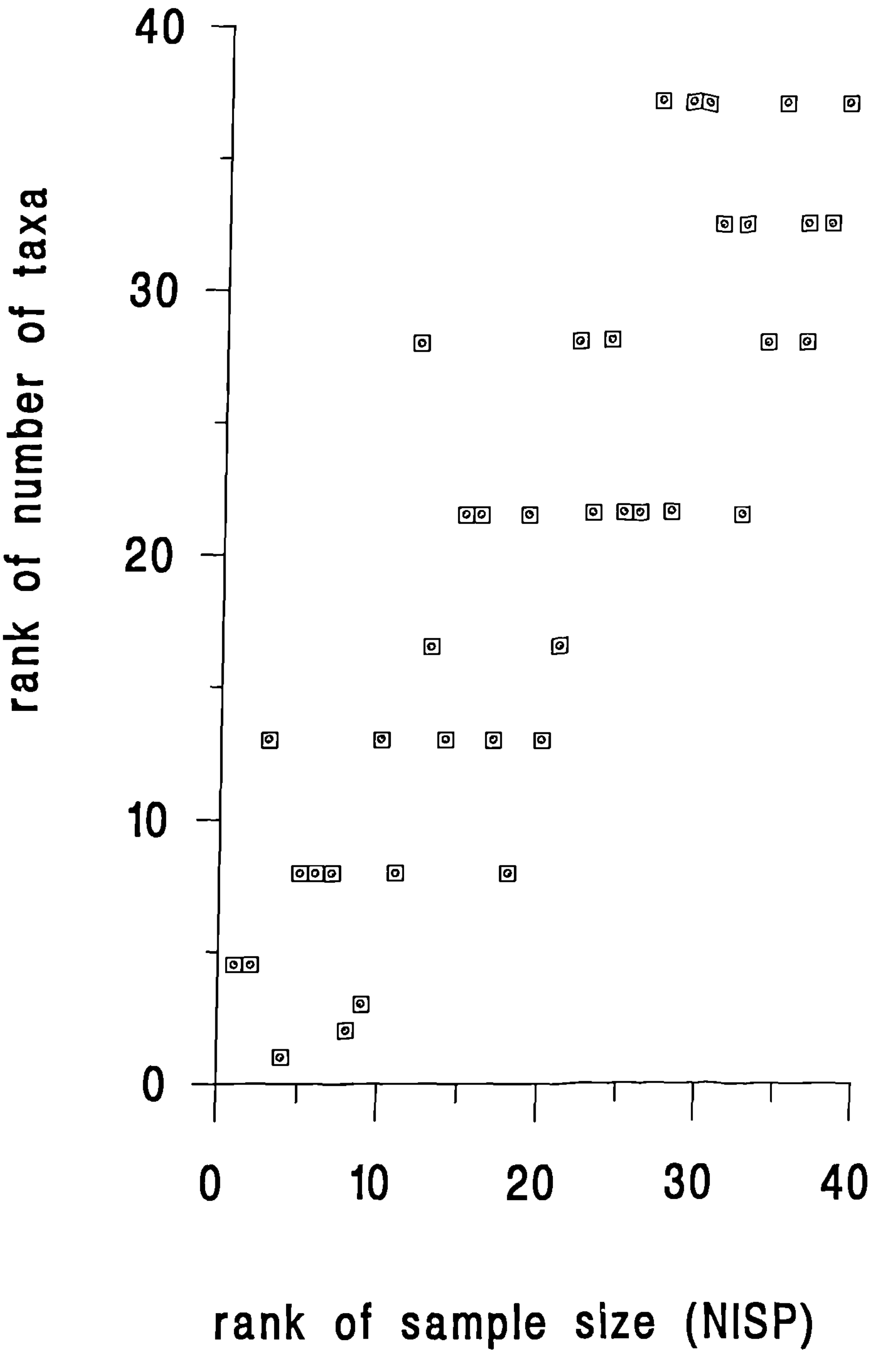


Figure 6.1. The rank of the number of taxa in each assemblage, plotted against the rank of the sample size.

Site/phase	NISP %	MNE/B %	NISP % - MNE/B %
PPNC/ELN			
WJ13 3	0.7	0.9	-0.2
WJ13 2	0.8	0.5	0.3
WJ13 1	3.1	1.4	1.7
WJ25	0.6	0.9	-0.3
PPNB			
WJ32	19.6	3.7	15.9
WJ7 4	12.2	5.2	7.0
WJ7 3	6.5	6.0	0.5
WJ7 2	22.1	4.1	18.0
WJ7 1	13.1	4.3	8.8
M EPAL			
WJ22 B	80.7	13.0	67.7
WJ22 C	91.4	11.9	79.5
WJ8	16.3	5.6	10.7
E EPAL			
UW18	16.5	4.1	12.4
KH4 D	1.4	0.5	0.9
KH4 C	0.3	0.5	-0.2
KH4 B	0.2	0.2	0
KH4 A	3.5	0.8	2.7
WJ6 B	28.6	8.9	19.7
WJ6 A	16.8	3.7	13.1

Table 6.41. The NISP% and MNE/B% of tortoise are shown for each assemblage containing tortoise remains. The right hand column shows the difference between these two percentages.

Use of the 'adjusted' MNE/B

Both the reason for 'adjusting' the counts of taxa with varying numbers of foot bones, and the methods by which this is done are explained in Chapter 5. The adjusted count applies only to equids, hare, canids, felids and badger; other artiodactyl taxa are considered to have standard skeletons.

In theory, the adjusted MNE/B will boost counts of equids (to compensate for them having single phalanges) and reduce the frequency of the other smaller animals (to compensate for them having more metapodia and phalanges than the standard). In order to examine the effects of these adjustments, tables 6.42 and 6.43 summarize MNE/B% and the adjusted MNE/B% for equid and hare, and show how much the percentages of each are altered.

Tables 6.42 and 6.43 show, not surprisingly, that for both equid and hare, the adjusted counts have a significant effect on representation only in assemblages where they are present in fairly high frequencies (>20%). Interestingly, at WJ32 where hare is present in very high proportions (86%), the adjusted count differs from the original very little (1%). This results from the fact that, although the adjusted hare count is much reduced from its MNE, the second most frequent taxon is fox, which is also greatly reduced after adjustment for foot bones. The relative proportions (%) of the adjusted MNE, therefore, change very little.

period/ assemblage	MNE/B %	adjusted MNE/B %	difference %
PPNC/ELN			
B27 2	5.6	5.8	+0.2
DH 2	0.7	0.8	+0.1
WJ13 3	0.1	0.2	+0.1
WJ13 2	0.1	0.2	+0.1
WJ13 1	0.1	0.2	+0.1
PPNB			
DH 1	1.0	1.1	+0.1
L EPAL			
AZ18	30.8	35.7	+4.9
M EPAL			
WJ22 C	14.8	15.9	+1.1
WJ22 B	7.4	9.4	+2.0
WJ8	5.6	8.1	+2.5
E EPAL			
UW18	13.6	19.4	+5.8
KH4 D	4.6	5.7	+1.1
KH4 C	3.6	6.0	+2.4
KH4 B	3.7	4.6	+0.9
KH4 A	14.3	17.8	+3.5
WJ6 B	31.1	39.2	+8.1
WJ6 A	9.8	11.4	+1.6

Table 6.42. A summary of MNE/B and adjusted percentages for equid bones for all assemblages. The right hand column shows how much the adjustment alters the representation.

period/ assemblage	MNE/B %	adjusted %	difference %
PPNC/ELN			
B27 2	15.8	14.5	-1.3
DH 2	2.4	1.9	-0.5
WJ13 3	34.4	21.5	-12.9
WJ13 2	27.9	17.0	-10.9
WJ13 1	25.6	18.6	-7.0
WJ25	22.9	16.0	-6.9
PPNB			
DH 1	1.9	1.6	-0.3
WJ32	85.7	84.7	-1.0
WJ7 5	44.3	31.7	-12.6
WJ7 4	52.4	37.2	-15.2
WJ7 3	33.7	24.7	-9.0
WJ7 2	20.7	20.7	0
WJ7 1	46.1	30.9	-15.2
L EPAL			
AZ18	1.0	0.9	-0.1
M EPAL			
WJ22 C	3.7	3.3	-0.4
WJ22 B	6.1	3.7	-2.4
WJ8	2.8	2.7	-0.1
E EPAL			
UW18	2.4	1.7	-0.7
KH4 D	5.3	3.9	-1.4
KH4 C	4.1	3.5	-0.6
KH4 B	2.7	2.7	0
KH4 A	3.1	3.0	-0.1
WJ6 A	5.0	4.9	-0.1

Table 6.43. A summary of MNE/B and adjusted percentages for hare bones for all assemblages. The right hand column shows how much the adjustment alters the representation.

It was decided not to use adjusted counts in further analysis for the following reasons:

1) The differences between the MNE/B% and the adjusted MNE/B% are generally not great. Even in cases where the % difference is highest, for example for hare in WJ7 1 and WJ7 4 (each with a difference of 15.2%), the percentage of error still falls within the levels of accuracy expected for these samples.

2) It is probable that the bones of larger taxa have survived better than those of smaller ones. 'Adjusted' counts, in this study, actually work to accentuate these preservational biases by reducing counts of small taxa like hare, and increasing counts of equid.

Diversity and relative diversity of taxa

Diversity

There are many problems related to the measurement of taxonomic diversity, yet alone to its interpretation (which is fraught with questions of what observed variation actually means and what resolution of activity one is measuring, e.g. Edwards 1989 and Madsen 1993). With regard to measuring taxonomic diversity in the eastern Jordanian assemblages, some obstacles are overcome by the fact that recovery techniques were constant, and what was classed as 'identifiable' was standardized. Sample sizes, however, are also a problem in that they have great potential to influence diversity (Grayson 1981; 1984; Edwards 1989). Table 6.44 ranks each assemblage in terms of sample size and number of taxa identified. (It should be noted that different species of bird have not been included in the count of taxa since the bird bones from some assemblages have not yet been identified. Instead, where bird bone is present it is counted as 1 taxon. Further, molluscs have not been counted even though they are often included in measures of faunal diversity). The rank of sample size is plotted against the rank of number of taxa in figure 6.1, showing that there is a high correlation between the two (Spearman's Rho correlation coefficient=.859). **These results imply that for the assemblages under study, any measures of taxonomic diversity alone are probably more reflective of sample size than anything else.** Spearman's Rho^2 indicates that 74% of the variation in the number of taxa can be accounted for by sample size. A more meaningful way to explore variation between assemblages is through relative diversity.

Site/phase	sample size	rank	number of taxa	rank
DH 2	6372	1	11	4.5
KH4 D	3659	2	11	4.5
DH 1	2202	3	8	13
WJ13 1	1880	4	14	1
KH4 A	1132	5	9	8
WJ6 A	845	6	9	8
KH4 B	803	7	9	8
WJ13 3	796	8	13	2
WJ13 2	642	9	12	3
WJ22 B	611	10	8	13
WJ7 2	469	11	9	8
WJ7 1	256	12	4	28
WJ7 4	248	13	7	16.5
WJ22 C	243	14	8	13
KH4 C	197	15	5	21.5
WJ7 3	184	16	5	21.5
B27 2	177	17	8	13
UW18	169	18	9	8
WJ32	161	19	5	21.5
WJ25 early	109	20	8	13
AZ18	104	21	7	16.5
WJ7 5	79	22	4	28
WJ6 B	45	23	5	21.5
B27 3	44	24	4	28
WJ8	36	25	5	21.5
Khallat Anaza	34	26	5	21.5
Ibn el-Ghazzi	20	27	2	37
WJ25 late	19	28	5	21.5
AZ17 sq 7-15	15	29	2	37
AZ17 sq 1-6	14	30	2	37
WJ22 E	13	31	3	32.5
WJ26	12	32.5	3	32.5
WJ10	12	32.5	5	21.5
Jebel Naja	8	34	4	28
WJ6 C	6	35	2	37
UW 14 middle	5	36.5	3	32.5
WJ9 A	5	36.5	4	28
UW14 upper	3	38	3	32.5
B27 1	2	39	2	37

Table 6.44. The sample size of each assemblage, the number of identified taxa, and the rank of each. (Note that different bird species are not included in the number of taxa, but the presence of bird is counted as 1 taxon).

Relative diversity

With regard to the problems outlined above, relative diversity indices (e.g. Grayson 1984; Edwards 1989) which produce quantitative measures of how evenly taxa are represented within assemblages have not been used in the present study. Instead, issues of taxon distribution are explored through a series of specific questions:

1) How does the relative abundance of medium-sized herbivores compare to large herbivores and smaller taxa?

Figure 6.2 shows the percentages (based on MNE/B) for each of these size categories (the same data are shown for both NISP% and MNE/B%, but as discussed above, the latter is considered more accurate). The information is plotted for the 21 group 1 and group 2 assemblages. The data on which this graph is based are shown in table 6.45. Counts of equid and cattle (and the single occurrence of camel) have been combined to produce the large herbivore category; gazelle, sheep and goat together constitute the medium herbivore category; the remaining taxa constitute the small taxa category. For the purposes of the graph, the six fragments of boar (from WJ6 A and KH4 D) are included in the medium-sized herbivore category even though boar is omnivorous. The counts are so small that they do not affect the picture.

It can be seen that only one assemblage, late Epipalaeolithic AZ18, has over 50% of large herbivores; four others, KH4 A, UW18, WJ6 A and WJ22 C (all early Epipalaeolithic except the last which is middle Epipalaeolithic) have 10-20%, whilst the remaining 16 assemblages have a relatively low representation of equids/cattle. It should be noted that all assemblages with over 10% of large herbivores are Epipalaeolithic, and four of the five date to the early part of the period.

The majority of assemblages, regardless of their period, lie in the top half of the graph, meaning that they consist of over 50% of medium sized herbivores. Ten of these assemblages have over 70% medium-sized herbivores. Six of these are Epipalaeolithic; one is PPNB and three PPNC/Late Neolithic.

Another point to note is that 11 assemblages lie either on, or very close to, the right hand edge of the graph - the axis which represents zero for large herbivores. These cases are all Neolithic, both PPNB and PPNC/Late Neolithic. Assemblages plotted on this line include varying proportions of medium-sized herbivores and small taxa. A single assemblage, PPNB WJ32, has a very high (97%) representation of small taxa, with only 3% medium-sized herbivores. Another, PPNB WJ7 4, is made up of over 70% small taxa, with 29% medium-sized herbivores. The assemblages of DH 1 and 2 (PPNB and LN respectively) represent the opposite case, with 96% of each constituting medium-sized herbivores, and only 3% small taxa (1% of each are large herbivores). The rest of the assemblages have intermediate proportions of the two categories.

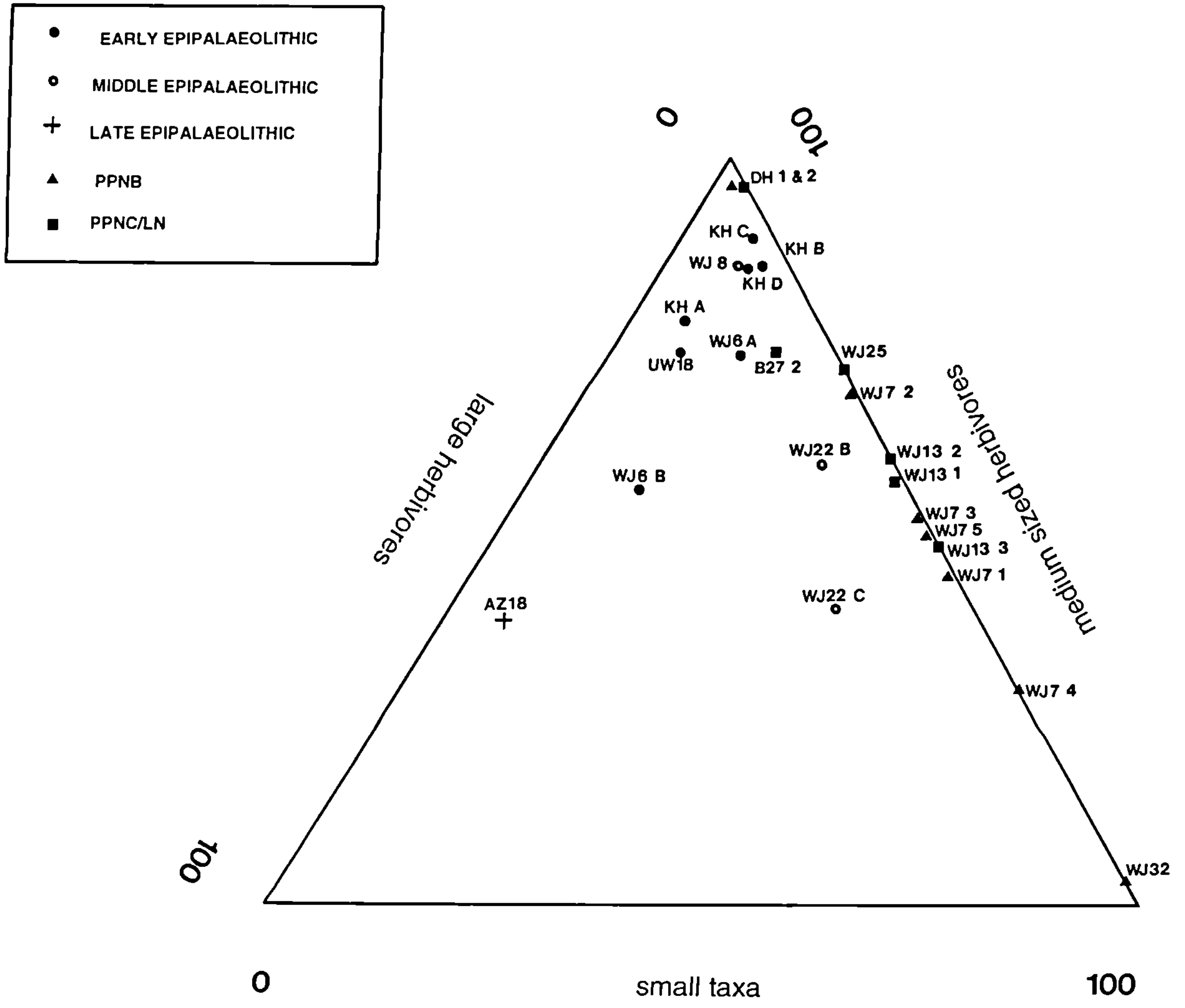


Figure 6.2. The relative abundances of medium-sized herbivores, compared to large herbivores and small taxa for each group 1 and group 2 assemblage.

	MNE/B %		
assemblage	large herbivore	medium herbivore	small taxa
PPNC/ELN			
B27 2	6	75	19
DH 2	1	96	3
WJ13 3	0	49	51
WJ13 2	0	60	40
WJ13 1	1	57	43
WJ25	0	72	28
PPNB			
DH 1	1	96	3
WJ32	0	3	97
WJ7 4	0	29	71
WJ7 3	0	52	48
WJ7 2	0	44	56
WJ7 1	0	68	32
L EPAL			
AZ18	56	38	7
M EPAL			
WJ22 B	9	59	32
WJ22 C	16	40	45
KH4 C	4	88	8
KH4 D	5	85	10
E EPAL			
UW18	18	74	8
KH4 B	4	85	11
KH4 A	15	78	7
WJ6 A	11	74	16

Table 6.45. The percentage of MNE/B falling into each of the three size categories, large herbivore, medium-sized herbivore and small taxa, for the 21 group 1 and group 2 assemblages. These data are plotted in figure 6.2.

2) Concerning medium-sized herbivores, how do relative abundances of gazelle compare to those of sheep/goat?

As seen in tables 6.2-6.40, gazelle, sheep and goat are the only medium-sized herbivores identified from the assemblages in eastern Jordan. Boar - an omnivore - is the only other medium-sized animal identified; only six fragments were found, five in WJ6 A and one in KH4 D. Table 6.46 shows the percentage of gazelle of the total of gazelle+sheep/goat, both by NISP counts and MNE/B counts, for group 1, 2 and a few group 3 assemblages. An overwhelming dominance of gazelle is seen in the Epipalaeolithic and PPNB assemblages; the total NISP for gazelle from these periods is 16,579 compared to a figure of eight for sheep/goat. (The MNE/B counts cannot be added in the same way, since MNE and MNB are derived in different ways, as explained above, but ratios in this column mirror those of NISP). The highest number of sheep/goat in any one assemblage is seen at DH 1, but these five bones are totally overshadowed by the number of gazelle (2,601).

In general, PPNC/Late Neolithic assemblages have a great increase in numbers of sheep/goat, although there is variation between them. DH 2 has very low proportions of sheep/goat relative to gazelle, and their ratio mirrors that of the PPNB levels (DH 1). The three assemblages from WJ13 all show more equal ratios of gazelle to sheep/goat, although WJ13 1 has slightly more gazelle, WJ13 3 has slightly more sheep/goat, and WJ13 2 has significantly more sheep/goat than gazelle. WJ25 and B27 2 both have much higher frequencies of sheep/goat than gazelle.

	% gazelle of total gazelle+sheep/goat			
	NISP		MNE/B	
assemblage	% gazelle	n	% gazelle	n
PPNC/ELN				
B27 2	18.9	90	20.2	84
DH 2	99.5	9756	99.4	5958
WJ13 3	45.8	299	45.6	263
WJ13 2	41.5	323	42.7	286
WJ13 1	50.5	915	51.0	790
WJ25	5.9	102	9.5	63
PPNB				
DH 1	99.8	2606	99.8	2056
WJ32	100	4	100	4
WJ7 5	100	41	100	37
WJ7 4	100	96	100	68
WJ7 3	100	125	100	82
WJ7 2	100	399	100	311
WJ7 1	100	136	100	107
L EPAL				
AZ18	100	55	100	39
M EPAL				
WJ22 C	100	113	100	91
WJ22 B	99.8	620	99.7	334
WJ8	98.6	74	96.7	31
E EPAL				
UW18	99.7	397	99.2	124
KH4 D	100	6697	100	3124
KH4 C	100	264	100	174
KH4 B	100	1428	100	697
KH4 A	100	1496	100	886
WJ6 B	100	53	100	25
WJ6 A	100	1983	100	619

Table 6.46. The percentage of gazelle of the total gazelle+sheep/goat (n), shown for both NISP and MNE/B counts.

3) For large herbivores, what is the relative distribution of equids and cattle between assemblages?

The large herbivore category is made up almost entirely of equids and aurochs/cattle. Two fragments of camel (from UW18 and WJ10) were also identified, but their rarity means that they are not included in the discussion here.

Table 6.47 shows the percentage of equid of the total of equid+aurochs/cattle bones, both by NISP and MNE/B for relevant assemblages. The general trend throughout the assemblages is for equids to be much more frequently represented than cattle, and over half show no cattle bones at all. The exception is the late Epipalaeolithic site of AZ18 where cattle bones are more than twice as common as those of equids in the NISP count, although the two are roughly equivalent by the MNB count. The only other assemblage where cattle outnumber equids is WJ13 1, but the numbers are too low to be meaningful.

	% equid of total equid+aurochs/cattle			
	NISP		MNE/B	
assemblage	%	n	%	n
PPNC/ELN				
B27 2	100	18	100	10
DH 2	100	58	100	44
WJ13 3	100	1	100	1
WJ13 2	100	1	100	1
WJ13 1	28.6	7	28.6	7
PPNB				
DH 1	100	29	100	22
WJ7 2	00	1	00	1
L EPAL				
AZ18	28.7	216	51.9	52
M EPAL				
WJ22 C	100	64	100	36
WJ22 B	100	163	100	45
WJ8	100	2	100	2
E EPAL				
UW18	92.5	53	85.2	27
KH4 D	94.2	206	96.5	173
KH4 C	100	7	100	7
KH4 B	96.8	31	96.8	31
KH4 A	96.5	200	95.9	169
WJ6 B	100	25	100	14
WJ6 A	96.1	179	93.3	89

Table 6.47. The percentage of equid of the total of equid+aurochs/cattle (n), shown for NISP and MNE/B counts.

4) For smaller taxa, which are most commonly represented and how does this vary between assemblages?

The smaller taxa identified at the sites are mainly mammals: hare, wolf/dog/jackal, fox, small feline, large feline, hyaena, badger, hedgehog and porcupine. Many species of bird are also present, and one reptile - tortoise - is found.

The percentages of these taxa combined is shown in table 6.45 above (percentages are based on MNE/B). Trends show that, relative to the other size categories, small taxa constitute less than 20% of early Epipalaeolithic assemblages (WJ6 A, KH4 A, B, C, D, UW18). WJ22, however, which has two middle Epipalaeolithic levels, shows higher percentages of smaller taxa in both: 32% in B and 45% in D. The single late Epipalaeolithic assemblage of AZ18 shows a relatively low frequency (7%).

In the PPNB, small taxa representation is variable. The four assemblages from WJ7 show them making up between 32% and 71% of the fauna; the nearby site of WJ32 has 97% small taxa, whilst DH 1 has a particularly low frequency of 3%.

The PPNC/Late Neolithic again sees variation with the three WJ13 assemblages showing between 40% and 50% small taxa representation, WJ25 seeing 28%, B27 2 seeing 19% and DH 2 having the same low percentage (3%) as the site's PPNB levels (DH 1).

To examine the relative frequencies of different 'small taxa' in each assemblage, each taxon has been calculated as a percentage of the category as a whole; results are shown in figures 6.3 to 6.12, which show percentages based on MNE/B only (the small taxa category is particularly susceptible to NISP distortions since it includes tortoise). Some group 2 assemblages have not been included because small taxa counts are too few to be meaningful. Small variations in relative abundance should not be interpreted as significant given the accuracy levels permitted by sample sizes. Figures 6.3 to 6.12 are based on data in tables 6.2-6.40.

Firstly, three 'rare' taxa can be noted, which occur in only one or two assemblages, and then in very small numbers: large cat is identified only from WJ13 1 and 2 (< 1% at each); hyaena only from KH4 B (<1%); and porcupine is found only at KH D (<1%).

Early Epipalaeolithic assemblages generally show hare, fox, bird and tortoise as the most common small taxa, with wolf/dog/jackal also present. The middle Epipalaeolithic is represented only by the assemblages from WJ22; these are both dominated by bird and tortoise, but also have varying frequencies of hare, canid and fox.

All PPNB assemblages have hare dominating the small animal category, followed by fox, tortoise, bird, canid, hedgehog and small cat.

Hare is also by far the most frequently represented taxon at PPNC/Late Neolithic assemblages, with others such as canid, fox, badger, hedgehog, bird and tortoise present in low numbers; small cat, and the very small numbers of large cat, are seen only found at WJ13.

Generally, hare bones outnumber all other small taxa in both PPNB and PPNC/Late Neolithic assemblages. In the Epipalaeolithic, a twinning of bird and tortoise at relatively high percentages is notable in several assemblages (WJ22 B and C, WJ6 A; less so at KH4 A). There is more variability in small taxa at these earlier sites, but the overall trend of hare, canid, fox, bird and tortoise is clear.

Summary

The relative diversity of the eastern Jordanian assemblages has been explored by breaking down the taxa into three size categories: large herbivore, medium-sized herbivore, small taxa. Trends both between and within the three size categories, show the following:

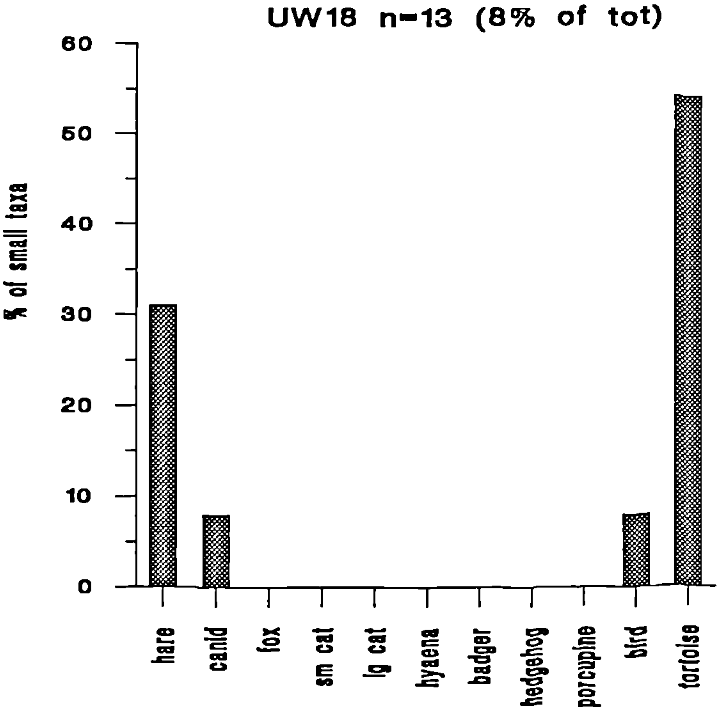
a) Gazelle is dominant throughout the Epipalaeolithic. The two exceptions to this are AZ18 where equid and cattle together are more common than gazelle (by MNB), and WJ22 B, where small taxa, particularly bird and tortoise, have a slightly higher representation than gazelle. In the PPNB, gazelle is the most frequently represented taxon in three assemblages: DH 1, WJ7 2 and 3. In another two, WJ7 1 and 4, hare bones outnumber those of gazelle. Hare constitutes an overwhelming majority at WJ32.

b) Caprines constitute over 10% of assemblages only in the PPNC/ELN (disregarding the non-representative late Epipalaeolithic assemblage of Khallat Anaza). Prior to this, they are either absent altogether or present at very low frequencies. For the PPNC/ELN, WJ13 1,2, and 3 have over 10% caprines; B27 2 has over 30%; and WJ25 over 50%. Gazelles fall in representation relative to earlier assemblages, to less than 20% at WJ13 and less than 10% at both WJ25 and B27 2. The ELN assemblage of DH 2, however, has over 90% gazelle and less than 1% caprines. The PPNC/ELN rise in caprines at some sites is explored in Chapter 9.

c) Large herbivores are present in varying, but mostly small numbers throughout the Epipalaeolithic (the exception being AZ18, where representation is high). Equids tend to outnumber cattle, although this is reversed at late Epipalaeolithic AZ18. In the Neolithic, cattle virtually disappear from assemblages, with only one fragment from PPNB WJ7 2, and five from Late Neolithic WJ13 1. Equids also drop greatly in frequency, although they continue to be found in most assemblages in very low proportions (B27 2 has by far the highest Late Neolithic equid count - 6%).

d) Of the smaller taxa, hare, fox, canid, bird and tortoise are most frequently represented. Great variation exists between assemblages in the Epipalaeolithic, but in the PPNB and Late Neolithic hare dominates the small taxa category.

In conclusion, general chronological patterns are noted, but also the 21 main assemblages show considerable variation within broad time periods. Chapter 7 aims to explore this variation, to consider site location, environmental reconstructions and available fauna as possible factors.



