Tel Aviv University
The Lester and Sally Entin Faculty of Humanities
The Chaim Rosenberg School of Jewish Studies
Department of Archaeology and Near Eastern Cultures

DIACHRONIC PATTERNS OF ANIMAL EXPLOITATION IN THE SINAI PENINSULA

Thesis Submitted For The Degree of "Doctor of Philosophy"

by

LIORA ROCHELLE KOLSKA HORWITZ

under the supervision of

(the late) Prof. Eitan Tchernov and Prof. Israel Finkelstein

Submitted to the Senate of Tel Aviv University
December 2005

this work was carried out under the supervision of

(the late) Prof. Eitan Tchernov & Prof. Israel Finkelstein

Department of Evolution,
Systematics & Ecology
The Hebrew University of Jerusalem

Department of Archaeology &
Near Eastern Cultures
Tel Aviv University

Acknowledgements

The many people I wish to thank can be divided into two groups - those who continued to nag me and those who gave up !! To all I offer my warm and sincere thanks for the discussions, criticism, assistance, encouragement, anger and good humour over the years.

It is with sadness that I offer my special gratitude to my dear mentor, friend and colleague the late Prof. Eitan Tchernov. His encouragement and guidance serve as a continuing inspiration. I hope he would have greeted this work with the enthusiasm and critical erudition that characterised his life and work.

My long suffering supervisor Prof. Israel Finkelstein whose challenging research on communities living "on the fringe" has served as a touch-stone for much of the research presented here.

Prof. Aharon Horowitz for his continued support and assistance in all matters – intellectual and amicable.

Prof. Patricia Smith an unparalleled mistress of both criticism and encouragement – my warm thanks for having persisted so long and so hard.

The many archaeologists who entrusted me with the "fruits of their labours" in Sinai – without their material, knowledge and input this project would obviously have not been possible: Dr. Uzi Avner (Arava Institute for Environmental Studies, Eilat), Prof. Ofer Bar-Yosef (Harvard University), Prof. Itzhaq Beit-Arieh (Tel Aviv University), Prof. Avi Gopher (Tel Aviv University), Mr. Avner Goren (Jerusalem), Prof. Nigel Goring-Morris (The Hebrew University of Jerusalem), Dr. Zeev Meshel (Tel Aviv University), Prof. Eliezer Oren (Ben-Gurion University, Beersheva), Prof. Jim Phillips (University of Illinois at Chicago).

Colleagues, in Israel and abroad, for their input and invaluable assistance in providing access to data (often unpublished) and publications: Dr. Daniella Bar-Yosef Mayer (Haifa University), Prof. Louis Chaix (retired-Musée de Histoire Naturelle, Genéve), Dr. Juliet Clutton-Brock (retired-Natural History Museum, London), Prof. Avinoam Danin (The Hebrew University of Jerusalem), Prof. Achille Gautier (Rijksuniversiteit, Gent), Dr. Caroline Grigson (retired-Odontological Museum, London), Dr**.** Sheila Hamilton-Dyer (Southampton, UK), Prof. Omri Lernau (Haifa University), Dr. Louise Martin (University College, London), Dr. Henk K. Mienis (The Hebrew University of Jerusalem), Dr. Wim Van Neer (Musée Royal de l'Afrique Centrale, Tervuren), Prof. Angela von den Driesch (retired-Ludwig-Maximilians University, Munich), Dr. Avi Perevolotsky (Beit Dagan, Rehovot), Prof. Joris Peters (Ludwig-Maximilians University, Munich), Prof. Steve Rosen (Ben-Gurion University, Beersheva), Dr. Jacqueline Studer (Musée de Histoire Naturelle, Genéve).

Dr. Rivka Rabinovich, curator of the mammal collection in the Department of Evolution, Systematics and Ecology at The Hebrew University with whom I have worked, talked, drunk and eaten for almost as long as I have worked in archaeozoology.
My colleagues in the Jerusalem zoo-lab in recent years: Shoshana Ashkenazi, Theodora Bar-El, Gali Beiner, Miriam Belmaker, Gila Kahila-Bar-Gal, Ron Kehati, Hadas Motro, Yoav Motro, Shlomo Simchowitz, Tabitha Stoker-Hofland.

My family and friends - a lesson in persistence.

“For every image of the past that is not recognized by

the present as one of its own concerns

threatens to disappear irretrievably”

Walter Benjamin

-Theses on the Philosophy of History*[1]*-

---

[1] **W. Benjamin (1955) *Schriften,* Frankfurt: Suhrkamp Verlag**

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

During the 15-year period that followed the Six-Day War of 1967 and up until the Israeli withdrawal from the Sinai Peninsula in 1982, Israeli archaeological institutions undertook large-scale surveys and excavations in this region. The faunal assemblages recovered during these excavations serve as the foundation of this thesis. They offer a unique opportunity to elucidate changing modes of subsistence in this little known region, which served both as a land-bridge and frontier between Egypt and the Levant.

These archaeofaunal assemblages are used to address several central topics:
(i) the extent to which the physical geography of Sinai influenced the composition of the faunal assemblages; (ii) the nature of diachronic changes in animal exploitation patterns in this region with specific reference to nomadism versus sedentism; (iii) the impact of climate change on subsistence strategies; (iv) the extent and nature of contact between Sinai, Egypt and the Levant.

The first two chapters lay the basis for the research undertaken. Chapter 1 provides an outline of the objectives of this study, discusses the excavations and samples used in this research, as well as providing background information on the archaeozoological methods applied. Limitations of the samples, such as poor preservation and small sample size are also discussed as well as solutions to resolve them. The second chapter describes the physical geography, and present-day flora and fauna of Sinai with reference to the three salient regions: northern, central and southern Sinai. These data serve as the base line for discussions of climate change, resource availability and subsistence strategies that are explored in the following chapters.

Chapters 3-7 describe a diachronic series of faunal assemblages from northern and southern Sinai. The first study relates to the PPNB period (9,600- 7,500 uncal. BP) which in the Mediterranean zone of the southern Levant is characterised by the establishment of large-scale sedentary villages, increased socio-political complexity and the cultivation of cereals, legumes and flax as well as the advent of sheep and goat husbandry. In contrast, in Sinai a hunting and gathering mode of subsistence continued characterised by seasonal transhumance, with domestic herd animals only entering the region by the Late or even Terminal PPNB. It is proposed that PPNB reliance on ibex herds laid the basis for later forms of nomadic pastoralism in the region. Chapter 4 discusses the timing, place of origin and mechanism for the first appearance of domestic herd animals in the Peninsula and the development of different strategies of herd

exploitation over time. Sheep and goat are the first domesticates introduced into the Peninsula from the Levant, and disperse both into southern Sinai and into the Nile Valley, the latter probably via the Mediterranean coast of Sinai. In the Chalcolithic and Early Bronze I period, herd management in the Peninsula was aimed at the production of meat for rituals as well as local household consumption, and in many ways duplicated PPNB ibex hunting. It is only in the Early Bronze II that secondary products (milk, wool, hair) became the primary goal of animal raising, probably aimed at markets and trade networks beyond the Peninsula. Secondary product exploitation may have necessitated/facilitated a greater degree of sedentism, although shepherds and their flocks would still have had to move in search of pasture and water sources. This shift in subsistence strategy relates to (i) the expansion of trade networks whereby produce from the desert regions (copper, Red Sea shells and tabular scrapers) was bartered with polities in the Mediterranean zone and (ii) the growing ties between the desert and the ‘sown’. In exchange, it appears that populations in the arid margins were supplied with agricultural produce and items of material culture unobtainable in the desert.

The third study offers a model of archaeozoological criteria for identifying food provisioning by a central government based on data from the Roman *Limes.* To this end, the fauna from a series of Egyptian, New Kingdom military-administrative centres in northern Sinai are examined. Although storage vessels at these sites originate in Egypt, the archaeozoological study clearly demonstrates that meat and fish were obtained locally, possibly as tax/tribute.

A similar theme is explored in the fourth study on the Iron Age site of Kuntillet ‘Ajrud, in north-eastern Sinai. The excavator identified the site as a religious centre while others have proposed that it served a secular function as a ‘khan’ for travellers. Conclusions based on the faunal remains recovered from this site indicate that it probably fulfilled both functions, and that at least a portion of the food resources came from outside the region.

The last study concerns a small faunal assemblage recovered from a Nabataean sanctuary in south-eastern Sinai that offers insights into their ritual world. Since little is known about the Nabataean animal economy, this study provides an interesting addition.

The final chapter offers a short resume of some of the salient conclusions reached for each data set/period and attempts to answer the questions posed in the introduction.
The main conclusions that may be drawn from this study are that:

(1) In all periods studied there is a marked distinction in the faunal composition of sites from southern and northern Sinai that can be directly related to differences in the topography, climate, water resources and vegetation of the two regions.

(2) The faunal record reflects the changing ethnic and political fortunes of the region.

Marked changes are found in animal exploitation patterns over time in the Sinai that relate to the movement of people and animals into the region, either relating to region-wide human dispersals as was the case with the advent of domestic animals at the end of the PPNB, or relating to trade networks and markets as was the case in the Early Bronze Age II, New Kingdom, Iron Age and Nabataean periods. Aside from the Early Bronze II, all the other faunal assemblages are derived from sites with specialised functions (forts, *khan*, temples), that served as socio-political satellites of an adjacent polity. Since they had specific roles to fulfil (and were probably inhabited by migrant populations), the life span of these sites was circumscribed.

(3) Climate primarily influenced the movement of people into the region, but also determined the viability of certain subsistence forms (e.g. continuation of hunting versus herding; management of herds for meat versus secondary products).

(4) Overall, the archaeozoological record of southern Sinai shows a closer resemblance to that of the southern Levant than to Egypt, while northern Sinai shows a mixed influence depending on the time period involved.

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND

1.1.1. The desert regions of the southern Levant

Human settlement of the semi-arid and arid regions of the southern Levant i.e. the deserts of eastern and southern Jordan, the Negev desert of southern Israel and the Sinai Peninsula, is mediated by the prevailing environmental conditions which include factors such as extreme temperatures (very hot days and very cold nights), seasons of high winds, low and often erratic precipitation, rarity and differential geographic distribution of water sources in the landscape, low density of wild animals, scarcity of arable land and marked seasonality in the availability of plant resources for humans and animals. Although past climatic conditions in the region obviously differed from those today, the archaeological record indicates that the desert zones were consistently a peripheral ‘fringe’ to the richer Mediterranean region of the southern Levant[1].

For many periods, the nature of relations between communities of the ‘desert’ and those of the ‘sown’ remain unclear. Moreover, there is a dearth of information concerning how and why socio-economic strategies practised by local communities changed. The role of external powers in moulding the trajectory of desert history - for religious, political, economic and/or military reasons, requires further investigation. Although it is patent to all that settlement and population densities in the arid regions fluctuated greatly in intensity over time, it is still debated whether, during low points in settlement, occupation was continuous or not; the interpretation hinging on whether the absence of archaeological remains denotes the absence of human communities or simply characterises the ephemeral nature of nomadic occupations (Cohen 1986; Finkelstein 1995; Finkelstein and Perevolotsky 1990; Rosen 1987, 1988, 1992). It is hoped that the examination of the

---

[1] The southern Levant is defined as the region incorporating Syria south of the Damascus Basin, Lebanon, Jordan, Israel, and areas governed by the Palestine Authority in the Gaza Strip and the West Bank.

archaeozoological record of the Sinai Peninsula undertaken in this study, will provide both additional information and insights into many of these topics. It will focus on changes in species representation, skeletal element representation, age and sex profiles, in order to assess shifts in animal exploitation strategies over time in relation to local and external developments.

1.1.2 The Sinai Peninsula

The Sinai is an extremely large landmass (ca. 61, 000 km^2 in area) composed of a mosaic of regions that are distinct in their geomorphology, topography, climate, and vegetation and fauna (Danin 1983; Eyal et al. 1987; Greenwood 1997; Zahran and Willis 1992). The Peninsula forms both a buffer zone between, and a bridge connecting, Asia and the Levant with Egypt and Africa (Fig. 1.1). Since prehistoric times, populations from the geo-political triumvirate, Egypt-Sinai-Israel, have interacted in different ways and with shifting intensity. Indeed, the significance of Sinai in this broader geographic and socio-political canvas fluctuated greatly over time.

In the context of trade in the Inca Empire, D’Altroy and Earle (1985) distinguished between staple finance involving the movement of textiles, plants and livestock compared to wealth finance which comprised high value but low bulk items which were exchanged or offered as tokens of power and status. The Sinai Peninsula is, and was in the past, relatively poor in staple finance, at least compared to the Mediterranean region or the Nile Valley. Moreover, it offered only three items of wealth finance - copper, turquoise and at certain points in the past, Red Sea shells. These resources are concentrated in south Sinai and at least the first two require great effort to extract. Consequently, given the paucity of its natural assets, its low carrying capacity, arduous climate and dispersed water resources, it is most likely that the region acted primarily as a conduit for the movement of materials and people to/from Egypt-Africa on the one hand, and the Levant–Asia on the other. Indeed, Joffe (1993) has proposed that the Egyptian colonial system was not motivated by the control of material resources or territory. Rather it served as an “exercise in the administration of socio-political power” (Joffe 1993:58) carried out by the Egyptian hierarchy as a means of exercising control over Egyptians by sending them abroad to establish administrative bureaucracies that paralleled, and were dependent upon, the Egyptian state.

Thus the Sinai Peninsula played a multiplicity of roles including: as a source of minerals and metals - mined and traded to areas beyond its borders; as a trade route (maritime and overland) to be protected and administered; as a place of pilgrimage or pilgrim route; and most frequently, from a political and military perspective, as a strategic buffer zone and frontier. The shifting geo-political boundaries as well as the extent and nature of foreign involvement and influence in the Peninsula, are clearly manifest in its archaeological record (e.g. Avner 2002; Bar-Yosef 1993; Beit-Arieh 2003a; Eddy and Wendorf 1999; Figueras 2000; Finkelstein 1980a, 1995; Na'aman 1987; Oren 1979, 1987a, b; Rainey 1987; Redford 1992; Rothenberg 1961, 1979).

During the 15-year period that followed the Six-Day War of 1967 and up until the Israeli withdrawal from the Sinai Peninsula in 1982, Israeli archaeological institutions undertook large-scale surveys and excavations in the Sinai (Bar-Yosef and Phillips 1977; Beit-Arieh 1984; Finkelstein 1980a, b; Gvirtzman et al. 1987; Lachish and Meshel 1982; Meshel and Finkelstein 1980; Rothenberg 1967, 1972a, 1973). Although, these were not the first archaeological investigations undertaken in this region (e.g. Anati 1958; Buzy 1927; Clarke 1916; Cledat 1919; Neuville 1952; Oren 1993a; Petrie 1906; Rothenberg 1961, 1969; Wiegand 1920), they were certainly the first large-scale and systematic research expeditions of their kind, spanning not only large tracts of the Sinai but also the entire chronological range represented in the Peninsula - from prehistoric to historic periods.

Israeli investigations were undertaken focusing either on specific geographic regions of Sinai, or as projects which concentrated on particular periods or topics. The projects that are relevant to this thesis are listed below.

Prehistoric and Protohistoric sites in southern and northern Sinai: Between 1971 to 1982 a series of surveys, probes and excavations of prehistoric and protohistoric sites was undertaken in southern and south-eastern Sinai by Prof. Ofer Bar-Yosef (then of The Hebrew University of Jerusalem) and Mr. Avner Goren (then of the Israel Department of Antiquities, now called the Israel Antiquities Authority) aided by numerous colleagues and students (e.g. Bar-Yosef and Goren 1980; Bar-Yosef and Killebrew 1984; Bar-Yosef and Phillips 1977; Baruch and Bar-Yosef 1986; Belfer-Cohen and Goldberg 1982; Gilead 1981,1984; Goldberg 1984; Goring-Morris and Mintz 1976). Large-scale excavations of more than five Neolithic sites were undertaken (Bar-Yosef 1980, 1981a, b, c, d, e, 1984, 1985), while several *nawamis* tumuli fields and their associated habitation sites, dating to the 5th-4th millennium BC, were excavated (Bar-Yosef et al. 1983, 1986; Goren 1980, 1998)

The Ophir Expedition: This project was undertaken during 1971-1982 and directed by Prof. Itzhaq Beit-Arieh (Tel Aviv University). This project surveyed some 1700 km^2, mainly in the high mountain region of south-central Sinai and included excavations of several Chalcolithic and Early Bronze Age I and II sites – 4th and 3rd millennium BC (Beit-Arieh 1977, 1981, 1982, 1983, 1986, 1993, 2003a, b, c).

The North Sinai Survey: This project was undertaken between 1972-1982 under the direction of Prof. Eliezer Oren (Ben-Gurion University). It constituted the most extensive investigation of this northern region and entailed the systematic survey of a strip some 250km long and 20km wide, from the Gaza Strip to the Suez Canal. The survey area was divided into six regions which ran from left to right: the area north-east of the Nile Delta (Area T); Lake Bardawil (Areas M and S); the coastline and dunes south of Lake Bardawil (Areas B, BEA, C and D), from the eastern most point of Lake Bardawil to Sheikh Zuweid (Area A); from Sheikh Zuweid to Rafiah (Area R) and from Rafiah to the Gaza Strip (Area G). Close to 1300 sites dating to the Chalcolithic through Islamic periods were located and investigated. Sites were either surface collected (with data on size and density of remains noted), sampled by test pits or excavated on a large-scale (Oren 1973a, b, c, 1979, 1980a, b, 1982, 1982-3, 1983, 1984, 1987a, b, 1993a, unpublished; Oren and Gilead 1981; Oren and Yekutieli 1990; Oren et al. 1979).

As a result of these investigations, a large corpus of archaeological material was accumulated, spanning the entire chronological range represented in the Peninsula, although not all periods are represented in all areas investigated. Aside from the abundant remains of material culture (stone and metal artefacts, ceramic and glass vessels, coins, *art mobilier* etc.), considerable quantities of botanical and faunal material were recovered. The latter primarily represent remains of animals hunted/ kept/consumed by the inhabitants of the archaeological sites. According to the terms of the Camp David Peace Accords signed between Israel and Egypt in 1979, it was concluded that all antiquities excavated during the Israeli occupation were to be returned to Egypt by 31st December 1994. Thus, in 1992 the

Israel Antiquities Authority established the Sinai Project, aimed at recording and studying all the archaeological material recovered, prior to their being returned to Egypt. At the time, in my capacity as archaeozoologist for the Israel Antiquities Authority, I was assigned the task of studying the archaeofaunal assemblages. These animal remains serve as the foundation upon which this thesis is based. They offer a unique opportunity to elucidate changing modes of subsistence in this little known region, which served both as a land-bridge and frontier between Egypt and the southern Levant.

1.2. OBJECTIVES

This thesis examines the faunal record of the Sinai Peninsula over the past 10,000 years in order to explore the following issues:

(1) To what extent has the mosaic physical geography of Sinai influenced the composition of archaeofaunal assemblages?

(2) What is the nature and extent of diachronic changes in the pattern of animal exploitation that have taken place in the circumscribed geographic region of Sinai?

(3) What is the significance of these changes on the development and transformation of human settlement in this region?

(4) To what extent has climate affected subsistence strategies and settlement pattern over time? (specifically with reference to nomadism versus sedentism)

(5) What was the nature and extent of contact between the Sinai and the neighbouring polities in Egypt and the southern Levant? and how did these affect subsistence strategies and settlement patterns in the Peninsula?

It is hoped that the diachronic series of faunal remains recovered from sites excavated by Israeli archaeological missions will fill the hiatus in our knowledge of the subsistence and animal exploitation practices of past populations of Sinai. This, since the published information currently available on the paleofauna of Sinai is incomplete. The few available faunal reports vary in the depth and type of analyses carried out and do not represent the full, temporal sequence of periods and/or regions within the Peninsula (for example: Chaix 2000a, b, 2002; Dayan et al. 1986; Hakker-Orion 1975; Lang 1998; Phillips and Gladfelter 1989; Tchernov and Bar-Yosef 1982).

In order to be able to assess these topics in a robust manner, the archaeozoological record not only of the Sinai, but also of the neighbouring geo-political regions, will be evaluated. A regional study of this kind will elucidate the form and extent of changing relations between Egypt and the southern Levant. These regions lend themselves to a study of this kind, since today as in the past; they are characterized by vastly different faunal biotopes. The wild mammals of Egypt are primarily Ethiopian (African) in character (Flower 1932; Hoogstraal 1963, 1964; Osborn and Helmy 1980). In contrast, the southern Levantine fauna is a mixture of African, European and Asian elements that reflect the complex climatic and biogeographical history of this region that served as a corridor between Africa and Asia (Mendelssohn and Yom-Tov 1999; Qumsiyeh 1996; Tchernov 1979, 1988). Moreover, there is sufficient data to indicate that the history of domestication and development of domestic breeds, as well as the pattern of their management, differed between the two regions (for example: articles in Blench and MacDonald 2000; Brewer et al. 1990; Epstein 1971; Osborn and Osbornová 1998). Consequently, examination of the faunal record from archaeological sites in Sinai should clearly reflect the varying extent of Egyptian versus Levantine intervention or influence in the Peninsula at a given point in time. Furthermore, an investigation of this type should augment our understanding of the role played by Sinai in the Near East as a whole.

For the southern Levant, the archaeofaunal history is perhaps one of the best documented in the world, due to the wealth of excavations that have been undertaken of well-dated sites covering all time periods (examples of review articles: Davis 1982; Grigson 1995a; Horwitz 2002a; Horwitz and Tchernov 1989a; Horwitz et al. 1999a; Tchernov 1988). In contrast, our knowledge of past Egyptian fauna has until recently been uneven, with a strong focus on prehistoric and Predynastic sites, mostly from the Nile Valley (e.g. Boessneck and von den Driesch 1990; Boessneck et al. 1989; Bokonyi 1985; Brewer 1989; Brewer et al. 1990; Gaillard 1934; Gautier 1978, 1984, 1987, 2001). Until recently, for later periods, most publications have dealt with mummified remains, iconographic or textual sources with little archaeozoology (e.g. Boessneck and von den Driesch 1987; Boessneck 1988; Brewer and Friedman 1989; Houlihan 1996; Lortet and Gaillard 1903). Lately, the emphasis on archaeozoological data, even in publications relating specifically to iconography, is evident (e.g. Ikram 1995; Nicolotti 1998).

Despite the numerous faunal reports that have been published on Egyptian material in the past two decades, the emphasis continues to be on remains recovered from monumental buildings and necropoli, as these continue to occupy prime place in the interests of Egyptian archaeologists (e.g. Bartosiewicz 2000; Boessneck 1988; Boessneck and von den Driesch 1992a, b; Gautier and Henrickx 1999; Van Neer et al. 2004b). Data from habitation sites are therefore sorely lacking (some exceptions are: Boessneck and von den Driesch 1997; Bokonyi 1985; von den Driesch 2001; Hecker 1982, 1984; Luff 2001; Redding 1984, 1992; Van Neer 1997).

Given the large-scale of the data sets available from Egypt and the southern Levant, as well as the broad spectrum of periods and problems represented in the record of Sinai, only selected topics were chosen for discussion within the framework of this thesis. The faunal analysis concentrated on the identification of species, skeletal element representation and age and sex profiles of the taxa. Only limited taphonomic analyses were undertaken. These focused on assessment of diagenetic process that may have winnowed the assemblages, thereby affecting the robusticity of the available data sets. The two main thrusts of this thesis are, firstly, in documenting and accounting for the observed variation in fauna between sites, regions and chronological periods within Sinai, and secondly in examining the impact of region-wide climatic, socio-economic and geo-political events that took place in the Peninsula on the logistics of animal exploitation.

Consequently, Chapter 1 describes the history of the project, objectives and the basic methods used in this study, while the present-day physical geography of the Sinai Peninsula as it relates to spatial variation in geomorphology and topography, flora and fauna is described in Chapter 2. These data provide a foundation with which to assess the archaeozoological assemblages as well as the contribution of the natural landscape and climate to variations in this record. The subsequent chapters present a series of case-studies focusing on different periods and problems associated with the archaezoological history of the Peninsula spanning the Neolithic through to the Nabataean period.

1.3. EXCAVATIONS AND SAMPLES

1.3.1. Excavation methods

The faunal assemblages analysed for this thesis are presented in Table 1.1. These samples were excavated or collected by several different archaeologists, using different excavation techniques. In all instances, students, specialists and Bedouin workers assisted them. Most excavations undertaken were small-scale and often represented only test pits.

For prehistoric sites the area to be excavated was laid with a standard grid of 1x1m2's. In most instances each metre was then sub-divided into 50x50cm quadrates during excavation and numbered a-d from left to right. Each square was given a unique number based on both the X-axis (numerals) and Y-axis of the grid (letters of alphabet). In the absence of stratigraphy, each square was excavated in arbitrary spits. Finds in most sites were piece plotted using three co-ordinates before removal. Material deriving from each square could then be precisely re-located. All deposit was dry-sieved using a 1mm mesh. In the case of test pits and probes, in most cases the material was treated in the same manner as a larger excavation.

For the *nawamis* built tombs, each structure was divided into equal quarters (numbered a-d from left to right), and each quarter excavated in arbitrary 5 cm spits. The human skeletal remains were separated out from the deposit and the sediment dry-sieved using a two-tiered sieve with mesh sizes of 1 mm and 3 mm respectively. The habitation sites of this period and the Early Bronze Age I and II, were excavated by architectural unit. Each feature/room was defined with a unique locus number and hand excavated with trowel, brush and fine implements. All deposit was dry-sieved using a 2mm mesh.

All sites dating to the New Kingdom through to Classical periods were excavated using methods currently applied by most Israeli archaeologists, which combines the "Wheeler-Kenyon" stratigraphic approach aimed at widespread exposure of architecture (see discussion in Mazar 1992: 21-28). For the large-scale excavations in Sinai, the excavation area was gridded in the same manner as for the prehistoric excavations (numeric and alphabetic square numbers) - but using 5x5 metre squares. Within this grid, a similar approach to that used for the proto-historic sites was applied and the sites were excavated by architectural units. Each feature/unit/room was given a unique number. Within each feature/unit/ room, material was then excavated stratigraphically using loci and basket numbers. Height readings were taken at the beginning and end of each locus. Thus, each feature/unit/room could be defined by either, or as well as, a square number (based on the site grid), a unit number, and a series of locus and basket numbers. In addition, once in the laboratory at Ben-Gurion University, each find (in the case of bones, each bag), was given a unique inventory number. In the final stages, phases of occupation within and between features/units/rooms were reconstructed based on architecture and finds. Due to the extensive sand-dunes that had covered most of these sites, in many cases only the outline of walls were exposed and contents of structures excavated. Sites were excavated by hand using tools ranging from ‘turiyas’ (local spade-equivalent), trowels and brushes. Sediments were sieved using a mesh size of 5mm. In some cases the groundwater levels were high which limited excavation.

1.3.2. Archaeozoological methods

For all assemblages, standard archaeozoological procedures were followed (for outlines see: Chaplin 1971; Davis 1987; Hesse and Wapnish 1985; Klein and Cruz-Uribe 1984; O’Connor 2000; Reitz and Wing 1999). I am solely responsible for the identification of the terrestrial mammalian taxa; while birds and rodents were identified together with the late Prof. Eitan Tchernov. Prof. Omri Lernau (Haifa University) identified the fish remains (see data given in Van Neer et al. 2004a) and the unpublished data on fish from sites in Sinai are cited here with his permission. Molluscs, which were found in all the sites documented here, are not directly discussed in this thesis as overall they do not represent dietary items. Shells from Neolithic and protohistoric sites in southern Sinai have been studied by Dr. Daniella Bar-Yosef Mayer (1989a, b, 1997, 1999, 2002a, b) while those deriving from the north Sinai sites were examined by Dr. Henk K. Mienis (1998).

All bones studied here were identified to element and species with reference to the comparative zoological collection of The Department of Evolution, Systematics and Ecology of The Hebrew University of Jerusalem. For sheep, goat, cattle and pig remains, metrical and/or morphological criteria were used to aid in distinguishing wild from domestic animals since changes in the robusticity and shape of certain bones, as well as the diminution in the size of bones and teeth, are commonly considered evidence of domestication. Where possible, age and sex profiles were also used for this purpose, since high proportions of immature animals and a shift in the sex ratio may denote domestication (e.g. Davis 1987; Meadow 1989).

Distinguishing domestic sheep from goat in highly fragmented collections is a major problem. Attempts to distinguish between these species were made using morphological and metric criteria outlined in Boessneck (1969), Payne (1969, 1985) and Prummel and Frisch (1986). Where no clear morphological or metric criteria could be applied, but the element was clearly from a domestic sheep or goat (based on its small size or specific morphology), it was placed in a joint sheep/goat category. Although it is well known that horncore morphology offers a good criterion for separating ibex from domestic and/or wild goat, no well-established criteria exist for separating these taxa on the basis of post-cranial elements. Consequently, together with Prof. Joris Peters (Ludwig-Maximilians University, Munich) I tried to create criteria for separating post-cranial elements of ibex (*Capra ibex*) from domestic or wild goat (*Capra hircus* and *Capra aegagrus* respectively). To date, our attempts have proved unsuccessful but are continuing. As such, in this study, goat material was often pooled. In the absence of specific identifications, where the element clearly belonged to a goat (*Capra*) as opposed to a sheep (*Ovis*), it was placed in a general *Capra* (goat/ibex) category. In other instances, where the identification was only certain to the level of caprine, the element was placed in a joint sheep/goat/ibex category, and where gazelle was present, a combined medium mammal category was used. As a result of these problems in species identification (wild versus domestic), it was not clear what system should be used to age caprines since the rate of bone fusion/tooth eruption in wild and domestic animals differs considerably (Hilzheimer 1961; Noddle 1974; Reitz and Wing 1999; Silver 1969). Consequently, for each data set the reference used for ageing is given.

In many instances, no species attribution could be made, and bones could only be identified to the level of body size. Three generalised body-size classes were created for this purpose:
Large mammal = cattle/aurochs/equid
Medium-mammal = goat/ibex/gazelle
Small mammal = fox/hare size
Furthermore, in many instances material could be identified to Family but not to Genus or Species. As such general terms such as Carnivore sp., Bird sp., Reptile sp. etc. were used.

Counts for all assemblages are given as the total number of identified bones per species (NISP). For some sites, the minimum number of individual animals (MNI) was calculated for the assemblage as a whole, with the highest number of a specific skeletal element in the sample taken as the MNI (Grayson 1984; Hesse and Wapnish 1985; Klein and Cruz-Uribe 1984; O'Connor 2000; Reitz and Wing 1999). To arrive at MNI estimates, all skeletal parts represented for each species were summed separately (distal epiphyses, proximal epiphysis and shafts), taking into account side of the skeletal element (left or right) as well as age (bone fusion/tooth eruption).

Given the time constraint imposed on the analysis of the Sinai material, bones were only identified by skeletal element and general region of the bone (distal epiphysis, shaft, proximal epiphysis) and not by more detailed zones or common landmarks on each skeletal element or portion. Moreover, given the poor preservation of most bones examined, the practical utility of landmark analysis is questionable (on this issue see the debate between Stiner 2002 versus Pickering et al. 2003). Consequently, more detailed methods such as those developed by Castel (1999) using lengths of long bones and ribs for estimating the portion of a bone represented in an assemblage, were not applied.

Depending upon the research question posed, appropriate tests were run for each bone assemblage including quantification of utility indices, % survivorship and assessment of the impact of bone mineral density on skeletal element survival.

Utility Index: Anthropogenic activities such as selective transportation of skeletal elements on and off-site, as well as cooking and consumption practices (e.g. boiling, burning) have potentially influenced the overall representation of taxa and skeletal elements in the Sinai assemblages (e.g. Bennett 1999; Nicholson 1993; Shipman et al. 1984; Stiner et al. 1995). Utility indices were calculated which examine the use value of skeletal elements (after Binford 1978; Lyman 1992, 1994).

Since left and right sides were distinguished in the Sinai assemblages, these were used in combination with skeletal element counts (NISP), broken down into distal and proximal epiphyses and shafts, in order to calculate the Minimum Number of Elements (MNE) represented i.e. 2 left and 3 right distal humeri gave a total of 3 distal humeri. MNE's. Following Binford (1978), Minimum Animal Units (MAU'S) were then calculated by dividing the MNE count by the number of times that element is represented in the skeleton of one complete animal (3 distal humeri are divided by 2 to give an MAU of 1.5). The MAU values were then 'normed' by dividing each MAU value by the maximum MAU value obtained for that assemblage. The resulting value (on a scale of 1 to 100) is the %MAU (Lyman 1994). Bivariate plots were then made of %MAU values against %MGUI values for sheep (%Modified General Utility Index) taken from Binford (1978). The %MGUI offers an assessment of the utility value of a skeletal element, based on its meat, marrow and grease content. A correlation coefficient between the two values was then calculated to determine if they were significantly correlated or not.

Bone fragmentation: A simple method used to assess the degree of skeletal element completeness in the assemblages was developed and is termed % Completeness. The NISP count for each portion of a bone (distal epiphyses, proximal epiphyses, shafts) was divided by the number of bones expected if all skeletal parts were represented given the specific MNI estimate for that species. Thus 4 distal scapula of goat with an MNI estimate of 5 animals i.e. 10 bones expected if all distal humeri from all 5 animals are present, will give a % Completeness of 40%. This offers a simply quantitative method for assessing the extent to which the assemblage is fragmented and/or skeletal elements are under-represented.

Bone Mineral Density Mediated Attrition: Two methods were used to assess the impact of bone density on skeletal element representation. Correlation coefficients were calculated from bivariate plots of %MAU against bone mineral density values (BMD) for each skeletal element using values for domestic sheep as proxies for gazelle, ibex as well as wild and domestic goats (Lyman 1994: Tables 7.6 data, and see Table 7.10 for definition of the maximum density scan sites). Since the location of the different scan sites could not be determined with precision on the archaeological material (since no landmark identification was made on shafts or epiphyses). For the whole long bone, a mean of all scanned BMD values was calculated for the shaft, distal and proximal epiphyses respectively, while for vertebrae, astragali and calcanea, a mean value was calculated based on scan values. For example, for the proximal end of a domestic sheep femur, Lyman (1994: Tables 7.6) there were three scan sites with BMD values of 0.28, 0.16 and 0.20 respectively. These were summed and divided by 3 in order to obtain the mean BMD value which was 0.21.

Another method of assessing bone attrition for inter-assemblage comparison was to examine a series of bones with different bone mineral density values such as: the sum of distal versus the sum of proximal ends of the same bone. Poorly preserved collections should have a higher representation of the more robust ends i.e. that which has a higher bone mineral density value.

Epiphyseal fusion and dental eruption stages were scored for all species: wild/domestic sheep, domestic goat and ibex (Hilzheimer 1961; Noddle 1974; Silver 1969); aurochs/cattle (Grigson 1982); boar/pig (Bull and Payne 1982; Silver 1969); equids (Hilzheimer 1961; Silver 1969) and gazelle (Davis 1980a). Age data for other wild taxa followed Hilzheimer (1961). In addition, dental attrition was scored for domestic/wild sheep/goat/ibex after Payne (1973) while Grant (1982) was used for aurochs/cattle and boar/pig. Standard measurements were taken on bones of mature individuals (with fused ends) following von den Driesch (1976), with additional measurements taken where necessary. These are defined in the relevant texts.

In order to examine patterns of butchery and consumption, skeletal elements were grouped into body part categories based on association with muscle mass (meat-rich elements versus those poor in meat i.e. primary butchery discards versus parts for consumption - Reitz and Wing 1999). Categories used were:
Cranial: antler, horn, skull, maxilla, mandible and loose teeth
Upper Forelimb: scapula, humerus, radius, ulna
Lower Forelimb: carpals, metacarpal
Upper Hindlimb: pelvis, femur, tibia, patella
Lower Hindlimb: calcaneum, astragalus, tarsals, metatarsal
Trunk: axis, atlas, cervical, thoracic, lumbar and caudal vertebrae, sternum and ribs
Feet: 1st, 2nd and 3rd phalanges

Where adhering matrix did not cover the bone surface, modifications such as cut marks, animal modifications (gnawing, pitting, puncture holes), as well as burning (Lyman 1994) were noted for both identified bones and all fragments. It may be possible to distinguish between burnt bone as a result of conflagrations or accidental exposure to hearths rather than food preparation activities, based on its archaeological context within the site. General descriptive features of modifications were noted such as the type of modification, position on the bone and where possible, number of marks. Cut marks were associated with function – carcass dismemberment, filleting, secondary butchery based on ethnographic data dealing with the location and type of marks following Binford (1978, 1981).

All bone identifications, measurements, age and sex data and descriptions of modifications, were computerized in spread-sheets to facilitate easy manipulation of the data sets for analysis.

1.3.3. Constraints

Sieving: It is well established that inadequate screening of sediments results in a marked loss of very small and fragile remains (e.g. Payne 1975; Reitz and Wing 1999). Since selective sieving was practiced for most of the later period sites (New Kingdom, Iron Age and Classical sites), with most bone retrieved by hand picking during excavation, this may have limited the quantity and quality of the samples. Even those deposits which were sieved, mesh size was often large (5mm or larger) such that the small-sized bones and teeth or rodents, reptiles, fish and birds probably fell through. Thus, in these sites, it is expected that small-sized elements of medium and large mammals, as well as bones of fish, rodents, reptiles and even birds, are under-represented.

Small sample size: Small samples are the result of limited excavation, since in many cases only test pits were dug, or a small portion of a site sampled in order to verify its date or uncover a specific feature. In north Sinai sites only small areas were excavated in most sites since they were covered by dunes. According to Prof. E. Oren the excavator of these sites, even following excavation, within a short period of time the dunes rapidly covered them. Logistically, this limited the extent of areas which could be excavated. Misak and Draz (1997) cite the extent of dune movement in north Sinai as ranging from severe (greater than 15 meters a year) in the area to the south of Lake Bardawil, through to slight (less than 5 meters a year) – in the area of El Arish and eastwards. However, most of north Sinai experiences moderate movement of dunes ranging between 5-15 meters a year.

A further factor contributing to the small size of bone samples is the ephemeral nature of many of the sites e.g. seasonal encampments, or the fact that even some of the larger sites were occupied for short periods of time.

Poor bone preservation: Perhaps, the most critical feature in determining the size of faunal assemblages from Sinai, is poor bone preservation. Irrespective of period, site size or depth of burial, the Sinai assemblages are characterised by small, highly fragmented bones, with relatively low frequencies of diagnostic material. Consequently, most assemblages were too small to examine with robust statistical methods, and even non-parametric statistics are at times inapplicable. Thus, in this study I have had to rely primarily upon a descriptive approach.

Although in most sites all body part categories are represented, it is evident that they have suffered from differential preservation of different parts of the skeleton due to anthropogenic and/or diagenetic processes. Attrition of skeletal elements can be mediated by biotic factors: animal ravaging, such as carnivore gnawing, or else by human selection, differential transport of skeletal elements as well as food preparation techniques (Binford 1978, 1981; Binford and Bertram 1977; Lyman 1985, 1992, 1994). Despite the fact that skeletal remains of both wild and domestic carnivores have been found in several sites studied here, as well as their scats and evidence for bone ravaging, the quantity of material affected by carnivores was found to be slight, a finding that may have been biased by the superficial nature of the taphonomic analyses. With respect to anthropogenic activities, a modified utility index was calculated to examine whether the skeletal element composition reflected human preferences for certain parts based on their meat/marrow/grease content.

In most cases, especially in the relatively shallow, single occupation-horizon prehistoric and protohistoric sites, the bone surfaces are cracked and splintered with exfoliated, flaked and irregular surfaces (Behrensmeyer 1978, stage 5- bone splintering, original shape not apparent). This may be due to weathering from exposure to both wind and sun, and extreme temperature changes. In many assemblages, salt and gypsum crystals were found growing on the bones and in their marrow cavities and their action has undoubtedly contributed to the destruction and fracturing of the bones. In some cases, water and mineral action has destroyed the fragile bones leaving only splinters, while in others abrasion through sand and wind action has resulted in bones that are polished and have rounded edges.

A further limiting factor that may have influenced the composition of the bone assemblages is bone mineral density mediated attrition whereby the more fragile fraction of the assemblage has been impacted resulting in loss of bones of immature animals, of less dense epiphyses relative to denser ones, of epiphyses relative to shafts, and of the more fragile bones of bird and fish bones etc. This has undoubtedly biased the representation of elements and/or taxa that are more resistant to destruction (for example see discussions in Binford 1978, 1981; Binford and Bertram 1977; Lyman 1994, Lam et al. 2003; Pickering et al. 2003; Stiner 2002). The assemblages at hand then differ markedly from those initially discarded by people in the past. The inferences that may be made with respect to past human behaviour based on the results obtained from the utility indices, are thus markedly weakened.

Limitations of time and facilities: A limited amount of time and facilities were allotted for archaeozoological analysis of the Sinai Project before the material was handed over to the Egyptian Antiquities Authority. Consequently, certain aspects of some of the assemblages were not studied at all e.g. fragmentation shape, or else aspects were studied in less detail than would be optimal (for example identification of precise limb shaft and epiphyseal portions). In addition, it was not possible to clean most bones from the hard sand matrix adhering to them in order to undertake an in depth study of bone weathering, cut marks and other surface modifications. The matrix could only be removed using a dilute solution of acetic acid followed by soaking in fresh water and drying slowly. Consequently, only selected specimens were treated in this manner – those which otherwise could not be measured, or where the matrix appeared to obscure surface modifications.

Given the poor state of bone preservation it is possible that many of the modifications, anthropogenic or other, may have been obscured through destruction (erosion and weathering) of the original bone surface. Furthermore, the presence of matrix may have obscured human and animal modifications. Therefore, the data collected reflects only the gross pattern of damage with much of the finer marks not having been preserved or recorded.

Similarly, little time was available for restoration of broken bones, such that this was only carried out if it facilitated measurement of the piece. Likewise, for the prehistoric and protohistoric sites, there was no time to attempt conjoining or refitting of fragments from different parts of the site. Taking into consideration the small size of most bone fragments (on average less than 5mm from southern Sinai and less than 10mm for northern Sinai), in most cases these were not counted, while for each period a random sample of bones were measured for length to assess degree of fragmentation. Weighing of bones was also not undertaken given the variation in rainfall, temperature and sediments between regions of Sinai (Chapter 2) (Greenwood 1997), factors which influence the extent of bone preservation and fossilisation and hence the weight of the bones.

1.3.4 Conclusions

The multitude of factors that have acted on the Sinai bone assemblages have limited the extent and nature of archaeozoological analyses that could be undertaken. For example, the scarcity of measurable bones has curtailed statistical studies of the osteometry of different taxa as sample sizes of measurable bones are exceedingly small. As such one ‘remedy’ has been to try and fit the questions posed to the capabilities of the data set available. For example, issues pertaining to sex ratios or identification of breeds, both questions which would require large-scale biometric analyses, have not been attempted in this thesis.

Small sample sizes have also meant that in most sites the full range of taxa are clearly not represented. To overcome this, in some cases statistical methods such as rarefraction (Magurran 1991) have been applied which assess this loss. However, there are instances where sample sizes are so small that even this method was inapplicable. Consequently, much of the data presented here is qualitative and hinges upon features such as presence/absence of certain parameters rather than a quantitative or statistical approach.

However, to end on a positive note, as David Lewis-Williams (2003: 268) has succinctly stated: “A partial insight is better than no insight at all. The course of true research never did run smoothly.”

CHAPTER 2

THE PHYSICAL GEOGRAPHY, FLORA AND FAUNA OF SINAI

2.1. INTRODUCTION

The Sinai Peninsula forms a continental bridge between Africa and Asia (Fig. 2.1). It is a triangular shaped Peninsula some 61, 000 km^2 in area. Its western boundary, the Gulf of Suez, is a 240 km long coastal strip including the Suez Canal. The eastern boundary, the Gulf of Aqaba also known as the Gulf of Eilat, comprises a 170 km long coastal strip while to the north-east the Negev desert of Israel forms a 220 km long continental strip. The northern boundary is formed by the Mediterranean Sea along a 200 km long coastal strip, while the southern tip comprises the Red Sea (Zahran and Willis 1992).

The Sinai constitutes part of the Saharo-Arabian desert belt which stretches from Atlantic coast of Africa through to the Sind desert in western India (Jaffe 1987; Yom-Tov 1987). The Sinai is characterized by arid (north region) to hyper-arid conditions (in the central and southern regions) with rainfall mainly in the winter months of January and February, and mean temperatures of 10-20^{o}C in the cold months and 20-30 ^{o}C in the warm months. Average annual precipitation drops from north-east to south-west (Ganor et al. 1973; Jaffe 1987; Zahran and Willis 1992).

Water in this region originates from three sources: surface water such as springs or streams (Fig. 2.2), paleo-water representing groundwaters recharged in the distant past under cooler climates, and rainfall which may create seasonal pools but also recharges the groundwater such as via flood flows (Gat and Issar 1974; Issar 1985; Tantawi et al. 1998; Zahran and Willis 1992). In southern Sinai, snow that covers the summits in winter is a further source of water. Bedouin and other local communities collect rainwater in cisterns and dams, excavate wells and practice runoff agriculture in the wadi beds (Ben David 1987; Danin 1983; Gat and Issar 1974; Hellström 1953; Perevolotsky 1981).

Due to its key location between Asia and Africa, the floristic and faunal compositions of Sinai reflect affinities to both regions. Thus although both the flora and fauna are primarily Saharo-Arabian in origin, elements of other phytogeographic and zoogeographic regions are also represented (Danin 1983, 1986, 1996; Danin and Plitman 1987; Tchernov 1979; Yom-Tov 1987; Zahran and Willis 1992). The high diversity of the flora of Sinai is due to the environmental heterogeneity of the Peninsula, with some 900 species of which 28 are endemic (Danin 1983, 1986). Greenwood (1997) places the species count even higher – at over 1,200. In addition 250-300 different associations of plant communities are recognized (Danin 1986). According to Danin and colleagues (Danin 1986, 1996; Danin and Plitman 1987), most of Sinai is dominated by Saharo-Arabian species. Exceptions are the mountains of southern Sinai, which are dominated by Irano-Turanian forms, while the coast of the Gulf of Aqaba is characterized by Sudanian species. In most of the Peninsula vegetation is restricted to the wadis (seasonal stream courses) as generally the soil is too saline to support vegetation and/or the rainfall too light to be absorbed and is rapidly lost through evaporation. However, despite the low precipitation, in outcrops of smooth-faced rocks, collection of run-off water has facilitated the growth of mesic flora (Danin 1986). Faunal biodiversity in the Peninsula (excluding avian passage migrants) is not very high, but includes several endemic sub-species termed Arabo-Sinaitic forms (Yom-Tov 1987).

2.2. GEOMORPHOLOGICAL REGIONS OF SINAI

Some researchers (e.g. Eyal et al. 1987) recognise two main geomorphological regions in Sinai – north and south with the border at the e-Tih plateau, while others (e.g. Greenwood 1997; Zahran and Willis 1992) recognise three (Figs. 2.1 and 2.3):

- the south comprises narrow coastal plains with a mountainous massif of Precambrian crystalline rocks in the centre cut by canyon-like wadis.
- the central region comprises an extensive plateau composed of sedimentary limestone ending in a sandstone escarpment dissected by large wadis at its southern edge.
- the north is a broad, sandy plain with insular mountains in the hinterland intersected by valleys.

The archaeozoological remains studied here derive from the northern and southern regions of Sinai, with a few sites in the eastern extremity bordering on the Negev desert (Israel) (see Chapter 1, Table 1.1). As can be seen from the following descriptions, the three geomorphological regions differ markedly in all natural features. Consequently, interpretation of the faunal record is dependent upon an understanding of the physical geography of each region.

2.2.1 Southern Sinai

Southern Sinai, which covers an area of circa 20,000 km^2, is the region south of the e-Tih plateau. Three salient features can be recognized: a central massif of rugged and high mountains, the Gulf of Aqaba to the east, the Gulf of Suez to the west with the Plain of Qa at its southern extremity (Figs. 2.1. and 2.3).

Southern Sinai is hyper-arid with an average annual precipitation of less than 50 mm, with a range of ca. 10 mm rainfall at the coast rising to a maximum of ca. 100 mm in the upper elevations of the mountains (Fig. 2.4) (Ganor et al. 1973; Jaffe 1987). Rainfall in the region is unstable and may stop for several years, while annually it varies with most falling in winter but some may fall in summer due to monsoon winds. Rainfall also varies spatially so that pasture areas may shift seasonally. Heavy rains result in flash floods while torrential rains can flood valleys, resulting in damage to crops and orchards. Most groundwater in southern Sinai is recharged from recent sources – rainfall, floods, snow melts, with a relatively small contribution from paleo-water (Gat and Issar 1974; Tantawi et al. 1998).

Temperatures in southern Sinai are the lowest in the Peninsula but vary with elevation (Ganor et al. 1973; Jaffe 1987). The region experiences dramatic extremes in seasonal temperature with very cold winters (lowest temperatures in January-February of 1-3^{o}C daily average with high of 5-8 ^{o}C) with snow on the mountain peaks (reaching low temperatures of -1 to -3^{o}C). The summers are hot and dry with the highest temperatures in June-July (mean summer temperature 17-19 ^{o}C). Year-round, daily temperature fluctuates with cool nights even on days that are extremely hot. The relative humidity is low ranging from 33.3% in May-June to 57.9% in February. In the high mountains, wind direction in the winter is west to south-west, while in summer the prevailing wind is north-east to north-west (Ganor et al. 1973; Jaffe 1987; Zahran and Willis 1992).

The central massif (covering an area of ca. 7500 km^2) is composed of igneous (magmatic) and metamorphic Precambrian rocks, chiefly granites that are dissected by wide valleys filled with arkose and alluvium (Eyal et al. 1987) (Fig. 2.5). The mountains are steep and attain heights of more than 2000 meters above sea level (m.a.s.l.). Three clusters of peaks may be recognized: Gebel Serbal (2070m) in the west, Gebel Catherina, which is the highest peak (2641m) and Gebel Musa (2280m) in the centre, and Gebel Umm-Shomar (2586m) in the south. The mountains are bare and rugged and produce soils that are unsuitable for cultivation because of resistance to root penetration, shallow soils and poor water retention. However, due to its impermeable lithology, the region is rich in water which following rainfall or snow melts, runs over the rocks and collects in pools or streams, or else percolates into the substrate and rock crevices. It emerges as springs and streams or may be exploited using wells. Consequently, there are areas in the mountain region that offer a rich biotope for cultivation, as illustrated by the Bedouin who maintain orchards of apples, quinces, pears, pomegranates and almonds (Perevolotsky 1981).

The natural vegetation of the Sinai massif is the richest in the Peninsula since the upper elevations of the mountains receive the highest rainfall; mean annual rainfall of 70-100mm (Figs. 2.4 and 2.6). This region also has the highest number of rare species and endemics (Danin 1983, 1986). The high mountains (Vegetation District 19 – Fig. 2.6), support a shrub-steppe of primarily Irano-Turanian vegetation (such as *Artemisia inculta [=A. herba-alba]*[2] and *Tanacetum sinaicum [=T. santolinoides*]) as well as a wide spectrum of non-desert trees which are associated with hard rock outcrops in the high elevations (e.g. *Pistacia khinjuk, Ficus pseudosycomorus, Crataegus sinaicus, Moringa peregrina*) and shrubs (*Rhamnus disperma, Rhus tripartita, Sageretia thea, Periploca aphylla*). Danin (1983, 1986) recognized eight vegetation associations in areas with fissured rock and stony soil, all include *Artemisia inculta* in association with other shrubs (e.g. *Anabasis setifera, Rhus tripartita*), while on smooth-faced granite six plant associations were identified by him (e.g. *Chiliadenus montanus* [=*Varthemia montana]-Pistacia khinjuk, Globularia arabica-Verbascum decaisneum*). The granitic gravel plains contain diffuse vegetation of drought-resistant plants such as the association *Anabasis articulate-Fagonia mollis*. In the lowest elevations, vegetation is restricted to the wide wadis, characterised by the association *Artemisia judaica-Achillea fragrantissima*, found together with *Zilla spinosa* and *Fagonia mollis* on stony alluvium. These localities offer good pasture especially of annuals in the growth season (Danin 1996; Heneidy 1996).

---

[2] The common sage-brush of Sinai used to be called *Artemisia herba-alba*. The component of the complex in Israel and eastwards is regarded as *Artemisia sieberi* while the taxon in North Africa, including Egypt, is *Artemisia inculta*. The status of *Artemisia* in the transition zone of Sinai remains unclear. The nominate *Artemisia inculta* is used in this thesis.

The lower massif - elevations of less than 1000 m.a.s.l., experiences annual rainfall of 30-50mm (Fig. 2.4). It is characterised by vegetation that is both diffuse on rocks (associations such as *Artemisia inculta-Echinops glaberrimus, Iphiona mucronata-Echinops glaberrimus)* and on the gravel plains (*Anabasis articulata-Fagonia mollis*), as well as contracted vegetation in the wadis (*Retama raetam, Zilla spinosa, Haloxylon salicornicum [=Hammada salicornica*]) (Vegetation District 18 –Fig. 2.6).

To the north lies the sandstone belt (Vegetation District 17-Fig. 2.6) that comprises a mixture of different sandstones, sand sheets of varying stability and sandy alluvium mixed with other substrates (Eyal et al. 1987). Each lithological type is characterized by its own plant community (Danin 1983, 1986). The sandstones are characterized by a diffuse vegetation comprising shrubs and semi-shrubs such as *Launea spinosa, Anabasis setifera, Ferula sinaica* and *Salsola schweinfirthii*; while the more sandy environments with finer sands, support vegetation only in wadi beds such as *Haloxylon salicornicum, Anabasis articulata, Retama raetam* and are rich in annuals in rainy years and offer excellent pasture for domestic and wild animals.

The southern Sinai massif is intersected by deeply incised wadis containing coarse alluvial deposits and lacustrine beds, which drain steeply eastwards into the Gulf of Aqaba and more gradually westwards into the Gulf of Suez (Greenwood 1997). The east coast (Gulf of Aqaba) comprises a narrow foreshore with four main wadi systems – Watir, Nasb, Kid and Adawi – of which only the first two exhibit plain development. Wadi Watir serves as the main drainage system for the Egma escarpment. Mean annual rainfall in this littoral strip ranges from 5 to 30mm. Three vegetation types are found here (Vegetation District 15- Fig. 2.6): mangroves of *Avicennia marina* which are found in the muddy soils of the tidewater of the south-eastern coastal area; littoral salt marshes which are subject to periodic flooding with sea water and are dominated by *Limonium axillare*; and coastal desert and wadi vegetation such as *Artemisia judaica, Panicum turgidum, Cyperus jeminicus* and *Abutilon fruticosum* to name but a few (Danin 1983, 1986). In the large wadis and wadi mouths, *Acacia raddiana* and *Tamarix nilotica* accompanied by semi-shrubs and annuals are found. In more mesic localities such as near springs, trees such as *Moringa peregrina* or *Phoenix dactylifera* grow (Danin 1983; Zahran and Willis 1992).

The western coastal plain (Gulf of Suez) is relatively broad, and extends to the edge of the e-Tih plateau in the north-west, down along the southern massif where is narrows. It experiences mean annual precipitation of 10-30mm and is characterised by vegetation that is contracted with diffuse cover in sandy and marshy localities (Vegetation District 14-Fig. 2.6). Sections of the north-west coast undergo flooding from the Gulf of Suez resulting in the formation of saline marshes vegetated with species such as *Halocnemum strobilaceum, Aeluropus massauensis, Zygophyllum album, Nitraria retusa, Tamarix nilotica* (Zahran and Willis 1992). Danin (1983, 1996) notes that vegetation in the north-west part of the Gulf of Suez is diffuse, while in the south it is restricted to wadis. The largest drainage systems are – Wadi Sudr, W. Isla, W. Hebron, W. Sidri and W. Feiran, the latter supporting the largest oasis[3] in southern Sinai with the most extensive palm grove in the region. South of Wadi Feiran, along the coastal plain, is a depression circa 20 km wide and 120 km long termed the Qa Plain [also termed El-Qaa Plain in the literature] (Figs. 2.1 and 2.3). The plain is covered with alluvial sediments- fine sands, pebbles and gravels - that have eroded from the Sinai massif. Greenwood (1997) notes that this plain and the large drainage areas at the wadi-mouths on this coast, offer good soils for cultivation in a region that has little arable land. The natural vegetation of the Qa Plain is primarily composed of the following families- Asteraceae, Fabaceae, Chenopodiaceae and Zygophyllaceae. Shrubs and semi-shrubs such as *Haloxylon salicornicum* constitute some 46%, while grasses such as *Panicum turgidum* comprise only 9% (Abd El-Ghani and Amer 2003; Danin 1996).

2.2.2. Central Sinai

The central part of Sinai comprises most of the Peninsula’s landmass (circa 27,000 km^2 including the el-Arish Basin that by itself covers ca. 17,000 km^2) (Figs. 2.1 and 2.3). This region is drier and colder than northern Sinai - mean average annual temperature of 18-20^{o}C and with average annual precipitation of 25-50 mm (compared to 90 mm on the coast) (Fig. 2.4), and lower values of relative humidity (Ganor et al. 1973; Jaffe 1987). It also has less water than northern Sinai, most of which is found in limestone springs or seasonal pools which form after the rains (Fig. 2.2). Abou Rayan et al. (2001) list 12 brackish-water wells around Bir–Hasana (located several kilometres east of Bir Gifgafa – Fig. 2.4), of

---

[3] Oases form in areas where the watertable in the wadi beds is shallow.

which some are exceptionally deep (approx. depth 12-1000 m) and 7 in the region of Nakhl (approx. depth 17-1200 m) (Fig. 2.4).

Central Sinai is dominated by the rocky high plateau of e-Tih (maximum elevation of 1,600 m) composed of two escarpments - Gebel el-Tih and Gebel Egma- bounded by tablelands. The stratigraphy of the plateau is as follows (from bottom upwards) (Eyal et al. 1987): Crystalline rocks topped by sands and silts the lowest of which are Cambrian to Lower Cretaceous in age (including a Nubian sandstone layer); above this a calcareous limestone of Cenomanian to Eocene age, and an upper layer alluvial and weathered material which makes up a barren and stony gravel plain (Fig. 2.5). On these plains, a silty soil is covered by chert gravels (reg or hammada soils). As the underlying soils are highly saline, the plains support little vegetation (Fig. 2.6). The underlying Nubian sandstone serves as the most important aquifer in the region due to its abundant storage of paleo-water. The present recharge of this aquifer through floodwaters is negligible (Gat and Issar 1974; Issar 1985). The calcareous plateau is dissected by northward draining wadis which flow into Wadi el-Arish, the main drainage channel for the mountainous region of northern Sinai. Wadi el-Arish flows into the Mediterranean Sea at the town of this name (Figs. 2.1 and 2.3). The most fertile soils in Sinai are associated with alluvial deposition in the wadis of the e-Tih plateau and lower drainage of Wadi el-Arish. The western and eastern edges of the e-Tih plateau are dissected by small wadis which drain into the Gulfs of Suez and Aqaba respectively. The eastern edge of the e-Tih plateau borders on Israel and is essentially a continuation of the Negev Desert.

The vegetation cover of most of the gravel plains of the e-Tih plateau is meagre and may be classified as desert scrub with predominantly Sudanian elements (Vegetation District 9-Fig. 2.6) (Danin 1983, 1986). Vegetation in this region is contracted and primarily found in the wadi channels where sufficient water accumulates (Danin 1996). Along the wadi channels, the vegetation undergoes replacement from the highest to lowest sections, with annuals only found in the uppermost sections, and this only in moist seasons with good rain. Lower down the wadi, small and short-living semi-shrubs or annual herbaceous plants are found such as *Aaronsohnia factorovskyi, Stipa capensis* and *Anastatica hierochuntica.* Further down the wadi, the vegetation association is made up of long-living semi-shrubs. This association comprises the largest portion of the vegetal biomass of this region. According to Danin (1996), the dominant semi-shrubs differ according to lithology and subtsrate:

Anabasis articulata (dominant in wadis with gravel fill), *Artemisia sieberi* (dominant in wadis with silt-sandy fill), *Gymnocarpus decander* (dominant in wadis where flint outcrops occur in the wadi channel), *Haloxylon salicornicum* and *Panicum turgidum* (dominant in wadi channels with sand accumulation among stones). The lowest section of the wadi system contains shrubs (*Retama raetam, Lycium shawii*) and trees such as *Tamarix nilotica, Acacia pachyceras* and *A. raddiana*. Where the water table is high, *Phoenix dactylifera* may also be found. The most important annual grass found on the e-Tih plateau is *Stipa capensis*.

Danin (1983, 1986) recognises Gebel Egma, located at the southern edge, as a separate vegetation district (No. 13 - Fig. 2.6) since this is a chalk plateau, dominated by xerohalophytes (Fig. 2.5). At high elevations (over 1200m) vegetation is diffuse and characterised by associations such as *Atriplex glauca-Bassia arabica [= Chenolea arabica]* and *Atriplex leucoclada-Artemisia inculta.* Vegetation in the lower elevations is characterised by semi-shrubs that are restricted to the wadi's (*Salsola tetrandra, Artemisia inculta, Haloxylon salicornicum*)

The northern extent of the e-Tih plateau is a massif composed of a series of insular unfolded limestone, dolomite, marls and chalk mountains, ranging in height from 370 to 1094m (Eyal et al. 1987) (Fig. 2.5). The dune fields and gravel plains between them form the edge of the northern desert. At the southern edge of the e-Tih, the large drainage systems of Wadi Feiran and Watir dissect the plateau from the southern Sinai massif forming a system of valleys some 20-30km wide (Figs. 2.1 and 2.3). This hilly region, (Vegetation District 12-Fig. 2.6) experiences a mean of 50-100mm of rain per annum and is characterised by diffuse vegetation associations of *Zygophyllum dumosum* associated with either *Reaumuria hirtella, Salsola cyclophylla* and *Gymnocarpos decander* as well as contracted vegetation in the wadi's (*Anabasis articulata*, *Artemisia inculta*).

2.2.3. Northern Sinai

Northern Sinai covers an area of circa 14,000 km$^{2.}$ Mean annual precipitation in this region is 50-150 mm, but it is not homogeneous and increases from south-west to north-east - ca. 60 mm in the south-west to 100 mm in the east (Fig. 2.4) (Ganor et al. 1973; Jaffe 1987). Precipitation falls mainly in January through February. Spring and autumn are dry with hot southern winds (*hamsin*) and occasional torrential rains. Temperatures are influenced by the Mediterranean Sea with the mean summer temperatures in August reaching 31-39°C, while mean winter temperatures in January range from 18-19°C. Mean annual temperature and daily temperature range increase away from the Mediterranean coast. Relative humidity is high on the coast reaching 74% and decreases as one goes inland, with the lowest humidity in the spring months. Wind force is greatest in summer and the most common direction year-round is westerly-north-westerly (Ganor et al. 1973; Jaffe 1987).

Five salient physical features can be recognized in the landscape of northern Sinai (Figs. 2.1 and 2.3): The sand fields (sheets) of the littoral plain, The el-Tineh plain and salines (*sabkhas*) to the west, Wadi el-Arish in the east, Lake Bardawil in the centre of the coastal plain, and the insular mountains in the interior.

The littoral plain is ca. 240 kms in length and stretches from the Isthmus of Suez (the Suez Canal) in the west to Rafiah in the east. The average width of the plain is 20-30km, but this varies from west to east - 75 km wide at the Suez Canal; 10-20 km wide at Lake Bardawil; to 40-50 km wide at el-Arish (Greenwood 1997). The topography is relatively flat, sloping slightly from south to north. The littoral plain is covered with mobile sand dunes, which shift at rates of 5 to over 15 meters per annum (Misak and Draz 1997). Their orientation is north-west to north-east, which parallels the north-westerly winds (Tsoar 1987), with some reaching heights of over 90m. Neev et al. (1987) have argued for a relatively recent date for these dunes (Pleistocene-Holocene). The mobile dunes are composed of fine to coarse sand with a low proportion of silt and clay overlying coarse sand-fields. The dune fields are poor in vegetation due to their low water retention capacity and their instability that prevents most plant development (Danin 1983). This also makes them unsuitable for cultivation. The predominant vegetation type on the coastal sands are Mediterranean semi-shrubs, while in the mobile dune fields perennial grasses such as *Stipagrostis scoparia* and *Ammophila arenaria* are found (Vegetation District 8-Fig. 2.6) (Danin 1983, 1986). *Ammophila,* the dominant grass found on these littoral dunes, only covers less than 5% of the total area of the dunes (Zahran and Willis 1992). Between the dunes are low pans which support halophytic vegetation.