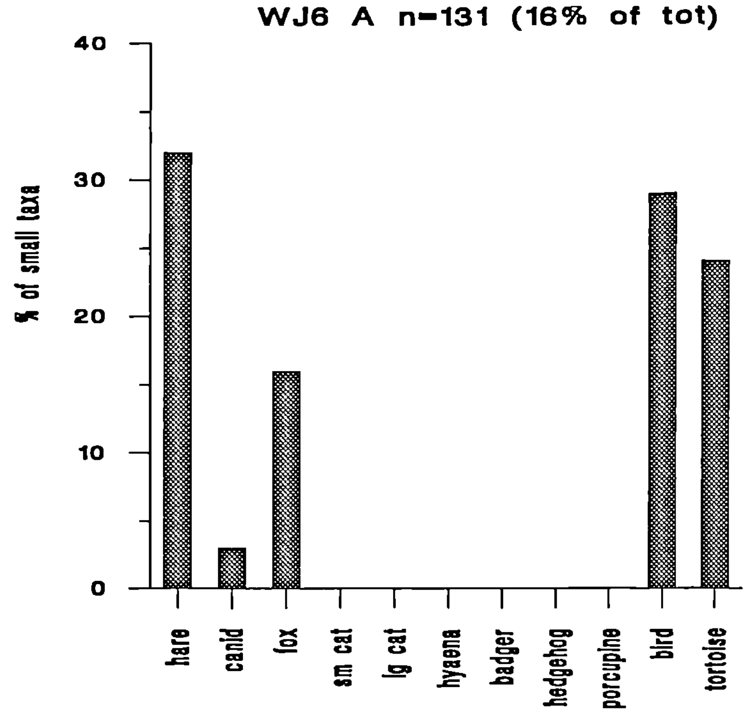


Figure 6.3. The relative proportions of small taxa (based on MNE/B) from WJ6 A and UW18 (E EPAL).

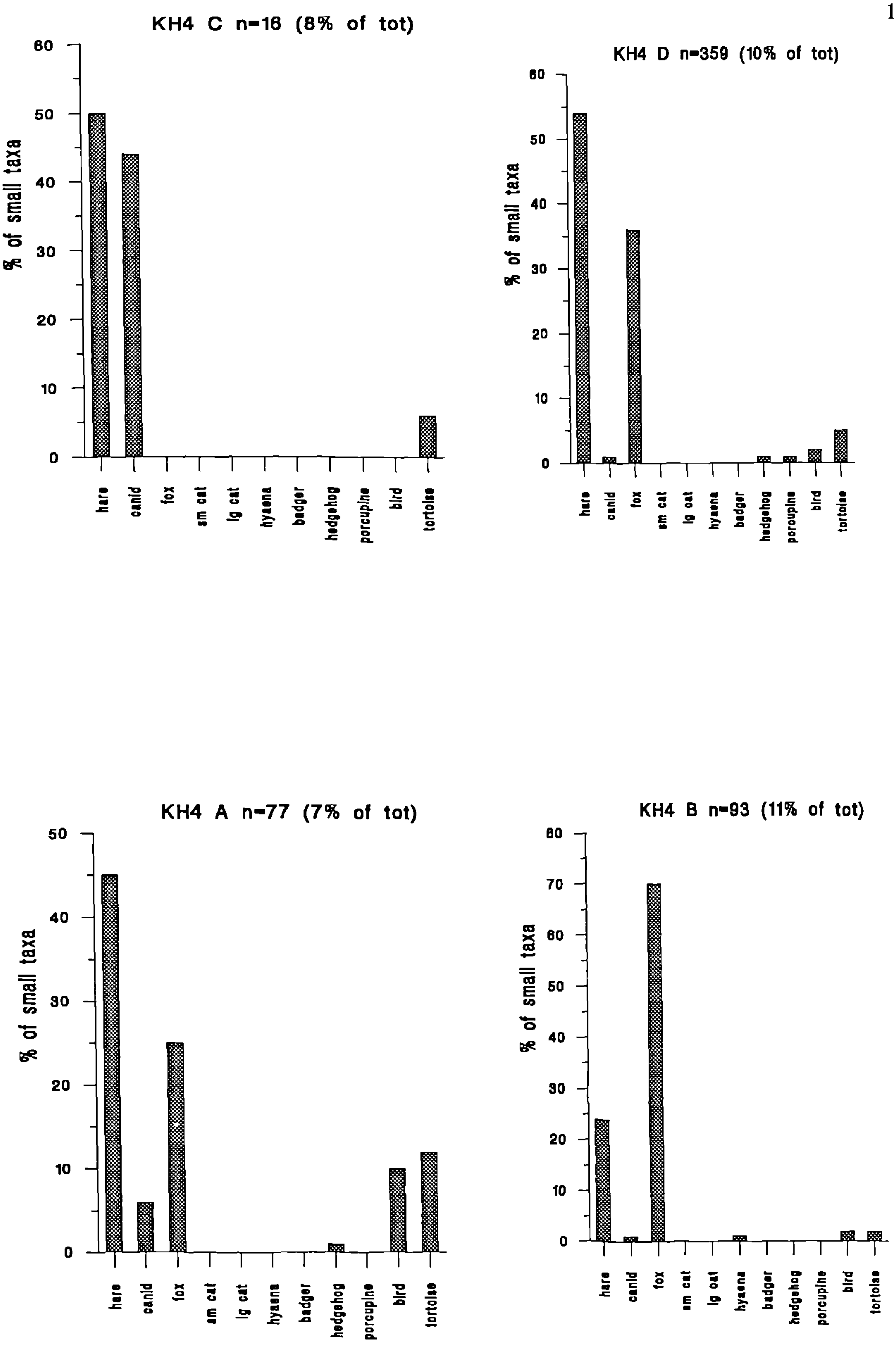


Figure 6.4. The relative proportions of small taxa (based on MNE/B) from KH4 A, B, C, D (E EPAL).

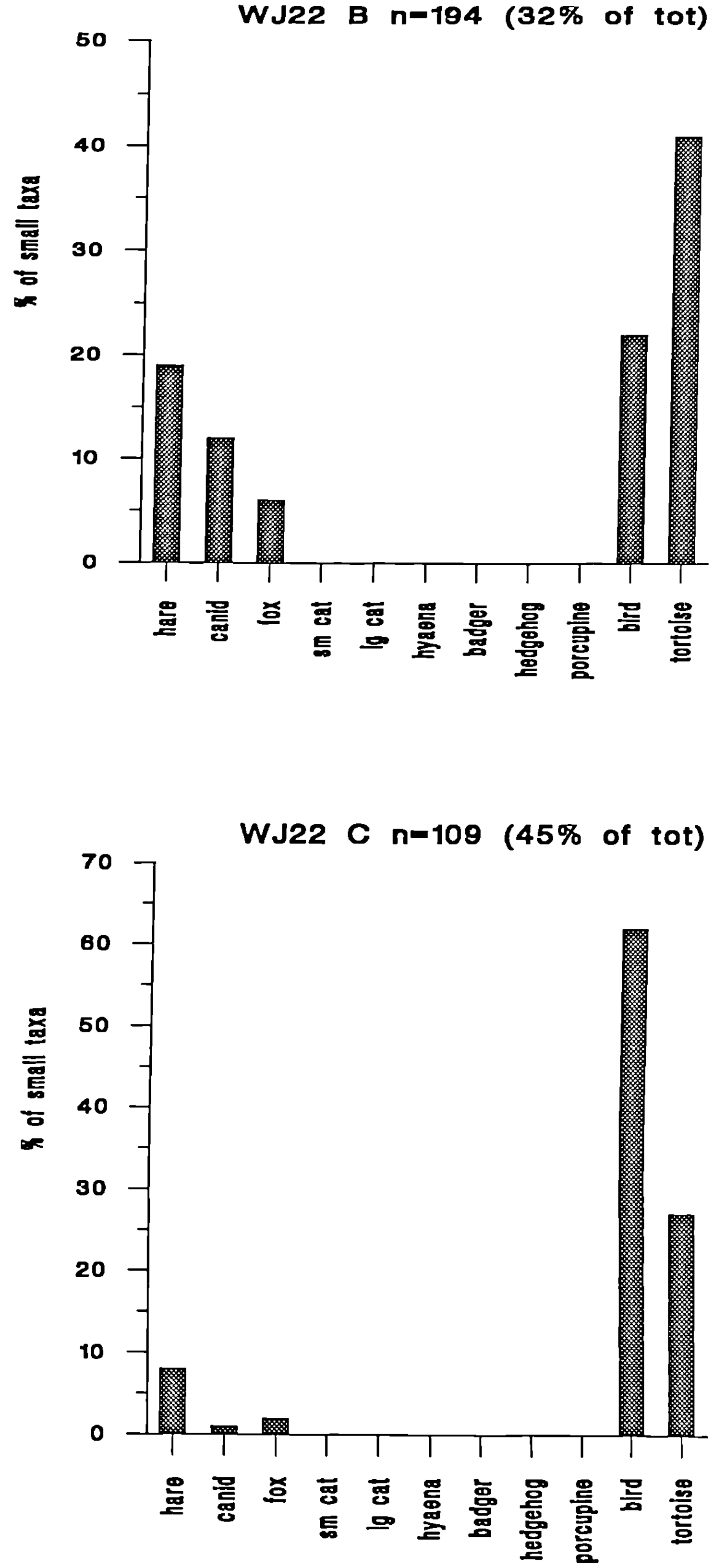
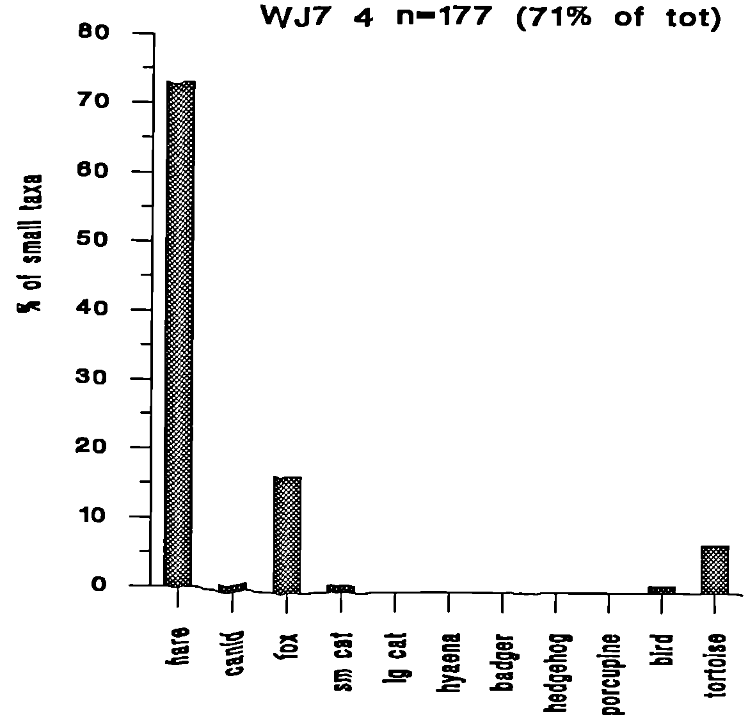


Figure 6.5. The relative proportions of small taxa (based on MNE/B) from WJ22 C and B (M EPAL).



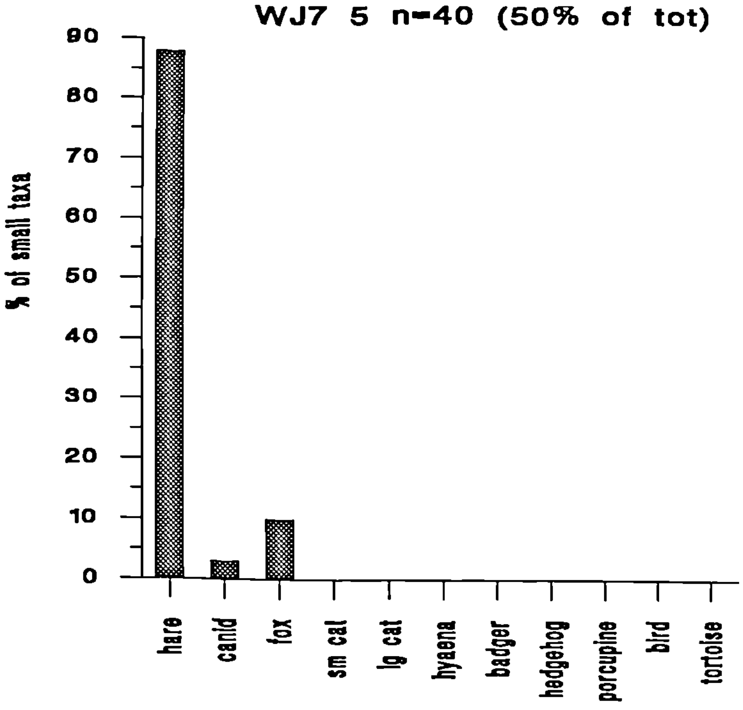
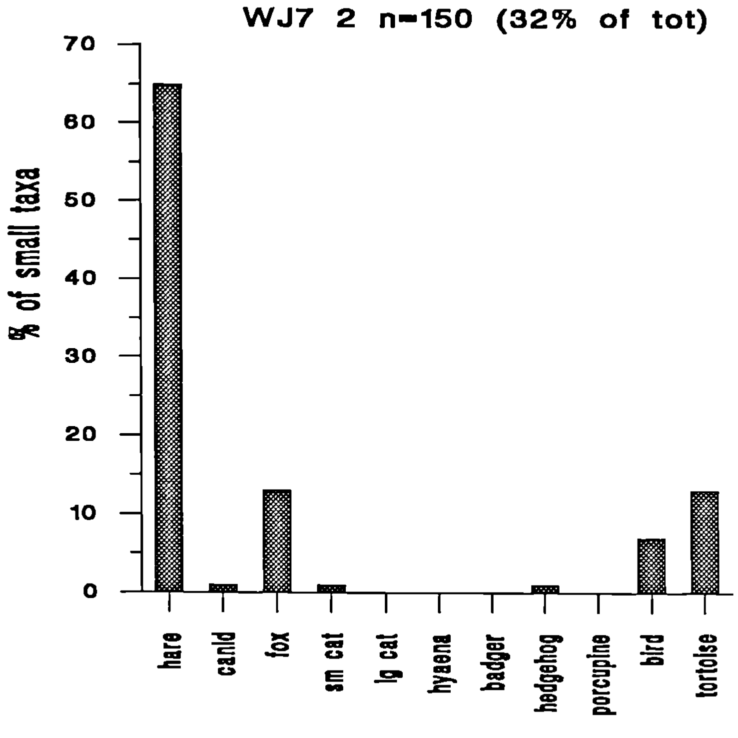


Figure 6.6. The relative proportions of small taxa (based on MNE/B) from WJ7 5, 4 (PPNB).



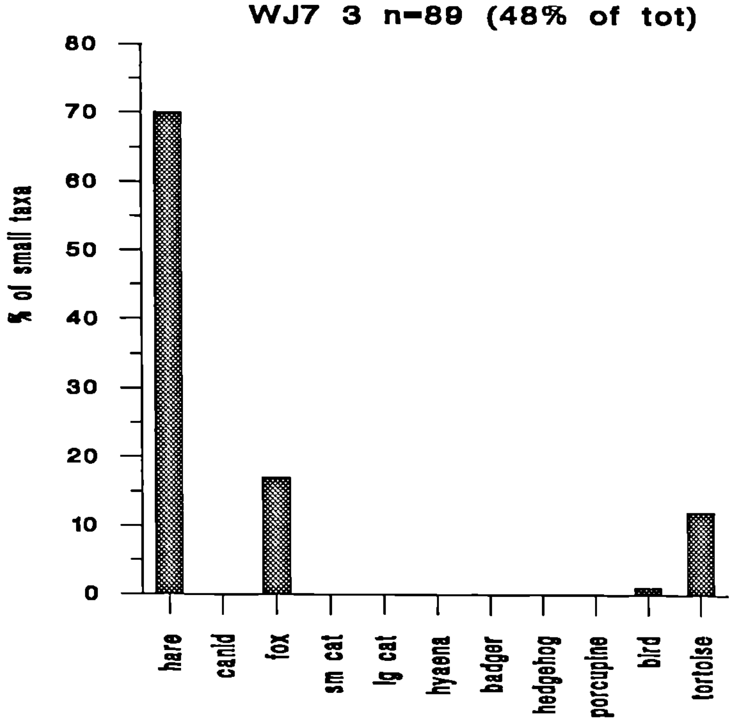


Figure 6.7. The relative proportions of small taxa (based on MNE/B) from WJ7 3, 2 (PPNB).

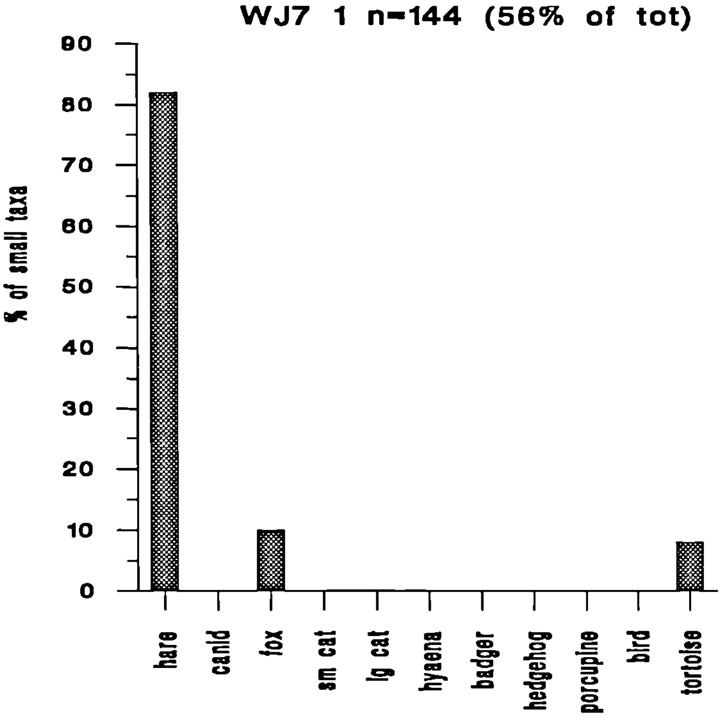


Figure 6.8. The relative proportions of small taxa (based on MNE/B) from WJ7 1 (PPNB).

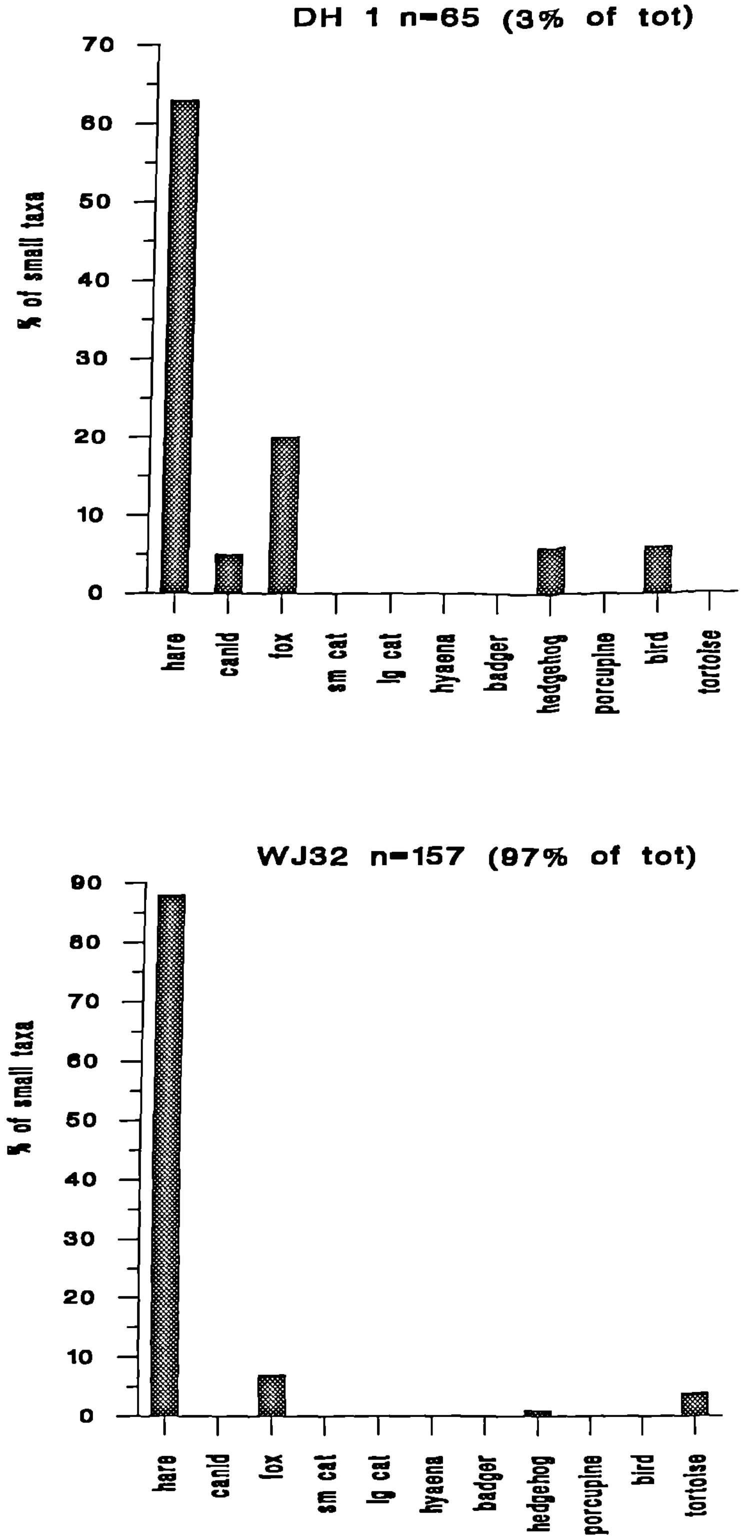
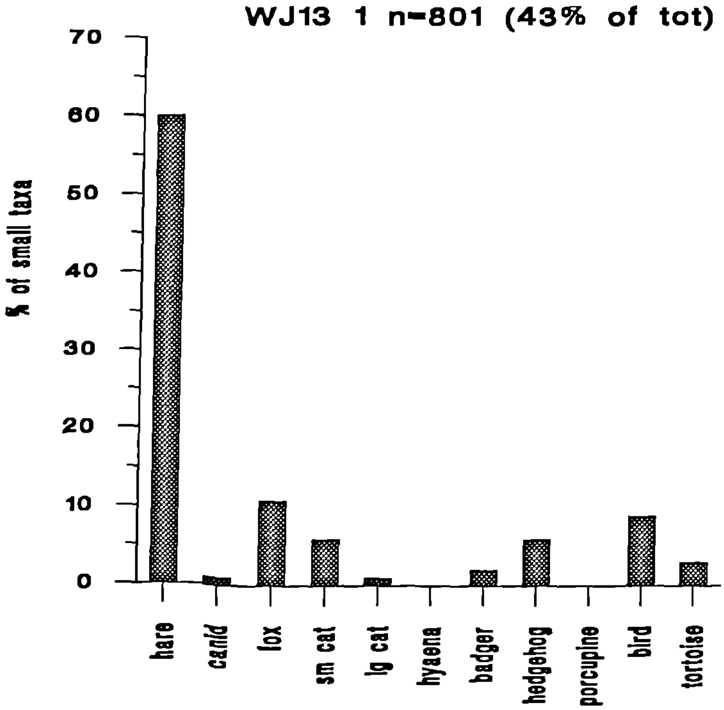


Figure 6.9. **The relative proportions of small taxa (based on MNE/B) from WJ32 and DH 1 (PPNB).**



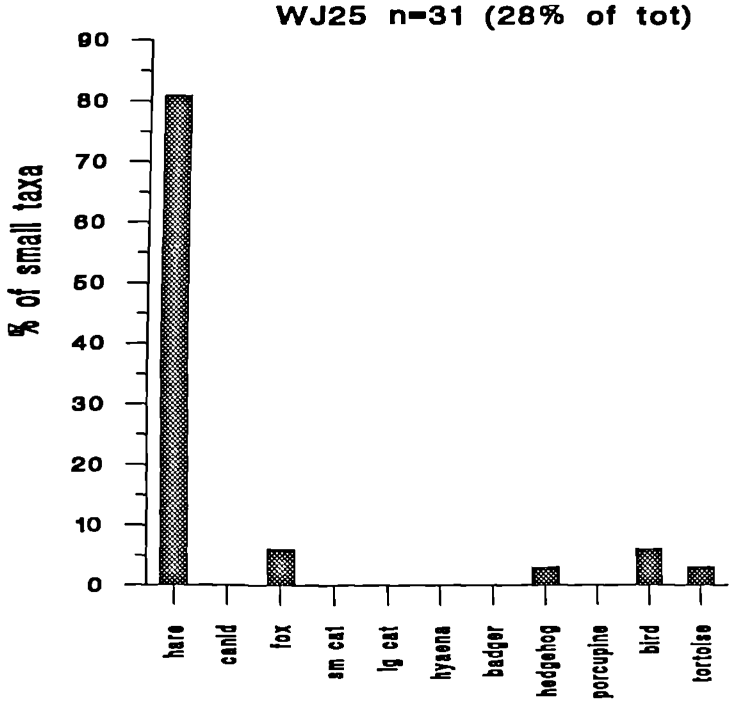


Figure 6.10. The relative proportions of small taxa (based on MNE/B) from WJ25 and WJ13 1 (PPNC/ELN).

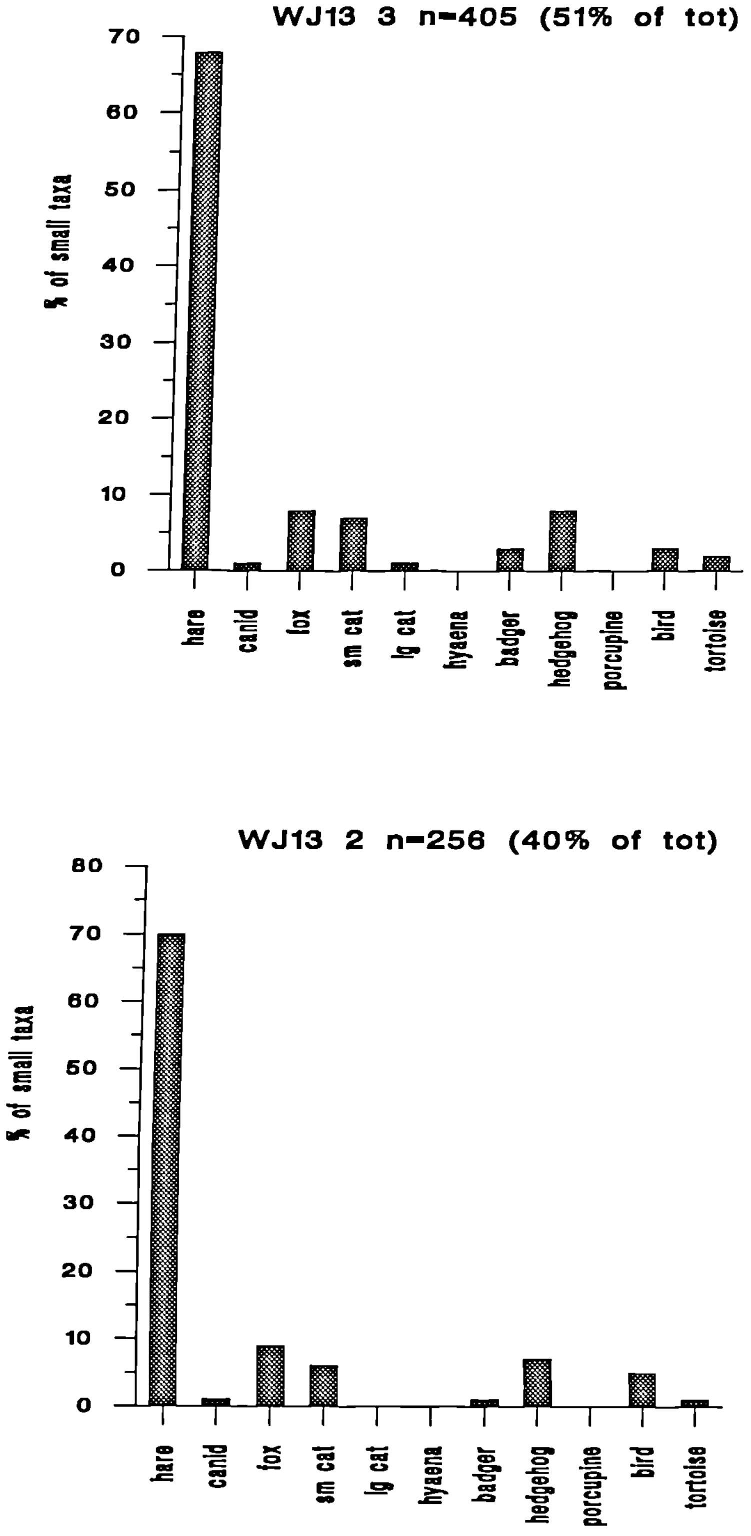
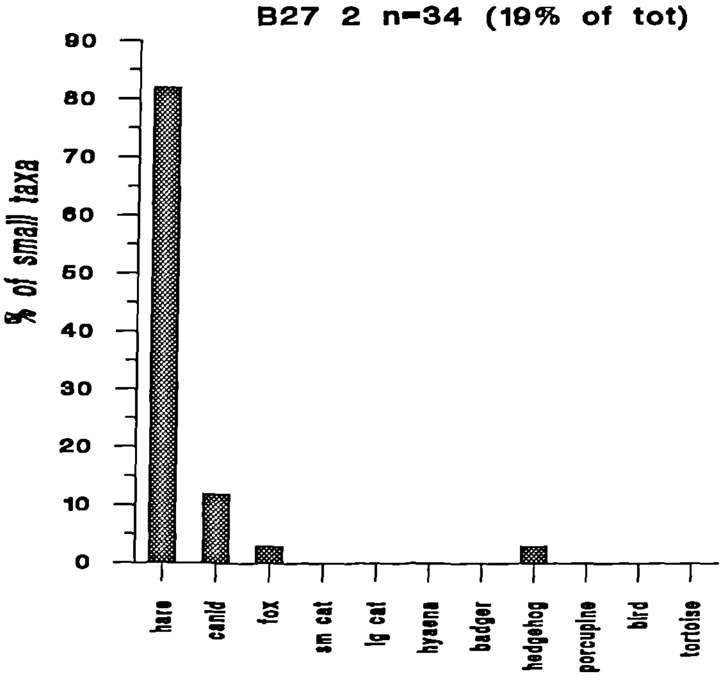


Figure 6.11. The relative proportions of small taxa (based on MNE/B) from WJ13 2 and 3 (PPNC/ELN).