Artemesia monosperma is the most common shrub species found growing on the less mobile sand drifts and dunes. Other species are *Convulvulus lanatus, Thymelaea hirsuta* and *Stipagrostis scoparia*. The most important grass species found growing here is *Stipagrostis scoparia,* in association with *Haplophyllum tuberculatum*, *Neurada procumbens* and *Urginea maritima* (Danin 1996). According to Zahran and Willis (1992), this plant community is currently subject to intense exploitation – through cutting and grazing. The dunes located further inlands vary in vegetation cover, depending on their substrate. Most are covered with *Panicum turgidum*.

Lake Bardawil (Sabkhat el-Bardawil), known in Classical times as Lake Sirbonis, lies along the central part of the Mediterranean coast of Sinai, between El-Arish and Port Said (Fig. 2.3). This is a shallow, hypersaline lagoon ca. 80 km long and 18 km wide. It is enclosed and separated from the Mediterranean Sea by an offshore sand bar, which is ca. 22 km long and up to 3 km wide at its broadest point (Mount Casius). The total area of the lagoon is ca. 600 km^2 (Ben-Tuvia and Golani 1987; Levy 1987). The extent of the lagoon varies up to several square kms depending on tides, seasons and dune incursion. The water depth averages a few centimetres along the southern coast to ca. 3 m in the western part. The lagoon experiences seasonal changes in salinity and temperature (Levy 1987). At the north-eastern corner of the lagoon is a natural and permanent opening in the bar some 300 m wide, which connects the lagoon to the Mediterranean Sea. This opening cleans itself every winter due to overflow from the Mediterranean Sea, which causes an eastward current inside the lagoon forcing it to seek an outlet at the eastern side (Neev et al. 1987). As described by Ben-Tuvia and Golani (1987), the lagoon supports over 12 fish species that are exploited by local fishermen. In the south-east part of the lagoon are internal ponds formed by sandbars. The terrestrial vegetation of the lagoon and its hinterland constitutes part of the el-Tineh saline and is almost devoid of annuals but supports typical halophytic shrubs and semi-shrubs the most common being *Arthrocnemum glaucum, Zygophyllum allum* and *Halocnemum strobilaceum*.

In the western part of the littoral lies a poorly vegetated region with a salt marsh called the e-Tenna or el-Tineh Plain (Figs. 2.3 and 2.6). It abuts Lake Bardawil and the Isthmus of Suez[4]. Its southern-most extent is the region of Qantara, while its north-western extremity

---

[4] In the past, water levels of the Isthmus fluctuated and were probably higher, creating a barrier between Egypt and Sinai for fauna and hominids (Greenwood 1997). Today the Suez Canal connects and traverses Lake Timsah, the Great and Little Bitter Lakes en route to the Gulf of Suez.

is the Suez Canal. The southern portion of el-Tineh is composed of Nile silts while the northern part is sandy (Dan and Yaalon 1987). Greenwood (1997) discusses the mosaic nature of arable soils in Sinai and notes that the saline soils are poor for agriculture and grazing. This area is characterised by halophytic associations. The sand sheets near the Suez Canal are covered with *Zygophyllum album* a saline loving species. In the depressions between the dunes where the saline water table is high, wet salines (sabkhas-salt affected lands) form which support species such as *Suaeda aegyptiaca* and *Halocnemum strobilaceum*. Occasional *Tamarix* trees are found near the Mediterranean Sea, and these probably germinate when the freshwater table is high (Danin 1996).

Wadi el-Arish, located at the eastern portion of the Mediterranean littoral, is another salient feature in the landscape (Figs. 2.1 and 2.3). This wadi serves as the main drainage artery for the mountains of the interior. The soils in the wadi and its environs have high calcium content which, with adequate management, are amenable to cultivation (Greenwood 1997). Indeed, before 1967 the alluvial plain of Wadi el-Arish was the only locality in Sinai with extensive agriculture (Osborn and Helmy 1980). Moreover, in north Sinai the optimal pastures lie along Wadi el-Arish and areas to its east. A concentration of water wells is found in the vicinity of el-Arish and in the wadi channel, all of which are fed by floodwaters.

On the coastal plain groundwater is high and is especially shallow near the sea. It is recharged directly by rainfall that permeates the sand as well as water draining towards the coast from the hills in the interior. In places where the water table is high, oases or salt marshes form (Gat and Issar 1974). The water which infiltrates the dunes is retained by the underlying sediment composed of sandy clay and loess which is less permeable. As described by Hellström (1953), this water source is tapped into by traditional wells, called "*thamila*", which comprise simple pits 2-4 meters deep dug into the sand. Excessive exploitation of this water results in salinization of the source. Groundwater in deep strata (i.e. the Nubian sandstone) requires engine driven pumps to reach water at depths of up to 70m. The British military survey of water sources published in 1914, notes 124 water sources of different kinds, in north Sinai (cited in Yekutieli 1998: 19), which is a similar number to that listed more recently by Abou Rayan et al. (2001) - 35 brackish-water wells

---

in the region of Rafiah (approx. depth 35-90m); 25 around Sheikh Zuwayid (approx. depth 30-80 m) and 50 in the vicinity of El-Arish (approx. depth 40-60 m) (Fig. 2.2).

In the hinterland of the Mediterranean littoral are a series of insular mountains of limestone, dolomite, marl and chalk (Eyal et al. 1987) (Fig. 2.5), which rise from the sand plain and experience 50-100mm of rainfall per annum (Fig. 2.4). The western-most massif comprises the mountains of Gebel Oum Mafrut, Gebel Risan Aneiza, Gebel Libni and Gebel Maghara (all approx. 500-700 m.a.s.l.). They are separated by wide transversal valleys between which the coastal dunes penetrate (Vegetation District 10-Fig. 2.6). These dunes cover gravel plains which are the extension of those of the e-Tih plateau to the south and have a more diffuse vegetation cover than found in either the dune fields to the north or gravel plains to the south. This is due to the water retention capacity of the reg soils and high permeability of the overlying sands (Danin 1983). Plants growing on the sand fields and dunes accumulating against the mountains include *Panicum turgidum, Artemisia monosperma, Anabasis articulata, Thymelaea hirsuta* and *Fagonia arabica*.

To the south-east of the massif runs another range comprising Gebel Yelleq (1100m), Gebel el-Halal (890m) and Gebel Dalfa. Although numerous small wadis drain this region, there is no surface drainage onto the dune fields of the north coast. This area, termed by Danin (1983) the anticlines of northern Sinai (Vegetation District 11-Fig. 2.6) experiences the same rainfall as the coast (50-100 mm mean per annum), but has slightly lower annual temperatures (16-20^{o}C). The vegetation growing on the inland dunes which have accumulated on desert plains is dominated either by *Panicum turgidum* (on low dunes) or by *Stipogrostis scoparia* (on higher dunes). Both species are grazed (Zahran and Willis 1992). The insular mountains have a rich, diffuse flora with a predominance of Irano-Turanian shrub-steppic associations. The tree component includes Mediterranean species such as *Juniperus phoenicea* which in some instances grow in the crevices of smooth rock outcrops as well as in the wadis. They are accompanied by Mediterranean relic species such as *Ephedra foemina* and *Rubia tenuifolia* and an endemic species *Origanum isthmicum* (Danin 1983, 1996). At lower altitudes on the limestone mountain slopes, a wide variety of semi-shrubs are found, which replace each other as the aridity increases. Common, mesic species include *Artemisia siebert, Helianthemum kahiricum, Thymelaea hirsuta*. In drier regions, the dominant species include *Zygophyllum dumosum* and *Anabastis articularis*.

2.3 THE PRESENT-DAY VERTEBRATE FAUNA OF SINAI

The Sinai Peninsula, as part of the Levantine land-bridge, represents a unique meeting point of continents where several zoogeographic zones overlap – Ethiopian, Palaearctic and Oriental (Tchernov 1979, 1988). The range of fauna found in the Peninsula reflects this; the majority of mammals are of desert origin (Saharo-Arabian) and are well-suited to living in arid environments, but tropical, steppic, Palaearctic and Mediterranean taxa are also found. In north Sinai there are more Saharo-Arabian species while southern Sinai has a larger number of endemic Arabo-Siniatic species (Yom-Tov 1987). Sinai offers a wide variety of rangelands suitable for raising herd animals, with varying floristic composition covering a broad spectrum of different landscapes (Heneidy 1996).

The most recent field survey of wild mammals in Sinai was published by Saleh and Basuony (1998) who reported finding 21 species. They claim the first sightings of porcupine (*Hystrix indica)*, marbeled polecat (*Vormela peregusna*) and a sub-species of red fox (*Vulpes vulpes arabica*). However, already in 1987, Yom-Tov noted the presence of both porcupine and red fox in the Peninsula. This oversight undoubtedly stems from the fact that Yom-Tov's paper was only published in Hebrew. The annotated faunal lists for Sinai that have been published since Anderson's first publications (Anderson 1898; Anderson and De Winton 1902), indicate that the current wild fauna represents only part of the spectrum of animals that once inhabited the region (Table 2.1). While climate change, especially the ongoing aridification, has played an important role, many taxa became extinct following the introduction of firearms in the late 19th-early 20th century. It is assumed though, that even in the past, the relatively arid conditions prevailing in the region precluded high densities of animals.

2.3.1. Insectivores

Three species of insectivore are reported from Sinai. Saleh and Basuony (1998) noted that the Ethiopian hedgehog (*Paraechinus aethiopicus)* is widespread in the rocky areas of Sinai. The long-eared hedgehog (*Hemiechinus auritus*) is only known from the northern littoral with a sighting from southern Sinai discounted by Harrison and Bates (1991). The lesser white-toothed shrew, *Crocidura suaveolens*, was found in both the southern, south-eastern and more recently north-eastern parts of Sinai. Yom-Tov (1987) raises the possibility that small sized specimens of the greater white-toothed shrew (*Crocidura russula*) may also be present but have been incorrectly identified. However, *C. russula* and *C. suaveolens* differ in their chromosome numbers. To date all specimens from the southern Levant have chromosome numbers identical to *C. suaveolens* which has led Qumsiyeh (1996) to conclude that *C. russula* does not occur in the region.

2.3.2. Chiroptera

Harrison and Bates (1991) have identified 11 species of bats that inhabit regions of both northern and southern Sinai.

2.3.3. Small mammals and rodents

Rock hyrax (*Procavia capensis*) is known only from the southern and south-eastern part of Sinai (Harrison and Bates 1991). Their numbers appear to be is decreasing due to hunting. In contrast, the Cape hare (*Lepus capensis*) is still common throughout both northern and southern Sinai.

Haim and Tchernov (1974) who studied the zoogeography of rodents in Sinai, recognized three main habitats –
rocky biotopes are inhabited by two *Acomys* species, both found in southern and south-western Sinai (golden spiny mouse, *A. russatus*; and the Egyptian spiny mouse *A. cahirinus*); the black-tailed dormouse, *Eliomys melanurus* (found until 1600 m.a.s.l. everywhere except western Sinai); and two species of gerbil (Wagner's gerbil, *Dipodillus* [previously *Gerbillus*] *dasyurus* (all over Sinai); and the Bushy-tailed jird, *Sekeetamys calurus* (not in northern or western Sinai).
soil biotopes inhabited by two species of gerbil (the Egyptian gerbil, *G. gerbillus* present all over Sinai except at altitudes over 1000 m.a.s.l.; and the Greater Egyptian gerbil, *G. pyramidum* not found in the south).
psammophile (sandy) biotopes inhabited by the fat jird, *Psammomys obesus* found in wadis and plains in northern and north-western Sinai below 1200 m.a.s.l.; Sundevall's jird *Meriones crassus* (found all over Sinai at altitudes of less than 1500 m.a.s.l.); the pygmy gerbil, *Gerbillus [Dipodillus] henleyi* (found in wadis all over Sinai); and two species of

Jaculus (the lesser jerboa, *J. jaculus* found at altitudes of less than 1600 m only in western and south-western Sinai; and the greater Egyptian jerboa, *J. orientalis* found in southern Sinai).

Recently Saleh and Basuony (1998) extended the distribution of several species studied by Haim and Tchernov (1974). For example, *Dipodillus dasyurus* which is common throughout the interior of Sinai has now been observed in the littoral regions; *Acomys russatus* which inhabits southern Sinai now includes locations along the east coast; *Acomys cahirinus* which is primarily found in the mountainous regions of western and southern Sinai is now found along the littoral of southern Sinai.

Several additional species, not noted by either of the above-mentioned publications, are listed in Yom-Tov (1987) and Harrison and Bates (1991). These are: the Baluchistan gerbil (*Gerbillus nanus*) present in southern and south-eastern Sinai; Anderson's gerbil (*Gerbillus andersoni*) in sands of northern Sinai; Tristram's jird (*Meriones tristrami*) in northern Sinai; Libyan jird (*Meriones libycus*) found throughout Sinai; Buxton's jird (*Meriones sacramenti*) in sands of south-east Sinai; and two commensals which are associated with human habitations in northern and possibly also southern Sinai - the house rat or black rat *(Rattus rattus*) and the house mouse (*Mus musculus*). Yom-Tov (1987) includes the brown rat (*Rattus norvegicus*) as inhabiting the Suez Canal region, and both Yom-Tov (1987) and Saleh and Basuony (1998) note that the short-tailed Bandicoot rat (*Nesokia indica*) is present in the Suez Canal region. The Palestine molerat (*Spalax ehrenbergi*) is identified by Yom-Tov (1987) as present in northern and central Sinai.

The porcupine (*Hystrix indica)* has been identified by Osborn and Helmy (1980), Yom-Tov (1987) and Saleh and Basuony (1998), however sightings include only northern and north-eastern Sinai.

2.3.4. Carnivores

Canids: Four species of fox occur in Sinai –a sub-species of the red fox, *Vulpes vulpes arabica* which is common in western and southern Sinai; Rueppell's fox (*Vulpes rueppellii*) in south-western Sinai; Blanford's fox (*Vulpes cana)* – in southern and south-eastern Sinai; and the fennec (*Vulpes [*previously *Fennecus] zerda*) which inhabits the sandy areas of north Sinai to the Suez Canal (Harrison and Bates 1991; Mendelssohn et al. 1987; Saleh and Basuony 1998; Yom-Tov 1987). Larger carnivores still found are wolf (*Canis lupus arabs*), caracal (*Caracal caracal*) and striped hyaena (*Hyaena hyaena*), (Ferguson 1981a; Saleh and Basuony 1998; Yom-Tov 1987). The golden jackal (*Canis aureus*) is noted by both Osborn and Helmy (1980) and Yom-Tov (1987) as present only in north Sinai.

Viverrids: Yom-Tov (1987) has tentatively listed the Egyptian mongoose (*Herpestes ichneumon*) among the carnivore taxa found in northern Sinai. However, no other records support this observation.

Mustelids: The first observation of a mustelid in Sinai is by Saleh and Basuony (1998) who identified the marbeled polecat, *Vormela peregusna* in sandy habitats of northern Sinai.

Felids: Four species of cats are known today from the Sinai: the wild cat, *Felis silvestris lybica* was observed in north, north-western and southern Sinai and the sand cat (*Felis margarita*) from the sand dunes of north Sinai (Saleh and Basuony 1998). Although it has been claimed that leopards (*Panthera* [previously *Felis] pardus jarvisi*) became extinct in Sinai in the mid-1950's (for example Levi 1976; Osborn and Helmy 1980), the mammal survey carried out by Saleh and Basuony (1998) found that they still exist though in small numbers in remote parts of southern and northern Sinai.

In addition, the cheetah (*Acinonyx jubatus)* was noted as common in the Sinai until the early part of the 20th century when the population became extinct (Saleh et al. 2001 and references therein). Cheetahs in the western Desert of Egypt are documented as preying on dorcas gazelle, golden jackal, young camels, adult donkeys, sheep, goats hare, rodents, birds and to this may also be added foxes (Saleh et al. 2001).

2.3.5. Wild artiodactyls

Of the two wild artiodactyl species still found in Sinai today, the Nubian ibex (*Capra ibex nubiana*) is the more common. At the time of their census, Baharav and Meiboom (1981) (see Chapter 3, Fig. 3.3 this thesis) estimated that 300 ibex inhabited Sinai, with only 50 animals in northern Sinai confined to the rugged peaks of Gebel Maghara, Yelleg and Halal. The remainder of animals inhabit the Sinai massif in southern Sinai (ca. 100 animals near Gebel Catherina – see Fig. 3.3. of this thesis). There was little evidence for the presence of ibex in central Sinai at this time (exceptions were slopes of Gebel Egma to Wadi Watir and Zalaqa) and they hypothesized that this was due to the Bedouin having monopolized water sources in this region. They found that ibex were sparsely distributed and confined to the most rugged regions in the high mountains where competition with Bedouin herds was absent and water easily available [since ibex need to drink water daily]. In addition, Baharav and Meiboom (1981) reported that patterns of ibex herd movement have adapted to the migratory cycle of the Bedouin herds, with the ibex moving into the high mountain in winter while the lower elevations were occupied by the Bedouin. The ibex have adapted to the extremely low winter temperatures at night by maximizing absorption of solar energy while grazing during the day, sleeping in rock crevices that preserve the heat, and having access to abundant food and water (Baharav and Meiboom 1982). In the spring and summer, the ibex moved into even more rugged and inaccessible elevations as the Bedouin migrated into the high elevations.

Until the 1980's the dorcas gazelle (*Gazella dorcas*) was found in open plains throughout Sinai, and was especially common in the Plain of Qa and adjacent low lying regions, but absent in the high mountain region of southern Sinai (Saleh 1987: Fig. 3 – reproduced in Fig. 3.5 of this thesis). Hunting pressure in northern Sinai was considered to be low, and focussed primarily on the region of Wadi el-Arish (Saleh 1987). However, since the 1980's pressure on the gazelle populations have increased resulting in a further decline in their number. Today they are limited to rugged and isolated regions due to hunting (Saleh and Basuony 1998).

Osborn and Helmy (1980) distinguished two sub-species of gazelle in Sinai – *Gazella dorcas saudiya* found throughout the Sinai especially the western and southern region, and *Gazella gazella arabica* along the littoral of northern Sinai. No specimens of *G. d. saudiya* were actually observed by them, and their attribution was based solely on biogeography. Today, this form is extinct in the wild and it is uncertain if it represents a hybrid form or not (Rebholz et al. 1991). It was excluded by Yom-Tov et al. (1995) from their survey of the dorcas gazelle as they did not consider it as belonging to this species. Osborn and Helmy's (1980) attribution of the north Sinai specimens to *G. g. arabica,* considered to be one of several closely related species of the central group *Gazella gazella* (Mendelssohn et al. 1995), is more problematic since this is considered a form inhabiting more mesic, northern climes. Groves and Harrison (1967) have noted that many specimens of *G. g. arabica* have horns resembling those of *Gazella dorcas*, which may explain this identification.

Ferguson (1980, 1981b) also identified two sub-species of gazelle in Sinai – a less specialized 'race' inhabiting the gravel plains of southern Sinai which he ascribed to the sub-species *G. dorcas littoralis* (a synonym for *Gazella dorcas isabella*) which is the sub-species found today in southern Israel (Yom-Tov et al. 1995; Mendelssohn and Yom-Tov 1999). The second sub-species, a more 'specialized race', is found in the sandy plains of western and northern Sinai. These Ferguson (1980, 1981b) placed under the nominate *G. d. dorca*s. However, as demonstrated by Groves (1983), not all the morphological features used by Ferguson to distinguish between the sub-species are diagnostic for this determination. Consequently, until more genetic studies are carried out on the Sinai gazelles, it seems simplest to follow the taxonomy outlined in Yom-Tov et al. (1995) and Groves (1983), namely that all living Sinai gazelles are referable to *Gazella dorcas isabella*.

Other terrestrial mammals known in historical periods from Sinai but no longer found there include the bubal hartebeest (*Alcelaphus buselaphus*), the straight-horned oryx, also known as the white oryx (*Oryx leucoryx)* and wild ass/onager (*Equus asinus/hemionus*). The last two species became extinct by the early 20th century, while the hartebeest was probably extinct by the Iron Age (Horwitz et al. 1999b; Qumsiyeh 1996; Yom-Tov 1987; Yom-Tov and Mendelssohn 1988).

2.3.6. Reptiles

Since the publication of the annotated list of the reptiles of Egypt (including the Sinai), by Anderson in 1898, there have been several studies dealing specifically with the reptiles of Sinai. One of the most recent based on surveys is that by Werner (Werner 1973, 1980). He reported a total of 52 species of terrestrial reptiles; 5 species also occur in the Negev desert, another 5 are reported also from Cisjordan and Egypt. For nine species, this was the first report of their presence in Sinai. A total of 21 species known from Israel, Egypt, or reported from Sinai in earlier literature, are missing in this sample.

Yom-Tov (1987) provided an annotated listing of reptiles, with some 22 species of snake (at least 6 of which are venomous), and 29 species of lizard, chameleon, agama, gecko and skink. The Egyptian desert tortoise, *Testudo kleinmanni* is the only species of terrestrial tortoise known from Sinai. This small tortoise (length less than 13 cm) is found in the sandy region of north Sinai including the banks of the Suez Canal (Werner 1973). It is diurnal and mainly active in the winter and spring (Bouskila and Amitai 2001).

Four species of marine turtle are found along the coasts of Sinai. Two species, the brown turtle (*Caretta caretta*) and the green turtle (*Chelonia mydas*) nest along the Mediterranean coast of Sinai, primarily in the region of el-Arish (Clarke et al. 2000). In the Red Sea, the hawksbill turtle (*Eretmochelys imbricata*) is the most common and there is some evidence that it nests on offshore islands. The green turtle (*Chelonia mydas*) nests in southern Sinai but has been observed infrequently, while the leatherback turtle *(Dermochelys coriacea*), which is the largest of living turtles, is found in both the Red and Mediterranean Seas (Frazier and Salas 1984).

The African soft-shell turtle (*Trionyx triunguis*) which inhabits freshwater rivers has not been reported from Sinai, although it is found in both the Nile and rivers of the Israeli littoral. Werner (1973) has suggested that *Trionyx* may be absent from Sinai due to the lack of suitable habitats. However, given the quantity of natural and artificial waterways that existed in northern Sinai in antiquity (i.e. the Pelusiac arm of the Nile and Pharaonic canals), this seems unlikely to have always been the case.

2.3.7. Amphibians

Only one species, the European green toad (*Bufo viridis*) has been documented in north Sinai in the vicinity of the oasis of ‘Ain Qadis (Yom-Tov 1987). This is a nocturnal animal that requires the presence of a water source during the breeding season and aestivates underground during the summer (Bouskila and Amitai 2001).

2.3.8. Birds

In autumn, birds of the Northern Hemisphere migrate south, primarily to Africa, and return in the spring. One of the most important migration routes follows the Syrian-African Rift

Valley and crosses the Red Sea and along the Nile, enabling the birds to fly overland rather than over large water bodies. Thus, the Sinai lies in the migration route of many Palaearctic species including birds of prey, water birds and songbirds, resulting in an incredibly rich and varied avian fauna (Tchernov 1979). In contrast, the density of resident breeding birds in Sinai is low and their distribution is patchy. Yom-Tov (1987) provides an annotated list of bird species found in Sinai – noting which species are endemic to Sinai, which are found there all year round, those which nest there, are passage migrants and those which are rare visitors. This list includes: 5 species of the Order Pelicanidae (pelicans, egrets); 16 species of the Order Ciconiiformes (herons, storks, flamingoes); 14 species of the Order Anatidae (ducks, geese); 23 species of the Order Laridae (gulls); some 40 species of the Order Charadriiformes (waders, terns); 10 species of the Order Gruiformes (rails, cranes, bustards); 3 species of Galliformes (gamebirds); 13 species of the Order Columbiformes (pigeons, doves); over 35 species of the Order Falconiformes (diurnal birds of prey); 7 species of the Order Strigiformes (nocturnal birds of prey); and some 125 species of the Order Passeriformes (songbirds).

Although the last sightings of the ostrich (*Camelus struthio*) in Sinai date to the 17th century AD (Manlius 2001), this species only became extinct in Egypt in the 1960's and in the southern Levant by the 1950's (Bodenheimer 1953).

2.3.9. Marine mammals

Marine mammals found in the Gulfs of Suez and Aqaba and the Red Sea are six species of dolphin: the pantropical spotted dolphin (*Stenella attenuate);* Risso's dolphin *(Gramphus griseus)*; Indian humpback dolphin (*Sousa plumbea)*; false killer whale (*Pseudorca crassidens)*; Indo-pacific bottlenose dolphins (*Tursiops gilli* and *Tursiops aduncas*) as well as the dugong (*Dugong dugong*).

2.3.10. Fish

The ichthyological fauna of Sinai is exceptionally rich as the Peninsula is bounded by several different water sources. Marine fish species found in archaeological contexts, can originate from the coral reefs and open seas of the Red Sea, Gulf of Suez and Gulf of Aqaba; from the Mediterranean Sea; or from the saline lagoon Lake Bardawil on the

Mediterranean coast. Freshwater fish may be derived from the Nile River and delta or from the coastal rivers of southern Israel. It is beyond the bounds of this work to provide an annotated list of the fish taxa of Sinai, and the reader is referred to the numerous books and articles dealing with the ichthyology of the Sinai and the Red and Mediterranean Seas in general (for example: Ben-Tuvia 1971; Ben-Tuvia and Golani 1987; Diamant 1987; Dor 1984; Golani 1997, 2005; Goren 1983; Le Berre 1989; Randall 1983).

2.3.11. Domestic mammals

Goats (*Capra hircus*): The most common domestic taxon is the Bedouin goat (*Capra hircus*), which belongs to the Hejaz dwarf goat breed. It is named after the hyper-arid Hejaz region of Saudi Arabia, where these animals inhabit the area bordering between the Nejd and the Red Sea. Their origin is unclear although Epstein (1946: 351) claimed that "the Hejaz goat goes back to….the first pastoral folk that entered the Arabian Peninsula". The Hejaz goats are uniform in colour and proportions. They are small-sized (withers height is less than 60cm; live weight 22 kgs for adult male and 19 kgs for adult female), have a bulging forehead, wedge-shaped heads with a pointed muzzle, prominent brown eyes, small and slender ears which point sideways. Horns are found in both males and females and differ in size. They are sickle-shaped, curving backwards and downwards from the skull. Most animals are black, but coats with brown and white tints are also found (Epstein 1946; Yom-Tov 1987). The black colour economizes metabolic energy expenditure in the morning and evening hours, while at peak sunlight hours, the negative effect of this colour is minimized by the use of shade to reduce energy output (Dmi'el et al. 1980). Due to their specialized metabolic adaptations to desert conditions, Bedouin goats can survive without drinking for four consecutive days, even in summer. They can then replenish their water supply, drinking up to 45% of their live body-weight at one time (Shkolnik et al. 1972, 1974). During this period of dehydration, the animal can lose 30-40% of its body weight (i.e. body water content) but its appetite appears to be unimpaired and milk production continues (10-20% of initial quantity) (Maltz 1980; Maltz and Shkolnik 1980). The weight loss is replaced entirely once the animal is watered, but the animal does not suffer harm from the sudden dilution of its blood as it slowly releases water into the system (Shkolnik et al. 1972). Following rehydration, even repeated bouts, milk production returns to previous high levels in 2-4 days (Maltz 1980; Maltz and Shkolnik 1980). In terms of forage, this breed is also the best-adapted domestic animal for exploiting the Sinai as they can efficiently utilize the high-fiber, low nitrogen dry desert pastures (Chosniak et al. 1995). In addition, its agility to climb mountain slopes in search of pasture, makes it well adapted to a region where resources of both water and food are unpredictable and dispersed.

The black goats milk production is copious (92 g/kg day) and kids can attain a weight of 15 kgs solely on lactation. The Hejaz breed can successfully raise young even in the dry summer seasons and under conditions of stable pasture, ewes can have 3 births in two years. The Bedouin goat also has a high incidence of twinning (44%) (Maltz 1980; Maltz and Shkolnik 1980).

Sheep (*Ovis aries*): Small numbers of sheep are also kept by the Bedouin in Sinai. Yom-Tov (1987) describes the sheep in Sinai as being a small-sized, fat-tailed hair sheep with a white head and black body (brown, blue and reddish hues are also known). These are probably animals related to the Najdi breed (also known as Nejd breed) of Arabia, deriving from a region of high steppe and desert. The Najdi sheep have long, slender necks and legs, narrow bodies. Average live weight for one year old rams is 56 kg and ewes 45 kg, but under poor grazing this may drop. Males have very small horns and ewes are hornless.

Today animals of the Awassi breed are also kept in Sinai, especially in the north-eastern region (Metawi et al. 1999). This is a fat-tailed, wool sheep, with white-yellowish bodies and brown or black faces and feet, or else entirely white. Black bodies are exceedingly rare (Epstein 1971). The head is long and narrow, legs long and straight. Withers height is 68 cm in ewes and 75 cm in rams. Rams have large horns, ewes are hornless. The fat tail can weigh up to 6 kgs in females and 10 kgs in males. Live weight of a 1 year old ewe is on average 49 kg while a ram can weigh 55 kg (Alamer and Al-Hozab 2004). Compared to most other sheep breeds, the Awassi are well suited to desert climes being long-limbed, with long ears and tails while most of their body-fat is accumulated in their tail. This leaves the body relatively fat-free thereby promoting dissipation of heat from the body (Yagil 1984). They are bred primarily for meat and slaughtered today between 7-12 months (Alamer and Al-Hozab 2004).

According to Alamer and Al-Hozab (2004), Awassi sheep show slightly better ability to withstand water deprivation than Najdi sheep, especially when this is coupled with higher environmental temperatures. Both breeds were however able to drink 19% of their body weight during rehydration in summer. Although this is far less than the local Bedouin goat, and may be attributed to the limited rumen volume in sheep that can accommodate water, both these sheep breeds possess a high capacity to withstand water deprivation (Alamer and Al-Hozab 2004). Although meat quality in Najdi sheep is quite poor, like the Awassi they are primarily bred for meat. Average fleece weight from an adult Najdi sheep is 2 kgs (Epstein 1971). Today, all sheep breeds to the north of Arabia and Sinai are woolly and the males are horned. The fact that the Najdi sheep have a hairy coat and small horns in the males led Epstein (1971) to suggest that they originate from a mixture of the original thin-tailed hair sheep that entered Africa from the east (via Bab el Mandeb) and the fat-tailed wool breeds of the north.

Cattle (*Bos taurus*): Cattle are rarely kept in Sinai (Yom-Tov 1987). This is probably due to several physiological characteristics which make them ill-adapted to such a hyper-arid environment such as: the fact that they dissipate body heat by sweating rather than panting and maintain relatively constant body temperature – unlike camels which also sweat but vary their daily body temperature; they have relatively higher water consumption rates compared to camels, sheep and goats; they are unable to meet their water needs solely through grazing even on lush pasture; due to their water requirements they are limited to grazing within a days walk of water (4-13km radius) which is far more limited than sheep, goats or camels; and the fact that under desert conditions they lose water at a greater rate than other taxa. Indeed, when ranked, according to water requirements and efficiency of water exploitation, camels top the list followed by goats, sheep with cattle the last (Macfarlane 1968a, b; Russell 1988 and references therein; Schmidt-Nielsen 1979).

Pigs (*Sus scrofa*): Pigs are not kept today in Sinai. This may in part be due to Islamic food prohibitions rather than environmental conditions, since humans could provide suitable living conditions and resources for them (e.g. Horwitz and Studer 2005; Zeder 1996). However, pigs are ill-adapted for rapid movement over long distances, combined with their high water requirements to cool their body temperature and poor adaptation to feed off the desert plants would have limited their mobility and probably made them unsuitable for breeding in most regions of Sinai.

Beasts of Burden: Domestic donkeys (*Equus asinus*) and horses (*Equus caballus*) are found in Sinai, but in small numbers as the one-humped dromedary camel (*Camelus dromedarius*) still serves as the main beast of burden where motor cars cannot be used due to its specialized adaptation to the desert. The camel can survive on unpalatable, dry vegetation and without drinking water for up to two weeks. It is able to lose over a 1/3 of body water after not drinking for ca. 2 weeks, without apparent damage and can replenish this within 3 minutes (Schmidt-Nielsen 1979; Yagil 1984). In summer when the pasture is dry and temperatures high, camels need to be watered about every 4-5 days and consume circa 4-5 liters a day. In contrast, in the winter camels require 1-2 liters per day, but in Sinai may be watered only every 15 days (Yehieli 1993). In order to make water sources accessible to camels in Sinai, the herders create and maintain tracks, construct dams to catch water and lead the camels to new water sources and draw water from wells (especially in the summer). The size, strength and endurance of camels means that they can be used for transport and draught, its dung is used for fuel, and its body provides a range of resources - milk (2-7 litres a day), meat and fibre. According to the early European travellers, camels in the Sinai were primarily exploited as beasts of burden and not for their meat or milk (Horwitz and Rosen 2005). The number of camels in Sinai, as in the southern Levant, has decreased due to the advent of motorized vehicles and roads, more lucrative employment opportunities, and the loss of land and restriction of movement (Ben-David 1987; Marx 1980).

The donkey is well adapted to living in arid environments. It can vary its daily body temperature so that it conserves water and can withstand water losses of up to 12-15% of its body weight. However, in summer they use four times more water for heat regulation than a camel. According to Schmidt-Nielsen (1979), in summer the water requirements of a domestic donkey range from 8-12% of body weight per day while in winter this drops to an average of 3.5% body weight per day. Rehydration is rapid, with a donkey able to consume almost the same amount of water that it lost in less than 2 minutes. If succulent pasture is available (e.g. in winter), a donkey can go almost indefinitely without drinking water.

Dogs (*Canis familiaris*): A desert dog's water requirements are about 2-3 liters per day in summer, similar to that of sheep and goats. Two dog breeds are commonly found in Sinai. According to Epstein (1971) and Sela (1971), the type most frequently found in Sinai is the smooth-haired, small-sized (sheepdog/collie sized) pariah dog (also known as the Cnaani breed) which attains heights of 45-55 cm (known in Arabic as 'Ajal'). Sela (1971) notes that it is most common in western Sinai. The Pariah has a narrow skull and forehead, with a well-developed parietal crest. The ears are short and erect and coat colour varies from lemon, brown, to pure white and occasionally even black, but usually two colours are present in the coat. The dog depicted on the 2000 BC tomb at Beni-Hassan, Egypt, is considered to represent a typical Cnaani. Epstein (1971) claims that the pariah dog owes its ancestry to several types of prehistoric dogs, including the greyhound, introduced into Africa. It is used by Bedouin in Sinai and the Negev to guard herds and gardens. Today there is an official dog breed called the Canaan Dog which was first developed in the 1930's in Israel by Drs. R. and R. Mentzel from feral pariah dogs captured in the Negev desert.

The other dog breed found in Sinai is more diverse in size and form but is more closely related to the greyhounds and is a Saluki/ Saluqi type (it is called in Arabic 'Selaj') (Bailey 1996). Epstein (1971: 64) notes that in Sinai there are also crosses between Saluki-types and Pariahs called 'Dirra'. In the 1970's the Saluki-type was primarily raised by the Tarabin Bedouin tribe of south-eastern Sinai. In a survey carried out by Sela (1971) between Eilat and Saint Catherine's monastery, he found that the ratio of thoroughbred males to females was 7:80, such that the chance of keeping the breed relatively pure was high. In addition, as on average only one dog was kept by a family, pups especially not pure bred ones, were frequently killed, while to prevent unwanted mating, the loins of the dogs were belted or bound (Bailey 1996). The dogs stay close to the Bedouin camp or follow their owners when they move about. The Saluki aids in guarding the herds or in hunting of ibex (Saluki's are members of the sighthound family, who hunt by sight not scent). However, due to the restrictions on hunting and paucity of ibex, this was rare in the 1970's.

The domestic fowl (*Gallus gallus* f. domestica): Chickens raised in Sinai belong to a small sized breed, known as the desert Sinai breed. It is especially well adapted to arid conditions being heat resistant and capable of withstanding water deprivation (Arad 1982; Arad and Marder 1982a, b).

2.4. CONCLUSIONS

It is interesting to note that both the wild and domestic animals found in the Sinai Peninsula today exhibit special physiological and behavioural characteristics that enable them to inhabit this extremely arid and unpredictable environment. Some of these features are: specialised thermoregulation mechanisms, low water requirements, ability to withstand dehydration followed by rapid rehydration, colouration suitable for hot climes, ability to consume rough and dry forage, ability to withstand extreme climate shifts, adaptation for mobility over sandy and/or hot terrain. The fact that even the domestic animals exhibit some of these features, points to a long-term adaptation and hence lengthy residence in this region.

For most plant and animal taxa, biodiversity decreases with increased aridity. However, Sinai has an astonishingly rich biodiversity, resulting from the mosaic of different habitats that it offers. As noted by Yom-Tov (1987:341), climate has been the critical factor in determining the distribution of animals in Sinai. Thus, north Sinai contains psammophylic and Mediterranean species which are missing in southern Sinai – for example porcupine, sand cat, fennec, marbled polecat, Anderson's gerbil, Tristram's jird, Palestine molerat and Egyptian desert tortoise. In contrast, species commonly found in rocky habitats such as Wagner's gerbil, the Golden spiny mouse and Egyptian spiny mouse, rock hyrax as well as Blanford's fox, are only found in southern Sinai. It should be borne in mind that hunting pressure over the last two centuries has undoubtedly influenced the biogeography of many species such that it is difficult to assess the past distributions of taxa. For example, today, the majority of large carnivores in Sinai are found in the rocky regions of the north and south, as these serve as refugia due to their relative inaccessibility. Ibex, gazelle, hare, hedgehog, Egyptian mastigure and a range of rodents are still hunted or trapped and consumed by the Bedouin as are partridges and quails (Yom-Tov 1987). In addition, the loss of natural environments through development has, as elsewhere, further restricted the biogeography of natural faunal populations in the Peninsula.

While carrying capacity of the Sinai Peninsula is on the whole low (when compared to the Mediterranean region of the southern Levant or along the Nile), it is clear that there is notable internal geographic variation within the Peninsula. Most marked are the differences between northern and southern Sinai, which have undoubtedly influenced past human settlement patterns, lifestyle and modes of subsistence including patterns of animal exploitation. Although no robust calculations of carrying capacity are available for Sinai (with the exception of estimates for the Gebel Gunna area in eastern Sinai using principal forage plants only - Perevolotsky and Baharav 1987, 1991), based on the data provided above, it is clear that for past human populations involved in animal husbandry and agriculture, southern Sinai offered a relatively more precarious existence, despite the perennial availability of water in the high mountains, even given more mesic climatic conditions in the past and improved rangeland. This is due to the limited availability of arable land and the markedly seasonal nature of suitable pasture. Indeed, aside from the Qa Plain and small pockets of alluvium in the valleys and high mountains, (see Perevolotsky 1981 on orchard cultivation in the high mountains), only small amounts of arable land are available in the south. The Irano-Turanian vegetation and higher rainfall that characterizes the high elevations of southern Sinai are unsuitable for year-round grazing by domestic herds due to their rough topography and harsh winter climate (Baharav and Meiboom 1982). Although the southern coastal strips and wadi channels offer high quality seasonal grazing of annuals, this varies according to the annual rainfall and cannot be relied upon. The best seasons for grazing are winter and late spring when after the first rains, annuals appear followed by perennials (e.g. *Haloxylon salicornicum* and *Retama raetam*). This period corresponds with lambing/kidding season, such that herds need not wander far in search of pasture, but can feed close to the camp. In summer, when pasture and water sources (especially in the sandstone regions) have dried up and annuals withered, people and their herds are forced to become more mobile. Traditionally they moved either to higher elevations where annuals for pasture and springs were still available, or to oases such as Wadi Feiran and onto the coastal plain (Levi 1987; Marx 1977, 1980, 1999).

For hunters and gatherers, both northern and southern Sinai would have offered a wide range of plants and animals suitable for exploitation as well as water resources. However, as noted above, it is difficult to assess current animal and floral distributions bearing in mind climate changes that have affected the region as a whole. It is clear though, that for all human communities, the high elevations of the southern mountains, their steep and rough topography and the harsh climatic conditions in winter, would have restricted human settlement and mobility in this region (at least on a seasonal basis), despite the presence of numerous perennial and seasonal water sources (pools and springs). These restrictions would have been of limited importance in northern Sinai. This difference is perhaps best expressed in the low population density of the south over time, with the high mountains almost uninhabited until monks in the Byzantine period settled there (Dahari 2000). Population estimates carried out by the Israeli authorities in 1967 counted a total of 33,441 persons in northern Sinai with an estimate for all other regions, including southern Sinai, as only an additional few thousand people (Orni and Efrat 1980). Other estimates from 1972 indicate that even at this time there were only some 8,000 Bedouin living in southern Sinai (Ben-David 1981, 1987), while Marx (1999) places the number at around 10,000 for the period 1972 to 1982. This is still less than 1 person per 2 km^2.

In contrast, in the north, although most of the arable land is limited to the Wadi el-Arish Basin, this still offers a relatively large area for agriculture. In addition, limited areas to the east of El-Arish contain soils that are suitable for cultivation. Based on a GIS model, Yekutieli (1998, 2002) proposed that extensive areas, including those to the west of el-Arish, could have been cultivated in the past. Together with the high water table, and hence relative ease with which water is available (though much of it of poor quality), the north would have facilitated far more extensive and intensive cultivation as well as stock raising than in the south. It should be noted though that even today, cultivation in north Sinai is limited and seasonal, and covers only some 251,000 feddans (Abou Rayan et al. 2001). Given an estimated size of north Sinai as 14,000 km^2, it is possible to calculate that even today only some 8% of north Sinai is cultivated. In addition to grazing in wadi courses such as Wadi el-Arish and seasonal pasture on the e-Tih plateau, which would have been easily accessible and plentiful, fodder from agricultural produce would have offered a further supplement for herds. The e-Tih plateau is still utilized today by Bedouin herders (Baharav and Meiboom 1981).

Recent estimates for north Sinai place the current population size around 254,000 inhabitants, with some 60% local Bedouin (Abou Rayan et al. 2001). This probably reflects the general demographic trend in the Peninsula in the past, with the north more intensively settled than the south, at least since the end of the Early Bronze Age (Avner 2002; Beit-Arieh 2003a; Oren 1987b, 1993a; Yekutieli 1998, 2002)

Aside from small pockets of soil which offer conditions for year-round cultivation and herding (e.g. the ‘Jifar’ region between Rafiah and El Arish in northern Sinai, the oasis of Qadesh Barnea in eastern Sinai and the oasis of Feiran in southern Sinai), the Peninsula is overall a region of low carrying capacity with restricted water sources dispersed over great distances. Notably the quantity and timing of rainfall is unpredictable, such that the availability of pasture – in both time and space - varies annually. These features are exacerbated by extreme temperatures, marked altitudinal gradients and strong seasonal winds, all physical conditions that must have influenced human lifestyle and subsistence strategies in the region over time. Moreover, shifts in global and regional climatic conditions would have further influenced all these parameters. Since little specific data is available on Holocene paleoclimates of the Sinai, recourse has been made to data for the southern Levant.

During the Holocene optimum ca. 9, 000-8,000 BP (equivalent to the Early and Mid-Pre-Pottery Neolithic B), the climate in the southern Levant was favourable and characterized by high precipitation, warm winters and wet summers (Goldberg and Rosen 1987; Roberts and Wright 1993; Rossignol-Strick 1999; Sanlaville 1999). It has been proposed that a northward shift of the African monsoon belt was responsible for the greater precipitation and summer rain (Bar-Matthews et al. 1997; El-Moslimany 1994; Geyh 1994; Goldberg and Bar-Yosef 1982; Goldberg 1994; Horowitz 1992). Such conditions would have favoured occupation of the Sinai and there are indications for increased population densities in the desert regions (Goring-Morris and Belfer-Cohen 1998). Moreover, summer rainfall would have increased the carrying capacity of the region such that communities could have remained within the confines of the Peninsula year-round.

The so-called ‘8.2k cal. BP climate event’ was characterised by the abrupt onset of desiccation and cooling characterized by a warmer and drier climate than before, but according to the speleothem record still wetter than today (Almogi-Labin et al. 1991; Bar-Matthews et al. 1997, 1998; Goldberg 1994; Rossignol-Strick 1993; Sanlaville 1999). In the Mediterranean region this period (equivalent to the Late Pre-Pottery Neolithic B/PPNC) was associated with site abandonment and dispersion of populations into new zones, possibly including the Levantine deserts (Galili et al 2002; Goring-Morris and Belfer-Cohen 1998; Martin 1998; Rollefson and Köhler-Rollefson 1989, 1993; Simmons 1997). These arid conditions prevailed through to ca. 6200 BP, but were broken by a short cold and humid phase accompanied by moderate rainfall that has been associated with the advent of the Chalcolithic period (Frumkin et al. 1991; Horowitz 1992; Issar 1998). Indeed, these amenable conditions may have facilitated the establishment of Chalcolithic settlements in the arid regions such as the Negev desert and southern Jordan (Henry 1995;

Levy 1995). Towards the end of the Chalcolithic (ca. 5000 BP) warmer and drier conditions return as illustrated by a marked drop in the level of the Dead Sea (Frumkin et al. 1991; Issar 1998). Beginning ca. 5,200 BP (the Early Bronze Age) the Levant experienced a further wet spell that was generally moister and more humid than today (Bar-Matthews et al. 1997, 1998; Frumkin et al. 1994; Goldberg 1994; Goldberg and Rosen 1987; Horowitz 1992; Issar 1998; A. Rosen 1989, 1997). However, it was followed shortly by a period of desiccation which ensued throughout the Early Bronze Age II and was characterized by sharp oscillations in rainfall and humidity, reaching a maximum warm and dry peak by the end of the 3rd millennium BC (Almogi-Labin et a. 1991; Bar-Matthews et al. 1998; Horowitz 1992). Both Frumkin et al. (1991) and Enzel et al. (2003) have demonstrated that by the end of the 3rd millennium BC the Dead Sea reached an extremely low level characteristic of drought conditions. This arid crisis has been implicated in the migration of populations and the collapse of communities including the abandonment of the EB III city of Arad (Issar 1998). Similar dry and warm conditions prevailed in the region during the Late Bronze Age (Enzel et al. 2003; Frumkin et al. 1991; Horowitz 1992; Issar 1998)

The Nabataean and Early Roman period (final centuries BC and first two centuries AD) experienced a more temperate climate than today which was colder, relatively wetter and more humid (Bar- Matthews et al. 1998; Bruins 1994; Goldberg 1986, 1994; Issar 1998). This wet phase peaked circa 90 AD, while the subsequent Byzantine period was characterized by more arid conditions (Bruins 1994; Enzel et al. 2003).

In the following Chapters, a diachronic series of studies will be presented which explore the interaction between culture, physical geography and climate in the Sinai Peninsula over the past 10,000 years.

CHAPTER 3

AND TIME STOOD STILL:
NEOLITHIC HUNTER-GATHERERS IN SOUTHERN SINAI

3.1. INTRODUCTION

In the history of Near Eastern populations, the period 13,500 through 10,500 cal. BP[5] marks the transition from an extractive mode of production - founded on hunting and gathering, towards one based on primary production through domestication of plants and animals. This process was initiated by the sedentary/semi-sedentary Epipaleolithic hunter-gatherers, the Natufians (13,500-12,000 cal. BP). The impetus for this change has commonly been attributed to the late Younger Dryas climatic crisis (Bar-Yosef and Belfer-Cohen 1989a, b, 1992, 1999; Bar-Yosef and Meadow 1995; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris and Belfer-Cohen 1998; Tchernov 1995).

A phase of "Neolithisation" followed, encompassing two periods: the Pre-Pottery Neolithic A (PPNA) 11,700-10,500 cal. BP and the Pre-Pottery Neolithic B (PPNB) ca. 10,500-8,250 cal. BP which in turn is divided into four phases – early (EPPNB), mid (MPPNB), late (LPPNB), final/terminal PPNB (= PPNC). In the Mediterranean zone of the southern Levant, this period was characterised by the establishment of large-scale sedentary villages, increased socio-political complexity, agriculture and animal husbandry (Bar-Yosef and Meadow 1995; Colledge et al. 2004; Garrard et al. 1996; Kuijt and Goring-Morris 2002 and references therein; Legge 1996; Tchernov 1993a, b, 1995). Specifically, the PPNB heralds a major break in architecture, lithic techno-typology and burial practices with the preceding Natufian and PPNA entities.

By the MPPNB domesticated cereals, legumes (lentils, chickpeas, broad bean) and flax were cultivated in the southern Levant, although this process was probably initiated earlier in south-east Anatolia (Colledge et al. 2004; Garrard 1999; Lev-Yadun et al. 2000).

---

[5] Dates used in this chapter are calibrated BP dates (using www.calpal-online.de) unless otherwise stated. Dates for the Neolithic follow calibrated radiocarbon years given in Kuijt and Goring-Morris (2002: Table 1)

Additional wild taxa exploited at this time include pistachio, fig, olive, almond, grasses and mallow, indicating that gathering of wild plants continued (Zohary and Hopf 1994). The rectangular houses that first appear in this period were spacious and constructed according to a standardized pattern with few internal divisions and separated by alleyways. These features testify to larger numbers of people living under conditions of increased crowding (Kuijt and Goring-Morris 2002).

In the Mediterranean region, domestic herd animals make their first appearance during the PPNB, but in a staggered fashion, and may post-date the appearance of domesticated cereals by at least 500 years. Until the last decade, the southern Levant was perceived as lying at the centre of the domestication process. However, current research has shown that the transition from complex hunter/gatherers to sedentised agro-pastoralists was initiated further to the north, probably in south-eastern Anatolia (e.g. Colledge et al. 2004; papers in Guilaine 2000; Lev-Yadun et al. 2000; papers in Ozdogan and Basgelen 1999; Peters et al. 1999). As summarised by several researchers (von den Driesch and Peters 2001; Horwitz 2003b; Horwitz et al. 1999a; Peters et al. 1999; Vigne and Buitenhuis 1999), from this ‘hearth area’, domestic herd animals or the knowledge of this process, dispersed. Thus, the earliest evidence for domestic sheep comes from the EPPNB site of Nevali Cori in the northern Levant, but this domesticate only reached the southern Levant by the LPPNB (Horwitz and Ducos 1998). For goats the picture is less clear, but there is some evidence to support their domestication already in the EPPNB of the northern Levant (von den Driesch and Peters 2001; Peters et al. 1999). It is clear that by the MPPNB, domestic goats were present in sites along the Euphrates (at Tel Halula and Abu Hureyra), while synchronically in the southern Levant (Abu Ghosh, Jericho) they were undergoing some form of management (termed by different authors: ‘proto-elevage/ proto-domestication’, ‘incipient domestication’ or ‘cultural control’) culminating in morphometric changes associated with zoologically domestic forms by the LPPNB (Horwitz 1989, 2003b; Horwitz et al. 1999; Legge 1996; Peters et al. 1999; Zohary et al. 1998).

On Cyprus, sheep, goats, pigs and cattle are found from the 10th millennium cal. BP. Vigne (2001, 2003) has identified these animals as domestic, primarily as they represent introductions onto an island where their wild progenitors did not form part of the earlier Pleistocene fauna. However, an alternative view proposed by Horwitz et al. (2004) is that they represent wild animals freed on the island to serve as a ‘walking larder’. They were constantly replenished with new stock from the mainland thereby arresting their extinction through hunting. This may also explain why they maintain their wild-type appearance and size for centuries (Vigne 2001, 2003; Vigne and Buitenhuis 1999). A further argument in support of their wild status is that in the early PPNB domestic pigs and cattle are as yet not found on the Levantine or south-east Anatolian mainland (Horwitz et al. 2004), this being the assumed place of origin of the Cypriot colonisers.

To date, the earliest domestic cattle in the Near East are those identified in the MPPNB levels at Tel Halula (northern Levant) (Peters et al. 1999). In the absence of large enough samples of cattle remains from sites in the southern Levant, it has been difficult to assess the precise timing of their appearance in this region. Researchers alternately place this event as falling in the Late PPNB ((Becker 2002) or even as late as the Pottery Neolithic (Haber and Dayan 2004). Pig domestication, as attested to by an increased frequency of immature animals, may have begun in the EPPNB at the Anatolian site of Cayönu Tepe (Ervynck et al. 2002). However, even here, animals that may be defined as domestic based on morphological traits and biometry are only found by the LPPNB. In the southern Levant, domestic pigs may already be present in PPNC sites (Horwitz et al. 1999), and are certainly present by the subsequent Pottery Neolithic (Haber and Dayan 2004; Horwitz et al. 2002a).

Thus, the southern Levant lay at the periphery of the nuclear zone of domestication and was primarily a ‘receiver’ rather than an ‘initiator’ of the domestication process. If the Mediterranean region of the southern Levant was distanced from the revolutionary changes taking place in south-eastern Anatolia, then how much more remote was its desert periphery?

Prior to10,000 BP the desert regions of the Levant appear to have been sparsely populated (Bar-Yosef and Gopher 1997; Goring-Morris 1987, 1993). Beginning in the EPPNB, population growth in the desert regions is visible (attested to by increased site densities), and is probably due to the movement of people into these regions from the adjacent Mediterranean region as well as due to local population growth (Gopher 1985, 1994; Goring-Morris 1993; Goring-Morris and Belfer-Cohen 1998). The ‘renaissance’ of the desert regions at this time was probably facilitated by a period of climatic amelioration- due to a shift in the monsoon rain belt which now penetrated the southern Levant (and Sinai) -

resulting in generally wetter conditions with the onset of summer rainfall (for discussion and references see Chapter 2) During this phase, in contrast to the fully sedentised, large agricultural villages of the Mediterranean zone, the desert communities in eastern and southern Jordan, and southern Israel, appear to have continued a mobile existence living in small bands, as attested to by low site densities, the small scale and form of their architectural remains. The presence of only wild animals, together with the absence of sickle blades and abundance of arrowheads in these sites, suggest that they perpetuated a hunter-gatherer mode of subsistence (Bar-Yosef 1980, 1981a, b, c, d, e, 1984, 1985, 1993; Betts 1998; Dayan et al. 1986; Garrard et al. 1994; Martin 1994, 1999; Tchernov and Bar-Yosef 1982).

3.2. NEOLITHIC RESEARCH IN SINAI

Archaeozoological investigations of the Neolithic in arid regions have been limited primarily by poor preservation of organic remains, and the small size of many of the samples. Thus, in Sinai, only a handful of Neolithic sites with faunal remains have been found (Bar-Yosef 1980, 1981b, c, e, 1985, 1993; Goring-Morris 1993). The majority of these derive from the 1976-1979 salvage archaeology project that was initiated under the auspices of the Archaeological Staff Officer for Sinai Mr. A. Goren, aimed at excavating endangered Neolithic sites.

This excavation program, directed by Prof. Ofer Bar-Yosef (Bar-Yosef 1981a, b, 1984, 1985), was aimed at testing a model of landscape use that was based on three assumptions:
(a) Southern Sinai was a rich habitat such that during the early Holocene it would have offered sufficient resources to maintain communities within its borders.
(b) the mosaic nature of the latitudinal ecozones in southern Sinai - coastal strips, sandstone plateau, low metamorphic hills, high granite mountains (see Chapter 2 of this thesis), would have necessitated seasonal transhumance from the lowlands (winter camps) to the highlands (summer camps).
(c) that site location relative to nature topography and altitude, site architecture, the character of the lithic and faunal assemblages, would all elucidate the season of site occupation and aid in identifying past patterns of human movement.

Furthermore, it was assumed that based on their material culture, Pre-Pottery Neolithic sites in the desert region could be identified with sufficient clarity so as to facilitate correlation with sites in the Mediterranean "core" zone.

To date, four PPNB sites excavated during this project have yielded large and relatively well preserved animal bone assemblages (Fig. 3.1). Animal remains from four sites in southern Sinai have already been published by other researchers - Ujret el-Mehed, Wadi Tbeik, Sheikh III and Wadi Ahmar Site 590, and are briefly summarised below. In addition, I present here original data for two more PPNB sites from southern Sinai - Abu Madi III and Gebel Rubsha, as well as a very brief description of the fragmented remains from the northern Sinai site of Mushabi VI.

Three of the sites are located in the high mountains of southern Sinai – Ujret el- Mehed, Gebel Rubsha and Abu Madi III and have been interpreted as summer camps; while the site of Wadi Tbeik is located on a sandstone plateau at the foot of Gebel Gunna and has been interpreted as a winter occupation site (Bar-Yosef 1981a, b, 1984, 1985). Unfortunately, animal bones were not preserved in Neolithic sites excavated on the coastal plain in Wadi Jibba, in the eastern Qa Valley (Gopher 1985, 1994; Bar-Yosef 1984).

These faunal assemblages are discussed with reference to the model described above in order to examine the evidence for seasonality at these sites. Furthermore, the animal remains will be assessed in relation to claims for climatic amelioration in the PPNB. Finally, the issue of whether PPNB communities in Sinai practised some form of cultural control of ibex will be briefly reviewed.

3.3. ADDITIONAL PPNB FAUNA FROM SINAI

3.3.1 Wadi Tbeik

The PPNB site of Wadi Tbeik is located on the north-eastern fringe of the highlands of southern Sinai at the foot of Gebel Gunna, at an altitude of 1200 metres a.s.l. The site was excavated during 1977-79 and had a surface area of ca. 250m^2 (Bar-Yosef 1980, 1981b, c, e, 1984; Gopher 1981). The one radiocarbon date obtained for the site (Pta-2700) 12,243±238 cal. BP has been rejected by the excavator as too early (Bar-Yosef 1985). Indeed, Kuijt and Goring-Morris (2002) place the site in the MPPNB. Some twelve oval structures/rooms, with diameters ranging from 2.5-3.5 meters, were excavated at Wadi Tbeik. They have below-ground foundations dug into the bedrock, and thick walls built of sandstone slabs - some 40-60 cm thick. Organic material was probably used for the upper part of the structure (Fig. 3.2). Although four PPNB strata were recognised, Gopher (1981, 1994) pooled them since they show no marked differences in their lithic composition. He notes that the site was probably occupied for a very short period of time. It has been identified as a winter occupation site on the basis of the physical location and nature of the architecture (Bar-Yosef 1985).

The lithic assemblage, studied by Gopher (1981, 1985, 1994) is dominated by blades produced on-site from bipolar cores. The most common tools are retouched blades and flakes, followed in decreasing order of importance by notches, denticulates, awls, borers and endscrapers. Arrowheads are another important component of the assemblage, with Byblos and Amuq points the most frequent types, followed by Jericho points. Flint used at the site originates in Gebel Gunna some 3km away, but the abundant debitage indicates on-site tool manufacture. A rich assemblage of groundstone artefacts was also found. Two human skeletons, probably young adult males aged 25-35 years old, were excavated in one of the rooms; one a primary burial and the other possibly a disturbed primary or a secondary interment (Hershkovitz et al. 1994).

The fauna were studied by E. Tchernov and published in 1982 (Tchernov and Bar-Yosef 1982). The 1077 identified bones represented 11 taxa (Table 3.1). The most common species at the site was ibex followed by gazelle. The identification of ibex was not based on morphology, but primarily on biogeography and ecological features, accompanied by limited biometric data. For ibex, a biased sex ratio was reported with a significantly larger proportion of male than females.

The two aurochs bones identified from this site were re-studied by the author and are now re-assigned to *Equus*. This is discussed in detail below. Small numbers of bones of equids, carnivores, birds, marine and freshwater fish were also found. The presence of the purple gallinule, a bird that inhabits biotopes of flowing water, as well as catfish a species associated with freshwater, may reflect the continued presence of shallow Pleistocene lakes in the nearby Wadi Feiran (Phillips and Gladfelter 1989). Alternately, they may represent imports from the Nile Valley or southern Levant. Red Sea shells indicate contact with the nearby Sinai coast (Bar-Yosef Mayer 1999).

3.3.2 Ujret el-Mehed (also known as Banana I)

Ujret el-Mehed is a single stratum site situated 1600m a.s.l. in the high mountains of southern Sinai near the Monastery of Saint Catherine. It has been proposed by the excavator that it served as a seasonal summer camp (Bar-Yosef 1980, 1981a, e, 1984). One date (Pta-2703) 9,204±119 cal. BP, places this site in the Late PPNB. Over the period 1977-79, ca. 250m^2 were excavated out of a total site area of ca. 300 m^2. Six circular and figure-of-eight shaped structures were uncovered with diameters ranging from 4.5-7 metres. Central hearths were found inside these structures, as well as adjacent areas that may have served as courtyards. Stone-lined installations and bell-shaped constructed pits were found, possibly representing silos. In four of these pits, 16 secondary human burials were found, while another skeleton was found nearby in a pit dug into the centre of a rounded structure. These remains represent both sexes, mainly adults, with few children and none under the age of 5 years (Hershkovitz et al. 1994). The lithic assemblage, studied by Gopher (1985, 1994) was dominated by arrowheads, primarily Amuq points. Retouched blades, awls, burins, borers, notches and denticulates are also represented. Tools appear to have been brought to the site as completed pieces since there is little evidence for on-site tool manufacture (few cores). Moreover, the numerous groundstone tools were made on local stone, as well as sandstone that had been brought to the site from ca. 30km away. An interesting find in the site were wheat phytoliths (Miller Rosen 1993), a plant species not known to have grown naturally in this region. This may indicate trade with the southern Levant. Other finds that may have been obtained via barter are Mediterranean Sea shells, although Red Sea taxa comprised the majority of molluscs found on-site (Bar-Yosef Mayer 1999).

The fauna from the site of Ujret el-Mehed was studied and published by Dayan et al. (1986). Ibex dominated the sample followed by gazelle (identified as *Gazella gazella*) (Table 3.1). The presence of horncores clearly indicates the presence of ibex (*Capra ibex*) rather than the wild bezoar goat (*Capra aegagrus*) or domestic goat (*Capra hircus*). No selective culling of the sexes is found at Ujret el-Mehed, as was reported for Wadi Tbeik (Tchernov and Bar-Yosef 1982).

Remains of hare were especially common at Ujret el-Mehed, but their overall contribution to the diet would have been minor due to their small size. Numerous bird bones were identified representing 6 different species. Some of these are thought to represent natural mortalities. The season of site occupation was inferred on the basis of quail bones, since they are passage migrants found in Sinai in the spring and summer (Yom-Tov 1987).

One bone belonging to an unidentified equid was recovered. As will be discussed below, the isolated aurochs bone from the site has been re-assigned to *Equus*.

3.3.3 Sheikh III

The site of Sheikh III is located in Wadi Feiran (Phillips and Gladfelter 1989). Fauna identified to date are: dorcas gazelle (*Gazelle dorcas*), ibex (*Capra ibex*) and porcupine (*Hystrix* sp.) (C. Reed quoted in Phillips and Gladfelter 1989: 119-120). In this report no data are given on bone counts, skeletal elements, age or sex profiles. Neither are criteria given as to why the gazelle remains were identified as those of the dorcas gazelle.

3.3.4 Wadi Ahmar, Site 590

This site, first excavated by Currelly (Currelly 1906) and subsequently by Rothenberg (1975) yielded architectural remains, groundstone tools and shells, while the lithic assemblage was dominated by Amuq points. Fauna recovered are listed by Rothenberg (1975) as goat, gazelle, wild ass and fish. No further details are given, but he concluded that since goats were present, herding may have been practised. However, Bar-Yosef (1981e) has commented that the goat remains are probably those of ibex.

3.3.5 Mushabi VI

This is the only PPNB locality from northern Sinai that was examined (Mintz and Ben-Ami 1977). Based on the lithic component, the excavators place this site within the mid-seventh millennium uncal. BC.

I examined the few faunal remains recovered from the site. They comprised several fragments of ostrich egg shell and a small unidentified mammalian bone fragment.

3.4 THIS STUDY

3.4.1 Gebel Rubsha (also known as Banana II)

This small site, ca. 30m^2 in extent, is located in the high mountains of southern Sinai near Saint Catherine's Monastery, on the lower slopes of Gebel Rubsha, some 150 metres from the site of Ujret el-Mehed. Sampling at the site was carried out in 1976, followed by excavation (Bar Yosef 1980, 1981e, 1984). Kuijt and Goring-Morris (2002) place this site in the MPPNB, making it contemporaneous with Wadi Tbeik, but earlier than the other sites located in the massif.