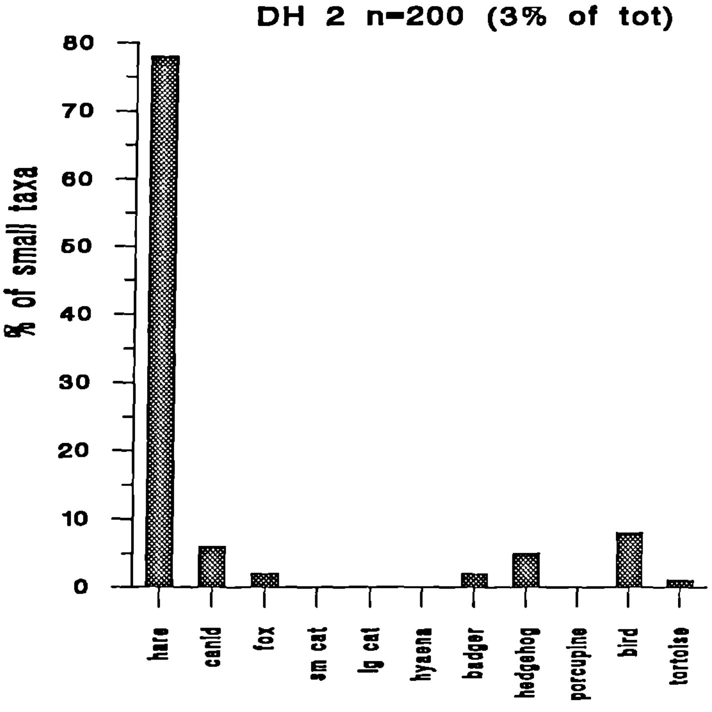


Figure 6.12. The relative proportions of small taxa (based on MNE/B) from DH2 and B27 2 (LN).

WJ9 (L UPAL)				
	NISP n	MNB n	adjusted MNB n	MNI
equid	11	1	1	1
gazelle	2	2	2	1
hare	1	1	1	1
rodent	1	1	1	1
tortoise	87	1	1	1
TOTAL	102	6	6	
TOTAL ex. rodent	101	5	5	

Table 6.2. The relative proportions of taxa from Wadi Jilat 9 - WJ9 - (L UPAL), shown by NISP, MNB, adjusted MMB and MNI.

WJ6 B (E EPAL)							
	NISP n		MNB n		adjusted MNB n		MNI
aurochs/cow							
equid	25	22.3	14	31.1	20	39.2	1
boar							
gazelle	53	47.3	25	55.6	25	49.0	2
hare							
wolf/dog/jackal							
fox	1	0.9	1	2.2	1	2.0	1
small rodent							
bird	1	0.9	1	2.2	1	2.0	1
tortoise	32	28.6	4	8.9	4	7.8	1
TOTAL	112		45		51		

Table 6.3. The relative proportions of taxa from Wadi Jilat 6 phase B - WJ6 B - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ6 C (E EPAL)

	NISP	MNB	adjusted MNB	MNI
	n	n	n	
gazelle	5	5	5	1
hare	1	1	1	1
TOTAL	6	6	6	

Table 6.4. The relative proportions of taxa from Wadi Jilat 6 phase C - WJ6 C - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ6 A (E EPAL)

	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	7	0.3	6	0.7	6	0.7	1
equid	172	6.2	83	9.8	101	11.7	3
large herbivore	3	0.1	2	0.2	2	0.2	1
boar	5	0.2	4	0.5	3	0.3	1
gazelle	1983	72.0	619	73.3	619	72.0	31
hare	57	2.1	42	5.0	42	4.9	4
wolf/dog/jackal	7	0.3	4	0.5	2	0.2	1
fox	18	0.7	16	1.9	16	1.9	2
small rodent	4		3		3		
bird	38	1.4	38	4.5	38	4.4	
tortoise	463	16.8	31	3.7	31	3.6	3
TOTAL	2757		848		863		
TOTAL ex. rodent	2753		845		860		

notes

a) 3 equid teeth identified as *Equus asinus/hemionus*
b) minimum of eight bird species

Table 6.5. The relative proportions of taxa from Wadi Jilat 6 phase A - WJ6 A - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

KH4 A (E EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	7	0.4	7	0.6	7	0.6	1
equid	193	10.5	162	14.3	209	17.8	6
large herbivore							
boar							
gazelle	1496	81.5	886	78.3	886	75.3	31
hare	38	2.1	35	3.1	35	3.0	4
wolf/dog/jackal	5	0.3	5	0.4	3	0.3	1
fox	22	1.2	19	1.7	19	1.6	2
hyaena							
hedgehog	1	0.1	1	0.1	1	0.1	1
porcupine							
bird	9	0.5	8	0.8	8	0.7	3
tortoise	65	3.5	9	0.8	9	0.8	1
TOTAL	1836		1132		1177		
TOTAL %		100		100		100	

notes

a) c. 10 gazelle horn cores identified as *Gazella subgutturosa*

b) minimum of three bird species

Table 6.6. The relative proportions of taxa from Kharaneh 4 A - KH4 A - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

KH4 B (E EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	1	0.1	1	0.1	1	0.1	1
equid	30	1.9	30	3.7	37	4.6	2
large herbivore							
boar							
gazelle	1428	90.8	679	84.6	679	84.0	24
hare	23	1.5	22	2.7	22	2.7	3
wolf/dog/jackal	1	0.1	1	0.1	1	0.1	1
fox	83	5.3	65	8.1	63	7.8	4
hyaena	1	0.1	1	0.1	1	0.1	1
hedgehog							
porcupine							
bird	2	0.1	2	0.2	2	0.2	1
tortoise	3	0.2	2	0.2	2	0.2	1
TOTAL	1572		803		808		

notes

a) one gazelle horn core identified as *G. subgutturosa*
b) minimum of one bird species

Table 6.7. The relative proportions of taxa from Kharaneh 4 B - KH4 B - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

KH4 C (E EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow							
equid	7	2.4	7	3.6	12	6.0	1
large herbivore							
boar							
gazelle	264	89.8	174	88.3	174	86.6	6
hare	15	5.1	8	4.1	7	3.5	1
wolf/dog/jackal							
fox	7	2.4	7	3.6	7	3.5	1
hyaena							
hedgehog							
porcupine							
bird							
tortoise	1	0.3	1	0.5	1	0.5	1
TOTAL	294		197		201		

Table 6.8. The relative proportions of taxa from Kharaneh 4 C - KH4 C - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

KH4 D (E EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	12	0.2	6	0.2	6	0.2	1
equid	194	2.6	167	4.6	204	5.7	5
large herbivore	2	0.0	2	0.1	2	0.1	1
boar	1	0.0	1	0.0	1	0.0	1
gazelle	6697	90.5	3124	85.4	3124	87.2	79
hare	220	3.0	194	5.3	138	3.9	8
wolf/dog/jackal	4	0.1	3	0.1	1	0.0	1
fox	154	2.1	128	3.5	71	2.0	3
hyaena							
hedgehog	5	0.1	5	0.1	5	0.1	1
porcupine	2	0.0	2	0.1	2	0.1	1
bird	8	0.1	8	0.2	8	0.2	3
tortoise	105	1.4	19	0.5	19	0.5	3
TOTAL	7404		3659		3581		

notes

a) c. three gazelle horn cored identified as *G. subgutturosa*

b) minimum of three bird species

Table 6.9. The relative proportions of taxa from Kharaneh 4 D - KH4 D - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

UW14 upper (E EPAL)				
	NISP	MNB	adjusted MNB	MNI
	n	n	n	
aurochs/cow	1	1	1	1
equid	1	1	1	1
gazelle	4	1	1	1
hare				
tortoise				
TOTAL	6	3	3	

Table 6.10. The relative proportions of taxa from Uwaynid 14 upper phase - UW14 - (E EPAL), shown by NISP, MNE, adjusted MNE and MNI.

UW14 middle (E EPAL)				
	NISP	MNB	adjusted MNB	MNI
	n	n	n	
aurochs/cow				
equid				
gazelle	2	2	2	1
hare	2	2	2	1
tortoise	1	1	1	1
TOTAL	5	5	5	

Table 6.11. The relative proportions of taxa from Uwaynid 14 middle phase - UW14 - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

UW18 upper (E EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	4	0.7	4	2.4	4	2.2	1
equid	49	8.9	23	13.6	35	19.4	4
camel	1	0.2	1	0.6	1	0.6	1
large herbivore	5	0.9	3	1.8	3	1.7	1
sheep/goat	1	0.2	1	0.6	1	0.6	1
gazelle	396	71.6	124	73.4	124	68.9	8
hare	4	0.7	4	2.4	3	1.7	1
wolf/dog/jackal	1	0.2	1	0.6	1	0.6	1
small rodent	1		1		1		
bird	1	0.2	1	0.6	1	0.6	1
tortoise	91	16.5	7	4.1	7	3.9	2
TOTAL	554		170		181		
TOTAL ex. rodent	553		169		180		

notes

a) two gazelle horn cores identified as *G. subgutturosa*
b) minimum of one bird species

Table 6.12. The relative proportions of taxa from Uwaynid 18 - UW18 - (E EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ8 (M EPAL)				
	NISP n	MNB n	adjusted MNB n	MNI
equid	2	2	3	1
sheep/goat	1	1	1	1
gazelle	73	30	30	2
hare	1	1	1	1
tortoise	15	2	2	1
TOTAL	92	36	37	

Table 6.13. The relative proportions of taxa from Wadi Jilat 8 - WJ8 - (M EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ10 (M EPAL)				
	NISP n	MNB n	adjusted MNB n	MNI
equid	36	6	7	1
camel	1	1	1	1
large herbivore	1	1	1	1
gazelle	2	2	2	1
wolf/dog/jackal	1	1	1	1
tortoise	26	1	1	1
TOTAL	67	12	13	

Table 6.14. The relative proportions of taxa from Wadi Jilat 10 - WJ10 - (M EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ22 E (M EPAL)				
	NISP n	MNE n	adjusted MNE n	MNI
equid	9	5	7	1
gazelle	7	7	7	2
tortoise	3	1	1	1
TOTAL	19	13	15	

Table 6.15. The relative proportions of taxa from Wadi Jilat 22 phase E - WJ22 E (M EPAL), shown by NISP, MNE, adjusted MNE and MNI.

WJ22 C (M EPAL)

	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
equid	64	2.1	36	14.8	39	15.9	3
large herbivore	2	0.1	2	0.8	2	0.8	1
sheep/goat							
gazelle	113	3.6	91	37.4	91	37.1	6
med. herbivore	6	0.2	5	2.1	5	2.0	1
hare	9	0.3	9	3.7	8	3.3	1
wolf/dog/jackal	1	0.0	1	0.4	1	0.4	1
fox	4	0.1	2	0.8	2	0.8	1
bird	68	2.2	68	28.0	68	27.8	
tortoise	2840	91.4	29	11.9	29	11.8	24
TOTAL	3107		243		245		

notes

a) minimum of six bird species

Table 6.16. The relative proportions of taxa from Wadi Jilat 22 phase C - WJ22 C - (M EPAL), shown by NISP, MNE, adjusted MNE and MNI.

WJ22 B (M EPAL)

	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
equid	163	3.1	45	7.4	56	9.4	2
large herbivore	18	0.3	11	1.8	13	2.2	1
sheep/goat	1	0.0	1	0.2	1	0.2	1
gazelle	619	11.8	333	54.5	333	56.1	16
med. herbivore	55	1.1	27	4.4	27	4.5	13
hare	53	1.0	37	6.1	22	3.7	2
wolf/dog/jackal	38	0.7	23	3.8	14	2.4	2
fox	20	0.4	12	2.0	6	1.0	2
bird	42	0.8	42	6.9	42	7.1	
tortoise	4229	80.7	80	13.0	80	13.5	26
TOTAL	5238		611		594		

notes

a) minimum of four bird species

Table 6.17. The relative proportions of taxa from Wadi Jilat 22 phase B - WJ22 B - (M EPAL), shown by NISP, MNE, adjusted MNE and MNI.

AZ17 1 (squares 1-6)				
	NISP n	MNB n	adjusted MNB n	MNI
large herbivore	2	1	1	1
gazelle	22	13	13	2
TOTAL	24	14	14	

AZ17 2 (squares 7-15)				
	NISP n	MNB n	adjusted MNB n	MNI
large herbivore	2	2	2	1
gazelle	23	13	13	2
TOTAL	25	15	15	

Tables 6.18 and 6.19. The relative proportions of taxa from Azraq 17 1 (squares 1-6) and 2 (squares 7-15) (M EPAL), shown by NISP, MNB, adjusted MNB and MNI.

AZ18 (L EPAL)							
	NISP		MNB		adjusted MNB		MNI
	n	%	n	%	n	%	
aurochs/cow	154	52.2	25	24.0	25	22.3	3
equid	78	26.4	32	30.8	40	35.7	4
large herbivore	1	0.3	1	1.0	1	0.9	1
gazelle	55	18.6	39	37.5	39	34.8	4
hare	1	0.3	1	1.0	1	0.9	1
wolf/dog/jackal	1	0.3	1	1.0	1	0.9	1
fox	1	0.3	1	1.0	1	0.9	1
bird	4	1.4	4	3.8	4	3.6	4
TOTAL	295		104		112		

notes

a) one horn core identified as *Bos primigenius*
b) two equid teeth identified as *Equus hydruntinus*
c) eight equid teeth identified as *Equus asinus/hemionus*

Table 6.20. The relative proportions of taxa from Azraq 18 - AZ18 - (L EPAL), shown by NISP, MNB, adjusted MNB and MNI.

Khallat Anaza (L EPAL)				
	NISP	MNB	adjusted MNB	MNI
	n	n	n	
equid	3	3	3	1
goat?	2	2	2	1
sheep/goat	16	16	16	2
gazelle	9	9	9	2
hare	3	3	3	1
wolf/dog/jackal	1	1	1	1
TOTAL	34	34	34	

Table 6.21. The relative proportions of taxa from Khallat Anaza (L EPAL), shown by NISP, MNB, adjusted MNB and MNI.

WJ7 1 (early PPNB)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
large herbivore							
gazelle	136	36.5	107	41.8	107	56.0	6
med. herbivore	7	1.9	5	2.0	5	2.6	
hare	158	42.4	118	46.1	59	30.9	3
wolf/dog/jackal							
fox	23	6.2	15	5.9	9	4.7	1
small cat							
hedgehog							
small rodent	2		2		2		1
bird							
tortoise	49	13.1	11	4.3	11	5.8	4
TOTAL	375		258		193		
TOTAL ex. rodent	373		256		191		

Table 6.22. The relative proportions of taxa from WJ7 phase 1 - WJ7 1 - (early PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ7 2 (middle PPNB)

	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow	1	0.1	1	0.2	1	0.2	1
large herbivore	1	0.1	1	0.2	1	0.2	1
gazelle	399	56.7	311	66.3	311	66.5	10
med. herbivore	9	1.3	6	1.3	6	1.3	1
hare	102	14.5	97	20.7	97	20.7	7
wolf/dog/jackal	1	0.1	1	0.2	1	0.2	1
fox	22	3.1	20	4.3	19	4.1	2
small cat	1	0.1	1	0.2	1	0.2	1
hedgehog	2	0.3	2	0.4	2	0.4	1
small rodent	11		6		6		
bird	10	1.4	10	2.1	10	2.1	5
tortoise	156	22.1	19	4.1	19	4.1	6
TOTAL	715		475		474		
TOTAL ex. rodent	704		469		468		

Table 6.23. The relative proportions of taxa from Wadi Jilat 7 phase 2 - WJ7 2 - (middle PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ7 3 (middle PPNB)

	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
large herbivore							
gazelle	125	45.3	82	44.6	82	53.2	4
med. herbivore	16	5.8	13	7.1	13	8.4	
hare	92	33.3	62	33.7	38	24.7	3
wolf/dog/jackal							
fox	24	8.7	15	8.2	9	5.8	1
small cat							
hedgehog							
small rodent	1		1		1		
bird	1	0.4	1	0.5	1	0.6	1
tortoise	18	6.5	11	6.0	11	7.1	2
TOTAL	277		185		155		
TOTAL ex. rodent	276		184		154		

Table 6.24. The relative proportions of taxa from Wadi Jilat 7 phase 3 - WJ7 3 - (middle PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ7 4 (middle PPNB)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
large herbivore							
gazelle	96	26.7	68	27.4	68	40.2	3
med. herbivore	3	0.8	3	1.2	3	1.8	1
hare	168	46.7	130	52.4	63	37.2	3
wolf/dog/jackal	1	0.3	1	0.4	1	0.6	1
fox	45	12.5	30	12.1	18	10.7	2
small cat	1	0.3	1	0.4	1	0.6	1
hedgehog							
small rodent	5		3		3		3
bird	2	0.6	2	0.8	2	1.2	1
tortoise	44	12.2	13	5.2	13	7.7	3
TOTAL	365		251		172		
TOTAL ex. rodent	360		248		169		

Table 6.25. The relative proportions of taxa from Wadi Jilat 7 phase 4 - WJ7 4 - (middle PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ7 5 (mid-late PPNB)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
large herbivore							
gazelle	41	45.1	37	46.8	37	61.7	2
med. herbivore	2	2.2	2	2.5	2	3.3	
hare	40	44.0	35	44.3	19	31.7	2
wolf/dog/jackal	2	2.2	1	1.3	1	1.7	1
fox	6	6.6	4	5.1	1	1.7	1
small cat							
hedgehog							
small rodent							
bird							
tortoise							
TOTAL	91		79		60		

Table 6.26. The relative proportions of taxa from Wadi Jilat 7 phase 5 - WJ7 5 - (mid-late PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ26 (mid PPNB)				
	NISP	MNE	adjusted MNE	MNI
	n	n	n	
gazelle	4	4	4	1
hare	7	7	4	1
fox	1	1	0	1
TOTAL	12	12	8	

Table 6.27. The relative proportions of taxa from all areas of Wadi Jilat 26 - WJ26 - (mid PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ32 (mid-late PPNB)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
gazelle	4	2.1	4	2.5	4	3.6	1
hare	139	71.6	138	85.7	94	84.7	7
fox	11	5.7	11	6.8	5	4.5	1
hedgehog	2	1.0	2	1.2	2	1.8	1
tortoise	38	19.6	6	3.7	6	5.4	2
TOTAL	194		161		111		

Table 6.28. The relative proportions of taxa from Wadi Jilat 32 - WJ32 - (mid-late PPNB), shown by NISP, MNE, adjusted MNE and MNI.

Ibn el-Ghazzi (late PPNB)				
	NISP	MNB	adjusted MNB	MNI
	n	n	n	
gazelle	16	16	16	2
med. herbivore	2	2	2	1
hare	2	2	2	1
TOTAL	20	20	20	

Table 6.29. The relative proportions of taxa from Ibn el-Ghazzi (late PPNB), shown by NISP, MNB, adjusted MNB and MNI.

DH 1 (PPNB)

	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
equid	29	1.0	22	1.0	24	1.1	2
large herbivore							
sheep	1	0.0	1	0.0	1	0.0	1
goat							
sheep/goat	4	0.1	4	0.2	4	0.2	1
gazelle	2601	93.4	2051	93.1	2051	93.5	67
med. herbivore	89	3.2	59	2.7	59	2.7	
hare	37	1.3	41	1.9	34	1.6	3
wolf/dog/jackal	3	0.1	3	0.1	2	0.1	1
fox	14	0.5	13	0.6	11	0.5	1
badger							
hedgehog	4	0.1	4	0.2	4	0.2	1
small rodent							
bird	4	0.1	4	0.2	4	0.2	3
tortoise							
TOTAL	2786		2202		2194		

notes

a) 1 equid tooth identified as *Equus asinus/hemionus*.

b) a minimum of three bird species present.

Table 6.30. The relative proportions of taxa from Dhuweila 1 - DH 1 - (PPNB), shown by NISP, MNE, adjusted MNE and MNI.

WJ25 early phase (PPNC/ELN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
sheep	27	17.0	11	10.1	11	11.0	2
goat	1	0.6	1	0.9	1	1.0	1
sheep/goat	68	42.8	45	41.3	45	45.0	3
gazelle	6	3.8	6	5.5	6	6.0	1
med. herbivore	24	15.1	15	13.8	15	15.0	2
hare	27	17.0	25	22.9	16	16.0	2
fox	2	1.3	2	1.8	2	2.0	1
hedgehog	1	0.6	1	0.9	1	1.0	1
small rodent	1		1		1		1
bird	2	1.3	2	1.8	2	2.0	1
tortoise	1	0.6	1	0.9	1	1.0	1
TOTAL	160		110		101		
TOTAL ex. rodent	159		109		100		

Table 6.31. The relative proportions of taxa from Wadi Jilat 25 early phase - WJ25 - (PPNC/ELN), shown by NISP, MNE, adjusted MNE and MNI.

WJ25 late phase (PPNC/ELN)				
	NISP	MNE	adjusted MNE	MNI
	n	n	n	
sheep	1	1	1	1
goat	1	1	1	1
sheep/goat	3	3	3	1
gazelle	3	3	3	1
med. herbivore	2	2	2	1
hare	8	8	5	1
fox	1	1	1	1
hedgehog				
small rodent				
bird				
tortoise				
TOTAL	19	19	16	

Table 6.32. The relative proportions of taxa from WJ25 late phase - WJ25 late - (PPNC/ELN), shown by NISP, MNE, adjusted MNE and MNI.

WJ13 1 (PPNC/ELN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow	5	0.2	5	0.3	5	0.3	1
equid	2	0.1	2	0.1	3	0.2	1
large harbivore	1	0.0	1	0.1	1	0.1	1
sheep	152	6.4	140	7.4	140	8.7	5
goat	56	2.4	53	2.8	53	3.3	2
sheep/goat	245	10.3	194	10.3	194	12.1	10
gazelle	462	19.5	403	21.4	403	25.1	16
med. herbivore	555	23.4	281	14.9	281	17.5	14
hare	522	22.0	481	25.6	298	18.6	15
wolf/dog/jackal	12	0.5	12	0.6	5	0.3	1
fox	95	4.0	92	4.9	43	2.7	2
small cat	51	2.1	51	2.7	22	1.4	2
large cat	2	0.1	2	0.1	2	0.1	1
badger	14	0.6	14	0.7	5	0.3	1
hedgehog	53	2.2	51	2.7	51	3.2	8
small rodent	19		19		19		
bird	72	3.0	72	3.8	72	4.5	
tortoise	74	3.1	26	1.4	26	1.6	2
TOTAL	2392		1899		1623		
TOTAL ex rodent	2373		1880		1604		

Table 6.33. The relative proportions of taxa from Wadi Jilat 13 phase 1 - WJ13 1 - (PPNC/ELN), shown by NISP, MNE, adjusted MNE and MNI.

WJ13 2 (PPNC/ELN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
equid	1	0.1	1	0.2	1	0.2	1
large herbivore	1	0.1	1	0.2	1	0.2	1
sheep	68	8.7	61	9.5	61	11.4	3
goat	31	4.0	30	4.7	30	5.6	2
sheep/goat	90	11.5	73	11.4	73	13.6	4
gazelle	134	17.2	122	19.0	122	22.8	5
med. herbivore	192	24.6	98	15.3	98	18.3	6
hare	183	23.4	179	27.9	91	17.0	8
wolf/dog/jackal	3	0.4	2	0.3	1	0.2	1
fox	24	3.1	24	3.7	11	2.1	2
small cat	15	1.9	15	2.3	9	1.7	2
large cat							
badger	1	0.1	1	0.2	1	0.2	1
hedgehog	18	2.3	18	2.8	18	3.4	2
small rodent	2		2		2		
bird	14	1.8	14	2.2	14	2.6	
tortoise	6	0.8	3	0.5	3	0.6	1
TOTAL	783		644		536		
TOTAL ex rodent	781		642		534		

Table 6.34. The relative proportions of taxa from Wadi Jilat 13 phase 2 - WJ13 2 - (PPNC/ELN), shown by NISP, MNE, adjusted MNE and MNI.

WJ13 3 (PPNC/ELN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
aurochs/cow							
equid	1	0.1	1	0.1	1	0.2	1
large herbivore							
sheep	57	5.9	56	7.0	56	9.2	3
goat	23	2.4	21	2.6	21	3.4	1
sheep/goat	82	8.4	66	8.3	66	10.8	5
gazelle	137	14.1	120	15.1	120	19.7	6
med. herbivore	256	26.4	127	16.0	127	20.9	7
hare	283	29.1	274	34.4	131	21.5	8
dog/wolf/jackal	6	0.6	6	0.8	3	0.5	1
fox	32	3.3	31	3.9	13	2.1	1
small cat	29	3.0	29	3.6	13	2.1	1
large cat	1	0.1	1	0.1	1	0.2	1
badger	11	1.1	11	1.4	4	0.7	1
hedgehog	32	3.3	32	4.0	32	5.3	5
small rodent	5		5		5		
bird	14	1.4	14	1.8	14	2.3	
tortoise	7	0.7	7	0.9	7	1.1	1
TOTAL	976		801		614		
TOTAL ex rodent	971		796		609		

Table 6.35. The relative proportions of taxa from Wadi Jilat 13 phase 3 - WJ13 3 - (PPNC/ELN), shown by NISP, MNE, adjusted MNE and MNI.

DH 2 (LLN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
equid	58	0.7	44	0.7	53	0.8	3
large herbivore	4	0.0	4	0.1	4	0.1	
sheep	9	0.1	9	0.1	9	0.1	1
goat	3	0.0	3	0.0	3	0.0	2
sheep/goat	27	0.3	26	0.4	26	0.4	2
gazelle	7919	94.2	5920	92.9	5920	93.4	152
med. herbivore	202	2.4	166	2.6	166	2.6	
hare	138	1.6	156	2.4	119	1.9	8
wolf/dog/jackal	15	0.2	11	0.2	6	0.1	1
fox	4	0.0	4	0.1	4	0.1	2
badger	3	0.0	3	0.0	3	0.0	1
hedgehog	9	0.1	9	0.1	9	0.1	2
small rodent	10		10		10		
bird	16	0.2	16	0.3	16	0.3	5
tortoise	1	0.0	1	0.0	1	0.0	1
TOTAL	8418		6382		6349		
TOTAL ex. rodent	8408		6372		6339		

notes

a) 3 equid teeth identified as *Equus asinus/hemionus*.

b) 2 gazelle horncores identified as *Gazella subgutturosa*.

c) 3 hedgehog humeri identified as *Hemiechinus/Paraechinus*.

d) minimum of 10 bird species.

Table 6.36. The relative proportions of taxa from Dhuweila 2 - DH 2 - (LLN), shown by NISP, MNE, adjusted MNE and MNI.

Jebel Naja (LLN)				
	NISP	MNB	adjusted MNB	MNI
	n	n	n	
sheep?	2	2	2	1
goat	1	1	1	1
sheep/goat	1	1	1	
gazelle	3	2	2	2
hare	2	2	1	1
TOTAL	9	8	7	

Table 6.37. The relative proportions of taxa from Jebel Naja (LLN), shown by NISP, MNB, adjusted MNB and MNI.

B27 1 (PPNB/ELN)				
	NISP	MNE	adjusted MNE	MNI
	n	n	n	
equid	4	1	1	1
sheep				
goat				
sheep/goat	1	1	1	1
gazelle				
med. herbivore				
hare				
wolf/dog/jackal				
fox				
hedgehog				
TOTAL	5	2	2	

Table 6.38. The relative proportions of taxa from Burqu 27 phase 1 - B27 1 - (PPNB/ELN), shown by NISP, MNE, adjusted MNE and MNI.

B27 2 (LLN)							
	NISP		MNE		adjusted MNE		MNI
	n	%	n	%	n	%	
equid	18	8.6	10	5.6	10	5.8	1
sheep	9	4.3	9	5.1	9	5.2	1
goat	1	0.5	1	0.6	1	0.6	1
sheep/goat	63	30.0	57	32.2	57	33.1	3
gazelle	17	8.1	17	9.6	17	9.9	1
med. herbivore	67	31.9	49	27.7	49	28.5	4
hare	29	13.8	28	15.8	25	14.5	3
wolf/dog/jackal	4	1.9	4	2.3	2	1.2	1
fox	1	0.5	1	0.6	1	0.6	1
hedgehog	1	0.5	1	0.6	1	0.6	1
TOTAL	210		177		172		

Table 6.39. The relative proportions of taxa from Burqu 27 phase 2 - B27 2 - (LLN), shown by NISP, MNE, adjusted MNE and MNI.

B27 3 (LLN/Chalco)				
	NISP n	MNE n	adjusted MNE n	MNI
equid	2	2	2	1
sheep	4	4	4	2
goat				
sheep/goat	8	8	8	1
gazelle				
med. herbivore	7	7	7	1
hare	22	22	17	3
wolf/dog/jackal	1	1	1	1
fox				
hedgehog				
TOTAL	44	44	39	

Table 6.40. The relative proportions of taxa from Burqu 27 phase 3 - B27 3 - (LLN/Chalco), shown by NISP, MNE, adjusted MNE and MNI.

CHAPTER SEVEN

HUNTED ANIMALS IN THEIR ENVIRONMENTS

This chapter addresses two issues: firstly, whether late Pleistocene/early Holocene environmental change is reflected in the faunal assemblages; and secondly, whether hunters show any selective biases in their prey.

Section 1: Do the faunal assemblages reflect environmental change?

The main methods used for exploring environmental change through faunal remains for the postglacial Levant are outlined in Chapter 1 and involve examination of faunal turnover (extinctions), the presence and proportions of micromammals, and intraspecific size change.

Conditions of palaeoclimatic and palaeoenvironmental change are fairly well documented for the southern Levant as a whole; the evidence for gradual, although interrupted, temperature elevation, and the fluctuations in precipitation are reviewed in Chapter 1. The data from eastern Jordan, however, are relatively sparse (Chapter 2) and ambiguous as to whether patterns reflect localized or more widespread conditions. This section aims firstly to document any faunal evidence for environmental change, and secondly to explore how far variability in the faunal assemblages can be explained in environmental terms.

In inferring environmental change from faunal evidence, great caution must be exercised. First, both the distribution and size of animals may be affected by human exploitation, competition or commensalism and the animals represented on archaeological sites may well represent human selection. Thus, while the presence of a taxon with particular ecological requirements may reveal something about environmental conditions, its absence must be interpreted very conservatively. Secondly, as Tchernov (1982) has pointed out, many large mammals are very poor indicators of environmental conditions, particularly if they can tolerate a wide range of conditions (e.g. through large body size) or are highly mobile. Thus microfauna tend to be more reliable indicators than larger animals. Thirdly, it is essential the avoid the circularity of argument which arises if the same faunal data are used both to reconstruct environment and to infer human selection of particular animals.

a) The implications of microfauna

Despite their potential ecological sensitivity, the rodent mandibles identified from the eastern Jordanian assemblages are problematic in that they may not be contemporaneous with the contexts in which they were found. All taxa identified are burrowing animals, and bone patination is often not consistent with that of the larger fauna. Although rodent burrows were isolated during excavation, and finds from them treated separately, the possibility that rodent material is intrusive cannot be dismissed, and therefore this material is not used as an environmental indicator.

b) Faunal turnover in large mammals

Of the two species which are believed to have disappeared from the Levant in the late Pleistocene, one - *Equus hydruntinus* - has its last known regional occurrence at the site of AZ18 in the Azraq Basin (Garrard 1991:240). Figure 7.1 shows two specimens of *E. hydruntinus* dentition from this site; the interpretation of the dental enamel folds of the mandibular tooth row and single mandibular tooth follows Davis 1980a. AZ18 has been dated between 12,500bp and 11,000bp on the basis of the lithic assemblage. The presence of a species can only indicate habitat preference, which is a combination of nutritional requirements, and temperature and moisture tolerances. Unfortunately, little is known of the ecology of *Equus hydruntinus*. Like all of the wild equids, it could be expected to be an open land grazer, and due to its later distribution in Europe can probably be associated with relatively cooler conditions (Garrard 1980, table 3B). Late Pleistocene finds from Palestine, however, tend to be from the better watered areas (Davis 1980a).

As described in Chapter 2, for the period when AZ18 was occupied there is a contradiction between palaeoenvironmental evidence from most of Jordan and the Levant (which suggests moisture) and from AZ18 itself (where sediments indicate aridity). Although the habitat preferences of *Equus hydruntinus* could be taken to suggest that the location was relatively moist, this form of evidence cannot safely be used to draw such conclusions. Equids are known to have large home ranges and some migrate, which accentuates the point that simple presence at a site cannot be used to infer a 'typical' preferred habitat. AZ18 is only very broadly dated on typological grounds to a period of a millennium and a half and may have seen reoccupations over a long time period, meaning that the site may well have seen both dry and moist conditions, and any inferences based on the presence of *Equus hydruntinus* cannot be taken as sound for the whole occupation. A last cautionary point is that, although unlikely, the equid bones may have been introduced to the site from elsewhere, and need not necessarily reflect local surroundings.

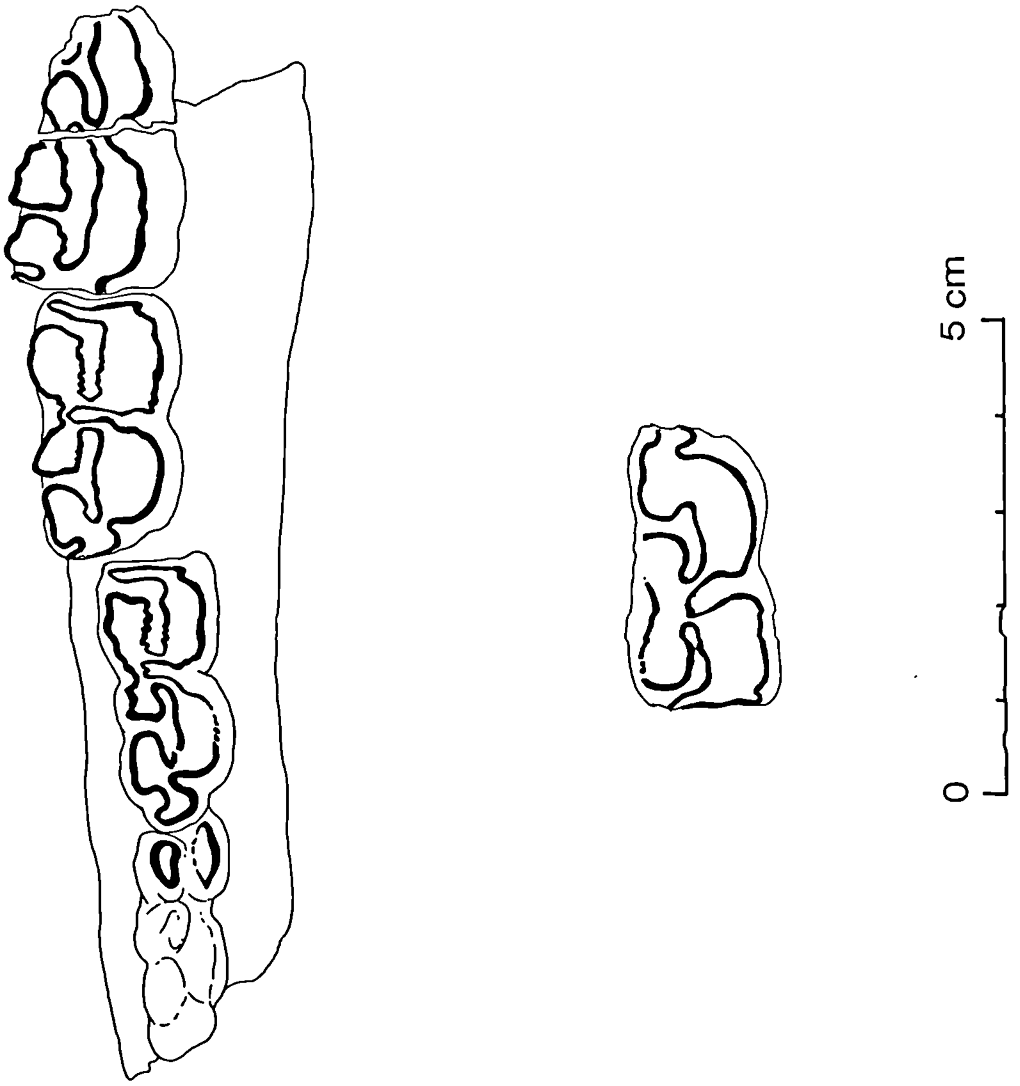


Figure 7.1. **A mandibular tooth row and single mandibular tooth of *Equus hydruntinus* from the late Epipalaeolithic site of AZ18.**

Considering the insurmountable problems in attempting to interpret the absence of species or taxa in assemblages (i.e. that it may represent selection), the apparent absence of *Equus hydruntinus* from post-11,000bp assemblages cannot be taken to have any direct environmental implications. It is possible, however, to see this case as part of a broader pattern of the decrease in the presence of larger herbivores from eastern Jordan, which may be explicable in environmental terms. Whereas equids and wild cattle are often present in relatively high proportions at late Pleistocene sites, their representation drops dramatically after 9,000bp (except for B27) (see figure 6.2). Although this trend could obviously be equally due to hunting selection as to the availability of equids and wild cattle, if the moisture and forage requirements of the large equids and wild cattle are viewed against the increased aridity of the Holocene, a decreased availability of these large herbivores may not be surprising. A decline in smaller equids, for example the half ass (identified at DH 2) is surprising, however, since they are considered well adapted to aridity (e.g. Garrard 1982).

c) Intraspecific size change

Two taxa - gazelle and hare - provide sufficient metrical data to examine size variation through the time sequence represented by the eastern Jordanian assemblages.

Gazelle size differences can be seen through measurements of the astragalus (Bd see figure 7.2, and GLl see figure 7.3), humerus (HTC see figure 7.4) and metatarsal (Bd see figure 7.5), the most frequently measurable elements (measurements follow von den Driesch 1976; Davis 1985). Each figure shows a similar pattern: larger bones are present in early Epipalaeolithic assemblages, and smaller ones in PPNB and PPNC/LN ones. Unfortunately, middle and late Epipalaeolithic assemblages do not provide large enough samples of measurements for patterns to be determined.

Figures 7.6-7.9 show hare bone measurements from the same assemblages (scapula BG in figure 7.6, humerus Bd in figure 7.7, tibia Bd in figure 7.8 and calcaneum GL in figure 7.9). Sample sizes are clearly inadequate, but when patterns for the different elements are viewed together, they **do** appear to show a consistently smaller size range, and smaller absolute size for PPNB and LN bones relative to early Epipalaeolithic bones. With the exception of a single distal tibia from WJ22 B, middle and late Epipalaeolithic assemblages did not yield any measurable hare bones.

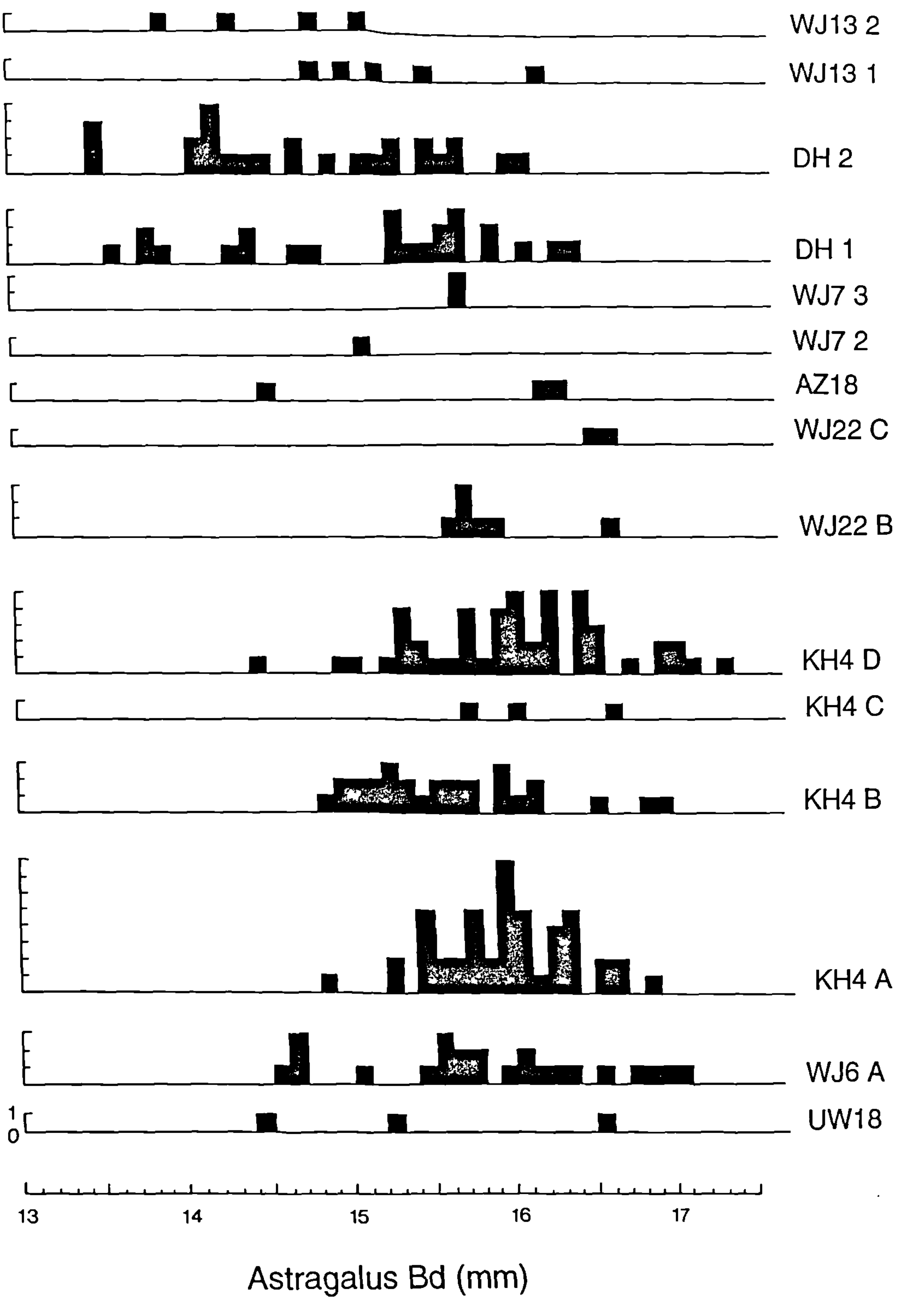


Figure 7.2. Gazelle astragalus sizes (Bd measurements, following von den Driesch 1976) for eastern Jordanian assemblages.
Jebel Naja, DH 2, B27 2 = LN.
WJ25, WJ13 1, 2, 3 = PPNC/ELN
WJ7 2, 3, 4, 5, DH 1 = PPNB
AZ18 = L EPAL
WJ22 B, C = M EPAL
UW18, WJ6 A, KH4 A, B, C, D = E EPAL

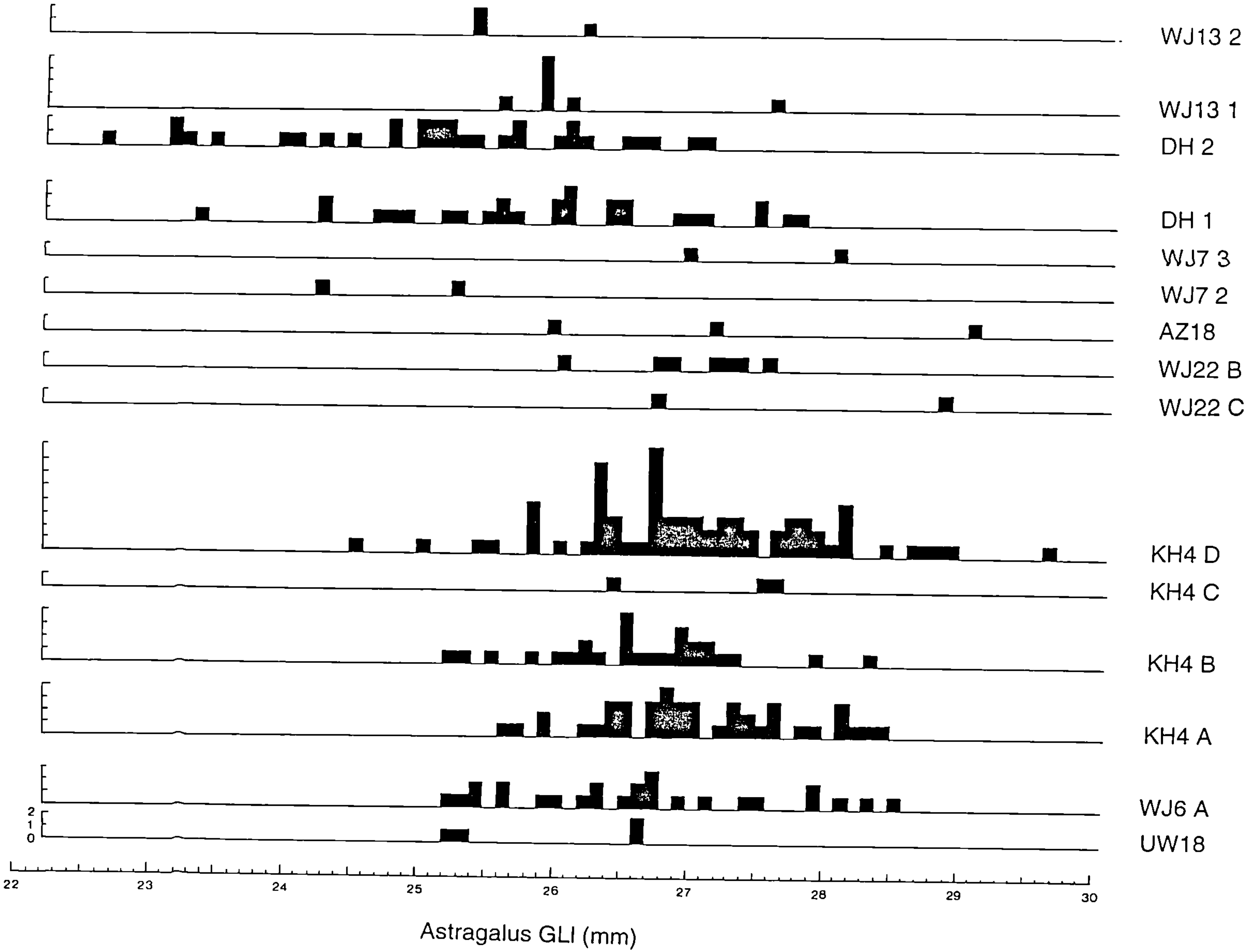


Figure 7.3. Gazelle astragalus sizes (GLl measurements) for eastern Jordanian assemblages. Site key follows figure 7.2.

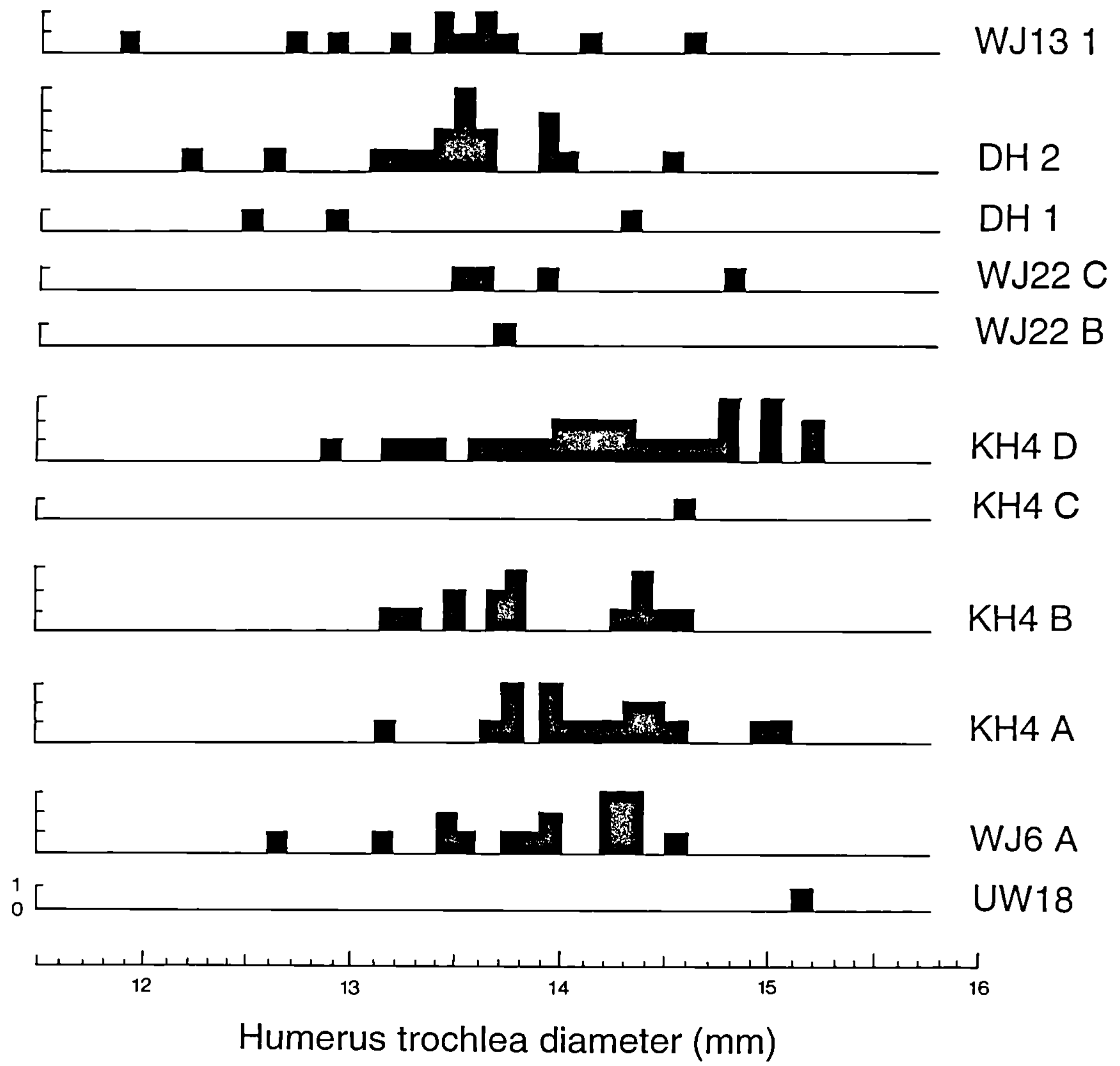


Figure 7.4. Gazelle humerus sizes (trochlea diameter, following Davis 1985) for eastern Jordanian assemblages. Site key follows figure 7.2.

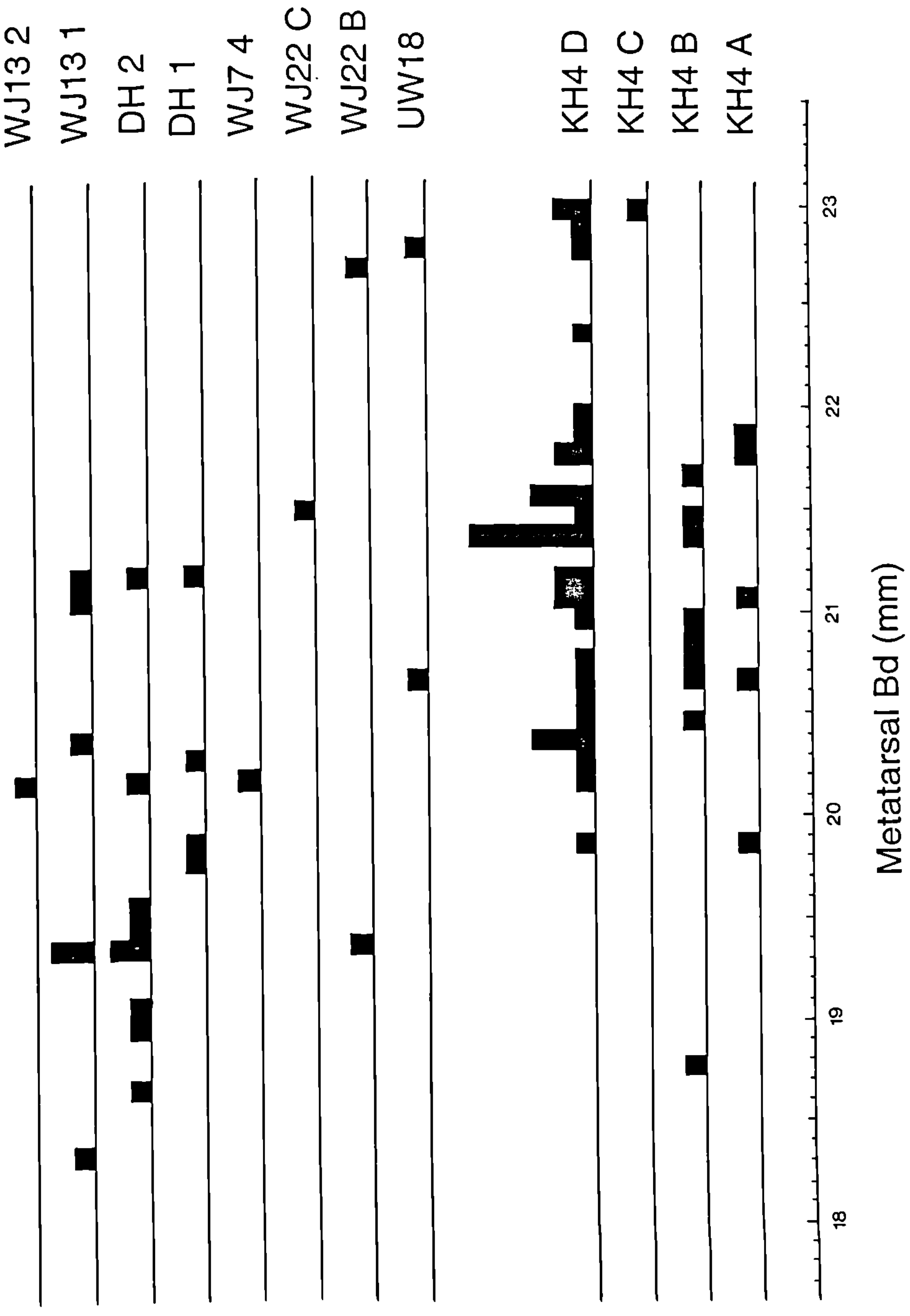


Figure 7.5. Gazelle metatarsal sizes (Bd) for eastern Jordanian assemblages. Site key follows figure 7.2.

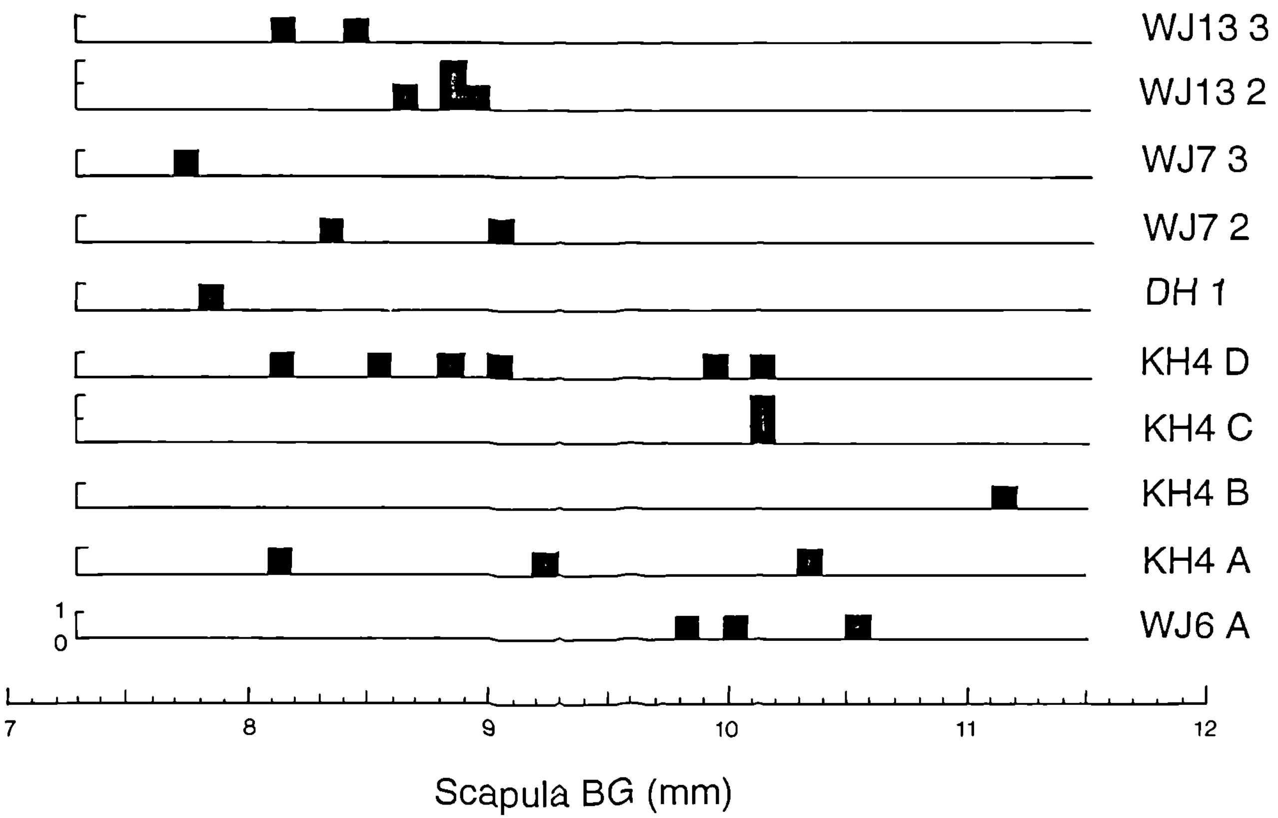


Figure 7.6. Hare scapula sizes (BG) for eastern Jordanian assemblages. Site key follows figure 7.2.

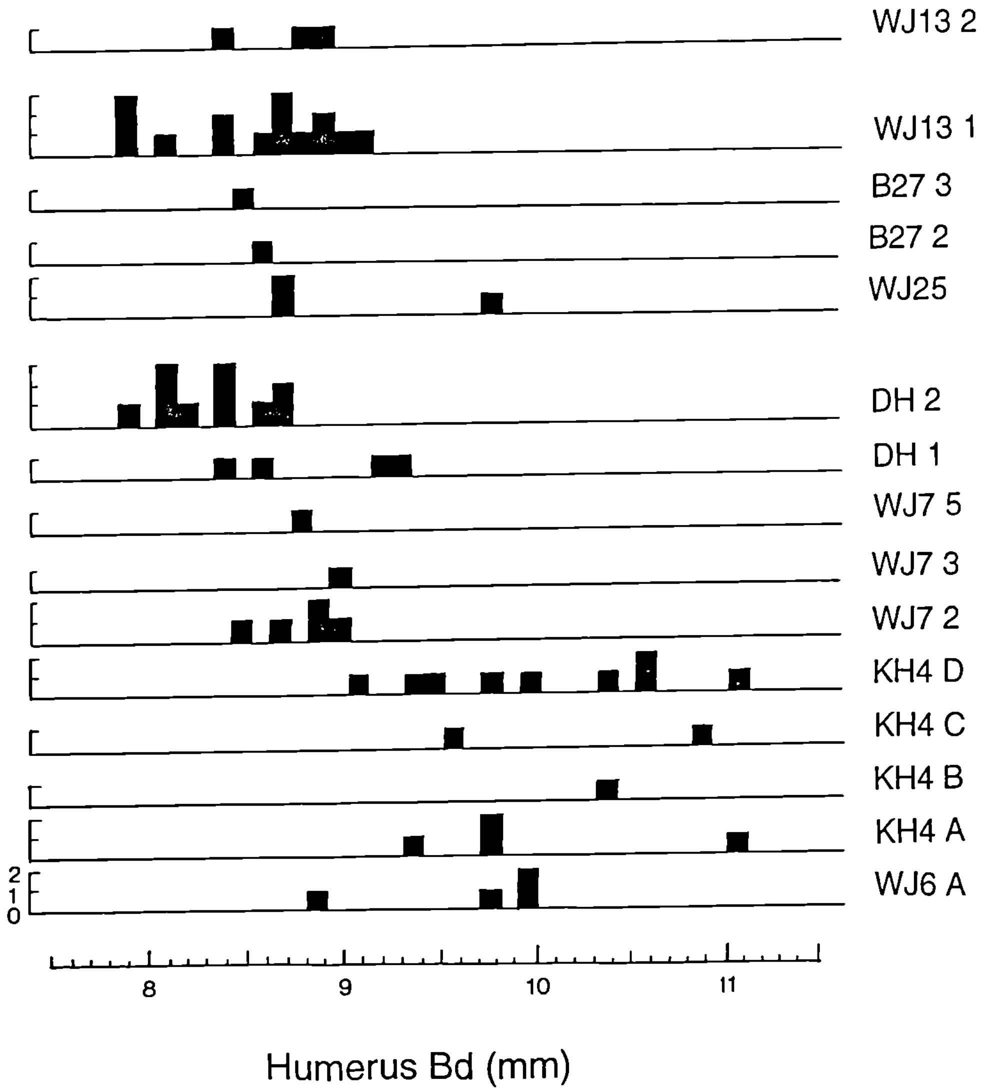


Figure 7.7. Hare humerus sizes (Bd) for eastern Jordanian assemblages. Site key follows figure 7.2.