Excavations at Gebel Rubsha did not reveal any architectural remains, but groundstone tools were recovered. The lithic assemblage was studied by Ashkenazi (cited in Bar-Yosef Mayer 1999) and Gopher (1985, 1994) who reported that the most common tool types were retouched blades, flakes, notches and denticulates, with awls, borers, endscrapers and burins found in lower frequencies. Jericho points are the dominant arrowhead type, followed by Byblos points. The high frequencies of cores indicate that tool manufacture took place on-site. Although Red Sea shells predominate in this sample, Mediterranean Sea species are also represented (Bar-Yosef Mayer 1999).

The faunal assemblage from this site is small and comprised 125 identified bones (Table 3.1). Unidentified bone splinters were extremely abundant and minute (812 fragments measuring less than 1cm in length were counted from half the packets of this assemblage, following which they were not quantified). A large proportion of these adiagnostic remains were burnt - heavily charred as well as calcined. A smaller proportion of the identified sample was burnt ca. 4% of the assemblage, probably relating to the increased propensity of burnt material to disintegrate such that it is difficult to identify (Stiner et al. 1995 – see discussion in Chapter 1 of this thesis).

3.4.2 Abu Madi III

This small site, located to the east of the Monastery of Saint Catherine, sits beneath a granite ridge in the high mountains of southern Sinai. It has been identified as a seasonal camp, probably used by a small hunter-gatherer group in the summer (Bar-Yosef 1985; Bar-Yosef and Gopher 1997). Based on the lithic assemblage, Goring-Morris and Gopher

(1983) postulated that Abu Madi III is probably coeval with Ujret el-Mehed and Wadi Ahmar.

An area of ca. 17 m^2 was excavated and yielded a hearth but no architectural remains (Bar-Yosef Mayer 1999). The lithic assemblage was primarily made on flint with a small portion manufactured on quartz (Garfinkel 1981). It comprised backed blades, endscrapers and points of which the Byblos type predominated. Other types of typical Levantine PPNB points were found (Helwan, Jericho, Amuq types) as well as a few examples of later forms (Herzliyya and Nizzanim). Since little debitage was found, Garfinkel (1981) proposed that most tools were brought to the site as finished items. Groundstone tools found were made of granite and sandstone. On the basis of the lithics, Garfinkel (1981) identified three separate PPNB phases at the site, a division corroborated in part by changes in the frequencies of molluscs outlined in Bar-Yosef Mayer (1999). However, given the small size of this assemblage, following both Garfinkel and Bar-Yosef Mayer the faunal remains were pooled for analysis.

The faunal assemblage from Abu Madi III was small and comprised 452 identified bones representing 12 species (Table 3.1). Abundant bone splinters (NISP=1125) were also represented, most less than 5mm in length. To avoid repetition, the fauna from this site will be presented in comparison to the neighbouring PPNB sites located in the high mountains of southern Sinai - Gebel Rubsha and Ujret el-Mehed - as well as Wadi Tbeik located on the limestone plateau at the base of Gebel Gunna (Tables 3.1-3.5).

Capra

As documented in Table 3.1, at Gebel Rubsha, the quantity of bones of *Capra* were double those of gazelle. Likewise, the most common taxon at Abu Madi III and the other PPNB sites in Sinai was goat (*Capra* sp.). The only wild goat found in the Sinai Peninsula today is a sub-species of ibex which has been identified as the Nubian ibex (*Capra ibex nubiana*) (Harrison and Bates 1991). As illustrated in Figure 3.3, the present distribution of this sub-species includes the mountainous region of the Sinai Peninsula. It is also found in the mountains of the Negev and Judean deserts, east and south of the 100mm isohyets, and the area immediately east of the Dead Sea in Jordan (Harrison and Bates 1991; Qumsiyeh 1996; Mendelssohn and Yom-Tov 1999).

Prior to 1948, the Nubian ibex was hunted almost to extinction in Israel. Due to rigorous legal protection implemented in 1954, their numbers have increased and today Israel supports the largest, most viable populations of this sub-species which has been upgraded from ‘endangered’ to ‘vulnerable’ (Harrison and Bates 1991; Hakha and Ritte 1993). The northern-most animal to be sighted in recent years was about 30 km north of Jericho at Ma’aleh Ephraim (Mendelssohn and Yom-Tov 1999). The population of ibex in Israel is said to number some 1500 animals (Mendelssohn and Yom-Tov 1999), with half their number (at least 350 animals), inhabiting the Judean desert, primarily in the Ein Gedi area. The other half inhabit the Negev desert with 400 animals concentrated in the Avdat region in the central Negev and 150 near Elat. In 1970, six ibex were introduced by the Israel Nature Reserves Authority into the Golan Heights, and they now number about 100 animals (Mendelssohn and Yom-Tov 1999). From historical sources it is clear that in the past the distribution of this species was more extensive.

In the late 1800’s there were numerous sightings of ibex in the area immediately west of the Dead Sea and in the Negev and Judean deserts as well as in the vicinity of Jerusalem (Qumsiyeh 1996). According to Lewis et al. (1968), the Nubian ibex inhabited the Antilebanon mountains and specimens were collected by Douglas Carruthers in 1905 in Karyatein, Syria (between Damascus and Palmyra some 140km east of Tripoli Lebanon and 60km east of the present border with Syria). However, in Lebanon and Syria, ibex has since become extinct due to over-hunting. In Jordan, since 1960, ibex specimens have been collected from the Wadi Arabah, Kerak and Dana regions east and south of the Dead Sea, while verbal reports have noted the presence of ibex in Wadi Rum and in the region of the Jordanian-Saudi border (Qumsiyeh 1996). In the past, the quantity of ibex in Jordan was undoubtedly greater as Tristram (1884) noted that they were very common in the area east of the Dead Sea.

In the Sinai, Allen (1915) cited the distribution of ibex as being “over all the rugged parts of the Sinai Peninsula, near Aqaba and up at least as far as the north-eastern end of the Dead Sea”. Though their numbers are sparse, ibex populations are still widely distributed throughout the Peninsula particularly in the rugged, southern mountainous region (Fig. 3.3) (Osborn and Helmy 1980; Baharav and Meiboom 1981). Until the 1960’s the population had been reduced to near extinction through hunting. Following the Israeli occupation in 1967, legislation was introduced prohibiting hunting. Subsequent surveys show a slow recovery of the Sinai ibex population which attained a size of circa 300 animals by the 1980's (Baharav and Meiboom 1981).

During the PPNB period three *Capra* species inhabited the southern Levant: the Persian bezoar goat (*Capra aegagrus*) which was primarily found in the Mediterranean zone; the ibex (*Capra ibex*) which mainly occupied the arid, desertic regions and the domestic goat (*Capra hircus*) (Davis 1982; Dayan et al. 1986; Horwitz 1989, 1993; Tchernov 1988; Tchernov and Bar Yosef 1982). Both ibex and wild goat are mountain dwellers, being good and fast climbers. They are generally considered to have been parapatric (Dayan et al. 1986: Tchernov and Bar Yosef 1982). However, in several Neolithic sites, remains of ibex, bezoar goat and domestic goat have been found in the same layer suggesting that in some areas of the southern Levant these species were sympatric. On the basis of horncores and limited metrical analysis of post-cranial bones, it has been suggested that all three species are represented at Beidha in the region of Petra, Jordan (Hecker 1975; Uerpmann 1979). Although this site lies at the possible border area between the two species, this is not the case for the Mid- to Late PPNB site of Abu Gosh located in the Mediterranean zone of Israel where remains of both bezoar goat and ibex have been found in the same layers. These identifications are based on aDNA sequences and not on morphology or biometry (Kahila Bar-Gal et al. 2002).

With the exception of Abu Gosh, the identification of ibex in archaeozoological assemblages has primarily been based on horncore morphology. This, as ibex horncores are broadly rounded and have regular, transverse bosses (knobs) which are absent in the wild bezoar *(Capra aegagrus*) and domestic goat (*Capra hircus*), while the shape and cross section of wild and domestic goat horns differ markedly, the latter being twisted with an oval cross-section (Davis 1987; Harrison and Bates 1991; Horwitz 1989). However, despite claims by von den Driesch and Wodtke (1997) and Uerpmann (1987) that the articular ends of some of the ibex long bones differ from those of the bezoar goat, archaeozoologists working in the Levant still lack rigorous morphometric criteria for distinguishing their post-cranial remains. As noted already by Perkins in 1966 (pg. 67) "at present it is impossible to separate the samples of the two species". This is best illustrated by the case of Abu Gosh where the presence of ibex in the assemblage, together with remains of bezoar goat, was not recognized using standard morphometric criteria and only came to light following the DNA analysis of a random sample of bones from the site that had been identified as those of wild goat (Kahila Bar-Gal et al. 2002).

It is possible then, that in the absence of remains of horncores, ibex remains have eluded identification at other Neolithic sites. A good example is the site of Jericho where, although no ibex horncores were recovered, Clutton-Brock (1971:51) has noted that some of the larger sized goat bones recovered at the site could belong to ibex. This is particularly feasible considering that Jericho, like Beidha lies at the inter-face between the Mediterranean zone and the arid Judean desert, an area which may have served as a zone of overlap between the species in the past. Considering that the distribution of ibex may have been larger than it is today, it is possible that it was more commonly exploited than we have appreciated to date.

At Gebel Rubsha, no specific identification could be made given the fragmented nature of the goat bones. At Abu Madi III, the species of goat represented is assumed to be ibex, based on the large and robust size of some of the bones which fall within the range of PPNB and modern ibex (Table 3.6). However, too few elements could be examined to fully ascertain this, and no diagnostic fragments of horncore were recovered. Ibex (as attested to by horncores - Fig. 3.4) is present in the earlier Pre-Pottery Neolithic A assemblage from the site of Abu Madi I, located some 500 metres from Abu Madi III, as well as at the nearby PPNB sites of Ujret el-Mehed, where fragmented ibex horncores were also found. Consequently, the likelihood of the goats at Abu Madi III representing a different species is negligible. As noted by Tchernov and Bar-Yosef (1982: 23) "it is ecologically improbable that *Capra aegagrus* have penetrated the high mountains of Sinai in pre-Neolithic times only to be replaced once again during the Holocene by the Nubian ibex."

Capra skeletal element representation

In order to facilitate comparison, skeletal elements of *Capr*a [and *Gazella*] from both Gebel Rubsha and Abu Madi III were categorised in the same manner as Ujret el-Mehed and Wadi Tbeik. In addition, trunk elements which were excluded from publications of the latter sites are reported here for Gebel Rubsha and Abu Madi III (Tables 3.4a, b-3.5).

For goats, skeletal completeness in the Gebel Rubsha and Abu Madi III samples appears to be quite high when the MNI counts are considered. Given an MNI of 2 animals at Abu

Madi III, the expected number of long bones in each category should be 4. Many of the skeletal elements approach this number (Tables 3.4a). This would suggest that complete goats were introduced into the site. In order to further examine this idea and test whether there was any selection of skeletal elements introduced into the sites from the kill location, carcass utility indices were calculated (after Binford 1978; Lyman 1994), and the relationship between %MGUI (modified general utility index), using sheep utility values as a proxy for ibex, and %MAU (minimal animal unit) for each site was tested using a bivariate regression plot. The data on which these plots were based are given in Table 3.4b. Results show that there are no statistically significant correlations between the two sets of variables for the three sites examined. This is illustrated by the correlation coefficients obtained: Ujret el-Mehed r_s=0.05, P=0.3; Wadi Tbeik r_s=0.04, P=0.4; Abu Madi III r_s= 0.03, P=0.4. This indicates that skeletal element representation was not determined by the utility value of the elements, a finding that may support the idea that complete carcasses were introduced on-site.

However, when skeletal element representation is examined, this does not appear to have been the case. As illustrated in Table 3.4a, ribs and vertebrae are poorly represented at Abu Madi III. When compared against bone mineral density values (using BMD values for sheep as a proxy for goat/ibex - taken from Lyman 1994: Table 7.6) that are given in Table 3.4b, it is evident that these are some of the least dense elements in the skeleton. In a similar vein, the cranial category is high since fragments of tooth enamel, the most robust material in the skeleton, comprise disproportionately high numbers of this body part category (NISP = 71 out of a total of 93 bones). If the tooth fragments are removed, then the cranial bones are represented in similar frequencies to the limb bones. These data suggest that a factor other than human selection and processing has moulded skeletal element representation of goats at Abu Madi III and probably at all the other PPNB sites in Sinai.

A simple method of further assessing this is to compare frequencies of distal versus proximal epiphyses of the same bone, ends which have different bone mineral density values. It is predicted that in sites with poor bone preservation, epiphyses with low bone mineral density values will be poorly represented, and vice versa. To this end, the distal and proximal humerus and tibia were examined (Table 3.7). These bones are suitable since they represent both a fore and a hind limb, both are rich in meat and their proximal and distal epiphyses have disparate bone mineral density values. Results for goat bones from all four PPNB sites are shown in Table 3.7. Irrespective of sample size, it is patent that in all cases, the denser, more robust distal ends are better preserved than their proximal partners. A second example is the 1st, 2nd and 3rd phalanges of goat (Table 3.7). Again, using values for sheep as a proxy, it is clear that their average bone mineral densities follow a linear decrease – the 1st phalanx has the highest value i.e. is the densest (0.46), while the 3rd phalanx is the least dense (0.30). In all PPNB sites the more robust 1st phalanx is the best represented, while the 3rd phalanx is the least represented.

Finally, bone mineral density values (BMD) for sheep were plotted against %MAU (Table 3.4b; Fig. 3.6a,b). The correlation coefficients for all three sites are positive and significant (Ujret el-Mehed r_s=0.40, P=0.00; Wadi Tbeik r_s=0.61, P=0.01; Abu Madi III r_s=0.31, P=0.01) demonstrating a strong tie between the two variables. It may be concluded then that all assemblages have been strongly influenced by bone density mediated attrition.

Although Dayan et al. (1986: 107) state, that since the Ujret el-Mehed assemblage exhibits extensive fossilization, with little evidence for abrasion or weathering "we consider any disproportions in the distribution of bones as due to human activities rather than to natural processes", the data presented here clearly show that diagenesis has biased the representation of skeletal elements in all the PPNB sites from Sinai. Consequently, human activities such as selective transport of carcass parts from the kill site or methods of food processing, are not the major factors responsible for the observed patterning in skeletal elements.

Thus, the relatively high numbers of cranial remains, especially fragments of horncores (NISP = 14 for *Capra*) at Gebel Rubsha do not indicate preferential transport of skulls to the site, while the absence of trunk elements and horncores of *Capra* at Wadi Tbeik, do not indicate selection of these elements - by size, weight and utility- for transportation back from the kill site (the 'schlepp effect') as suggested by Dayan et al. (1986). Moreover, as shown in Table 3.4, when body part categories are converted into frequencies without the trunk elements (since these are also not listed for Ujret el-Mehed), it is evident that Wadi Tbeik and Ujret el-Mehed have similar frequencies of cranial components, but differ in the relative frequencies of other body parts. In addition, 55% of the Wadi Tbeik assemblage is composed of phalanges (compared to 34% at Ujret el-Mehed). These low meat-bearing elements are therefore super-abundant at Wadi Tbeik, (*contra* claims by Dayan et al. 1986 for selection of elements with high utility values). Therefore, there is sufficient evidence to indicate that complete carcasses of ibex, including low utility elements, were introduced into all the PPNB sites discussed here.

Capra ageing

With the exception of one unfused bone (a proximal calcaneum) that represents an age of less than 48 months, all goat bones found at Gebel Rubsha that could be aged, are fused (Table 3.2). Bone fusion times for *Capra* in Abu Madi III were assessed using standards given in Noddle (1974) for feral animals that fuse later than domestic forms. It was thought that these would serve as a better proxy for wild ibex than Silver's data (Silver 1969) for domestic breeds. As illustrated in Table 3.2, at Abu Madi III, some 20% of animals were culled before their first year. This remained the same into the second year, but dropped sharply to ca. 50% by 3 years and reached a plateau which it maintained into the 4th year. It is difficult to assess what occurred in the 4 years and over age group, since the absence of unfused bones in this group has caused a 'rebound' in the data set, with frequencies rising to 100% fused bones. Rebounds such as this characterise sites with poor bone preservation resulting in the under-representation of remains of immature animals since, being less dense, these are more fragile.

The epiphyseal data from Abu Madi III correspond roughly to those given by Dayan et al. (1986) for Ujret el-Mehed (Table 3.2). One difference is that at Ujret el-Mehed a lower cull was found in the 0-12 month range than at Abu Madi III. Even if data for the two skeletal elements selected by them in this age category are averaged, then only some 6% of the animals were culled at this time in the Ujret el-Mehed sample, compared to just over 20% at Abu Madi III.

It was suggested that the absence of animals under 10 months of age at Ujret el-Mehed reflected intentional, age-based selection. The reason for this, as put forward by the analysts (Dayan et al. 1986), was that hunting such young animals was uneconomic due to their small meat yields. Although mention is made of the contribution of taphonomic factors in influencing skeletal elements represented at this site (e.g. a disproportional number of astragali- Dayan et al. 1986:107), the impact of differential destruction on the more fragile immature bones which could have biased the age profiles, was not investigated.

Averaging of data for the two skeletal elements falling in the next age group from Ujret el-Mehed (12-24 months), gives similar result to those found at Abu Madi III – a cull of 20%. If the frequencies for the three bones examined from Ujret el-Mehed in the next age group (24-36 months) are averaged, then the cull of 50% falls in the same age group as at Abu Madi III. It may then be concluded that at least 50% of animals represented in both sites were adult.

Dayan et al. (1986) have shown that the age distribution at Ujret el-Mehed corresponds well to that of a living herd of Nubian ibex from the Judean desert. The Abu Madi III data show a similar correspondence, indicating, as concluded by Dayan et al. (1986: 111), that "it seems unlikely that any age based selective culling was practiced". Thus, there is nothing to suggest a domestic cull, or any management strategy *vis a vis* goats at these two sites. The culled sample reflects the respective proportions of animals available in the wild. Loss of bones from diagenetic attrition would account for the missing animals aged less than 10 months.

Sexing of *Capra*

Ibex are very dimorphic with males considerably larger than females; 51 kgs versus 25.3 kgs live weight (Mendelssohn and Yom-Tov 1999). This manifests itself in differential size of the bones of the skeleton. At Ujret el-Mehed, the male to female ratio was 36:48, which tallies well with modern ibex survival rates (43% males to 57% females-Dayan et al. 1986: 110). Only at Wadi Tbeik is there some evidence for selective culling of the sexes. The male to female ratio for ibex at this site was 33:16. It has been suggested that this is probably due to seasonal constraints rather than cultural manipulation, since the site was occupied in winter. It reflects a preference for the meat of males since in the winter calving period females will have reduced fat reserves (Bar-Yosef 1984; Tchernov and Bar-Yosef 1982). There is no further evidence for attempted 'cultural management' of ibex in the Sinai faunal assemblages such as age biases (with more immature animals culled), or morphological changes in size or horncore conformation.

Gazella

Gazelle was the second most common taxon represented at Gebel Rubsha and Abu Madi III, comprising 16% and 15% of the identified samples respectively (Table 3.1).

Two species of gazelle are found in the southern Levant today – the mountain gazelle (*Gazella gazella*) that inhabits the Mediterranean zone and the dorcas gazelle (*Gazella dorcas)* limited to the arid regions of Sinai, southern Jordan, the Negev and Judean deserts, south and east of the 150 mm isohyet (Mendelssohn and Yom-Tov 1999). The two species of gazelle are distinguished by size, with average weight of male mountain gazelle 24.8kgs and 18kgs for females, while dorcas gazelle males weigh 16.4kgs and females 12.2kgs respectively (Mendelssohn and Yom-Tov 1999).

No species attribution was possible for the Gebel Rubsha remains but based on the size of the few measurable gazelle bones recovered from Abu Madi III (Table 3.7) they probably represent the mountain gazelle (*Gazella gazella*). This corroborates the findings of Dayan et al. (1986) and Tchernov et al. (1986/87) who demonstrated that the dorcas gazelle, the species currently inhabiting the Sinai, was a post-PPNB migrant into this region. Until then, the sole inhabitant of Sinai and the southern Levant was the mountain gazelle. It is probable that the sub-species *Gazella gazella acaciae*, found in the Arava (Negev desert) today, represents a relict of this population as it retreated northwards, following climate change and the onset of more arid conditions at the end of the PPNB (Mendelssohn and Yom-Tov 1999).

As shown in Fig. 3.5, gazelle are rare or absent today in the region of the high mountains of southern Sinai, but present in the lowlands and coastal plain. This may explain the lower frequencies of gazelle relative to ibex in Abu Madi III, Ujret el-Mehed and Gebel Rubsha (Table 3.1). However, the site of Wadi Tbeik also has low proportions of gazelle despite the fact that it lies at a lower elevation on a plateau on the north-eastern fringe of the highlands. Since this site was probably occupied during the winter, it is possible that this region was not attractive to gazelle at this time of year.

The few measurements that could be taken on gazelle bones (Table 3.8) show that they fall within the upper range of modern mountain gazelle. Although modern mountain gazelle are smaller than their PPNB counterparts (Ducos and Horwitz 1998), since dorcas gazelle is considerably smaller than mountain gazelle, we can be confident that the Abu Madi III specimens represent *Gazella gazella*.

Gazella skeletal element representation

Due to the small sample sizes, only gazelle data for Abu Madi III was tested using a bivariate regression plot of carcass utility indices against %MAU. The data on which this plot was based are given in Table 3.4b. The correlation coefficient shows that as for ibex, there was no statistically significant correlation between the variables; $r_s=0.16$, $P=0.10$.

The same taphonomic analysis as carried out for *Capra* was undertaken for gazelle. The data are less robust than for goat, since sample sizes are smaller. However, as illustrated in Table 3.9, a similar pattern is found. For the humerus and tibia, the denser distal ends are consistently better preserved than the proximal ends. For the phalanges, a different pattern is evident with far higher frequencies of 2nd phalanges than 1st's. This result is undoubtedly due to the fact that bone mineral density values for sheep were used as a proxy. However, the morphology of gazelle toes differs from that of sheep, with the 1st phalanx considerably longer in the gazelle and as a result probably less dense than its counterpart in a sheep. Hence, the gazelle 2nd phalanx is probably denser than the 1st phalanx. Following this explanation, the results obtained are logical.

Thus, even the small gazelle sample exhibits some degree of bone density mediated attrition, with the result that many of the less dense elements are under-represented. This limits our understanding of human involvement in gazelle exploitation. However, as shown by the body part categories, all parts of the carcass are represented, hinting that complete animals may have been brought to the site.

Gazella ageing and sexing

At Gebel Rubsha and Abu Madi III, few bones could be aged. However, in both sites at least one immature animal aged less than 10 months was present (Table 3.3). At
Wadi Tbeik, Tchernov and Bar-Yosef (1982) note that the frequency of young animals (3-4 months) was very low, and that all bones recovered from the site were fused. This patterning is explained as hunters avoiding immature animals or that the site was occupied outside the calving season (ibex are born at the end of March–early April). However, given the data on skeletal element representation presented above, it is clear that immature

animals in all the PPNB assemblages discussed here are under-represented, such that the Wadi Tbeik data reflect preservation biases rather than human selection.

Dayan et al. (1986) postulated that Ujret el-Mehed could not have served as a summer camp (i.e. inhabited during October-March) due to the absence of ibex aged less than 10 months. They arrived at this conclusion by reducing the age of epiphyseal fusion for ibex to the level of domestic animals (e.g. 6-8 months for the distal humerus instead of 10 months). The reason for their having reduced the age of fusion used is unclear since wild animals and unimproved domestic breeds grow slower and their bones fuse later than domesticates and improved breeds (e.g. Hilzheimer 1961; Noddle 1974; Tchernov and Horwitz 1991 and references therein). The absence of young animals at this site, as at Wadi Tbeik, is undoubtedly related to biases in bone preservation rather than anthropogenic filters.

Unidentified Large Mammal

At Gebel Rubsha, three long bone shaft fragments belonging to a large mammal were found but could not be identified to skeletal element let alone species. Potential candidates for these remains include aurochs, equids, hartebeest and oryx.

Carnivora

Few remains of the red fox (*Vulpes vulpes*) were found in either the the Gebel Rubsha or the Abu Madi III assemblage. The species was identified on the basis of overall size of the remains compared to modern specimens, since none of the bones or teeth could be measured. One of the Abu Madi bones (a mandible corpus fragment) was burnt, suggesting an anthropogenic association.

Red fox is still a common carnivore in southern Sinai (see Chapter 2) and was found in all PPNB sites in Sinai. In the Mediterranean region, red fox increases in frequency in the PPNB (Horwitz 1996), and it has been suggested that a special, perhaps ritual, relationship existed between this species and PPNB communities in the Levant and on Cyprus (Horwitz and Goring-Morris 2004; Vigne 2001). Charred bones of fox at Jericho led Clutton-Brock (1979) to suggest that they were exploited for both meat and pelts.

Part of a first phalanx of a large felid was present in the Abu Madi III assemblage. It most closely resembles that of a leopard (*Panthera pardus*), but since it is partial and could not be measured or its detailed morphology checked, the possibility that it is a cheetah (*Acinonyx jubatus*) cannot be discounted since both felids inhabited the region (see Chapter 2). Leopard remains have also been reported from Ujret el-Mehed.

Lepus

Only 6 bones of the Cape hare (*Lepus capensis*) were identified in the Abu Madi III assemblage and 4 at Gebel Rubsha. Today, this is a common species in both northern and southern Sinai. Two of the bones (ribs) in this assemblage were burnt, although this may have resulted during food processing, accidental post-depositional burning of intrusive bones cannot be excluded. One may expect to find more complete carcasses in the case of natural mortalities. However, at Abu Madi III, no articulations of hare bones were found, while at Ujret el-Mehed only two sets were identified and at Wadi Tbeik only one (Bar-El and Tchernov 2001). These data would seem to support the contention that hare served as a dietary item in all four sites. The Cape hare is usually hunted by trapping since it is a nocturnal animal and extremely fast (breaks away at 70km/hour – Mendelssohn and Yom-Tov 1999).

Hare is the third most common taxon at Ujret el-Mehed, but its frequency in the assemblage as a whole, is still extremely low (5%) (Table 3.1). Similarly, few hare remains were reported from the neighbouring sites of Gebel Rubsha and Abu Madi III (3% and 1.5% respectively), indicating that in the high mountains this taxon was not intensively exploited. In contrast, hare comprised 55% of all identified bones at Wadi Tbeik located in the sandstone plateau.

As illustrated by Bar-El and Tchernov (2001), in both Wadi Tbeik and Ujret el-Mehed, all elements of the skeleton of hare are represented – although no scores for trunk elements are given. Cranial remains, especially isolated teeth, and the distal humerus, both extremely dense skeletal elements, are the most common parts in the assemblage, while toes i.e. third phalanges, are absent in both assemblages. This suggests that both Wadi Tbeik and Ujret el-Mehed have been negatively affected by attrition. Too few elements were found at both Gebel Rubsha and Abu Madi III to assess this issue.

Insectivora

A single jaw of the Ethiopian hedgehog (*Paraechinus aethiopicus)* was found at Abu Madi III. No remains were recovered from the nearby site of Ujret el-Mehed but bones and teeth were identified at Wadi Tbeik. This species is still found in the region today (see Chapter 2), especially in rocky habitats. It may represent remains of an animal that accidentally became incorporated in the deposit.

Reptilia

Only one species of reptile has been identified from Abu Madi III, the roughtail rock agama (*Laudakia* [formerly *Agama*] *stellio*). The lizard is represented by at least three individuals (lower left jaws). An additional four vertebrae found in two adjoining squares, may derive from this same species. The geographic distribution of the roughtail rock agama in the arid regions of the southern Levant indicates that it is mainly restricted to the higher mountains. According to Bouskila and Amitai (2001), the sub-species found in the southern Negev and Sinai still needs to be defined. Remains of Agamidae are known from both Wadi Tbeik and Ujret el-Mehed. However, it is unclear for these contexts whether this lizard was consumed or represents a natural mortality. Dayan et al. (1986) note that this species of lizard is still hunted and consumed by Bedouin in Sinai.

Aves

The Abu Madi III sample yielded a total of 12 bird bones, of which the chukar partridge (*Alectoris chukar)* was the most common. This species is a glacial relict currently found in the high mountains of Sinai (see Chapter 2). At Abu Madi the chukar is represented by bones of the leg – tarsometatarsus and tibiotarsus, while at Ujret el-Mehed and Wadi Tbeik the corocoid is the most common element.

Other species are represented by isolated bones, with quail identified only at Wadi Tbeik.

Pisces

A spine and vertebra of an unidentified fish were found in the sample. Fish remains have been found at Ujret el-Mehed and Wadi Tbeik, the latter having been identified as remains of freshwater catfish (*Clarias* sp.) as well as marine fish. It is not known whether the freshwater fish derive from paleo-lakes in Wadi Feiran that have since dried up, or represent trade items from the Nile. The presence at Wadi Tbeik of bones of *Porphyrio*

porphyrio, a large, sedentary waterfowl that requires running freshwater, as well as the freshwater mollusc *Theodoxus jordanii*, offer further indications that such a habitat existed near this site. At Wadi Tbeik bones of marine fish were found, possibly representing dried fish that was transported to the site together with the abundant marine shells found there (Bar-Yosef Mayer 1999). It should be emphasized that all PPNB sites lie high above the coast; Ujret el-Mehed and Wadi Tbeik at 1600 m.a.s.l. and Abu Madi III at 1200 m. a.s.l.

Bone modifications

No butchery data is available for Wadi Tbeik and Ujret el-Mehed. At Abu Madi III, 5 unidentified bone shafts exhibit isolated and short cut marks. There is no evidence for percussion fractures at this site or Gebel Rubsha, but the bones are highly fragmented and broken, thus masking anthropogenic damage. Of the 452 identified bones in the Abu Madi assemblage, 41 were burnt. Of the 1125 unidentified bone splinters, 503 (45%) were burnt. A very high frequency of burnt bone was also found at Gebel Rubsha, mainly on unidentified bone splinters.

The burnt material at both these sites is associated with hearths, found in most rooms and courtyards at these sites, indicating that the bones were burnt either inadvertently, or during food processing. With reference to Wadi Tbeik, Bar-Yosef (1985: 118) has stated that the infilling of the structures at this site were mixed with ash indicating “a continuous cleaning and spreading hearths residues”. This activity may account for the large quantity and dispersion of much of the burnt material found in all sites.

3.5. ARE CATTLE PRESENT IN THE PPNB SITES OF SINAI?

In the analyses of faunal assemblages from the PPNB sites of Wadi Tbeik, (Tchernov and Bar-Yosef 1982), and Ujret el-Mehed (Dayan et al. 1986), bones of *Bos* were positively identified; two at Wadi Tbeik - a second phalange and distal scapula, and one at Ujret el-Mehed - a second phalange. The presence of *Bos* was considered by the authors and their colleagues to reflect the wetter and cooler conditions prevailing in Sinai in the Neolithic period since this species represented a relict of taxa that had moved southwards during the last glaciation. These taxa were ’left behind’ as the majority of faunal elements migrated north in post-Neolithic times, while others such as the chukar partridge, continued to inhabit mesic micro-environments such as the high altitudinal regions of the southern mountain region of Sinai (Tchernov and Bar-Yosef 1982; Tchernov 1988; Danin 1983, 1996). The climatic implications of these *Bos* remains, coupled with the fact that even in later proto-historic periods cattle are extremely scarce in sites in southern Sinai (see Chapter 4), necessitated re-examination of the PPNB cattle remains.

In both reports (Dayan et al. 1986; Tchernov and Bar-Yosef 1982), the three bones assigned to *Bos* were assumed to represent aurochs (*Bos primigenius*). The paucity of their remains in the PPNB sites was explained as due to their dwindling numbers as a result of ecological change – aridification (Dayan et al. 1986). A similar argument was recently used by Martin (1994) to account for the paucity of cattle remains in Late to early Late Neolithic sites in the desert of eastern Jordan.

My re-examination of the *Bos* bones from PPNB sites in Sinai suggests, that based on morphology and biometry, there is room to query the initial identification of these remains as *Bos*, and to consider them rather as representing *Equus* sp.

In both sites isolated 2nd phalanges (also called intermediate or middle phalanx) are represented. Both are broken in half, vertical to the long axis of the bone such that only half the distal and proximal epiphyses are represented – the abaxial aspect (Fig. 3.7). In addition, the specimen from Ujret el-Mehed is burnt. Hillson (1992: 54) has succinctly summarised the major morphological differences in the second phalanx between equids and bovids. As shown in Figure 3.6, the shaft of the 2nd phalanx of equids is broad medio-laterally with a slight and short waist and a symmetrical 'd-shaped' cross-section, while that of bovids is much slimmer medio-laterally, has a marked waist and an asymmetrical 'd-shaped' cross-section.

There are also differences between these taxa in the proximal articular surface of the 2nd phalanx which comprises two 'dished areas' separated by a low ridge. In equids the proximal end is very broad, elongated and crescent in outline, while in bovids the dished areas are asymmetrical and have a 'd-shaped' outline. The distal articulation in equids is very broad medio-laterally and symmetrical whereas in bovids it is deeply grooved, asymmetrical and narrow relative to the shaft length of the bone.

A third criterion that may be added and one that is clearly defined in the PPNB remains due to their fragmented condition can be observed on the dorsal aspect (Figs. 3.7). The distal end of the 2nd phalanx in equids is pointed and juts out sharply so that it lies on the same plane as the furthest projection of the proximal end forming a sharp v-shape relative to the shaft of the phalanx. In bovids the distal epiphysis tends to be rounded and tucked in relative to the furthest-most projection of the proximal epiphysis forming a rounded u-shape relative to the phalanx shaft.

At Wadi Tbeik a very fragmented distal scapula with a partial glenoid cavity that was also attributed to *Bos*, was found. My re-examination indicates that this piece too shows a closer resemblance to *Equus* than *Bos*. However it is too damaged for definite assignation to either Genus.

Based on the data presented here, I propose that the skeletal elements previously identified as those of *Bos*, should be reassigned to *Equus*. Since remains of equids, identified as either *Equus hemionus* or *E. asinus*, are found in both Wadi Tbeik (NISP = 17) and Ujret el-Mehed (NISP =1) this is not surprising. Hence, the answer to the question posed at the start of this section, are cattle present in the Neolithic of Sinai? should be: No.

3.6 CLIMATIC EVIDENCE FROM THE FAUNA

The fauna from the PPNB sites in southern Sinai reflect the varied biotopes that were exploited (Table 3.10). They mirror the environment in the immediate vicinity of the site. Thus, Wadi Tbeik, located in an open plain with in sandy environments contains typical taxa of this biotope – fennec, sand rat, jird, Houbara bustard and high numbers of equid remains etc. Likewise, the faunal composition of the sites in the high massif reflects their location, with the presence of many rock dwelling taxa (see Table 3.10).

Horowitz (1992) stated that in the southern Levant, arboreal pollen frequencies in the PPNB were higher than before (10-15% in PPNA to 20% in PPNB). Pollen spectra from the Negev highlands at this time include Mediterranean taxa such as oak, cypress, pistachio, olive and almond trees. From the sites of Wadi Tbeik and Ujret el-Mehed in Sinai, Horowitz (quoted in Bar-Yosef 1981b) identified oak, olives and *Umbelliferae*. This reflects that a moister climate than experienced at present prevailed in this southern desert belt.

With the exception of - porcupine (Sheikh III), catfish, waterfowl and freshwater mollusc *Theodoxus jordanii* (Wadi Tbeik), all taxa found in the PPNB sites inhabit southern Sinai today (see Chapter 2). The present-day distribution of porcupine includes only northern Sinai, while the freshwater taxa are found in the Nile delta or parts of the Jordan Valley. These species may have survived in oases or paleo-lake areas that persisted into the MPPNB. However, the possibility that they served as trade items, like the Mediterranean Sea shells found in PPNB sites in Sinai, cannot be discounted [6].

With *Bos* removed from the list, the faunal basis on which to reconstruct more mesic conditions in Sinai during the PPNB is weakened. However, the fact that mountain gazelle is found, indicates that sufficient water and feed were available to support this ungulate. During summer, the mountain gazelle preferentially drinks daily, but can also survive in regions without standing water provided they have sufficient green pasture. If feeding only on dry food, they must drink (even in winter). To improve water balance they are known to dig for bulbs/corms as well as travel to distant water sources (Mendelssohn and Yom-Tov 1999). The mountain gazelle is both a grazer and browser. According to Mendelssohn and Yom-Tov (1999), they can consume almost all plants, including species that are poisonous to other herbivores. In the Negev, the sub-species *G.g. acaciae* feeds primarily on green leaves and pods of *Acacia* trees. They feed early in the morning when the water content of the leaves is higher than later in the day. This would serve as a good model for mountain gazelle feeding behaviour in Sinai. The dorcas gazelle however is far better adapted than the mountain gazelle to withstand harsh desert environments, especially in terms of water metabolism. It is not surprising then that they succeeded in colonising the Sinai and Negev as more arid conditions set in.

At least one glacial relict is represented in these sites, the chukar partridge (*Alectoris chukar*), a species that still survives in the high mountains of Sinai (Yom-Tov 1987). It may be concluded then that with the re-assignment of the *Bos* remains to *Equus*, that claims for more mesic conditions in the PPNB based on fauna are weakened. However, in the

---

[6] With respect to fauna, it is sometimes difficult to distinguish changes in the natural distribution of a species as a result of shifts in climate, from trade.

PPNB site of Nahal Divshon from the Negev desert, remains of both aurochs and fallow deer were reported (Tchernov 1976), such that the re-assignment of the Sinai bones may reflect local trends in the biogeography of this taxon rather than the prevailing regional climate.

3.7 INTER-SITE COMPARISON

The PPNB communities of southern Sinai had much in common in terms of subsistence base. They subsisted from hunting as attested to by the absence of domestic stock and the predominance of medium and small-sized game in the faunal assemblages. This is corroborated by the fact that arrowheads comprise a large component of their tool kits while sickle blades, a common agricultural artefact used for harvesting cereals in Mediterranean PPNB sites, are absent in the Sinai tool kit (Garfinkel 1981; Gopher 1981, 1985, 1994). This demonstrates the unavailability of suitable grasses/cereals in the region and lack of agriculture. The presence of wheat phytoliths, a taxon that does not grow in the region, denotes trade in cereals, probably with the Levant, emphasizing that crops were not grown in Sinai at this time. Groundstone tools, which are abundant in most sites, indicate the extensive exploitation of wild plants and/or processing of traded cereals, further corroborated by the presence of silos at Ujret el-Mehed.

The four sites discussed here also differ in several features. In terms of location (and hence season of occupation), Ujret el-Mehed, Gebel Rubsha and Abu Madi are situated in the valleys of the high massif at elevations of 1600 m.a.s.l., and identified as summer occupations. In contrast, Wadi Tbeik, which is situated within the high mountains on a plateau some 1200 m.a.s.l., between the e-Tih plateau and Gebel Gunna, is identified as a winter occupation. In terms of chronology, Wadi Tbeik and Gebel Rubsha are attributed to the MPPNB, while Ujret el-Mehed and Abu Madi III are attributed to the LPPNB (Kuijt and Goring-Morris 2002).

The sites differ in several archaeological features as well. In terms of size, Wadi Tbeik and Ujret el-Mehed are classified as slightly larger than 250m^2, while Gebel Rubsha is listed as 30-80 m^2 (Bar-Yosef 1981c). Another difference is that unlike Abu Madi III and Ujret el-Mehed, there is evidence for on-site tool manufacture at Wadi Tbeik, and it has been proposed (Bar-Yosef 1981b.c) that the site may have served as a flint-knapping workshop for the manufacture of blades, used to produce points, since it is situated in close proximity to the flint sources of Gebel Gunna and the e-Tih plateau, flint sources being absent in the crystalline massif. It should be noted that at Gebel Rubsha artefacts also appear to have been manufacture on-site. At this site, and others in the massif that are similarly located at some distance from the sources of raw material, limited knapping of roughouts into their final form probably took place rather than large-scale flint knapping. A further difference, though this may simply reflect extent of area excavated, is the presence of silos at Ujret el-Mehed, installations that are absent at Wadi Tbeik. Inside these silos human burials were found. Furthermore, Ujret el-Mehed has yielded a large number of human skeletons (N=17), while Wadi Tbeik has yielded only two, which given the size of the site is considered an under-representation by Hershkovitz et al. (1994).

Have these factors affected the respective faunal compositions of each site?
Of the sites discussed here, Wadi Tbeik has the lowest frequencies of gazelle, but highest frequencies of hare and equids. It is the only site with remains of Houbara bustard, which like the hare and equids inhabits semi-desert plains. It is also the only site to have yielded taxa associated with freshwater – catfish and the gallinule. An additional unique feature of this site is the marked sex bias reported for ibex (more males than females), a feature not found in any of the other sites studied. However, just how significant are these apparent differences?

Since the sample sizes of the assemblages vary greatly, a rarefaction test was run using the data in Table 3.1. This test overcomes the incompatibility of unequal sample sizes by calculating the number of species expected from different communities if all samples were reduced to a standard size. Ujret el-Mehed was used as the standard since it is the largest sample. Results demonstrate that all sites have the expected number of species given their respective sample sizes: Wadi Tbeik - 7 species, Abu Madi – 6 species and Gebel Rubsha – 4 species. Thus, the absence of a wider spectrum of taxa in the smaller samples is correlated with their small sample size rather than attributable to ecological or cultural parameters.

Given that sample size has played a critical role in determining the composition of the samples, a chi square test was run on the data given in Table 3.1 to test for differences in species composition for the two largest assemblages – Wadi Tbeik and Ujret el-Mehed. The results show that they differ significantly in species composition (P=0.00). It may be concluded then, that differences in location/season of occupation and/or chronology have affected species composition of the sites. However, distinguishing between these factors is problematic. One way is to evaluate them is to examine the faunal evidence for seasonality and see if this offers a more parsimonious explanation for the apparent patterning.

3.8 THE FAUNAL RECORD AND TRANSHUMANCE

Based on modern ethnographic parallels, the ecological diversity of southern Sinai and the physical location of the PPNB sites and their architecture, Bar-Yosef (1981b, 1984) proposed that local environmental conditions would have determined the annual cycle of human movement in the past, much as they do today. This entailed transhumance with "seasonal movement from one zone to another with exploitation of common and special resources in each zone" (Bar-Yosef 1981b: 230).

This model assumes that human populations remained in southern Sinai and did not leave the area either for the central or northern regions of the Peninsula or places beyond. Moreover, transhumance was attitudinally based and followed a circular trajectory rather than a radial one (Bar-Yosef 1981a, 1984).

In the summer months (June-October), communities would occupy the high mountains of southern Sinai enjoying the water resources and limited grazing/arable land. These sites should attest to exploitation of wild fruits and cereals, as well as wild animals such as ibex and hare found in this region. Summer sites are found in unsheltered localities and comprise 'flimsy' structures, together with imported lithics, numerous grinding stones, silos and marine shells (Bar-Yosef 1981c: 12). It has been suggested that in these sites, processing of meat for storage (smoking, dying) may have taken place (Bar-Yosef 1984).

In fall/winter (early to mid-October), people left the cold and often snow-covered high mountains, moving to lower altitudes of 250-500 metres in the lowlands of western Sinai near the seashore (rather than eastern Sinai) since these areas experience milder winters, offer sheltered environments as well as numerous springs and pasture for wild/domestic herds. Winter camps are characterised by well-built structures, few grinding stones, lithic workshops and many marine shells (for bead production?). It is hypothesized that molluscs were collected along the coast at this time of the year, a period when people also fished (Bar-Yosef 1984). There is also "evidence for hunting in remote-from-camp areas" in the fall/winter months (Bar-Yosef 1981c: 12).

Spring would see them on the plateau or on the fringes of the high mountains, possibly following the wadi courses as do modern Bedouin (e.g. Levi 1987; Ben-David 1987). Thus, a full annual cycle would be composed of coastal lowland areas in eastern or western Sinai in winter, and the mid- to high altitude areas in summer.

Even in environments where seasonal transhumance is not practiced by people or animals, and the same prey species are found throughout the year in all parts of the region, there are marked seasonal differences in resource harvests. This is not due to scarcity of prey, but to changes in the physical condition of the landscape which affect visibility of the animals, their density and distribution in the landscape. In concert with an array of technological and social factors, such as time allocated to capture prey and weaponry used, this constrains access to prey species (Wilmsen and Durham 1987). It can be assumed that in a regime where transhumance to a new biotope is practised, seasonal changes in all aspects relating to resources will be even more marked.

Using fauna to evaluate the season of occupation of an archaeological site is facilitated by several factors that include:
(i) that the ecology of an animal today mirrors that of the species in the past (usually assumed)
(ii) that an animals range is not ubiquitous but habitat specific
or
(iii) that an animal uses different localities on a seasonal basis.
(iv) that the animal has a defined birth season.
(v) that the composition of the social grouping in which the animal lives changes over time (either by season or by age/sex cohorts).
The presence of even one of these features can facilitate extrapolation as to the season of site use. It is with these parameters in mind, that the Sinai PPNB data is examined.

Bar-Yosef (1984) noted that both the preference for male ibex as well as the large number of remains of hare offers some support for his interpretation of Wadi Tbeik as a winter occupation site. Examination of the biology of gazelle and ibex offers corroboration for this claim, but the biology of the Cape hare, is less compelling in their support of this model (Table 3.11).

Lepus capensis is a solitary, nocturnal animal that lives in burrows. Males and females may be found together only in the reproduction season. Pregnancy lasts 42 days with litter size of 1-3 young in the desert regions. According to Mendelssohn and Yom-Tov (1999), in the desert they reproduce in the winter and spring. The young are born either in a hidden place in vegetation, or in a hollow in the ground which the female digs. Nursing lasts one month.

Taking this information into consideration, if Wadi Tbeik was occupied during the winter months, then one would expect a high proportion of immature hares in this assemblage (Table 3.11). However, according to Bar-El and Tchernov (2001) this is not the case. Only three immature hare bones were recovered from this site (0.2% of the hare sample). Although it cannot be discounted that diagenetic factors have acted to destroy the small and very fragile immature hare bones, one would expect at least a small proportion to survive. Admittedly young hares offer little sustenance, but on the other hand they are easier to catch than adults. Perhaps the majority of adult hares found in the assemblage represent adult mothers that would have been nursing in this season, a factor that may have facilitated trapping them. Nursing females do not remain near the young but return to suckle them once or twice a night and as such could be trapped with relative ease. Today, hares are hunted by the Bedouin in Syria using dogs (salukis) or falcons, or both together, or else simply by stalking the hare in the vegetation near its burrow and bagging it once it tries to hide in the shrubbery (Jabbur 1995). Thus, the data on hare exploitation at Wadi Tbeik, offer ambiguous support for the seasonality model other than that this taxon is abundant in the lowland plateau and was commonly trapped for food. However, the presence of quail offers support for a late winter-early spring occupation for this site (Table 3.11).

With regard to seasonality data from the gazelle, information is limited by the small samples. What can be demonstrated (Table 3.3) is that at least at Abu Madi III and Gebel Rubsha, no new-borns are represented and that all animals culled were at least 8 months old. Given that gazelle are born in the spring, culling of an 8-10 month year old would have had to take place in the summer, this being the suggested season of occupation for these sites (Table 3.11).

As shown in Table 3.11, ibex are social animals, and live either in exclusively male herds or female herds (females with or without young). Only very old males are solitary (Mendelssohn and Yom-Tov 1999). The biased sex ratio found at Wadi Tbeik could then easily be explained as encounters with male only herds, rather than cultural control. Such herds may contain only adult males, or mixed age groups. Since the winter months coincide with the ibex herds moving onto the plains in search of annuals, they would have been easily accessible to the PPNB hunters living on the plateau of Wadi Tbeik at this time of year. Like wild goats, ibex are fast climbers but slow on level ground (Rollefson and Köhler-Rollefson 1993). This restricts their home range and escape behaviour, making them vulnerable to predation in open habitats.

At Ujret el-Mehed, the number of male to female ibex has been calculated as 57% females to 43% males (Dayan et al. 1986). Age data from this site reflect a normal herd structure with relatively few young, and close to 50% mature animals culled. Sex ratios of ibex at Abu Madi III could not be calculated due to the small sample, however based on the preponderance of fragments from large horncores, it appears that some adult males are represented in this assemblage (females have very small horns). Age data resembles the composition found at Ujret el-Mehed. Data from both sites then show a similar pattern of ibex exploitation, which does not reflect selection of specific age or sex groups. A herd structure such as this would be found in the summer months, when herds of both female and male ibex (all age groups) congregate around water sources, making ambush hunting in the mountain valleys, a viable strategy.

Kingdon (1990) states that in Arabia ibex are generally ambushed at water holes. Other ethnographic examples from the Near East corroborate this. Jabbur (1995: 367) notes that in order to hunt ibex, Bedouin in Syria used to conceal themselves near mountain springs or along paths that the animals used in order to come down to drink. Similarly, in the Red Sea hills, traditional methods of ibex hunting used by the Beja tribe of eastern Sudan (semi-nomads who practice seasonal transhumance-El Mahi 2000), employ what appear to resemble 'desert kites' (e.g. Perevolotsky 1980; Perevolotsky and Baharav 1991; Rosen and Perevolotsky 1998). This entails building an enclosure adjacent to a locality with water frequented by ibex. The structure is built of rocks and has one entrance. The hunters are divided into groups – one to find and then drive a herd of animals towards the enclosure, another group placed at strategic spots to prevent animals from escaping en route. Once the animals are in the enclosure the hunters set upon them with knives and throwing sticks (El Mahi 2000). A second traditional method employed by communities in southern Arabia uses nets that are set and camouflaged in a locality with water that is visited by ibex. Once the animals approach the water they are set upon by the hunters and driven into the nets. The animals that get caught in the nets are killed, and these are usually large males whose horns easily become entangled (El Mahi 2000). The adoption of such a hunting method may perhaps explain the higher proportion of males in the Wadi Tbeik archaeozoological sample. These descriptions tally well with the suggestion offered by Betts and Yagodin (2000: 41) that some of the kite systems in the *harra* of Jordan were designed to catch animals 'passively' in the course of "regular movement" such as migration., while others were used to actively trap animals, either singly or in herds.

These data are of some relevance to the archaeological record due to the depiction of ibex-hunting using a 'kite' on a rock engraving from southern Sinai as well as the remains of numerous 'kites' in southern Sinai (Hershkovitz et al.1987; Perevolotsky 1980; Perevolotsky and Baharav 1987, 1991; Rosen and Perevolotsky 1998). Similar rock engravings and constructed 'kites' are known from other deserts in the region, for example: Syria (Legge and Rowley-Conwy 1987; Van Berg et al. 2004), eastern Jordan (Betts 1998; Betts and Helms 1986; Betts and Yagodin 2000), the Negev (Holzer 2002) and North Arabia (Helms and Betts 1987). That 'desert kites' functioned as hunting traps rather than as corrals for domestic animals has been cogently argued on the basis of ethology by Rosen and Perevolotsky (1998). Their arguments are largely corroborated by ethnographic examples and historical accounts of ibex and gazelle hunting in the desert regions of the Near East (see discussions on this point in Holzer 2002; Van Berg et al. 2004).

Aside from the debate concerning their precise use, the dating of these installations is problematic. Helms and Betts (1987: 47-49) have noted that "by their very nature 'kites' are virtually undatable since they are built directly on bedrock in most cases, and since they have been repeatedly altered". The limited chronological information available, based on architecture and typology of arrowheads, shows that in eastern Jordan 'kites' were in use already in the late 7th millennium uncal. BC and continued to be exploited in this region through to the 5th millennium uncal. BC if not later (Helms and Betts 1987). Architectural typology of the installations, ceramic sherds recovered within 'kites' as well as radiocarbon and OSL dates of 'kites' from the Negev indicate that they, and by extension (although not proven) also those from Sinai, belong to the final phase of this phenomenon i.e. the 4th-mid 2nd millennia uncal. BC (Holzer 2002; Rothenberg 1970, 1972). It should be noted however that the absence of datable material as well as the re-use of 'kites' over time may have obscured the full chronological history of these installations.

To conclude this brief discussion of 'desert kites', it is suggested here that:
(a) they served as hunting traps for ibex as well as a range of other ungulates - gazelle and equids
(b) that kites were probably already used in Sinai during the PPNB

Ibex was the most common species exploited in the PPNB in both mountain and lowland areas of Sinai[7]. It was also the species most commonly depicted in rock art, much of which has been assigned to the Neolithic period (Anati 1979; Hershkovitz et al. 1987; Perevolotsky and Baharav 1991). From these data it is evident that Neolithic communities in Sinai had a 'special' relationship with ibex. Taking this concept even further, it is proposed here that the underlying motivation for human transhumance in the PPNB was based on the availability of ibex. Strategic hunting of migrating herds ('intercept hunting') has been commonly discussed in both the archaeological and ethnographic literature. Much as the Bedouin historically used kites to hunt gazelle and ibex (as described above), so Ingold (1980) documents the ethnographic data for hunting migrating reindeer through the construction of fences and the use of large numbers of people to channel the animals in the desired direction - in other words 'kites'. Although ibex do not migrate on such as large-scale as do reindeer, their predictable seasonal use of the altitudinal gradient of the Sinai landscape, as well as their use of set paths and water sources would have facilitated planning the best location for 'kites', as has been demonstrated by Perevolotsky and Baharav (1991) for gazelle. Their study indicates that in Sinai, 'kites' were preferentially located in proximity "to the centres of seasonal and transient pasture" (Perevolotsky and

---

[7] Of interest is the fact that the Sinai faunal record shows no evidence of large-scale seasonal shifts in prey preference despite changes in the fat content of ibex (and gazelle) that take place in spring and early summer (see general discussion of this topic in Speth and Spielmann 1983).

Baharav 1991: 247). This would have entailed cognisance of the best season in which to 'cull' the herds. The strategy adopted in Sinai did not then resemble that of *herd following* as defined in the literature of the upper Paleolithic in Europe (see references and review of this concept in White 1989), since this entailed both following a herd for long-distances and exercising some control over it. Rather, the pattern of seasonal movement corresponded closely to that defined by Binford (1980) as "tethered nomadism". As will be discussed in the following chapter, PPNB dependence on ibex and the manner of their exploitation, in many ways pre-adapted the local human population to the later incorporation of domestic herds into their lifestyle, and as such served as a precursor for later forms of pastoralism.

If the attribution of season to the different PPNB sites is indeed correct, then what we see in Sinai is a year-round dependence on ibex supplemented by gazelle, equids and other smaller game. The cycle of seasonal transhumance between the mountains and the lowlands then coincides with the movement of the ibex herds. As such, it is suggested here that the 'desert kites' in Sinai were already used in the PPNB period, and primarily functioned in this region as traps for ibex rather than gazelle, contrary to what has been assumed in most publications dealing with this topic (e.g. Betts 1998; Betts and Helms 1986; Holzer 2002; Perevolotsky 1980; Perevolotsky and Baharav 1991; Rosen and Perevolotsky 1998; Van Berg et al. 2004).

Specialised seasonal hunting camps dating to the PPNB have been identified throughout the deserts of the Levant, denoting that this was a standard adaptation to life in the arid regions. Unfortunately in most cases they lack faunal remains; for example the PPNB levels at Abu Salem in the Negev (Gopher and Goring-Morris 1998). In contrast, the well preserved fauna from Dhuweila in eastern Jordan (Betts 1998; Martin 1994) offer substantial evidence to support a model of seasonal usage of this site focusing on gazelle hunting. Martin (1998, 1999) demonstrates that gazelle cull patterns and the presence of certain species (little bittern pin-tailed sandgrouse and Pallas's sandgrouse) indicate an autumn to spring hunting season.

It is clear that some communities, or individuals, moved beyond the borders of southern Sinai, if only for trade - attested to by Mediterranean Sea shells in the southern Sinai sites and Red Sea shells in Mediterranean region sites (Bar-Yosef Mayer 1999). It has also been suggested that perishable goods were exchanged (meat of wild for cereals) (Bar-Yosef and Belfer-Cohen 1989a) as attested to by the presence of domestic wheat, identified from phytoliths (Miller Rosen 1993) as well as from pollen (A. Horowitz quoted in Bar-Yosef 1981b). Since cereals do not grow naturally in this region, these finds were interpreted as trade items. Ibex hunting on a large-scale may have supplied the excess meat required for such exchanges, as has been suggested by Bar-Yosef and Belfer-Cohen (1989a, b).

Trade with the Nile Delta or Jordan Valley may be attested to by the catfish, waterfowl and presence of the freshwater mollusc *Theodoxus jordanii*, while the presence of porcupine (*Hystrix indica*) bones in Sheikh III, a species not found today in southern Sinai or Egypt, may indicate trade with northern Sinai or the southern Levant.

It is not possible as yet to evaluate whether such excursions were part of a seasonal round, or undertaken only in exceptional circumstances - such as during periods of drought. Indeed, Perevolotsky and Baharav (1991) have suggested that if the climate of Sinai was similar to that today i.e. hyper-arid, then there would not have been adequate vegetation or rangeland, at least in south-eastern Sinai, to support more than 150 people, necessitating contact and barter with farmers outside the region. Given slightly wetter climatic conditions than prevail today (i.e. summer as well as winter rains-see discussion in Chapter 2), coupled with a strategy of radial seasonal transhumance of the kind described above, it is probable that southern Sinai could have offered sufficient resources to support year-round occupation within its confines for a larger population than suggested above.

3.9 SPATIAL AND TEMPORAL TRENDS IN THE SOUTHERN LEVANT AND EGYPT

3.9.1 Levantine MPPNB (ca. 10,100-9250 cal. BP)

Little is known about the EPPNB period (10,500-10,100 cal. BP) in the southern Levant, and even less about the animal based economy of these communities. The two EPPNB sites in the southern Levant to have yielded faunal remains, Horvat Galil in northern Israel (Horwitz 1993) and most recently Motza in the vicinity of Jerusalem (H. Khalaily and L. Sapir pers comm. 2005) point to the continuation of a hunting and gathering mode of subsistence focused on gazelle. It is only with the commencement of the MPPNB that a sharp break is found with preceding faunal traditions.

The mid-PPNB in the southern Levant is characterised by a sudden and marked rise in caprine numbers, a feature generally accepted by researchers as marking the onset of the process of their domestication (Clutton-Brock 1979; Davis 1982; Ducos 1993a, b; Garrard et al. 1996; Horwitz 1989; Legge 1996; Rollefson and Köhler-Rollefson 1989, 1993). Since, it is possible to follow the changing status of goats in the archaeozoological record of the region, from this point in time onwards (as shown by changes in their frequency, morphology and biometry), Horwitz (2003b) has suggested that this species may have undergone autochthonous domestication in the southern Levant. This would have entailed the diffusion of the concept of domestication rather than the physical introduction of domestic animals themselves. In contrast, it seems quite clear that domestic sheep were physically introduced from the northern Levant by the LPPNB (Ducos 1993a; Legge 1996; Horwitz and Ducos 1998).

Figure 3.8 illustrates the changing frequencies of caprines in the PPNB record of the southern Levant relative to frequencies of mountain gazelle. By presenting the data by geographic region it is possible to track the course of this trend both spatially and temporally, from the MPPNB through the PPNC.

For the MPPNB, it is clear that changes in caprine frequencies do not engulf all parts of the region simultaneously. Elaborating on earlier models developed by Bar-Yosef and Belfer-Cohen (1989a, b), Horwitz (1989, 2003b) proposed that in the initial period of incipient domestication three different strategies of animal exploitation co-existed in the southern Levant. The first strategy (Type A) characterised sites located in the Mediterranean zone and the Jordan-Beqa'a Valleys. These were agrarian communities (cereal cultivators), whose animal economy was based on the management of goats (Fig. 3.8). In terms of their morphology and biometry, these animals can still be categorised as wild (although see Wasse 2000 for a different interpretation). According to this view, the caprines may be considered as in the first stages of incipient domestication, which entails focused exploitation through the creation of a founder population and maintainance of animals under anthropogenic conditions. Hunting, including of gazelle, continues at these sites but is relatively unimportant especially in sites located in the Mediterranean zone where goat frequencies are highest (Fig. 3.8).

The second strategy (Type B), as represented by sites in the western Mediterranean zone and reflects some degree of continuity in subsistence strategies with the PPNA and EPPNB traditions in the region. Gazelle hunting is dominant with caprines a minor component (Fig. 3.8). Some evidence for cultivation of legumes and cereals is found at these sites. The lower frequencies of caprines observed in these sites compared to those in the Jordan-Beqa'a Valley and Mediterranean zone may reflect the staggered diffusion of domestication, as the idea (and/or animals) fanned out to the east and west. Although Bar-Yosef and colleagues (Bar-Yosef 2002; Bar-Yosef and Belfer-Cohen 1989a, b; Bar-Yosef and Meadow 1995) suggested that the Jordan-Beqa'a Valley (termed the Levantine Corridor) served as the main conduit for the diffusion of livestock into the southern Levant from south-eastern Anatolia, it is evident from Fig. 3.8 that during the MPPNB the highest caprine frequencies are found in the Mediterranean zone sites and not those in the Jordan-Beqa'a Valleys. This may reflect either (a) the presence of both hunted and proto-domestic caprines in the former sites resulting in inflated caprine frequencies, or (b) a more complex pattern of dispersion of early domesticates.

The third strategy (Type C) characterizes sites in the desert regions. For greater resolution the deserts have here been divided into the eastern desert of Jordan and the southern deserts comprising the Judean desert, Negev desert, southern Jordan desert and Sinai Peninsula. These assemblages closely resemble earlier Epipaleolithic ones, with subsistence based on hunting and gathering. In the deserts of eastern Jordan gazelle are the favoured quarry, while in the southern deserts ibex appear to have been the preferred prey (Fig. 3.8).

Several PPNB sites from the Negev desert are not shown in Fig 3.8 since they yielded small sample sizes that could only be assigned to presence/absence of species. The EPPNB site of Nahal Lavan 109, located in the western Negev, yielded remains of an unidentified species of gazelle (Goring-Morris 1993). It is interesting to note that this site contains fragments of Anatolian obsidian attesting to long-distance trade with communities to the north. The MPPNB site of Nahal Divshon D-1 (Tchernov 1976), spanning the period 9,961±236 cal. BP to 9,085±259 cal. BP, yielded fragmentary remains of ibex (*Capra ibex*) and gazelle, the latter tentatively identified as dorcas gazelle (*Gazella dorcas).* Isolated remains of aurochs (*Bos primigenius*) and fallow deer (*Dama mesopotamica*) were also found at this site attesting to a more mesic environment than today. Finally, the PPNB Layer III at Nahal Nekarot (dated to 9,455±183 cal. BP) has yielded only dung pellets which have been identified as those of ibex (Rosen et al. 2005).

Several archaeological features set the MPPNB desert sites (Type C) apart from the two Mediterranean groups (Types A and B). For example, site size is far smaller in the arid margins than in the Mediterranean region; people continue to build round structures as in the preceding PPNA while in the Mediterranean region they switch to rectangular ones; in the desert the manufacture and use of abundant numbers of arrowheads continues - probably a reflection of the intensity of hunting still practised; and most importantly, they show no evidence at this time for the adoption of either cultivated plants [8] or domesticated animals (Bar-Yosef 1985; Goring-Morris 1993; Goring-Morris and Gopher 1983; Kuijt and Goring-Morris 2002; Rosen 1988).

3.9.2 Levantine LPPNB (9,250-8,700 cal. BP)

By the LPPNB, caprine frequencies have increased markedly and they are far more common than gazelle in sites throughout the Mediterranean zone and the Jordan-Beqa'a Valleys – Type A (Fig. 3.8). In addition, there is extensive data to demonstrate that the majority of these animals confrom to the domestic-type in both their morphology and biometry (e.g. Becker 2004; von den Driesch and Wodtke 1997; Horwitz 2003b; Köhler-Rollefson 1989; Wasse 2000). In contrast, at this time in the eastern desert of Jordan (Type C), wild taxa - in this case gazelle, continues to be the most common species, with extremely small quantities of caprines encountered that probably represent wild animals (Martin 1994). Likewise, in the southern deserts, such as Sinai, ibex are almost exclusively exploited. However, in sites located in the southern-most part of the Jordan Valley such as Wadi Fidan A and Ayn Abu Nukhayla[9], remains of domestic goats and sheep have been identified at this time.

---

[8] The wheat phytoliths identified from Ujret el-Mehed do not constitute the adoption of agriculture - they probably represent traded items.

[9] The chronological attribution of this site follows that given in Kuijt and Goring-Morris (2002).

To this group of Type C sites, may tentatively be added the Judean desert site of Nahal Heimar. This site probably served as a ritual locality. It yielded bones belonging to goat/ibex, ibex, gazelle, cattle, hare, fox, bats, insectivores, rodents, reptiles and birds. The domestic status of the cattle was not resolved. While ibex was definitely identified in the collection (on the basis of horncores), the species attribution of the remaining goat remains could not be determined with any certainty (Davis 1988). There is however, some suspicion that all, if not part, of the Nahal Heimar bone assemblage was introduced into the cave by hyaenas rather than humans, and as such may not be coeval with the archaeological assemblage (Davis 1988). Consequently, it has not been illustrated in Fig. 3.8.

Of special interest is the LPPNB layer from the site of Nahal Issaron which lies north of Eilat (Goring-Morris and Gopher 1978, 1983; Gopher et al. 1994). Layer C at this site, dated on the basis of radiocarbon to the LPPNB has yielded circular structures 2-3.5 metres in diameter, resembling those found in PPNB sites in southern Sinai. Numerous groundstone tools were found, and the lithic assemblage contains typical PPNB elements. The high frequency of arrowheads in this layer at Nahal Issaron signifies the continued importance of hunting in most desert sites at this time. In terms of the faunal component, preliminary results indicate that this site shows great similarities with the PPNB assemblages from Sinai dominated by hunted fauna especially goat (either *C.ibex* or *C. aegagrus* or both species), gazelle, wild ass, aurochs, hare, bird (including ostrich eggshell) and fish (Goring-Morris and Gopher 1983). No precise numeric data are available for this assemblage, but goat remains predominate. These data are in conflict with the identification of domestic sheep and goats in the coeval site of Ayn Abu Nukhayla, which lies circa 100km away in southern Jordan (Henry et al. 2003). This issue can only be resolved when both assemblages are published in full.

3.9.3 Levantine Final PPNB/PPNC (8,600-8,250 cal. BP)

By the PPNC, no change from the MPPNB is found in the ratio of gazelle to caprines in Mediterranean zone and Jordan-Beqa'a Valley sites (Fig. 3.8). Faunal composition in the western Mediterranean sites (Type B) shifts and they are now clearly dominated by domestic sheep and goats with negligible quantities of gazelle (Fig. 3.8). The status of cattle and pigs in Type A and B sites at this point in time is still unresolved, but Becker (2002) has offered a compelling argument for the presence of domestic cattle already in the

LPPNB of Basta[10]. If these data are accepted then this site still remains the exception, since at the PPNC sites on the Mediterranean coast (Atlit Yam and Ashqelon) as well as in the Jordan Valley (Hagoshrim), researchers have opted to define the cattle and pigs as still in a stage of incipient or proto-domestication (Galili et al. 2002; Garfinkel et al. 2005; Haber and Dayan 2004). It is only by the Pottery Neolithic period (late 8th-7th millennium cal. BP), that all four domestic artiodactyls are commonly found in sites throughout the region (Horwitz et al. 1999, 2002a).

Coeval sites in the eastern desert of Jordan and in the southern desert region continue to contain a high proportion of hunted taxa (gazelle) but are accompanied by increasing numbers of domestic caprines (Fig. 3.8). The site of Mesad Mazzal located in the Judean desert may also fall into this time range. This site probably served as an asphalt processing location, and has produced several radiocarbon dates that place it within the Late PPNB (Taute 1981). However, Goring-Morris (1993) suggests that it may actually be somewhat later, the dates having been contaminated by asphalt. Certainly, the faunal composition would support a late date since they include gazelle as well as domestic goat and domestic cattle (bones identified by H-P Uerpmann and J. Boessneck cited in Taute 1981).

No sites dating to the Terminal PPNB are known from southern Sinai, although Goring-Morris (1993) tentatively suggests that Wadi Jibba IIA in south-western Sinai may be associated with this period. Slightly more robust data is given for a series of sites from the western Negev, and the site of Qadesh Barnea 31 in north-eastern Sinai (Goring-Morris 1993). However, even here data on faunal and/or botanical remains are missing (not preserved). Based on the fact that the western Negev sites have yielded remains of silos (but no sickle blades), few arrowheads, and unifacial blades that “closely correspond in concept, if not in function” to later Predynastic knives used to butcher and process animal carcasses, Goring-Morris (1993:77) has postulated that these sites may represent the earliest pastoralist occupations in the southern desert region. The implications of this are that a ‘package of domestic plants and animals’ was introduced via the western Negev and Mediterranean coastal plain of Sinai to the Egyptian delta. Although this hypothesis is intriguing, it remains largely uncorroborated, both by radiocarbon dates as well as by faunal or botanical data. Some support for this idea may be found in the faunal assemblage

---

[10] based on their small size, von den Driesch (in Horwitz et al. 1999), also argues for domestic cattle in the LPPNB of Ba’ja.

from the PPNC site of Ashqelon located along the Mediterranean coastal plain (Garfinkel 1999b), which has yielded large numbers of domestic sheep and goat remains, although the domestic status of cattle and pig is unresolved (Garfinkel et al. 2005)[11].

It may be concluded then, that in terms of archaeozoology, the PPNC sites are characterised by mixed hunting and pastoral economies. Those in the Mediterranean zone and Jordan-Beqa'a Valleys are based primarily on sheep and goat herding, with sites along the coast exceptionally rich in cattle (domestic status unclear) and accompanied by domestic sheep and goats. In the eastern desert regions assemblages continue to be dominated by hunted taxa (gazelle) together with small numbers of domestic caprines. In the southern desert site of Wadi Fidan C domestic sheep and goat are predominant, although some hunting of gazelle, ibex and small game appears to have continued (Richardson 1997).

Since, no PPNC sites with faunal remains have been found in the Sinai, it is currently not possible to determine whether at this time domestic herds entered this region. On the basis of the currently available data, two equally viable overland routes may be proposed for this diffusion: via the Jordan Valley (Wadi Fidan sites A and C, Ayn Abu Nukhayla) and then to sites in north-east Sinai like Qadesh Barnea 31 with the option of further dispersal to Wadi Jibba IIA within Sinai, or alternately along the Mediterranean coast and the western Negev (sites of Atlit Yam and Ashkelon) then dispersing south-west and east to sites like Wadi Jibba IIA and Qadesh Barnea 31. A third option is that a sea route was used for the dispersion of domestic animals into Egypt which by-passed the southern Levantine Mediterranean and Sinai coasts (Bar-Yosef 2002). This would account for the absence of sites with domestic animals in Sinai dating to the LPPNB, PPNC and Pottery Neolithic.

The LPPNB-PPNC has been characterised as a period of increased aridity and cessation of summer rains (Simmons 1997). These climatic conditions together with factors such as the destruction of the environment around the sites are considered by some (Köhler-Rollefson 1988, 1989b; Rollefson and Köhler-Rollefson 1989, 1993) to have contributed to the

---

[11] It should be noted that this site was first published by Perrot and Gopher (1996) as a Pottery Neolithic occupation (Yarmukian?), despite the absence of ceramics. However, no radiocarbon dates were available then.

collapse of sedentary agro-pastoral communities and dispersion of populations including until then sparsely occupied regions such as the deserts. However, given such adverse climatic conditions it seems unlikely that this would have been an appropriate time to 'take on' the desert. Indeed, there is evidence to suggest that at this time there was a gradual disintegration of communities in the south, as population density in the desert regions decreased due to climatic deterioration (Goring-Morris 1993; Goring-Morris and Belfer-Cohen 1998). Recently, Kislev et al. (2004) presented contradictory evidence citing a colder more humid climate in the PPNC. However, this was based on data from a single Mediterranean coastal site and as such may reflect the local micro-climate rather than a regional trend.

3.9.4. Egypt

For the equivalent time period covered by the MPPNB-PPNC in the southern Levant (10,100-8,250 cal. BP), there are no sites in the Nile delta that have yielded faunal remains. Indeed, almost nothing is known about communities in Lower Egypt at this time - the region of greatest interest with respect to Sinai. The most intensively studied sites lie at a great distance from Sinai, in Upper Egypt (Nubia-Aswan area), the Fayuum depression or in the oases of the western desert (Close 2002; Hassan 1988; Vermeersch 1978, 1992; Wendorf and Schild 1998; Wenke et al. 1988).

The salient feature of Epi-Paleolithic and early Holocene subsistence in Egypt is the focus on the entire fluvial system of the Nile and its associated resources, complemented by generalised hunting and foraging of a broad range of terrestrial foods. In these features, these communities resemble precedent Upper Paleolithic populations, although technological innovations facilitated the expansion of the food base exploited by early Holocene peoples.

The Shamarkian (9,947±170 cal. BP) (=MPPNB) and Elkabian industries (9,288±177 to 8,744±112 cal. BP) (=LPPNB) of Upper Egypt (dates based on Hassan 1988: Table 2), attest to a nomadic hunter-gatherer lifestyle with occupation of seasonal camps along an east-west route; winter hunting (and cattle raising?) in the western desert and summer hunting-fishing in the Nile Valley (Schild et al. 1968; Vermeersch 1978, 1992; Wetterstrom 1993). In contrast to preceeding Upper Paleolithic communities, fishing now included deep-water species which indicates intensive exploitation of both side channels/tributaries of the Nile as well as the main river channel. Exploitation of the latter necessitated the development of innovative new fishing equipment. Archaeozoological studies document hunting of terrestrial mammals - aurochs, dorcas gazelle, hartebeest, barbary sheep (?), porcupine, carnivores, as well as exploitation of riverine elements aside from fish – hippopotamus and turtles (Gautier 1978, 1984; Wetterstrom 1993).

Further to the north, in the Fayum depression, the Qarunian culture (9,210±145 to 8,300±111 cal. BP) (=LPPNB), previously called Fayum B (dates based on Hassan 1988: Table 2)[12], focused on exploitation of the Fayum lake and its associated marshes, with site location following the shifting levels of the lake (Vermeersch 1992; Wendorf and Schild 1976). As described by Brewer (1989), fishing and hunting practices closely resemble those of the Nile Valley communities with a focus on gazelle, hartebeest and aurochs, in addition to canids, hare, waterfowl and ostrich. Lacustrine elements are abundant – turtle, some hippopotamus and both shallow and deep-water fish. Seasonality of occupation of these sites is indicated from fish otoliths, which show both a late spring/early summer catch and another in the summer/autumn. These data may attest to occupation of the region when lake levels were low, such that fish were trapped in residual pools (Wetterstrom 1993). The presence of migratory waterfowl in the assemblages indicates exploitation of the region in the winter months. There is no evidence for agriculture or exploitation of domestic animals.

One archaeozoological issue, relevant to the discussion of the origins of domestication during the PPNB, concerns the domestic status of *Bos* remains from two sites in south-western Egypt. These contentious cattle remains, derived from the sites of Bir Kiseiba E-79-8, dating to ca. 9,500 uncal. BP and those from Nabta E-75-6, dating to 9,926±177 cal. BP/ 9,279±121 cal. BP, almost overlap with the earliest claims for domestic *Bos* in the northern Levant (mid-MPPNB), but pre-date the advent of domestic cattle in the southern Levant (LPPNB – Becker 2002) by several hundred years (Close 2002; Gautier 1987, 2001, 2002; Wendorf and Schild 1994, 1998). This, together with recent genetic data which

---

[12] Hassan (1988: Table 2) cites one extremely early radiocarbon date for the Qarunian site of I/79 of 8835±890 uncal BP (=10,099±1158 cal. BP). This date seems however to be too early since Hassan (1988: 142) gives the range of the Qarunian as 8220-7140 BP.

demonstrate an independent origin for African cattle (Bradley et al. 1996), has led researchers to suggest that an early and autochthonous domestication event for cattle took place in North Africa. Biologically, this is a viable proposition since a North African form of aurochs (*Bos primigenius*) that could have fitted the role of domestic progenitor, inhabited North Africa since Pleistocene times.

Since the *Bos* bones from both Egyptian sites are highly fragmented, claims in support of their domestic status have been based on ecological grounds rather than on morphology or biometry. With regard to Bir Kiseiba, Gautier (1987, 2002) has asserted that the absence of other large-sized wild taxa in this sample (that is an assemblage dominated by dorcas gazelle and hare), indicates that the environment around the site was too arid to sustain *Bos* without human involvement. However, this is only an assumption and it has been strongly contested by several researchers (Grigson 2000; MacDonald 2000; Smith 1986) who note that the small size and poor preservation of the bone samples make their identification to species unreliable. Furthermore as noted by Grigson (2000: 48): "It is difficult to believe that domestic animals could survive in an environment that was too inimical for their wild progenitors". Moreover, her comparison of the size of the Nabta and Bir Kiseiba specimens with those of domestic and wild cattle from Egypt, show them to be far larger than domestic animals. Currently arguments in favour of early autochthonous domestication of cattle in Egypt do not appear to be substantiated by archaeozoological analysis. Until further, more convincing data for their domestic status is obtained, the more parsimonious explanation is that they be considered as wild.

It may then be concluded, that during the PPNB, both Sinai and Egypt were occupied by hunter-gatherer populations. Based on species exploited, the Egyptian populations were focused primarily on lacustrine and riverine resources (fishing-hunting), while communities in Sinai targeted medium-sized terrestrial ungulates with little or no exploitation of marine or lacustrine resources. Both communities were involved in exploitation of wild plants. Neither community had adopted agriculture or animal husbandry at this time, although there is some indication that communities in Sinai obtained cereals through trade, presumably from the southern Levant.

4.0 CONCLUSIONS

Based on the data presented here, what can we conclude with regard to patterns of animal exploitation in the PPNB period in Sinai?

(1) There appears to be ample archaeozoological support for the model of seasonal transhumance as proposed by Bar-Yosef (1984, 1985). The three sites located in the high mountains (summer occupations) – Abu Madi III, Gebel Rubsha and Ujret el-Mehed, differ substantively in the composition of their faunal assemblages from that found in the single winter occupation site, Wadi Tbeik, located at a lower elevation.

(2) There is no evidence to support the contention that ibex were culturally controlled, either based on sex or age profiles. The patterning observed in these parameters is consistent with the culling of wild herds. Thus, there is no evidence to indicate the presence of proto-domestic or domestic animals in Sinai at this time.

(3) In a similar manner to the 'edge of the woods' pattern of reindeer subsistence as outlined by Ingold (1980), it is proposed that PPNB dependence on ibex and the manner of their exploitation, served as a precursor for later forms of pastoralism in Sinai since the latter required little reorientation in the pattern of human migration and landscape use.

(4) The pattern of carpine domestication for the southern Levant followed an overland route entailing gradual dispersion of domestic stock/the technology of domestication (with or without people) throughout the region, beginning in south-east Anatolia and diffusing southwards via the Mediterranean zone and Beqa'a-Jordan Valleys, and then to the west and east of the Valley. The earliest point in time when domestic goats and sheep reach the borders of Sinai varies according to the route taken. An inland route to north-eastern Sinai is based on data from the southern Jordanian site of Ayn Abu Nukhayla, where claims for the presence of domestic sheep and goat have been made by the Late PPNB. These are contentious given that at the coeval site of Nahal Issaron, located on the outskirts of Eilat, the faunal assemblage is identical to the MPPNB of Sinai and lacks evidence for domestic animals. In contrast, along the Mediterranean coast/north-west Negev route, the PPNC site of Ashkelon offers the southern-most occurrence of domestic sheep and goat. In the absence of LPPNB and PPNC sites with fauna in Sinai, it remains unclear whether herders crossed the arid 'rubicon' at this time or only later.

(5) Despite the continuation of a hunter-gatherer lifestyle during the period 10,100-8,250 cal. BP in both Egypt and the Sinai, there is no evidence to indicate close ties between the regions at this time. Indeed, in terms of the archaeological record, Neolithic Sinai appears to be more closely related to the southern Levant than to Egypt. The lithic assemblages from northern Sinai resemble those from the northern, western and central Negev as well as sites along the Israeli coastal plain and Judean hills. The lithics from southern Sinai sites show clear ties to sites in the southern Negev and southern Jordan (Gopher 1985; Goring-Morris 1993). However, according to Gopher (1985), there is evidence of a time-lag in the adoption of lithic technology and typology between the regions, a feature which ties in well with the lag-time apparent in the dispersion of domestic herds southwards.

(6) In terms of their physical anthropology, the human populations of Sinai also show a greater affinity to the southern Levant than to Egypt. According to Hershkovitz et al. (1994), stature for Neolithic populations from Sinai falls within the range of PPNB populations from the southern Levant. Similarly, burial customs such as the presence of both primary and secondary in the same site is reminiscent of Levantine burial customs.

Human skeletal remains from North Africa (including Nubia) pre-dating and post-dating the PPNB, differ significantly in their robusticity, cranial and dental parameters from those of their near contemporaries in the southern Levant and Sinai (Smith 2002). As such, it is highly unlikely that the indigenous population of Lower Egypt was ancestral to the PPNB population of Sinai.

Thus, during the period 10,100-8,250 cal. BP Egypt and Sinai appear to have belonged to two separate worlds, while Sinai and the southern Levant shared much, but not all in common.

CHAPTER 4

THE GRASS IS GREENER ON THE OTHER SIDE: THE ORIGINS AND EVOLUTION OF PASTORALISM IN SINAI

4.1 INTRODUCTION

Today, herds of domestic caprines – primarily goats – are a common sight in the landscape of Sinai. However, the timing, place of origin and mechanism of their first appearance in the Peninsula, remains an open issue.

The previous chapter has shown that in the desert regions during the Mid- and Late Pre-Pottery Neolithic B – spanning the period 10,100-8,700 cal. BP (ca. 8,030-7,250 cal. BC)[13], Epipaleolithic traditions of hunting wild animals continued, while at the same time, in the northern and southern Levant, animal husbandry was developing or already established (e.g. Bar-Yosef and Meadow 1995; Garrard et al. 1996; Guilaine 2000; Horwitz 2003b; Horwitz et al. 1999a; Martin 1994, 1999; Peters et al. 1999). Consequently, with regard to the adoption of agro-pastoralism, Sinai and its adjacent desert regions appear to have lagged considerably behind their coeval sites to the north. Questions pertinent to archaeozoological research in Sinai arising from this conclusion include:

(a) were domestic animals introduced into the arid margins from the Mediterranean zone rather than develop autochthonously? and if so when and how did this occur?
(b) how were these first herds kept and for what purpose? did this management strategy change over time? and if so why?
(c) was Sinai a conduit for the introduction of domesticates into Egypt?

These issues have been raised in various publications dealing with the earliest pastoral economies in the Levant and Egypt (e.g. Avner 1998, 2002; Bar-Yosef 1981d, 1986-87, 2002; articles in Bar-Yosef and Khazanov 1992; articles in Blench and MacDonald 2000; Close 1992; Eddy and Wendorf 1998; Goring-Morris 1993; Hassan 1988; Rosen 1988,

---

[13] Calibrated BP dates used in this Chapter derive from Kuijt and Goring-Morris 2002: Table 1. Calibrated BC dates derive either from Horwitz et al. 1999: Table 1 or Martin 1999: Table 2.

1998). However, many of the current claims for early pastoralism remain tentative since they are based on indirect evidence from settlement type, architecture and material culture, with little faunal data to support their contentions. This chapter aims to fill some of these gaps by providing new data on the archaeozoology of Sinai for the period spanning the Late Neolithic through end of the Early Bronze Age II (first half of the 6th-3rd millennia BC). It is hoped that this will provide a baseline with which to assess the origins and subsequent development of pastoralism in Sinai, and enable us to examine in greater detail the subsistence ties between the 'desert and the sown'.

4.2 THE LATE NEOLITHIC/ POTTERY NEOLITHIC (ca. 6,000-4,300 BC)

As discussed in Chapters 2 and 3, none of the wild progenitors of the earliest domestic herd animals constitute part of the natural wild fauna of the Sinai Peninsula. Furthermore, there is no evidence to indicate that the ibex underwent autochthonous domestication in Sinai. Although it was suggested that ibex herds in Pre-Pottery Neolithic B sites such as Wadi Tbeik or Ujret el-Mehed experienced some degree of cultural manipulation - whether by age or sex class (Dayan et al. 1986; Goring-Morris 1993; Tchernov and Bar-Yosef 1982), as illustrated in the previous chapter, these activities clearly fall within the realm of selective hunting strategies practised by hunters and gatherers, delineated by season and site location. They do not attest to the practice of 'cultural management', proto-domestication or full domestication of this taxon. Consequently, the origin of domestic stock in Sinai must be sought outside the Peninsula.

As discussed in the previous Chapter, herding of sheep and goats and possibly cattle, was well established throughout the Mediterranean zone of the southern Levant by the PPNC (8,600-8,250 cal. BP) and was associated with cereal and legume cultivation. In a series of papers, Köhler-Rollefson and Rollefson (e.g. Köhler-Rollefson 1988, 1989, 1992; Rollefson 1996; Rollefson and Köhler-Rollefson 1989, 1993) have argued that specialised pastoralism was initiated in this period. They have outlined a model of 'devolution' of the Neolithic culture during the PPNC which is characterized by widespread abandonment of sites, contraction of others and expansion into marginal areas – deserts and the coastal plain. They suggest that the prime factor responsible was over-exploitation of resources resulting in the deterioration of the environment, although increasing aridity has also been implicated (Simmons 1997). Goat herds would then have less pasture available close to sites, while their competition with agricultural resources would have forced all/part of the herd to be kept away from the cultivated areas, at least on a seasonal basis, developing into specialised pastoralism in the semi-arid regions of eastern Jordan (Köhler-Rollefson 1988, 1989, 1992). A shift in herd management strategy geared to milk production would have been a necessary requirement in order to provide these pastoralists with sufficient resources from their herds in remote and marginal zones (Köhler-Rollefson 1989). An alternative view put forward by Byrd (1992), perceives the presence of caprines in eastern Jordan as simply the adoption of a new resource by local hunter-gatherers.

In a recent paper, Martin (1999) attempted to resolve these two alternatives with reference to the archaeozoological record of eastern Jordan. She established that domestic sheep and goats were introduced into the region by the Early Late Neolithic (ca. 6,830-6,270 cal BC). They are first found in sites in the Wadi Jilat and Azraq region, and subsequently by ca. 6,270-5,840 cal BC in sites in the basalt desert and areas beyond such as Dhuweila 2 and Burqu 27-2 (Table 4.1). In these sites high ratios of sheep to goats (9:1) are found, which contrasts to preceding periods in the Levant. Martin (1994, 1999) summarises the multiple explanations offered for this as either: the greater ease with which sheep may be herded compared to goats, a preference for grazers (sheep) over browsers (goats) in more arid conditions or a preference for their meat. It is important to note that pig remains are missing from all these assemblages, although present in PPNC/Early Neolithic sites in the Mediterranean zone of Jordan, while cattle occur only in the Azraq sites but even here in very low numbers (Garrard et al. 1996; Martin 1994, 1999). This is probably not surprising given the availability of perennial water in the Azraq Basin. From her detailed study of the available data (quantity of caprines in the assemblages, evidence for seasonality and secondary products exploitation), Martin (1999: 100) concludes that there “is little support for the idea of large scale nomadic caprine pastoralism in the PPNC/ELN”, and proposes that the caprines represent trade items obtained from their sedentary neighbours to their west. If so, then when (and where) did nomadic pastoralism first develop in this region ?

The Pottery Neolithic period (PN) in the Mediterranean zone is well documented, and is characterised by a mixed agro-pastoral economy composed of all four domestic herd animals – sheep, goat, cattle and pig, as well as cultivation of cereals, legumes and flax (e.g. Garfinkel 1999a; Garfinkel et al. 2002; Gopher and Gophna 1993; Grigson 1995a; Haber and Dayan 2004; Horwitz et al. 1999a, 2002a; Rollefson and Köhler-Rollefson

1993). However, in the arid regions, identification and definition of sites dating to this period is problematic. This is due to the absence of *fossile directeurs* unique to these periods, paucity of ceramic sherds (especially in the Negev and Sinai), and the dearth of radiocarbon dates on which to build a robust chronology (Avner 2002:7-9). These problems are compounded by the fact that throughout the desert periphery, sites were commonly re-occupied resulting in mixing of material (e.g. Avner and Carmi 2001; Beit-Arieh 2003a; Eddy and Wendorf 1999; Yekutieli 1998). Consequently, for the period spanning the terminal PPNB and PN, most researchers working in the desert regions have preferred to use the generic term 'Late Neolithic' to describe sites falling within this general time span (Avner 2002; Eddy and Wendorf 1998, 1999; Garrard et al. 1996).

This scenario offers a daunting challenge to the archaeozoologist attempting to investigate the timing and development of pastoralism in the desert regions, and exacerbates the 'mundane' archaeozoological problems discussed in Chapter 1, such as small sample sizes and poor bone preservation resulting in a paucity of bones that can be identified, measured, aged or sexed. Despite these drawbacks, it is possible to attempt a chronological reconstruction of the origins of pastoralism in Sinai.

Mediterranean Coast: For the Mediterranean littoral the sites of Nizzanim, Ziqim and Qatif Y3, constitute the southern-most sites bordering on the Sinai which have yielded ceramics. All three lie close to the northern border of Sinai. They contain typical 'Nizzanim' ceramic ware (suggested by Garfinkel 1999a to be parallel to the Pottery Neolithic Yarmukian and Jericho IX wares), and more importantly for this study, all three have yielded faunal remains.

Two excavations were undertaken at the site of Nizzanim, located slightly north of Ashkelon (Gilead 1990; Yeivin and Olami 1979). A radiocarbon date of 7,599±72 cal. BP was obtained by Yeivin and Olami (1979) (Table 4.1). They reported the presence of domestic cattle, sheep and goat, but no numerical data concerning the fauna were given in their report. In terms of the pottery assemblage, Gilead (1990) notes that the assemblage resembles that from the coastal sites of Givat Haparsa and Ziqim located just to the south of Ashqelon.

The site of Ziqim has recently been republished (Garfinkel et al. 2002). The small collection of terrestrial faunal assemblage, initially studied by Ducos (1968) was reanalysed by the author and published in Garfinkel et al. (2002). In the new study, a total of 87 bones were identified, comprising both domestic sheep and goats (a total of 61% of the sample), domestic cattle (30%) and pigs (6%). The domestic status of the pig could not be assessed with certainty since the majority of the remains are derived from immature animals. In itself, this may be taken as an indication of their domestic status (Meadow 1989). The remaining 3% of bones represent wild taxa – gazelle, red fox, tortoise and ostrich eggshell. In addition, 154 fish bones representing three Mediterranean Sea Families (Serranidae, Sparidae and Sciaenidae) were recovered.

The third site and most critical site for the Sinai is Qatif Y3, since it is located in the Gaza strip (Table 4.1). Gilead (1990) and Grigson (1984a, 1995: Table 1) report the presence of the full complement of domestic herd animals – 34% sheep and goat, 28.5% cattle, 29% pig, 5% dog, 1% equid and 3% wild taxa (hare, carnivores). In addition domestic cereals were found.

Based on the data outlined above, it is clear that the situation along the Mediterranean coastal strip of the Levant changed in the PN relative to the precedent PPNC. Two newcomers - domestic cattle and pig – are now found together with domestic sheep and goat herds. This attests to the continued southerward diffusion of the agro-pastoral package in the Levant.

Surveys undertaken by Caneva (1992) along the northern Sinai coast at the eastern edge of the delta, reported finding no Predynastic or earlier sites. She suggested that this was due either to this region was uninhabited during this time period, or that these occupations are now covered by silts that were deposited ca. 7,000 uncal. BP such that earlier occupations are not visible.

Negev and Sinai Deserts: Recent compilations of radiocarbon dates (Avner 2002; Avner and Carmi 2001; Avner et al. 1994) clearly illustrate that the southern deserts of the Levant were occupied throughout the period spanning the Late Neolithic through Early Bronze Age. In the Negev, the southern-most PN site (Yarmukian?) is Qadesh Barnea 3, located in north-eastern Sinai (Table 4.1) (Bar-Yosef 1980, 1981b, d; Eddy and Wendorf 1998, 1999;

Goring-Morris 1993; Goring-Morris and Gopher 1983). Ceramic sherds and lithic artefacts were found on the surface of this site.

Based on the lithic assemblage collected from the surface of the site of Beer Ada in south-central Negev, it has also been assigned to this time span ca. 7,500-7,000 BP (Goring-Morris 1993). A large circular structure (40 metres in diameter) was identified at this site and thought to represent an animal pen (Goring-Morris 1993). Carnelian beads from Egypt attest to contact between the two regions. Unfortunately, neither Qadesh Barnea 3, Beer Ada or the three Late Neolithic sites located in the ‘Uvda Valley in the southern Negev (sites #4, #7 or #9 – Avner 2002), have yielded animal bones (radiocarbon dates given in Tables 4.1 and 4.2). Recently however, Rosen et al. (2005) dated domestic caprine dung from the site of Ramon I in the Negev Highlands to the early Pottery Neolithic (radiocarbon dates given in Table 4.1). Unfortunately, no detailed information on the faunal remains from this site is currently available.

Two sites that have yielded 6th millennium BP dates and fauna are both located in the Elat area: Nahal Issaron (Carmi et al. 1994; Gopher et al. 1994; Goring-Morris and Gopher 1978, 1983) and the Elat burial site (Avner 1991, 2002; Avner et al. 1994). The lithic assemblage from Nahal Issaron, Layer B is dominated by typical PN points - Nizzanim, Haparsa and Herzliyah types, despite the absence of ceramic remains (Goring-Morris and Gopher 1983). Preliminary identifications of species undertaken by S.J. Davis (in Goring-Morris and Gopher 1983) did not discriminate between this strata and the underlying Late PPNB Layer C. However, no mention is made in his species list of domestic taxa with only wild species, especially goats (? ibex), represented. Since most of the bone found at this site is derived from the lower Layer C (LPPNB), the composition of fauna from Layer B remains unknown. This key site is certainly one that requires attention in the near future.

Another site that has yielded a small faunal sample spanning the Late Neolithic-Chalcolithic periods, is the Elat cemetery (Avner 1991), located on the edge of the city of Elat. The animal bones were found together with human interments and have been interpreted as representing grave goods. In Grave VI, 4 bones of goat (*Capra)* were found that may represent a domestic animal. The finds comprise: part of a left mandible with an unworn M3 (Payne wear stage A) i.e. from a young animal aged ca. 24 months; an isolated left lower M2 (Payne wear stage A), probably from the same animal; a tibia shaft and a fragment of a vertebral body, both belonging to medium sized mammal, probably sheep/goat (Horwitz in press a). In addition, there were 7 rodent bones – representing the brown/black rat and a species of jird, 11 bones of hare, 2 bones of quail, 2 bones of songbird and wading birds. It is possible that the rodent, hare and birds represent accidental intrusions. This site potentially represents the earliest and southern-most remains of domestic caprines in the Negev. Due to the poor preservation of the bones only aDNA can aid in resolving the question of whether or not they represent remains of domestic animals. Furthermore, since the cemetery spans both the Late Neolithic and Chalcolithic periods, the bones will have to be dated so as to establish from which phase they derive.

Although, the data described above point to a slow expansion of domestic sheep and goats (possibly without cattle or pigs) into the Negev desert up to the northern and eastern edges of Sinai, the situation within the Peninsula at this time appears unchanged since we have no data. In fact as early as 1981, Bar-Yosef wrote (1981b: 231): “While Pottery Neolithic sites are known from eastern and northern Sinai, which geographically forms a continuity with the Negev, none have been discovered yet in other parts of Sinai”.

An interesting data-set and one which may offer a break-through, derives from Sodmein Cave in the Red Sea Mountains of Egypt (Vermeersch et al. 1994). This site has yielded thick dung layers associated with a Neolithic industry dating to 7,910±73 cal. BP (5,960±73 cal. BC) and 7,791±97 cal. BP (5,841±97 cal. BC) i.e. equivalent to the eary Pottery Neolithic in the southern Levant. Poorly preserved bones from these layers have been identified as representing either wild or domestic sheep/goat, but only one bone could definitely be attributed to *Capra*. This find was compared to bones of modern barbary sheep and ibex following which the archaeozoologist concluded that because of its small size it represented a domestic goat (Vermeersch et al. 1994; W. Van Neer pers comm. 2005). However, the main reasons for attributing this assemblage to early pastoralists are the presence of dung layers in the upper levels and the fact that they are absent in the lower ones in the cave.

At present, the Sodmein finds should be related to with caution given that remains of ibex commonly occur in the lowest strata at the site, and that only one bone from the upper levels has been positively identified to date as belonging to a domestic goat. These findings need to be corroborated further (aDNA analyses, larger samples) before they can be unequivocally accepted as the earliest evidence of pastoralists in Egypt. Furthermore, the earliest corroborated evidence for domestic caprines in Egypt, some 22 sheep/goat bones from the Fayum A (Brewer 1989), post-date the Sodmein finds by some 500 years. This as the earliest date for the Fayum Neolithic is 7,367±159 cal. BP = 5,417±159 cal. BC (Kozlowski and Ginter 1989), while Hassan (1988) sets the time range for this cultural entity as slightly younger spanning 5200-4500 cal. BC. In the Neolithic levels at Merimde in the western part of the Nile Delta, dating to 7,016±141 cal. BP = 5,066±141 cal. BC[14] (Eiwanger 1988: 54), over 1300 bones of domestic sheep, goat, cattle and pig were identified (von den Driesch and Boessneck 1985: Table 1). Most importantly, Merimde contains ceramics that point to close ties with ceramic traditions of the Levant and which differ from those found in the Fayum sites (Eiwanger 1984). It is interesting to note that as in Late Neolithic sites of eastern Jordan (Martin 1994, 1999), in the Fayum A assemblages, "the strong presence of wild fauna suggests that domesticates offered merely another resource to be utilized in an overall generalised procurement strategy (Brewer 1989:171; Wenke et al. 1988), suggesting that in this region, the initial adoption of herd animals was perhaps 'informal' and via trade items rather than the adoption of pastoralism as a subsistence base. The large sample of bones of domestic animals from Merimde and the presence of domestic cereals, together with the large size of the site, emphasises the sedentary and developed nature of this community and its economy rather than its being a respository for exotic imports' from the Levant.

The question to be posed then is how domestic animals, with the exception perhaps of cattle which had a wild progenitor in North Africa, arrive in Egypt? Bar-Yosef (2002) has suggested a maritime route which by-passed the southern Levant and Sinai. An alternative is an overland route, although as demonstrated above, the faunal record of Sinai was seemingly 'dormant' for close to 1000 years following the PPNB. Based on the Egyptian data from Merimde in the delta, and to a lesser extent from the Fayum, it has commonly been proposed that pastoralists who traversed the Negev desert, southern Jordan and Sinai during the Pottery Neolithic, then continued into Lower Egypt (see discussions in Close 1992; Eddy and Wendorf 1998; Hassan 1988). This finds support in the presence of all four herd taxa at Merimde, species that first appear together in PN sites in the southern Levant. Furthermore, the distance between the Gaza Strip (site of Qatif) to the Suez is only some

---

[14] Hassan (1988: Table 1) gives a more recent time range for the Neolithic of Merimde as: Neolithic I ca. 5900 BP = 4800 BC; Neolithic V ca. 5700 BP = 4600 BC; Neolithic BS ca. 5550 BP = 4400 BC

240km long, and was traversed by Tuthmosis III and his army in 9 days by covering 25 km a day (Oren 1982-83). Lancaster and Lancaster (1991) note that a well watered flock of sheep and goats can cover ca. 40km a day in the *badia* of Jordan (though not in the height of summer), such that the entire northern Sinai coast could be crossed by herders and their flocks in under a week.

Corroboration for the role played by southern Levantine populations in the introduction of domesticates into Egypt is found in new data on Y-chromosome markers of recent human populations from the eastern Mediterranean (Al-Zahery et al. 2003; Cinnioglu et al. 2004; Di Giacomo et al. 2004; Nebel et al. 2002; Semino et al. 2000, 2004). These publications demonstrate that the haplotype J, which originated in the Fertile Crescent, had two sub-haplotypes: J-p12f2* and J-M172. These follow opposite geographic clines: sub-haplotype J-p12f2* is found in high frequencies (38%) in the southern Levant compared to only 16% in the northern Levant (Syria), 3% in Turkey and 12% in Iraq. The opposite pattern is found for sub-haplotype J-M172 with 17% in the southern Levant, 29% in the northern Levant, 40% in Turkey and 28% in Iraq. Thus, it has been postulated that the origin of J-M172 is in the region of Turkey, while that of J-p12f2* is the southern Levant. Genetic dating places the advent of the expansion of the two haplotypes as during the Neolithic period; J-p12f2* at 9000-6000 years BP, and that of J-M172 at 9800-7000 BP, thereby supporting the hypothesis of demic diffusion in this period.

In these studies, two directions for this diffusion have been identified: the southern Levantine sub-haplotype J-p12f2* appears to have marked southward migrations into the Arabian Peninsula, North and East Africa, while the sub-haplotype J-M172 characterises westerwards migrations into Europe. Although more recent small-scale or regional migrations have undoubtedly contributed to the observed geographic clines, it is clear that the earlier Neolithic migrations were the major contributors to the patterns observed today. Most importantly, the human genetic data support the migration of Late Neolithic southern Levantine communities into North Africa, undoubtedly with their domestic livestock.

4.3 THE CHALCOLITHIC-EARLY BRONZE I (ca. 4300-3050 BC)

4.3.1 The 'North Sinai Survey'

During the 'North Sinai Survey' directed by Prof. Eliezer Oren, a total of 191 Chalcolithic sites and 250 EB I sites were identified. An especially dense occupation was found in the area between Rafiah and El Arish with occupation density thinning out towards the Nile delta (Yekutieli 1998), the latter finding corroborates that of Caneva (1992). Overall, the pattern of occupation indicates that the region was densely inhabited at this time. Furthermore, the presence of both Egyptian and Canaanite vessels in these sites, indicates that North Sinai served as a major conduit for communication and transport between the two regions (Oren 1973a, 1987b, 1993a; Oren and Gilead 1981; Oren and Yekutieli 1990; Yekutieli 1998, 2002).

Three of the Chalcolithic sites in the area of Rafiah that were tested yielded faunal remains - R48, R79 and B51 (Fig. 4.1). All sites were covered by active dunes. They represent seasonal encampments or short-lived permanent settlements as shown by the flimsy nature of the mudbrick structures and shallow deposits (Oren and Gilead 1981; Yekutieli 1998). Installations constructed of stone and clay, hearths and ash pits were found in all sites. Finds included ceramic sherds, flint artefacts, stone vessels and animal bones. Although these sites contained later ceramic and other finds, these were scanty, and the Chalcolithic remains clearly dominant. Moreover, the animal bones are all derived from the excavated deposit and were clearly associated with the Chalcolithic layer.

4.3.1.1. The finds

Site R45

Site R45 was tested by Oren and Gilead (1981). It is listed in the Gazeteer of Sinai (Oren unpublished Gazetteer) as covering an estimated 1.5 dunams. The test excavation yielded remains attributed to the Chalcolithic period: hearths and ash patches, fragments of fired brick and clay ovens, lithics, a stone bowl, sherds and animal bones (Table 4.3). Only 11 ceramic sherds dating to the Roman through Islamic period were found, such that it is highly likely that the bones relate to the Chalcolithic period.

The faunal assemblage comprised only 9 identified bones and 5 unidentified fragments. Species represented are: sheep/goat, cattle, donkey and snake. The latter is probably recent since the four vertebrae represented were still found in anatomical articulation.

Site R46

This site is in the same region as R45. Surface investigation yielded scanty Chalcolithic (N=7) sherds as well as EBIV ceramics (N=5 sherds). Test excavation of the Chalcolithic deposit, revealed remains of ash patches, clay oven fragments, stone implements and faunal remains (Table 4.3). Four teeth of an adult domestic donkey were identified here- probably from the same animal.

Site R48

Site R48 lies some 2km west of R45 and R46. The surface of this site was systematically collected (an area of 200m^2) and excavated to sterile soil (180m^2). All deposit was sieved. It is estimated to have been 3 dunams in extent and comprised two phases of occupation, although no apparent differences were found in content (Oren and Gilead 1981). Remains of mudbricks, hearths, a tabun and ash pits were found. Associated material culture comprised lithic artefacts (including numerous sickle blades), stone vessels, a violin-shaped figurine, and pottery, the latter indicating close ties to the Chalcolithic of the northern Negev, especially the Besor area. Egytian pottery and a fragment of a palette attest to ties with Egypt (Oren and Gilead 1981).

The absence of churns and cornettes in the ceramic assemblage led Oren and Gilead (1981) to conclude that the site was occupied on a seasonal basis (probably autumn/winter), when milking and milk product manufacture was not carried out. A total sample of 13 identified bones representing 3 taxa: sheep/goat (5 bones and teeth) representing at least one very mature animal aged 8-10 years (Payne wear stage I), and another young animal aged less than 3 years (based on an unfused proximal calcaneus). A further 5 bones of an unidentified medium mammal, probably also sheep/goat, were found as well as 2 cattle bones (Table 4.3).

Site R79

This site is also located in the Tell Aheimar region. Test excavation revealed a Chalcolithic occupation 30-40cm below the active dune. The deposit included ash patches, a stone vessel, ceramic sherds and animal bones.

The 17 identified bones represented sheep/goat, cattle and pig (Table 4.3). Only one sheep/goat bone could be assigned to species- an unfused first phalanx of a goat, belonging to an animal aged less than 16 months. The unfused femur and calcaneum may belong to this same animal. Of special interest is the presence of pig in this site, represented by a mandible fragment and an unfused scapula from an animal aged less than 1 year. In addition 23 unidentified bone fragments were found.

4.3.1.2 Conclusions

Analysis of the settlement data for North Sinai during the 5th-3rd millennia BC (Yekutieli 1998, 2002) best fitted the model of “the Canaanite periphery” which predicted that the region served as a branch of the Canaanite socio-economic system. This meant that the local population was fundamentally self-sufficient with additional products imported, primarily from Canaan, as attested to by the ceramic and lithic assemblages. Thus, despite evidence for ties with Egypt, these sites represent the south-western most extension of the Chalcolithic culture of Canaan.

The flint industry from these sites is characterised by high frequencies of sickle blades; 13-14% at sites R48 and R45. Grinding slabs are also common, which taken together indicates processing of agricultural foods, probably cereals. Based on the faunal data presented here it is evident that domestic caprines predominate (55% of identified bones from all sites summed), which would be even higher if the medium mammal category was included. The caprine remains included both mature and immature animals; one aged 6-8 months, three aged less than 3 years and one aged less than 3.5 years. Small numbers of bones of cattle (N=5), pig (N=2) and donkey (N=5) were also identified. The presence of donkey bones is especially interesting given the role played by this animals in trade between Egypt and Canaan, and the fact that their remains are generally rare in Chalcolithic sites in the Negev - comprising less than 1% of fauna (e.g. Ducos 1968; Grigson 1987, 1995b).

The finds from the 'R' sites reported here, correspond well with fauna identified from the neighbouring Chalcolithic sites of Wadi Gazze D (Ducos 1968) and Qatif Y2 (Grigson 1984b, 1995a). In these sites, remains of sheep and goat were found (23% at Wadi Gazze and 63% at Qatif Y2) with slightly more than 30% cattle represented in each. Pig frequencies differed greatly between sites – 34% at Wadi Gazze and only 1% at Qatif Y2, but small numbers of donkey bones were found in both assemblages. At Qatif Y2, 128 bones of Mediterranean Sea fish were found, including remains of sharks and dolphins (Gilead 1988; O. Lernau unpublished data). In addition, hippopotamus remains attest to the presence of a deep, perennial freshwater source nearby, probably in Nahal Besor (Grigson 1984b). Wild taxa (birds, fish and wild mammals) constitute less than 15% of the assemblage at Qatif Y2 and some 2% at Wadi Gazze. Thus, the absence of fish as well as wild ungulates and carnivores in the Rafiah sites described here (the 1 hare bone and 4 snake vertebrae may be intrusions), may relate to the small size of these assemblages as well as to factors influencing bone preservation. Based on the picture from the two nearby Chalcolithic sites, it would seem that although the relative frequencies of domestic species vary greatly between sites; wild taxa including fish were of minor importance even in sites located close to the sea. Given the limitations imposed by the small size of the samples, the Rafiah fauna could fit both Yekutieli's "Canaanite periphery" and the "Egyptian periphery" models since both predicted that faunal composition at these sites should be based on sheep and goat herding with donkeys for transport.

Of special interest is the presence of pig in Site R79, which lies below the 300mm isohyet. Grigson (1987, 1995a,b) has demonstrated that the distribution of pigs in Late Neolithic, Chalcolithic and Early Bronze age sites from the western Negev closely follows the rainfall isohyets, with pigs absent or very rare in sites receiving less than 300mm of rainfall annually. Obviously, it is not possible to assess the relative importance of pig in the 'North Sinai Survey' sites given the meagre samples, but the fact that even in these small samples – a total of 39 identified bones from the four sites - 2 bones (i.e. 5% of identified remains) are those of pig, suggesting that they were a relatively common taxon. Admittedly, it has not been possible to assess whether they represent wild or domestic animals (the only complete bone, a distal scapula, being unfused), but wild boar are not known from the region today. However, Mendelssohn and Yom-Tov (1999) state that the pigs sighted in Nahal Besor in recent times may represent introduced animals and are probably hybrids. Manlius and Gautier (1999) claim that there were no wild boar in Egypt prior to the 5th millennium BC but that it is possible that at this time, wild boar may have migrated south along the Mediterranean coast from Canaan. How this was achieved, given the paucity of open water sources (aside from wells) and the sandy terrain of the region, is not elucidated. The Late Neolithic site of Qatif Y3 contained 32% pig (out of the total number of cattle, sheep/goat and pig remains), the majority, if not all these animals are assumed by Grigson (1984a) to represent domestic animals. A marked regional decrease in pig frequencies is documented when the Qatif Y3 data are compared to the neighbouring Chalcolithic site of Qatif Y2, which contained only 1% pig remains. This is attributed to ongoing regional aridification in the Chalcolithic (Grigson 1995a). However, the EB I level at Tel es-Sakan, also in the Gaza Strip, produced 24.5% pig remains (when re-calculated from data given in Miroschedji et al. 2001 in the same manner as Grigson 1995a i.e. as a percentage of all domestic herd animals at the site). This indicates that factors other than rainfall may have played a critical role in determining pig raising/exploitation in this region. Indeed, the Tel es-Sakan frequencies resemble those found in Chalcolithic sites in the southern Mediterranean zone of Israel (Ducos 1968; Whitcher 1999).

Assuming that the pigs in site R79 and the Qatif sites are domestic, given the unsuitability of pigs to long-distance nomadism, especially in an arid environment (Zeder 1996), this would imply that far from being seasonal encampments, as proposed by the excavators (Oren and Gilead 1981), the Rafiah sites may represent permanent settlements. An alternative explanation is that their remains represent smoked/salted pork that was imported to the R79 locality. However, the presence of a lower jaw fragment, a bone not usually associated with transport of joints of processed meat, makes this option unlikely.

4.3.2 Southern Sinai - *Masseboth* incorporated in tombs

Faunal remains were recovered from four 4th-5th millennium BC ‘standing stone’ sites (*masseboth*) that were associated with *tumuli* (burial cairns) (Tables 4.4). All sites, (excavated by Dr. Uzi Avner), are located in eastern Sinai; a single *tumulus* at the sites of Bir Sawaneh and Hadj 1 (Muyat Galla) respectively (Fig. 4.2) and two in Wadi Zalaqa (Avner 2002). *Masseboth* are cult objects, which according to Avner (1984, 1993, 2002) “served as an abode for the spirit and power of the gods and ancestors” (Avner 2002: 98, see this reference for a detailed discussion of this point). They are found in Levantine deserts in the form of natural or shaped stones which have been set vertically in the ground, either singly or in groups. They vary in size as well as in raw material used. Avner (2002) dates the earliest such desert localities to the Epipaleolithic (Natufian) period (11th millennium BC). Despite the abundance of tumuli and *masseboth* sites (together or separate) that are known in both the Negev and Sinai deserts (e.g. Avner 2002; Beit-Arieh 2003a; Haiman 1992), the systematic excavation and recovery of material, including faunal remains, from such locations has been rare. For this reason, the small bone samples recovered from the four sites described here offer interesting insights into desert rituals and belief systems.

4.3.2.1. The finds

Bir Sawaneh, Tumulus 6

Bir Sawaneh represents a complex of habitation sites and associated tumuli which together span the 5th-3rd millennia BC (Avner 2002: 71). Of six tumuli identified, one was excavated that yielded a primary flexed burial of a young female.

The *tumulus* at Bir Sawaneh comprises a circular burial cairn in front of which three standing stones had been placed as well as a stone pedestal which is set against the standing stones (Fig. 4.2). No animal bones were recovered from inside the *tumulus*, but four bones were recovered from the area adjacent to the stone pedestal, in front of the *tumulus* (Table 4.4.). The bones comprised: two unidentified mammalian shaft fragments, a fragment of an ungulate tooth and the shaft of a left femur of a medium-sized ungulate (with a mid-shaft width of 11.8 mm). It is possible that the bones all derive from the same animal. Based on the relatively large size and shape of the femur shaft and size of the tooth fragment (over 7mm long), it is possible to exclude gazelle (*Gazella dorcas/Gazella gazella*). Most likely then they represent remains of a caprine. However, it was not possible to determine whether they represent domestic sheep (*Ovis aries*), domestic goat (*Capra hircus*) or ibex (*Capra ibex*).

Hadj 1 (also called Moyat Galla)

The site of Hadj I is situated some 20km east of the Valley of the Moon adjacent to a seasonal water (Muyat Galla) (Goring-Morris and Avner 1986). The excavated *tumulus* was located on the edge of a complex of tent and habitation units covering half a kilometre dating to the 6th-3rd millennia BC. An earlier Epi-Paleolithic (Ramonian) occupation in this same locality had previously been tested with a small sounding (Goring-Morris and Avner 1986).

The *tumulus* contained fragmentary remains of a young male and had five *masseboth* located on its eastern part (Avner 2002). The faunal remains were recovered from the area in front of the *tumulus* (Fig. 4.2) and comprised five unidentifiable fragments of mammalian bone, all less than 10cm in length. Although no species determination was possible, it is important to note that the bones represent terrestrial mammals (e.g. ungulates or carnivores) and not birds or reptiles. Due to the presence of the underlying Epi-Paleolithic occurrence, it is not clear whether the bones relate to this occupation, or the overlying *tumulus*. If they are associated with the *tumulus*, then their presence may be taken as indicative of ritual activities that were celebrated at the site, involving the placing of animal offerings in an area in front of the tumulus. As at tumulus 6 at Bir Sawaneh, no animal remains were recovered from within the burial cairn itself.

Wadi Zalaqa, Tumulus 2 (M308)

This is a semi-circular *tumulus* with a *masseboth*. A human skull fragment was found in the cairn. Radiocarbon dates for the tomb are 6,387±63 and 6,210±94 cal. BP; calibrated means = 4425 and 4235 cal. BC respectively (Table 4.2; Avner 2002).

Two unidentified fragments of mammal bone shafts and a fragmentary long bone shaft of an unidentified rodent were recovered from *tumulus* 2 (Table 4.4). As in the other two *tumuli* described above, the faunal remains were recovered from an area adjacent to, but not within, the burial cairn.

Unfortunately the material was too fragmentary to facilitate identification as to species. However it was possible to determine that the bones are derived from terrestrial mammals and not birds or reptiles. The rodent long bone shaft may be an intrusive element.

Wadi Zalaqa, Tumulus M 301

This is a *tumulus* with a flexed male burial and three *masseboth* on the eastern side of the tomb (Avner 2002: 71). Two unidentified fragments of mammalian bone (Table 4.4) were recovered from outside this *tumulus* which is dated to the 4th millennia BC (U. Avner pers comm. 2000).

Tumulus S-74

Some very poorly preserved bone was found within a tumulus in the cemetery S-74 excavated by Eddy and Wendorf (1998, 1999) in central-eastern Sinai. However they state that " the badly broken up bone fragments were too small to say whether they were human or animal" (Eddy and Wendorf 1998:14). They date this tumulus to the Late Chalcolithic.

4.3.3 Southern Sinai - Shrines

During excavations by Dr. Uzi Avner, animal bones were recovered from two 5th-3rd millennia BC shrines or ritual areas adjacent to settlements in Wadi Sa'al and Wadi Daba'iyeh in eastern Sinai (Tables 4.4, 4.5; Fig. 4.3). In both instances, the bones were found at the base of standing stones, suggesting that they represent the remains of ritual provisions.

4.3.3.1 The finds

Wadi Sa'al

This site, situated to the south-east of the oasis of 'Ein Huderah, has been attributed to the 5th-3rd millennium B.C. based on its material culture (Avner et al.1994; Avner 2002: 79). It comprises two groups of *masseboth* erected some 100 metres apart and a tent camp and two stone-built habitations (Avner 2002: 78). The southern group comprises a line of nine standing stones.

A total of 23 animal bones were recovered during excavations of the southern group (Table 4.4). Three species were represented in the small sample of eight identified bones: a fragmented tooth and distal humerus shaft of domestic sheep/goat (*Ovis aries/Capra hircus*, quail (*Coturnix coturnix*) and a vertebral spine of hare (*Lepus capensis*). The remaining bones were too fragmentary to facilitate positive identification beyond the fact that they belong to a terrestrial mammal. However, based on the relative size and texture of these bones, and the fact that sheep/goat are the only species identified from the site that fits this category, it is most likely that the fragments belong to this taxa.

As for the wild species represented at the site, hare is commonly found throughout Sinai and so its remains may represent an accidental inclusion. In contrast the quail (represented by a proximal tarsometatarsus) is a migrant and is usually found in Sinai in the early spring.

Wadi Daba'iyeh

A large assemblage of 90 animal bones (Table 4.4) was recovered from the shrine or ritual area located adjacent to the habitation site of Moyat Daba'iyeh (see Table 4.2 for radiocarbon date for the site). The habitation site, excavated by A. Goren (1980), is described in a section below. As at the Wadi Sa'al cultic site, the bones at Wadi Daba'iyeh were found in close association with a series of standing stones.

Despite the large size of the assemblage, most of the bones were too fragmentary to facilitate identification, such that only 19 were identifiable to species and/or body part (Tables 4.4, 4.5). Species represented included: 4 bones of quail (*Coturnix coturnix*) –1 femur shaft, 1 tibiotarsus shaft, 2 tarsometatarsi; 3 bones of hare (*Lepus capensis*)- distal scapula, mastoid, rib; 3 bones of goat, probably domestic *Capra hircus,* and one which may belong to an ibex. As illustrated in Table 4.6, the ibex is represented by an extremely large but unfused proximal calcaneum which is unlikely to represent even a domestic male, although this possibility cannot be entirely excluded. This extremely large specimen represents an animal aged 36-48 months (Noddle 1974). A second, probably domestic, goat aged older than 2 years was represented by a fused calcaneum and possibly also a fused distal metapodial, while a third sheep/goat was aged less than 2 years on the basis of an unfused distal metapodial (Table 4.5) (Silver 1969). In addition, 3 bones belonging to a foetus or neonatal sheep/goat were identified (Table 4.5). It probably represents a foetus as the canon bones making up the metapodial are still unfused (Prummel 1988). However, as there is some variation between breeds, as well as wild versus domestic animals, in the rates of epiphyseal closure it is difficult to assess with accuracy the age of archaeozoological specimens. The remaining sheep/goat bones may belong to the same ibex and goat specimens rather than to an additional animal since there is no duplication of skeletal elements (Table 4.5).

The sheep/goat are represented by both cranial and post-cranial remains. However, toe bones (phalanges) and trunk elements (ribs and vertebrae) are absent (Table 4.5). Of the 15 bones sheep/goat limbones, 12 (80%) are lower hindlimb elements (metatarsals, tarsals, astragali and calcanea), which are poor in meat. Two explanations may account for this patterning. The first relates to differential survival of denser, more robust bones. Examination of bone mineral density values for sheep (Lyman 1994: Table 7.6- see also values given in Table 4.10b) indicates that the skeletal elements that are missing – ribs, vertebrae, scapulae, skull bones - are amongst the bones with the lowest bone mineral density values, while tarsals, astragali and calcanea are indeed those with some of the highest values. For metapodia, it is also not accidental that the proximal ends are preserved rather than the mid-shafts, since this is the densest portion of the bone. Consequently, the skeletal element representation at this site may simply represent differential preservation of bones. However, the presence of bones of neonate or foetal animals would indicate that bone preservation at the site is reasonably good. Thus, it seems unlikely that the absence of certain bones is solely related to bone density mediated attrition.

An alternative hypothesis is that the elements found represent complete lower hindlimb joints that were intentionally interred, rather than isolated bones. Since these bones are poor in meat, and are often discarded during primary (initial) carcass dismemberment (Binford 1981), they may have been favoured for symbolic offerings. In this case, although animals were probably slaughtered at the shrine, it would seem likely that these remains do not represent refuse of ritual meals consumed but rather food offerings intentionally placed at the shrine.

4.3.3.2 Conclusions

Animal bones, like remains of material culture, may serve as useful indicators of mortuary practices of past desert populations. By studying the range of animal species represented, their age, sex and skeletal element representation, it may be possible to reconstruct past ritual activities. Consequently, despite the small size and fragmentary nature of the *tumuli* and shrine assemblages from southern Sinai, they offer importance insights into the belief systems of early herders in this region.

(1) <u>Location of remains</u>: For all assemblages described here, the animal bones were concentrated in an area in front of the *tumulus* and at the base of the pedestal/standing

stones. This suggests that they had been intentionally placed there as offerings. The consistency of this activity indicates a common pattern of behavior at ritual sites.

The very presence of animal bones associated with burial *tumuli* provides some indication as to the type of ritual activities that took place at the site, either during or following interment of the deceased, or in honour of ancestors. These included animal sacrifice and the placing of meat offerings on the pedestal outside the burial area.

The absence of animal bones from inside the *tumuli* is consistent, and does not appear to be related to differential preservation since human remains have been recovered from the latter. The placing of provisions or burial offerings within or next to a tomb, may be related to a belief that the deceased required sustenance during or after burial, while intentional placing of animal remains outside the tumulus suggests that they did not serve as provisions intended to accompany the deceased (as perhaps exemplified by food items recovered from Middle Bronze II tombs in the southern Levant - Hallote 1995:114; Horwitz 2001]. Rather, the close association of the fauna with the stone pedestal situated outside the *tumulus* suggests that it served as a shrine or altar area on which the food offerings were placed. Its position external to the interment area of the *tumulus* suggests that it needed to be accessible to the living rather than to the dead.

Likewise, at the shrines, the animal bones were all interred at the base of the *masseboth*.

(1) <u>Faunal composition</u>: The range of animals represented in both *tumuli* and shrines reflects not only the nature of the economy of the community using these sites, but also selection of animals chosen for offerings.

In this regard it is clear that medium sized ungulates (either sheep, goat or ibex), were the favoured species. However, due to the poor preservation of the material, it is not possible to state whether only one species was selected, or whether both wild and domestic ungulates were exploited for this purpose. Since Chalcolithic and Early Bronze Age sites in the northern Negev and Sinai (Grigson 1984b, 1987, 1995b; Horwitz 2003a; Horwitz et al. 2002b; Whitcher 1999) have yielded remains of both domestic stock and wild ungulates, both would have been available.

The use of hunted prey for ritual purposes has to be considered since hare and quail are both represented in the shrines and *tumuli* collections. The excavation records from both sites indicate that there bones were found in sealed archaeological contexts adjacent to the standing stones, and in close association with the other bones such that they also represent offerings. The use of taxa other than ungulates for burial offerings has been recorded in the Levant, but for later periods (e.g. Klenck 2002; Weissbrod and Bar-Oz 2004).

(3) <u>Age of animals</u>: Aside from the assemblage from the shrine at Wadi Daba'iyeh, all other samples were too fragmentary to offer information on ageing and bone element representation. The Wadi Daba'iyeh assemblage indicates the predominance of young sheep/goat: a foetus/newborn, a second animal aged less than 2 years old, a third ca. 2 years, and a fourth a young adult (possibly an ibex) which was aged ca. 3.5-4 years. If a foetus is represented then probably the mother was sacrificed. Even the large ?ibex specimen was represented by a young animal, indicating preferential selection of this age cohort for offerings.

(4) <u>Skeletal elements represented</u>: The Wadi Daba'iyeh sample contained a high frequency of hindlimb elements a feature that does not appear to be the result of differential preservation. This, as teeth, usually the best preserved element, are poorly represented at the site. Consequently this patterning is interpreted as representing intentional selection of body parts used as food offerings at the shrine.

(5) <u>Seasonality</u>: The faunal remains provide some indication as to the timing of the last use of the shrine. The quail (*Coturnix corturnix*) is a migratory species which is found in Sinai primarily in the spring (but also in the autumn) (Paz 1987). Its presence in both the Wadi Sa'al and Wadi Daba'iyeh assemblages provides some indication as to the general season of occupation for these sites. Paz (1987: 81) cites Diodorus (2nd century AD) who describes criminals exiled to the town of Rinocorura (El Arish) catching quails with nets during their annual migration. Today, the Bedouin exploit this annual migration by catching the birds in a series of vertical mist-nets specially constructed for this purpose. The presence of quail bones in Pre-Pottery Neolithic B (see Chapter 3) indicates that the migration of this species has been an annual event for many millennia.

Further support for a spring use of the shrines and tumulus-*masseboth* sites is the presence of a foetal/neonatal sheep/goat at Wadi Daba'iyeh. Since lambing/kidding is in the spring, this animal must have died in or close to that season.

.

In terms of ritual procedure for this period, the faunal assemblages studied here suggest that selection of animals was practiced when choosing an offering, both in terms of the species, age of the animal and body parts used. These data, provide the first evidence for the use of animal offerings in shrines from the Sinai Peninsula and resemble other ritual assemblages from the 'Uvda Valley in the Negev Desert, which have been studied by the author (see; Avner 1998 for information on the sites; fauna Horwitz et al. in prep.). Calibrated dates of these sites are given in Table 4.2.

Site 124/ IV

Site 124/ IV in the 'Uvda Valley is located close to a habitation site (#916) and has been dated by radiocarbon to the 5th to early 2nd millennium B.C. (Table 4.2; Avner and Carmi 2001). The 52 animal bones comprising this sample were found in close proximity to a stone platform. The identified portion of the assemblage comprised 2 bones of domestic goat (*Capra hircus*), 14 bones of domestic sheep/goat (*Ovis aries/Capra hircus*) and 8 of hare (*Lepus capensis*). In addition, 28 unidentified bone fragments were recovered. As in the Sinai shrines, all the sheep/goat bones represent immature animals, including at least one foetus or new-born animal ca. one week old, as well as 2 animals aged ca. 2 years of age.

A total of 77% of the bones recovered from the site were burnt. Of the two shells recovered, one was identified by Dr. H.K. Mienis as *Melanopsis buccinoidea,* a freshwater snail that lives exclusively in springs and streams and probably originates in springs located to the east of the 'Uvda Valley (in the Arava). The other was identified as *Mitrella albina*, a common Red Sea snail that had been perforated for use as a shell-bead.

Site 124/XVII

This shrine was located adjacent to habitation Site #9 in the 'Uvda Valley. Here too, the animal bones were found in close proximity to a stone platform and adjacent to a hearth which has been dated to the 6th-5th millennia B.C. (Table 4.2; Avner and Carmi 2001). Three bones of sheep/goat (a goat metacarpal and two sheep/goat tooth fragments) were identified in addition to 12 mammalian long bone fragments and 3 pieces of ostrich eggshell. Two of the long bone fragments were burnt.

4.3.3.3. Summary

Based on the combined information presented above from both the Sinai Peninsula and the ‘Uvda Valley in the southern Negev, it is possible to conclude that the faunal assemblages from these ritual sites bears witness to a unique but consistent pattern of cultic activities associated with *tumuli*, *masseboth* shrines and altar areas.