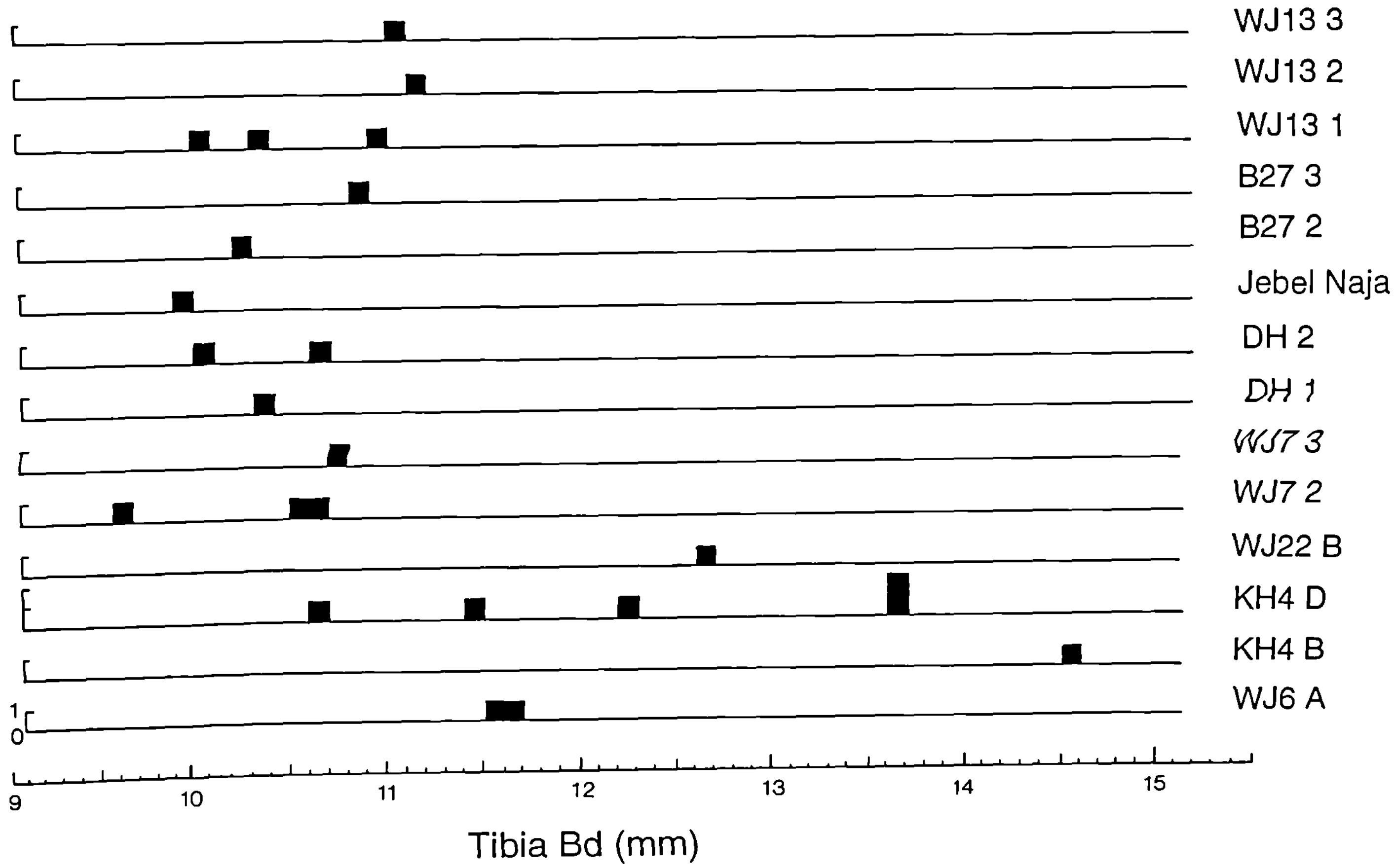


Figure 7.8. **Hare tibia sizes (Bd) for eastern Jordanian assemblages. Site key follows figure 7.2.**

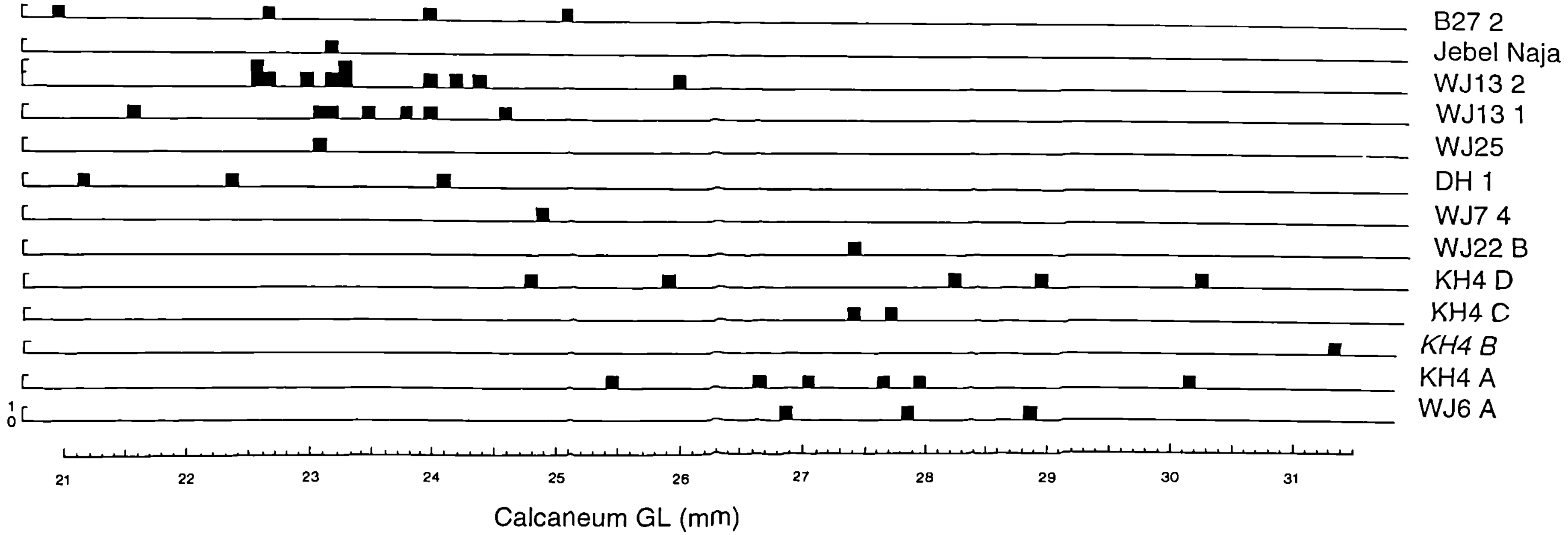


Figure 7.9. Hare calcaneum sizes (GL) for eastern Jordanian assemblages. Site key follows figure 7.2.

Are the size differences significant?

In order to see whether the size differences between the Epipalaeolithic (early and middle) and Neolithic (PPNB and LN) gazelle and hare bones are significant, the **means** of certain measurements were compared, and the probability of the samples deriving from the same populations was tested using Student's t test. Tables 7.1b, 7.2b, 7.3b, 7.4b and 7.5b show that for gazelle humerus HTC, astragalus Bd and GLl, and hare humerus Bd and calcaneum GL, there is a significant size difference (at the 0.05 level) between the Epipalaeolithic and Neolithic samples. The other measurements were not tested because sample sizes are too small.

Interpreting these size patterns is problematic for two reasons:

i) For the gazelle bones, the largest samples from the pre-Holocene assemblages are from the Wadi el-Jilat area, whereas the largest samples of Holocene material are from the Basalt Desert. As described in Chapter 3, these two areas could be expected to differ in terms of rainfall and vegetation, and it would not be surprising to find smaller animals in the more arid easterly area - the Basalt Desert (represented by DH 1 and DH 2 in figures 7.2-7.5). In this respect it is unfortunate that large samples of measurements are not available from both Epipalaeolithic and Neolithic assemblages from both areas, for better comparative treatment of within-area size variation through time. It is possible, therefore, that the metrical patterns simply show geographical size **difference** and not temporal size **change**.

Two lines of evidence, however, hint that the gazelle bones **do** exhibit size change. Firstly, although sample sizes are very small, measurements for LN WJ13 (in the Wadi el-Jilat) suggest similar sizes and ranges to those from DH 1 and DH 2, and are hence smaller than the Epipalaeolithic material from the same region.

Secondly, the same species of gazelle, *Gazella subgutturosa*, has been identified by horncores from both areas (e.g. from KH4, UW18 and DH 2), from both the early Epipalaeolithic and the LN. Accepting that within-species size variation could exist, the above point would suggest that we are looking at a single species which gets smaller over time, rather than shifts in the presence of different-sized species. It is, of course, possible that these few horn cores are not representative of the total assemblages, and that other different-sized species could be present but are archaeozoologically unrecognizable. The issue of whether more than one species could be represented is explored through a metrical comparison with a modern gazelle population, described below.

ii) The patterns observed could be the result of differences in the selection of individual animals within populations of similar body size. The nature of animal bone assemblages means that the measurements represent only samples of the gazelles present at any given time. Hunters theoretically could have selected larger or mainly male animals at Epipalaeolithic sites, and smaller or predominantly female individuals at Neolithic sites, and this could create the observed patterns.

To explore both of these problems an expectation of what a complete gazelle population, and both male and female parts, might look like metrically is required for comparison. For this purpose I have used the measurements of a skeletal collection of modern *Gazella gazella* from Israel. The material derives predominantly from a single population of gazelles inhabiting the Galilee. Individuals are of known sex. The material was collected and measured by Simon Davis (pers. comm.). Although the modern bones differ in absolute size (and probably species) from the archaeological material from eastern Jordan, here the standard deviations, and hence the **internal variability** of the samples, are compared. (The modern material, being larger in size, should be expected to have slightly larger standard deviations because the means of any measurements will be larger than those of the archaeological material; this effect is assumed to be negligible). It should be pointed out that ancient and modern populations cannot be assumed to have had the same size distributions, since there are multiple factors (e.g. level and spacing of nutrition, competition, selective culling) which govern this. In addition, the modern population of gazelles in the Galilee has bred from a fairly small herd in recent times (Mendelssohn 1974; Davis pers. comm.), which introduces the possibility that their sizes may not have a 'normal' spread, but may have reduced variation. Despite these problems, the modern population is used here in the absence of any other comparative material.

The first issue - that of whether more than one species is represented by the archaeological material - is explored by comparing the variances of the Epipalaeolithic gazelle measurements or Neolithic gazelle measurements to that of the complete modern gazelle population by an F test. The F test is used to see if the samples come from metrically similar populations. Results are presented in tables 7.1c, 7.2c and 7.3c. There is either no significant difference (at the 0.05 level) in variance between the two (for Epipalaeolithic and Neolithic humerus HTC; Neolithic astragalus Bd and Neolithic astragalus GLl) **or**, where there is a significant difference, the archaeological samples are less variable than the modern, and compare better with a single sex sample of modern gazelles (Epipalaeolithic astragalus Bd; Epipalaeolithic astragalus GLl). **The results of the tests, therefore, suggest that there is not more than one species present, if the variability of a modern sample is used as a standard.**

To examine the second point - whether the Epipalaeolithic measurements could represent all males and the Neolithic all females - variances of each measurement (humerus HTC, astragalus Bd and astragalus GLl) were also compared to those of the modern material.

The first stage of this analysis uses the same results of the F test described above, with the additional comparison of the complete archaeological sample (Epipalaeolithic and Neolithic **together**) with the total modern sample (tables 7.1c, 7.2c and 7.3c). Results show that for humerus HTC (the smallest of the three samples) there is no significant difference (at the 0.05 level) between any of the groupings (EP, NEO, EP+NEO) and the modern population; that for astragalus Bd and GLl, there is no significant difference between the Neolithic or total (EP+NEO) groupings and the modern population, but there is a significant difference between the Epipalaeolithic measurements and the modern. In these two cases, the Epipalaeolithic material shows significantly **less** variance than the total modern population. On the basis of size distribution, therefore, these three measurements show that all of the archaeological material **could** derive from one population of animals, and suggest that the patterns of size difference **could** be produced by selection of different sized/sex animals.

The second step, following these results, is to compare the larger Epipalaeolithic measurements with modern males and the smaller Neolithic material with the modern sample of females, to see if it is likely that each period could represent a single sex cull (taking into account the high degree of overlap between the sexes). The results of these tests are shown on the same tables (7.1-7.3). For humerus HTC, again no significant difference (at the 0.05 level) is seen either between the Epipalaeolithic sample and modern males, or between the Neolithic sample and modern females. For the astragalus, however, both measurements show that the Epipalaeolithic samples are not significantly different from modern males in their dispersion (although they are in means), whilst the Neolithic samples, although not significantly different from modern females, are even less significantly different in dispersion to the total modern population. These results show that whilst it is statistically **probable** that the archaeological measurements represent predominantly male culls earlier, it is very unlikely that predominantly female culls **from the same sized populations** are represented later. It is more likely, statistically, that the later measurements represent a total population. If the Neolithic material is seen as a total population, then the largest animals in this period (presumably males) are still consistently smaller than the largest animals in the Epipalaeolithic samples. **Even supposing that the Epipaleolithic material represents predominantly male animals (which is discussed and argued against on other grounds in the next section), there is seen to be a reduction in size between these males and the later Neolithic males, which would suggest diminution.**

a) Gazelle humerus HTC (mm)			
sample	mean	SD	n
mod. F	13.6	.51	18
mod. M	14.2	.47	21
modern	13.9	.57	39
EP + NEO	13.9	.65	117
NEO	13.4	.60	33
EP	14.1	.56	79

b) 1 tail probability	
	NEO
EP	.000

c) 1 tail probability						
	EP	NEO	EP+NEO	modern	mod. m.	mod. f.
EP+NEO				.185		
NEO	.295			.369		.244
EP				.435	.181	

Table 7.1. a) the means, standard deviations and sample sizes (n) of both the archaeological (EP and NEO) and modern gazelle measurements of humerus HTC (modern sample=*Gazella gazella* from Israel, S. Davis pers. comm.; M=male; F=female). b) the results of the t test comparing sample means. c) the results of an F test comparing sample variance.

a) Gazelle astragalus Bd (mm)			
sample	mean	SD	n
mod. F	16.4	.59	23
mod. M	17.3	.68	31
modern	16.9	.78	54
EP + NEO	15.7	.76	227
NEO	15.1	.79	62
EP	15.9	.60	153

b) 1 tail probability	
	NEO
EP	.000

c) 1 tail probability						
	EPAL	NEO	EP/NEO	modern	mod. m.	mod. f.
EP/NEO				.393		
NEO	.003			.459		.065
EP				.007	.150	

Table 7.2. a) the means, standard deviations and sample sizes (n) of both the archaeological (EP and NEO) and modern gazelle measurements of astragalus Bd (modern sample=*Gazella gazella* from Israel, S. Davis pers. comm.; M=male; F=female). b) the results of the t test comparing sample means. c) the results of an F test comparing sample variance.

a) Gazelle astragalus GL1 (mm)

sample	mean	SD	n
mod. F	27.5	1.00	18
mod. M	29.0	.97	20
modern	28.3	1.24	38
EP + NEO	26.6	1.15	259
NEO	25.6	1.18	73
EP	27.0	.88	174

b) 1 tail probability

	NEO
EP	.000

c) 1 tail probability

	EPAL	NEO	EP/NEO	modern	mod. m.	mod. f.
EP/NEO				.248		
NEO	.001			.341		.226
EP				.002	.252	

Table 7.3. a) the means, standard deviations and sample sizes (n) of both the archaeological (EP and NEO) and modern gazelle measurements of astragalus GLl (modern sample=*Gazella gazella* from Israel, S. Davis pers. comm.; M=male; F=female). b) the results of the t test comparing sample means. c) the results of an F test comparing sample variance.

a) Hare humerus Bd (mm)

sample	mean	SD	n
NEO	8.61	.401	45
EP	10.0	.632	20

b) 1 tail probability

	NEO
EP	.000

Table 7.4. a) the means, standard deviations and sample sizes (n) of the Epipalaeolithic and Neolithic hare measurements of humerus Bd. b) the results of the t test comparing sample means.

a) Hare calcaneum GL (mm)			
sample	mean	SD	n
NEO EP	23.34 27.82	1.09 1.67	32 18

b) 1 tail probability	
	NEO
EP	.000

Table 7.5. a) the means, standard deviations and sample sizes (n) of the Epipalaeolithic and Neolithic hare measurements of calcaneum GL. b) the results of the t test comparing sample means.

In conclusion, it is argued here that neither the possibility of different sized gazelles inhabiting different areas of eastern Jordan, nor human selection of animals of different sexes, satisfactorily explains the patterns of size differences seen in figures 7.2-7.5. The size change is therefore interpreted as a **reduction** in the size of gazelles between the Epipalaeolithic and the Neolithic, which is consistent with the postglacial body size reduction noted for many species in other areas of the Levant, and indeed worldwide.

Interpretation of the hare bone measurements is less problematic than for gazelle, because for the Wadi el-Jilat/Kharaneh area there are samples of relatively similar size from the earlier (Epipalaeolithic) and later (Neolithic) periods, even though sample sizes themselves are very poor. Geographic variation, therefore, cannot be responsible for the pattern in this case. The chance that selection of different sized/sex animals produced the pattern cannot be ruled out, and modern comparative data are not available to investigate this point, but again it seems highly unlikely that selective hunting strategies would remain so consistent over such long periods of time. Given that many other taxa in the region show size reduction over a similar period, it would be consistent to interpret figures 7.6-7.9 as demonstrating reduction in the body size of hares.

The degree of diminution

Tables 7.6 and 7.7 show the drop in mean size of gazelle and hare elements respectively between the Epipalaeolithic and Neolithic assemblages.

Gazelle humerus HTC

period	assemblage	range (mm)	mean	SD	n
L NEO	WJ13 1	11.9-14.6	13.4	0.68	12
L NEO	DH 2	12.2-14.5	13.5	0.52	18
E EPAL	KH4 D	12.9-15.2	14.3	0.63	28
E EPAL	KH4 B	13.2-14.6	13.9	0.47	15
E EPAL	KH4 A	13.2-15.1	14.2	0.47	18
E EPAL	WJ6 A	12.7-14.6	13.9	0.52	16

Gazelle astragalus GL1

period	assemblage	range (mm)	mean	SD	n
L NEO	WJ13 1 + 2	25.4-27.6	26.0	0.63	10
L NEO	DH 2	22.7-27.1	25.1	1.18	31
PPNB	DH 1	23.4-27.8	26.0	1.11	28
E EPAL	KH4 D	24.6-29.7	27.1	0.94	70
E EPAL	KH4 B	25.3-28.4	26.7	0.71	27
E EPAL	KH4 A	25.7-28.5	27.1	0.72	43
E EPAL	WJ6 A	25.3-28.6	26.7	0.97	26

Gazelle astragalus Bd

period	assemblage	range (mm)	mean	SD	n
L NEO	WJ13 1 + 2	14.0-16.3	15.1	0.66	9
L NEO	DH 2	13.6-16.2	14.8	0.78	26
PPNB	DH 1	13.7-16.5	15.2	0.84	24
E EPAL	KH4 D	14.5-17.4	16.1	0.61	48
E EPAL	KH4 B	14.9-17.0	15.7	0.56	28
E EPAL	KH4 A	14.9-16.9	16.0	0.41	47
E EPAL	WJ6 A	14.6-17.1	15.9	0.74	24

Gazelle metatarsal Bd

period	assemblage	range (mm)	mean	SD	n
L NEO	DH 2				
	WJ13 1 + 2	18.4-21.2	19.8	0.84	16
E EPAL	KH4 D	19.9-23.0	21.4	0.80	34
E EPAL	KH4 A + B	18.8-21.9	20.9	0.79	14

Table 7.6. The size ranges, means, standard deviations and sample sizes (n) of gazelle bone measurements from the eastern Jordanian assemblages. Note that for each element the mean of the Neolithic (PPNB and LN) bones is smaller than that for the early Epipalaeolithic material. Due to small sample sizes, assemblages of the same period have sometimes been grouped.

Hare scapula BG					
period	assemblage	range (mm)	mean	SD	n
PPNB/LN	DH,WJ7,WJ13	7.8-9.1	8.5	0.46	10
E EPAL	WJ6 A, KH4	8.2-11.2	9.7	0.90	15

Hare humerus Bd					
period	assemblage	range (mm)	mean	SD	n
LN	DH 2,WJ25, B27, WJ13	7.9-9.8	8.5	0.41	34
PPNB	DH 1, WJ7	8.4-9.3	8.8	0.28	11
E EPAL	WJ6 A, KH4	8.9-11.1	10.0	0.63	20

Hare tibia Bd					
period	assemblage	range (mm)	mean	SD	n
PPNB/LN	DH, WJ7, JN B27, WJ13	9.7-11.2	10.5	0.44	15
EPAL	WJ6 A, KH4 WJ22 B	10.7-14.6	12.5	1.28	9

Hare calcaneum GL					
period	assemblage	range (mm)	mean	SD	n
PPNB/LN	DH, WJ7, JN WJ25, B27 WJ13	21.0-26.0	23.3	1.09	32
EPAL	WJ6 A, KH WJ22 B	24.8-31.3	27.8	1.67	18

Table 7.7. The size ranges, means, standard deviations and sample sizes (n) of hare bone measurements from the eastern Jordanian assemblages. Note that for each element the mean of the Neolithic (PPNB and LN) bones is smaller than that for the early Epipalaeolithic material. Due to small sample sizes, assemblages of the same period have been grouped.

Table 7.6 shows the mean of each measurable gazelle element to decrease by approximately 1mm in size between the early Epipalaeolithic and Neolithic (PPNB and LN). Mean hare bone decrease is more variable (see table 7.7): the scapula BG shows less than 1mm diminution; humerus Bd has an approximately 1mm reduction; tibia Bd gets 2mm smaller, and calcaneum GL shows a decrease of 4.5mm over the same time period.

The timing of diminution

Early Epipalaeolithic assemblages are dated, either by C^{14} or typology, to c. 20,000-14,500bp. The PPNB and LN covers a period from c. 9,000-7,000bp. The diminution observed takes place between these two broad periods, i.e. between c. 14,500 and 9,000bp, but unfortunately the assemblages which date to this intermediate period (WJ22 B and C, AZ18) do not provide adequate samples of measurable bones for patterns to be observed.

The very rough and unquantifiable impression that is gained from some of the figures is that the size of material from WJ22 B and C and AZ18 is more similar to the early Epipalaeolithic cases than the Neolithic ones. Gazelle astragalus GLl, for example, appears to show this, although sample sizes are very small, as does metatarsal Bd (see figures 7.3 and 7.5). It could be argued that the plots of WJ22 B hare tibia Bd and calcaneum GL (figures 7.8 and 7.9) show the same trend. If this impression is taken to be representative (which clearly cannot be assumed with such small sample sizes), then the diminution of bones would postdate WJ22 C (dated to 13,040±180bp and 12,840±140bp), and B (dated to 11,920±180bp), and perhaps also AZ18 (placed between 12,500 and 11,000bp on typological grounds). If this line of argument is followed, then diminution could perhaps be seen to occur in the two millennia surrounding the Pleistocene/Holocene boundary at 10,000bp. Larger sample sizes from these intermediate sites, however, would be needed to evaluate this properly.

Discussion

Having identified both gazelle and hare as showing a size reduction sometime between the late Pleistocene and early Holocene in eastern Jordan, this phenomenon needs explaining. In his discussion of similar trends observed in a number of species over the same time periods in Palestine, Davis (1981) outlines five factors which may govern mammalian body size. Interspecific competition can push size up or down if a competitive feeder enters a region; changing predator-prey interaction can produce the same effect; variation in carrying capacity or food availability can alter body size, and variations in temperature can also influence this. Lastly, 'domestication', and presumably also management of an animal population, can alter its size (Davis 1981:109-111). Of these possibilities, Davis favours temperature elevation as being causal to the dwarfing he observes in fox, wolf, boar, aurochs, goat and gazelle between the late Pleistocene and early Holocene, and sees the principles of Bergmann's rule as being in operation. He finds no strong supportive evidence for any of the other suggestions, but finds that the timing of the size change (sometime in the early Natufian, c. 12,000-11,000bp) correlates with evidence for a worldwide temperature elevation at the end of the Pleistocene. Davis, for example, finds that for gazelle, the mean measurement for the distal breadth of the humerus changes from 24mm at Hayonim Cave B (12,360±160, 12,010±180bp) to 23mm at Hayonim Terrace (11,920±90bp). Likewise, the mean distal width of the metatarsal drops from c. 22.7mm to 21.5mm in the same assemblages (Davis 1981:109, figure 11).

The results from eastern Jordan can be evaluated against the same possible explanations for body size diminution. There is no evidence to support ideas of new similar-sized competitive feeders entering the area, or for changing predator-prey relationships, although the latter would probably not be easily visible. Davis' next two factors appear related: carrying capacity/food availability and temperature change. The temperature elevation which is believed to begin c. 14,000bp in the Levant is just one of the palaeoclimatic changes taking place at the end of the Pleistocene; the integral effect would have altered vegetation patterns and distribution and hence also carrying capacity. Davis argues that a reduction in the carrying capacity of the late Pleistocene Levantine environment would not have been harsh enough to result in the body size reductions observed. Instead, following Bergmann's rule, he hypothesises that temperature alone could be responsible for the mammalian diminutions (Davis 1981:110-111). Bergmann's rule is concerned with the direct correlation between body size and temperature, i.e. that maintenance of body temperature is the overriding explanation for variation. If, however, one takes the (albeit poor) evidence from eastern Jordan, and from Davis' plots of gazelle size (1981:109 figure 11), there is no significant change in gazelle body size from c. 20,000-c. 12,000bp even though evidence suggests that temperatures were rising from 14,000bp onwards. It would appear, then, that either the temperature changes between 14,000bp and 12,000bp were not severe enough to result in diminution but between 12,000bp and 11,000bp they were, or that additional factors such as food availability are involved. Could the shift to greater seasonality c. 12,000bp (cf. McCorriston and Hole 1991:52) have altered patterns of forage availability to favour the survival of smaller individuals through the longer drier summer months? It seems that more holistic views of environmental and ecological change could equally well, or perhaps even better, explain the observed mammalian size diminution as opposed to temperature elevation alone.

The possibility that domestication, or any form of interference with animal breeding, can result in size diminution must be considered. Cope (1991) has suggested that gazelle breeding underwent severe human interference in the Natufian (12,500-10,000bp) in Palestine, and that the intensive culling of males led to a reduction in gene pool, resulting in gazelle dwarfism. Legge and Rowley-Conwy (1987) hypothesise that gazelles in the late Natufian of northern Syria may have experienced over-predation from human groups, an idea which could presumably encompass a disturbance in breeding patterns. Both of these ideas are investigated in relation to the eastern Jordan assemblages in Chapter 7, section 3. Here, it should only be asked whether such practices of interference in animals' breeding patterns could be responsible for the observed diminution in body size. That similar diminution patterns are seen for both hare and gazelle is strong evidence that this is not the case: it would be highly unlikely that both of these taxa experienced equivalent hunting pressure over the same periods, to produce the same physical results.

Section 2: Do hunters show selectivity in taxa?

Many interpretations of Levantine hunting practices find early and middle Epipalaeolithic faunal assemblages to reflect opportunistic, or random, hunting of animals in the vicinity of sites, whereas late Epipalaeolithic (Natufian) assemblages are often believed to show selective hunting - in terms of a focus on gazelle **beyond** the expectations of the site's location (see Chapter 2). Here, the eastern Jordanian study assemblages are examined for indications of either opportunistic or selective hunting.

To approach this issue, predictions of the fauna likely to exist around sites are needed for comparison with the faunal assemblages. Chapter 2 discusses how such a method has successfully been employed in fertile areas of the Levant, where assemblages were found to diverge from environmental expectations; these environments, however, are fairly distinct, with equally distinct 'signature' faunas (e.g. woodland/fallow deer, open country/gazelle, see Garrard 1982). Eastern Jordan poses more of a problem because distinct environmental niches (e.g. oases) are few, with most of the region representing differing gradients of steppe. This means that the faunal make-up is likely to have been similar for much of the area.

Any attempting to model relative taxonomic abundances in nature is even more problematic when so many influential variables are unknown. Climate and vegetation patterns, for example, are not predictable in any detail. The effects of species interaction and commensal or predator/prey relationships are too intangible to be explored in this situation. Furthermore, the time resolution is so coarse for both the palaeoenvironmental evidence (upon which a reconstruction would be based) and the dating of the assemblages, that trying to correlate the two is futile. The accuracy of any resulting model of relative faunal abundance would be indeterminable.

In the face of these problems, it was decided to simplify the issue by concentrating on **water availability** which is likely to have been a prime limiting factor in eastern Jordan. Most taxa present in the assemblages are very adaptable and have a wide range of habitats (e.g. hare, fox, wolf, tortoise). Of the larger mammals, gazelles are virtually independent of standing water, equids need water every few days, but wild cattle require continued access to water sources. The approach here, therefore, is to use the relative proportions of these three taxa to explore whether hunting may have been opportunistic or selective. The relative availability of water in the different areas of eastern Jordan is perhaps easier to estimate than other environmental factors, firstly because permanent bodies of water are known from either their continued existence or from sedimentary analysis; secondly because rainfall patterns for the late Pleistocene/early Holocene have been reconstructed; and thirdly because local topography probably dictates where seasonal runoff will collect. Correlations of predicted water availability with the ratio of gazelle:equids:cattle will allow other environmental factors and archaeological data to be discussed.

The tolerances and water requirements of gazelles, equids and wild cattle are summarized in table 7.8.

	Gazella spp.
water requirements wet season dry season	 water obtained from vegetation water obtained from vegetation and conserved through restricted movement
adherence to water	year-round independence from standing water
group size	large groups form in wet season and more dispersal in dry season

	Equus spp.
water requirements wet season dry season	 water obtained from vegetation water needed every 3-4 days
adherence to water	adherence in dry season: migration may be forced by scarcity of water or grazing
group size	onager and wild horse possibly live in nomadic large herds

	Bos sp.
water requirements wet season dry season	 drinking water needed every 2 days drinking water needed every 2 days
adherence to water	in hot weather grazing restricted to c. 1 day's walk away from water sources, or a c. 13km radius of water
group size	fluctuates with vegetation: smaller groups in wooded areas; larger groups in open country

Table 7.8. Summary of information on the water tolerances and group size of gazelles, equids and cattle, taken from Baharav 1980, 1981, 1982; Garrard 1980:table 3B; Klingel 1974; Russell 1988:59; Legge and Rowley-Conwy 1988:19; Uerpmann 1987:72. For further details see Chapter 4 and Appendix 1.

The implications of the information presented in table 7.8 are as follows:

1) gazelle distribution would probably not be limited in any area of eastern Jordan since they are independent of standing water.

2) equids could probably also be present in any area since movement allows them to travel long distances for water requirements.

3) wild cattle would be restricted in distribution to areas close to permanent water sources.

Since none of these animals are solitary, their presence in an assemblage would indicate the potential availability of a herd of animals, although clearly the size and density of the herd is dependent on other factors such as time of year and forage availability.

Water availability

Following the environmental modelling in Chapter 3, water sources are divided into two types: 1) permanent, reliable bodies and 2) seasonal collections in stream beds, rain pools and mud flats. Predictions of water available in each of the five areas where study sites cluster are shown in table 7.9. Background evidence upon which this is based is in Chapter 3.