Together these assemblages attest to:
(a) selection of faunal species, with a predominance of caprines (sheep/goat/ibex)
(b) a preference for young animals
(c) a predominance of skeletal elements rich in meat i.e. long bones
(d) burning of animal carcasses, whether as part of, or following a ceremony
(e) interment of bones on-site close to cultic architectural features - standing stones or stone platforms.

These features accord well with the criteria outlined in Horwitz (1987, 1999) for distinguishing faunal remains recovered from sacred contexts as opposed to those from domestic or profane ones. Moreover, based on the data from both the Sinai and Negev sites, it is possible to specify that, at least part, if not all of the rites documented here took place in the spring.

Similar practices continue today as an integral part of mortuary activities amongst different religious and ethnic groups (e.g. Buddhists, animist religions, Bedouins), both in the form of ritual meals consumed at the graveside and/or as food offerings placed in, on or near the grave (e.g. Barley 1995; Klenck 1995; Ucko 1969). These practices emphasize that mortuary activities do not cease with interment but continue long after, either at the *tumulus* of the deceased, or at a *masseboth* which represents the spirit of the ancestors (Avner 2002). The faunal assemblages recovered from the Sinai sites clearly demonstrate that archaeozoological remains "may be at least as sensitive an indicator of ritual and symbolism as may building plans or pottery decoration" (Grant 1991: 113).

4.3.4 Southern Sinai- The *Nawamis* fields

A unique occurrence in southern Sinai are the *nawamis*. These are above-ground structures, rounded or beehive-shaped. They were first documented and excavated in the late 19th century by members of the Sinai Ordnance Survey, Holland (1870, 1871) and Palmer (1871). Subsequently, several archaeological missions investigated them: Currelly (1906) working with Flinders Petrie, followed by Albright and colleagues (Albright 1948a, b). With the exception of Palmer who thought they served as habitations, all researchers concluded that the *nawamis* were tombs. On the basis of the lithic artefacts, copper implements, copper and shell beads and shell bracelets recovered, Currelly (1906) attributed them to the Predynastic period of Egypt. Initially, radiocarbon dates (Table 4.2) placed them in the Late Chalcolithic/EB I (Bar-Yosef et al. 1977, 1983, 1986; Carmi and Segal 1994; Rothenberg 1972a), but this has subsequently been qualified by Avner (2002:59), who has shown that the use of the *nawamis* began in the Late Neolithic. However, the majority appear to have been built in the Chalcolithic period and continued to be used into the EB I (Avner 2002: 59).

The *nawamis* structures are double-walled with the outer one standing straight while the inner one makes an arch to form a corbelled roof. They were built of dry-stone, usually slabs of local granite or sandstone that have not been shaped. The structures range in size from 3-6 metres in diameter and between 1.80-2.10 meters in height (Bar-Yosef et al. 1977, 1983; Goren 1980, 1998) and are usually covered with a stone slab about a meter square, while the inner floor is frequently composed of gravel and dust/ash fill. There is only one entrance per structure and in all cases this faces west or as at the 'Ein Huderah *nawamis*, west-south-west. This feature has been interpreted as reflecting a symbolic association between death on earth and the sun setting in the west (for details see Bar-Yosef et al. 1983; Goren 1980, 1998).

The *nawamis* occur in clusters (fields) that vary in size and number from several to more than 200 structures, such as the fields at Wadi Solaf and Wadi Hebran which extend over an area of some 5 km. As part of the surveys and excavations undertaken by Israeli archaeologists in Sinai, 21 such fields were investigated from 1971 through 1982 (Fig. 4.1) (Bar-Yosef et al. 1977, 1983, 1986; Goren 1980, 1998; Rothenberg 1972a, 1975, 1979).

With the exception of one group comprising three structures, that is located in Wadi Fuqiyah on the Tih plateau (Rothenberg 1975), all other fields are located in southern Sinai and form an arc around the high mountains, with Saint Catherine's monastery at the centre (Goren 1998). None are located in the high mountains but the fields are usually located on hilltops and in proximity to ancient routes. Especially rich concentrations are found in Wadi Solaf, the southern part of Wadi Nasb and along Nakb Hibran.

Nine fields were excavated by Israeli teams (Fig 4.1) (see Goren 1980, 1998 for details of excavations): Ein Um Ahmed, Ein Huderah, Gebel Gunna, Wadi El Abar, Hzeimeh (also termed Upper Wadi Nasb), Wadi Hebar, Wadi Sawawin, Abu Halil and Nakb Hibran.

4.3.4.1 Cultural remains

Nearly all the *nawamis* contained human remains, often multiple burials representing both sexes and all ages. Secondary burial was the most common but primary flexed burials were also found. It is possible that, as suggested by Bar-Yosef et al. (1977), many of the apparent secondary burals actually represent disturbed primaries. This finds support in the spatial patterning of human bones most of which were found adjacent to the inner walls indicating that older interments had been pushed aside to make room for newer ones. On the basis of the age and sex of the interred, as well as the presence of a congenital pathology, it has been suggested that the *nawamis* represent family tombs (Bar-Yosef et al. 1977, 1986; Goren 1980, 1998; Hershkovitz et al. 1982). Bone preservation was extremely poor in all structures (Bar-Yosef et al. 1983:57).

Remains of cloth were found in some tombs in addition to a wide range of artifacts, presumably representing grave goods. Items recovered included: bone and wooden points, arrows with their shafts, copper awls, flint artefacts - especially tabular scrapers and transverse arrowheads, groundstone utensils - made of basalt, sandstone and limestone. Two sherds of typical Predynastic vessels were found. The most abundant finds were ornaments, especially beads - made of carnellian, faience, turquoise, hematite, copper, ostrich eggshell, bone and marine shell, as well as bracelets, bangles and pendants made of marine shell (Bar Yosef et al. 1977, 1986; Bar-Yosef Mayer 1999; 2002a, b; Goren 1980; Goren and Arad-Ayalon n.d; Hovers 1981; Ilan and Sebbane 1989; Sass 1980). The presence of grave goods in close association with the human remains has been interpreted as evidence for a belief in an after-life (Avner 2002; Goren 1998). Intrusive items of glass and plastic were found in some *nawamis*, and may be due to tomb robbery or the re-use of some of the tombs by the Bedouin as documented by Goren (1998: 62) in the *nawamis* at Wadi Solaf.

The transverse arrow-heads, faience beads, Predynastic ceramics all point to an Egyptian connection, while the copper awls, tabular scrapers indicate a tie to the EB I of the southern Levant, while some of the ornaments are unique to the Sinai (Bar-Yosef et al. 1977, 1986; Ilan and Sebbane 1989). The malacological assemblage recovered from the nine clusters of nawamis excavated by Bar-Yosef, Goren and colleagues in southern Sinai were analysed by Bar-Yosef Mayer (1999, 2002a, b). She noted that the species of marine shells and types of shell ornaments recovered are the same as those commonly found in sites dating to the Chalcolithic and EB I periods in Israel and Jordan. However, beads manufactured from *Conus* shell, that are known only from EB II sites in central Israel, indicate that the *nawamis* continued to be used in this period.

4.3.4.2 Faunal remains

Animal remains were recovered from 8 of the 9 *nawamis* fields excavated by the Israeli teams: Ein Um Ahmed, Gebel Gunna, Wadi El Abar, Hzeimeh (also termed Upper Wadi Nasb), Wadi Sawawin, Abu Halil and Nakb Hibran. Bone preservation in all sites was poor and sample sizes extremely small. Consequently, the faunal remains are described below and listed in Table 4.7 by *nawamis* field rather than individual tomb.

Ein Um Ahmed

The site is located on a tributary of Wadi El Ein. Based on the field notes, between 13 and 15 *nawamis* were excavated in this field (Bar-Yosef Mayer 1999).

A total of 9 bones were recovered from this *nawamis* field of which 2 were unidentified fragments (Table 4.7). Two bones were identified as goat/ibex while five represented sheep/goat/ibex. Irrespective of whether bone fusion and tooth eruption rates are used based on Silver (1969) for unimproved breeds, or Noddle 1974) for feral goats, at least one goat from this *nawamis* was aged 12 months or slightly less (an unfused distal scapula and an erupted but unworn upper second molar). The MNI count is thus 1.

Ein Huderah

The field is located on the banks of Wadi ʻAbaya, on a Nubian sandstone plateau. A total of 42 *nawamis* were identified by Bar-Yosef et al. (1977) at this location. Of these, 24 were cleared and included 18 that had been previously disturbed but were undamaged, and another 6 that had collapsed.

No faunal remains from these *nawamis* were available for study by the author. However, Bar-Yosef et al. note (1977: 78, note 48) that 38 bones were found in this field including three animal bones that were found in association with human burials: a horncore of a female dorcas gazelle (*Gazella dorcas*), and two horntips – one possibly of a gazelle, the other possibly from a goat (*Capra* sp.). In a subsequent paper, the species inventory for Ein Huderah is given as: goat, gazelle and cattle (Bar-Yosef et al. 1983: 57). The reference to cattle (*Bos* sp.) probably relates to a modified cattle pelvis which constitutes an implement (Bar-Yosef 1977: 78). A further 8 *nawamis* in this area that were subsequently excavated by A. Goren did not yield animal remains for study.

Gebel Gunna

No animal remains were recovered from this *nawamis* field. However, a special find noted by Bar-Yosef et al. (1986: 137) was the presence of ivory beads – possibly of hippopotamus tusk.

Wadi El Abar

Forty-nine bones were recovered from the *nawamis* field at Wadi El Abar of which 30 belonged to caprines either domestic goat, sheep or ibex, 2 to either ibex or domestic goat; and 10 small tooth enamel fragments to gazelle/caprines (Table 4.7). Two vertebrae had unfused epiphyses, representing at least one animal aged less than 4-5 years (Hilzheimer 1961). In addition, an unfused proximal goat humerus gave an age of 23-24 months, if domestic (Silver 1969), or 48 months if wild (Noddle 1974). The MNI count for this assemblage was 1 immature goat, with all medium-sized mammal remains probably belonging to the same animal.

Small quantities of bones of hare (*Lepus capensis*), rodent - jird (*Meriones* sp.) and reptile - mastigure (*Uromastyx* sp.), were also found. They are all species currently occurring in the region and as such may represent natural mortalities. Until species identification is completed, the origin of the isolated shark tooth found in this tomb cannot be determined. It may represent: an accidental inclusion from earlier geological formations in the region, a paleontological relic collected by the local population and placed in the tomb as a grave offering, or a freshy scavenged or fished tooth from a Late Neolithic shark from the Red or Mediterranean Seas.

Hzeimeh, also termed Upper Wadi Nasb

Only 13 unidentified bone fragments were recovered.

Wadi Sawawin

A total of 15 animal bones were recovered from this *nawamis* field (Table 4.7). On the basis of the presence of a fused goat first phalanx, it was possible to age at least one of the animals represented. If this specimen represents a domestic goat, then it was aged at least 1 year of age, while if wild, the age would probably be closer to 2 years (Noddle 1974). The MNI count for caprines is 1. Other species represented are hare, unidentified rodent and mastigure.

Abu Halil

Of the 26 faunal remains found in this field, half could be identified to taxon (Table 4.7). Interestingly, of the unidentified fragments recovered, 6 were burnt making this the only *nawamis* to have yielded burnt bones. *Glycymeris* shells (from the Mediterranean Sea) found at the Ein Huderah *nawamis* “show black stains of apparently burnt organic matter, but no positive identification could be made” (Bar-Yosef et al. 1977: 79).

Identified faunal remains were primarily fragments of tooth enamel, some so small as to make it difficult to distinguish whether they derive from gazelle, goat or ibex. The pelvis of a hare was an additional find.

Nakb Hibran

A total of 11 bones were identified from this field; one tooth fragment of gazelle/caprine, 8 bones of hare and a rodent incisor identified as a species of jird (Table 4.7).

4.3.4.3 Conclusions

Bar-Yosef et al. (1977: 78) state that at the Ein Huderah *nawamis* field, “practically no animal bones were found”. This is borne out by data from the other fields such that only 161 animal bones were recovered from all the *nawamis* examined here, of which 98 (61%) could be identified to taxon or body size (Table 4.7). The small size of the bone sample may be attributed to the fact that in so many instances, the tombs had been disturbed in antiquity or collapsed, although the possibility that to begin with few faunal items were introduced as grave offerings, cannot be excluded.

The most common animal remains recovered from the *nawamis* are bones of medium-sized ungulates – sheep/goat, goat and gazelle. Other than their small size, there is no evidence to support the identification of the goat remains as those of domestic animals as opposed to ibex. Fauna from the associated *nawamis* habitation sites (that are discussed in the section below- Table 4.8), offer some support for the identification of all remains as those of domestic goat, since they comprise the bulk of the finds from the domestic sites, and no sheep bones have been positively identified..

Although it is assumed that the *nawamis* population subsisted primarily from caprine herding, the presence of arrowheads and gazelle bones in the tombs indicate that hunting was still practiced. Perhaps the latter represent ‘elite’ items selected for interment. Indeed, horned animals, identified as ibex or Persian wild goat, are a motif commonly found in the iconography of Chalcolithic mortuary or cultic contexts (Milevski 2002; Miroschedji 1993). The presence in the *nawamis* of goat horns as well as those of gazelles, may represent a desert variant of this symbolic behaviour relating to sexuality and fertility, and more concretely to milking (Milevski 2002). To this interpretation may tentatively be added the presence of a fragment of a churn from the ‘Ein Huderah *nawamis* (Bar-Yosef et al. 1977:80).

Few of the goat elements could be aged. Those which could indicate that in the *nawamis* there was a preference for immature animals. At least some of the animals were aged less than 1 year (unfused distal scapula), but bones of an adult animal aged at least 3.5 years (if a domestic form, or slightly older if wild) were also found (a fused distal femur). Skeletal element representation indicates that foot bones and hindlimb elements are rare, but all body parts are represented. When skeletal elements are summed (Table 4.7), they show that of the 49 identified goat bones, 55% were teeth (fragments) but only 4% were cranial bones/horns and 2% lower jaws; 28.5% were vertebrae and only 8% were ribs. Upper forelimbs (humerus and scapula) constituted only 4% of the sample while lower hindlimbs were represented by only 1 bone – 2.5% of the sample. Given that trunk elements have low bone mineral density values (Lyman 1994: Table 7.6), their prominence in this assemblage should be taken to indicate preferential selection of this body part. They have a lower utility index value than most long bones suggesting selective interment of the least meaty skeletal elements. This is corroborated by the the high number of cranial remain, similarly poor in meat (unless the brain is taken into consideration).

Remains of hare, rodent and reptile found in the *nawamis* (as well as the Elat burial site) may represent recent intrusions and natural mortalities of animal that inhabit the region. Indeed, Currelly (1906: 2440) notes that although the *nawamis* entrance was small, "it was necessary to place a flat stone inside *to prevent small animals from entering*". Even the archaeological association of the gazelle-caprine remains is in question. Hume (1906: 51-52) notes that " On the low rocks occurring at its junction with Nasb are a number of the *nawamis* or bee-hive stone dwellings which were only met by us in this portion of eastern Sinai. One of these, which was of small size was opened after first removing the flat granite slab which is always place on the top of the main construction. Underneath was the skeleton of an ibex, which had probably crept through a small opening in the side of the building. Finally, on sweeping away the rubble, a number of small cylindrical and ring-like beads were obtained, and a few pieces of very decomposed bone, tending to confirm the view previously expressed by Mr. Holland that these were most probably graves". An alternative explanation is that what Hume describes is an *in situ*, articulated offering of an ibex.

Coeval analogues to the *nawamis* faunal offerings are difficult to find in the archaeological record of the southern Levant. From the PPNB and PPNC of the southern Levant, several examples of intentional association between faunal remains and human burials are known (Goring-Morris and Horwitz in press; Horwitz and Goring-Morris 2004). In most cases the skeletal elements chosen for interment were those with least meat – horns, jaws, skulls, terminal long bones – and as such may symbolize *pars per toto,* or in other instances represent remains of mortuary feasts (Goring-Morris and Horwitz in press; Horwitz and Goring-Morris 2004). Two instances of faunal-burial associations are known from the

Pottery Neolithic period in Israel; Sha'ar Hagolan and Lod (Gopher and Orelle 1995), but both are problematic. At Lod a human burial was found in what probably served as a general refuse pit, while at Sha'ar Hagolan both the fauna and cultural remains relate to a house floor rather than to the human burial.

The Late Neolithic-Early Chalcolithic burial site at Elat offers the closest parallel to the *nawamis*, both in terms of period, architectural context as well as finds. As described in first part of this Chapter, at this site skeletal elements of animals were intentionally interred with human burials. Sheep/goat were the preferred taxa but remains of hare, rodent and bird were also identified, some of which may represent intrusions.

To date, from the Mediterranean region of the southern Levant there are no published examples from the Chalcolithic or Early Bronze Age I periods of faunal remains that have been intentionally interred together with human remains. All Chalcolithic examples - Ben Shemen, Sha'ar Ephraim, Nahal Qanah etc.- are extremely problematic and appear to represent random associations following disturbance to tombs (Davis 1980b; Smith and Horwitz 1998). Likewise, a partial gazelle skeleton found at the entrance, but not inside, an Early Bronze Age tomb at Bab edh-Dhra (Hesse and Wapnish 1975/78), may also represent an accidental association.

In contrast, the Predynastic period in Egypt has yielded a wealth of human-animal interments (see Flores 2003 for a resume of this topic). The Egyptian practice of funerary sacrifice of animals is considered Nubian in origin (Van Neer et al. 2004b). As such it is not surprising that most of these cemeteries are clustered in Upper Egypt, although some examples are also found in Lower Egypt at Maadi, Wadi Digla and Heliopolis (Flores 2003). In Egypt, parts of an animal were often interred with a human, or whole animals in pits of their own, the latter being an early form of this custom. In addition, a wide range of animal species were used for this purpose. Given that there are several other features that tie the *nawamis* to Predynastic Egypt, it is possible that animal interments with humans can be added to this list.

In the present chapter, the numerous marine shells, mainly from the Red Sea, and shell ornaments (Bar-Yosef Mayer 1999), bone tools made on bird and small mammal bones, and ostrich egg shell fragments and beads recovered from the *nawamis*, are not described since they do not constitute dietary items. However, one find should be noted and this is the ivory (?hippopotamus) bead from the Gebel Gunna *nawamis*. Bar-Yosef et al. (1986: 137 state that the hippopotamus ivory "could have come from various parts of the Near East and North-East Africa". If indeed the ivory derives from hippopotamus, then two closer sources for this raw material were at hand - the Nile delta and/or the Israeli Mediterranean coast (Horwitz and Tchernov 1990). In fact, the earliest evidence for hippopotamus in the latter region is an astragalus from the Chalcolithic site of Qatif Y2 (Grigson 1984b). Additional finds of hippopotamus bones which attest to the continuous presence of this taxon along the southern coast have recently been reported from the EB III levels at Tel es-Sakan, Gaza (Miroschedji et al. 2001). A rich corpus of ornaments and objects made of elephant and hippopotamus ivory are known from the Chalcolithic sites in the Beersheva Basin (e.g. Levy 1995; Perrot 1959), such that it may be possible to add to the list of items traded between Sinai and regions to the north, hippopotamus ivory or ornaments made of this material. Such trade may have been facilitated by Canaanites coming to Sinai to mine turquoise as has been proposed by Beit-Arieh (2003b).

However, the option that the ivory from the *nawamis* originated in the Nile Valley, cannot be negated since:

(i) there is evidence for the movement of other faunal items – shells and fish – from the Nile to Chalcolithic and Early Bronze Age sites in the Mediterranean region of Canaan (e.g. Bar-Yosef Mayer 1999, 2002a, b; Reese et al. 1986; Van Neer et al. 2004a), and

(ii) there are many cultural objects of Egyptian origin in the *nawamis* (Bar-Yosef et al. 1977, 1983, 1986).

To conclude, since in all features the animal remains from the *nawamis* in southern Sinai and the Elat burial site so closely resemble each other, it would appear that they reflect a unique Late Neolithic desert mortuary tradition. It is possible that this has its origins in Predynastic Egypt, although the range of taxa buried appears to differ markedly between the regions. The placing of parts of animals in the burials as well as the offering of animals at standing stones and other shrines offers a tantalizing insight into the spiritual world of these communities.

4.3.5 Southern Sinai - The *Nawamis* habitation sites

In southern Sinai, five habitation sites were attributed to the *nawamis* tomb population. Two of the sites were located 1.5 km east of the Gunna *nawamis*; Gunna 25 and Gunna 50 (Fig. 4.1). Two additional sites were excavated in the area - Gunna 32 and Gunna 100, but they yielded EB II remains, and so are described in the following section.

The association of these sites with the *nawamis* tombs was based on the resemblance of the archaeological remains recovered from both site types, including transverse arrowheads, *Conus* shell beads and shell bracelets (Goren 1980; Bar-Yosef et al. 1986). Other ornaments were similar in type, but were represented in lower frequencies than in the tombs, demonstrating selection of precious items for interment with the deceased. In contrast, in the habitation sites items used in daily life were found in greater abundance such as groundstone utensils, awls and pottery. Lithic debitage was also more common at the habitation sites while primarily finished artefacts were recovered from the tombs (Hovers 1981). On this basis, the association between the habitation sites and the *nawamis* tombs was established (Goren 1980). Moreover, as shown in Table 4.2, radiocarbon dates demonstrate that they span the same time period.

The *nawamis* habitation sites are located on low ridges or slopes under the high cliffs of the e-Tih plateau, often adjacent to sites dating to the EB II. The structures within the *nawamis* habitation sites were distanced from each other and dispersed in the landscape according to topographic features suggesting a loose communal structure. Most were constructed of two connected oval or round units. The smaller unit may have served as a base for a tent or hut, and the larger as a courtyard or animal pen (Goren 1980: 254). These definitions of function are also based on finds; in the smaller oval (the house) remains of food were recovered, while in the larger oval (the courtyard), organic material resembling goat dung, was found. The architecture of these habitation sites differs markedly from that of the PPNB hunter-gatherers which comprised a series of linked round/oval rooms which Rosen (1998) characterises as “clustered or honeycomb”.

Goren (1980) notes that it was clear that all of these sites had been re-used repeatedly. The walls exhibited signs of repair, additions and changes. Also, in some instances it was possible to identify sequences of more than one living floor. The floors of the houses and courtyards were filled with ash and dirt.

4.3.5.1. The finds

It is assumed that the people who lived in the habitation sites and constructed and used the *nawamis* were pastoralists. However, the archaeozoological information to support this claim has to now been partial, and based only on limited species lists. Bar-Yosef et al. (1983: 57) list ass, goat and an unidentified bovine as present in these habitation sites, but no details are given as why the goat remains were identified as those of domesticates rather than ibex. Since fauna found in the *nawamis* probably represent specially selected taxa rather than the full range of the animal based economy, examination of bone remains from the domestic sites can fill the gaps in our knowledge of subsistence activities of these communities.

Moyat Daba'iyeh

At Moyat Daba'iyeh, also known as 'Abu Halil Megurim', tens of structures were identified but only the two most intact buildings were excavated (Goren 1980). In one, which was completely empty of finds, one of the walls was built of tall stone slabs. The tallest slab, which was located in the middle of the wall, was some 2 meters high. On either side were two shorter stones (Goren 1980). This grouping is reminiscent of *masseboth* found in the Negev and Sinai (Avner 1984, 2002).

In the second structure, there was a courtyard divided by a broad and long wall circa 1.5 meters high. In the centre of this dividing wall was a niche. A section of this courtyard was excavated and according to the excavator (Goren 1980) yielded remains of large mammals. However, no large mammal bones were found in the small bone assemblage that I analysed indicating that this material has been misplaced. Of the 34 bones checked, 25 were unidentified fragments (4 were burnt), 2 belonged to hare (*Lepus capensis*), and 7 were small tooth enamel fragments of goat or ibex (Table 4.8).

Gunna 25

The pottery recovered from Gunna 25 dates the occupation of the site to the EB I with possible continuation into the EB II (Bar-Yosef et al. 1986: 149). Some 25 individual structures were identified at this site, of which 16 were excavated (Fig. 4.4) (Goren 1980: 254). The outer walls of the structures were built of stone. Inside some of the structures a series of stone-lined installations or silos were found. In the publication of the site, Bar-Yosef et al. (1986) noted the presence of skull and leg remains of two specimens of *Capra*, a phalanx of a gazelle, a hare bone and remains of recent rodents.

Species, age and skeletal remains

In the analysis of the faunal assemblage from Gunna 25, a total of 361 bones were identified and another 269 represented unidentified fragments. Medium sized mammals – goat/ibex and gazelle constituted some 40% of the assemblage; comprising 9% goat/ibex, 2% gazelle and the rest unidentified medium-sized mammal i.e. sheep/goat/ibex/gazelle (Table 4.8). No remains of sheep or ibex have been positively identified in this site. Consequently, it is assumed that the majority of goat/ibex as well as medium mammal bones belong to domestic goats.

Gazelle bones with ends preserved were all fully fused, while the fragmented teeth that were found were well worn and belonged to adult animals. Examination of bone fusion for goats (Table 4.9) indicates that 25% of the herd died in their first year, this increased to 50% by 2 years of age, and increased further so that by 3.5 years 60% of the herd had been killed i.e. only some 40% of the herd survived into adulthood. No detailed data on ageing of teeth was available due to fragmentation.

As shown in Table 4.10a, cranial remains constitute 42% of the skeletal elements, with over 60% of these representing small tooth fragments. Fore and hindlimb elements were represented in similar quantities. Since the sample size of identifiable material from Gunna 25 was small, the skeletal elements from this site were combined with those from the coeval site of Gunna 50 (described in the following section). These combined data are illustrated in Table 4.10b, and clearly show that in these assemblages, all bone elements have a low %Completeness.

Bivariate regressions were run on %MAU (for data from Gunna 25 and 50 combined-as given in Table 4.10b) against both the General Modified Utility Index for sheep (%MGUI) as well as Bone Mineral Density Values (BMD). The correlation coefficient for both tests showed that for %MAU against %MGUI there was a slight but non-significant correlation

(r_s=0.03, P=0.4) while for %MAU against BMD there was no correlation at all (r_s=0.00, P=0.7). These results indicate that selection of skeletal elements based on their utility value was not practiced at these sites, while bone mineral density was not a significant factor in shaping bone element representation. The latter finding is surprising given the low % Completeness values for both these assemblages (Table 4.10b), such that it is clear some factor, anthropogenic or natural, has played a role in winnowing these assemblages. Burning has been shown to accelerate breakage and fragmentation of bones and teeth (Stiner et al. 1995). Since a large portion of both assemblages was burnt, it is most probable that this has played a crucial role in determining the low % Completeness values observed.

Hare, rodent, reptile and birds made up the remainder of the sample. The Cape hare (*Lepus capensis*) was a popular dietary item in Epipaleolithic and Aceramic Neolithic diet (Chapters 3 and 4). The large number of bones of hare found in Gunna 25 (NISP=30; 8% of the assemblage- Table 4.8), would indicate that at this site it continued to be consumed. Examination of skeletal element representation for hare shows that complete animals were probably exploited on-site, since all skeletal elements are represented. Fore and hindlimb bones as well as cranial remains are the most common (NISP = 8, 10 and 9 respectively) while only 2 trunk elements and 1 foot bone were represented. This may reflect differential preservation of ribs and vertebrae, while the phalanges (toe bones) are so small as to have been lost unless extremely fine sieving was carried out. No cut marks were observed on the hare bones, but two were burnt. This could either indicate cooking or be accidental due to the proximity of a hearth.

The only species of rodent identified was a jird (*Meriones* sp.), represented by upper and lower jaws, isolated teeth and incisors. Post-cranial rodent remains were not identified to species level, but probably all can be attributed to the same species of jird. Three *Meriones* species are found in Sinai (see Chapter 1), but due to time constraints the *nawamis* habitation material was not identified to species.

Three species of bird were identified. The first, identified on the basis of a tarsometatarsus, is a small-sized raptor of the Family Falconiformes, probably *Accipiter nisus* (sparrowhawk). The sparrowhawk is a passage migrant passing through the Sinai and Israel in autumn (especially October) and spring (especially late March to early May) (Paz 1987).

The sand partridge *Ammoperdix heyi* (Family: Phasianidae) was identified on the basis of two bones (a proximal ulna and a humerus). This species is a resident of rocky, arid environments experiencing less than 100 mm of rainfall annually. *Coturnix coturnix*, the quail, yet another member of the Phasianidae is well represented in the Gunna 25 assemblage. This is also a passage migrant passing through the region in the autumn and spring (Paz 1987).

A jaw and three vertebrae of the desert monitor (*Varanus griseus*) were identified, all in the same Locus. Like the rodent and some of the bird remains, it is difficult to tell whether it represents a natural mortality or a dietary item consumed by the inhabitants of the site since male monitor lizards can reach weights of 2 kgs or more (Bouskila and Amitai 2001).

Spatial analysis

When the distribution of bones was examined by architectural unit (illustrated in Fig. 4.4), it was patent that they were unevenly spread throughout the site. Many loci yielded no bone at all: L1- unexcavated; L3 – storage installation; L7 – a small room with no material finds; L8 – unexcavated; L10 – open area; L14, L15 and L16 – two attached rooms that yielded few other finds as well.

Other loci contained large numbers of bones, usually both identified and unidentified remains. As shown in Figure 4.4, it is clear that L4, 5 and 6 contained most of the bone recovered from the site. L4 and L5 were identified as installations or silos, and it is possible that they were used as rubbish pits in their final phase, while L6 is an oval room with a low bench along one wall attached to the large enclosure L8. This room yielded the largest number of lithic artefacts and retouched pieces found at the site. According to Bar-Yosef Mayer (1999), most of the marine shells were recovered from L6 and L11, which also yielded high concentrations of bone.

Few bone remains were recovered from L2 – a storage installation and L9 – an oval room attached to the large enclosure L8. In contrast, L11- a circular room, yielded a rich deposit of bones as well as sherds, lithic artefacts, grinding stones and charcoal. Two other loci contained smaller quantities of bones: L12 - a large enclosure with a bedrock floor and ash lenses, and L13 – a small isolated room with 10m thick deposit and many sherds.

Burnt remains were also concentrated in the loci with the largest bone samples, while rodents and birds (Passeriformes and quail) were concentrated in L4 and L5, which would corroborate their having been used as silos for grain at some point in the past. This implies that the rodents and birds do not represent dietary elements, but commensal animals attracted to the stored foods. In contrast remains of hare were found in all loci, probably an indication that it was consumed.

Gunna 50

This site is located several hundred metres east of Gunna 25. It comprises two large courtyards with stone built walls with two adjacent rooms and windbreaks (Bar-Yosef et al. 1986: 129 ff). A built-up hearth was observed in one of the courtyards (Fig. 4.5).

Some of the faunal remains were briefly described in Bar-Yosef et al. (1986: 130) who noted that they were poorly preserved and very fragmentary. They listed the presence of 11 bones of *Capra* sp., 4 of *Gazella* sp., 7 bones of gazelle/goat and two fragments of an ass jaw. The domestic status of this animal was not determined. The entire assemblage has been re-examined and the results are presented here.

A total of 422 bones were recovered from the site of Gunna 50 of which 235 (56%) represented unidentified fragments. The 187 bones that could be identified represented four species: goat/ibex 32%, gazelle 4% and the remaining 58% comprised medium sized mammals (i.e. goat/ibex/gazelle) (Table 4.8). At least 2 very large and robust bones are present in the assemblage and may represent ibex. Unfortunately, neither could be measured.

In terms of ageing of caprines, data on bone fusion is available but this is limited by the small number of bones (Table 4.9). Few animals, ca. 20%, were slaughtered in their first year. This increased to 40% by the second year. No data is available for the 2-3 year range but by 3 years only immature bones are represented indicating that few animals survived into adulthood. Ageing using dental eruption and wear is also constrained by the small number of suitable specimens, and these on the whole represent isolated teeth. Two lower lateral permanent incisors were found and represent animals older than 27-36 months. For dental attrition, isolated teeth were aged with reference to the Aşvan Kale assemblage (Payne 1973). Dental wear of two lower PM4's is severe deriving from animals at least 3-4 years of age (Payne stage F), if not older. A lower M1 and M2, from the same jaw belong to an animal 1-2 years of age (Payne stage D), and another isolated M3 just in wear belongs to an animal aged ca. 2-3 years (Payne stage E). Taken together, the two data sets illustrate culling of mainly immature animals, but the size of the samples on which this is based is small, necessitating that the conclusion be treated with some caution.

Skeletal element representation for goats and medium mammals (Table 4.10) clearly shows a predominance of cranial remains (40%). They are primarily composed of unidentified tooth fragments, while trunk elements are the next most common (22%), mostly comprising rib fragments. As discussed in the previous section on Gunna 25, the combined data sets indicate low %Completeness of skeletal elements. Since the Gunna 50 bone sample also has a high burnt component, it seems most likely that this has been the main cause of bone attrition in both samples rather than selection due to utility value or bone density mediated attrition. Both the latter parameters were tested and found not to be statistically significant.

Gazelle is represented by a few bones and an upper molar, all from an adult animal. A tooth and a small jaw fragment of an equid were found. The tooth is an unworn lower right second molar, while the jaw fragment is quite fragmented. Based on size and morphology it represents a donkey. However, it was not possible to determine whether it is belongs to a domestic or wild animal. Based on the state of tooth eruption and slight wear, this animal was just older than 2 to 2.5 years (Silver 1969) when the M2 erupts. Ostrich eggshell fragments were found throughout the site, as was a large assemblage of marine shells (Bar-Yosef Mayer 1999).

Spatial distribution

The large eastern courtyard contained 30% of all bone recovered from the site. The western courtyard yielded 54% of all bone and the area outside the courtyards yielded only 16% of all bones. The numbers of identified remains was proportional to the quantity of bone recovered from an area (Fig. 4.5). In terms of species, no marked differences were found between the areas for goat/ibex and medium mammal. Bones of gazelle were found in the eastern courtyard and the area outside, equid remains only in the area outside the courtyards and large mammal fragments inside the western courtyard. The quantity of burnt bones was proportional to the size of the samples, with the highest concentrations derived from the loci with the largest bone samples.

4.3.6 Published sites from Sinai

Serabit el-Khadim site 1105

During the 'Survey of Southern Sinai' only one Chalcolithic site (No. 1105), dated to 4216-3985 cal. BC, was identified and excavated as part of the 'Ophir Expedition' under the direction of Prof. Itzhaq Beit-Arieh (Bet-Arieh 2003b). The site lies at the foot of Mount Serabit el-Khadim in southern-western Sinai and has been attributed to Canaanite turquoise miners who came to Sinai during the Chalcolithic period (Ghassulian phase), for this purpose.

The site comprised a rectangular structure (Structure A) with 5-6 metre long walls with a stone block in the centre that probably served as a support for a wooden roof. Indeed, remains of charred wooden beams of *Acacia raddiani* and *Populus euphratica* were found during the excavation of this structure, tree species that today do not grow in this part of Sinai. In addition, two oval stone-built structures (B and C), and several stone-lined pits interpreted as storage pits or silos were found. The pottery corpus contained typical southern Levantine Chalcolithic forms, but one First Dynastic jar of Egyptian origin was also found attesting to ties between this region and Egypt in the late EB I-early EB II. The lithic assemblage contained Canaanite blades commonly found in Chalcolithic and EB sites in the southern Levant, as well as numerous black haematite hammers, probably used to mine turquoise found in the region.

Several animal bones that were recovered from Structure A, were identified by Prof. E. Tchernov (quoted in Beit-Arieh 2003b: 97). The majority comprised small fragments of sheep/goat long bones, but a large fragment of a right cattle (*Bos taurus*) calcaneus was also identified. Beit-Arieh (2003b: 97) has proposed that this may not attest to cattle herding at the site, but that a cut of beef was brought to the site from the southern Levant or Egypt.

Khasem el Taref (Site S-18)

A test excavation at the site of Khasem el Taref (Site S-18) in north-eastern Sinai by Eddy and Wendorf (1999) gave two radiocarbon dates of 5586-5416 cal. BC and 5263-4905 cal. BC respectively (Miller 1999:192). The site represents a cultic complex and has yielded outlines of animals made from small stones, in the same manner as the Biqat 'Uvda temple

(Avner 2002). “Heavily decayed bone fragments” and enamel plates were recovered from several localities at this site (Miller 1999:191). A premolar and other tooth fragments were tentatively identified as falling within the size range of gazelle or ibex (the premolar is illustrated in Miller 1999: Fig. 11-7 on the bottom-right hand corner, third from the bottom). Fragments of enamel plate recovered from the same locality as the gazelle/ibex remains, were however identified in the field as comparable in size to *Bos primigenius.* These appear in the illustration in Miller (1999: Fig. 11-7) as the second from the top of the figure. In my opinion they are too small to be aurochs and slightly too large for domestic sheep/goat, such that the best fit would be a large adult ibex.

4.3.7 Conclusions

The Chalcolithic-Early Bronze Age I (EB I) assemblages from southern Sinai studied here reflect the full range of activities undertaken by communities in the Sinai Peninsula at this time; burials (*tumuli, nawamis*), ritual locations (shrines and *masseboth*) and habitation sites. It is surprising that despite the variation in function, the sites have a broad range of common features in terms of the species exploited, age profiles, season of exploitation etc. which corroborates that they were part of the same socio-economic system.

In all sites, domestic goats (*Capra hircus*) or caprines comprised the major portion of animals exploited. No bones of sheep (*Ovis*) have been identified in any of the samples suggesting that this species may not have been present in southern Sinai at this time. In a few instances ibex have been identified, and some of their bones are undoubtedly represented in the general *Capra* or goat/ibex samples. Few caprine bones could be measured (Table 4.6), but these point to quite small-sized animals, although without larger samples with which to assess the full range of size variation represented, it is difficult assess if this is due to sexual dimorphism (i.e. a large proportion of small females) or other factors. Unfortunately, no complete jaws of caprines were available for study, while few of the isolated teeth were complete. As such only limited data on dental wear was available for ageing adult animals. The few teeth that could be examined were all from immature animals under 3 years of age (mainly 2-3 years). Likewise, ageing based on long bone epiphyseal fusion indicated that the majority of animals were culled while young (under 3.5 years), with few surviving into adulthood. Following the criteria outlined in Payne for the identification of herd management strategies, these data, although based on small sample sizes, clearly show that the primary goal of herd management in southern Sinai at this time was meat production, with a high cull in the 2-3 year age group.

Only two equid remains, a tooth and a small jaw fragment were found in the southern Sinai sites, both were identified as donkey/ass. It was not possible to determine whether they represented a domestic or wild animals. It is reported (Bar-Yosef 1986-87) that remains of a wild donkey were recovered from a 4th millennium BC desert 'kite' such that hunting of wild equids appears to have been practiced at this time.

One cattle bone was reported from Serabit el-Khadim (Site 1105) and a worked cattle pelvis was reported from the Ein Huderah *nawamis*. Neither of these bones has been relocated such that it was not possible to corroborate the identifications. In both instances, the isolated nature of these remains and the fact that at least in one instance it was worked into an artefact, suggests that they represent trade items rather than attest to cattle keeping in southern Sinai. Game animals such as gazelle, ibex, hare, birds and reptiles, as well as the presence of ostrich eggshell point to the continuing importance of hunting in these economies, corroborated by the high frequencies of arrowheads. Despite the presence of marine shells in all sites (Red Sea as well as Mediterranean Sea), no fish remains were found. This may of course be a function of bone collection techniques and lack of fine sieving. However, the small sized, fragile bones of rodents, reptiles and birds are represented in the sites suggesting that fishing was not a common activity.

Both the presence of term foetal/newborn caprines and quails point to the use of the ritual sites in the spring. The *nawamis* habitation sites have also yielded remains of quail and sparrowhawk, both species that are found in the Sinai in spring, attesting to the occupation of these sites at this time. However, occupation in other seasons cannot be disproved.

The small bone assemblage from the 'R' sites in northern Sinai more closely resembles that found in sites from the Mediterranean region of the Levant than southern Sinai. There is evidence from the 'R' sites for exploitation of pigs and cattle. Pig remains have not been found in any southern Sinai sites in any of the periods studied in this work, while the evidence for cattle in this region are problematic (Chapter 3, and sections in this Chapter). Moreover, if the large assemblage from Qatif Y2 is taken to represent a typical Chalcolithic faunal spectrum for the north Sinai Mediterranean coast, then abundant fish remains are also to be expected, a feature missing in the southern Sinai sites.

The presence of pig and cattle tie the ‘R’ sites to the economic system of the Mediterranean region and Jordan Valley, rather than to southern Sinai. Adjacent Chalcolithic-EB I sites from Qatif Y2 (Grigson 1984b, 1995a), Afridar (Ashqelon) on the Mediterranean coast, the Halif Terrace in the northern Negev (Whitcher 1999), and the site of Taur Ikhbeineh located some 3km from the coast in Nahal Besor, northern Negev (Horwitz et al. 2002b), contain the same spectrum of species- including cattle and pigs, as the ‘R’ sites. Pigs and cattle are also present in sites such as Wadi Gazze D, Grar, Gilat (Ducos 1968; Grigson 1995a), located in the hinterland along Nahal Besor and Nahal Grar in the western Negev. Pigs are absent (but cattle are present) in the more arid Beersheva Basin sites located along Nahal Beersheva such as Shiqmim, Horvat Beter, Bir es-Safadi and Abu Matar (Grigson 1987; Whitcher 1999). It seems then that in terms of pig and cattle keeping there is a clear environmental gradient, with both species present in sites along the coast - reflecting the wetter and relatively lusher environment of this region compared to southern Sinai. Cattle but not pigs are found in the moist but more arid Beersheva Basin Chalcolithic sites in the northern Negev which lie below the 200mm isohyet, while neither species is found in southern Sinai.

For Egypt, there is some debate as to whether pigs occurred there prior to the arrival of domestic animals (Manlius and Gautier 1999). If Manlius and Gautier (1999) are correct in assuming that wild pigs were not part of the local Pleistocene fauna of Egypt then this species too must have been introduced as a domesticate. Thus, as attested to by the R and Qatif sites, northern rather than southern Sinai would have offered a suitable overland corridor for the transfer of pigs into Egypt.

4.4. THE EARLY BRONZE AGE II (ca. 3050-2300 BC)

4.4.1 Background

Animal bones were recovered from six Early Bronze Age II (EBII) sites investigated by the ‘Ophir Expedition’ (Beit-Arieh 1977, 1981, 1982, 1983, 1986, 1993, 2003a). Five of the sites, Wattiya North, Site 1014, Sheikh ‘Awad, Sheikh Muhsein, Nabi Salah, are located some 20kms north of Saint Catherine's Monastery while Feiran I is located some 50kms east of the others (Fig. 4.6). In addition, material from the EBII site of Gunna 100 in southern Sinai, that had been excavated by Prof. Ofer Bar-Yosef and colleagues (Bar-Yosef et al. 1986), was analysed.

The faunal remains from Wattiya North, Site 1014, Sheikh Muhsein, Nabi Salah were initially studied by Dr. D. Hakker-Orion (Hakker-Orion 1975, in Beit-Arieh 1977: 142-143), while those from Feiran I and Sheikh 'Awad were analyzed by Dr. S. Hellwing (Hellwing in Beit-Arieh 1981:117, Beit-Arieh 1982:154-155). These reports were preliminary in nature and provided species lists per site, accompanied by general comments on the assemblages. Re-examination of fauna from two of the largest assemblages investigated by the 'Ophir Expedition' - Sheikh Muhsein and Nabi Salah – was undertaken and the results of these studies are presented here. Remains from the other sites are briefly summarized based on the preliminary reports published by Beit-Arieh (1977, 1981, 1982) (Table 4.11).

4.4.2. Published faunal studies

Site 1014

This site was not fully excavated. Bones of goat were identified from Locus 7, a room immediately adjacent to the central courtyard (Hakker-Orion in Beit-Arieh 1977: 143). No further data concerning the abundance, skeletal element representation or age of these remains are given in this report.

Wattiya North (Site No. 1042)

This site was only partially excavated. Remains of goat were identified from Locus 4, an oval-shaped room adjacent to the courtyard (Hakker-Orion in Beit-Arieh 1977: 143). As for Site 1014, no further data concerning the abundance, skeletal element representation or age of these remains are given in the report.

Feiran I (Site No. 1150)

A total of 300 bones were recovered from all rooms at this site. Only 15 well preserved pieces could be identified to species. Taxonomic identifications made by Hellwing (reported in Beit-Arieh 1982) list the presence of sheep/goat (*Ovis/Capra*), gazelle (*Gazella* sp.), cattle (*Bos* sp.) and dog (*Canis familiaris*) (Table 4.11).

Sheikh ‘Awad (Site No. 1118)

The site comprises two units; a double domestic complex (Unit A) and two dwelling units (Units B and C). Two radiocarbon dates obtained on charcoal from this site are 3030-2900 cal. BC and 2897-2696 cal. BC. Finds recovered from the units included ceramics, flint and copper artifacts, groundstone tools, beads and ornaments, charred wood, shells and animal bones.

According to Hellwing (Beit-Arieh 1981), animal bones were recovered from all stratigraphic units and were found in both dwelling rooms and adjoining compartments or chambers (Table 4.11). The assemblage was dominated by remains of a small-sized domestic goat (*Capra hircus*), similar to the Black Bedouin goat found in the region today. The presence of a very young kid (Locus 80) attested to a spring occupation of the site since this is the kidding season for goats. Other taxa represented were gazelle (identified as the dorcas gazelle, *Gazella dorcas*), ibex (*Capra ibex*), Cape hare (*Lepus capensis*), hyrax (*Procavia capensis*) and dog (*Canis familiaris*). According to the intial report (in Beit-Arieh 1981), primarily post-cranial elements were represented such as humeri, femora, metapodia and phalanges.

Examination of the spatial distribution of the bones (based on Beit-Arieh 1981: Table 4), indicates that not all rooms and compartments yielded bones. In Unit A, two adjacent rooms (L1 and L8) contained bones of goat, ibex and gazelle, while in only three of the small side compartments (L5, L29 and L47) were bones found (goat, including a male animal, ibex, gazelle and hyrax). No faunal remains were recovered from the central courtyard in this structure. Only one room in Unit B, which was located in the northern part of the site (L60), yielded remains of goat and gazelle. Similarly, in Unit C, animal bones (goat, ibex, hare and dog) were found only in two rooms (L80 and L81), both adjacent to the central courtyard. In addition, the side compartments L82 and L87 yielded bones of goat. Based on these data it may be concluded that the majority of rooms and small side chambers in this site did not contain animal remains, and furthermore, that the central courtyard was kept clean of such refuse.

Guna 100

This site, excavated by Bar-Yosef and colleagues (1986), comprised several oval structures and associated courtyards. One of the courtyards yielded deposits of organic material which were interpreted as dung. Several hearths were identified and an oven filled with charcoal, was also excavated. The radiometric date obtained for this site was 5001±110 cal. BP = 3051±110 cal. BC. The pottery assemblage clearly places this site within the EB II (Bar-Yosef et al. 1986: 147). Only a few broken molar teeth of *Capra* sp. were identified (Bar-Yosef et al. 1986: 132) (Table 4.11).

4.4.3 New faunal studies

The EB II sites are characterized by a similar architectural plan comprising a series of dwelling-rooms, mostly rectangular broadrooms (‘the Arad house’) with rounded corners, arrayed around a large central courtyard which is round or oval in shape (Fig.4.7). The dwelling rooms had earthen floors, with stone-benches and ledges arrayed along the wall. Most rooms had a hearth. Adjoining the dwelling rooms were smaller, stone-lined compartments or chambers which may have served as storerooms or workshops (Beit-Arieh 1977, 1993, 2003a).

Sheikh Muhsein (Site No. 1046/7)

This site extends over an area of approximately 2.5 acres and comprises five domestic Units (A, B, C, D and F). A total of 1209 animal bones were identified from the site as a whole, the majority of which are derived from Unit A (NISP = 822), which was the largest and most thoroughly excavated. As illustrated in Table 2, no marked differences were evident between the Units in the range and relative proportions of the taxa represented which could not be attributed to differences in sample size. Remains of domestic goat (*Capra hircus*) dominate all samples followed by ibex (*Capra ibex*) (Table 4.12). The MNI count for goat was 9 and for ibex 3. Due to the difficulties in distinguishing between their bones, it cannot be excluded that some ibex remains may be mixed with those of the goats. However, clearly diagnostic remains of ibex (identified subjectively on the basis of robusticity and their large size when they could not be measured), constitute only a minor portion of this sample with many more domestic goats exploited at the site (86% goats versus 12% ibex –Table 4.12).

The presence of several twisted goat horncores confirms the domestic status of most of the goat remains at this site, while in some instances, fragments of ibex horncore were found in the same locus together with remains of domestic goat (Fig. 4.8). Comparison of the few measurements of *Capra* post-cranial remains that could be taken on material from Sheikh Muhsein, show these animals to resemble domestic goats from other Chalcolithic and Bronze Age Sites in the southern Levant (Table 4.13a-c). It is clear though, that for certain measurements, the Sinai sample has a lower size range (e.g. humerus HT, astragalus GLl, 1st phalanx Bp), while the upper range resembles that of other domestic goats. This broad size range may be due to the presence of both goat and ibex in the same assemblage, with the ibex represented in the upper size range and domestic goats in the smaller one (Fig. 4.9). The observed differences in size between the goats exceed those expected due to sexual dimorphism within domestic caprines, such that it is most likely that two size classes of caprines are represented in the site. Until better distinction can be made on post-cranial remains between ibex and domestic goats, this problem cannot be resolved.

Since no differences were evident between archaeological units in the representation of skeletal elements, age of specimens or spatial distribution of the bones, they were combined into a single assemblage for the purpose of analysis. Burnt bones were common in all units, in rooms as well as side chambers, but this varied as well. In Unit B all bones in L101, L104 and L108 were burnt so that they were either black or calcined. In contrast, in the same Unit, only some of the bones in L102 and L113 were burnt. At this stage of the research it is not possible to determine the cause of burning - pre or post-depositional. In most instances the burnt bones were recovered from ashy midden deposits together with remains of material culture -ceramics, flints etc. which suggests intentional firing of refuse.

Bone fusion for goats (Table 4.14) shows that 83% survived until 1 year of age, with only a small proportion of animals dying before then. By 2 years this had dropped to a survivorship of 62%, with a further slight reduction by 3 years (53% survivorship). This dropped again slightly to 50% by 3 1/2 years. Thus, at least half the herd survived into adulthood. Following the model outlined by Payne (1973), this is characteristic of a management strategy aimed at the exploitation of a herd primarily for their renewable resources - milk and wool. The 38% of animals slaughtered by 2 years of age probably represent surplus males culled for meat (Payne 1973).

The few ibex remains which could be aged, show that even fewer animals (some 10%) were killed before 1 year of age (Table 4.14). In the older age classes the data 'rebounds' and rises back to 100% instead of dropping or staying at the same level. Since bones of immature animals, which are more prone to destruction than those of adults, are under-represented in this sample, this has undoubtedly resulted in a skewed mortality profile. Given the limitations of these samples, it is still evident that goat and ibex were exploited using different strategies -one of a domestic herd managed for their secondary products with over 50% culled before 3 years, compared to a wild animals hunted for their meat, skins and horns (high status items ?) which were culled primarily as older adults.

No clear distinction could be made between ibex and goats on the basis of their teeth. Consequently, the data on dental attrition given in Table 4.15 includes both taxa. Moreover, as no complete jaws with teeth were available, attrition scores were made on isolated teeth. Despite the limitations of the sample and method, the results do corroborate the overall pattern established with reference to bone fusion. It reflects the dearth of immature animals under 1 year of age in this sample, and the emphasis on older, mature animals.

In order to examine whether skeletal elements of goats were selected by humans due to their utility value, %MAU was plotted against the Modified Utility Index (%MGUI). The results show that there is no statistically significant correlation between these parameters (r_s=0.27, P=0.06). However, examination of the skeletal element representation for goats (Table 4.16a) clearly illustrates that not all skeletal elements are represented given the MNI count. Moreover, as shown by the %Completeness values, many of the bones in the assemblage are highly fragmented (have %Completeness values of over 100%). Bones with low %Completeness values may either be more complete (i.e. less fragmented), or else fewer in number than the expected count. Irrespective of which interpretation is favoured, most bones in this assemblage are under-represented relative to the expected count. This is evident when the relative frequencies of proximal and distal epiphyseal ends of the same bones are examined. It is clear that the more robust (denser) ends of each of the bones are better represented. For example, for the humerus only 11% of the proximal ends are present compared to 55.5% of the denser distal ends, or 55.5% of the distal metacarpal compared to 88.8% of the denser proximal end. Thus, there is some indication that density mediated attrition has modified this assemblage and has contributed to the intense fragmentation of the shafts. In order to explore this issue in greater detail, %MAU was plotted against BMD values. The resulting correlation coefficient was positive but not significant (r_s=0.27, P=0.06), suggesting that diagenetic factors other than bone mineral density have contributed to this pattern. As for the EBI sites discussed before, it is most likely that burning is responsible.

For ibex, fewer bones could be examined by skeletal element (Table 4.16b). The bones appear to be less fragmented than those of goat, but are still under-represented compared to the expected number. It is possible that the identification of ibex in the more fragmented part of the assemblage from this site was not possible given that features used were the size and robusticity of the elements.

Due to the role of non-anthropogenic factors in shaping this assemblage, some caution should be exercised when interpreting the skeletal element representation. For both goat and ibex, elements of the entire range of body parts are represented. Meat-rich parts (limbs and trunk) are only slightly less common than those poorest in meat (cranial plus foot bones: 55% for goat and 58% for ibex) (Table 4.17). The high numbers of teeth and horncore fragments in the assemblage may have inflated the cranial category, such that for both ibex and goat, meat-rich elements are probably as commonly represented as those poor in meat.

No remains of sheep were identified in this assemblage. Few remains of other large and medium-sized mammals were present: dorcas gazelle (*Gazella dorcas*), with an MNI of 2, which includes an adult female represented by a pair of horncores and an equid (*Equus* sp.). Due to the fragmentary nature of the equid remains, a fragmented tooth, no specific identification could be made. Other, wild taxa represented were Cape hare (*Lepus capensis*); sand partridge (*Ammoperdix heyi*) and hyrax (*Procavia capensis*). Several bones of a large felid were recovered (a second phalanx, two proximal metacarpals and a metatarsal) which closely resemble leopard (*Panthera pardus*) (Fig. 4.10)..

Compared to the preliminary species list for this site compiled by Hakker-Orion (Table 4.11), three notable differences are evident. Rodent and dove/pigeon which are listed in Beit-Arieh (1977), were not identified in this study, while a large carnivore, sand partridge and equid were identified for the first time. However, for the main taxa represented in the assemblage, the same general pattern was found, with a clear abundance of goat and ibex. Moreover, the current re-analysis of the fauna from Sheikh Muhsein could not verify the claim for cattle at this site. A single, large long bone fragment recovered from this sample was deemed too fragmentary to facilitate identification of the skeletal element let alone taxon. Consequently, it was excluded from this analysis. As equid has already been identified from the same domestic unit at Sheikh Muhsein (represented by an isolated tooth) and it would logically serve as the most likely candidate for this large long bone fragment.

Nabi Salah (Site No. 1049)

This was the first site to be excavated by the 'Ophir Expedition' in 1971. It is located in Wadi esh-Sheikh. A preliminary note on the fauna from this site was first published by Hakker-Orion (1975). However, a more complete study by her appears in Beit-Arieh (1977). Hakker-Orion reported that the animal bone sample was dominated by remains of goat with scanty remains of ibex and gazelle (Table 4.11). Only 8% of the caprine remains were from immature animals, which she interpreted as reflecting the maintenance of herds for "long periods of time". On-site slaughter was attested to by the presence of all skeletal elements of sheep/goat.

Re-analysis of the fauna has yielded 1425 identified remains. As shown in Table 4.18, goat remains far outnumber those of the other taxa (92%), and are represented by an MNI of 12 animals. The domestic status of the goats is attested to by the presence of twisted horncores, and the small size of their bones (Tables 4.13a-c). As at Sheikh Muhsein, the lowest size range of some of the Nabi Salah bones is smaller than that of goats other Early Bronze Age sites in the region, while the upper range is the same. This implies that the Sinai goats were of small size, perhaps similar to the present-day dwarf black goats found in this region. Ibex are the next most common taxon at this site, with an MNI estimate of 4. They are represented by both cranial and post-cranial remains. In addition, a small number of wild taxa are also represented - gazelle, probably the dorcas gazelle (*Gazella dorcas*), Cape hare (*Lepus capensis*), hyrax (*Procavia capensis*) and sand partridge (*Ammoperdix heyi*), but together they constitute only 3% of the assemblage

The size of the sample of ibex bones that could be used for aging was too small to enable construction of a meaningful mortality curve. Consequently, data are presented in Table 4.4 only for goats. The age profile follows a similar trend to that reported for Sheikh Muhsein, with few animals culled before 1 year (92% survivorship), reduced to 70% survival rate by 2 years. This is followed by a sharp drop by 3 years, with under 50% of animals surviving by this age. This reflects a similar management strategy to that described above for Sheikh Muhsein, with close to half the herd being maintained into adulthood, probably for secondary produce exploitation and reproduction, while the majority of animals culled until 3 years represent surplus males (Payne 1973). Dental attrition for goat/ibex combined, corroborates the findings based on bone fusion and denotes a herding strategy aimed at managing mature animals. Only 7% of the teeth belong to animals under 1 year, while 59% of animals were culled between 2-4 years of age (Table 14.5).

For the Nabi Salah goat assemblage, a bivariate plot of %MGUI against %MAU showed that these parameters were not significantly correlated (r_s=0.17, P=0.1) (data given in Table 4.19a). Likewise, a plot of %MAU against bone mineral density values (BMD) was not significant (r_s=0.06, P=0.2). These results indicate that neither the utility of the skeletal elements, not their bone density were the main factors affecting skeletal element representation in this assemblage. As for the other EB I and II faunal samples form southern Sinai, it seems most likely that burning has played the most important role in winnowing the samples.

%Completeness frequencies at Nabi Salah are presented in Table 4.19a and b. The small size of the ibex sample provides only a partial picture for this taxon. However, it is clear that for this species as well as for goats, the majority of bones are under-represented relative to expected numbers. Of the epiphyseal ends, the proximal radius as opposed to the distal end of this same bone is almost twice as common indicating that density mediated attrition in addition to other factors are responsible for shaft fragmentation that has biased this skeletal sample.

As shown in Table 4.17, the pattern of body part representation for the Nabi Salah goats closely resembles that of Sheikh Muhsein, with an abundance of cranial remains (due to abundant tooth enamel fragments), few foot bones and an almost even representation of limb bones. When examined with respect to skeletal parts that are rich in meat versus those poor in meat, the majority of the goat remains represent those poor in meat. For ibex, this pattern is even more pronounced with fewer limb bones and higher frequencies of cranial and foot bones.

As in the other sites, all bones were recovered from domestic rooms and side chambers, with none recovered from the central courtyard (Fig. 4.7). The vast majority of bones (both identified and unidentified) were burnt, and several exhibited animal-inflicted damage such as rodent and carnivore damage. Two goat bones exhibited cut marks - along the medial aspect of a distal scapula and a small hyoid fragment. The rarity of butchery damage is probably related to the extremely fragmented nature of the assemblage as well as to the erosion and exfoliation of the outer surface in most cases which has destroyed these modifications.

Gunna Site 32

During excavations and surveys in the region of Gebel Gunna in southern Sinai, Bar-Yosef et al. (1986) excavated the EB II site of Gunna 32. Unfortunately, the archaeological remains and architecture of this site have as yet not been published.

With regard to the faunal sample from Gunna 32, it resembles that described here from coeval sites in southern Sinai. Goat/ibex remains predominate and constitute 93% of the assemblage (Table 4.20). No bones of ibex were positively identified at this site, while only 8 bones could be attributed to domestic goat; including a twisted horncore and three phalanges. The phalanx measurements fall within the range for domestic animals from other Early Bronze Age sites in the region. No bones or teeth of sheep or gazelle were identified at Gunna 32. Other taxa represented are hare and the rodent *Meriones* sp., both of which may represent natural mortalities.

For caprines all body parts are represented (Table 4.17). However, skeletal remains at this site have been severely biased by preservation. This is illustrated both by the % Completeness index (Table 4.21) with most elements under-represented. Moreover, the majority of remains comprising the cranial category (73%) represent teeth and tooth fragments, these being the most robust elements in the skeleton. A factor that has undoubtedly contributed to the poor preservation of this bone assemblage is the high percentage of burnt material. A total of 100 of the 189 unidentified fragments were burnt (53%), while 12 (13%) of the caprine bones showed evidence of burning.

Due to the paucity of complete teeth or bones with epiphyses, few of the caprine bones could be aged. Thus, all that may be stated is that both immature animals, aged less than 2 years as well as animals that are older, are present in this sample.

4.4.4 Conclusions

In terms of species representation, the EB II sites from the Sinai Peninsula described here closely resemble one another. Domestic goat (*Capra hircus*) was the predominant taxon in all sites. Hakker-Orion (cited in Beit-Arieh 1977) noted that the goat remains recovered from the EB II sites in Sinai were those of a small-sized breed, similar to the black goat that inhabits Sinai today. However, no morphometric data were given by her to substantiate this claim. In the current study, the biometry of the Sinai EB II goats was investigated, albeit based on extremely small sample sizes. The results show the presence in Sinai of some animals that were smaller than those from Chalcolithic and Bronze Age sites located further to the north (Table 4.13). Furthermore, in terms of horn conformation, the EBII Sinai goats resemble the dwarf Hejaz goats from Saudi Arabia described by Epstein (1971), which are characterised by considerable lateral compression so that the anterior edge forms a sharp keel, with a relatively smooth outer surface with small furrows and vascular openings (Fig. 4.8). It is clear then that the EB II goats in Sinai represented a small-sized breed, which may have resembled the present-day black goat. The breed of small black goat found in Sinai today requires watering only every 2-4 days, even in summer (Shkolnik et al. 1972, 1974). As such the EB goats may have been as well adapted as those today to the arid conditions of the Sinai Peninsula, although it is not possible to assess their physiological adaptation on the basis of body size alone.

With respect to management strategy of these herds, when animals are bred for meat, it is most economic to slaughter them before they attain 2-3 years of age (Payne 1973) while for milk exploitation as well as for wool, slaughter age is delayed into maturity (3 1/2 years or older). For milk production, obviously more females are required such that excess males will be slaughtered while still immature. In both the Chalcolithic and EB I sites studied here, there was a predominance of young animals slaughtered between the age of 2-3 years, reflecting a management strategy aimed at meat production. In contrast in the EB II samples, fewer than 30% of animals were slaughtered before 2 years of age, and these probably represent immature (surplus) males. The prevalence of mature adults in the EB II assemblages probably represent animals kept into adulthood both for their secondary products (milk and hair)[15] as well as reproduction. Unfortunately, sex ratios could not be assessed due to the poor preservation of the material. However, based on the age profiles, meat production does not appear to have been the primary goal of herd management in the EB II sites studied here, while this appears to have been the goal of the preceding Chalcolithic and EBI herders. In the light of these data, the high frequencies of tabular scrapers and awls in these EB II sites, tools that have been associated with animal butchery and the processing of hides (Goren 1980, Rosen 1997), does not fully concur with the husbandry strategy practised, although even in milk herds slaughter of excess rams and aged ewes takes place.

The shift in herd management that is recorded here for Early Bronze Age Sinai, echoes a similar coeval trend observed in sites in the Irano-Turanian and Mediterranean zones. This is clearly seen at sites with both EB I and EB II phases such as Tel Halif, Tel Yaqush, Bet Yerah and Qiryat Ata (Horwitz 1997, 2003d; Seger et al. 1990). Preliminary results from the study of the Arad fauna undertaken by the author, document a similar shift. This is especially interesting considering the hypothesis put forward by Finkestein (1995) of Arad as a town established by nomads, which would tie it closely to the economies of the arid margins. Although several EB II sites exhibit a shift in husbandry strategy to one based on secondary products, some inter-site diversity is visible in patterns of herd exploitation at this time, depending on site function, size and geographic location. Consequently, at some sites with both EB I and EB II occupations, for example Tel Dalit (Horwitz et al. 1996), this trend is not clearly evident.

Although the archaeological record of the Sinai Peninsula contains a significant corpus of information dealing with human interactions with wild animals, such as the so-called

---

[15] Since no sheep remains have been positively identified from EB II sites in Sinai, wool does not appear to have played a role in the animal based economy.