Table 7.9 predicts only two large permanent bodies of water for the late Pleistocene/early Holocene study area. The first is at Azraq oasis and is believed to have been in existence throughout the period, although lake levels apparently fluctuated (with evidence for low levels at some time between c. 12,500 and 11,000bp, i.e. at the time of occupation of AZ18). The other standing pool is at Burqu where Helms estimates that a surface area of over 30,000m^2 of water would have been available in prehistory (Betts *et al.* 1991:11). Other smaller collection points where water was permanently available may well have existed, but these two are the only substantial pools so far identified. In addition to these sources, sedimentary evidence shows there to have been a marshy area in the Wadi el-Jilat at the time of occupation of WJ22 (both phases C and E), therefore in the 14th-13th millennium bp. Also, copious spring activity is evidenced in the Wadi el-Uwaynid between c. 20,000 and 18,000bp. It is assumed, at least from the Wadi el-Jilat marsh (and the presence of *Phragmites* stems), that in these cases water would have been available year-round.

approx yrs bp	**Wadi el-Jilat** water availability	site/ phase
8,000	arid; seasonal rain; pool collection?	WJ13,25
9,000	arid; seasonal rain; pool collection?	WJ7, 32
10,000	?	
11,000	moist; seasonal rain; standing water?	
12,000	moist; seasonal rain; standing water?	WJ22 B
13,000	moist; marsh/standing water	WJ22 C
14,000	moist; marsh/standing water	
15,000	arid; seasonal rain/? flowing wadi	
16,000	arid; seasonal rain/? flowing wadi	WJ6 A
17,000	arid; seasonal rain/? flowing wadi	

approx yrs bp	**Wadi el-Kharaneh** water availability	site/ phase
15,000	arid; seasonal rain/? flowing wadi	KH4 D
16,000	arid; seasonal rain/? flowing wadi	?KH4 C
17,000	arid; seasonal rain/? flowing wadi	
18,000	moist; seasonal rain/flowing wadi	
19,000	moist; seasonal rain/flowing wadi	?KH4 B
20,000	arid; seasonal rain/? flowing wadi	?KH4 A

approx yrs bp	**Azraq Central Basin** water availability	site/ phase
11,000	moist; permanent lake but levels low?	
12,000	moist; permanent lake but levels low?	AZ18
13,000	moist; permanent lake	

approx yrs bp	**Wadi el-Uwaynid** water availability	site/ phase
19,000	moist; spring activity/standing water?	
20,000	moist; spring activity/standing water?	UW18

approx yrs bp	**Dhuweila** water availability	site/ phase
7,000	arid; seasonal rains/filling of mudflats	DH 2
8,000	arid; seasonal rains/filling of mudflats	DH 1
9,000	arid; seasonal rains/filling of mudflats	

approx yrs bp	**Burqu** water availability	site/ phase
7,000	arid; lake; permanent standing water	B27

Table 7.9. Water availability predictions for the five study areas, for periods covered by the sites only.

At other periods in the Wadi el-Jilat, and for the other areas, water availability would probably have been seasonal, during the months of winter rainfall. In both the Wadi el-Kharaneh and Wadi el-Jilat, rainfall is likely to have been sufficient to cause seasonally flowing streams, but these would probably not have lasted through the summers. The incision of a gorge in the Wadi el-Jilat, however, may have provided circumstances for water retention for longer parts of the year. The gorge formation is not well dated, but indirect evidence (see Baird 1993) suggests that it postdates the occupation at WJ22 (c. 12,000bp) but was in existence, if not fully formed, by the PPNB (i.e. c. 9,000bp). Today the gorge has deep rock pools which, according to Bedouin informants, would have remained filled throughout the year before water extraction by pumping was undertaken (Garrard pers. comm.).

In the area around Dhuweila in the Basalt Desert, the wide *wadis* and mudflats would have filled (as they do today) in the wet seasons, but again, year-round water availability in the vicinity of the site seems unlikely.

Correlating water availability with the ratio of gazelle:equids:cattle

Several problems are encountered in attempting to correlate assemblage data with the environmental predictions in table 7.9.

1) Both assemblage data and the water availability predictions have very coarse time resolution. The faunal assemblages show, by their nature, an averaging of hunting episodes over potentially long time periods. Also, the water availability predictions cannot account for fluctuations between years.

2) The availability of some animals may be seasonal, meaning that the total fauna in the vicinity of the site could differ if the time of occupation alters. Indications of the occupation times during the year must be considered when arguing for either opportunistic or selective hunting.

3) It is initially assumed that the faunal remains of wild species in the assemblages result from hunting activity in the rough area of the site, and do not represent imports.

	Percentage ratio of gazelle:equid:cattle for each site in each area					
approx. yrs bp	W. el-Jilat	W. el-Kharan.	Azraqc basin	W. el-Uwaynid	Dhuweila	Burqu
7,000						
					DH 2 **99:1:0**	B27 **63:37:0**
	WJ13 3 **99:1:0**					
	WJ13 2 **99:1:0**					
	WJ13 1 **97:1:2**					
8,000	WJ25 **100:0:0**					
	WJ32 **100:0:0**				DH 1 **99:1:0**	
	WJ7 4 **100:0:0**					
	WJ7 3 **100:0:0**					
	WJ7 2 **99:0:1**					
9,000	WJ7 1 **100:0:0**					
10,000						
11,000						
12,000	WJ22 B **88:12:0**		AZ18 **41:33:26**			
13,000	WJ22 C **72:28:0**					
14,000						
15,000						
16,000	WJ6 A **87:12:1**	KH4 D **94:5:1**				
17,000		KH4 C **95:4:1**				
18,000						
19,000		KH4 B **95:4:1**				
20,000		KH4 A **84:15:1**		UW18 **82:15:3**		

Table 7.10. The percentage ratios of gazelle:equid:cattle for each assemblage.

Results

Table 7.10 shows the percentage ratio of gazelle:equid:cattle for each of the 21 assemblages with representative sample sizes. Assemblages are ordered by geographical area to facilitate comparison with the information on water availability in table 7.9 above.

It should be noted that the analysis includes Late Neolithic assemblages in which, as will be argued below, hunting coexisted with the herding of sheep and goats.

If the areas predicted as having permanent bodies of water are viewed first, contrasts are seen. Late Epipalaeolithic AZ18 has 41% gazelle, 33% equid and 26% cattle, whilst Late Neolithic B27 has 17% gazelle, 37% equid and no cattle.

The high representation of cattle at AZ18 is not surprising ecologically since the lake and lush surrounding catchment area would provide a suitable habitat for this animal. The relatively even representation of the three taxa may, therefore, indicate opportunistic hunting. This is particularly interesting because AZ18 is a Natufian (period) site (12,500-11,000bp on chipped stone typology), and it is during this period that sites in Palestine apparently show a selective focus towards gazelle. Henry (1975) argues for a Natufian preference for gazelle not only from their high frequencies in assemblages, but also because of their consistently high frequencies across a range of environments (Mediterranean woodland to steppe/desert zones) where faunal availability would be expected to differ. Garrard (1982) suggests that land management in the form of firing may have been responsible for Natufian faunal patterns, as an alternative to direct selection for gazelle. However the dominance of gazelle bones are explained in Natufian period Palestine - through intentional selection or indirect/direct management - these same hunting practices and preferences are not seen at AZ18 in eastern Jordan.

The absence of cattle at Late Neolithic B27, in an area with abundant standing water, at first sight seems to contradict expectations and so perhaps to indicate selective hunting, involving the avoidance of cattle. On the other hand, the increasing aridity of the early Holocene may have caused the area around Burqu to be sparsely vegetated for much of the year. If so, although the spring-fed pool would have provided adequate water for the requirements of wild cattle, the lack of forage may have been a limiting factor. Cattle could not have moved great distances away from the standing water for food, and so may have been prevented from inhabiting the Burqu area in the early Holocene. Given this uncertainty, the B27 assemblage cannot be used as evidence for selective hunting or avoidance of cattle. The fact that no other sites in the Basalt Desert have produced remains of *Bos* sp. supports the case for cattle not being in the region, rather than avoidance of these animals.

Two other assemblages might be expected to have wild cattle remains due to their locations near standing water or springs. Early Epipalaeolithic UW18 (19,800±350 and 19,500±250bp) has 82% gazelles, 15% equids and 3% cattle. That cattle constitute such a low proportion in a *wadi* which could probably have supported a fair cover of vegetation as well as provided water could be taken as some sort of bias towards the other two taxa, or avoidance of cattle. Alternatively, the general aridity noted for the time of the Glacial Maximum may have isolated this local water source from others, preventing it from being a suitable permanent habitat for wild cattle.

The other assemblage, WJ22 C (12,840±140-13,040±180bp), has no cattle at all (72% gazelle, 28% equids). This period of the late Pleistocene has been interpreted as one of widespread increasing temperatures and precipitation (see Chapter 1), and therefore the lack of any cattle in an area of perhaps fairly dense grassland and marsh (and therefore year-round water) is surprising. The upper level of the same site, WJ22 B (11,920±180bp), is not itself in marsh sediments, but is likely to correlate to a time of similar general environmental conditions. This level also has no cattle (but 88% gazelle and 12% equid). The lack of cattle is again difficult to interpret: even though there is evidence for water in the Wadi el-Jilat itself, the more general rise in moisture may not have been sufficient to allow cattle distribution to extend so far into the steppe. On the other hand, the spectrum of fauna seen in both levels of WJ22 is quite different from that at any other Epipalaeolithic site in the steppe, with relatively high frequencies of tortoise and bird (12% and 28% respectively for C, and 14% and 7% for D), and lower relative proportions of gazelle (37% in C and 56% in D). Is it possible that the array of animals on which the inhabitants of WJ22 focused their hunting activities did not include cattle for some reason (i.e. was there avoidance of cattle, or preferential selection of other animals?).

There are two possible reasons why cattle may have been avoided, and hence not appear in assemblages such as UW18, B27, WJ22 B and C, despite being expected to inhabit these environments.

Firstly, due to their great feeding requirements but restrictions on movement, cattle may have roamed in more dispersed herds than either equids or gazelles, which could render them unsuitable for certain hunting techniques such as driving. Secondly, their large size and behaviour may have made them difficult to hunt: Speth (1983) notes how bison in North America become very awkward at different times of the year, with bulls being aggressive during the late summer rut, and cows becoming unpredictable in the spring after calving. Such factors may have made them less favourable prey.

An alternative explanation should be considered for the apparent absence of cattle bones at these sites, which relates to their large size. Adult wild cattle weigh 700-900kg as opposed to 250-450kg for wild horse, 200-400kg for wild ass and 14-28kg for gazelles (Garrard 1980:table 3B). Their greater size and weight could mean that they were butchered and processed at the kill, rather than carcasses or bones being returned to the study sites. Cultural avoidance of wild cattle, or different treatment of their bones, should not be dismissed either. If, for example, cattle bones were more frequently worked or curated than those of other taxa (e.g. KH4 D and AZ18 have examples of worked cattle bone) then they may not necessarily be found at sites where they are being consumed. This last factor, however, would probably not fully explain the low cattle representation at B27, UW18 and WJ22.

The early Epipalaeolithic assemblages in the Wadi el-Jilat and Wadi el-Kharaneh areas all show similar trends (see table 7.10 for the percentage ratios of KH4 A, B, C and D and WJ6 A). Wild cattle are present in low frequencies in some of the assemblages, and the proportions do not alter significantly over a period of potentially 5,000 years, despite there being changes in the predicted relative moisture/aridity in the area (see table 7.9). Even through the periods of varying wetness, however, the suggestion is that water availability was always seasonal in the *wadis*, so that faunal assemblages are consistent with environmental reconstructions.

The remaining assemblages to be discussed are all post-Holocene. Following the water availability predictions in table 7.9, it is not surprising to find that most of the 11 assemblages do not show any cattle bones at all. Middle PPNB WJ7 2, however, has one *Bos* sp. bone, constituting less than 1%, and Late Neolithic WJ13 1 has five, making up 2% of the percentage ratio (i.e. total of gazelle, equid, cattle). The latter case in particular would seem to defy expectations since the Late Neolithic is thought to have been as arid as the present day. The possibility that body parts (or even whole animals?) were being taken into the area at this time should be considered.

One further point to note about the Late Neolithic is that the relative proportions of gazelle and equids in the assemblages from the Wadi el-Jilat (i.e. WJ13, WJ25) are similar to those for DH 2. This is of interest because the Wadi el-Jilat assemblages all contain significant proportions of herded animals by this period whereas DH 2 does not. If the fact that there are domesticates at WJ13 is disregarded, and the hunting practices alone between the areas (Wadi el-Jilat and Dhuweila) are compared, it can be seen that there is no evidence in the taxonomic abundances that hunting was more selective at DH 2 than at WJ13. The ratio of gazelle to equids is 99:1 in the former assemblage and varies from 99:1 to 98:1 in the latter assemblages. In other words, hunting seems to have been no more selective at DH 2 - a Late Neolithic hunting site - than at WJ13 - a herding and hunting site.

Conclusions

1) Selection or non-selection of certain animals in hunting is very difficult to infer when the environmental modelling, and hence faunal expectations, are so imprecise.

2) As elsewhere in the Levant, many of the Epipalaeolithic assemblages in eastern Jordan contain very 'high' frequencies of gazelle, ranging between 84% and 96% at WJ6 A and KH4, but there is no evidence to suggest that these patterns result from selective hunting rather than hunting the fauna in the vicinity of the site.

3) The late Epipalaeolithic assemblage of AZ18 provides some evidence for opportunistic hunting, because the fauna from this distinctive location matches ecological expectations in containing a high percentage of cattle. This assemblage does not support Henry's (1975) suggestion that most Natufian sites have very high proportions of gazelle, regardless of site location.

4) Most of the other study sites which are argued to be in localities suitable for cattle in terms of water availability, have assemblages (gazelle:equid:cattle ratio) which diverge from this expectation. These discrepances, however, are always ambiguous and can be explained in more than one way: the lack of cattle may reflect an avoidance of this animal in hunting, or incorrect ecological modelling.

5) Nonetheless, if the assemblages lacking cattle, despite predicted availability of water, are viewed chronologically, the following picture emerges: one of the six early Epipalaeolithic assemblages shows possible selection/avoidance; both middle Epipalaeolithic assemblages show possible selection/avoidance; the single late Epipalaeolithic assemblage implies opportunistic hunting; the six PPNB assemblages show no evidence for selection/avoidance, and of the six Late Neolithic assemblages, one shows possible avoidance and one may show the presence of an imported taxon.

In terms of opportunistic or selective hunting, therefore, no temporal trends are visible. The suggestion made for the more fertile areas of the Levant, that the late Pleistocene saw a change from opportunistic to more selective hunting practices, does not appear to apply to eastern Jordan. Instead, there seems to be inter-site variation which is not related to time.

Section 3: Is gazelle hunting 'specialized'?

The previous section concludes that there is no firm evidence for the selection of gazelle above other taxa in eastern Jordan. That they occur in high proportions at many sites could be explained equally well as a reflection of their frequency in the area as by preferential selection. This section explores whether particular age or sex groups were the focus of the culls **within** gazelle hunting, and whether evidence exists for particular hunting techniques, such as herd driving. The history of ideas relating to Levantine gazelle hunting, which includes suggestions of loose management, 'proto-domestication' and mass-killing, is reviewed in Chapter 2.

Exploration of these issues is undertaken primarily through age and sex profiles of the gazelles culled. These then require comparison with **expected** compositions of gazelle populations. The model in Chapter 4 predicts the age and sex structures of populations for prehistoric eastern Jordan, and suggests both seasonal and regional variations in the social compositions of herds. Indicators of probable hunting times, or seasons, are ideally required for such an analysis.

Firstly, gazelle age and sex data are presented. Secondly, any evidence for hunting times/seasons is examined. Lastly, these patterns are assessed in relation to the models of gazelle population structure developed in Chapter 4.

Gazelle age data

Age determination has used dental eruption and wear sequences, and the relative timing of epiphyseal fusion.

Dental eruption and wear

The method for identifying deciduous and permanent dentition from mandibular root sockets, and the reasons for resorting to such a coarse assessment of age classes, are described in Chapter 5.

Table 7.11 shows the counts and ratios of deciduous to permanent dentition for each assemblage, and for the larger samples these have been calculated as percentages of juveniles, shown in table 7.12. The figures in both tables 7.11 and 7.12 should be treated with great caution, firstly because sample sizes are often very small, and secondly because preservation may well be biased against the survival of juvenile mandibles. Despite these misgivings, table 7.12 shows the three early Epipalaeolithic assemblages from KH4 as having similar proportions of juveniles (23-31%), whilst WJ6 A has a much lower 9%. The two PPNB assemblages, DH 1 and WJ7 2, both have 28% juvenile dentitions, although samples sizes are very small. The sample from WJ13 is also too small to be of use, but the other Late Neolithic assemblage, DH 2, has the highest percentage of juveniles observed (60%). Observations on modern *Gazella gazella* and *Gazella dorcas* from Israel (Davis 1980b), find that the deciduous dentition is replaced by the permanent teeth by the time the animal is 20 months old, with dP_4 being shed at varying times between 14 and 20 months. Although it is not wise to extrapolate these kind of figures directly onto archaeological specimens, data on the **relative timings** of tooth eruption and wear which modern samples can provide can be usefully applied.

gazelle mandibles			
assemblage	deciduous dentition	permanent premolars	ratio of juvenile:adult
PPNC/L NEO			
B27 2	1	0	1:0
JEBEL NAJA	0	0	
DH 2	18	12	3:2
WJ13 1,2,3	6	8	3:4
WJ25	0	0	
PPNB			
DH 1	5	13	1:3
WJ26	0	0	
WJ32	0	0	
IBN EL-GHAZZI	0	0	
WJ7 1	0	0	
WJ7 2	5	13	1:3
WJ7 3	0	0	
WJ7 4	0	0	
WJ7 5	0	0	
LATE EPIPAL			
KH ANAZA	0	0	
AZ 18	1	2	1:2
MIDDLE EPIPAL			
WJ22 B	7	1	7:1
WJ22 C	4	3	4:3
WJ22 E	0	3	0:3
AZ17	0	1	0:1
WJ10	0	0	
WJ8	0	0	
EARLY EPIPAL			
WJ6 A	3	32	1:11
WJ6 B	0	0	
WJ6 C	0	0	
KH4 D	27	75	1:3
KH4 C	1	1	1:1
KH4 B	11	25	1:2
KH4 A	8	27	1:3
UW14	0	0	
UW 18	1	1	1:1
LATE U PAL			
WJ9	0	0	

Table 7.11. Gazelle dental data. The two left-hand columns show the number of deciduous to permanent premolar tooth rows, counting either teeth in jaws or root sockets (this data is reduced to the minimum number of units, and both left- and right-hand sides counted). The right-hand column shows these data as a ratio.

gazelle mandibles		
assemblage	% juveniles	sample size
L NEO		
DH 2	60%	30
PPNB		
DH 1	28%	18
WJ7 2	28%	18
EARLY EPIPAL		
WJ6 A	9%	35
KH4 D	26%	102
KH4 B	31%	36
KH4 A	23%	35

Table 7.12. The percentages of juvenile gazelle mandibles, based on data in table 7.11.

In an attempt to clarify the age of the older animals represented in the assemblages, wear stages of the mandibular third molar (M_3) have been used. The M_3 is used since this tooth potentially documents the period of the animal's life after 20 months of age, therefore after deciduous tooth replacement, and is also easily identifiable when out of the jaw (whereas M_1 and M_2 prove hard to separate). The number of these teeth with recordable wear patterns, however, is very few. Such meagre data cannot be used to create proportions of age groups, but are presented here to show the presence of animals of two particular adult age categories. Table 7.13 shows the number of M_3s at Payne (1987) wear stage 11G compared to the number at more advanced stages of wear (therefore any of the stages between 12G and 20G following Payne 1987). At stage 11G, all three cusps of the tooth are in wear and the infundibula of the two anterior cusps are isolated into 'islands' of enamel.

gazelle M_3		
assemblage	M_3 at stage 11G	M_3 beyond stage 11G
PPNC/L NEO		
DH 2	4	2
WJ13 1,2,3	3	0
PPNB		
DH 1	1	0
WJ7 2	3	0
LATE EPIPAL		
AZ18	1	0
MIDDLE EPIPAL		
WJ22 B	0	1
WJ22 C	1	0
WJ22 E	1	1
EARLY EPIPAL		
WJ6 A	1	0
KH4 D	4	2
KH4 C	0	1
KH4 B	2	1
KH4 A	5	0

Table 7.13. The number of gazelle M_3s at earlier (stage 11G) and later (beyond stage 11G) adult wear stages (following Payne 1987). Both left- and right-hand side teeth are counted.

Assigning approximate time ranges to these wear stages is difficult. Davis has documented the wear sequences of a sample of modern gazelles from Israel (Davis 1980b), but his samples only include individuals of up to 30 months of age. He finds that the M_3 is fully erupted by 20 months, with all three cusps in wear after 21 months. Payne's (1973) stages G and H (which equate to stage 11G, using his 1987 codes for isolated teeth) are reached between 21 and 30 months. Since, however, there are no individuals older than 30 months these stages may well continue for longer, and we know from studies on other taxa that stages G and H can last a long time (e.g. 4 years in the modern sheep studied by Payne 1973). It is impossible, therefore, to estimate the approximate ages at which gazelle M_3s are likely to enter the wear stage 11G, and the timing of such events will most likely vary between populations anyway. Instead, wear stage 11G is taken simply to represent younger adults, whilst stages above 11G describe older adults. A more detailed picture of the relative wear sequence could be constructed if large numbers of M_3s were available, but as table 7.13 shows, samples are too small to give much resolution of the adult age classes.

Interpretation of table 7.13 is problematic because samples are so small as to make any differences virtually meaningless. A slight bias, however, towards younger adults over older adults may be suggested overall, and this would be the expected pattern for populations in life. A related observation is that none of the assemblages shows a predominance of animals in the older adult category, which might be the expected pattern if slower or weaker animals were the targets of hunting, although without knowing even roughly what ages these stages represent, this may be a false conclusion. That the younger adult category is always present (except at KH4 C) suggests that prime age groups were also taken.

Epiphyseal fusion

Unusually, gazelle fusion data from the sites provides an often more reliable and detailed picture of age determinations than that given by the dentition. Fusion is recorded in all cases for the minimum number of bone ends (MNE), so that results are not influenced by fragmentation, although the differential preservation of fused and unfused bones is always an unquantifiable problem with fusion data. Results for assemblages which have at least 15 gazelle bones yielding fusion information are shown in tables 7.14-7.32. There are four main age groupings which provide useful information: ends which fuse at c. 2 months; those which fuse between 3 and 8 months; one end which fuses at 8-10 months; and those which fuse from 10-18 months. This fusion sequence is based on Davis' (1980b) study of modern *Gazella gazella* from Israel (outlined in Chapter 5), and although the absolute ages and age-ranges of fusion may differ between populations, it is the **relative** sequence which is important for the archaeological application (although Davis' ages have been given for comparison). Tables 7.14-7.32 also give counts of newborn postcranial elements compared to the total number of postcranial elements.

There are only nine assemblages which provide large enough samples of fusion data to give significant results. For these, the percentages of unfused ends of the total number of unfused and fused ends have been calculated, using only those bones which fuse between 10 and 18 months (so as to avoid depressing the percentage of juveniles by including fused bones which fuse at 2-8 months). Watson (1978) has warned against grouping elements when assessing fusion, because to do so is to assume that each fragment comes from a different individual. Grouping of elements, plus left- and right-hand sides, has been done in this study, however, firstly because sample sizes would be very small if they were not, and secondly, it is believed that grouping may compensate for potential distortions of differential body part representation. The percentage of unfused ends at 10-18 months is taken to represent juvenile animals in dental terms, and results are shown in table 7.33. Davis' observations of modern *Gazella gazella* show all bones to have fused by 12-18 months, meaning that juveniles are less than c. 18 months (Davis 1980b:133).

gazelle fusion results		
assemblage	% juveniles	sample size (ends fusing at 10-18 months)
PPNC/L NEO		
WJ13 1	32%	57
DH 2	44%	845
PPNB		
DH 1	55%	366
WJ7 2	42%	48
MIDDLE EPIPAL		
WJ22 B	36%	33
EARLY EPIPAL		
WJ6 A	32%	183
KH4 D	34%	587
KH4 B	27%	164
KH4 A	25%	232

Table 7.33. The percentage of juvenile gazelles from 9 assemblages, calculated using the number of unfused to fused bones in the group which fuse between 10 and 18 months (i.e. proximal femur, calcaneum, distal metapodials, distal femur, proximal humerus, ulna, proximal tibia and distal radius).

For an examination of cull patterns within the period when the animal is considered 'juvenile', the data for 10 assemblages with larger sample sizes are summarized in table 7.34.

gazelle fusion data*					
Assemblage	% culled < c. 2 months	% culled < 3-8 months	% culled < 8-10 months	% culled <10-18 months	n
PPNC/L NEO					
WJ13 1	3	25	25	32	158
DH 2	12	22	38	44	1729
PPNB					
DH 1	17	25	43	55	745
WJ7 2	0	23	50	42	100
MIDDLE EPIPAL					
WJ22 B	3	15	25	36	107
EARLY EPIPAL					
WJ6 A	0	1	29	32	403
KH4 D	0	2	26	34	1673
KH4 C	0	0	25	35	73
KH4 B	0	1	12	27	456
KH4 A	0	2	28	25	508

Table 7.34. Summary of data from tables 7.14-7.34, showing the percentage of animals culled in the four different fusion groupings. n=sample size. *Note that ranges given should read, for example for the < 3-8 months category, that 25% of animals died below 8 months, but not necessarily below 3 months (cf. Watson 1978).

From table 7.34 it can be seen that the early Epipalaeolithic assemblages show roughly similar patterns, with no gazelles of less than c. 2 months of age being represented, and very few below 8 months of age. It should be remembered that unfused bones in these age groups will probably always be under-represented because their small size and relative fragility mean that they survive badly, and are hence less identifiable than older, fused specimens. It would appear, however, that the paucity of bone from animals of less than 8 months of age may not be entirely due to preservational factors, since the later sites all have a higher representation of this age group. There may, of course, be preservational differences between the earlier and later sites, but this is argued against for two reasons. Firstly, the assessment of bone taphonomy and treatment in Chapter 8 suggests that there are no great differences in the survival of bone between assemblages. Secondly, as will be discussed below, all of the early Epipalaeolithic assemblages contain bones of newborns. These are admittedly not present in large numbers (between 1 and 8 newborn ends in each assemblage), but they at least show that extremely small and fragile bones are surviving at these sites. It is argued here, therefore, that the early Epipalaeolithic assemblages show very low numbers of gazelles below the age of 8 months.

It is in the next fusion stage, below 8-10 months, that most of the early Epipalaeolithic sites show the greatest increase in the number of animals culled. KH4 B shows the lowest percentage of animals in this age bracket (12%); the rest range between 25 and 29%. Compared to this jump, the next age range, that of < 10-18 months, does not represent such an increase, with four of the assemblages showing only a 3-10% increase in the number of animals culled. The exception to this is again KH4 B, where a much higher number of animals is shown to have been culled at the < 10-18 stage than at the previous age stage (27% versus 12%). As has already been seen in table 7.33, the number of animals culled < 10-18 months, i.e. the percentage of juveniles, is fairly similar between all of the early Epipalaeolithic assemblages (between 25 and 35%).

The single middle Epipalaeolithic sample, although showing a similar percentage of animals culled at the < 10-18 month stage (36%), has a rather different cull pattern to the early Epipalaeolithic ones. This assemblage, WJ22 B, shows that 3% of the animals represented were culled at less than c. 2 months of age, and 15% of animals were culled at the < 3-8 month stage. Thus a much greater proportion of animals is seen to have died below 8 months of age at WJ22 B than in any of the earlier assemblages.

All Neolithic assemblages, both PPNB and Late Neolithic, show higher percentages of gazelles dying below 8 months of age (from 22-25%). DH 1 and DH 2 also show relatively high numbers of animals culled at up to c. 2 months of age (17% and 12% respectively). The three assemblages of WJ7 2, DH 1 and DH 2 each show higher percentages of animals culled at the higher age brackets also, resulting in higher overall numbers of juveniles than seen in any of the Epipalaeolithic assemblages. Late Neolithic

WJ13 1, however, sees lower percentages of animals culled in the < 8-10 and < 10-18 ranges. These low percentages are more similar to those seen in the Epipalaeolithic assemblages than the other Neolithic ones, and they produce an overall juvenile percentage of 32% - much lower than the other Neolithic counts.

Summary of ageing data

1) The percentages of juvenile gazelles in the assemblages have been calculated using both dental data and fusion data. (The results of both methods of calculating juveniles should be comparable since in modern *Gazella gazella* 'juvenile' dentition is seen to reflect animals of less than 20 months old, and unfused 'juvenile' bones represent animals of less than 18 months (Davis 1980b)). Table 7.35 compares the percentages of juveniles found by the two different methods, and shows that although they are fairly similar for some assemblages (KH4 A, KH4 B, KH4 D), results vary considerably for others (WJ6 A, WJ7 2, DH 1, DH 2). The sizes of the dentition samples from DH 1 and WJ7 2, however, are so small (18 mandibles each) as to be unrepresentative. The percentages based on fusion data would appear more accurate, both because sample sizes are larger and more elements are used to produce the result, thereby reducing the potential effect of differential use of parts. These, therefore, are the figures that are used in further discussion. The proportion of juveniles is higher in the PPNB assemblages than in the early Epipalaeolithic; for the Late Neolithic, DH 2 has a 'high' percentage, whilst the figure for WJ13 1 is lower.

percentages of juvenile gazelles		
assemblage	% juveniles based on dentition	% juveniles based on fusion
PPNC/L NEO		
WJ13 1	-	32%
DH 2	60%	44%
PPNB		
DH 1	28%	55%
WJ7 2	28%	42%
MIDDLE EPIPAL		
WJ22 B	-	36%
EARLY EPIPAL		
WJ6 A	9%	32%
KH4 D	26%	34%
KH4 B	31%	27%
KH4 A	23%	25%

Table 7.35. A comparison of the results of the two methods of calculating the percentages of juvenile gazelles. The left side shows the % juveniles based on a count of deciduous versus permanent dentition (data from table 7.12); the right side shows % juveniles based on fusion data (see table 7.33).

2) Tooth wear data are very few. Wear patterns of M_3s suggest that some younger adults are always present in the assemblages, and are slightly better represented than the older adult category. None of the assemblages has a predominance of older adults.

3) Fusion data show few animals in the early Epipalaeolithic to be culled before 8 months of age, whilst the middle Epipalaeolithic, and particularly Neolithic assemblages have higher percentages of animals culled before 8 months. Early Epipalaeolithic samples generally show that a lot of animals are culled by the age of 8-10 months, and relatively fewer in the later juvenile months. Neolithic assemblages, with the exception of WJ13 1, show an increasing number of animals to be culled at each fusion/age bracket, suggesting that all the juvenile age classes were being culled.

Gazelle sex data

Two methods have been used for exploring sex distribution: counts of male and female horn cores, and metrical analyses.