"leopard-traps", "desert kites" and rock engravings (e.g. Anati 1979; Hershkovitz et al. 1987; Levi 1976; Perevolotsky and Baharav 1987, 1991; Finkelstein 1995), the faunal remains indicate that, at least in the EB II, wild taxa did not constitute an important dietary component. Wild taxa such as ibex and gazelle were still hunted in the EBII but in reduced quantities. Other wild taxa have also been identified (leopard, sand partridge, hyrax, hare, ostrich – eggshell only), but these are mainly isolated remains suggesting that hunting was sporadic. This is corroborated by the dearth of projectile points in EB II lithic assemblages from this region (Gunna 100 in Bar-Yosef et al. 1986; other sites in Beit-Arieh 1977, 2003a) which contrasts to the Chalcolithic-EB I habitation sites from southern Sinai which have abundant arrowheads (Goren 1980:257).

With the exception of cattle, all taxa found in the EB II sites are well adapted to desert regions and have been documented from the Sinai Peninsula up until historic times (Chapter 2; Osborn and Helmy 1980; Yom-Tov 1987). In the Chalcolithic and EB I sites from southern Sinai, only two dubious reports of cattle bones, both isolated, are known. Likewise, for the EB II isolated cattle remains were reported from two sites (Feiran I and Sheikh Muhsein), but neither bone could be located for reanalysis by the author. Even though the southern mountain region of Sinai, where most EBI and EB II sites are located, has a markedly higher precipitation rate per annum (70-100mm) than the rest of the Peninsula (see Chapter 2), and a wetter climate may have characterised the Chalcolithic and EB I (see Chapter 2), the presence of cattle in this arid region is surprising due to the water and pasture needs of this species (Russell 1988). Moreover, given that in all instances we are dealing with isolated bones, it is likely that they represent imported items or else misidentified equid remains.

All bones from the EB II sites are under-represented relative to the MNI estimates and extremely fragmented. This is thought to be the result of burning which is known to promote bone breakage and splintering. In all EB II sites, thick ash lenses were identified (Beit-Arieh 1977), and the abundant quantities of burnt bone can undoubtedly be attributed to these conflagrations. Intentional burning of food remains, other refuse as well as animal dung, may have been a means of cleaning the site between occupations.

4.5 CONCLUSIONS

With respect to the advent of pastoralism, the records of northern and southern Sinai differ markedly. As has been discussed in this Chapter, in terms of its animal economy northern Sinai functioned more as an extension of southern Canaan (and to a lesser extent as a part of Egypt), than as an integral part of the Sinai Peninsula.

Given its more amenable conditions in terms of water and pasture resources and hence its ability to support not only sheep and goats but also cattle and pigs, northern Sinai would have served as a prime overland route for the movement of early stock into Egypt from the Levant. As noted by Caneva (1992) and recently by Ofer Bar-Yosef (2002), most of these Neolithic sites are probably covered by Nile delta sediments as a result of the rise in Holocene sea level. Despite the presence of coastal sands and marshes, this route is favoured over that of the eastern coast of Sinai – from the Arava and southern Jordan – following the Sinai coast and then traversing the Peninsula via one of the large wadis (such as Wadi Feiran) to the Suez coast - due to the great distance involved, and the unreliability and spatial dispersion of resources.

Alternative sources and routes have also been suggested. If one accepts the claims made for the presence of domestic cattle in Upper Egypt (at Bir Kuseiba and Nabta E-75-6) in the period equivalent to the late MPPNB-LPPNB in the southern Levant (ca. 10,100-9,250 cal. BP), and domestic goats in Sodmein Cave by the Pottery Neolithic period (8,250-7,800 cal. BP), then an alternative source of at least some of the domestic stock in Egypt needs to be considered. In the wake of evidence from Cyprus for large scale movement of animals and plants from the south-west Asian mainland to this island already in the EPPNB (10,500-10,100 cal. BP), Bar-Yosef (2002) has proposed a maritime route that would have brought early domesticates into the Nile Valley directly from the northern Levant, thereby by-passing the southern Levant and Sinai. However, Sodmein Cave has as yet yielded no domestic cereals, especially 6-row barley, or remains of sheep and pig, all domestic taxa occurring in the northern Levant by the MPPNB. Remains of these crops and herd animals are first found together in Egypt only at the site of Merimde in the Nile delta by 7016±141 cal. BP, such that their introduction via the southern Levant and Sinai is a more feasible option.

The history of the onset of pastoralism in the southern Sinai is as complex as that of Egypt but in many ways less well known. Rosen (1998) has developed a 4-phase sequence to account for the rise of pastoralism in the southern Levantine periphery, beginning with the PPNB hunter-gathers through to the adoption of the camel in the 2nd millennium BC or later. He characterizes the earliest herder-hunter phase, which he places as contemporaneous with the Late Neolithic-Chalcolithic discussed at the beginning of this Chapter, by saying: "Domesticated animals in this phase substitute for hunted animals in a subsistence economy which at its start is little different from hunting-gathering". This point ties in well with the model of PPNB transhumance discussed in Chapter 3. Here, the seasonal use of altitudinal belts based on the behaviour of ibex herds has been proposed, a system which served as the precursor for systems of landscape use by early pastoralists in the Peninsula. However, instead of following wild ibex, the early herders followed their domestic caprine flocks.

This idea is further echoed in the work of Henry (1995) on Timnian sites of southern Jordan (ca. 4,000-5,700 cal. BP), which is chronologically equivalent to the 4th millennium BC Chalcolithic of the southern Levant. Henry (1995) surveyed and excavated 24 Timnian sites, but aside from the pastoral camp of Gebel el Jill (J14), no faunal remains were recovered. In the latter site, caprines constituted 73% of the identified assemblage and gazelle some 25%, indicating that as in Sinai, game continued to provide an important source of animal protein at this time. Cereal pollen was found in one site, but as in Sinai there is no evidence for crop cultivation, and wheat and barley phytoliths were not found. Moreover, a rock-built structure uncovered at the site has been interpreted as a corral. Basing himself on a model of present-day Bedouin transhumance, in much the same manner as proposed by Bar-Yosef for PPNB hunter-gatherer transhumance, Henry (1995) noted that in order to exploit the local resources of southern Jordan, hunter-gatherer-herder communities would have altered their residential mobility on a seasonal basis by moving to different elevational belts. Thus, they occupied the piedmont zone in the wet season (winter) for ca. 8-12 weeks, inhabiting long-term camps with storage facilities, corrals and pithouses. This was followed by a move to lower attitudes in spring-summer to smaller, more ephemeral sites which in turn was followed by a summer migration into the uplands, to the plateau where they remained until the wet season.

The idea that early pastoral strategies 'mimicked' earlier patterns of resource exploitation established by hunter-gatherers is not a new idea. Ingold (1980) has offered some illuminating insights on this topic in the distinctions he draws between carnivorous pastoralism and milch pastoralism. He defines carnivorous pastoralism as a continuation of hunting in that the domestic herds are a substitute for their wild counterparts. The herded animals are exploited primarily for meat, although they may be milked occasionally. They do not need to be tame since they follow each other. Protection and harvesting of herds "are directly conditioned by the ecological requirements of herding and husbandry and are clearly derived from the antecedent repertoire of hunting skills" (Ingold 1980: 116). As in hunting, the carnivorous pastoralist is not intimately familiar with his herds - they are like wild animals, with the difference that he now has a responsibility towards them as well as to the pasture and water resources. On the long term, carnivorous pastoralism may be no more efficient than hunting since to supply him and his family with food and items for trade, the herder has paradoxically to destroy a part of his wealth, thereby terminating his labour and care of the herd. There is then the constant threat of impoverishment, and little subsistence security. Consequently, Ingold remarks, that group size under carnivorous herding will be small, as the more people there are the more they drain the herders assets. In addition, given the fact that the herder is no longer intercepting animal herds as in hunting, but rather following them, these communities may be more mobile than hunter-gatherers since they need to exploit available grazing and water resources when and where these occur, and adjust the schedule and route of their movement accordingly. This will result in a diminished reliance on stored foods and shorter periods of site occupation. According to Ingold (1980), the full development of carnivorous pastoralism can take place only under arid ecological conditions. Indeed, among Bedouin communities in southern Sinai, the creation and maintainance of a loose social and political structure, as well as the unusual practice of 'open grazing territoiries', have been attributed by Perevolotsky (1987) to the unpredictable nature of rain storms in both space and time, which results in the patchy distribution of spring pasture upon which livestock production in the region is based.

It is clear to see the many ways in which the characteristics of 'carnivorous pastoralism' fits the archaeozoological and archaeological record of the Late Neolithic-EB I of southern Sinai as documented in this Chapter. The faunal assemblages in this time period are a mixture of domestic and hunted taxa. In terms of domesticates, only goats are found, but this may relate to the local ecology. The absence of cattle and pigs may also relate to the local environmental conditions, while the presence of donkey (albeit in low numbers) attests to the use of beasts of burden for transport. Indeed Stager (1992), suggests that during the EB Ib donkey caravans between Sinai and Egypt intensified contact between the regions.

Most importantly, caprine herd management in this period was geared to the production of meat, with a high cull of animals in the 2-3 years age range, primarily representing surplus males, with few animals surviving into adulthood. A wide range of animal taxa were exploited as shown by the importance of hunting. This is also demonstrated by the high numbers of arrowheads in these Late Neolithic-EB I sites and the low density of settlements – attesting to the small size of the populations and/or short term nature of occupation. Finally, there is evidence for seasonal use of ritual sites (spring in this case), a feature attesting to the itinerant nature of these communities.

In contrast milch pastoralism, which entails exploitation of secondary products, exists where tending the animal is a precondition for using it. The animal is an integral part of the owners domestic herd and household. The extraction of a resource from the herd constitutes an essential part of its everyday care and this in turn confers direct control to the person over the distribution of the produce. This produce may be converted e.g. milk into cheese or yoghurt. In fact, milch pastoralism promotes diversification in stock since animals cannot be milked all year round, while different taxa provide milk for varying lengths of time. This offers greater security to the herder in terms of food supply. From this one may extrapolate that sites of milch herders will contain a broader spectrum of domestic species and that they may be more sedentary than their carnivorous counterparts. Although Ingold (1980) perceives diversification, aimed at improving subsistence security, in terms of adding large animals (cows) to herds of sheep and goats, in the ecological context of Sinai, which may have limited the raising of pigs and cattle, this may have entailed the development of alternative economic activities such as raiding, the expansion of trade links (through the export of new or under-exploited materials), or the development of craft specialisation of which animal products were but one example. Secondary products from animals (skins, cheese, yoghurt, cloth, wool), would have been sold at markets. In return the milch herder would receive produce unavailable in the desert region which would alleviate subsistence insecurity – for example olives, wine, cereals – all foodstuffs that could be stored. It is evident that such an economy bears much in common with the Early Bronze Age II occupations in southern Sinai, with their extensive ties to sites in or on the edge of the Mediterranean region of the southern Levant – such as Arad (Beit-Arieh 1983, 1986), or else to Egypt (Ben-Tor 1991), although the extent of ties with the Nile appears to have declined reative to the preceding period as reflected in the paucity of Egyptian materials in Canaan, perhaps indicating one-way trade (e.g. Mazar 1990).

The EB II subsistence in Sinai continued to be based on goat herds, but the hunted component decreased as evidenced by the reduced number of arrowheads. This may also serve as an indication of greater sedentism on the part of EB II herders, since hunting is associated with mobility. Of special note is the unequivocal evidence for secondary products exploitation as the primary subsistence goal. This increased production of animal commodities (hair, dairy products but probably not wool since no sheep are found in these sites) would have necessitated and opened markets for their distribution, facilitating greater contact with areas of the 'sown'. Rosen (2002a, b) has argued that essential links existed between Bronze Age pastoral nomadic groups and the Mediterranean zone. He cites several archaeological features to substantiate this claim such as the presence of large numbers of grinding stones in desert sites but the absence of sickle blades indicating that cultivation was not intensively practiced and that cereals were imported; the presence of northern ceramic jars, including storage vessels, in southern sites (and *vice versa*); evidence for on-site manufacture of exotic objects in southern sites and the presence of these objects in northern assemblages including turquoise, copper, specialised lithic implements (e.g. tabular scrapers), shell ornaments and ostrich eggshell beads. In many of these features the EB II sites differ from those of the EBI. There are indications that population size increased in the desert regions during the EB II (Cohen 1986; Haiman 1992; Rosen 1987). However, these data may also be interpreted as reflecting a shift to increased sedentism with greater aggregations of people necessitated by craft specialisation, dependency on markets, access to reduced resources, while in preceeding periods the settllement pattern was more dispersed.

The desert periphery as a supplier of animal foodstuffs to the 'sown' is a long tradition that has its roots in the Late Neolithic-Early Bronze Age discussed here. As Jabbur (1995:35) notes, even today the sedentary population of Syria consumes large quantities of meat raised by the Bedouins, especially mutton and goat followed by camel. He further states: "It would be difficult to provide here specific figures for the amount of livestock the desert supplies to the settled areas in every Arab country, but up until recent years it undoubtedly provided a large part of what was consumed in settled areas (Jabbur 1995: 35). Sheep are favoured - meat, wool and milk most of which is made into clarified butter (*samn*). This is sold to villagers for their cooked dishes. " Indeed many people in Syria, Lebanon and Iraq, until recently relied on Bedouin *samn* for their cooked dishes" (Jabbur 1995: 37).

The observed changes in faunal composition of Late Neolithic through Early Bronze Age II sites documented here, offers a unique picture of the diachronic development of pastor-nomadism in the desert margins of the southern Levant; from hunting and gathering to carnivorous pastoralism and finally to milch pastoralism based on the exploitation of secondary products and their marketing. It is clear that these changes in subsistence base were accompanied by concomitant shifts in lifestyle as well as in the socio-political structure of these communities. However, at this point in the research, the faunal record cannot shed light as to which factor may have served as the primary catalyst for these changes.

CHAPTER 5

LIVESTOCK FOR THE *LIMES*: IDENTIFICATION OF STATE PROVISIONING OF NEW KINGDOM MILITARY-ADMINISTRATIVE CENTRES

5.1 INTRODUCTION

The study of provisioning of military installations, administrative centres or settlements that have specifically been created to carry out a particular governmental function, is a topic of great interest. Examination of the food supply to such satellite sites provides an indicator of the extent to which the central government was organised and able to procure and distribute produce, as well as the scope of its commitment to maintain these sites and/or their function. In an archaeological context where administrative records are missing, access to such information may be obtained either through examination of the material culture recovered from a site (e.g. presence of imported storage vessels), or via the food remains – flora and fauna.

In all periods, the faunal remains recovered reflect only a part, often minor, of all the dietary components consumed at sites. However, due to variable preservation in Near Eastern sites, frequently, little primary information is available from botanical remains. Thus, the animal bones often offer the most substantial evidence of food resources and hence provisioning.

This chapter describes and compares faunal remains[16] recovered during excavations by Prof. Eliezer Oren (Ben-Gurion University) of sites along 'The Way of Horus' in northern Sinai (Fig. 5.1). This route, which follows the Mediterranean coastal strip from the eastern Nile delta to Gaza, served as a vital artery for trade and commercial activity between Egypt and Asia from the New Kingdom (NK) onwards (Oren 1980a, b, 1982-3, 1984, 1987a, b,

---

[16] All fish identifications used in this study were undertaken by Prof. O. Lernau, and they are cited here with his permission.

1993a, b). This case study explores provisioning in a series of New Kingdom (NK) (= Late Bronze Age of the southern Levant - ca. 1550-1200 BC) military-administrative centres and compares the faunistic evidence for diet to that of a coeval transit camp and contemporaneous domestic sites.

5.2 THE MODEL

An excellent analogue with which to understand the mechanism of central provisioning of NK military and administrative centres in Sinai, is that of the Roman *Limes*. The *Limes* comprised a series of fortifications linked by roads that was established along the eastern frontier of the Roman empire (marked in many instances, but not all, by a natural or artificial obstacle) to secure the border as well as trade-routes (e.g. Isaac 1988; Maxfield 1996; Parker 1987). Aharoni (1967) likened the network of Iron Age fortresses in the Negev which maintained security of frontiers and control over trade-routes desert to the *Limes*. He further commented that extra-mural settlements were attached to most fortresses, some of whose inhabitants may have been members of the soldiers' family. Buildings characterised by large courtyards (identified by Aharoni as enclosures for stock), may have served as inn's for travellers. However, most of the inhabitants "found their living in stock rearing and agriculture" with the produce sold "to those engaged in services and to the garrisons" (Aharoni 1967: 13).

Several archaeozoological investigations have specifically focussed on the mechanisms of provisioning meat to the Roman settlements, fortresses and garrisons of the *Limes* of eastern Jordan and the eastern desert of Egypt (Hamilton-Dyers 2001; Leguilloux 1997; Toplyn 1994; Van Neer 1997; Van Neer and Sidebotham 2002; Wattenmaker 1982), while general research on provisioning of the Roman army offers insights into how this functioned throughout the empire (e.g. Roth 1999). These studies have served as the foundation for the model outlined below, which offers archaeozoological criteria for identifying the extent to which sites were provisioned by a central government, as opposed to local communities having to see to their own subsistence needs.

Fauna recovered from sites that were provisioned are expected to have a unique pattern characterised by the following features:

The type and quantity of faunal species represented

(a) Presence of taxa that are rare or absent from unfortified sites.

(b) A marked degree of uniformity in the faunal assemblage, with the same range of taxa represented in similar frequencies in coeval sites fulfilling a similar function.

(c) Low frequencies of wild species, which are usually costly to obtain and in this period represent luxury items.

(d) Evidence for consumption of beasts of burden (camels and equids), which may reflect delays in the supply of provisions of meat that forced the inhabitants of the site to eat local transport animals.

Skeletal elements

If animal products were imported we would expect to find a predominance of meat-bearing bones and few skeletal elements that are poor in meat (feet, skull) that would have been discarded at butchery. If all skeletal elements are represented, this should indicate that animals were brought to the site 'on-the-hoof' and slaughtered locally, raising the probability that they derive from local herds.

Butchery damage

This will provide information on the size, shape and type of meat cuts. Taken together with the data on skeletal element representation, if butchery is standardised, this will provide further evidence for provisioning.

Mortality profiles

In a provisioned economy we expect to find a narrow age range of animals, usually of prime slaughter age for meat. Consequently, if only immature animals are found this will indicate that no breeding animals were kept on-site and that animals or meat cuts were imported. In the case of beasts of burden, the majority should represent old animals which were eaten when supplies failed to arrive.

It is clear that by themselves, none of these points can be interpreted unequivocally as evidence of provisioning. However, when considered together as well as in concert with other archaeological data (such as the presence of storage facilities, the presence of imported storage vessels etc.) they provide a good indication as to whether a site may have been provisioned or not. Aside from the Roman period studies cited above, few archaeozoological studies have been published dealing with provisioning. Thus, the Egyptian NK administrative centres and fortresses that were created along the Way of Horus, offer a unique body of data from a constrained geographic region, with which to examine the contribution of archaeozoology to elucidate the issue of central provisioning in a military-administrative context.

5.3 Literary sources on provisioning

Most written sources pertaining to army provisioning for the time period studied here relate to the Middle and New Kingdom periods in Egypt. They do offer insights into provisioning that provide a baseline against which to assess the archaeozoological finds.

There is good evidence from New Kingdom *papyri* and *ostraca* that Egyptian military and administrative centres received wages/rations from the state (Warburton 1997, 2000). Wages represent foods given that are more than you can eat i.e. surpluses, and they imply that you can use these items to barter-buy other things. Mueller (1975) and Janssen (1975) have shown that in the New Kingdom, foodstuffs had set exchange rates. Similarly, in the Middle Kingdom, the bread and beer allowance was convertible into objects of all kinds. In contrast to wages, rations represent foods consumed directly by a person, with little or no surplus. However, in these ancient texts, no terminological distinction is made between rations and wages and both are listed as income, which engenders some confusion. In this text the generic term rations/wages is used.

5.3.1 Food given as wages/rations: quality and quantity

Corvee laborers/workmen

Provision lists show that allowances could be paid out in different commodities: cereals, cakes, beer, wine etc. Sources indicate that in the New Kingdom, the quantity and quality of food supplied varied with occupation and rank and increased accordingly. Workers could expect to receive 10 loaves per day, a commander of a work force could expect 100 loaves daily, while the head of an expedition would receive 200 loaves a day (Gnirs 2001).

Janssen (1975: 463) writes that workmen at Deir el Medinah received monthly rations/wages from the State of emmer wheat for bread and barley for brewing beer. The quantity was 10 litres of emmer a day (this compares with 45 litres for a Roman workman). In addition, workmen at Deir el Medinah received oil, vegetables, fish and dates. Other foods that are mentioned in the Deir el Medinah *ostraca* are: lubia beans, cattle, pigs, sheep, fat and cheese. As emphasized by Janssen (1975), these foodstuffs were probably the result of barter, rather than part of the original wages/rations supplied by the State. Indeed Miller (1991) notes that they were not part of the animals and foods listed as having been delivered (i.e. supplied) to the site. The Turin papyrus gives prices for all the goods listed at Deir el Medinah indicating that bartering/exchange of food items was an accepted practice. However, Janssen (1975) also quotes *ostraca* from Deir el Medina mentioning that fishermen were attached to the workforce their job being to supply quantities of fish to the workers. We also know that workers at Deir el Medina undertook crop cultivation either to supplement their diet or to exchange for other items. In addition, they received firewood/dung as part of their wage/rations (Janssen 1975). Archaeozoological research on the New Kingdom 'workers village' at Amarna (Kemp et al. 1994: 143) indicates that while goats, pigs and a few cattle were probably kept in the village, joints of beef were brought in from the outside and distributed periodically.

Mueller (1975) discusses a Middle Kingdom stele from Serabit el Khadim (Sinai) which lists cakes, assorted breads, various wines and beer which were presumably given to the workmen working on the mines as their wage/rations. However, the stele is badly preserved and not all terms could be interpreted. Ten loaves per day was the quantity paid to the lowest paid workers both at Serabit el Khadim and in the Egyptian expedition sent to Wadi Hammamat. However, Miller (1991) notes that 30 hunters were included in the expedition sent to Wadi Hammamat. They received one and half times more rations than the workers, while the craftsmen on this expedition received double rations. The fact that hunters were officially sent on this mission provides some indication that the local force was expected to 'live-off- the land'. Moreover, this document indicates that some people received more than others, once again raising the question of whether these items served as rations or wages.

A Middle Kingdom quarry inscription (Gnirs 2001) documents daily rations for workers as: three jars of beer, three cakes and two units of meat. In contrast, in Middle Kingdom Abydos (reign of Sesostris I) corvee labourers received the equivalent of 8 loaves a day. However, these estimates exclude other sources of calories from vegetables, meat, fish or fowl. Indeed, Miller (1991) suggests that given the small size of the wages/rations, the diet at Abydos must have been supplemented by food from home. Based on the Amarna letters, Na'aman (1981) notes that local (Canaanite) corvee workers used in Egyptian garrison cities and surrounding areas were supplied with rations/wages. Items mentioned are sacks of cereals (largely wheat), oil, wine and forage. Meat is not specifically mentioned.

Military rations/wages

Middle Kingdom remuneration for military service included food rations, goods, land endowments and cattle (Gnirs 2001). Calculation of the minimum bread wage per day in the Middle Kingdom period for a soldier (calculated to a specific weight ratio) gives 0.6 kgs of grain per day (Gnirs 2001) which is very little food. Assessing the caloric value of cereals supplied by the State to Middle Kingdom workforces and soldiers, Miller (1991) states that in the Middle Kingdom fort of Uronarti, the amount of wheat and barley supplied translates into approximately 2000 calories per person/per day that is the equivalent of ten loaves.

For Iron Age forts in Palestine, there is almost no written documentation on military rations. Limited information may be gleaned from *ostraca* recovered from the Arad fort (Aharoni and Naveh 1981), but none of these refer to animal foods. These early documents do however indicate that provisioning of forts was undertaken by the central government. During the Iron II, the Arad garrison fulfilled both a military and military-administrative purpose. Based on the *ostraca* it appears to have served as a distribution centre for supplies of flour, oil and wine, which originated in settlements in the southern Hebron region. The supplies were re-distributed from Arad to Greek mercenaries serving in the army of Judah (*Kittiyim/Kittim*) who occupied the forts of the northern Negev (Aharoni and Naveh 1981).

Melmet (1964) provides a more comprehensive account of rations supplied to the New Kingdom Egyptian army based on the Anastasi I papyrus. Food given to the Egyptian army based in Canaan was comprised of local produce and Canaanite terms were used to describe it. The bulk of the food comprised cereals, supplemented by meat (sheep/goat) and wine. In contrast to the situation in Egypt, baked bread rather than grain was supplied (Melmet 1964). Melmet contends that the Egyptian army received three times more meat than David's army as described in the Old Testament (Samuel 1: 25). The latter did however receive rations of dates and figs. Critical to this debate is the fact that it is unclear how long the Egyptian and David's armies rations were intended to last.

5.3.2 Provisions from tribute/tax

Provisioning of permanent outposts situated at strategic localities, such as the north Sinai NK fort complexes, obviously differs from that of supplying workmen, an expedition or an army on campaign. However, information available on these topics may shed light on the interaction between the Egyptian force and local inhabitants given that most of the Sinai forts were located amidst local settlements.

In the absence of a permanent army, military campaigns prior to the New Kingdom were waged by mustering a temporary force of Egyptians. Redford (1992:219) states that: “A campaign was an armed excursion planned in advance to coincide with an optimum period for travelling in Asia, and the receipt of ‘tribute’ and captives as its goal”. As such campaigns were planned to coincide with a time when “an army was easy to supply with fresh resources along its line of march through allied territory” (Redford 1992: 402). During the New Kingdom, Egyptian vassals in Syro-Palestine were obliged to supply troops in transit with food, commodities and fodder for their animals (Ahituv 1978; Gnirs 2001; Redford 1990). Indeed Brewer and Teeter (1999: 75) categorically state that “There is no evidence for supply trains, and the armies presumably requisitioned necessary food and fodder from their allies or took it more forcibly from others”. It is evident then that, as contended by some researchers (Ahituv 1978; Warburton 2000), a large part of the produce taken as tax/tribute would have been redistributed locally and used by the local Egyptian administration and soldiers. Only luxury and prestige items were transported back to Egypt. This is indirectly confirmed by the mention of bakers, brewers and butchers as part of Egyptian expeditionary forces (Gnirs 2001: 404). Ahituv (1978) lists as items of tribute/tax from Canaan, cereal, oil, wine and livestock in addition to raw materials (wood, metals) as well as slaves. Livestock are listed as taken as booty/tribute/tax from Canaan. For example, Ahituv (1978) cites the booty lists from Megiddo which give the numbers of animals taken as ranging from 20,500 sheep and 2000 goats or ca. 21,670 small stock. The ratio of sheep to goats range from 1:10 to 1:7. Redford (1990) postulates that the tributes of livestock from Megiddo were probably intended for the upkeep of the Egyptian expeditionary forces. To the list of animals requisitioned from Syrio-Palestine during the New Kingdom, Redford (1990: 49-52) adds that the quantities of horses taken were “equally divided between booty and benevolence", while the cattle taken included both long and short-horned types.

Given this information, it is possible that provisioning of the north Sinai forts was based on local produce paid locally as a tribute or tax, rather than foodstuffs sent as provisions from Egypt (Na'aman 1981). However, based on the Egyptian texts, it is difficult to distinguish linguistically between tribute sent directly to Egypt to the Pharoah and taxed items used by the local Egyptian authorities (Na'aman 1981). Na'aman (1981), states that the majority of tribute/tax sent from Canaan to Egypt (as opposed to being consumed locally) included silver, cattle and slaves. In these lists, other agricultural products - grain and oil - are mentioned only once, and wine and honey are not mentioned at all, nor are sheep, goat, pig, fowl or fish. However, these items may have been sent even though they are not mentioned. For example, in the Amarna letters it is stated that Shubandu, one of the princes of southern Canaan, supplied 500 cattle (Naaman 1981), while Biridiya of Megiddo sent 30 cattle. The price of an ox in Egypt at this time was the equivalent of 5 silver sheqels (1/2 a deben) and in countries to the north (Canaan included), it was worth between 10-20 silver sheqels. i.e. cattle cost double or quadruple in Canaan than in Egypt.

5.3.3 Mechanism of provisioning

The existence of a sophisticated administration (scribes, officials), in both Middle and New Kingdom Egypt, would have ensured the realization of state enterprises. Indeed, according to Warburton (2000, 2001), Egyptian border fortresses were commandeered by officials who preformed mainly administrative rather than military functions i.e. customs duties and conduct of official trade. Thus, the bureaucracy required to handle provisioning was in place. This high level of organisation is well illustrated by the fact that in his first campaign, Thutmose III took only 9-10 days to traverse the ca. 250 km from Sile on the Nile Delta to Gaza (Oren 1993a).

With respect to how foodstuffs could have been transported, Gnirs (2001) notes that wagons were known in Egypt from the Middle Kingdom onwards, and though primarily associated with transport of foreign booty, they could also have ensured the steady supply of provisions for the troops. Ikram (1995) however, places the advent of the ox-wagon in Egypt in the New Kingdom period. Although horse-drawn chariots were introduced by the

New Kingdom (Gnirs 2001; Redford 1990), it is unlikely that they were used to transport provisions, given their small size and light structure, as well as the expense of buying and keeping horses. For cereals and other processed items, donkeys and later camels, the first beast of burden available since the end of the Neolithic and the second since the Late Bronze Age (Horwitz and Rosen 2005), would undoubtedly have been used. Livestock could have been transported on the hoof, if not via water (Ikram 1995). Maritime transport is an economic solution since large quantities of goods and animals can be transported relatively cheaply at one time. With respect to north Sinai, since many of the forts are located inland, this would have necessitated overland transport, either from the source or at least for part of the distance. An alternative means of transportation of stock into northern Sinai would have been the freshwater 'East Frontier Canal' that began west of the city/fort of Taphanes, ran east and then turned north where it then joined the Pelusiac branch of the Nile before entering the Mediterranean Sea (Sneh et al. 1975).

5.3.4 Conclusion

The common element to all these texts on wages/rations, irrespective of period or region, is the focus on cereals - bread - as the main dietary component. Little mention is made of meat, whether from cattle, pig, sheep/goat, fowl or fish, while the presence of butchers and hunters in specific texts strongly suggests local requisitioning and/or hunting of fauna to supply fresh meat. At the New Kingdom site of Amarna, there is good evidence to show that preserved meat was transported and stored in special ceramic vessels that were wide-mouthed, wide-bellied and had no handles, since these jars were often labelled as to their contents (Kemp et al. 1994). This appears though to have been the exception and although preservation of meat, fowl and fish (smoking and salting) was carried out during these periods (Ikram 1995), the absence of such produce in the lists of provisions given as wages/rations, would indicate that they were rarely if ever included in the staple diet. We would expect that in most instances, the archaeozoological record such as that of the northern Sinai NK military sites, should comprise local fauna rather than imported elements. As such, although containers and storage areas used for cereals, wine and oil may reflect centralised provisioning, this will not be reflected in the animal component of these sites.

5.4 NEW KINGDOM MILITARY-ADMINISTRATIVE CENTRES

5.4.1. Introduction

During the New Kingdom period, north Sinai became the principle land route between Egypt and Canaan and Asia. It served as an important artery for communications as well as for military expeditions between these regions (Oren 1980a, b, 1987a, b, 1993a). Egyptian control manifested itself in the construction of a series of forts, administrative centres, customs and supply stations equipped with reservoirs and granaries along the “Way of Horus” in north Sinai (Clarke 1916; Oren 1987a) (Fig. 5.1). This route is recorded from Egyptian documents beginning in the 5th Dynasty and is described in detail in Papyrus Anastasi I (13th century BC) and in the pictorial representation from the temple of Amun in Karnak, which features the campaign of Seti I against Canaan (1309-1291 BC) (Figueras 2000). These centres were interlinked and were an essential part of the administration of the territory by supervising trade, collecting taxes and monitoring the local population (Oren 1987a).

5.4.2 The New Kingdom sites

The Ben-Gurion University team which surveyed north Sinai during 1972-1982, found that most of the 150 NK sites they identified, were located on or adjacent to the old frontier water canal stretching between Pelusium (Tel Farama) and Qantara (Sneh et al. 1975). Almost no New Kingdom sites were found on the sand bar enclosing Lake Bardawil or on the Mediterranean coastal strip. Oren (1993a) has therefore suggested that New Kingdom sites were not directly related to maritime traffic in the region.

The NK settlements were arranged in clusters (of which at least 10 were identified by the Ben-Gurion University survey team), with a central site (fortress or central station) surrounded by smaller campsites probably representing transit caravans as well as seasonal camps used by nomads (who were incorporated into the administrative functioning of the “Way of Horus”).

Four NK sites that were excavated yielded faunal remains. Site A-289 which represents a fort (Haruvit/Harouba), and sites BEA-10 and A-345 which represent administrative centres, while site A-343 represents an encampment or station.

5.4.2.1.1 Site BEA-10 (Bir el-Abd)

This site served as an Egyptian outpost and base camp for a cluster of ca. 30 smaller satellite sites in its vicinity. Based on ceramics, scarabs and architecture, the site of Bir el-Abd dates to the late 18th-early 19th Dynasties. It covers approximately 1 acre (35 dunams) and contains the remains of a fort originally 1,600 m2 in extent (Oren 1973a, 1973c, 1973-75, 1982). This structure is poorly preserved but comprised a large mud-brick enclosure with 3m thick walls and installations in the courtyard. Mammalian and fish bones were found in patches on the courtyard floor that survived. To the south of the fort, the foundations of a mud-brick storage facility were found. This warehouse had long narrow halls which fronted onto open courtyards. Near to the stores, a below ground level granary with four mud brick silos, each ca. 4 metres in diameter, was excavated (Fig. 5.2). The silos originally had corbelled domes and plastered walls and floors. The estimated potential holdings of the 4 silos together were 40 tons of cereal or legumes. A layer of organic residue was preserved on the silo floor beneath a fill of ceramics, alabaster and faience vessels as well as animal bones indicating that following their disuse as silos these structures served as refuse pits for the fort. Some 200m south of the fortress, remains of what appears to have been a reservoir for collecting rainwater was found. The majority of ceramic vessels found at BEA-10 are Egyptian in origin with few imports of Canaanite, Cypriot and Mycenean ware (Goren et al. 1995; Oren 1993a).

Only 14 bones of terrestrial mammals were recovered, all derived from fill of the silos (Table 5.1). Three bones were unidentified splinters while identified remains represented sheep, *Ovis aries* (N=2), sheep/goat (*Ovis/Capra*) (N=7) and pig (*Sus scrofa*) (N=2). Sheep/goat were represented by all skeletal elements (Table 5.2), with at least one adult animal aged 3.5 years or older. The pig was a young animal aged 16 months or slightly less based on tooth eruption and wear (Silver 1969).

A total of 187 fish bones were identified, the majority derived from the fill of the silos. Representatives of seven families were identified, the majority being marine in origin, primarily representatives of the breams (Sparidae) and meagers (Sciaenidae), taxa which inhabit marine inshore or lagoon environs (Ben-Tuvia 1971). Small numbers of remains were also found of: Mugilidae a marine family which inhabits coastal waters as well as lagoons and estuaries, and two other marine families – groupers (Serranidae) and elasmobranchs (Chondrichthyes). Both the latter taxa inhabit sandy, muddy bottoms and inshore areas. The only freshwater family identified were members of the Cichlidae (tilapia), represented by only 4 bones.

5.4.2.1.2 Site A-289 (Hareba or Haruvit)

The site lies on the edge of an active dune area and represents remains of a NK structure covering an area of ca. 3 dunams with four occupation phases discernable (from oldest to youngest) (the following description is based on publications by Oren (Oren 1980a, b, 1982-3, 1983, 1987a,b, 1993a, unpublished) (Fig. 5.2).

Level IV - a domestic occupation which preceded the construction of the fort.

Level III - reconstruction of fort in 13th century BC by Seti I (19th Dynasty). In this period the fort extended over an area of ca. 2,500m^2 and comprised a mud brick enclosure wall 4m thick with a gatehouse located in the eastern part (13x12m). The wall enclosed a large courtyard of which approximately 1/3 was not built – possibly for chariots and tents. The remaining 2/3 of the courtyard was flanked by rooms which may have served as kitchens, warehouses for equipment and provisions, or residential units. Large buttresses on the north wall and north-east corner may have served as watchtowers, while a mud-brick platform in the north-east corner probably supported wooden stairs that facilitated access to the walls. Inside the buttresses which flanked the gatehouse were storage cells entered by ladders from above. Finds from inside the fort included abundant Canaanite vessels dating to the end of the Late Bronze Age-beginning of Iron Age, Cypriot and Mycenean imports, and Egyptian pottery typical of the 19th-20th Dynasties.

Level II - extensive repairs and reuse of original structure. It ceased to function as a fortress and may have become an administrative centre as attested to by spacious new buildings erected in the western wing. However, refuse pits and human burials in the residential areas suggest that part of the site was unused already in this phase. A fire destroyed this occupation in the early to mid- 12th centuries BC.

Level I – use of the site perhaps by squatters using characteristic Philistine ceramics which indicate an Iron Age I date of ca. 1050-1000 BC.

The majority of animal remains available for study are derived from Levels III, with only a small sample from the refuse pits in Level II. For the purpose of this study only material from Level III are presented here.

The faunal assemblage comprises a large component of fish (43% of identified sample) (Table 5.1). A total of 238 fish bones were identified representing 8 Families. The most common bones were those of marine families that inhabit inshore waters - Elasmobranchs, Chondrichthyes (N=89) and breams (Sparidae) (N=67). Three other marine families were the next most important, represented by slightly less than 20 bones each – mullets (Mugilidae), groupers (Serranidae), and meagers (Sciaenidae). Freshwater families were poorly represented - Cichlidae (tilapia), Claridae (Nile catfish) and Centropomidae (Nile perch).

Sheep/Goat

Due to limited time allotted for study of this assemblage by the Israel Antiquities Authority, only a representative sample of the terrestrial fauna was examined. As illustrated in Table 5.1, domestic sheep/goat were the most common taxa and constituted some 35% of the identified sample. When calculated against cattle, these small livestock constitute 71% of the assemblage. Both sheep and goat are represented their ratio being 1:3.

Bone mineral density has been shown to be well correlated with the extent of bone survivorship. Dense bones (such as the distal humerus and tibia) have high bone density values, while their proximal counterparts have low values (Lyman 1994). In order to test the extent of post-depositional attrition on the assemblage, three features in the samples were examined. the relative proportions of teeth and bones was examined. The first was the proportion of teeth to cranial bones (Table 5.2a). Since tooth enamel is the densest material in the skeleton and is usually the most resistant to destruction, if a sample is poorly preserved due to bone mineral density mediated attrition (Lyman 1994), then one would expect to find a far higher number of teeth. At Haruvit the numbers were almost equal (22 teeth to 23 cranial bones) suggesting that bone preservation at the site is good. A further test of preservation status of the assemblage examined the frequency of proximal to distal epiphyses in two long bones – the humerus and the tibia (Table 5.2a). For sheep/goat at Haruvit there were 73% distal compared to 27% proximal humerus ends, while for the tibia the proportion was 50%-50%. Admittedly sample sizes are small, which may mask some of the patterning. However, together with the cranial-tooth results, it would seem that although the sample has suffered some degree of attrition, it is not of great magnitude. Thus, at this site, body part categories can be perceived as a good reflection of what was initially discarded on-site.

With respect to skeletal elements, all body parts are represented (Table 5.2a, Fig. 5.3). There is a very high frequency of trunk and cranial elements - probably due to the inclusion of fragmented teeth and rib shafts. In order to assess whether there was any statistically significant correlation between the skeletal elements represented at the site and their carcass utility values, in terms of quantities of meat, marrow and grease that may be obtained from each, a bivariate scatterplot (Fig. 5.4a) was made of %MAU values (Minimal Animal Unit, following Binford 1978: 74-81; Lyman 1994:225-229) for sheep/goat skeletal elements from the site, against a normed General Utility Index for sheep (%MGUI) as given in Binford (1978). Table 5.2b gives the raw %MAU data used in the plot, calculated using data in Table 5.2a, as well as the %MGUI values for sheep from Binford. When a bivariate regression was plotted there was no significant correlation between the two parameters ($r_s < 0.10$) $P=0.09$), such that the individual skeletal elements represented in the site appear not to have been selected with regard to their utility value.

Age at death based on bone fusion shows that very few immature sheep/goat died (11%) in their first year. This frequency increased to 40% by the second year. By 2-3 years of age mortality rates reached 56% meaning that over half the herd was culled by then. It dropped again, slightly to 62% by 3.5 years (Table 5.3). A mortality profile such as this fits a herd managed primarily for meat with a high cull of immature animals aged less than 2 years and few animals kept into adulthood for reproduction, milk and wool (Payne 1973). As shown in Table 5.2, there were insufficient numbers of lower teeth to undertake age assessments based on dental attrition.

Cattle

Cattle are the second most abundant mammal but constitute only18% of the assemblage as a whole, or 29% when calculated against sheep/goat only. All parts of the skeleton are represented, but trunk elements are very abundant (Fig. 5.3). Examination of limb elements indicates a fairly even representation. Unfortunately the data set was too small to run a meaningful correlation test.

Pig

Few pig bones are represented and represent only 3.5% of the identified sample (Table 5.1). Aside from foot bones, all parts of the carcass are present, and in similar proportions.

5.4.2.1.3 Site A-345

Some 400 metres north of Tel Qedwa (site T-21), a New Kingdom administrative centre Site A-345 was found, dating to the 18th Dynasty. The site was covered by active dunes and only some 1.5 dunams were exposed (Oren unpublished). Three building units were excavated, the largest being a long-halled warehouse in the centre of the site (Oren 1987a, 1993a). The warehouse comprised a series of long and narrow halls that opened onto a central courtyard which was enclosed by a wall and partly divided by a partitioning wall (Fig. 5.3). The floors of the warehouse and courtyard were covered with carbonized grain. Surrounding the warehouse was a series of small rooms which, according to the excavator, may have served as houses, offices and archives for the civil administration. Underlying the warehouse, earlier domestic remains and refuse installations were found.

To the east of the warehouse, on the edge of the site, an industrial area was found. It was separated from the storerooms by a partition wall. Investigations yielded remains of a potter's workshop complete with kilns which specialised in the manufacture of Egyptian type ceramics that were probably distributed to other Egyptian settlements in north Sinai. Few Canaanite and Mycenean vessels were found, but abundant Cypriot imports were present.

A 'casement walled' structure ca. 25 metres long, was found to the north-west of the stores, and formed the northern border of the site (Oren 1993a). It was constructed of thin plastered walls and plastered brick benches and partitioned on its inner aspect by thin buttressed walls. It does not appear to have formed a defensive wall, this coupled with the absence of a destruction layer indicates that the site was abandoned peacefully.

Bone taphonomic resembles that of Haruvit, with equal numbers of teeth and cranial bones (teeth=20, cranial bones=24) (Table 5.2). Similarly, distal humeri are far more abundant than proximal ends (78% to 22%), while for the tibia the proportion was 50%-50%.

Site A-345 shows a predominance of small stock (77%), with a preference for goats over sheep (33 to 5 bones positively identified) (Table 5.1). Skeletal element breakdown shows that all body part categories are well represented, with a preponderance of trunk and hindlimb elements (Table 5.2a, Fig. 5.3). Feet are the least abundant body part followed by forelimbs and cranial remains, the latter comprises relatively few teeth, and those found are from the upper jaw. Due to the paucity of mandibular teeth no data on dental attrition is available for this site. A bivariate plot of %MAU for sheep/goat skeletal elements at the site against %MGUI based on for sheep (Table 5.2b) shows that there is no significant correlation between the two variables ($r_s<0.10$; $P=0.07$) such that the skeletal elements represented at the site appear not to have been selected due to their utility value.

With respect to ageing based on bone fusion, it seems that few sheep/goat died or were slaughtered in their first year (11%), this frequency increased to 40% by the second year. It levelled off at 2-3 years to a mortality rate of about 60% a cull level that continued into adulthood - 3.5 years (Table 5.3). This best fits a herd managed primarily for meat, with few adult animals kept.

Cattle are the second most common taxon but constitute only 13% of the remains, while pig bones are scarce (4% of sample). Cattle and pig are represented by all body parts, especially trunk elements (Table 5.2, Fig. 5.3), with the exception of foot bones which are absent in the pig sample. Cattle bone fusion indicates the presence of calves, however the sample is too small to elaborate upon this finding.

Fish are also poorly represented (only 4% of the remains) (Table 5.1). The 11 fish bones represent an equal number of marine/inshore taxa (Sparidae, Sciaenidae, Mugilidae) as well as freshwater species (Cichlidae). Birds were only represented by a fragment of ostrich eggshell.

A total of 99 of the unidentified bones are burnt (45%), while in the diagnostic portion of the sample, this was considerably lower with only 31 bones showing signs of burning (12% of identified sample).

Cut marks were evident on only one bone a sheep/goat humerus. On the shaft, just above the distal epiphysis, two parallel cut marks were visible.

5.4.2.1.4 Site A-343

This site lies on the slope of a consolidated dune and unlike the other sites, probably represents a temporary encampment or transit station. On the surface, installations made of stone clusters as well as hearths, faience scarabs, beads and lithic artefacts all dating to the NK were found (Oren 1993a, unpublished). A small assemblage of 88 animal bones was associated with these finds. Of these 58 could be identified to species and skeletal element.

Sheep/goat are the most common taxa (55% of assemblage); only 2 bones were positively identified as those of goat, and 1 of sheep (Table 5.1). Equids, primarily donkey are the next most common (31%), followed by cattle (12%).

Given the small data set, only tentative conclusions can be reached concerning age and skeletal element representation. The few sheep/goat bones that could be examined for bone fusion indicate a predominance of very young animals – including some culled under 1 year of age (Table 5.3). Unfortunately no dental ageing was possible. Skeletal element breakdown for sheep/goat shows few trunk and foot elements, mainly crania (inflated due to isolated teeth) and long bones (Table 5.2a, Fig. 5.2). No correlation was found between %MAU and %MGUI (Table 5.2b). One sheep/goat patella and one unidentified fragment were burnt, while a sheep astragalus had cut marks on the anterior aspect.

Cattle were represented by a jaw fragment, vertebra, tibia shaft and foot bones. All appear to belong to adult animals. Although teeth are the most abundant element, the equids are represented by the full range of skeleton parts. Only adult animals are represented. A donkey third phalanx is burnt, and a rib shaft had been severed at one end.

5.4.3 Discussion

Despite the fact that they are located in different parts of northern Sinai (Fig. 7.1), in terms of their faunal component, the NK military-administrative centres closely mirror one another. Since they also appear to have experienced similar taphonomic conditions, biases due to bone mineral density mediated attrition are minimal.

All sites are dominated by sheep and goat (with more goat than sheep), followed by cattle. When the two groups are summed, sheep/goat constitute over 70% of each sample compared to cattle with ca. 30%. All sites contain abundant fish remains, primarily of inshore species, with few deep sea species, indicating that they were probably fished locally off the north Sinai coast. The few freshwater taxa may have been fished in the nearby ‘East Frontier Canal’. Pigs are represented but in low numbers, and wild fauna are absent with the exception of a gazelle bone from A-345. An unidentified bird bone from this same site may represent either a wild or domestic species.

In terms of age profiles of sheep/goat (Table 5.3), few animals were aged under 1 year while only ca. 40% reached adulthood - 3.5 years. A kill-off pattern with a high mortality in the 2-3 year age range, as found at these sites, is typical of a management strategy aimed at meat production. According to Payne (1973), both rams and ewes not needed for reproduction are preferentially culled around 2 years of age, when food intake does not exceed output.

Skeletal element representation for sheep/goat also shows a remarkable inter-site concordance, with very high frequencies of trunk elements, few foot bones and similar frequencies of limb and cranial remains (Fig. 5.3). Although no significant correlation was shown between utility indices and individual skeletal elements, it is evident that when grouped into body part categories that meat-rich limb and trunk elements are the most common, while foot bones and crania, which have the lowest utility value, are present in the lowest frequencies. Given the ageing data, such a pattern tallies well with a production strategy aimed at meat.

For cattle, an almost identical pattern for body parts is found (Fig. 5.3), which is a high frequency of trunk elements while all other skeletal elements are poorly represented.

While sheep and goat are the most common species found in all the New Kingdom sites presented here, there is a clear division between the military-administrative centres on the one hand (Sites A-345, A-289 and BEA-10), and the transit site or temporary encampment (A-343) on the other.

The military- administrative sites are characterised by:

- an absence of beasts of burden – donkey, horse, camel.
- presence of pig (albeit in low numbers).
- presence of abundant fish remains.

-sheep/goat are represented by very high frequencies of trunk elements and low frequencies of foot bones.

The transit camp (A-343) is characterised by exactly the opposite pattern – no pigs or fish, few cattle remains and a high frequency of beasts of burden - equid as well as camel (Table 5.1). Differences are also evident in terms of sheep/goat skeletal elements, with the camp containing low frequencies of trunk elements and very high numbers of cranial remains (Fig 5.3). The limited data on ageing (Table 5.3) indicates that animals were also slaughtered young at this site.

The absence of pig remains at A-343 is logical given their unsuitability for nomadism (Horwitz and Studer 2005; Zeder 1996), which emphasizes that this was a temporary camp. Likewise, the presence of equid in this sample, may relate to its role as a transit camp.

Based on these results it may be postulated that the observed differences in patterning relate to the different function of the sites and the fact that the military-administrative sites were provisioned, while the transit camp was not. In terms of the model of provisioning outlined above, the NK sites correspond closely to the expected pattern of a provisioned site:

(a) In terms of species composition they contain a narrow range of taxa, almost no wild species, no exotic animals, no beasts of burden, and the same seven or eight fish families.

(b) In terms of species, they are all represented in similar frequencies – predominance of sheep/goat, 13-16% cattle and 3-4% pig. Although the fish families vary between sites in their importance, this may be an artefact of the extent of area excavated.

(c) With respect to age profiles, the sites follow the same standardised pattern for sheep/goat with a large number of animals slaughtered when immature for meat: ca. 40% of the herd culled by 2 years, and 60% by 3 years.

(d) In terms of skeletal elements they show a standardised pattern with relatively higher frequencies of meaty bones (especially trunk elements), than non-meaty ones.

It may be concluded then that the New Kingdom Egyptian military-administrative sites in northern Sinai were probably provisioned. It is not clear whether these meat provisions came from Egypt or Canaan. A hint in this direction may be obtained by examining the place of origin of ceramic vessels found at the sites. Petrographic analysis undertaken by

Goren et al. (1995) shows that a high proportion of jars (that may have functioned as storage vessels) were imported from Egypt. However, this same study shows that the majority of ceramics classified as 'table ware' were locally produced.

Further insights into this issue may be obtained by comparing the species composition of the NK military-administrative forts to that of another NK fort in the same system, Tel el-Borg, which lies close to the Suez Canal some 10 km north-east of Qantara East (Hoffmeier 2002). Unfortunately no quantitative data are available as yet for this site, but based on the short species list posted on the web (Loyet 2003), it is clear that a broader range of taxa are found than in the NK sites studied here. The species list for Tel el-Borg comprised of cattle, pig, sheep/goat, donkey, small horse, dog, fish, turtle, crocodile, birds, rodents and ostrich eggshell. Fish taxa are predominantly freshwater species (catfish, Nile perch, drum fish), while the birds are dominated by waterfowl (ducks and geese) either attesting to hunting or that they were kept. Most of the cattle remains belong to young animals which has been interpreted as reflecting animals preferentially selected for meat. In turn, this indicates that the site was probably provisioned with cattle herds brought in from the delta or elsewhere in the Nile Valley (Loyet 2003). In contrast, pigs show a broader age range, which together with their poor adaptation to long distance travel and their ability to live in urban environments, has led Loyet (2003) to consider that they may have been raised on-site, as at Tel el Amarna.

Given the incomplete data set from Tel el-Borg, comparisons are limited. However, it is clear that at all NK forts there is a preference for young animals. A salient difference is that instead of sheep/goat dominating the assemblage, "of the domesticates, cattle and pig were by far the most common, and most likely represent the majority of the food resources at Tel Borg" (Loyet 2003). This difference cannot be attributed to chronology since Tel el-Borg was part of the same system of Egyptian forts manning the 'Way of Horus". Moreover, in the NK sample studied here, similarities in faunal composition cut across chronology with Sites A-343 (transit camp) and A-345 (military-administrative centre) slightly earlier than A-289, that also represents a military-administrative centre (Goren et al. 1995).

How can this inter-site variation in faunal composition be accounted for? I propose that it relates to the specific location of the sites. Tel el–Borg is located on the edge of the well-watered Nile delta this being the eastern-most edge of Egypt proper at this time. In contrast the NK sites presented in this study are located either mid-way along the coastal plain or at the extreme western-end of the "Way of Horus", on the edge of Canaan. The border area with Canaan is more arid, while the edge of the Nile delta offers an extremely well watered region with lush vegetation that can support animals with high water requirements such as pigs and cattle. This difference is also evident in the presence of mainly freshwater fish and waterbirds at Tel el-Borg, while in the other NK sites, the fish are primarily marine taxa and few bird remains were found (this does not appear to relate to problems of bone recovery and preservation since abundant fish bones were recovered from the sites of A-289 and A-345).

Sites in Egypt

Not only do animal remains reflect local ecosystems, but they may also reflect ethnic dietary preferences. Thus, the high numbers of cattle and pigs at Tell el-Borg must be examined to see whether it relates to cultural differences between Egyptians and Canaanites, to ecological factors, or to both. Since el-Borg is situated on the very edge of the NK Egyptian Empire, it is possible that this proximity dictated local diet. Is the Tel el-Borg assemblage then typical of Egyptian assemblages or does it simply reflect the specific environmental conditions prevailing around the site?

Unfortunately, there are currently no detailed archaeozoological reports available for NK sites from the delta region[17], such that of necessity, comparison was made with Old and Middle Kingdom sites from this region - Kom el-Hisn (Moens and Wetterstrom 1988; Redding 1992), Tel el-Fara'in-Buto I (Boessneck and von den Driesch 1997) and Tel el Daba'a (Boessneck and von den Driesch 1992a), as well as New Kingdom sites such as Tel el Amarna (Hecker 1982, 1984), Memphis (Ghaleb 1995) and El-Hibeh (Redding 1984) located in Middle and Upper Egypt.

The Old Kingdom site of Tel el-Fara'in-Buto I in the western part of the delta, yielded similar proportions of cattle and pig remains (41% and 55% respectively) while sheep and goat together comprised only 1% of the large mammal remains (Boessneck and von den

---

[17] An exception is the slightly earlier, 19th-20th Dynasty Ramesside campsite at Al Qantir in the easten delta (Boesssneck and von den Driesch 1992b) which yielded a small sample of predominantly wild taxa including elephant, gazelle, antilope, hippotragus as well as domestic donkey, horse and goat.

Driesch 1997). The site of Kom el-Hisn, located on the western edge of the delta, and was the capital of the third nome of Egypt in the Old Kingdom. Its physical location is therefore quite comparable to that of Tel el-Borg. Redding (1992) reports that sheep, goat and pigs were the main animals in the assemblage; pigs comprised 51%, sheep/goat 45% and cattle only 2% of the identified remains. Birds and fish comprised a large portion of the sample as well, reflecting the access to freshwater resources. Although cattle are poorly represented, high pig frequencies as found here are unparalled in coeval sites in Canaan (see examples in Horwitz and Milevski 2001).

At the Middle Kingdom site of Tel el Daba'a (Boessneck and von den Driesch 1992a), cattle and sheep/goat are the most common taxa in all excavated areas (approximately equal frequencies), with relatively few remains of pig (on average less than 10% of the large mammals), this despite the fact that this site is located in the well-watered delta. For the New Kingdom site of Memphis, no quantitative data are available, but Ghaleb (1995: 23) notes (in order of importance) that "domesticated cows, sheep, goat and pig were the staples".

Examination of these archaeozoological reports then indicate that in Egypt, pig and cattle frequencies fluctuate between sites even within the same period. Pigs comprise 51% at Kom el-Hisn, while at the contemporaneous Old Kingdom site of Giza they make up only 1% of the large mammals. Similarly, in the New Kingdom site of Tel el Amarna pig frequencies reach a high 47% (Hecker 1982), but at coeval El-Hibeh located close to the Nile in Middle Egypt, they comprise a low 5% (Redding 1984). At Amarna sheep/goat and not cattle are the second most common animal (38% of the total compared to 15% respectively), while at El-Hibeh cattle are the second most common taxon. However, when dominant, cattle and especially pigs attain high numbers seldom found in any of the coeval sites in Canaan.

Domestic Sites in Canaan

Horwitz and Milevski (2001) examined the faunal composition from six Late Bronze Age II sites in Israel. They found that in five sites located in different parts of the country, sheep and goat were clearly the preferred species and comprised 40% or more of all identified remains. The exceptional site, Tel Dan, which has more cattle than sheep/goat, may simply reflect the extremely rich resources available in the environs of the site. Indeed, generally cattle frequencies varied depending upon region, with higher numbers in sites in the north of the country versus lower numbers in sites in the central and southern regions (Horwitz and Milevski 2001: Fig. 16.2). Even in the two sites included in this study with a strong Egyptian presence – Tell Jemmeh and Lachish, cattle remains were less than a third of the caprines. To these sites can be added the recent data from the Late Bronze II levels at the site of Miqneh-Ekron, where caprines comprised 57% of the remains followed by cattle with only 27%, the remainder represented pigs and wild taxa (Lev-Tov 2000).

The Late Bronze Age II levels at the site of Tel Halif, located in southern Canaan some 15km north of the modern town of Beersheva, represents one of the Late Bronze Age sites from Israel that are nearest to north Sinai for which the faunal data have been published. Here comparable proportions of sheep and goats to those reported from the north Sinai military-administrative centres were found; sheep/goat 78%, cattle 6% and pig ca. 14% (remaining 2% are equids and gazelle) (Seger et al. 1990). At Tell Jemmeh, the southern-most site in this group, sheep and goat together comprised 81-85% of all identified large mammals in the Late Bronze Age levels (Wapnish 1982). Cattle were second with a range of 14-18%. Other taxa identified were camel, equids, chicken and pig, the latter comprising a low 1% throughout the Late Bronze Age sequence. In fact, relative to the preceding Middle Bronze Age, pigs decrease in importance in the Late Bronze Age a feature that was interpreted as either reflecting increasing aridification or dietary prohibitions of the Egyptian elite (Horwitz and Milevski 2001).

As a whole, this brief resume of faunal assemblages from a range of domestic sites in Israel contrasts with that for Egypt in that:
(1) sheep and goat remains are consistently the most plentiful in sites from Canaan
(2) pigs never attain the high frequencies found in Old, Middle or New Kingdom sites in Egypt, or for that matter the high 51% reported for Tel el-Borg.
It is possible to conclude that Egyptian sites are characterised by preferential consumption of beef and pork, as opposed to mutton/lamb and goat/kid which were consumed throughout Canaan.

Sites in Canaan with Egyptian 'Governors' Residencies'

A final test of the hypothesis, as to whether the differences between Tel el-Borg and the NK sites studied here reflect local provisioning differences due to environment or ethnic dietary preferences, is to examine the archaeofauna from sites located deep in Canaan but containing clear evidence of Egyptian administration, such as the presence of an Egyptian 'Governors' Residency' (Oren 1984). Archaeozoological data, albeit uneven, is available for two such sites: Bet Shean and Aphek (Oren 1984).

The Late Bronze Age Governors Residency/Palace at Tel Aphek reveals an interesting pattern, with an equal number of remains of cattle and sheep/goat – 44% compared to 40% (Horwitz in press c). Few pig remains were found – only 3%. Since no statistically significant difference was found in the proportions of the main domestic taxa between the Late Bronze Age II Residency and the Late Bronze-Iron I residential area that was built on top of it, it may be concluded that equally high cattle and caprine frequencies in the Late Bronze Age are not aberrant but the result of local ecological conditions. The site lies at the source of the Yarkon River, which would have offered both lush vegetation and an abundant perennial water supply. Thus an ecological rather than ethnic explanation appears to be the most parsimonious explanation for the observed faunal patterning.

.

Archaeozoological infomation is available from two excavations of the Late Bronze Age Egyptian Garrison/Residency (Bld. 1500) at Bet Shean. The first (cited in James and McGovern 1993: 199-201) provides limited quantifiable data with species identified listed as: ca. 53 cattle bones some of which were identified as large mammal possibly cattle, 12 goat horns, ca. 30 sheep/goat bones and teeth, ca. 6 fallow deer antler pieces, 2 equid teeth, ca. 3 dog remains, 2 fish vertebrae, freshwater as well as marine shells – 2 from the Red Sea the remainder from the Mediterranean (James and McGovern 1993). The authors state that the paucity of caprine remains and high numbers of cattle bones reflect the selective recovery of large bones during the excavation. The second study undertaken on a small sample recovered from this same building (Horwitz 2006: Table 26.10) describes 196 bones representing sheep, goat, cattle, pig, dog, donkey, fallow deer and gazelle. Some 49-51% (depending on the phase) of the remains belong to sheep/goat and 22-28.5% cattle, while pig frequencies range from 9-13%.

From this discussion it is clear that all sites in Canaan, including ones under Egyptian administration, were either dominated by sheep and goats followed by cattle or else had similar proportions of caprines and cattle. All sites had low frequencies of pig. Cattle frequencies particularly vary according to a geographic gradient which relates to availability of pasture and water sources. In contrast, species ratios in sites from Egypt examined here appear to be even more variable but less dominated by one taxon than another. Admittedly, Egyptian sites deriving from different ecological zones and time periods were examined, which may have obscured the picture to some extent. However, several Egyptian sites have yielded extremely high frequencies of pig, a feature which is unparalleled in the Israeli archaeozoological record. In this feature, the Egyptian sites show no clear ecologically based patterning nor one that is chronologically determined (for discussions of this issue see Hecker 1992; Miller 1990; Redding 1992). Clearly, further research is needed to clarify this issue.

It may be concluded then, that not only were the northen Sinai NK military-administrative centres provisioned, but that the fresh meat was obtained locally, from settlements in Canaan. In contrast, the source of the provisions supplied to the NK fort of Tel el-Borg was Egypt. Thus, for north Sinai it seems that local environmental conditions rather than ethnic dietary preferences *per se*, have dictated the faunal composition of these contemporaneous Egyptian forts/administrative centres.

CHAPTER 6

THE IDENTIFICATION OF SITE FUNCTION BASED ON ANIMAL REMAINS: THE CASE OF KUNTILLET 'AJRUD (HORVAT TEIMAN), NORTH-EAST SINAI

6.1 INTRODUCTION

Kuntillet ‘Ajrud is located in north-east Sinai on a hilltop adjacent to Wadi Quraiya, some 50 kms south of Qadesh Barnea (Figs. 6.1 and 6.2). The site straddles an important intersection of three desert routes; the first, the “Darb el-Ghazza” which passed from El Arish/Gaza to Elat, the second, a route which crossed Sinai from west to east via Wadi Quraiya, and a third route which ran to southern Sinai (Fig. 6.1) (Meshel 1982-3, 2000). During 1975-1976, three seasons of excavation were carried out at the site of Kuntillet ‘Ajrud (Israel grid 0940.9560) under the direction of Dr. Zeev Meshel (Tel Aviv University) (Meshel 1976, 1977a, c, 1978, 1979, 1981, 1982-3, 1987 1993). Based on radiocarbon dates, the site’s occupation appears to have been short-lived, and spanned a single period from the end of the 9th century BC to the beginning of the 8th century BC i.e. Iron Age II (Carmi and Segal 1996; Segal 1995).