Horn cores

Table 7.36 shows the numbers of male and female gazelle horn cores identified from assemblages. As can be seen, sample sizes are often very small, especially since both left- and right-hand sides have been included. There are two main reasons why gazelle horn core counts, even if they constitute large samples, may not provide an accurate reflection of the proportions of males and females at a site. Firstly, since female horn cores are short, slender, bud-like pieces of bone, whilst (adult) male horn cores are much larger and more robust, a preservational bias against females is likely. Secondly, because of their different morphology, the horn cores of the two sexes may be treated differently. Male horns, for example, could be removed in butchery (maybe away from site?) if they hinder the skinning process, or maybe male and female horn cores would be treated differently in terms of bone working, tool manufacture or in their use as trophies (in this respect, it is notable that the burial in KH4 B had male gazelle horn cores placed either side of the head (Rolston 1982)). The figures shown in table 7.36, therefore, should be treated with caution. An interesting difference, however, is seen between KH4 A and B, which have very low numbers of female horn cores counted, and KH4 D, where females make up almost 50% of the total of male and female identifiables.

gazelle horn core data			
assemblage	males	females	tot horn cores
PPNC/LN			
B27	0	0	0
JEBEL NAJA	0	0	0
DH2	9	4	16
WJ13 1	2	0	3
WJ13 2	0	0	0
WJ13 3	0	0	1
WJ25	0	0	0
PPNB			
DH1	3	3	11
WJ7 5	0	1	1
WJ26	0	0	0
WJ32	0	0	0
IBN EL-GHAZZI	0	0	0
WJ7 2	3	2	5
LATE EPAL			
KH ANAZA	0	0	0
AZ18	0	0	0
MIDDLE EPAL			
WJ22 B	0	0	1
WJ22 C	0	0	1
WJ22 E	0	0	0
AZ17	0	0	0
WJ10	0	0	0
WJ8	0	0	0
EARLY EPAL			
WJ6 A	0	2	4
WJ6 B	0	0	0
WJ6 C	0	0	0
KH4 D	30	13	54
KH4 C	3	0	3
KH4 B	15	0	15
KH4 A	41	3	47
UW14	0	0	0
UW18	5	0	5
LATE UPAL			
WJ9	0	0	0

Table 7.36. The number of male and female gazelle horn cores from each assemblage (both left- and right-hand sides counted), with the total number of horn cores represented by fragments shown in the right hand column.

Metrical analysis

As already seen in section 1 of this chapter, where gazelle measurements are used to explore size change over time, there are few elements which provide sufficient measurements for analysis. The astragalus is the only bone which is frequently measurable, and it is therefore fortunate that this bone has a degree of sexual dimorphism (Cope 1991; Garrard

1980; Horwitz *et al.* 1990), although there is much overlap between the sexes and no clear bimodality. Payne and Bull state, with reference to pig bones, that "bimodality only starts to be apparent when the means are separated by three or four standard deviations; and only when means are separated by four or five standard deviations does it start to be possible to assign most specimens to one group or the other with some reliability" (Payne and Bull 1988:32). By this definition, two morphometric studies of modern *Gazella gazella* from Israel (Horwitz *et al.* 1990; Davis pers. comm.) both show the means of male and female astragali to be separated by 2 or less standard deviations, and therefore suggest that the two sexes will form a single broad group. A method which has been used for separating the sexes of prehistoric gazelle bones in Palestine is to compare astragalus measurements (greatest length of lateral side=GLl and breadth of distal end=Bd) directly with modern equivalents of known sex (Horwitz *et al.* 1990). This cannot be done with the eastern Jordanian material, since the species of gazelles are not known in most cases, and the sizes of the bones do not fall within the ranges of the modern samples of known sex.

Instead, the approach followed here is to use the **variance**, rather than sizes alone, of the modern population (of the complete population, and male and female parts), for comparison with the variance of the archaeological samples.

It has already been argued in section 1 of this chapter that the patterns seen in figures 7.2, 7.3, 7.4 and 7.5, reflect a reduction in size of gazelles between the Epipalaeolithic and Neolithic, rather than different selective hunting practices (i.e. males earlier and females later). Further, tests showed that the variance of the Neolithic measurements compared better with that of the complete modern population than with that of a single female group, i.e. it is more likely that both sexes are present in the Neolithic samples. For the early Epipalaeolithic samples, however, the tests showed that for the astragalus measurements, there is a significant difference in variance between the archaeological material and the complete modern population. Rather, the variance of the early Epipalaeolithic samples compared well with that of the modern male group alone. This could suggest that by statistical comparison with a modern population, the Epipalaeolithic gazelle bone measurements would seem to reflect predominantly male animals. There are two reasons why this is not believed to be the case:

1) Despite the misgivings of using horn core evidence, table 7.36 shows that females **are** present in the early Epipalaeolithic assemblages, particularly at KH4 D where they constitute almost 50% of the identifiable horn cores. It would be surprising if this (possibly under-represented) presence of females did not show up in the bone measurements.

2) The early Epipalaeolithic assemblages potentially cover a period of 5,000 years of repeated occupation, and each assemblage contains the accumulated results of

multiple hunting events. Although obviously possible, it would be fairly improbable that such strong selective practices towards the hunting of males would exist in all hunting circumstances, and over such a long duration of time. In fact, the horn core evidence suggests that this is definitely not the case.

If the suggestion that the early Epipalaeolithic measurements reflect predominantly male culls is rejected, then another explanation is required for the relatively narrow variance of the bone measurements. Why do the early measurements compare better with modern males alone, than with the whole population of males and females, when the above two points argue for both sexes being present? Firstly, the narrower variance of the Epipalaeolithic measurements, when compared to Neolithic and modern gazelle measurements, should be taken as reflecting a narrower degree of variation in the animal sizes **in life**, with the largest and smallest being relatively closer than they are in later or modern samples. One set of factors which affect the size range of wild animals are those which determine sexual dimorphism (another factor could be the over-predation of a certain size group, thus reducing variability).

Sexual dimorphism

Clutton-Brock, Guinness and Albon (1982) describe how size differences between males and females in a population can be explained in terms of the different selective pressures bearing on reproductive success. In brief, females compete amongst one another for nutritional resources, both for themselves and their offspring, and in any given environment, their body size will favour efficiency of food collection and processing. Male reproductive success, however, is usually limited by access to females. If competition between males is intense, then larger body size would favour their fighting ability, and hence be advantageous in terms of selection (Clutton-Brock *et al.* 1982:4-5).

In the early Epipalaeolithic in eastern Jordan, in the region around the Wadi el-Jilat, palaeoenvironmental reconstructions suggest cool, moist conditions which may have supported fairly dense grassland (see Chapter 3). If the models of gazelle behavioural ecology given in Chapter 4 are correct, then one would expect small scattered herds to form under such conditions. The formation of male territories would **not** be limited by patchy resources, but would presumably be feasible over wide areas, and hence competition between males may be relatively low. Under these circumstances, large body size may not have been necessarily advantageous for males, and females may not have found a selective advantage in small size, since food resources were not limited.

By the early Holocene, the climate of eastern Jordan is believed to have been similar to that of today: semi-arid, hot, with rainfall limited to winter months. At any period, rainfall in the Basalt Desert area - where the more varied gazelle size ranges are seen - is expected to be less than in the more westerly Wadi el-Jilat area, but by the Holocene, the aridity of this area may well have limited plant growth, as it does today. Following the modelling presented in Chapter 4, gazelle herds may have become more concentrated in areas of patchier vegetation, especially in the autumn at the time of the rut. Under these circumstances, males may have been under intense competition in the formation of territories, and larger body size would have been an advantage. Females, on the other hand, who compete for food resources rather than for males, would probably be favoured by smaller body size under conditions where vegetation is sparse.

In conclusion, it is argued that **differences in the constraints acting on sexual dimorphism could explain the increase in gazelle size variance observed between the Epipalaeolithic and Neolithic bone measurements.** Other possible explanations for the pattern, such as selection or over-predation having reduced variability in the Epipalaeolithic, find no support in the data. Firstly, there are no earlier assemblages in the region with which to compare variance, and so the Epipalaeolithic assemblages cannot be considered 'narrow' in variance, when the norm is not known. Secondly, if the 'narrow' variance is seen to be a result of over-predation of animals with a **wider** range of variance (therefore leaving a narrow range as the breeding pool), then this practice would need to be continued over the period of occupation of the sites, for the effects to be continuously visible. The larger and smaller animals would have to be cropped elsewhere, and over long periods of time, and, as yet, there is no evidence for this in the region.

Having presented a case for both sexes of gazelle being represented by both the Epipalaeolithic and Neolithic measurements, an analysis of variation **within** each of these groups allows possible sex distributions to be explored.

Tests for the analysis of variance were done on humerus HTC, astragalus Bd and GLl within the early Epipalaeolithic group and the Neolithic group. The early Epipalaeolithic measurements used are from WJ6 A, KH4 A, B and D; for the Neolithic, DH 1 and 2 were used for astragalus measurements, and DH 2 and WJ13 1 were used for comparison of humerus HTC (since these provide the largest sample sizes). Results of the analysis of variance are shown in tables 7.37, 7.38 and 7.39.

a) Epipalaeolithic: gazelle humerus HTC		
assemblage	mean (mm)	sample size
WJ6 A	13.9	16
KH4 D	14.3	28
KH4 B	13.9	15
KH4 A	14.2	18
significance of F: .137		

b) Neolithic: gazelle humerus HTC		
assemblage	mean (mm)	sample size
WJ13 1	13.5	18
DH 2	13.4	12
significance of F: .670		

Table 7.37. Results of the analysis of variance of gazelle humerus HTC from a) the Epipalaeolithic, and b) the Neolithic measurements.

a) Epipalaeolithic gazelle astragalus Bd		
assemblage	mean (mm)	sample size
WJ6 A	15.9	24
KH4 D	16.1	48
KH4 B	15.7	28
KH4 A	16.0	47
significance of F: .013		

b) Neolithic gazelle astragalus Bd		
assemblage	mean (mm)	sample size
DH 2	14.9	26
DH 1	15.2	24
significance of F: .110		

Table 7.38. Results of the analysis of variance of gazelle astragalus Bd for a) the Epipalaeolithic, and b) the Neolithic measurements.

a) Epipalaeolithic gazelle astragalus GL1		
assemblage	mean (mm)	sample size
WJ6 A	26.7	26
KH4 D	27.1	71
KH4 B	26.7	27
KH4 A	27.1	43
significance of F: .047		

b) Neolithic gazelle astragalus GL1		
assemblage	mean (mm)	sample size
DH 2	25.1	31
DH 1	26.0	28
significance of F: .007		

Table 7.39. Results of the analysis of variance for gazelle astragalus GL1 for a) the Epipalaeolithic, and b) the Neolithic measurements.

Tables 7.37 a) and b) show that there is no significant difference (at the 0.05 level) in the variance of humerus HTC measurements within either the early Epipalaeolithic group or the Neolithic group. This is not surprising since it was already shown in section 1 of this chapter that there was no significant difference in variance **between** these two groups for this measurement. Although measurements of the forelimb of ungulates are generally considered useful for separating the sexes, Payne and Bull note that humerus HTC measurements often show little sexual dimorphism (Payne and Bull 1988). The results shown in table 7.37, therefore, are not useful for examining sex distributions.

Turning to the astragalus, it can be seen that a significant difference (at the 0.05 level) in variance exists within the early Epipalaeolithic groups for both measurements (see tables 7.38a and 7.39a). Also, for each measurement, the means of the WJ6 A and KH4 B samples are smaller when compared to those of the KH4 A and D. This trend is shown graphically in figure 7.10, where the two astragalus measurements are plotted against each other for each early Epipalaeolithic assemblage. The smaller sample sizes of WJ6 A and KH4 B (Bd=24, 28; GLl=26, 27, respectively), compared to KH4 A and KH4 D (Bd=47, 48; GLl=43, 70, respectively), may be, in large part, responsible for the difference in variance noted for these assemblages: figures 7.2 and 7.3 (in section 1) show how the smaller samples produce a low, flat 'curve', whilst the larger ones see higher curves at their centres. Sample size, however, cannot be responsible for the lower means of WJ6 A and KH4 B, which reflect the higher number of smaller bones in these two assemblages.

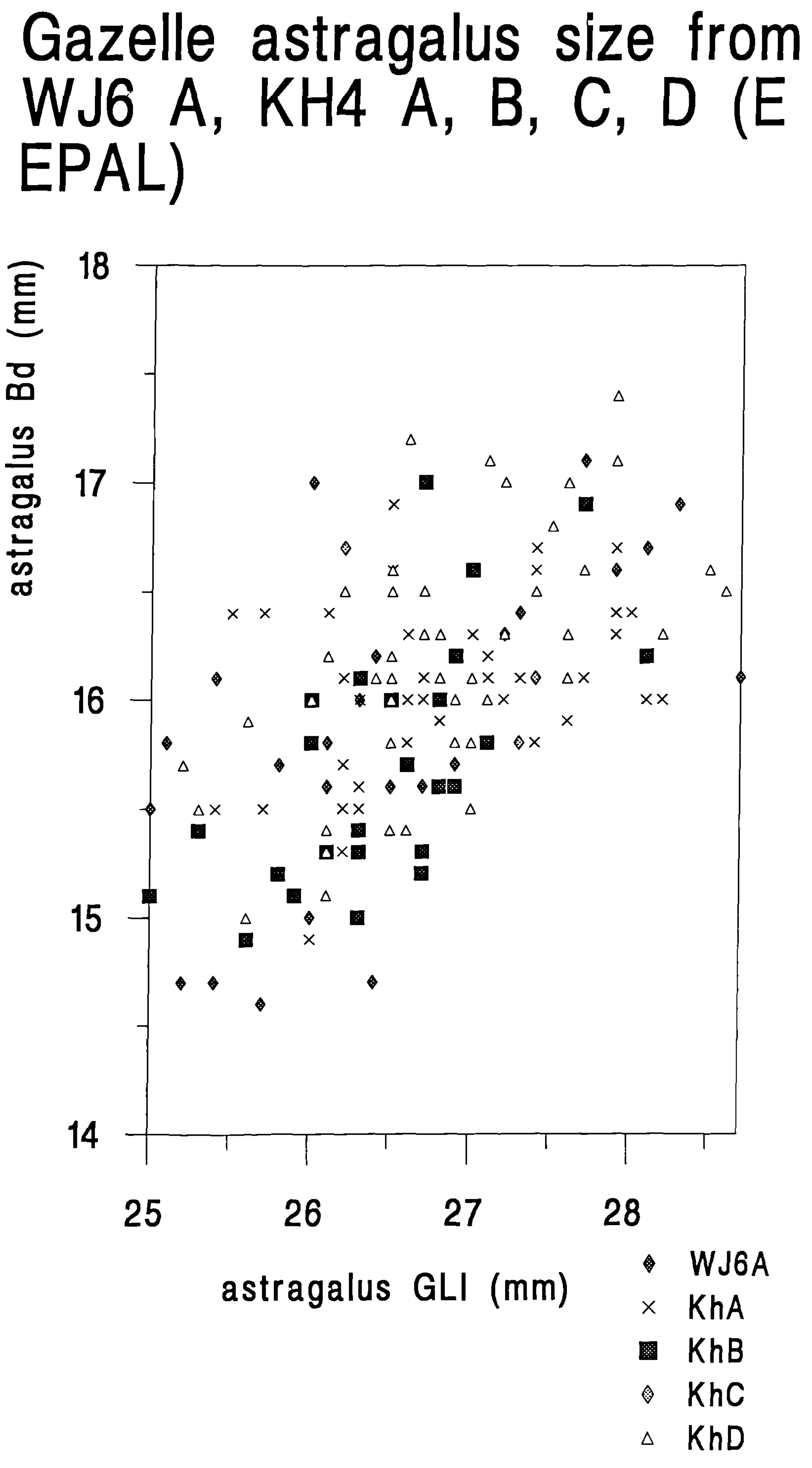


Figure 7.10. Graph showing gazelle astragalus size from WJ6 A, KH4 A, B, C, D.

If the larger samples are taken to show fairly equal numbers of males and females, represented in their more normal distributions, then WJ6 A and KH4 D are tentatively interpreted as showing higher numbers of females. Since absolute sizes and ranges of the two sexes are unknown, quantification of this observation is impossible.

For the Neolithic sites, i.e. DH 1 (PPNB) and DH 2 (Late Neolithic), results of the analysis of variance are shown in tables 7.38 b) and 7.39 b). Since these two assemblages could potentially be separated by a period of c. 1,000 years (on C^{14} dating), a period which is believed to experience increasing aridity and temperature elevation, the possibility of a further climate-related size decrease in animals should not be ignored. That astragalus Bd measurements show no significant change between the two samples, however, would argue against this being the case.

From her morphometric observations of modern *Gazella gazella*, Cope states that the astragalus of the male is not only different in size, but also in **proportions**, from that of the female (Cope 1991:345). She describes male astragali as being longer and proportionally narrower than their female equivalents. Accordingly, measurements of modern gazelle astragali show that there is a greater difference in means between males and females on the GLl measurement than there is on Bd (Horwitz *et al.* 1990). This is very interesting in relation to the test results for Neolithic astragali seen in tables 7.38 b) and 7.39 b). In the PPNB, the Bd mean is 15.2mm, compared to a lower 14.9mm in the Late Neolithic; the difference is not statistically significant (at the 0.05 level). The difference between astragalus GLl measurements from the two assemblages, however, is highly significant (0.007), with the Late Neolithic bones being much shorter than those from the PPNB. That the size difference is mainly in the length of astragali may point to differences in sex distributions between the two assemblages, following Cope's (1991) observations on the sexual dimorphism of this bone. An interpretation of more males in DH 1 (PPNB) and more females in DH 2 (Late Neolithic) would seem to fit the data.

In the above discussion, the use of slightly different criteria for interpreting the same measurements in different periods (i.e. astragalus size differences in the Epipalaeolithic, but differences in astragalus **proportions** in the Neolithic) should be justified. An increase in gazelle sexual dimorphism between the Epipalaeolithic and Neolithic has already been argued for above. Cope (1991:345) attributes the different proportions of the gazelle astragalus to sexual dimorphism, with those of males being longer and narrower as a response to different mobility needs. (This phenomenon, however, seems best explained by descriptions of male gazelles fighting behaviour during the rut: Habibi *et al.* observe competing males locked at the horns and engaging in a pushing and shoving contest (1993:48), whereby strength (and length) in the hind leg would presumably be a great advantage) . If, therefore, there is an increase in sexual dimorphism in gazelles in the Neolithic, this would suggest that the

Neolithic astragali may have different proportions to the earlier Epipalaeolithic ones which experience less dimorphism. The metrical criteria used to interpret sex distributions may then be different between the two periods.

Summary of sexing data

1) Horn core data should be treated with great caution. The early Epipalaeolithic assemblages of KH4 A, B and D show fairly high numbers of male horn cores, whereas only KH4 D has a notable presence of female horn cores (they constitute almost 50% of the total identifiable to sex). Data from the Neolithic are poor; DH 1 has equal numbers of male to female horn cores, whereas DH 2 has twice the number of males to females.

2) Results of a metrical analysis of the astragalus suggest that of the early Epipalaeolithic assemblages, WJ6 A and KH4 B may have a higher number of females than do the other samples (which are taken to represent roughly equal proportions of the two sexes). For the Neolithic, DH 1 sees a slight male bias, whereas DH 2 may show a slight bias towards females.

3) It is interesting to note that the horn core data show no accordance with the metrical data. Conclusions based on the measurements are assumed to be more representative than any based on horn core evidence, for reasons outlined above.

Indications of hunting times

A single line of evidence - inferences from gazelle culls - can be used to suggest which times of the year hunting may have been taken place.

Following the reconstruction of gazelle behaviour in Chapter 4, births are expected to take place once a year, in the spring; the months of March/April are used (from comparisons with modern Near Eastern herds) as reference points. The presence of bones from newborn animals, therefore, indicates that they were culled in spring. Likewise, the presence of unfused distal humeri and proximal radii, which fuse at c. 2 months of age, suggests that some animals were culled between spring and early summer (i.e. March to June). Table 7.40 summarises the data for newborns and animals of less than c. 2 months for each assemblage where these categories are present.

gazelle newborns and animals < 2 months old			
	% (and number) of newborn ends (i.e. March/April)		% of bones fusing < 2 months old (%) (i.e. < May/June)
PPNC/L NEO			
WJ13 1	0.2	(1)	3
DH 2	0.07	(4)	12
PPNB			
DH 1	0.0	(0)	17
LATE EPIPAL			
AZ18	0.0	(0)	33*
MIDDLE EPIPAL			
WJ22 B	0.6	(2)	3
WJ22 C	12.1	(11)	12*
EARLY EPIPAL			
WJ6 A	0.2	(1)	0
KH4 D	0.1	(4)	0
KH4 C	0.6	(1)	0
KH4 B	0.9	(6)	0
KH4 A	0.9	(8)	0

Table 7.40. The left column shows the percentage of newborn ends (of the total of postcranial ends) and their number in brackets. The right column gives the percentage of bones fusing at c. 2 months which are unfused. *NB: AZ18 figure based on total of 3 ends, and WJ22 C figure based on total of 16 ends. Data taken from tables 7.14-7.32.

It is fairly unsatisfactory to use the older stages of fusion data to indicate hunting times since the ranges of fusion times often cover many months, but in the absence of informative dental data these have been explored. Large drops in animal survivorship in the < 3-8 and < 8-10 age classes, shown in table 7.34, are taken to represent an increase in the number of animals hunted (the < 10-18 class is not used because the information provided is too broad). So, for example, if 29% of animals died in the < 8-10 month bracket, as they do in WJ6 A, and only 1% die at the earlier stage of < 3-8 months, then this drop can be significant for implying the timing of culls. Because of the nature of fusion data, however, the drop is strictly between 3 and 10 months, indicating that the cull occurred between June and February. Figure 7.11 shows the results of such an analysis of fusion data, and includes the evidence for newborns and animals of less than c. 2 months which is shown in table 7.40.

The inferences of figure 7.11 should be treated with caution for two main reasons. The first obvious problem is that the sample sizes of some of the classes of data are very small (e.g. newborns and bones unfused below c. 2 months). The preservational biases likely to act against these age classes, however, mean that their presence is more significant than their small number may imply. Secondly, to use animals' ages, or age stages, as seasonal indicators relies heavily on the identification of the time(s) of birth. In this study, a single birth peak is assumed for gazelles. If, however, there were fawns born outside this period (stragglers), any interpretation may be inaccurate.

Figure 7.11 (following page). At the top of the table the ages (in months) are shown, which correlate with actual months if a March/April birth is assumed for gazelles (March=0 months). The data shown for each assemblage are: number of newborn ends (dashed line); number of unfused proximal humeri and distal radii (dotted line) which fuse at c. 2 months; increases in the percentage of unfused bones, implying increase in number of animals culled (bold line).

gazelle culls: possible timing												
age in months	0 12	1 13	2 14	3 15	4 16	5 17	6 18	7	8	9	10	11
assembl	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	jan	feb
WJ13 1	1 newb. -------	------- ____	1 unf. .... ____	.... ____	.... ____	22% incr. cull ____	____	____	____	____		
DH 2	4 newb. -------	-------	40 unf.	.... ____	.... ____	16% incr. cull ____	____	____	____	____	____	____
DH 1			23 unf.	.... ____	.... ____	18% incr. cull ____	____	____	____	____	____	____
WJ7 2		____	____	____ ____	____ ____	23% incr. cull ____ ____	____ ____	____ ____	____ ____	27% incr. cull ____ ____	____	____
AZ18			1 unf.	....	....							
WJ22 B	2 newb. -------	------- ____	1 unf. .... ____	.... ____	.... ____	12% incr. cull ____	____	____	____	____		
WJ22 C	11 newb. -------	-------	2 unf.	....	....							
WJ6 A	1 newb. -------	-------		____	____	28% incr. cull ____	____	____	____	____	____	____
KH4 D	4 newb. -------	-------		____	____	24% incr. cull ____	____	____	____	____	____	____
KH4 C	1 newb. -------	-------		____	____	25% incr. cull ____	____	____	____	____	____	____
KH4 B	6 newb. -------	-------		____	____	11% incr. cull ____	____	____	____	____	____	____
KH4 A	8 newb. -------	-------		____	____	26% incr. cull ____	____	____	____	____	____	____

Having outlined these problems, some patterns emerge. All the early Epipalaeolithic assemblages (KH4 A, B, C, D and WJ6 A) show the presence of some newborns, indicating spring hunting (March/April). None, however, has evidence for hunting in the following two months - May/June. All of the assemblages except KH4 B then show a substantial increase in the number of animals culled (i.e. % of juveniles) at 3-10 months. (This age stage is shown in figure 7.11 as covering June to February, the extra month being added to account for births probably spanning two months). For these assemblages, the 3-10 month cull is not very informative; it suggests that hunting took place at some time between June and February, but any more detailed picture of **when** cannot be gained from this line of evidence. The pattern from KH4 B differs from the others in that it does not have a very large increase in animals culled between June and February (11%). Interpretation of small drops in survivorship are more prone to error (e.g. differential preservation, sampling bias etc.), meaning that the culls from KH4 B do not show strong patterning.

Both the middle Epipalaeolithic assemblages at WJ22 (B and C) indicate hunting from March to June. The fusion evidence from the later assemblage, WJ22 B, suggests animals were being taken between June and December, but again, the increase in juvenile cull is fairly small.

The only line of evidence from late Epipalaeolithic AZ18 is a single bone indicating a May/June death.

There are distinct patterns for the Neolithic assemblages. Both DH 1 and 2 have a very high representation of animals culled in May/June (although only DH 2 has newborns). They then both show strong evidence for culling between June and February, although **when** within this broad period is not clear. There is, therefore, a strong suggestion of hunting in the spring and early summer months at the site, both in the PPNB and Late Neolithic, although interpretation of other possible seasons is not possible from the cull data alone.

Of the other two Neolithic assemblages, PPNB WJ7 2 has no evidence for any spring hunting (i.e. no newborns or < 2 month olds), and cull evidence suggests June to February hunting. Late Neolithic WJ13 1 has some evidence for spring and early summer hunting, and the greatest drop in juvenile survival is between June and December.

The above discussion shows that the evidence for newborns and < 2 month olds is most informative in terms of identifying some culling seasons. The hunting times suggested by the drops in the proportions of juveniles are too broad to be informative. Inferences for the seasonality of hunting from other data are potentially misleading, since other activities need not coincide with hunting. Here, the newborn category (early spring) will be played off against the < 2 month old category (late spring/early summer), in full realization that culls could, and probably were, taking place at other times too.

Discussion

An integration of the age, sex and hunting time data with the models of gazelle social composition finds two main problems:

1) The assemblages represent the accumulated results of multiple hunting events, potentially covering long time periods. Any attempt to identify 'events' in the assemblages has proved impossible. The gazelle age/sex patterns, therefore, can only be attributable to an **accumulation** of events, which may have varied in season or herd target. In short, there is great potential for blurring the information which is of interest here. Patterns will be strongly identifiable if gazelle hunting is selective and consistent (in terms of selectivity and season). If it is selective but inconsistent - for example young males targetted one season and female groups another - then a blurring will result. If particular hunting techniques were used, such as whole herd driving, this will be identifiable only if the season was consistent, because of varied herd structures throughout the year. If hunting is non-seasonal, and non-selective, then a blurred picture will undoubtedly emerge.

2) None of the assemblages provide unambiguous evidence for seasonal culls, which proves problematic when the aim is to assess age/sex data against expected herd structures at different times of the year.

The solution is to examine only broad trends.

The main points of the gazelle behaviour model are summarized here; Chapter 4 has a full discussion of predicted group sizes, densities and mobility patterns for animals in each of the study areas and periods.

1) Age structure: the number of juveniles (animals < 18 months) in a population would vary between approximately 20% and 40% during the year. Accepting spring births, 40% juveniles might be expected between March and September, whilst as low as 20% could be expected between September and March.

2) Sex ratio: roughly equal proportions of males and females would be expected, although maybe a predominance of adult females in the Neolithic in the Basalt Desert.

3) Herd composition: sexually active males would become territorial and solitary during the rut (October/November); non-sexually active males and sub-adults form bachelor herds;

groups of females would wander through male territories. Winters would see mixed groups. At birthing time (spring) females will become solitary, remaining so for a time after the birth of their fawns whilst the latter 'lie out'. Mother/fawn groups (nursery herds) can form after this period (late spring/early summer). During summers, both sexes and different age groups may aggregate.

From the early Epipalaeolithic in the limestone area, certain trends are observed. Assemblages from KH4 A, B, D and WJ6 A all include newborn gazelle bones indicating culls in early spring (March/April). The proportions of juveniles in these samples are 25%, 27%, 24% and 32% respectively - low figures which accord with their expected representation in herds in winter/spring (September-March/April), by which time animals in their second year will have all bones fused. The lack of any bones suggesting late spring/early summer culling should be noted.

Although samples are small, we can see that hunters were taking newborn animals, or even pregnant females, in the spring. Newborns would probably have been 'lying out', being nursed and protected by their mothers, who were solitary and away from the group at this time. These groups must have made fairly easy targets. We might infer that there was no avoidance of these weaker animals, and in fact, no 'conservation' of the young and breeding females.

It is fairly difficult to interpret other hunting practices from the evidence available. If hunting was primarily taking place in winter/spring (although the only evidence for this comes from the newborn data, the temporary nature of occupations, and environmental expectations), then large mixed herds would probably have been in evidence. It is impossible to say how culling might have taken place, but the above discussion of the newborns might hint at the stalking of groups rather than whole herd kills. Also, the lack of older adults seen in the dental wear data (e.g. from KH4 A, WJ6 A) contradicts the idea of whole herds being indiscriminately taken, since mass kills in winter should include all age classes.

The roughly equal proportions of adult males to females at at KH4 A and D indicates that selecion of particular adult sex groups was not consistent practice. This pattern would not contradict expectations for the taking of mixed herds either, however. The slight over-representation of adult females at WJ6 A and KH4 B might reflect some selection, but the data are not convincing enough to argue for specialized hunting practices.

Lastly, the model of gazelle behaviour might be used to inform on possible hunting practices. In the wide *wadis* of the limestone region, gazelle densities are predicted to be high and herd sizes large in the Epipalaeolithic. Animals are not, however, expected to be tightly clustered (as they are in the Basalt Desert), because forage would probably have been fairly evenly distributed. Although it may be fairly unwise to infer hunting practice on the basis of animal behaviour, it could be suggested that herds around KH4 and WJ6 would not lend themselves to mass capture techniques, because they would probably not have been forced into tight clusters by forage conditions.

The middle Epipalaeolithic assemblages of WJ22 B and C from the same (limestone) area show a slightly different pattern to those discussed above. Both samples show evidence of gazelle hunting in spring and early summer, and from WJ22 B the percentage of juveniles is 36% - higher than those seen earlier. This figure might be consistent with the proportion of juveniles expected in the summer months (March/April-September) - indicating a shift in hunting times from the early Epipalaeolithic. The difference may also be due to the preferential hunting of young animals. This issue is discussed further below.

A major contrast to the limestone Epipalaeolithic is seen at DH 1 and 2 - the large Neolithic assemblages from the Basalt Desert. From both, there is quite strong evidence for primarily early summer (May/June) hunting. The PPNB sample shows 55% of the gazelles killed to have been juvenile, and the LLN sample has 44% juveniles. Both of these figures are higher than predictions would lead us to expect from a random cull of herds, even in summers when the number of (anatomically identifiable) juveniles in a herd is at its maximum. Explanations for this pattern could include the selection of juveniles above adults, the targetting of certain herds where juveniles are dominant (such as the spring/early summer nursery herds), or that the actual proportion of juveniles within populations increased. These alternatives are considered in the discussion below.