The settlement comprises only two buildings; a well preserved main structure (A) located to the west, rectangular in shape and some 15 x 25 metres in extent comprising a large central courtyard surrounded on three sides by long casement rooms with towers at each corner (Fig. 6.3). The walls of this structure were constructed of local chalkstone reinforced with tamarisk branches, which were then plastered over with a mud-straw mixture. The smaller structure (B) was situated slightly lower on the hillside some 10 metres to the east and was badly eroded (Meshel 1976, 1977a, c, 1978, 1979, 1982-83, 1987, 1993) (Fig. 6.3). Based on the architecture and ceramic finds (abundance of large storage jars and pithoi), a series of compartments along the western (L10, L71, L86, L92, L93), southern (L3, L8, L11, L41/50, L52, L256) and north-east (L18) part of the main structure were identified as storerooms (Figs. 6.3 and 6.4). Finds of note from the site include a large corpus of ceramic vessels (Ayalon 1995) and extremely well preserved organic remains including cloth mostly woven from flax, rope, wooden vessels, lentils and pomegranate seeds (Meshel 1977a, 1978). Most outstanding though is the large corpus of inscriptions in Phoenician and early Hebrew script (Hadley 1993; Meshel 1982-83), and drawings of human figures, plants and animals executed on the plaster covering the walls, doorjambs and benches, as well as on ceramic and stone vessels (Fig. 8.3) (Beck 1982; Meshel 1977b).

In features such as location, architecture, material culture (presence of inscriptions and drawings, rarity of cooking vessels, absence of agricultural implements, abundance of small ‘special’ vessels in cubicle-rooms) and limited time of occupation, the site of Kuntillet 'Ajrud stands out from other contemporaneous Iron II sites (Meshel 1993; Ayalon 1995). These features have led the excavator to propose that the site functioned as a religious centre or roadside shrine inhabited by priests (Meshel 1976, 1981, 1982-83, 1993). However, Hadley (1993) has proposed that it probably served as a road-station (‘khan’) for travellers, thus serving a secular rather than ritual function, while more recently Finkelstein (1995: 151) noted that its physical isolation combined with the presence of storage facilities “dictated its nature as a combination of cult place and road station”.

This chapter describes the small faunal sample recovered during excavations at ‘Ajrud and investigates whether these bone remains can help clarify the function of the site. This, as faunal assemblages recovered from ritual sites often differ markedly from those recovered from secular contexts in features such as the range of species and skeletal elements represented, the age and sex profiles of animals slaughtered, frequencies of burnt bones and butchery marks, as well as the spatial distribution of the remains (Horwitz 1987, 1999, 2001; and papers in Ryan and Crabtree 1995).

Identification of the animal bones recovered from ‘Ajrud was initiated by the late Dr. S. Hellwing (Tel Aviv University) in the early 1980’s, but his findings were never published and this material was mislaid. The current description is based on Hellwing’s listings, supplemented by additional material studied by the author (Table 6.1 and Appendix A). Unfortunately, in most cases no details concerning skeletal element represented, body side or state of fusion were provided in Hellwing’s list, such that the data are not wholly comparable with the newly examined portion of the assemblage. His list does however provide some indication as to the taxa represented and their spatial distribution and has therefore been incorporated in this chapter.

6.2 FAUNAL REMAINS FROM ‘AJRUD

6.2.1. Artiodactyls

<u>Sheep/Goat</u>: The most common artiodactyl remains were those of domestic sheep and goat (*Ovis aries*/*Capra hircus*) (Table 6.1). Their bones were recovered from four loci: L51, L65, L67 and L251 (Fig. 6.5.1) and represent a minimum number (MNI) of four animals, including at least one sheep and one goat (Appendix A). The majority of bones were recovered from L51, a cooking area with ovens situated in the eastern portion of the central courtyard (Fig. 6.3). These finds comprise an almost complete post-cranial skeleton of a young sheep (*Ovis aries*) aged less than 2 years old and a horn sheath of an adult ram (male sheep) which although partially decayed, may have survived due to the extreme aridity of the region. The young animal is represented by fore and hind-limb elements as well as cervical vertebrae (see appendix for element breakdown). One of the cervical vertebrae has a deep puncture mark on its body as a result of carnivore gnawing. In addition, in L51, a pair of scapulae (unfused epiphyses) of a very young sheep/goat aged less than 1 year was found. None of the skeletal elements in L51 showed damage resulting from butchery or burning. Neither did the isolated goat bones (including least one femur) from adjacent loci, L65 and L67. These remains may belong to the same animal.

<u>Cattle</u>: In his species list for the site, Hellwing identified cattle (*Bos taurus*) as present in L252 (the courtyard) (Fig. 6.5.1 and Appendix A). However, no details were provided as to the number or type of skeletal element/s represented, nor of metrical or morphological features relating to this find. The additional material from the site contained no other cattle bones. Since cattle have high water requirements (Schmidt-Nielsen 1979) it seems unlikely (but not impossible) that large numbers of this species were kept at ‘Ajrud, given the high temperatures experienced in Sinai and generally arid environment of the site.

6.2.2. Carnivores

<u>Sand Fox</u>: An almost complete skeleton of an adult, small-sized canid was recovered from the kitchen area (L51) (Fig. 6.5.2). Bones represented were: paired mandibles, scapulae, radii, ulnae, a right femur and tibia, ribs, 4 cervical and 1 lumbar vertebrae (see Appendix A). All epiphyses are fused. Comparison of dental and limb measurements of the 'Ajrud specimen with skeletons of recent canids housed in the comparative zoological collections

of The Hebrew University of Jerusalem and Tel Aviv University (Table 6.2), indicated that the ‘Ajrud specimen represents a sand fox (*Vulpes rueppellii*). Desiccated scats from a small carnivore were recovered from this same locus (Fig. 6.5.2) such that it is feasible that they originate from the sand fox. Given the completeness of the skeleton and presence of coprolites, it is most likely that the fox represents a more recent intrusion, possibly attracted to the site by food remains. The presence of carnivore damage on a sheep vertebra from the same locus serves to corroborate this suggestion.

Additional carnivore scats, not associated with skeletal remains were found in L16, L68 and L104. They too are probably of recent origin, and based on their morphology and size, probably derived from the fox.

Dog: In addition to the fox, skeletal remains of a larger sized canid, probably dog (*Canis familiaris*) were identified by Hellwing in L41 and the adjacent L256 (Fig. 6.5.2 and Appendix A). Since both loci are in the southern storeroom, it is possible that they represent remains of the same animal.

6.2.3. Small mammals, birds and reptiles

Hare: Remains of hare (*Lepus capensis*) were identified in three loci: L19, L51, L65 (Fig. 6.5.3 and Appendix A). L51 contained the larger collection of hare representing hind limb elements of at least two animals (see Appendix A), both immature (with unfused epiphyses).

Rodents: The late Prof. E. Tchernov (The Hebrew University of Jerusalem) confirmed all the rodent identifications made by the author. Cranial and post-cranial remains of a rodent, identified as Sundevall's jird (*Meriones crassus*), were identified from L14, L19 and L51 (Fig. 6.5.3 and Appendix A). This nocturnal rodent inhabits desert regions below the 125 mm isohyet (Shalmon 1993). It is commonly found in concentrations around refuse dumps, suggesting some level of commensalism with humans (Haim and Tchernov 1974). It is therefore not surprising to find this species at the site of ‘Ajrud. An isolated limb bone in L18 may also belong to this species. In addition, Hellwing identified remains of the house mouse, *Mus musculus*, in L50. Like Sundevall’s jird it is a commensal taxon.

Birds: Birds were represented by fragments of ostrich eggshell (*Struthio camelus*) in L81 and feathers (L16, L51, L80, L101, L104) (Fig. 6.5.4 and Appendix A). Like the carnivore scats, the latter probably represent recent intrusions. In Hellwing's list the presence of bird remains are noted in L65, but no indication is given as to whether they represent bones or feathers. The absence of bird bones at the site reinforces the idea that the feathers represent recent intrusions.

Snake: In L18, a rectangular cubicle in the north-east portion of the courtyard, post-cranial skeletal remains (vertebrae and a few patches of skin) of a snake were found (Appendix A). The remains were not identifiable to species as they lacked the diagnostic cranial elements. It probably represents an accidental mortality associated with the deposit. Scales of an unidentified reptile were recovered from L51 and are also probably recent in origin.

6.2.4. Fish (data from O. Lernau)

Seven identifiable fish bones, representing three families, were recovered from the site (L8, L50, L251, L254, L262, L266) (Fig. 6.5.5). Hellwing also noted fish bones in his list, deriving from L14, L51, L104 and L162 (Appendix A), but he offered no identification as to their Family or species. The presence of fish remains in so many loci may indicate that they comprised a substantial component of the faunal assemblage and hence local diet.

One of the families identified is a Mediterranean species; the gilt-head sea bream, termed in Arabic, Denis (*Sparus auratus*, Sparidae), while the other, a grouper (*Epinephelus* sp. Serranidae) originates from either the Mediterranean or Red Sea. The third species, the Nile perch (*Lates niloticus*, Centropomidae), is a fresh water fish found in the Nile and was traded throughout Israel since the Bronze Age (Van Neer et al. 2004a).

The gilt-head bream is represented by two elements of the upper jaw, both from the left side, a left maxilla (L251) and a left premaxilla (L50). The minimum number (MNI) count for this species is one, with both bones probably derived from the same fish. The grouper is represented by one dental bone, the posterior element of the lower jaw (L264). The Nile perch is represented by three abdominal (anterior) vertebrae, the 4th, 5th and 6th along the vertebral column (L262 & L8) and a left neurocranial element (L266). All four elements could conceivably belong to the same fish. The MNI for fish at the site is therefore 3.

6.2.5. Molluscs (Information confirmed by H.K. Mienis)

Three species of shells were identified in the list compiled by Hellwing (Appendix A). Since the material has been mislaid, the identifications could not be directly re-evaluated.

Two species originate from the Mediterranean Sea: the bivalve: *Glycymeris insubrica* (Family Glycymerididae) and the gastropod: *Stramonita haemastoma* (Family Muricidae), both are represented by a single shell. *Stramonita* was exploited for purple dye during historic times. One species: the money cowrie, *Monetaria moneta* (Family Cypraeidae), was represented by three shells. It is an extremely rare species in the northern part of the Red Sea (Heiman 2002), becoming more common towards the Gulf of Aden, while in the Indian Ocean it is a locally abundant species. This species receives its name as Arab merchants shipped millions of these shells, mainly from the Maldives and Andaman islands, to Africa where it was used for centuries as currency (Jackson 1916).

6.3 DISCUSSION

A limitation in the study of the ‘Ajrud faunal assemblage is its small size. Taking into consideration that almost the entire site of Kuntillet ‘Ajrud was excavated (Ayalon 1995), one would have expected a larger faunal assemblage to have been recovered than was the case. While bearing in mind that for a portion of the faunal assemblage from ‘Ajrud no quantitative data are available (the Hellwing list), the assemblage recovered from the site is still relatively small (probably a total of far less than 100 identified remains – 22 occurrences of faunal remains were noted by Hellwing, while in this paper, 31 occurrences were noted – with two comprising articulated skeletons). Ayalon (1995: 190) has raised the possibility that the site was abandoned with ceramic vessels concentrated in the storerooms and the kitchen “cleaned out”. This proposal offers a suitable explanation for the paucity of animal remains. It is also possible that refuse from the site was dumped outside the structure and that this ‘garbage dump’ was not excavated and/or preserved.

In order to try and assess site function based on the faunal remains, several features will be briefly discussed – the depositional processes that have affected the assemblage, the spatial distribution of faunal remains in the site and the representation of species, age and sex classes relative to roughly contemporaneous domestic, military and ritual sites located in the arid areas of the southern Levant.

6.3.1. Depositional history of the assemblage

Before comparing the faunal remains from ‘Ajrud to those recovered from contemporaneous domestic, military and ritual sites, it is first necessary to clarify the relationship between the animal remains and their archaeological context. Certain elements present at ‘Ajrud, such as the rodent and reptile remains, bird feathers and carnivore scats, raise the possibility that at least a portion of this assemblage represents recent intrusions. All are taxa commonly found in the vicinity of the site today and include burrowing animals (rodents) and animals known to utilise abandoned structures or caves for shelter (fox, snake, hare). This, despite the fact that during excavation, the bones and other faunal remains appeared to be *in situ* (Z. Meshel pers comm.1995).

To counter this argument, examination of the spatial distribution of rodent remains (Fig. 6.5.3) shows that they are found in contexts where food was stored or processed – either in areas with many ceramic vessels at the corners of the courtyard (Ayalon 1995: Fig. 29), in the southern storeroom or in the kitchen area. In addition, it is clear that both species of rodent found at ‘Ajrud (*Mus* and *Meriones*) are commensal species, which indicates that they are probably contemporaneous with the archaeological deposit. In contrast, the snake remains were found in anatomical association still with skin adhering, such that it is more likely to represent a more recent element. Similarly, the presence of bird feathers suggests that they too are of recent origin, especially as the majority are derived from the courtyard area (Fig. 6.5.4) which was described by the excavator as being almost totally empty (Meshel 1977a). The partly articulated fox skeleton from L51 may represent an intruder attracted to the site by food waste, shortly after it was abandoned. This is supported by the location of this find in the kitchen area, the presence of small-sized desiccated scats and a sheep vertebra damaged by a carnivore, all from the same locus. Puncture marks are commonly found on remains that have been scavenged (Lyman 1994). Based on its small width dimension (less than 0.5mm), this mark fits the parameters of a fox canine. Consequently, this species may have died on-site shortly after it was abandoned.

An additional issue to be considered is that most species found at 'Ajrud (fox, snake, and sheep) are represented by almost complete skeletons of single animals. This is a rare occurrence in most archaeological sites, with the exception perhaps of some ritual contexts (e.g. Klenck 2002; Wapnish and Hesse 1993). It is however a common characteristic of animals that died due to natural causes or accidents (Thomas 1971). Finally, the ‘Ajrud assemblage contains skeletal elements, such as horn sheaths and faeces, which are rare in most archaeological contexts. However, it is well known that arid environments, such as prevailing in the Judean desert or the Sinai Peninsula, offer an excellent milieu for the preservation of all types of ancient organic remains (botanical, human or animal) and can therefore <u>not</u> be used as a valid criterion for identifying intrusive elements (Horwitz 2002b).

None of the bones found at the site exhibit modifications of human origin, namely cut marks or burning (Lyman 1994). Consequently, it is not possible to link them directly to human culinary or ritual activities.

Based on the points outlined above, it is evident that the association between the archaeological remains and some elements in the faunal sample is unclear. It is highly likely that we are dealing with an assemblage created by multiple processes and agents (Lyman 1994), and that both intrusive and *in situ* material is represented in the assemblage. This factor needs to be taken into consideration when interpreting the fauna in relation to site function.

6.3.2. Spatial distribution

Examination of the spatial distribution of the animal remains from ‘Ajrud shows that with two exceptions, all remains are derived from Building A (Figs. 6.5.1 to 6.5.5). Only fish bones and a few unidentified fragments were recovered from Building B (Figs. 6.5.1 and 6.5.5). For ceramics, a similar paucity of vessels was reported by Ayalon (1995: Table 3) from Building B. This patterning may be explained by the fact that Building B “has been almost completely eroded away” (Hadley 1993: 115; Meshel 1982-83).

Within Building A (Figs. 6.5.1 to 6.5.5), the majority of remains are concentrated in the southern and south-eastern portion of the structure. This follows the pattern reported for ceramics, with 23% of vessels found in the southern storeroom, and 18% in the eastern corner rooms (calculated from Ayalon 1995: Table 3). Few faunal remains were recovered from the open courtyard, which fits with the excavators comment that it was “found essentially empty” (Meshel 1977a: 52), although according to Ayalon (1995: Table 3), 24% of the ceramic assemblage originated from this locality. As illustrated in his Figure 29, the majority of finds were located in the corners of the courtyard. The entrance to the building, located to the east, yielded few faunal or ceramic remains. Similarly, the western portion was poor in both elements (Figs. 6.5.1 to 6.5.5) (Ayalon 1995: Table 3).

There is a marked concentration of sheep, goat, cattle and fish remains close to the cooking facility in L51 suggesting that this served as the main cooking area in this building. As noted by Ayalon (1995: Fig. 29a), “no complete vessels were discovered there, not even pots” which led him to hypothesize that the kitchen area had been cleaned out. In the western part of the building with the exception of the oven in L104, the majority of remains comprised unidentified bones or potentially intrusive elements (rodent remains and feathers).

As shown in Figure 6.3, many of the unique cultural finds, especially the majority of small votives, were recovered from and adjacent to the ‘bench rooms’ located on either side of the entrance to Building A (north bench room: L6, L262; south bench room: L14, L259). In these localities no terrestrial animal bones were found only faunal items representing trade goods – shells from the Red Sea (*Monetaria*) and Mediterranean Sea (*Glycymeris* and *Stramonita*), and fish from the Mediterranean (*Sparus*), Mediterranean or Red Sea (*Epinephelus*) and the Nile (*Lates*). These exotic items may have served as votive offerings. These data provide some support for the archaeologist’s interpretation that the bench rooms were not used as waiting rooms but “for the reception of votive offerings” (Meshel 1982-83: 52).

6.3.3. Species representation

The species represented at ‘Ajrud are given in Table 6.3 and compared to several, roughly coeval Iron II assemblages from the desert regions of the southern Levant. The comparative samples include: four assemblages from military forts located in Sinai or just over the border in the Negev desert (Quseima, Qadesh Barnea, Ein Kadeis, Nahal Sirpad); three ritual localities from the northern Negev Desert – an Edomite cultic complex at Horvat Qitmit, and two Israelite cultic localities at Tel Arad and Horvat ‘Uza; and domestic sites which are represented by the Edomitic site of Tawilan in southern Jordan, and three (?Israelite) sites from the northern Negev (Tel Arad, Horvat Uza and Tel Ira).

Irrespective of site function, domestic sheep and goat are the most common taxa exploited, ranging from 61%-97% in the forts, 91%-96% in cultic sites, and 81%-92% in domestic sites (Table 6.3). Unfortunately, in most reports these species were not separated, such that it has not been possible to explore potential differences in their representation relative to site function. There is some degree of variation between sites (based on function) as to the second most common species. In the forts, beasts of burden and hunted taxa (such as gazelle) comprise the next most common species while in cultic and domestic sites cattle are preferred. However, domestic sites are distinguished from cultic contexts in that they comprise a far broader range of other taxa – carnivores, beasts of burden, birds and fish (Table 6.3).

The ‘Ajrud assemblage differs markedly from the three cultic sites in that it has a far wider range of species. Indeed, of the taxa identified from ‘Ajrud, only four (sheep, goat, fish and possibly hare) are typical Iron Age food items, while at least two of these taxa (sheep, goat and fish) are known to have been used in this region for ritual offerings at this time (e.g. Horwitz 1999; Horwitz and Raphael 1995; Wapnish and Hesse 1993). Noteworthy is the fact that the only shells recovered at the Edomite shrine at Horvat Qitmit, belonged to *Monetaria annulus*, a cowrie species closely related to *Monetaria moneta* (Mienis 1995). Both species have been exploited intensively not only for currency but also as amulets and charms (Jackson 1916). At Horvat Qitmit, cowrie shells appear even in the form of adornments on jar-shaped anthropomorphic statues (Beck 1995: Figs. 3.16-3.17, 3.19-3.20).

At ‘Ajrud, the other species (snake, rodent, dog and fox) are not documented as having been exploited for either purpose. Furthermore, animals represented in ritual sites tend to have been slaughtered young (Horwitz 1999; Horwitz and Raphael 1995). Of the three sheep/goat represented at the site, two are young, but the third is an adult. The hare represents a young animal, but the fox is a mature adult. In ritual contexts, selection of skeletal elements is frequently observed (Horwitz 1999, 2001). However, for the ‘Ajrud sample it has not been possible to examine body part breakdown in any detail. Aside from the fact that two species are represented by almost complete skeletons, the only other interesting feature is the absence of sheep/goat cranial and dental remains, with the exception of the horn sheath. Whether this is a bias resulting from the small sample size or the fact that the animals were slaughtered elsewhere on or off-site and their skulls discarded there, is unclear.

The salient difference between the four Iron Age II fortresses located in close proximity to ‘Ajrud (Table 6.3), as well as to others located further north (Hakker-Orion 2004), is that the ‘Ajrud assemblage lacks remains of beasts of burden –horses, donkeys and camels. In general, as shown in Table 6.1, the faunal spectrum at ‘Ajrud closely compliments that known from Iron Age domestic settlements in the southern Levant (e.g. Hellwing and Feig 1989; Horwitz and Tchernov 1989b; Lernau 1986/87; Lernau and Lernau 1992; Wapnish and Hesse 1991). These sites have a predominance of remains of domestic herd animals – sheep, goat and cattle – and in contrast to cultic sites, also have a broad spectrum of wild and other domestic taxa. However, ‘Ajrud differs from typical domestic sites in that it lacks hunted ungulates (gazelle, deer) and pack animals (equids and camels). It should be noted that the absence of pigs at ‘Ajrud may be related to the arid environment. Based on these data, albeit limited, it is suggested that the faunal remains from 'Ajrud do not comply with the pattern observed at coeval military, cultic or domestic sites. The data also exclude this site from having served a purely cultic function (due to the broader range of species represented) or as a fortress (due to the absence of beasts of burden and hunted ungulates). It should however be borne in mind that the extremely small size of the faunal assemblage may have biased species representation, with rare taxa – such as hunted animals, or those unlikely to have been consumed - such as beasts of burden, not represented.

A final point to note is the absence of any similarity between the spectrum of taxa found on-site and those painted on the pithoi recovered from the site. The paintings include a horse, wild boar, deer, a lion, an ibex and a cow suckling a calf (Beck 1982). The wall paintings are less well preserved but include a goat or another horned animal, the head of an animal that may represent a lion, and a hoofed animal depicted by its forelegs. According to Beck (1982) the same painter or painters, with an identical technique and background, produced the animals. The motifs represented are common in Phoenician and north Syrian art, but their execution is simple and unprofessional. They are probably the work of a local, perhaps amateur artist who imitated themes from other well-known artworks. This would explain the depiction on vessels of non-desert species, such as deer and boar, side by side with ibex.

6.4. CONCLUSIONS

The shallow wells situated at the base of the hill below the site (Ayalon 1995) have obviously played a significant role in determining the location and importance of the site. They would have offered a stable supply of water for both people and their stock. Although sheep and goats animals do not require daily access to water, cattle have a high, daily water requirement (especially in regions with high temperatures and poor pasture) (Schmidt-Nielsen 1979). However, the wells would probably have been inadequate to support large-scale, year-round pastoralism in this hyper-arid region. The keeping of small herds of animals may have been possible, but obviously limited in terms of the quantity of food they would have provided unless their stock was frequently replenished. Traditionally, the keeping of large herds of sheep and goat in the Sinai is contingent upon seasonal migration in search of pasture, either to higher altitudes or out of the region (e.g. Ben-David 1981; Levi 1987). This would have necessitated seasonal mobility of at least a portion of the ‘Ajrud community, making the idea of provisioning of the site from the outside a more viable option especially if it served as a cultic centre or way station rather than as a domestic settlement. An alternative management strategy would have been to supplement the animals’ diet with fodder, including grazing on stubble after harvest and storage of suitable vegetal matter. However, in the absence of evidence for agricultural activities at ‘Ajrud, such as agricultural tools (sickle blades or milling devices) or structures that may have served as granaries, this does not appear to have been the case. The absence of beasts of burden (equids, camel), animals essential to agricultural activities and local trade, illustrates that no large-scale agriculture or specialized production was practiced at this locality.

The absence at ‘Ajrud of medium to large sized hunted taxa (such as gazelle or ibex) that were commonly consumed by Iron Age communities in the desert regions (Table 6.1), may also attest to provisioning at the site. Moreover, the presence of a wide range of imported animal taxa at the site (relative to the size of the faunal sample available), lends further credence to the view that the site was provisioned. Fish were imported from the Mediterranean Sea (located 120kms away) as well as the Nile River (located 330kms away), and seashells from both the Mediterranean and Red Sea (the latter located less than 50kms away) (Fig. 6.1). Finally, the presence of a small fragment of ivory (see Fig. 8.3, L90) from either elephant or hippopotamus, attests to another item that was imported either from Egypt or Syria. In contrast, the other terrestrial taxa recovered from ‘Ajrud are all local species that still inhabit the region today (Osborn and Helmy 1980; Yom-Tov 1987). Several of these though probably represent accidental intrusions (hare, fox, rodents, reptiles, birds). The ostrich eggshell may be a local element collected in Sinai, or else imported from Egypt or the Mediterranean coastal plain.

The idea that the site was provisioned from the outside is supported by the archaeological record. There is a very large corpus of storage vessels and storage areas (in Building A) while Gunneweg et al. (1985), Goren (1995) and Ayalon (1995) have illustrated that the ceramics were imported from a variety of sources within Israel, including the southern coastal region. In a similar vein, Meshel (1978) has noted the presence at the site of wood from both northern and southern sources. Taking into account its unique location at the intersection of routes connecting Sinai with the Mediterranean and Red Sea coasts as well as regions to the north and the proximity of the site to a permanent water source, it is then not surprising to find at the site traded botanical, ceramic and faunal items from a range of northern and southern sources.

It is possible that ‘Ajrud served as a religious centre visited by pilgrims (Meshel 1981, 1982-83, 1993), possibly related to traditions concerning Mount Sinai as suggested by Mazar (1992: 449). If this is this case, then it does not fit the typical pattern for faunal remains documented in other Iron Age cultic localities in the desert regions of the southern Levant. Nor does it clearly fit the pattern recorded for Iron Age II fortresses or strongholds in this region, while it differs in several features from typical Iron Age domestic settlements. An option that accounts for most of the features observed here is that it functioned as a desert way station (Hadley 1993), perhaps with specialized localities within the complex (such as the bench rooms), which served a ritual function, as suggested by Finkelstein (1995). Although the faunal remains cannot offer an equivocal answer concerning the function of the site of ‘Ajrud, whichever interpretation is favored, the results of the faunal analysis discussed here tend to support the contention that the site was largely, if not wholly, provisioned from the outside.

CHAPTER 7

THE SACRED SUMMIT: FAUNA FROM A NABATAEAN SANCTUARY ON GEBEL SERBAL

7.1 INTRODUCTION

Until the 1970's little was known about the Nabataean presence in Sinai since it was thought that they had only entered the Peninsula following the incorporation of their Kingdom into the Roman Province of Arabia in 106 AD (Negev 1967). Even the numerous rock inscriptions in Sinai executed in Nabataean script (Negev 1967, 1987b; Stone 1992) were thought to have been executed by local, non-Nabataean nomads who adopted this script following contact with the Nabataeans (Meshel 1980). With further excavations in both the Negev and Sinai deserts (e.g. Meshel 1982, 2000; Negev 1977, 1987a; Oren 1982, 1993; Rothenberg 1961) and critical research on Nabataean chronology and settlement patterns (e.g. Elliott 1996; Rosen in press; Schmid 2001) this picture has begun to change. The excavation of a small Nabataean sanctuary on Gebel Serbal in south eastern Sinai, carried out in 1976 by Dr. U. Avner (Avner 1982, in press), has added to this growing corpus of data. Most importantly, based on the remains recovered from this site it is now clear that the Nabataean presence in the Peninsula ante-dated their incorporation into the Roman Empire.

7.2. THE SANCTUARY

The following description is based on that of the archaeologist as it appears in Avner (1982, in press).

The sanctuary (Figs. 7.1 and 7.2) is located at the summit of a high mountain, Gebel Serbal. In the valley below the sanctuary, Nabataean inscriptions were identified, as well as caves with built walls and the remains of circular structures (that may have served as housing for pilgrims), and a staircase leading up to the sanctuary on the summit,. The sanctuary at the summit comprised a natural rock surface 15x20 metres in extent, surrounded by steep cliffs that probably served as an open courtyard. At the northern end is a natural rock terrace with remains of a staircase leading up to it. The sanctuary was built ontop of the terrace and comprised a small rectangular structure with an inner square some 2x2 metres in extent (L5). An outer rectangle some 4x6 metres in extent (L1) formed a portico that surrounds the inner structure.

The inner square (L5) appears to have served as a platform since it was filled with small to medium sized stones and the walls were uneven and unplastered. Finds from the bottom of the fill included an amethyst bead, a shell and botanical remains which may have served as foundation offerings.

The outer rectangle of the structure (L1), resembled a portico which opened to the south-south-west. There is evidence that the walls of the rectangle were plastered. A large stone slab lying on the portico floor was interpreted by the excavator as a fallen *masseboth* (standing stone). Material remains recovered from this courtyard included pottery, glass and two engraved sandstone profiles that were probably part of an architectural feature, as well as unidentified organic material, botanical and animal remains.

The area between the inner and outer walls of the structure, termed by the excavator ‘the passage’, was ca. 50cm in width and had a rock floor (L2-4). It appears that all the walls were originally plastered. The fill of this ‘passage’, which may represent a cultic fill (*temenos*), was rich in finds including ceramics, beads, copper items, a Nabataean coin, an unidentified organic substance, botanical and faunal remains. The external perimeter of the structure was also investigated (L7-9) and yielded pottery sherds, animal bones and goat dung.

Based on the material culture, ceramics and coins, the sanctuary appears to have been active from the 1st century BC through to 80 AD i.e. from the 2nd century BC through to the early part of the 2nd century AD (Avner 1982, in press).

7.3 MOLLUSCS (based on Daphi cited in Avner in press).

A small number of molluscs were also recovered from the site comprising three Red Sea species – *Cypraea nebrites*, *Turbo* sp. and *Lambis* sp. - as well as a freshwater mollusc *Melanopsis* that probably originates from the nearby spring of ‘Ein Loza.

7.4 THE FAUNA

7.4.1 Terrestrial Mammals

A total of 70 animal bones were recovered from the site of which 51 (73%) were burnt or calcined fragments that could not be identified to species (Table 7.1). Since burning accelerates bone fragmentation and decay (e.g. Bennett 1999; Stiner et al. 1995), it is not surprising that only 19 bones (27% of total sample) could be identified to species and skeletal element (Table 7.1). Of these, 5 bones (26% of identified sample) were burnt.

Bones were recovered from two main localities. The first locality included material from L2 and L3; the second locality included material from L8 and L9 (Table 7.1).

Loci 2 and 3: These loci are located inside the structure in ‘the passage’ (Fig. 7.2). In this narrow space 20 animal bones were recovered. They included: 12 burnt, unidentifiable bone fragments (60% of this sample); 3 bones of what appear to be a very small sized Galliformes, probably a domestic fowl (*Gallus gallus* f. domestica); 2 bones of a small-sized gazelle, probably *Gazella dorcas*; 3 bones of a ruminant that could either be sheep, goat or ibex (*Ovis/Capra/Capra ibex*).

The gazelle is a juvenile animal, represented by a left astragalus and a tarsal, both of which are burnt. It is likely that the other mammalian fragments, identified as medium-sized mammal, all belong to this same animal. Due to the poor preservation of the bones, and the fact that they are burnt, it has not been possible to determine which gazelle species is represented. Tchernov et al. (1986/87) report that following the continued aridification of western Sinai in the post-glacial period, the dorcas gazelle (*Gazella dorcas*), an African element, migrated into the region after the Pre-Pottery Neolithic B. This resulted in the northward migration of most mountain gazelle (*Gazella gazella*), leaving only a small isolate population that is still found today in a limited region of the Negev desert (Mendelssohn and Yom-Tov 1999). It is most likely that by the Nabataean period, only the dorcas gazelle was present in the Sinai Peninsula. In addition to the 12 unidentified fragments, both the gazelle bones and a fragmented astragalus identified as belonging to a medium-sized ruminant are burnt.

An incomplete left carpometacarpus, a fragment of a left ulna and a rib were identified as those of a small-sized Galliformes, probably chicken.

Loci 8 and 9: The bulk of the animal bones found at the site are derived from this locality, situated outside the perimeter of the structure. In addition to 11 identified bones, 39 unidentified and burnt bone fragments were found here.

The identified material included: 5 fragmented long bones belonging to a medium-sized bovid, either sheep/goat/ibex. Bone elements represented were not diagnostic as to species and included 2 rib fragments, fragments of tibia and femur shafts, and a portion of a left, ascending ramus. The femur and tibia shafts, as well as the ascending ramus are burnt.

In addition, a small sized fowl, probably *Gallus gallus* f. domestica, is represented by 7 bones. Bone elements represented are: an intact left humerus, a right distal humerus, a left distal femur, a left distal tibiotarsus, right and a left ulnae and an intact left carpometacarpus.

7.4.2 Bird remains

An especially interesting feature of the Gebel Serbal assemblage is the presence of 10 bird bones of a small-sized member of the Order Galliformes, Family Phasianidae. In addition to domestic fowl (*Gallus gallus* f. domestica), three species of wild Galliformes are found in the Sinai Peninsula today, differing in size and morphology of their skeletons: the desert partridge (*Ammoperdix heyi*), the chukar partridge (*Alectoris chukar*) and the quail (*Coturnix coturnix*) (Paz 1987; Yom-Tov 1987).

The measurements of the Gebel Serbal bones were compared to skeletal remains of quail, desert partridge and chukar partridge held in the comparative zoological collections of The Hebrew University, Jerusalem the results show the Serbal specimens to be both larger as well as differently proportioned. The chukar is the largest of the wild Galliformes found in Sinai. However, even these specimens were notably smaller than the Gebel Serbal remains (Table 7.2). The limited literature on domestic fowl from Roman-Byzantine sites in the Levant and Egypt, have shown them to belong to a small-sized breed (e.g. Hamilton-Dyer

1997; Lindner 1979; Van Neer and Ervynck 1998). Given the fact that the Serbal bones are larger than wild Galliformes found in Sinai today but still relatively small sized, it must be assumed that they represent a small sized domestic chicken (*Gallus gallus* f. domestica). They may represent the ancestors of the present day desert Sinai breed that is especially well adapted to heat and water deprivation (Arad 1982; Arad and Marder 1982a, b).

Although there are claims for domesticated fowl being present in China already in the 6th millennium BC (West and Zhou 1988), it is generally accepted that the chicken was first domesticated by 2500-2100 BC in south-east Asia (Harappan culture, India) (Crawford 1984). From there it spread into south-west Asia and Europe (West and Zhou 1988), however little is known about the introduction of domestic fowl into the Levant. To date, the earliest chicken remains have been identified from Bronze Age contexts - the Middle Bronze Age I/Intermediate Bronze Age levels (dated to circa 2400-2000 BC) at the site of Sweyhat (north Syria) and the Middle Bronze Age II (MB II) levels at Tel Hadidi (north Syria) dated to circa 2000-1400 BC (Buitenhuis 1979; Clason and Buitenhuis 1997). In Israel the earliest remains of domestic fowl are currently based on tentative identifications from three MB II burial contexts (2000-1550BC): burial caves at the Holyland, Jerusalem (Horwitz 2003c); a tomb in Nahal Refaim, Jerusalem (Sade and Milevski 2004) and a burial cave complex in Rishon Le-Ziyyon (quoted in Sade and Milevski 2004). Aside from the Holyland, none of the other reports contain metrical data, such that it has not been possible to characterize these early chicken breeds.

7.5 DISCUSSION

Information concerning the animal economy of the Nabataeans is sorely lacking. In a recent summary of Nabataean archaeozoology, Studer (in press) indicates that less than ten publications are available, of which only one deals with faunal remains from Sinai (Hellwing and Agiman 2000). The latter is a short report on the fauna from the site of Quseima, north-eastern Sinai, a site that may have served as a caravanserai since it is located on one of the main routes traversing southern Sinai to the Mediterranean coast (Meshel 2000). At this site one large building was excavated which yielded a small assemblage of 45 bones, predominantly domestic taxa. The majority of bones (NISP= 34) were identified as domestic sheep/goat, 1 to domestic cattle, 1 to pig, 2 to camel and 5 to birds, including chicken and song birds. Two pieces of coral were also identified, indicating contact with the Red Sea coast (Hellwing and Agiman 2000: Table 5). At least two sheep/goat represented young animals, while limb bones were the most common elements followed by parts of the trunk (ribs and vertebrae). The pig too was an immature animal, while the camel, cattle and chicken bones all belonged to adults (Hellwing and Agiman 2000: Table 4).

None of the Nabataean archaeozoological reports cited by Studer (in press) deal with remains from a ritual context, a fact that augments the importance of the Gebel Serbal collection. Faunal remains recovered from ritual contexts are often distinct from those recovered from domestic ones (Grant 1991; Horwitz 1987, 1999). Features in which they may differ include selection of animal species, age and/or sex as well as skeletal elements represented, a consistent or unique butchery pattern and the presence of a high frequency of burnt bones (examples of such assemblages from the southern Levant: Horwitz 1986-87, 1999, 2001; Horwitz and Raphael 1995; Klenck 1995, 2002; Lernau 1988; Lev-Tov and Maher 2001; Vila 2004; Wapnish and Hesse 1991, 1993, 2000). The analysis of the Gebel Serbal assemblage was carried out bearing these criteria in mind.

Unfortunately, the small size and poor preservation of the Gebel Serbal bone collection limited the extent of the analysis that could be carried out. However, in at least four aspects the assemblage conforms to features characteristic of ritual assemblages:

(1) Firstly, the assemblage contains an extremely high frequency of burnt bones. Of the 70 bones found at the site, 56 (80%) were burnt (Table 7.1).

(2) Little data is available concerning the age or sex of animals represented in this assemblage apart from the fact that the gazelle bones in Locus 3 belong to a juvenile animal. In Classical periods, immature animals appear to have been favoured for ritual activities world-wide (e.g. Crabtree 1990; Legge and Dorrington 1985; Peters 1993).

(3) With the exception of a small fragment of sheep/goat/ibex jaw, all bones represent long bone shafts, suggesting selection of skeletal elements rich in meat.

(4) The majority of remains were recovered from the fill between the platform of the sanctuary and its outer walls. Together with the archaeological information on their

context, the animal remains from Gebel Serbal are reminiscent of a *temenos* deposit. Such deposits usually contain the remains of animals sacrificed or dedicated in the sanctuary. Following ritual activities, which often included placing a joint of meat on a fire (hence burning evident on the bones) or burning the remains of an offering, the resulting bones and ash, which are sacred, are buried on or near the sanctuary grounds often in pits or crevices.

In one aspect the Gebel Serbal sample does not appear to conform to what we might expect of a ritual assemblage, namely that it does not contain a limited range of species or reflect a clear preference for either wild or domestic taxa. Of the 19 bones identified in this sample, at least three species are represented: gazelle, domestic fowl and sheep/goat/ibex (Table 7.1). However, given the small size of the sample it is difficult to assess whether the Serbal remains are characteristic of Nabataean ritual assemblages as a whole. Domestic sheep, goat and to a lesser extent, cattle, appear to have been the preferred taxa used in rituals in the southern Levant from the Early Bronze Age onward (e.g. Horwitz and Raphael 1995; Lernau 1988; Lev-Tov and Maher 2001; Vila 2004; Wapnish and Hesse 1991, 2000 and references within these articles). Other species such as dogs, birds, fish and a variety of wild animals and molluscs were also exploited but in most cases in smaller numbers (e.g. Klenck 2002; Raphael and Lernau 1996; Vila 2004; Weissbrod and Bar-Oz 2004; for an exception see Wapnish and Hesse 1993).

Of note is that all three taxa found at Serbal have been identified from Nabataean domestic contexts in the region – Petra (Zeitler 1990; Studer 2002, in press), Rujm Beni Yasser (Toplyn 1994) and Deir Ain Abata (Beech in press) in Jordan; Avdat (Horwitz unpublished data) in Israel; and as outlined above, Quseima in the Sinai Peninsula (Hellwing and Agiman 2000). Perhaps this reflects the local nature of the sanctuary, with pilgrims bringing offerings of the animal species commonly raised in the region. Avner (1982) suggested that the Serbal sanctuary primarily served the Nabataean community of the Feiran oasis, since a Nabataean city is known to have been located there. However, it is possible that pilgrims from further afield also used this location.

Although a large corpus of archaeozoological literature exists on the exploitation of animals in sacred rites throughout the Hellenistic and Roman world (e.g. Crabtree 1990; Legge and Dorrington 1985; Mashkour et al. 1998; Nobis 1976-77; Peters 1993; Studer and Chenal-Velarde 2003), almost no parallel literature exists for the southern Levant. One exception is the Iturian temple of Qalat Bustra located on the slopes of Mount Hermon in the Golan Heights, dating to the 4-5th centuries AD (Dar 1993). At this site, 49 animal bones were identified representing domestic sheep (*Ovis aries*) (NISP=1), domestic goat (*Capra hircus*) (NISP=6), undistinguished sheep/goat (N=23), domestic cattle (*Bos taurus*) (N=5), and of special interest, 1 chicken bone (*Gallus gallus* f. domestica) (L.K. Horwitz quoted in Dar 1993). Toynbee (1973:256) notes that in ancient Rome, domestic fowl, especially cocks, were commonly used as sacrificial animals.

The age breakdown of animals at Qalat Bustra documents the presence of at least one large male goat, 2 immature sheep/goat aged less than 1 year, another sheep/goat aged less than 2 years and a third aged 2-3 years. One of the cattle bones, a distal metatarsal shaft, exhibited deep cut marks, while two goat vertebrae also had cut marks on the centrum. All butchery damage is consistent with primary carcass dismemberment. Only one bone, a goat 2nd phalanx was burnt. Although of a slightly later date, the small assemblage from the temple at Qalat Bustra shows some marked parallels with that from Gebel Serbal especially in the choice of species and presence of burnt bones.

Little is known about Nabataean ritual practices. Summarising current information, Schmid (2001) writes that common features of Nabataean temples are, the fact that they tend to be square rather than rectangular, a feature especially true for the inner part of the temple building, and that there is a podium in the inner area of the temple. In addition, numerous ‘high places’ located at high elevations in the natural landscape have been found at Nabataean sites especially Petra and attest to the fact that they worshipped their gods in a natural setting. These ‘high places’ comprise some form of an altar and a small scale hydraulic system (cistern, channels, basins) “probably related to a procedure, that is, the pouring of a liquid such as wine, water or the blood of animals offered to the deity” (Schmid 2001:377). Schmid quotes Strabo (Geography 16.4.27) as saying that the ‘Nabataeans worship the sun, building an altar on the top of the house, and pouring libations on it daily and burning frankincense’. No mention is made of animal sacrifice or the offering of meat/joints.

Both the location and architecture of the Gebel Serbal sanctuary correspond closely to that of other Nabataean ritual localities. Although it comprises less than 100 bones, this assemblage is of great importance as it offers interesting insights into the little known world of Nabataean ritual activities in general, and those in the Sinai Peninsula in particular. From a zoological perspective it offers unique information on the little known development of domestic fowl breeds in the southern Levant.

CHAPTER 8

DISCUSSION AND CONCLUSIONS

Human occupation of the Sinai Peninsula goes back at least 200,000 years as attested to by the presence of Upper Acheulian artifacts (Bar-Yosef 1985). Although this thesis deals only with the record of the last 10,000 years - a period of accelerated human activity in the area - the case studies presented here document the broad range of fauna and associated ecosystems that existed in the Peninsula, the variation in subsistence patterns between northern and southern Sinai, the changing strategies employed by local and foreign communities inhabiting the Peninsula, and how neighbouring polities - Egypt and the southern Levant – related to the region and its resources.

8.1 Faunal biogeography

"*The Fauna. Meeting Point of Two Continents*", the title of a paper by Eitan Tchernov focusing on the past and present animals of Sinai, encapsulates the very essence of the faunal community of Sinai (Tchernov 1979). Indeed, during the Quaternary, the Peninsula served as the only land bridge connecting Africa and Asia. Plants and animals as well as humans used this passage such that Palaearctic, Oriental and Ethiopian fauna are found side by side, together with endemic Arabo-Siniatic species. This is illustrated by the broad spectrum of wild taxa pertinent to this work shown in Table 2.1.

As discussed in Chapter 2, the regional variation that exists within the Peninsula in topography, climate, water resources and vegetation is reflected in the modern and paleofauna, with a marked dichotomy in faunal components between northern and southern Sinai in all periods. For example, the northern Sinai sites (e.g. R-series sites, Qatif Y2 and Y3, BEA-10, A-345, Haruvit) contained significant quantities of cattle, pig and Mediterranean fish bones. These elements are rare or missing from the southern Sinai sites (e.g. *Masseboth* sites**,** *Nawamis* tombs and habitation sites, Gebel Serbal). In contrast, ibex and other wild taxa such as leopards, small carnivores and hare, that is rare or absent in north Sinai assemblages, are abundant in most southern sites irrespective of period.

Cattle remains are an interesting case in point since their presence in southern Sinai has been reported from a diachronic series of sites in this region: two PPNB sites (Wadi Tbeik and Ujret el-Mehed), a Chalcolithic site (Serabit el Khadem), a Late Neolithic-EBI *nawamis* (Ein Huderah) and two EB II sites (Feiran I and Sheikh Muhsein). Cattle are also found in ‘Ajrud - which is located in the north-east of Sinai and close to springs. It must be emphasized that in all sites only isolated bones of this taxon have been found. Since the specific environmental conditions prevailing in this region today - unreliability of resources (both water and pasture), extremely cold winters and harsh topography - would undoubtedly have mitigated against the keeping of cattle as well as pigs in southern Sinai, unless major climatic changes took place, an attempt was made to re-examine all these cattle bones. Only the two PPNB 2nd phalanges were relocated and examined (Fig. 3.7). Through the application of current morphological criteria, I was able to show that both bones probably represent those of equids. Based on biogeography, this is a more feasible identification since wild equids were common in Sinai. However, the removal of *Bos* from the list of species found in the PPNB, is a set-back for paleoclimatic reconstructions that favour wetter conditions in the Levant at this time. In contrast, cattle comprise a common element in north Sinai faunal assemblages.

The more arid natural conditions of the southern part of the Peninsula probably promoted the exploitation of ibex, gazelle and other wild taxa, albeit on a small scale, even when domestic animals were available. Indeed, as today, the high mountains of this region probably served in the past as refugia for animals from hunters.

For southern Sinai, fish bones – marine and freshwater – have been recovered from the PPNB onwards. However the intensity of marine resource exploitation, other than shells, especially from the Red Sea, appears to have been a low priority to all communities living in this region. The paucity of remains of marine fish in these faunal assemblages is puzzling given the proximity of sites to the coast. Since all deposits were sieved using a fine mesh, it seems unlikely that this is an artefact of bone retrieval. In contrast, Pottery Neolithic, Chalcolithic and Early Bronze Age sites along the Mediterranean such as Qatif Y2 and Y3, Tel es Sakan and Taur Ikhbeineh, appear to have exploited marine fish on a regular basis (Grigson 1984a, b; Horwitz et al. 2002b; Miroschedji et al. 2001), while remains of the freshwater Nile catfish were recovered even from the inland Early Bronze Age site of En Besor (Horwitz et al. 2002b). Freshwater fish remains were also retrieved from the PPNB site of Wadi Tbeik, and may either originate in the Nile or from paleo-lakes in Sinai that have since dried up. The variation between regions in marine resource exploitation may reflect ethnic dietary preferences since there do not appear to be marked differences in technology in coeval sites from southern and northern Sinai.

In the Late Bronze Age (New Kingdom), freshwater fish such as Cichlidae (tilapia), Claridae (Nile catfish) and Centropomidae (Nile perch), that would probably have been imported from the Nile, are poorly represented in the fort/administrative centers. Instead, the majority of fish exploited were taxa that inhabit inshore coastal waters as well as lagoons and estuaries primarily, bream (Sparidae), mullet (Mugilidae), grouper (Serranidae), indicating that in this period too, local Mediterranean Sea marine resources were preferred. Even the land-locked site of Kuntillet ‘Ajrud yielded two Mediterranean Sea species and one Nile taxon. Ben-Tuvia and Golani (1987) note that the same Mediterranean fish taxa are commonly found in the Bardawil lagoon and are categorised today as having the highest commercial value. Due to the specific natural conditions in the lagoon, species that can survive there are larger and occur in far higher densities than their same-species counterparts living in the Mediterranean Sea, making this a preferred locality for fishing.

Although in all periods discussed here Mediterranean and Red Sea marine shells were exploited in both northern and southern Sinai sites, it seems clear that they represent raw material collected specifically for the manufacture of ornaments rather than for consumption (Bar-Yosef Mayer 1989a, b, 1997, 1999, 2002). Sites in southern Sinai contain higher quantities of Red Sea shells and vice versa, indicating local exploitation of this resource.

There is no evidence for the independent domestication of animals in the Peninsula. Remains of dogs, the earliest domesticate, first appear only in the EB II faunal record (in Feiran I, Sheikh Awad). This does not mean that dogs were not kept by the Neolithic communities of Sinai. To the contrary, indirect evidence from rock engravings thought to date to this time period, clearly depict dogs with curling upright tails hunting alongside people armed with bows and arrows (Anati 1979; Hershkovitz et al. 1987; Perevolotsky and Baharav 1987, 1991). With respect to the progenitors of the main domestic herd species - bezoar goat (*Capra aegagrus*), aurochs (*Bos primigenius*), wild boar (*Sus scrofa*) and wild sheep (*Ovis orientalis*) – they appear not to have inhabited the southern part of the Peninsula since they are absent from the faunal assemblages studied here, as well as from the earlier Upper Palaeolithic bone collections that I examined as part of the Sinai campaign project. Consequently, the first appearance of domestic stock, possibly as early as the Late Neolithic but certainly by the Chalcolithic period (Chapter 4), represents an introduction of a new species that originates in the Mediterranean zone of the Levant. Although it is feasible that domestic sheep (*Ovis aries*) were also kept in the region, at least in periods of climatic amelioration, to date, only remains of domestic goats have been positively identified from southern Sinai, while sheep are present only at 'Ajrud (Iron Age) and in the new Kingdom sites from northern Sinai. Methodological problems of distinguishing sheep from goats in poorly preserved assemblages may in part be responsible for their poor representation, although environmental differences between these regions seem a more likely explanation.

In sites from both northern and southern Sinai, it is evident that the frequencies of ibex and gazelle remains decreased dramatically once domestic herd animals were available. Either hunting became a less profitable activity at this time or else the local wild taxa were displaced due to inter-specific competition. Indeed, Baharav and Meiboom (1982) describe how today, due to competition with domestic goats for pasture, the ibex exploit the high mountain ranges even in winter in order to evade Bedouin herds. It is difficult to know when this geographic displacement occurred, but certainly today most large wild carnivores and ungulates favour relatively inaccessible refuge areas in the high mountains (Saleh 1987; Saleh and Basuony 1998).

On the other hand, when comparing species lists of past and present fauna, it is interesting to note that with few exceptions (notable is the replacement of *Gazella gazella* with *Gazella dorcas* – Tchernov et al. 1986/87), the fauna of the Sinai, has changed very little throughout the Holocene. There is no evidence for large-scale extinction of faunal taxa in the periods under discussion, while glacial relicts such as the chukar partridge (*Alectoris chukar*), are still found in the high mountains of southern Sinai. Obviously, following the introduction of firearms, many species have become threatened and their natural distribution curtailed (Saleh and Basuony 1998; Tchernov 1979; Yom-Tov 1987). Although the situation in Sinai is far from good *vis a vis* conservation of large mammals, the situation is far better than that in the Mediterranean zone of the southern Levant, where large-scale extinctions have resulted from human encroachment on natural areas and hunting (Yom-Tov and Mendelssohn 1988; Tchernov 1988). Perhaps the fact that for many millennia the region was unattractive to people has helped to preserve the natural faunal.

This study also offers information as to the timing of the replacement of *Gazella gazella* by the African taxon *Gazella dorcas (*Tchernov et al. 1986/87). As illustrated in Chapter 3, remains of *Gazella gazella* have been identified from all PPNB sites in southern Sinai. However, horncores of *G. dorcas* are first found in the Late Neolithic-Chalcolithic *nawamis* of Ein Huderah and subsequently in the EB II site of Sheikh Muhsein, both located in southern Sinai. This indicates that by the Late Neolithic-Chalcolithic, *G. gazella* had probably been replaced, which would co-incide with the onset of more arid climatic conditions in the region as discussed in Chapter 2.

With respect to beasts of burden, the data from Sinai are somewhat surprising. Based on the evidence for trade links with areas outside of Peninsula beginning in the PPNB and especially during the EB II, it was expected that a large number of remains of donkeys would be found, these equids having served as the main beast of burden at this time. However, this was not the case. [For a discussion of the reasons for the paucity of skeletal remains of beasts of burden in archaeological sites see- Horwitz and Rosen 2005]. It is only in the New Kingdom forts/administrative sites that large quantities of donkey bones are found, and these derive from a transit camp (A-343). Camel also makes its first appearance in this New Kingdom site, attesting to their use in trade along the 'Way of Horus'.

8.2 Diachronic patterns in settlement type and animal subsistence

The earliest models relating to the history of occupation of the desert regions of the southern Levant were based on data from regional site surveys, primarily in the Negev desert (e.g. Baron 1978 on Glueck's Surveys; Cohen 1986; Rothenberg 1961). These studies laid the basis for perceptions of desert occupation as cyclical, characterized by periods of human occupation interspersed with hiatuses when the arid region was uninhabited. Multiple explanations have been offered to explain the observed gaps in the archaeological record as being due to the external influence of neighbouring powers, changing geo-political balance in the Near East, migration of communities out of the desert region – either as refugees or the retreat of temporary intruders out of the desert zone, the seasonal nature of site occupation in deserts, *in situ* destabilizing developments within the desert region and climate change (e.g. Beit-Arieh 1983; Cohen 1986; Rosen 1987; Rothenberg 1969).

In this regard, a central issue is the visibility of archaeological remains in desert regions. Rosen (1987, 1988, 1992) maintains that nomads always leave remains, even if these are scanty. Thus, the absence of archaeological material denotes a real occupational gap. Related to this notion is the claim that desert occupation is ephemeral, seasonal and of short duration since arid regions cannot sustain local communities for extended periods of time (e.g. Beit-Arieh 1986; Haiman 1992). These contentions were challenged by Finkelstein (1988, 1989, 1990, 1995; Finkelstein and Perevolotsky 1990) who claimed that the absence of archaeological remains does not necessarily indicate that nomads were not continuously present in the desert regions but rather, that the mode of usuage of the region changed. Thus, the history of occupation of the desert regions reflects a gradient of cyclical strategies that are bound to the zeniths and nadirs of the agrarian communities occupying the fertile regions to the north. In times of crisis in the Mediterranean zone, nomadic groups were forced to shift to sedentism in order to produce the crops usually supplied by agrarian communities, resulting in more visible remains. In contrast, when the agrarian communities flourished, inhabitants of the arid regions turned to nomadism, prospering from trade with the fertile regions. Archaeological visibility will obviously be increased in periods of sedentism.

Finkelstein's view has received some corroboration from three recent syntheses of over 160 radiocarbon dates for sites in southern Jordan, the Negev desert and Sinai Peninsula spanning the Neolithic to Middle Bronze Ages i.e. 6th to 3rd millennia BC (Avner 2002; Avner and Carmi 2001; Avner et al. 1994). These studies demonstrate that there is an uninterrupted sequence of human occupation in the southern desert regions with no observable gaps. Admittedly, in these studies, not all periods are represented by large numbers of sites. However, this represents the first comprehensive and robust framework of absolute dates with which to assess the issue of human occupation of the desert regions of the southern Levant, and offers a convincing argument in favour of continuous occupation of the region. Perhaps the lynch-pin to this issue, as implied in Finkelstein's argument, lies in the issue of shifting population densities rather than the presence/absence of human communities *per se*.

The archaeozoological information presented in this thesis can aid in elucidating some aspects of this issue. Examination of the diachronic sequence in patterns of animal exploitation, shows that there have been at least four major developments during the Holocene: beginning with transhumant hunter-gatherer communities in the PPNB, transhumant carnivorous herders in the Late Neolithic to EB I, semi-sedentary/sedentary milch herders in the EB II, and ending with foreign colonists that subsisted from provisioning in the New Kingdom/Late Bronze and Iron Ages.

As described in Chapter 2, the Sinai is a vast arena offering a wide range of different ecozones for both animals and humans to exploit. However, the extreme temperatures, aridity and sparse water resources makes this a challenging environment. It is not surprising then that the animal species inhabiting this region are highly adapted to arid conditions, both in their physiology and behavior. Moreover, the specific physical geography, flora and fauna of each of the three salient phytogeographic regions in Sinai have to a large extent dictated the pattern of human landscape use.

Central Sinai including the e-Tih plateau, would have been exploited primarily on a seasonal basis (in spring) due to the limited availability of both pasture and water. In contrast, the perennial availability of water and arable land on the Mediterranean coastal strip of northern Sinai, especially on its eastern margin, would have facilitated year-round occupation. As illustrated in Chapters 4 and 5, from the Chalcolithic onwards, relatively dense settlement is found in this region with a range of subsistence strategies ranging from nomadism through urbanism (Oren 1982, 1987, 1993; Yekutieli 1998), while its hinterland (a sandy plain inter-fingering with rugged mountains), was not settled but was probably only exploited seasonally by nomads.

The situation differs for southern Sinai. As shown by modern population census in Chapter 2, the region enjoyed relatively low population density even in historical periods. It is a zone that most likely experienced a more uneven pattern of human settlement than northern Sinai, with fluctuations in climate making a marked impact on the numbers of people inhabiting the region. Moreover, until the 20th century, the small-scale of their activities and limited agriculture and herding probably had little impact on the natural environment. Despite plentiful water in the high massif (precipitation is some ten times higher that of the southern coastal plain since it is augmented by snow), the natural resources in this the region are dispersed throughout the landscape with a low mean precipitation which is unpredictable and falls in geographically limited areas. At high elevations vegetation is diffuse, while at lower elevations it is limited to the wadi beds, with the exception of annual plant species that form long strips of pasture along the coastlines of the Gulfs of Aqaba and Suez (Heneidy 1996). These offer year-round nutritious pasture for wild as well as domestic animals. Water is restricted to perennial springs or wells.

Given the nature of this ecosystem, it is unlikely that a year-round, sedentary occupation by a large population would have been viable at any time during the Holocene, even given climatic amelioration. In order to successfully exploit this area, human populations like animals, would have had to develop adaptive strategies, for example altitudinal transhumance with occupation of the high massif in the summer, and the lowlands in the winter. Such a model, proposed by Bar-Yosef (1980, 1981a, 1984), and was tested for the PPNB period based on fauna from 5 sites in southern Sinai. Good corroboration was found between the faunal data (using species represented, age and sex profiles) and the seasonality model. In fact, it is suggested that a critical feature of this system was human dependence upon ibex herds such that seasonal movement coincided with that of the animals, corresponding to what Binford (1980) defined as “tethered nomadism”. Following Ingold (1980), it has been suggested that this seasonal pattern of landscape use served as a prototype for the first pastoralists (carnivorous pastoralism).

A similar model of itinerant resource use has been proposed for Chalcolithic herder-hunters in southern Jordan (Henry 1995). This fits the available data for Late Neolithic-EB I sites in southern Sinai, where there is evidence for short term site occupation by small numbers of people, and seasonal (spring) visitation of some localities in the landscape - *nawamis* habitation and burial sites, shrines and *masseboth* sites - as attested to by the presence of seasonally occurring taxa (quail, sparrowhawk), age profiles (newborn kids), combined with a sustained investment in hunting (arrowheads, high numbers of wild taxa). This is also the only manner in which herders with a mode of production based on exploitation of herds for meat (‘carnivorous pastoralists’), could have survived in this area – by moving seasonally according to the availability of pasture and water resources.

Seasonal migration out of the region could have offered another solution. Mahmuud Mansuur, a recent Bedouin informant of the Jabaliya tribe, recounts:

"*Sometimes nature was hard on us. Our grandfathers told us about terrible things that have happened seven times since the Jabaliya came to Sinai. I know about one of these. It was a twenty- to thirty-year drought. When it happened the waters dried up and people abandoned their gardens. Many people settled in Rafah and Cairo*" (in Hobbs 1995:12).

Thus, feasible routes out of Sinai, either on an annual basis or only in times of crisis, may have included: traversing the e-Tih plateau into northern Sinai, following the western coastal plain up into the Nile Delta, following the eastern littoral into the southern Negev and even continuing into the mountains of Edom in Jordan. It is possible that the introduction of domestic animals and cereals into the Nile Delta originated from such a crisis.

In the subsequent EB II, the faunal data offer only limited evidence for a reduction in mobility - reduced frequencies of hunted prey. But there are other archaeological indicators attesting to increased aggregations of people and to some degree of sedentism (e.g. site number and density, site size, use of space within sites, size of corrals/pens, development of craft specialization). Features, such as exploitation of milk products or wool, can be considered characteristic of either nomadic, sedentary or semi-sedentary communities, although large-scale production and marketing of secondary products generally requires some degree of sedentism (such as in the lambing/kidding season in order to safeguard the young and minimize predations), as well as specialisation (even if it is only seasonal – such as for plucking/shearing wool, preparation of milk products). There is no evidence from the faunal record that would testify directly to greater sedentism at this time other than that the animal bone assemblages are larger and bones more densely concentrated within the structures. It is difficult to assess how much of this relates to the extent of the site excavated, bone collection techniques, bone preservation etc.

The fact that people in the EB II developed a new mode of production ('milch pastoralism') indicates that (a) the old one was no longer relevant or satisfactory (b) a new set of relations was established with their herds. As described by Ingold (1980) milch pastoralists relate to herd animals as an integral part of their household, which reflects a growing interest in /awareness of private property and differential wealth. This should coincide with periods of greater stability in the area of the 'sown', rather than crises, since they would be the beneficiaries of secondary produce marketed from the desert region. Marketing of meat products under carnivorous pastoralism would also be viable except when market demands outstrip the ability of the herd to reproduce itself. Although selling animals on the hoof would have been the most viable option, technologies of smoking and salting may have been known by this time. Drought, snow, floods or other natural disasters would have disrupted herding strategies and trade links for both carnivorous and milch pastoralism. It would have had more severe consequences for carnivorous pastoralists given the longer time period required to build up a viable herd from which to cull animals annually. In a computer simulation model of herd growth on Cyprus at the outset of the Neolithic, Ducos (2000) estimated that given a founder herd of 10 animals (equal numbers of males and females) and a cull of 70% of immature males (similar to that found in the Late Neolithic-EB I sites of Sinai), a minimum of 25 years would be required for a herd to establish itself and be culled at 50 animals per year i.e. 1 animal per week. Bearing in mind that unlike Cyprus, the Sinai was not a predator-free zone, a herd would take longer to become established.

In a recent study on sheep productivity in northern Sinai, Metawi et al. (1999) showed that under the tranhumant herding system, biological efficiency (i.e. measured as number of lambs born, number weaned, lamb mortality, average weight gain etc.) was significantly lower (by 52% productivity per ewe) compared to their farm raised ewes. The only efficiency of the transhumant herding system was in the higher proportion of non-feed costs [fodder]. These data have interesting implications for the earliest pastoralists entering the region, both concerning how long it would have taken to establish themselves and their herds, as well as in relation to long term reproductive trajectories of herd growth given that they primarily raised caprines for meat.

Of further interest is the fact that during the PPNB, populations in southern Sinai retained a conservative mode of subsistence, persisting in hunting and gathering at a time when in the southern Levant, sedentary agricultural communities were established and animal husbandry in the throes of development. Sinai 'lagged' behind areas to the north-east not only in its animal economy but also in architecture and lithic technology. These data indicate, that despite evidence for trade ties with the southern Levant at this time (lithics, shells, minerals, cereals), this had little impact on the foundations of the local PPNB economy. From the Late Neolithic-EB I onwards, and especially in the EB II, evidence for specialized production of goods, extensive trade and/or movement of foreign communities through the Peninsula increases. However, no new faunal taxa are evident in the sites studied here until the Late Bronze-Iron Ages, when sheep are first found in the New Kingdom sites and at ‘Ajrud, camel in the New Kingdom and chicken in the Nabataean period.

The New Kingdom forts/ administrative centers, ‘Ajrud a way-station and/or ritual center and Gebel Serbal a temple were either established by foreigners and/or used by them. There is evidence from ‘Ajrud of northern artistic influences in the decorative motifs, suggesting that the site may have served foreign as well as the local populations, while the Gebel Serbal sanctuary is thought to have served the population of the large Nabataean town in Wadi Feiran.

Additional evidence from these sites for ties beyond Sinai is that the faunal remains recovered from both ‘Ajrud and the New Kingdom sites points to provisioning. At the Egyptian New Kingdom sites, provisioning of animal foods was undertaken in the immediate environs of the settlement, as reflected in the local signature of the faunal remains - Mediterranean Sea fish probably from Lake Bardawil, high frequencies of sheep/goat and few remains of cattle or pig, and few hunted taxa. In contrast, evidence from ceramic vessels illustrates that cereals to these forts were supplied from Egypt. Faunal evidence to indicate that ‘Ajrud was provisioned is the presence of fish and shells from the Nile, Mediterranean and Red Seas and possibly the presence of cattle. Furthermore, the absence of agricultural implements, presence of storerooms and storage jars offer good evidence that provisions were sent to the site.