In terms of gazelle sex ratios, the earlier assemblage (DH 1) has been interpreted as seeing a slight over-representation of adult males, whilst the latter sees a slight bias towards adult females. The targetting of bachelor herds might be an explanation for the former, and the hitting of birthing females or mother-offspring groups could result in the latter, although neither trend is pronounced enough to see these as consistent practices.

As with the Neolithic in the Basalt Desert, the PPNB assemblage from WJ7 2 in the limestone desert sees a 'high' proportion of juvenile gazelles (42%) and there is no evidence for hunting times. The juvenile count could be explained as reflecting the proportion in nature in the summer months (March/April-September), or alternatively, the population structure of gazelles may have altered since the Epipalaeolithic in the same region. This is discussed below.

Interestingly, the juvenile count from LN WJ13 1 in the limestone area is relatively low (32%) compared to that from WJ7 2, and is closer to that observed in Epipalaeolithic assemblages. There is some evidence for spring and early summer culling, but no sex data.

The increase, and decrease in proportions of juveniles

The most striking trend seen in the assemblages is the increase in the proportion of juveniles from the early Epipalaeolithic to the Neolithic (25-32% to 42-55%). This trend, however, applies to assemblages consisting only of wild fauna; the PPNC/LN assemblage with herded animals again has a 'low' percentage of juveniles (32%).

A second, less marked trend is that early Epipaleolithic hunting is interpreted as primarily a winter/spring practice (in the studied assemblages, at least), whilst most middle Epipalaeolithic and Neolithic assemblages have some signs of early summer hunting.

Since the gazelle behaviour model predicts that there will be more juveniles in a herd in the summer months than winter/spring, the first question to ask is whether the observed increase in juvenile proportions could simply result from a change in hunting times (i.e. from winter/spring to summer). Such an explanation would assume non-selective hunting, where a rather random sample of adults and juveniles was taken in any particular season.

The data fit this scenario to some extent: three of the early Epipalaeolithic assemblages with 'low' proportions of juveniles (KH4 A, D, WJ6 A) primarily show evidence for winter/early spring culls; the three Neolithic sites with 'high' proportions of juveniles (DH 1, 2, WJ7 2) include early summer, or summer, culls. The main opposition to such a simple sole explanation for the pattern, however, is that the 'high' juvenile counts exceed all predictions for the proportions of juveniles in herds, **even in summers**.

Consequently, whilst the argument for Epipalaeolithic assemblages reflecting winter/spring encounter hunting appears unproblematic, further explanations for the Neolithic data should be considered.

In the archaeozoological literature, three main suggestions have been forwarded for the presence of 'high' proportions of juveniles in assemblages; the first involves a change to more intensive hunting; the second proposes human management of populations; and the third sees selective hunting of juvenile animals.

Intensive hunting

Davis quotes Elder's study of the diachronic change in deer age profiles from North American Indian sites (Elder quoted in Davis 1983:61). In this case, an increase in the proportion of juveniles was attributed to a more intensive exploitation of the deer, resulting from improved hunting techniques (the use of firearms) and more animals being killed generally. The effect on the animals' population structure was firstly, that a preponderance of juveniles existed which did not survive into adulthood, and secondly, a marked diminution in older age classes was observed, because of the demographic shift. Over-hunting, or more intensive hunting, therefore, pushes the population structure down. Unfortunately, the study sites have provided such poor ageing data for the older age classes of gazelles that assessment of complete demographic shifts is impossible for the Neolithic sites. Another way of exploring whether intensification or over-hunting could have been responsible for the high numbers of juveniles at sites is to seek evidence beyond the bones.

The Neolithic assemblages with 'high' proportions of juveniles - which can't be explained by summer hunting alone - are DH 1, DH 2 and WJ7 2. In areas close to DH 1 and 2 in the Basalt Desert large numbers of game drives, or 'kites' have been identified (see Chapter 3), and a kite wall has been tentatively associated with the occupation at DH 2 (Betts in press). Although only a few finds of Neolithic arrowheads link most of these structures with Neolithic use, they are very difficult to date, and it is plausible that they were used for gazelle hunting in the PPNB and LN.

If kites were used for gazelle driving, large numbers of animals could potentially have been killed. Some have argued that whole herds could have been slaughtered at one time with such mass capture techniques, and although this need not necessarily have been the case, ethno-historical accounts do suggest that drives serve as efficient hunting devices (cf. Legge and Rowley-Conwy 1987; Campana and Crabtree 1990). If the occupants of DH 1 and 2 were killing gazelle in kites, this could have resulting in a downward shift in the population structure. A further comment relevant here is that the model of gazelle behaviour and ecology predicts animals to have been more clustered in the Basalt Desert in the early Holocene than in the limestone region, because of the topography, runoff and foraging constraints. Although the area probably carried a lower density of animals, they are likely to have been more aggregated around water sources and patches of vegetation. It is therefore possible that the hunting technique used at DH 1 and 2 **created** herds with a high proportion of juveniles in the area. The interpretation of the site of DH as a short-term hunting camp might give weight to this scenario.

No kite structures have been identified from the Wadi el-Jilat area. This does not rule out the use of (now invisible) animal drives by hunters at PPNB WJ7, although it does make mass capturing a less obvious explanation for the high juvenile count at this site. Intensive hunting, however, may still have existed: PPNB occupation in the area witnesses clusters of structures which might equate with fairly large groups; there is also evidence for cultivated crops, which may have tied people to the area for extended periods. In addition, others have argued that hunter-gatherers were involved with intensive exchange systems in the PPNB, perhaps of meat (Bar-Yosef and Belfer-Cohen 1989), and their territories in the arid zones may have been reduced (suggested by the increase in the number of sites dated to this period). All these factors may have led to a greater exploitation of gazelle in the PPNB, which might have created higher number of juveniles within populations than there were in Epipalaeolithic populations in the same area.

That the juvenile count drops in the PPNC/LN at WJ13 to the same level as it was in the Epipalaeolithic (32%) might support this idea. The WJ13 assemblage includes roughly 20% of herded caprines, and the introduction of these animals onto the site, and their use in subsistence, may have led to a decrease in gazelle hunting compared to the PPNB, and a relative decrease in the proportion of juveniles in herds. On the other hand, if culling at WJ13 mainly took place during the winter/spring months, when lower frequencies of juvenile animals were around, this could also explain the pattern.

To interpret variations in the juvenile count as resulting from increases and decreases in the intensity of gazelle hunting assumes that groups culled a rough cross section of the age and sex categories within gazelle populations. The following two suggestions differ in that they see intentional selection of animal classes as being critical.

Gazelle population management

The 'high' proportions of juvenile gazelles observed at some Levantine sites (particularly Natufian) have sometimes been interpreted as resulting from human control over gazelle populations (e.g. Legge 1972). Suggestions of gazelle domestication have been generally refuted, on the grounds that their behavioural characteristics would not have allowed close herding, penning, or direct interference in breeding (Clutton-Brock 1978:50; Garrard 1984; Davis 1983). Loose herding, or the selective culling of age or sex classes for herd maintenance, however, are ideas still very much alive (Cope 1991; Tchernov 1993). The underlying assumptions with these interpretation is that human groups operated with a great deal of choice in their hunting activities. Ideas clearly draw on concepts of herd management as practised with domesticates, when a single product (meat), and 'efficiency' are the goals. For some Natufian faunas, this suggested form of gazelle exploitation has even been described as 'proto-domestication' (Cope 1991:357).

Different authors see various other signatures of herd management practice (see Chapter 2 for details), which include combinations of:

1) gazelle remains predominating over ungulate remains, regardless of the local environment (Henry 1975; Tchernov 1993).
2) selective male culling, either of adults or juveniles (Saxon 1974; Cope 1991; Tchernov 1993).
3) gazelle dwarfism, accompanied initially by an expanded range of size variation (Cope 1991).

The three study assemblages with 'high' proportions of juvenile gazelles will be examined in relation to each of these points.

Each assemblage (DH 1 and 2, WJ7 2) shows gazelle to be the dominant taxon represented. Section 2 of this chapter, however, concludes that this is unsurprising since gazelles are likely to have been the most common ungulate inhabiting the vicinity of the sites. Therefore, no selection of gazelle above other taxa is evident.

Of the three assemblages, only DH 1 appears to show a slight over-representation of adult males (whilst no sex ratio is available for WJ7 2). At sites which have been interpreted as seeing intensive male culling, Cope finds their proportions fluctuating between 60% and 80% (Cope 1991); their percentage at DH 1, however, is unquantifiable due to a lack of adequate comparatives, but it appears unpronounced. This male bias might be seen as selection, but not necessarily for management purposes.

Cope (1991) interprets both the size diminution and the expanded range of size variation which she observes in Natufian gazelle bones as resulting from 'proto-domestication' or herd management. She sees both as being the effects of gene pool reduction, resulting from the intensive culling of males. Under conditions of true domestication, animal are seen to undergo size decrease, and size **variation** also tends to decrease initially, as Cope herself acknowledges. It is not clear, therefore, why Cope argues that gazelle 'proto-domestication' should witness the opposite trend - an increase in size variation, apart from this being her observation of Natufian faunas. If she believes selective male culling to have had a severe impact on the gazelle gene pool, then reduced size variation would be the expected result (also because reduced inter-male competition would probably reduce dimorphism, and hence lead to a smaller size range).

If size diminution is to be explored, where should we expect to find it? The size diminution observed in Chapter 7 section 1 between Epipalaeolithic and Neolithic gazelle is argued to have resulted from climatic change and temperature elevation (following Bergmann's Rule). Anyway, these broad time periods do not represent unbroken time sequences through which to explore the possible effects of hunting practice. The only sequence where such patterns may be observed is between PPNB DH 1 and LN DH 2. What's more, DH 1 does see a slight bias towards males. Gazelle astragalus measurements from the two phases do show a reduction in mean over time (for Bd, DH 1=15.2, DH 2=14.9; for GLl, DH 1=26.0, DH 2=25.1), but this could presumably be equally attributable to variations in the proportions of sexes between the two phases, e.g. more males in DH 1 and more females in DH 2. Also, no great differences in size variation are observed between the two assemblages: for astragalus Bd, Pearson's coefficient of variation is 5.5% for DH 1 and 5.2% for DH 2; for GLl, the same figure is 4.2% for DH 1 and 4.8% for DH 2.

In conclusion, there is little evidence in any of the 'high juvenile count' assemblages, besides the slight bias towards culling adult males at DH 1, that herd management practices involving the selective culling of juvenile males may have been responsible for the patterns observed. The relatively high number of bones from animals of up to 2 months of age seen at DH 1 and 2 would seem to support this: animals in their first two months of life would live in small mother-offspring groups, and the culling of these groups at DH 1 and 2 would not appear to indicate a preservation or maintenance of breeding stock. On the contrary, breeding females and their young appear to have been, in part, the targets.

Selective hunting

Other explanations for the high proportions of juvenile gazelles in some assemblages may relate to selectivity in hunting, whether intentional or not.

For both European and American deer, sub-adult males are seen to be very vulnerable to predation when they leave mother-offspring groups to join bachelor herds (Collier and White 1976:99; Legge and Rowley-Conwy 1988:44-45). Young male gazelles are likely to have experienced the same vulnerability. Walther (1972) records bachelor groups of *Gazella gazella* in Tanzania as including both sub-adult and adolescent males (between 1 and 2 years, and 7 months-1 year respectively), meaning that animals leave the protection of their mothers at any time after 7 months of age. The young age classes may be well represented in assemblages simply because they were easier to catch or hunt.

Alternatively, there are numerous reasons why immature gazelle may have been more desired than adults. Their meat or hides may have been more highly prized than that from adults, or they may have provided particular kinds of fat or bone marrow (cf. Ingold 1980:72 for preferences of reindeer products from animals of different age and sex classes; Noble and Crerar 1993 for possible Iroquois preferences). Different animal age classes may also have had social significance beyond their physical products. In short, juvenile animals may have been selected by hunters for reasons **other** than herd management or maintenance of breeding stock, as discussed above.

Summary and conclusion

The gazelle age and sex data from the study sites have rather low-level resolution, and do not lend themselves to an informative analysis of gazelle hunting practices. The main lines of evidence derive not from detailed age profiles or firm sex ratios, but from 1) the percentages of juveniles culled in assemblages, and 2) slight variations observed in hunting times between spring and late spring/early summer. Combining these two lines of evidence with the reconstruction of gazelle birthing times and social structure has allowed exploration of four alternative models of gazelle hunting. Of these models, the first two assume that hunters took a cross-section of gazelle populations, and the second two propose some form of selection:

1) the seasonal variation in the proportion of juveniles accounts for most differences seen in the assemblages.
2) the population structure was pushed down by intensive hunting.
3) herd management involving the selection of males and/or young to maintain breeding stock.
4) either intentional or non-intentional selective hunting of juveniles.

The correlation between 'high' juvenile counts and evidence for May/June culls, and 'lower' juvenile counts and March/April culls suggests that differences in hunting times could be, **in part**, responsible for the higher proportions of juveniles seen in the Neolithic assemblages. Early Epipalaeolithic assemblages such as KH4 A, B, C, D and WJ6 A appear to reflect winter/spring hunting; I argue that the presence of newborn animals may indicate that birthing mothers were targetted, and since these are weak and rather immobile individuals at that time, a practice of encounter hunting or stalking might be inferred. A corrolary of this argument would be that a roughly representative cross-section of age groups in gazelle populations would have been killed.

Neolithic DH 1 and 2 show later spring/early summer hunting, but their juvenile counts are too high to be accounted for by this alone. Of the further alternative explanations, I would favour arguments either for intensive hunting pushing the population structure down (maybe with the help of kite structures), or for selective hunting of juveniles (perhaps an unintended consequence of their greater vulnerability); the idea of herd management finds little support in the data.

Seasonal data are altogether lacking for PPNB WJ7 2, but if we accept ideas of crop cultivation taking place locally in the area, then WJ7 would probably have been occupied in the early summer during harvest time. The high juvenile count could, in part, be explained by this, but ideas of intensive hunting during the PPNB and maybe even selection should not be dismissed.

The assemblage of WJ13 1 has a lower proportion of juveniles than any other of the Neolithic sites. Hunting might have taken place in winter/spring (suggested by the herded sheep and goats at the site, and the newborn gazelle and caprine bones) and/or in the early summer (if the cultivated crops are seen to be harvested locally; and also the evidence of unfused gazelle bones of < 2 months old). This potentially long hunting time makes it fruitless to assess the juvenile count against seasonal variations. All that can be said is that whatever determined the high juvenile count at PPNB WJ7 2 (whether seasonality of culls, intensive hunting of selection) does not seem to have been the practice at LN WJ13.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ6 B

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	0	00.0
p radius	c.2	0	3	100.0
TOT >c.2 months		0	3	100.0
scapula-coracoid	3-6	0	0	00.0
p first phalanx	5-8	0	9	100.0
TOT >3-8 months		0	9	100.0
d tibia	8-10	0	0	00.0
TOT >8-10 months		0	0	00.0
p femur	10-16	0	1	100.0
calcaneum	10-16	0	0	00.0
d metacarpal	10-16	0	0	00.0
d metatarsal	10-16	1	2	66.7
d femur	10-18	0	0	00.0
p humerus	12-18	0	0	00.0
p ulna	12-18	0	1	100.0
p tibia	12-18	0	1	100.0
d radius	12-18	0	1	100.0
TOT>10-18 months		1	6	85.7

Total number of bones with fusion data=19

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
0	25

Table 7.14. WJ6 B: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli Gazella gazella. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ6 A

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	12	100.0
p radius	c.2	0	33	100.0
TOT >c.2 months		0	45	100.0
scapula-coracoid	3-6	0	13	100.0
p first phalanx	5-8	1	132	99.2
TOT >3-8 months		1	145	99.3
d tibia	8-10	8	20	71.4
TOT >8-10 months		8	20	71.4
p femur	10-16	4	7	63.6
calcaneum	10-16	11	25	69.4
d metacarpal	10-16	14	23	62.2
d metatarsal	10-16	13	21	61.8
d femur	10-18	1	10	91.0
p humerus	12-18	1	1	50.0
p ulna	12-18	4	13	76.5
p tibia	12-18	2	4	66.7
d radius	12-18	9	20	69.0
TOT>10-18 months		59	124	67.8

Total number of bones with fusion data=402

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
1	619

Table 7.15. WJ6 A: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: KH4 A

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	51	100.0
p radius	c.2	0	36	100.0
TOT >c.2 months		0	87	100.0
scapula-coracoid	3-6	1	19	95.0
p first phalanx	5-8	2	121	98.4
TOT >3-8 months		3	140	97.9
d tibia	8-10	13	33	71.7
TOT >8-10 months		13	33	71.7
p femur	10-16	1	13	92.9
calcaneum	10-16	19	47	71.2
d metacarpal	10-16	3	24	88.9
d metatarsal	10-16	4	11	73.3
d femur	10-18	9	20	69.0
p humerus	12-18	1	13	92.9
p ulna	12-18	1	15	93.8
p tibia	12-18	6	12	66.7
d radius	12-18	13	20	60.6
TOT>10-18 months		57	175	75.4

Total number of bones with fusion data=508

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
8	886

Table 7.16. KH4 A: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: KH4 B

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	33	100.0
p radius	c.2	0	59	100.0
TOT >c.2 months		0	92	100.0
scapula-coracoid	3-6	0	22	100.0
p first phalanx	5-8	1	135	99.3
TOT >3-8 months		1	157	99.4
d tibia	8-10	5	37	88.1
TOT >8-10 months		5	37	88.1
p femur	10-16	6	10	62.5
calcaneum	10-16	11	25	69.4
d metacarpal	10-16	1	17	94.4
d metatarsal	10-16	2	12	85.7
d femur	10-18	5	7	58.3
p humerus	12-18	5	11	68.8
p ulna	12-18	5	11	68.8
p tibia	12-18	3	5	62.5
d radius	12-18	6	22	78.6
TOT>10-18 months		44	120	73.2

Total number of bones with fusion data=456

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
6	679

Table 7.17. KH4 B: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: KH4 C

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus p radius	c.2 c.2	0 0	8 10	100.0 100.0
TOT >c.2 months		0	18	100.0
scapula-coracoid p first phalanx	3-6 5-8	0 0	2 28	100.0 100.0
TOT >3-8 months		0	30	100.0
d tibia	8-10	2	6	75.0
TOT >8-10 months		2	6	75.0
p femur calcaneum d metacarpal d metatarsal d femur p humerus p ulna p tibia d radius	10-16 10-16 10-16 10-16 10-18 12-18 12-18 12-18 12-18	1 3 0 0 1 1 0 0 0	0 5 2 2 0 0 0 0 2	00.0 62.5 100.0 100.0 00.0 00.0 00.0 00.0 100.0
TOT>10-18 months		6	11	64.7

Total number of bones with fusion data=73

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
1	174

Table 7.18. KH4 C: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: KH4 D

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	80	100.0
p radius	c.2	0	164	100.0
TOT >c.2 months		0	244	100.0
scapula-coracoid	3-6	1	47	97.9
p first phalanx	5-8	10	622	98.4
TOT >3-8 months		11	669	98.4
d tibia	8-10	43	119	73.5
TOT >8-10 months		43	119	73.5
p femur	10-16	24	15	38.5
calcaneum	10-16	52	110	67.9
d metacarpal	10-16	15	68	81.9
d metatarsal	10-16	17	52	75.4
d femur	10-18	11	13	54.2
p humerus	12-18	19	12	38.7
p ulna	12-18	10	34	77.3
p tibia	12-18	17	12	41.4
d radius	12-18	34	72	67.9
TOT>10-18 months		199	388	66.1

Total number of bones with fusion data=1673

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
4	3124

Table 7.19. KH4 D: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: UW18

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	1	100.0
p radius	c.2	0	2	100.0
TOT >c.2 months		0	3	100.0
scapula-coracoid	3-6	0	1	100.0
p first phalanx	5-8	0	46	100.0
TOT >3-8 months		0	47	100.0
d tibia	8-10	0	3	100.0
TOT >8-10 months		0	3	100.0
p femur	10-16	0	1	100.0
calcaneum	10-16	3	5	62.5
d metacarpal	10-16	2	4	66.7
d metatarsal	10-16	0	4	100.0
d femur	10-18	2	0	00.0
p humerus	12-18	0	0	00.0
p ulna	12-18	0	3	100.0
p tibia	12-18	1	1	50.0
d radius	12-18	1	0	00.0
TOT>10-18 months		9	18	66.7

Total number of bones with fusion data=80

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
0	124

Table 7.20. UW18: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ22 C

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	1	8	88.9
p radius	c.2	1	6	85.7
TOT >c.2 months		2	14	87.5
scapula-coracoid	3-6	0	1	100.0
p first phalanx	5-8	0	3	100.0
TOT >3-8 months		0	4	100.0
d tibia	8-10	2	3	60.0
TOT >8-10 months		2	3	60.0
p femur	10-16	1	0	00.0
calcaneum	10-16	0	0	00.0
d metacarpal	10-16	1	0	00.0
d metatarsal	10-16	1	1	50.0
d femur	10-18	0	3	100.0
p humerus	12-18	0	1	100.0
p ulna	12-18	1	0	00.0
p tibia	12-18	0	5	100.0
d radius	12-18	1	1	50.0
TOT>10-18 months		5	11	68.8

Total number of bones with fusion data=41

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
11	91

Table 7.21. WJ22 C: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends. compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ22 B

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	1	6	85.7
p radius	c.2	0	30	100.0
TOT >c.2 months		1	36	97.3
scapula-coracoid	3-6	2	6	75.0
p first phalanx	5-8	0	5	100.0
TOT >3-8 months		2	11	84.6
d tibia	8-10	6	18	75.0
TOT >8-10 months		6	18	75.0
p femur	10-16	1	0	00.0
calcaneum	10-16	0	2	100.0
d metacarpal	10-16	2	9	81.8
d metatarsal	10-16	3	4	57.1
d femur	10-18	2	3	60.0
p humerus	12-18	0	1	100.0
p ulna	12-18	0	0	00.0
p tibia	12-18	0	0	00.0
d radius	12-18	4	2	33.3
TOT>10-18 months		12	21	63.6

Total number of bones with fusion data=107

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
2	333

Table 7.22. WJ22 B: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: AZ18

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	1	1	50.0
p radius	c.2	0	1	100.0
TOT >c.2 months		1	2	66.7
scapula-coracoid	3-6	0	0	00.0
p first phalanx	5-8	0	2	100.0
TOT >3-8 months		0	2	100.0
d tibia	8-10	0	2	100.0
TOT >8-10 months		0	2	100.0
p femur	10-16	0	0	00.0
calcaneum	10-16	0	1	100.0
d metacarpal	10-16	2	1	33.3
d metatarsal	10-16	1	0	00.0
d femur	10-18	0	0	00.0
p humerus	12-18	0	0	00.0
p ulna	12-18	0	0	00.0
p tibia	12-18	0	0	00.0
d radius	12-18	0	3	100.0
TOT>10-18 months		3	5	62.5

Total number of bones with fusion data=15

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNB)
0	39

Table 7.23. AZ18: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ7 1

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	1	100.0
p radius	c.2	0	0	00.0
TOT >c.2 months		0	1	100.0
scapula-coracoid	3-6	0	1	100.0
p first phalanx	5-8	2	7	77.8
TOT >3-8 months		2	8	80.0
d tibia	8-10	0	1	100.0
TOT >8-10 months		0	1	100.0
p femur	10-16	2	2	50.0
calcaneum	10-16	1	1	50.0
d metacarpal	10-16	1	0	00.0
d metatarsal	10-16	0	2	100.0
d femur	10-18	0	0	00.0
p humerus	12-18	0	0	00.0
p ulna	12-18	1	1	50.0
p tibia	12-18	0	2	100.0
d radius	12-18	1	1	50.0
TOT>10-18 months		6	9	60.0

Total number of bones with fusion data=27

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	107

Table 7.24. WJ7 1: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ7 2

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	6	100.0
p radius	c.2	0	9	100.0
TOT >c.2 months		0	15	100.0
scapula-coracoid	3-6	2	7	77.8
p first phalanx	5-8	5	17	77.3
TOT >3-8 months		7	24	77.4
d tibia	8-10	3	3	50.0
TOT >8-10 months		3	3	50.0
p femur	10-16	5	2	28.8
calcaneum	10-16	2	3	60.0
d metacarpal	10-16	2	3	60.0
d metatarsal	10-16	2	4	66.7
d femur	10-18	0	1	100.0
p humerus	12-18	0	0	00.0
p ulna	12-18	0	1	100.0
p tibia	12-18	3	6	66.7
d radius	12-18	6	8	57.1
TOT>10-18 months		20	28	58.3

Total number of bones with fusion data=100

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	311

Table 7.25. WJ7 2: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ7 3

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus p radius	c.2 c.2	0 0	1 6	100.0 100.0
TOT >c.2 months		0	7	100.0
scapula-coracoid p first phalanx	3-6 5-8	0 3	0 6	00.0 66.7
TOT >3-8 months		3	6	66.7
d tibia	8-10	2	4	66.7
TOT >8-10 months		2	4	66.7
p femur calcaneum d metacarpal d metatarsal d femur p humerus p ulna p tibia d radius	10-16 10-16 10-16 10-16 10-18 12-18 12-18 12-18 12-18	0 0 1 2 0 0 0 0 0	0 0 0 1 0 0 0 1 1	00.0 00.0 00.0 33.3 00.0 00.0 00.0 100.0 100.0
TOT>10-18 months		3	3	50.0

Total number of bones with fusion data=28

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	82

Table 7.26. WJ7 3: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ7 4

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus p radius	c.2 c.2	0 0	2 2	100.0 100.0
TOT >c.2 months		0	2	100.0
scapula-coracoid p first phalanx	3-6 5-8	0 0	1 10	100.0 100.0
TOT >3-8 months		0	11	100.0
d tibia	8-10	0	1	100.0
TOT >8-10 months		0	1	100.0
p femur calcaneum d metacarpal d metatarsal d femur p humerus p ulna p tibia d radius	10-16 10-16 10-16 10-16 10-18 12-18 12-18 12-18 12-18	0 0 0 0 0 1 0 0 0	0 0 0 2 0 0 0 0 0	00.0 00.0 00.0 100.0 00.0 00.0 00.0 00.0 00.0
TOT>10-18 months		1	2	66.7

Total number of bones with fusion data=19

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	68

Table 7.27. WJ7 4: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE FUSION DATA

Assemblage: DH 1

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	21	68	76.4
p radius	c.2	2	45	95.7
TOT >c.2 months		23	113	83.1
scapula-coracoid	3-6	9	56	86.2
p first phalanx	5-8	33	71	68.3
TOT >3-8 months		42	127	75.1
d tibia	8-10	32	42	56.8
TOT >8-10 months		32	42	56.8
p femur	10-16	14	25	64.1
calcaneum	10-16	58	23	28.4
d metacarpal	10-16	21	32	60.4
d metatarsal	10-16	26	22	45.8
d femur	10-18	17	14	45.2
p humerus	12-18	6	3	33.3
p ulna	12-18	8	10	55.6
p tibia	12-18	26	19	42.2
d radius	12-18	24	18	42.9
TOT>10-18 months		200	166	45.4

Total number of bones with fusion data=745

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	2051

Table 7.28. DH1: fusion data is shown above. *Approximate ages taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ13 1

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	1	21	95.5
p radius	c.2	0	15	100.0
TOT >c.2 months		1	36	97.3
scapula-coracoid	3-6	2	7	77.8
p first phalanx	5-8	11	32	74.4
TOT >3-8 months		13	39	75.0
d tibia	8-10	3	9	75.0
TOT >8-10 months		3	9	75.0
p femur	10-16	1	5	83.3
calcaneum	10-16	2	8	80.0
d metacarpal	10-16	2	6	75.0
d metatarsal	10-16	3	9	75.0
d femur	10-18	2	2	50.0
p humerus	12-18	0	0	00.0
p ulna	12-18	1	1	50.0
p tibia	12-18	4	1	20.0
d radius	12-18	3	7	70.0
TOT>10-18 months		18	39	68.4

Total number of bones with fusion data=158

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
1	403

Table 7.29. WJ13 1: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ13 2

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	3	100.0
p radius	c.2	0	1	100.0
TOT >c.2 months		0	4	100.0
scapula-coracoid	3-6	0	2	100.0
p first phalanx	5-8	0	7	100.0
TOT >3-8 months		0	9	100.0
d tibia	8-10	1	1	50.0
TOT >8-10 months		1	1	50.0
p femur	10-16	0	1	100.0
calcaneum	10-16	3	3	50.0
d metacarpal	10-16	2	2	50.0
d metatarsal	10-16	0	1	100.0
d femur	10-18	0	1	100.0
p humerus	12-18	0	1	100.0
p ulna	12-18	3	0	00.0
p tibia	12-18	0	1	100.0
d radius	12-18	1	3	75.0
TOT>10-18 months		9	13	59.1

Total number of bones with fusion data=37

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	122

Table 7.30. WJ13 2: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: WJ13 3

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	0	3	100.0
p radius	c.2	0	4	100.0
TOT >c.2 months		0	7	100.0
scapula-coracoid	3-6	0	1	100.0
p first phalanx	5-8	2	12	85.7
TOT >3-8 months		2	13	86.7
d tibia	8-10	0	2	100.0
TOT >8-10 months		0	2	100.0
p femur	10-16	0	0	00.0
calcaneum	10-16	0	0	00.0
d metacarpal	10-16	0	0	00.0
d metatarsal	10-16	1	1	50.0
d femur	10-18	0	0	50.0
p humerus	12-18	0	0	00.0
p ulna	12-18	0	0	00.0
p tibia	12-18	0	0	00.0
d radius	12-18	0	1	100.0
TOT>10-18 months		1	2	66.7

Total number of bones with fusion data=27

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
0	120

Table 7.31. WJ13 3: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40), based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranian bone ends, is shown below.

GAZELLE POSTCRANIAL AGEING DATA

Assemblage: DH 2

ELEMENT	FUSION AGE* (months)	NUMBER UNFUSED	NUMBER FUSED	% FUSED
d humerus	c.2	38	145	79.2
p radius	c.2	2	150	98.7
TOT >c.2 months		40	295	88.1
scapula-coracoid	3-6	5	40	88.9
p first phalanx	5-8	74	247	76.9
TOT >3-8 months		79	287	78.4
d tibia	8-10	70	113	61.7
TOT >8-10 months		70	113	61.7
p femur	10-16	51	86	62.8
calcaneum	10-16	52	97	65.1
d metacarpal	10-16	50	47	48.5
d metatarsal	10-16	59	74	55.6
d femur	10-18	34	35	50.7
p humerus	12-18	10	10	50.0
p ulna	12-18	8	32	80.0
p tibia	12-18	44	36	45.0
d radius	12-18	68	52	43.3
TOT>10-18 months		376	469	55.5

Total number of bones with fusion data=1729

NUMBER OF NEWBORN POSTCRANIAL ENDS	TOTAL NUMBER OF POSTCRANIAL ENDS (MNE)
4	5918

Table 7.32. DH 2: fusion data is shown above. *Approximate ages of fusion taken from Davis (1980b:133, 1987:40); based on zoo-bred Israeli *Gazella gazella*. The number of newborn ends, compared to the total number of postcranial bone ends, is shown below.