Finally, some reference needs to be made to the faunal evidence for contact with Egypt. A critical factor is the role played by Sinai as a conduit for domestic plants and animals. As discussed in Chapter 4, the latter scenario still seems the most viable although alternatives, including maritime transport, have been offered. Typical African i.e. Egyptian faunal elements, are found in all periods and in all sites in Sinai spanning the PPNB through to the Nabataean. Taxa represented are typically associated with freshwater resources such as the Nile – freshwater shells (*Aspatharia* sp.) or fish (*Clarias lazera, Lates niloticus*), hippopotamus (ivory) or occasionally birds (e.g. the sedentary waterfowl *Porphyrio porphyrio*).. The Levant offers fewer 'unique' faunal elements, exceptions are the freshwater mollusc *Theodoxus jordanii* which is endemic to the region and could only have been found in the springs of the Jordan Valley. In general, the archaeozoological record of southern Sinai shows a closer resemblance to that of the southern Levant than to Egypt, while northern Sinai shows a mixed influence, changing over time as the socio-political status of the region changed.

8.3 Paleoclimate

In most periods human settlement of the desert areas was mediated by climatic conditions (Avner 2002; Goring-Morris and Belfer-Cohen 1998; Issar 1998). Due to the ecological sensitivity of deserts even a slight increase in precipitation can make an arid region flourish (e.g. the Negev Desert during the Byzantine period - Issar 1998). Although changes in climatic regimes influenced the arid margins, it was the form of the human response to these shifts and their adaptations that determined the impact of the climate change, with immigration into and out of these regions just one option. Despite the important role played by broader political, social and economic concerns in determining which choice people took - such as to stay or to migrate, to change subsistence base or not (Finkelstein 1995), it is difficult to under-estimate the importance of climate and particularly rainfall in these marginal zones, especially for pastoralists for whom the availability of both natural water and grazing is critical. Pasture production in Sinai is generally sparse and of poor quality and its nutritive value in the dry season a major limiting factor for livestock production in this region (El Shaer 2000). Moreover, the quantity of pasture species (shrubs, semi-shrubs and herbs) found in Sinai that are suitable for grazing directly relates to the amount of annual rainfall (30-70mm/year) (Heneidy 1996). Increased rainfall in the past would have resulted in a significantly higher carrying capacity, as has been discussed by Perevolotsky and Baharav (1991).

Paleoclimatic reconstructions available for the region are rife with contradictory conclusions. This is probably due to the multitude of sources and techniques used that differ in their level of chronological refinement. However, the brief summary given in Chapter 2 outlines the main points of agreement.

The PPNB was associated with the Holocene optimum and enjoyed a favourable moist and cool climate and was followed by a relatively dry phase in the Late Neolithic – 'the 8.2 k climatic event' (Bar-Matthews et al. 1998; Rossignol-Strick 1999; Sanlaville 1999). During this latter period there is a single but dramatic shift in species biogeography in the Sinai - the invasion of the arid-adapted dorcas gazelle from Africa. This invasion implies a desiccation event of great magnitude, one which would have had a major impact impact on the entire natural ecosystem. It is possible that at this time, taxa such as ibex may have been forced to retreat upwards into higher altitudes in their search for water making them less accessible to hunters. Such a large-scale crisis, could have forced local hunter-gatherer communities to look for alternative sources of subsistence. Thus, the process of aridification, may have served as a catalyst for the adoption of pastoralism by local hunter-gatherers and/or for pastoralists in the southern Levant to enter Sinai as has been suggested for the eastern desert of Jordan (Köhler-Rollefson 1988, 1989b, 1992). Alternately, it may have deterred people from entering the hyper-arid regions. Thus, the presence of domestic sheep, goat and cattle on the borders of Sinai at this time does not mean that herders were able to, or interested in entering this 'promised land'.

Based on data for alluviation, mollusc-shell carbon isotopes, Dead Sea levels, fauna and arboreal pollen frequencies (Frumkin et al. 1991; Goldberg 1994; Goldberg and Bar-Yosef 1982; Horowitz 1992; Rosen 1989), it is evident that a wetter and cooler phase occurred at the onset of the Chalcolithic. This moist interval may have offered attractive conditions and encouraged people to settle in the marginal regions. As such, the development of carnivorous pastoralism could perhaps have been initiated under these more optimal climatic conditions which in turn would have fostered herd growth and hence economic security. The subsequent shift to milch pastoralism in the EB II was also initiated under moist and humid conditions, but developed under increasing dessication (Bar-Matthews et al. 1998; Issar 1998; Rosen 1997). This factor may have forced people to explore new subsistence strategies as under adverse environmental conditions, herd survival and growth would have been threatened. Pastoralists could compensate for this by (a) keeping smaller herds (b) exploiting them in a more intensive and secure manner. The fact that most EB II sites in Sinai are located on main routes running along the wadis where water and pasture can be found (Beit-Arieh 2003a), offers some corroboration for this scenario. The reduced numbers of hunted animals in these sites may also attest to reduced availability of wild taxa due to increased sedentism of the herders, reduced numbers of wild animals or greater difficulty in hunting taxa that had sought refuge in the high mountains.

In later periods the patterns of human settlement changed markedly, with the Sinai serving more as an outpost of foreign powers. These sites appear to have been less self-sufficient than earlier communities, relying on provisioning from abroad. Despite some evidence for climatic amelioration in the Roman-Byzantine period, there is no evidence for the establishment of dense settlements in the Sinai such as attested to in the Negev. Perhaps, the scale and/or nature of climatic improvement at this time was of a limited scale such that it did not affect the hyper-arid Peninsula to the same extent as the semi-arid Negev desert. There is evidence that some towns were established, such as the Byzantine settlement in Wadi Feiran (Dahari 2000), but historial sources point to the local population as being composed of nomads.

In conclusion, the faunal remains from Sinai have offered a unique opportunity to elucidate changing modes of subsistence over time in this little known region. From the case studies presented in this thesis it is clear that a mixture of geo-political, cultural and ecological concerns all played a role in determining past human exploitation patterns of animals in the Peninsula.

BIBLIOGRAPHY

Abd El-Ghani M.M. and Amer W.M. 2003. Soil-vegetation relationships in a coastal desert plain of southern Sinai, Egypt. *Journal of Arid Environments* 55: 607-628.

Abou Rayan M., Djebedjian B. and Khaled I.. 2001. Water supply and demand and a desalination option for Sinai, Egypt. *Desalination* 136: 73-81.

Aharoni Y. 1967. Forerunners of the *Limes*: Iron Age fortresses in the Negev. *Israel Exploration Journal* 17 (1): 1-17.

Aharoni Y. and Naveh J. 1981. *Arad Inscriptions*. Jerusalem: Israel Exploration Society.

Ahituv S. 1978. Economic factors in the Egyptian conquest of Canaan. *Israel Exploration Journal* 28 (1-2): 93-105.

Al-Zahery N., Semino O., Benuzzi, G., Passarino G., Torroni A. and Santachiara-Benerecetti A.S. 2003. Y-chromosome and mtDNA polymorphisms in Iraq, a crossroad of the early human dispersal and post-Neolithic migrations. *Molecular Phylogenetic Evolution* 28: 458-472.

Alamer M. and Al-Hozab A. 2004. Effect of water deprivation and season on feed intake, body weight and thermoregulation in Awassi and Najdi sheep breeds in Saudi Arabia. *Journal of Arid Environments* 59: 71-84.

Albright, W.F. 1948a. Exploring in Sinai with the University of California African Expedition. *Bulletin of the American Schools of Oriental Research* 109: 5-20.

Albright, W.F. 1948b. The early alphabetic inscriptions from Sinai and their decipherment. *Bulletin of the American Schools of Oriental Research* 110: 6-22.

Allen, G.M. 1915. Mammals obtained by the Phillips Palestine Expedition. *Bulletin of the Museum of Comparative Zoology, Harvard University* 59: 3-14.

Almogi-Labin A., Hemleben C., Meischner D., and Erenkeuser H. 1991. Paleoenvironmental events during the last 13000 years in the central Red Sea as recorded by Pteropoda. *Paleoceanography* 6: 83-98.

Anati E. 1958. Recherches préhistoriques au Sinai. *Bulletin de la Société Préhistorique Francais* 55: 209-212.

Anati E. 1979. *L'arte Rupestre del Negev e del Sinai*. Milan: Jaca Books.

Anderson J. 1898. *Zoology of Egypt vol. I. Reptilia and Batrachia*. London: Quaritch

Anderson J. and de Winton W.E. 1902. *Zoology of Egypt vol. II. Mammalia.* London: Hugh Rees.

Arad Z. 1982. Effect of water deprivation and heat exposure on body weight loss and drinking capacity in four breeds of fowl (*Gallus domesticus*). *Comparative Biochemistry and Physiology, Part A: Physiology* 73 (2): 297-299.

Arad Z. and Marder J. 1982a. Strain differences in heat resistance to acute heat stress, between the Bedouin desert fowl, the white leghorn and their crossbreeds. *Comparative Biochemistry and Physiology, Part A: Physiology* 72 (1): 191-193.

Arad Z. and Marder J. 1982b. Effect of long-term heat acclimatization on the thermoregulatory mechanisms of the desert Sinai and white leghorn fowls (*Gallus domesticus*). *Comparative Biochemistry and Physiology, Part A: Physiology* 72 (1): 185-190.

Avner U. 1982. New evidence for the Nabatean presence in Sinai. In: I. Lachish and Z. Meshel (eds.), *South Sinai Researches 1967-1982*. Tel Aviv: Society for the Protection of Nature. Pp. 25-32. (Hebrew).

Avner, U. 1984. Ancient cult sites in the Negev and Sinai deserts. *Tel Aviv* 11: 115-131.

Avner, U. 1991. Late Neolithic-Early Chalcolithic burial site in Eilat. *American Journal of Archaeology* 95: 496-497.

Avner U. 1993. *Mazzebot* sites in the Negev and Sinai and their significance. In: A. Biran and J. Aviram (eds.) *Biblical Archaeology Today, 1990*. Jerusalem: Israel Exploration Society. Pp. 166-181.

Avner, U. 1998. Settlement, agriculture and paleoclimate in ‘Uvda Valley, southern Negev Desert, 6th-3rd millennia B.C. In: A. Issar and N. Brown (eds.), *Water, Environment and Society in Times of Climate Change*. Dordrecht. Pp. 147-202.

Avner, U. 2002. *Studies in the Material and Spiritual Culture of the Negev and Sinai Populations During the 6th-3rd millennia B.C.* Unpublished PhD Thesis. The Hebrew University of Jerusalem.

Avner U. in press. Nabatean sanctuaries on Gebel Serbal and Gebel Moneijah, southern Sinai. *‘Atiqot*.

Avner U. and Carmi I. 2001. Settlement patterns in the southern Levant deserts during the 6th-3rd millennia BC: A revision based on 14C dating. In: H.J. Bruins, I. Carmi and E. Boaretto (eds.), *Near East Chronology: Archaeology and Environment*. Radiocarbon 43, Arizona: University of Arizona. Pp. 1203-1216.

Avner U. Carmi I. and Segal D. 1994. Neolithic to Bronze Age settlement of the Negev and Sinai in light of radiocabon dating: a view from the southern Negev. In: O. Bar-Yosef and R. Kra (eds.), *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean*. Radiocarbon, Arizona: University of Arizona. Pp. 265-300.

Ayalon E. 1995. The Iron Age II pottery assemblage from Horvat Teiman (Kuntillet ‘Ajrud). *Tel Aviv* 22 (2): 141-205.

Baharav D. and Meiboom U. 1981. The status of the Nubian ibex *Capra ibex nubiana* in the Sinai desert. *Biological Conservation* 20: 91-97.

Baharav D. and Meiboom U. 1982. Winter thermoregulatory behaviour of the Nubian ibex in the southern Sinai desert. *Journal of Arid Environments* 5: 295-298.

Bailey C. 1996. Chapter 8. The Saluqi in Bedouin culture. In: G. Goodman (ed.), *The Saluqi: Coursing Hound of the East.* Arizona: East. Midbar Inc. pp.402-410.

Bar-El T. and Tchernov E. 2001. Lagomorph remains at prehistoric sites in Israel and southern Sinai. *Paléorient* 26 (1): 93-109.

Bar-Matthews M., Ayalon A. and Kaufman A. 1997. Late Quaternary paleclimate in the eastern Mediterranean region from stable isotope analysis of speleotherms at Soreq Cave, Israel. *Quaternary Research* 47: 155-168.

Bar-Matthews M., Ayalon A. and Kaufman A. 1998. Middle to late Holocene (6,500 Yr. Period) paleoclimate in the eastern Mediterranean region from stable isotopic composition of speleothems from Soreq Cave, Israel. In: A.S. Issar and N. Brown (eds.)*, Water, Environment and Society in Times of Climate Change*. Kluwer Academic Press. Pp. 203-214.

Bar-Yosef O. 1980. The Stone Age in Sinai. In: Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Hakibbutz Hameuchad. Pp. 11-40. (Hebrew).

Bar-Yosef O. 1981a. Settlement patterns during the Pre-Pottery Neolithic periods in the southern Levant. *Cathdera* 20: 5-18. (Hebrew).

Bar-Yosef O. 1981b. Neolithic sites in Sinai. In: W. Frey and H-P. Uerpmann (eds.), *Beitrage zur Umweltgeschichte des Vorderen Orients (Contributions to the Environmental History of Southwest Asia).* Beihefte zum Tubinger Atlas des Vorderen Orients Reihe A (Naturwissenschaften) Nr. 8. Wiesbaden: Ludwig Reichert Verlag. Pp. 216-235.

Bar-Yosef O. 1981c. Pre-Pottery Neolithic sites in southern Sinai. *Biblical Archaeologist.* Winter, Pp. 9-12.

Bar-Yosef O. 1981d. From hunter to herder in southern Sinai. In: A. Biran (ed.), *Temples and High Places in Biblical Times*. Jerusalem: Hebrew Union College. Pp. 156-157.

Bar-Yosef O. 1981e. Neolithic sites in Sinai. *Eretz-Israel* 15: 1-6. (Hebrew).

Bar-Yosef O. 1984. Seasonality among Neolithic hunter-gatherers in southern Sinai. In: J. Clutton-Brock and C. Grigson (eds.), *Animals and Archaeology 3: Early Herders and their Flocks*. Oxford: BAR International Series 202. Pp. 145-160.

Bar-Yosef O. 1985. The Stone Age of the Sinai Peninsula. In: *Studi di Paleontologia in Onore di Salvatore M. Puglisi. Universita di Roma " La Sapienza"*. Pp. 107-122.

Bar-Yosef O. 1986-87. The origin of pastoralists in the Levant. *Israel- People and Land vol. 4.* Tel Aviv: Eretz Israel Museum. Pp. 85-100. (Hebrew).

Bar-Yosef O. 1993. Sinai. Prehistoric periods. In: E. Stern (ed.) *The New Encyclopedia of Archaeological Excavations in Israel*. Jerusalem: Israel Exploration Society. Pp. 1384-1386.

Bar-Yosef O. 2002. Early Egypt and the agricultural dispersals. In: H.G.K. Gebel, B. Dahl Hermansen and C. Hoffman Jensen (eds.), *Magic Practices and Ritual in the Near Eastern Neolithic*. Studies in early Near Eastern Production, Subsistence and Environment No. 9. Berlin: ex Oriente. Pp. 49-65.

Bar-Yosef O. and Belfer-Cohen, A. 1989a. The Levantine "PPNB" Interaction Sphere. In: I. Hershkovitz (ed.) *People and Culture in Change*. Oxford: BAR International Series 508 (I). Pp. 59-72.

Bar-Yosef O. and Belfer-Cohen A. 1989b. The origins of sedentism and farming communities in the Levant. *Journal of World Prehistory* 3: 447-498.

Bar-Yosef O., Belfer-Cohen A. 1992. From foraging to farming in the Mediterranean Levant. In: Gebauer A.B., Price T.D. editors. *Transitions to Agriculture in Prehistory. Monographs in World Archaeology No. 4.* Wisconsin: Prehistory Press. p. 21-48.

Bar-Yosef O. and Belfer-Cohen A. 1999. Facing environmental crisis. Societal and cultural changes at the transition from the Younger Dryas to the Holocene in the Levant. In: R.T.J. Cappers and S. Bottema (eds.), The *Dawn of Farming in the Near East*. Berlin: ex oriente. Pp. 55-66.

Bar-Yosef O. and Gopher A. 1997. Discussion. In: O. Bar-Yosef O. and A. Gopher (eds.), *An Early Neolithic Village in the Jordan Valley. Part I: The Archaeology of Netiv Hagdud*. American School of Prehistoric Research Bulletin 43. Cambridge MA: Peabody Museum of Archaeology and Ethnology, Harvard University. Pp. 247-266.

Bar-Yosef O. and Goren N. 1980. Afterthoughts following prehistoric surveys in the Levant. *Israel Exploration Journal* 30 (1-2): 1-16.

Bar-Yosef O. and Khazanov A. 1992. *Pastoralism in the Levant*. Monographs in World Archaeology No. 10. Madison, Wisconsin: Prehistory Press.

Bar-Yosef O. and Killebrew A. 1984. Wadi Sayakh –A Geometric Kebaran site in southern Sinai. *Paléorient* 10 (2): 95-102.

Bar-Yosef O., Meadow R.H. 1995. The origins of agriculture in the Near East. In: T.D Price and A.B. Gebauer (eds.), *Last Hunters, First Farmers*. Houston: School of American Research. Advanced Seminar Series. Pp. 39-94.

Bar-Yosef O. and Phillips J.L. (eds.). 1977. *Prehistoric Investigations in Gebel Maghara, Northern Sinai. Qedem 7*. Jerusalem.

Bar-Yosef, O., Belfer-Cohen, A., Goren, A. and Smith, P. 1977. The Nawamis near 'Ein Huderah (eastern Sinai). *Israel Exploration Journal* 27 (2-3): 65-88.

Bar-Yosef, O., Hershkovitz, I., Arbel, G. and Goren, A. 1983. The orientation of Nawamis entrances in southern Sinai: Expressions of religious belief and seasonality? *Tel Aviv* 10 (1): 52-60.

Bar-Yosef, O., Belfer-Cohen, A., Goren, A., Hershkovitz, I., Ilan, O., Mienis, H. and Sass, B. 1986. *Nawamis* and habitation sites near Gebel Gunna, southern Sinai. *Israel Exploration Journal* 36 (3-4): 121-167.

Bar-Yosef Mayer D.E. 1989a. *Sea Shells of PPNB Sites in Southern Sinai*. Unpublished MA Thesis, Hebrew University of Jerusalem.

Bar-Yosef Mayer D.E. 1989b. Late Palaeolithic and Neolithic marine shells in the southern Levant as cultural markers. C.F. Hayes III (ed.), *Proceedings of the 1986 Shell Bead Conference. Research Records no. 20*. New York: Rochester Museum and Science Center. Pp. 169-174.

Bar-Yosef Mayer D.E. 1997. Neolithic shell bead production in Sinai. *Journal of Archaeological Science* 24: 97-111.

Bar-Yosef Mayer D.E. 1999. *The Role of Shells in the Reconstruction of Socio-Economic Aspects of Neolithic Through Early Bronze Age Societies in Sinai*. Unpublished PhD Thesis, The Hebrew University of Jerusalem.

Bar-Yosef Mayer, D.E. 2002a. Egyptian-Canaanite interaction during the Fourth and Third millennia BCE: The shell connection. In: E. C.M. van den Brink and T.E. Levy (eds.), *Egypt and the Levant. Interrelations from the 4th through the Early 3rd millennium B.C.E.* London: Leicester University Press. Pp. 129-135.

Bar-Yosef Mayer D.E. 2002b. The shells of the nawamis in southern Sinai. In: H. Buitenhuis, A.M. Choyke, M. Mashkour and A.H. Al-Shiyab (eds.) *Archaeozoology of the Near East vol V*. Groningen: ARC-Publicaties 62. Pp. 166-180.

Barley N. 1995. *Dancing on the Grave. Encounters with Death*. London: Abbacus.

Baron A. 1978. *The Glueck Survey. Issues and Problems in the Archaeology of the Negev*. Unpublished PhD Thesis, University of California.

Bartosiewicz L. 2000. Cattle offerings from the temple of Montuhotep Sankhkara (Thebes, Egypt). In: M. Mashkour, A.M. Choyke, H. Buitenhuis and F. Poplin (eds.), *Archaeozoology of the Near East* Vol. IVB. Groningen: ARC-Publicaties 32. Pp. 164-176.

Baruch U. and Bar-Yosef O. 1986. Upper Palaeolithic assemblage from Wadi Sudr, western Sinai. *Paléorient* 12 (2): 69-83.

Beck P. 1982. The drawings from Horvat Teiman (Kuntillet ‘Ajrud). *Tel Aviv* 9 (1): 3-68.

Beck P. 1995. Catalogue of cult objects and study of the iconography. In: I. Beit-Arieh (ed.), *Horvat Qitmit. An Edomite Shrine in the Biblical Negev*. Tel Aviv: Monograph Series of the Institute of Archaeology 11, Tel Aviv University. Pp. 27-197.

Becker C. 2002. Nothing to do with indigenous domestication ? Cattle from Late PPNB Basta. In: H. Buitenhuis, A.M. Choyke, M. Mashkour and A.H Al-Shiyab (eds.), *Archaeozoology of the Near East Vol. V*. Groningen: ARC Publicaties 62. Pp. 112-137.

Becker C. 2004. On the identification of sheep and goats: The evidence from Basta. In: H.J. Nissen, M. Muheisen and H.G. Gebel (eds.), *Basta I. The Human Ecology*. Berlin: ex oriente. Pp. 219-310.

Beech M. in press. The mammal bones from Deir ‘Ain Abata, Jordan. In: K.D. Politis (ed.), *Deir ‘Ain Abata*. London: The British Museum.

Behrensmeyer A.K. 1978. Taphonomic and ecologic information from bone weathering. *Paleobiology* 4 (2): 150-162.

Beit-Arieh I. 1977. *Southern Sinai in the Early Bronze Age Period*. Unpublished PhD Thesis, Tel Aviv University. (Hebrew).

Beit-Arieh I. 1981. An Early Bronze II site near Sheikh ‘Awad in southern Sinai. *Tel Aviv* 8: 95-127.

Beit-Arieh I. 1982. An Early Bronze II site near the Feiran Oasis in southern Sinai. *Tel Aviv* 9: 146-156.

Beit-Arieh I. 1983. Central southern Sinai in the Early Bronze Age II and its relations with Palestine. *Levant* 16: 39-48.

Beit-Arieh I. 1984. Fifteen years in Sinai. Israeli archaeologists discover a new world. *Biblical Archaeology Review* 10 (4): 26-54.

Beit-Arieh I. 1986. Two cultures in southern Sinai in the third millennium BC. *Bulletin of the Association for Oriental Studies* 263: 27-54.

Beit-Arieh I. 1993. Southern Sinai in the Early Bronze Age. In: E. Stern (ed.), *The New Encyclopedia of Archaeological Excavations in Israel*. Jerusalem: Israel Exploration Society. Pp. 1397-1399.

Beit-Arieh I. 2003a. *Archaeology of Sinai. The Ophir Expedition*. Emery and Claire Yass Publications in Archaeology. Tel Aviv.

Beit-Arieh I. 2003b. Excavated sites in south central Sinai. VII. A Chalcolithic site. In: I. Beit-Arieh (ed.) *Archaeology of Sinai. The Ophir Expedition*. Emery and Claire Yass Publications in Archaeology 21. Tel Aviv. Pp. 78-100.

Beit-Arieh I. 2003c. Survey of southern Sinai. In: I. Beit-Arieh (ed.) *Archaeology of Sinai. The Ophir Expedition*. Emery and Claire Yass Publications in Archaeology 21. Tel Aviv. Pp. 273-435.

Belfer-Cohen A. and Bar-Yosef O. 2000. Early sedentism in the Near East. A bumpy ride to village life. In: I. Kuijt (ed.), *Life in Neolithic Farming Communities: Social Organization, Identity and Differentiation*. New York: Kluwer Academic. Pp. 19-36.

Belfer-Cohen A. and Goldberg P. 1982. An Upper Palaeolithic site in south central Sinai. *Israel Exploration Journal* 32 (4): 185-189.

Ben-David Y. 1981. *Jabaliyeh. A Bedouin Tribe in the Shadow of the Monastery*. Jerusalem: Caneh. (Hebrew).

Ben-David Y. 1987. Economic changes as a factor in the sedentarization of the Bedouin of southern Sinai. In: Gvirtzman G., Shmueli, A., Gradud Y., Beit-Arieh I. and Han-El M. (eds.), *Sinai- Human Geography*. Tel Aviv: Ministry of Defence. Pp. 827-846. (Hebrew).

Bennett J.L. 1999. Thermal alteration of buried bone. *Journal of Archaeological Science* 26: 1-8.

Ben-Tor A. 1991. New light on the relations between Egypt and southern Palestine during the Early Bronze Age. *Bulletin of the American Schools of Oriental Research* 281: 3-10.

Ben-Tuvia A. 1971. Revised list of the Mediterranean fishes of Israel. *Israel Journal of Zoology* 20: 1-39.

Ben-Tuvia A. and Golani D. 1987. Fish and fishing in the Bardawil lagoon. In: G. Gvirtzman, A. Shmueli, Y. Gradud, I. Beit-Arieh and M. Han-El (eds.), *Sinai (Human Geography) Part II*. Tel-Aviv: Eretz, Ministry of Defence. Pp. 441-446. (Hebrew).

Betts A.V.G. (ed.) 1998. *The Harra and the Hamad. Excavations and Explorations in Eastern Jordan*. Sheffield: Sheffield Academic Press.

Betts A.V.G. and Helms S. 1986. Rock art in eastern Jordan: 'Kite carvings ? *Paléorient* 12 (1): 67-72.

Betts A.V.G. and Yagodin V.N. 2000. A new look at desert kites. In: L.E. Stager, J.A. Greene and M.D. Loogon (eds.), *The Archaeology of Jordan and Beyond*. Indiana: Eisenbrauns. Pp. 31-43.

Binford LR. 1978. *Nunamiut Ethnoarchaeology*. London: Academic Press.

Binford L.R. 1980. Willow smoke and dogs' tails: Hunter-gatherer settlement systems and archaeological site formation. *American Antiquity* 45: 4-20.

Binford L.R. 1981. *Bones. Ancient Men and Modern Myths*. New York: Academic Press.

Binford L.R. and Bertram J.B. 1977. Bone frequencies and attritional processes. In: L.R. Binford (ed.), *For Theory Building in Archaeology*. New York: Academic Press. Pp. 77-153.

Blench R.M. and MacDonald K.C. (eds.). 2000. *The Origins and Development of African Livestock, Genetics, Linguistics and Ethnography*. London: UCL Press. Pp. 38-60.

Bodenheimer F.S. 1953. *The Fauna of the Land of Israel.* Tel Aviv: Dvir Publishers. (Hebrew).

Boessneck J. 1969. Osteological differences between sheep (*Ovis aries* L.) and goat (*Capra hircus* L.). In: D.R. Brothwell and E.S. Higgs (eds.), *Science in Archaeology*. New York: Praeger. Pp. 331-358.

Boessneck J. 1988. *Die Tierwelt des alten Ägypten untersucht anhand kulturgeschichtlicher und zoologischer Quellen*. Munich: Beck.

Boessneck J. and von den Driesch A. 1987. Die tierknochenfunde aus den Paven- und Ibisgalerien von Tuna el-Gebel. Tuna el-Gebel I. Die Tiergalerien. *Hildesheimer* Ä*gyptologische Beitrage* 24: 37-221.

Boessneck J. and von den Driesch A. 1990. Tierreste aus vorgeschichtlinchen siedlung von El-Omari bei Heluan/UnterÄgypten. In: F. Debonbo and B. Mortensen (eds.), *El Omari. A Neolithic Settlement and Other Sites in the Vicinity of Wadi Hof, Helwan*. Mainz: Verlag Philipp von Zabern. Pp. 99-107.

Boessneck J. and von den Driesch A. 1992a. *Tiere und Historische Umwelt im Norost-Delta im 2 Jahhrtausend v. Chr. Anhand der Knochenfunde der ausgrabungen 1975-1986. Tell el-Dab'a VII.* Vienna: Verlag der Ostetteichischen Akademie der Wissenschaften.

Boessneck J. and von den Driesch A. 1992b. *Studied an Subfossilen Tierknochenfunde au Ägypten.* Munich: Münchner Ägyptologische Studien vol. 40.

Boessneck J. and von den Driesch A. 1997. Tierknochenfunde. In: T. von der Way (ed.), *Tell el-Fara'in-Buto I.* Mainz: Philipp von Zabern. Pp. 206-216.

Boessneck J., von den Driesch A. and Ziegler R. 1989. Die tierreste von Maadi und Wadi Digla. In: Rizkana and Seeher J. (eds.), *Maadi III.* Mainz: Verlag Philipp von Zabern. Pp. 87-128.

Bokonyi S. 1985. The animal remains of Maadi, Egypt. A preliminary report. In: *Studi di Palentologia in Onore di Salvatore M. Puglisi.* Universita di Roma " La Sapienza". Pp. 495-499.

Bouskila A. and Amitai P. 2001. *Handbook of Amphibians and Reptiles of Israel*. Jerusalem: Keter Publishing. (Hebrew).

Bradley D.G., MacHugh D.E., Cunningham P. and Loftus R.T. 1996. Mitochondrial diversity and the origins of African and European cattle. *Proceedings of the National Academy of Science, USA* 93: 5131-5135.

Brewer D. J. 1989. *Fishermen, Hunters and Herders: Zooarchaeology in the Fayum, Egypt (ca. 8200-5000 bp).* Oxford: BAR International Series 478.

Brewer D. J. and Teeter E. 1999. *Egypt and The Egyptians*. Cambridge: Cambridge University Press.

Brewer D.J. and Friedman R.F. 1989. *Fish and Fishing in Ancient Egypt*. Warminster: Aris and Phillips.

Brewer D.J., Redford D.B. and Redford S. 1990. *Domestic Plants and Animals: the Ancient Egyptian Origins*. Warminster: Aris and Phillips.

Bruins H.J., 1994. Comparative chronology of climate and human history in the southern Levant from the Late Chalcolithic to the Early Arab period. In: O. Bar-Yosef and R. S. Kra (eds.) *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean.* Arizona, Radiocarbon, pp. 301-314.

Buitenhuis H. 1979. The Faunal remains from Tell Hadidi. In P. Kubasiewicz (ed.), *Archaeozoology*. Szczecin. Poland. Pp. 164-175.

Bull G. and Payne S. 1982. Tooth eruption and epiphysial fusion in pigs and wild boar. In: B. Wilson, C. Grigson and S. Payne (eds.), *Ageing and Sexing Animal Bones from Archaeological Sites*. Oxford: BAR, British Series 109. Pp. 55-72.

Buzy D. 1927. Les stations lithiques d'el Qeseime. *Revue Biblique* 36: 90-92.

Byrd B.F. 1992. The dispersal of food production across the Levant. In: A.B. Gebauer and T.D. Price (eds.), *Transitions to Agriculture in Prehistory*. Madison, Wisconsin: Prehistor Press.

Caneva I.1992. Le littoral nord-sinaïtique dans la prehistoire. *Cahiers de Recherche de l'Institut Papyrus Egyptien de Lille* 14: 33-38.

Carmi I. and Segal D. 1994. Radiocarbon dates from sites excavated in Sinai. Unpublished Report No. 42. Radiocarbon Lab. Wiezmann Institute.

Carmi I. and Segal D. 1996. ^{14}C Dating of an Israelite Biblical site at Kuntillet Ajrud (Horvat Teman): Correction, Extension and Improved Age Estimate. *Radiocarbon* 38 2: 385-386.

Carmi I., Segal D., Goring-Morris A.N. and Gopher A. 1994. Dating the prehistoric site Nahal Issaron in the southern Negev, Israel. *Radiocarbon* 36: 391-398.

Castel J-C. 1999. *Comportements de Subsistence au Solutréen et au Badegoulien d'Après les Faunes de Combe-Saunière (Dordogne) et du Cuzoul de Vers (Lot)*. Unpublished PhD Thesis, Universite de Bordeaux I.

Chaix L. 2000a. A Hyksos horse from Tell Heboua (Sinai, Egypt). In: M. Mashkoour, A.M. Choyke, H. Buitenhuis and F. Poplin (eds.), *Archaeozoology of the Near East* vol. IVB. Groningen: ARC-Publicaties 32. Pp. 177-186.

Chaix L. 2000b. L'occupation romaine tardif á Tell el-Herr (250-400 apr. J.-C.). In: D. Valbelle and J-Y. Carrez-Maratray (eds.), *Le camp romain du Bas-Empire á Tell el-Herr*. Paris: Editions Errance. Pp. 228-233.

Chaix L. 2002. Animal exploitation at Tell el-Herr (Sinai, Egypt) during Persian times: First results. In: H. Buitenhuis, A.M. Choyke, M. Mashkour and A-H. Al-Shiyab (eds.), *Archaeozoology of the Near East Vol. V*. Groningen: ARC-Publicaties 62. Pp. 268-272.

Chaplin R.E. 1971. *The Study of Animal bones from Archaeological Sites*. Seminar Press.

Chosniak I., Maltz and Shkolnik A.. 1995. Metabolic adaptations for desert survival in the Bedouin goat. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology* 268: 1101-1110.

Cinnioğlu C, King R, Kivisild T, Kalfoglu E, Atasoy S, Cavalleri GL, Lillie AS, Roseman CC, Lin AA, Prince K, Oefner PJ, Shen P, Semino O, Cavalli-Sforza LL, Underhill PA. 2004. Excavating Y-chromosome haplotype strata in Anatolia. *Human Genetics* 114: 127-148.

Clarke M., Campbell A.C., Hameid W.S. and Ghoneim S. 2000. Preliminary report on the status of marine turtle nesting populations on the Mediterranean coast of Egypt. *Biological Conservation* 94 (3): 363-371.

Clarke S. 1916. Ancient Egyptian frontier fortresses. *Journal of Egyptian Archaeology* 3: 155-179.

Clason A.T. and Buitenhuis H. 1997. Change and continuity in the animal food resources in Bronze Age towns of the Orient. In: G. Wilhem (ed.), *Die Orientalische Stadt: Kontinuitat Wandel Bruch 1*. Berlin: Internationales Colloquium der Deutchen Orient –Gesellschaft 9-10. Pp. 199-219.

Cledat J. 1919. Notes su l'Isthme de Suez. *Bulletin de l'Institut Français d'Archéologie Orientale* 16: 201-228.

Close A.E. 1992. Holocene occupation of the eastern Sahara. In: F. Klees and R. Kuper (eds.), *New Light on the Northeast African Past. Africa Praehistorica* 5: 155-183.

Clutton-Brock J. 1971. The primary food animals of the Jericho Tell from the Proto-Neolithic to the Byzantine period. *Levant* 3: 41-55.

Clutton-Brock J. 1979. The mammalian remains from the Jericho Tell. *Proceedings of the Prehistoric Society* 45: 135-157.

Cohen R. 1986. *The Settlement of the Central Negev*. Unpublished PhD Thesis. The Hebrew University of Jerusalem. (Hebrew).

Colledge S., Conolly J. and Shennan S. 2004. Archaeobotanical evidence for the spread of farming in the eastern Mediterranean. *Current Anthropology* 45: 35-47.

Crabtree P. 1990. Faunal skeletal remains from Cyrene. In: D. White (ed.), *The Extramural Sanctuary of Demeter and Persephone at Cyrene, Libya. Final Reports Vol IV*. Pennsylvania, University Museum, University of Pennsylvania. Pp. 113-123.

Crawford R.D. 1984. Domestic fowl. In: I.L. Mason (ed.), *Evolution of Domesticated Animals*. London: Longman. Pp. 298-311.

Currelly C.T. 1906. Gebel Musa and the Nawamis. In: Flinders Petrie, W.F. (ed.), *Researches in Sinai*. London: John Murray. Pp. 229-244.

Dahari U. 2000. *Monastic Settlements in South Sinai in the Byzantine Period: The Archaeological Remains*. Israel Antiquities Authority Reports No. 19.

D'Altroy T.N. and Earle T.K. 1985. Staple finance, wealth finance and, storage in the Inca political economy. *Current Anthropology* 26 (2): 187-206.

Dan Y. and Yaalon D.H. 1987. Soils of the Sinai Peninsula. In: G. Gvirtzman, A. Shmueli, Y. Gradud, I. Beit-Arieh and M. Han-El (eds.), *Sinai (Human Geography) Part II*. Tel-Aviv: Eretz, Ministry of Defence. Pp. 213-229. (Hebrew).

Danin A. 1983. *Desert Vegetation of Israel and Sinai.* Jerusalem: Cana Publishing House.

Danin A. 1986. Flora and vegetation of Sinai. *Proceedings of the Royal Society of Edinburgh* 89B: 159-168.

Danin A. 1996. Vegetation of Israel and Sinai. *Botanicheskii Zurnal* (St. Petersburg) 81 11: 14-31.

Danin A. and Plitman U. 1987. Revision of the plant geographical territories of Israel and Sinai. *Plant Systematics and Evolution* 156: 43-53.

Dar S. 1993. *Settlements and Cult Sites on Mount Hermon, Israel*. Oxford:BAR International Series 589.

Davis S.J. 1980a. A note on the dental and skeletal ontogeny of *Gazella. Israel Journal of Zoology* 29: 129-134.

Davis S.J. 1980b. Les ossements d'animaux. In: J. Perrot and D. Ladiray (eds.), *Le cimetiére de Ben Shemen. Tombes a ossuaires de la region côtiére Palestinienne au IVe millenaire avant l'ere Chretienne.* Memoires et Travaux du CNRS de Jerusalem No. 1. Paris: Association Paléorient. Pp. 94.

Davis S.J. 1982. Climatic change and the advent of domestication: the succession of ruminant artiodactyls in the late Pleistocene-Holocene in the Israel region. *Paléorient* 8: 5-15.

Davis S.J.M. 1987. *The Archaeology of Animals*. London: Batsford.

Davis S.J. 1988. The larger mammal remains. In: O. Bar-Yosef and D. Alon (eds.) Excavations in the Nahal Hemar Cave. '*Atiqot 18*. Pp. 68-72.

Dayan T., Tchernov E., Bar-Yosef O. and Yom-Tov Y. 1986. Animal exploitation in Ujrat el-Mehed, a Neolithic site in southern Sinai . *Paléorient* 12 (2): 105-116.

Diamant A. 1987. The fishes of the southern Sinai coasts. In: G. Gvirtzman, A. Shmueli, Y. Gradud, I. Beit-Arieh and M. Han-El (eds.), *Sinai (Human Geography) Part II*. Tel-Aviv: Eretz, Ministry of Defence. Pp. 407-422. (Hebrew).

Di Giacomo F, Luca F, Popa LO, Akar N, Anagnou N, Banyko J, Brdicka R, Barbujani G, Papola F, Ciavarella G, Cucci F, Di Stasi L, Gavrila L, Kerimova MG, Kovatchev D, Kozlov AI, Loutradis A, Mandarino V, Mammi' C, Michalodimitrakis EN, Paoli G, Pappa KI, Pedicini G, Terrenato L, Tofanelli S, Malaspina P, Novelletto A. 2004. Y chromosomal haplogroup J as a signature of the post-Neolithic colonization of Europe. *Human Genetics* 115: 357-371.

Dmi'el R., Perevolotsky A. and Shkolnik A. 1980. Is a black goat in the desert a means of saving metabolic energy ? *Nature* 283: 761-762.

Dor M. 1984. *Checklist of the Fishes of the Red Sea*. Jerusalem: Israel Academy of Sciences and Humanities.

Driesch von den A. 1976. *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Harvard University, Peabody Museum of Archaeology and Ethnology Bulletin 1, Cambridge MA.

Driesch von den A. 2001. Eine aufsammlung von tierknochen aus einer Pharaonischen bergwerk-station auf dem Gebel Zeit am Roten Meer. In: H. Buitenhuis and W. Prummel (eds.), *Animals and Man in the Past*. Groningen: ARC Publicatie 41. Pp.346-356.

Driesch von den A. and Boessneck J. 1985. *Die Tierknochenfunde aus der Neolithischen Siedlung von Merimde-Benisalame am Westlichen Nildelta*. Munchen-Cairo: Deutsches Archäologisches Institut.

Driesch von den A. and Wodtke U. 1997. The fauna of ‘Ain Ghazal, a major PPN and early PN settlement in central Jordan. In: H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.), *The Prehistory of Jordan II. Perspectives from 1997.* Berlin: Studies in Early Near Eastern Production, Subsistence and Environment 4. Pp. 511-556.

Driesch von den A. and Peters J. 2001. Früheste haustierhaltung in der Südostturkei. In: R.M. Boehmer and J. Maran (eds.), *Lux Orientis. Archäologie zwischen Asien und Europa. Festschrift fur Harald Hauptmann*. Rahden: Verlag Marie Leidorf. Pp. 113-120.

Ducos, P. 1968. *L'Origine des Animaux Domestiques en Palestine*. Publications de l'Institute de Prehistoire de l'Universite de Bordeux, Memoire 6.

Ducos P. 1993a. Some remarks about *Ovis, Capra* and *Gazella* remains from two PPNB sites from Damascene, Syria, Tell Aswad and Ghoraife. In: H. Buitenhuis and A.T. Clason (eds.) *Archaeozoology of the Near East vol I.* Leiden: Universal Book Services. Pp. 37-42.

Ducos P. 1993b. Proto-elevage au Levant sud au VIIe millenaire BC. Les donnees de la Damascene. *Paléorient* 19: 153-174.

Ducos P. 2000. The introduction of animals by man in Cyprus: An alternative to the Noah’s ark model. In: M. Mashkour, A.M. Choyke, H. Buitenhuis and F. Poplin (ed.) *Archaeozoology of the Near East vol. IV.* Groningen: ARC Publicaties 32. Pp. 74-83.

Ducos P. and Horwitz L.K. 1998. The influence of climate on artiodactyl size during the late Pleistocene-early Holocene of the southern Levant. *Paleorient* 23 (2): 229-247.

Eddy F.W. and Wendorf F. 1998. Prehistoric pastoral nomads in the Sinai. *Sahara* 10: 7-20.

Eddy F.W. and Wendorf F. 1999. *An Archaeological Investigation of the Central Sinai, Egypt.* Boulder, Colorado: University Press of Colorado.

Eiwanger J. 1984. *Merimde-Benisalâme I. Die Funde der Urschicht.* Vierter Berichtung Deutsches Archäologisches Institut Abteilung Kairo. Mainz: Philipp von Zabern.

Eiwanger J. 1988. *Merimde-Benisalâme II. Die Funde der Mittleren Merimde-Kultur.* Vierter Berichtung Deutsches Archäologisches Institut Abteilung Kairo. Mainz: Philipp von Zabern.

Elliott J.D. Jr. 1996. The Nabatean synthesis of Avraham Negev: A critical appraisal. In: Seger J.D. (ed.), *Retrieving the Past.* Cobb Institute of Archaeology. Pp. 47-60.

El Mahi A.T. 2000. The ibex hunt in the rock art of Oman. *New Arabian Studies* 5: 33-46.

El-Moslimany A. P. 1994. Evidence of early Holocene summer precipitation in the continental Middle East. In: O. Bar-Yosef and R.S. Kra (eds.), *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean.* Tucson: Radiocarbon. Pp. 121-130.

El Shaer H.M. 2000. Utilization of *Acacia saligna* as livestock fodder in arid and semi-arid areas in Egypt. In: L. Sulas (ed.), *Legumes for Mediterranean Forage Crops, Pastures and Alternative Users Vol 45*. Cahiers Option Mediteranee. Pp. 213-217.

Enzel, Y., Bookman R., Sharon D., Gvirtman H., Dayan U., Ziv B. and Stein M. 2003. Late Holocene climates of the near East deduced from Dead Sea level variations and modern regional winter rainfall. *Quaternary Research* 60: 263-273.

Epstein H. 1946. The Hejaz dwarf goat. *Journal of Heredity* 37 (11): 345-352.

Epstein H. 1971. *The Origin of the Domestic Animals of Africa* (2 volumes). New York: Africana Publishing.

Ervynck A., Dobney K., Hongo H. and Meadow R. 2002. Born Free!: new evidence for the status of pigs from Cayonu Tepesi, eastern Anatolia. *Paléorient* 27 (2): 47-73.

Eyal M., Bartov Y., Shimron A. and Bentor Y. 1987. The geology of Sinai: Explanation to a geological photomap. In: G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 1. Pp. 21-41. (Hebrew).

Ferguson W.F. 1980. The systematic position of *Gazella dorcas* (Artiodactyla: Bovidae) in Israel and Sinai. *Israel Journal of Zoology* 29: 209 (Abstract).

Ferguson W.W. 1981a. The systematic position of *Canis aureus lupaster* (Carnivora: Canidae) and the occurrence of *Canis lupus* in North Africa, Egypt and Sinai. *Mammalia* 45 (4): 459-465.

Ferguson W.F. 1981b. The systematic position of *Gazella dorcas* (Artiodactyla: Bovidae) in Israel and Sinai. *Mammalia* 45: 453-457.

Figueras P. ed. 2000. *From Gaza to Pelusium. Materials for the Historical Geography of North Sinai and Southwestern Palestine (332BCE-640CE).* Beer-Sheva XIV. Beersheva: Ben-Gurion University of the Negev Press.

Finkelstein I. 1980a. Archaeological research in Sinai 1967-1979. *Teva Vaaretz* 23 (1): 28-31. (Hebrew).

Finkelstein I. 1980b. The northern coast of Sinai- Geographic and historical aspects. In: Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Tel Aviv: Hakibbutz Hameuchad. Pp. 181- 197 (Hebrew).

Finkelstein I. 1988. Arabian trade and socio-political conditions in the Negev in the Twelfth-Eleventh centuries BCE. *Journal of Near Eastern Studies* 47: 241-252.

Finkelstein I. 1989. Further observations on the socio-demographic structure of the Intermediate Bronze Age. *Levant* 21: 129-140.

Finkelstein I. 1990. Early Arad – Urbanism of the nomads. *Zeitschrift des Deutschen Palästina Vereins*: 106: 34-50.

Finkelstein I. 1995. *Living on the Fringe. The Archaeology and History of the Negev, Sinai and Neighbouring Regions in the Bronze and Iron Ages*. Monographs in Mediterranean Archaeology 6. Sheffield: Sheffield Academic Press.

Finkelstein I. and Perevolotsky A. 1990. Processes of sedentarization and nomadism in the history of Sinai and the Negev. *Bulletin of the American Schools of Oriental Research* 279: 67-88.

Flores D.V. 2003. *Funerary Sacrifice of Animals in the Egyptian Predynastic Period*. Oxford: BAR International Series 1153.

Flower S.S. 1932. Notes on the recent mammals of Egypt, with a list of the species recorded from that Kingdom. *Proceedings of the Zoological Society, London* 102: 369-450.

Frazier J. and Salas S. 1984. The status of marine turtles in the Egyptian Red Sea. *Biological Conservation* 30: 41-67.

Frumkin A., Margaritz M., Carmi I. Zak I. 1991. The Holocene climatic record of the Salt caves of Mount Sedom. *The Holocene* 1: 191-200.

Gaillard M. C. 1934. *Contribution a l'etude de la faune préhistorique de l'Egypte*. Lyon: Societe Anonyme de l'imprimerie A. Rey.

Galili U., Rosen B., Gopher A., and Horwitz L.K. 2002. The origin and dispersion of the eastern Mediterranean Fishing Village: Evidence from submerged Neolithic settlements off the Carmel coast, Israel. *Journal of Mediterranean Archaeology* 15 (2): 167-198.

Ganor A., Markowitz R., Kessler Y. and Roznan B. 1973. *Climate of Sinai*. Bet Dagan: Israel Meteorological Authority Publication 22. (Hebrew).

Garfinkel Y. 1981. *Abu Madi III: A Neolithic Site in the High Mountain Area of Sinai*. Unpublished Seminar Paper, Institute of Archaeology, The Hebrew University. (Hebrew).

Garfinkel Y. 1999a. *Neolithic and Chalcolithic Pottery of the Southern Levant*. *Qedem* 39. Jerusalem: Institute of Archaeology, The Hebrew University.

Garfinkel Y. 1999b. Radiometric dates from Eighth Millennium B.P. Israel. *Bulletin of the American Schools for Oriental Research* 315: 1-13.

Garfinkel, Y., Dag, D., Horwitz, L.K., Lernau, O. And Mienis, H. 2002. Ziqim, A Pottery Neolithic site in the southern coastal plain of Israel. A final report. *Journal of the Israel Prehistoric Society* (*Mitekufat Haeven*) 32: 73-145.

Garfinkel Y. , Dag, D. Hesse, B., Wapnish, P., Rookis D., Hartman, G. Bar-Yosef Mayer D.E., and Lernau O. 2005. Neolithic Ashkelon: Meat processing and early pastoralism on the Mediterranean coast. *Eurasian Prehistory* 3(1): 43-72.

Garrard A. 1999. Charting the emergence of cereal and pulse domestication in South-West Asia. *Environmental Archaeology* 4: 67-86.

Garrard A.N., Baird D., Colledge S., Martin L. and Wright K. 1994. Prehistoric environment and settlement in the Azraq Basin: an interim report on the 1987 and 1988 excavations seasons. *Levant* 26: 73-109.

Garrard, A., Colledge, S. and Martin, L. 1996. The emergence of crop cultivation and caprine herding in the "Marginal Zone" of the southern Levant. In: D.R. Harris (ed.), *The Origins and Spread of Agriculture and Pastoralism in Eurasia.* London: UCL Press. Pp. 204-226.

Gat J.R. and Issar A. 1974. Desert isotope hydrology: water sources of the Sinai desert. *Geochimica et Cosmochimica Acta* 33: 1117-1131.

Gautier A. 1978. La faune de vertébrés des sites Epipaleolithique d'Elkab. In: P.M. Vermeersch (ed.), *L'Elkabien, Epipaléolithique de la Vallee di Nil Egyptien*. Leuven: Leuven University Press. Pp. 103-114.

Gautier A. 1984. Quaternary mammals and archaeozoology of Egypt and the Sudan: a survey. In: L. Krzyzaniak and M. Kobusiewicz (eds.), *Origin and Early Development of Food-Producing cultures in North-Eastern Africa.* Posnan: Polish Academy of Sciences. Pp. 43-56.

Gautier A. 1987. Prehistoric men and cattle in North Africa: A dearth of data and a surfeit of models. In: A.E. Close (ed.), *Arid North Africa. Essays in Honour of Fred Wendorf.* Dallas: SMU Press. Pp. 163-187.

Gautier A. 2001. The early to late Neolithic archaeofauns from Nabta and Bir Kiseiba. In: F. Wendorf and R Schild (eds.), *Holocene settlement of the Egyptian Sahara, Vol. 1. The Archaeology of Nabta Playa.* New York: Plenum. Pp. 609-635.

Gautier A. 2002. The evidence for the earliest livestock in North Africa: Or adventures with large bovids, ovicaprids, dogs and pigs. In: F.A. Hassan (ed.), *Droughts, Food and Culture: Ecological Change and Food Security in Africa's Later Prehistory*. New York: Plenum. Pp. 195-207.

Gautier A. and Henrickx S. 1999. Vultures and other animal remains from a tomb in the Elkab necropolis, Upper Egypt: an exercise in salvage archaeozoology. In: C. Becker, H. Manhart, J. Peters and J. Schibler (eds.), *Historia Animalium Ossibus. Beiträge zur Palaoänatomie, Archäeologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin. Festschrift fur Angela von den Driesch.* Rahden: Verlag Marie Leidorf. Pp. 161-179.

Geyh M.A. 1994. The paleohydrology of the eastern Mediterranean. In: O. Bar-Yosef and R.S. Kra (eds.), *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean*. Tucson: Radiocarbon. Pp. 131-145.

Ghaleb B. 1995. Choice cuts: Butchery practices at New Kingdom Memphis. *Egyptian Archaeology* 7: 23-25.

Gilead I. 1981. *Upper Palaeolithic in Sinai and the Negev: Sites in Gebel Maghara, Qadesh Barnea and Nahal Zin*. Unpublished PhD Thesis, The Hebrew University of Jerusalem.

Gilead I. 1984. Palaeolithic sites in northeastern Sinai. *Paléorient* 10 (1): 135-142.

Gilead I. 1988. The Chalcolithic period in the Levant. *Journal of World Prehistory* 2 (4): 397-443.

Gilead I. 1990. The Neolithic-Chalcolithic transition and the Qatifian of the northern Negev and Sinai. *Levant* 12: 47-63.

Gnirs A. 2001. Military. In: Redford D.B. (ed.), *The Oxford Encyclopedia of Ancient Egypt Vol 1*. Oxford: Oxford University Press. Pp. 400-406.

Golani D. 1997. *Handbook of the Fishes of Israel*. Jerusalem: Keter. (Hebrew).

Golani D. 2005. *Checklist of the Mediterranean Fishes of Israel*. Auckland: Magnolia Press.

Goldberg P. 1984. Late Quaternary history of Qadesh Barnea, northeastern Sinai. *Zeitschrift für Geomorphologie* 28: 193-217.

Goldberg P., 1986. Late Quaternary environmental history of the southern Levant. G*eoarchaeology* 1 (3): 225-244.

Goldberg P. 1994. Interpreting late Quaternary continental sequences in Israel. In: O. Bar-Yosef and R.S. Kra (eds.), *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean*. Tucson: Radiocarbon. Pp. 89-102.

Goldberg P. and Bar-Yosef O. 1982. Environmental and archaeological evidence for climatic change in the southern Levant. In: J. Bintliff and W. van Zeist (eds.), *Paleoclimates, Paleoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory*. Oxford: BAR International Series 133. Pp. 399-414.

Goldberg P. and Rosen A. 1987. Early Holocene paleoenvironments of Israel. In: T.E. Levy (ed.) Shiqmim I. Oxford: BAR International Series 356. Pp. 55-66.

Gopher A. 1981. *The Stratigraphy and Lithic Industry of Wadi Tbeik, a Pre-Pottery Neolithic Site in Sinai*. Unpublished MA Thesis, The Hebrew University. (Hebrew).

Gopher A. 1985. *Flint Tool Industries of the Neolithic period in Israel*. Unpublished PhD Thesis, The Hebrew University.

Gopher A. 1994. *Arrowheads of the Neolithic Levant*. Winona Lake: Eisenbrauns.

Gopher A. and Gophna R. 1993. The cultures of the Eighth and Seventh millennia B.P. in the southern Levant. – A review for the 1990's. *Journal of World Prehistory* 7: 297-253.

Gopher A. and Orelle E. 1995. New data on burials from the Pottery Neolithic period (6th-5th millennium BC) in Israel. In: S. Campbell and A. Green (eds.), *The Archaeology of Death in the Ancient Near East*. Oxford: Oxbow Monograph 51. Pp. 24-28.

Gopher A., Goring-Morris A. and Gordon D. 1994. Nahal Issaron. The lithics of the Late PPNB occupation. In: H-G. Gebel and Kozlowski S.K. (eds.), *Neolithic Chipped Stone Industries of the Fertile Crescent. Studies in Early Near Eastern Production, Subsistence and Environment*. Berlin: ex Oriente. Pp. 479-486.

Gopher A. and Goring-Morris A.N. 1998. Abu Salem: A Pre-Pottery Neolithic B camp in the central Negev highlands, Israel. *Bulletin of the American Schools for Oriental Research* 312:1-20.

Goren A. 1980. The *Nawamis* in southern Sinai. In Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Hakkibutz Hameuchad Publishing House Pp. 243-263. (Hebrew).

Goren A. 1998. The Nawamis in southern Sinai. In: S. Ahituv (ed.), *Studies in the Archaeology of Nomads in the Negev and Sinai*. Beersheva: Ben Gurion University Press. Pp. 59-85. (Hebrew).

Goren, A. and Arad-Ayalon, N. n.d. The *nawamis of Wadi Sawawin*. Unpublished Manuscript, Israel Antiquities Authority Archives.

Goren M. 1983. *Fresh-water Fishes of Israel. Biology and Taxonomy*. Tel Aviv. (Hebrew).

Goren Y. 1995. Appendix A. Petrographic analyses of Horvat Teiman (Kuntillet 'Ajrud) Pottery. *Tel Aviv* 22 (2): 206-207.

Goren Y., Oren E. and Feinstein R. 1995. The archaeological and ethnoarchaeological interpretation of a ceramological enigma: Pottery production in Sinai (Egypt) during the New Kingdom period. *KVHAA Konferenser* 34: 101-120.

Goring-Morris A.N. 1987. *At the Edge: Terminal Pleistocene Hunter-Gatherers in the Negev and Sinai*. Oxford: BAR International Series 361.

Goring-Morris A.N. 1993. From foraging to herding in the Negev and Sinai: The early to late Neolithic transition. *Paléorient* 19/1: 65-89.

Goring-Morris A.N. and Belfer-Cohen A. 1998. The articulation of cultural processes and Late Quaternary environmental changes in Cisjordan. *Paléorient* 23: 71-93.

Goring-Morris A.N. and Gopher A. 1978. Nahal Issaron – A Neolithic site in the southern Negev. *Qadmoniot* 20/ 77-78: 18-21. (Hebrew).

Goring-Morris A.N. and Gopher A. 1983. Nahal Issaron: A Neolithic settlement in the southern Negev. *Israel Exploration Journal* 33: 149-162.

Goring-Morris A.N. and Mintz E. 1976. Surveys in southern Sinai. Notes and News. *Israel Exploration Journal* 137-138.

Goring-Morris N. and Avner U. 1986. An Epi-Paleolithic occurence in eastern Sinai, Haj I, and some observations on the use of the microburin technique. *Journal of the Israel Prehistoric Society* 19: 58-65.

Goring-Morris, A. N. and Horwitz, L.K. in press. Funerals and feasts during the Pre-Pottery Neolithic B of the Near East. *Antiquity*.

Grant A. 1991. Economic or symbolic ? Animals and ritual behaviour. In P. Garwood, D. Jennings, R. Skeates and J. Toms (eds.), *Sacred and Profane*. Oxford Committee for Archaeology Monograph No. 32. Oxford.

Grant A. 1982. The use of tooth wear as a guide to the age of domestic ungulates. In: B. Wilson, C. Grigson and S. Payne (eds.), *Ageing and Sexing Animal Bones from Archaeological Sites*. Oxford: BAR British Series 109. Pp.91-108.

Grayson D.K. 1984. *Quantitative Zooarchaeology. Topics in the Analysis of Archaeological Faunas.* Orlando: Academic Press.

Greenwood N. 1997. *The Sinai. A Physical Geog*raphy. Austin: University of Texas.

Grigson C. 1982. Sex and age determination of some bones and teeth of domestic cattle: a review of the literature. In: B. Wilson, C. Grigson and S. Payne (eds.), *Aging and Sexing Animal Bones from Archaeological Sites* (British Archaeological Report 109). Oxford. Pp. 7-23.

Grigson C. 1984a. *Preliminary report on the mammal bones from Neolithic Qatif, site Y3 on the Sinai coastal plain (Excavations of 1979, 1980 and 1983).* Unpublished manuscript.

Grigson C. 1984b. *Preliminary report on the mammal bones from Chalcolithic Qatif, site Y2 (including Y2a), on the Sinai coastal plain (Excavations of 1979, 1980 and 1983).* Unpublished manuscript.

Grigson C. 1987. Shiqmim: Pastoralism and other aspects of animal management in the Chalcolithic of the northern Negev. In: T.E. Levy (ed.), *Shiqmim*. Oxford: BAR International Series 356. Pp. 219–241; 535–546.

Grigson C. 1995a. Plough and pasture in the early economy of the southern Levant. In; T.E. Levy (ed.), *The Archaeology of Society in the Holy Land*. London; Leicester University Press. Pp. 245-268.

Grigson C. 1995b. Cattle Keepers of the northern Negev: Animal Remains from the Chalcolithic of Grar. In: I. Gilead (ed.), *Grar, a Chalcolithic Site in the Northern Negev.* (Beer-Sheva 7). Beer Sheva. Pp. 377–452.

Grigson C. 2000. *Bos africanus* (Brehm)? Notes on the archaeozoology of the native cattle of Africa. In: R.M. Blench and K.C. MacDonald (eds.), *The Origins and Development of African Livestock. Archaeology, Genetics, Linguistics and Ethnography*. London: UCL Press. Pp. 2-17.

Groves C.P.1983. Notes on the gazelles. IV. The Arabian gazelles collected by Hemprich and Ehrenberg. *Zeitschrift fur Saugetierkunde* 48: 371-381..

Guilaine J. (ed.) 2000. *Premiers paysans du monde*: *Naissances des agricultures*. Paris: Errance.

Gunneweg J., Perlman I. and Meshel Z. 1985. The origin of the pottery of Kuntillet 'Ajrud. *Israel Exploration Journal* 35 (4): 270-283.

Gvirtzman G., Shmueli, A., Gradud Y., Beit-Arieh I. and Han-El M. (eds.). 1987. *Sinai*. Tel Aviv: Defence Ministry 2 Vols. (Hebrew).

Haber A. and Dayan T. 2004. Analyzing the process of domestication: Hagoshrim as a case study. *Journal of Archaeological Science* 31: 1587-1601.

Hadley J.M. 1993. Kuntillet 'Ajrud: Religious centre or desert way station ? *Palestine Exploration Quarterly* 125: 115-124.

Haim A. and Tchernov E. 1974. The distribution of myomorph rodents in the Sinai Peninsula. *Mammalia* 38: 202-223.

Haiman M. 1992. Sedentarism and pastoralism in the Negev Highlands in the Early Bronze Age: Results of the western Negev Highlands emergency survey. In O. Bar-Yosef and A. Khazanov (eds.), *Pastoralism in the Levant; Archaeological Materials in Anthropological Perspectives*. Madison, Wisconsin: Monographs in World Archaeology 10. Pp. 93-104.

Hakha E. and Ritte U. 1993. Foraging pressure of the Nubian ibex *Capra ibex nubiana* and its effect on the indigenous vegetation of the En Gedi natural reserve, Israel. *Biological Conservation* 63: 9-21.

Hakker-Orion D. 1975. Hunting and stock breeding in Israel. In: A.T. Clason (ed.), *Archaeozoological Studies*. New York: Elsevier. Pp. 295-301.

Hakker-Orion D. 2004. Animal bones from sites of the Iron Age and Persian periods in the Negev Highlands. In: R. Cohen (ed.), *Ancient Settlement of the Negev Highlands Vol. II. The Iron Age and Persian Period*. Israel Antiquities Authority Report No. 20. Pp. 220-222.

Hallote R.S. 1995. Mortuary archaeology and the Middle Bronze Age southern Levant. *Journal of Mediterranean Archaeology* 8 (1): 93-122.

Hamilton-Dyer S. 1997. The domestic fowl and other birds from the Roman site of Mons Claudianus, Egypt. *International Journal of Osteoarchaeology* 7: 326-329.

Hamilton-Dyer S. 2001. The faunal remains. In: V.A. Maxfield and D.P.S. Peacock (eds.), *Survey and Excavation. Mons Claudianus 1987-1993. Vol II. Excavations: Part 1.* Cairo: Institute Francais d'Archeologie Orientale. Pp. 251-310.

Harrison D.L. and Bates P.J. 1991. *Mammals of Arabia.* 2nd edition. Seven Oaks, Kent: Harrison Zoological Museum Publication.

Hassan F. A. 1988. The Predynastic of Egypt. *Journal of World Prehistory* 2 (2): 135-185.

Hecker H. 1975. *The Faunal Analysis of The Primary Food Animals from Pre-Pottery Neolithic Beidha (Jordan).* University Microfilms International. Ann Arbor: Michigan.

Hecker H. 1982. A zooarchaeological inquiry into pork consumption in Egypt from Predynastic to New Kingdom times. *Journal of the American Reesearch Center in Egypt* 19: 59-69.

Hecker H. 1984. Preliminary report on the faunal remains. In: B. J. Kemp (ed.), *Amarna Reports I.* London: Egypt Exploration Society. Pp. 154-164.

Heiman, E.L. 2002. *Cowries of East Sinai*. Jerusalem: Keter.

Helms S. and Betts A.V.G. 1987. The desert 'kites' of the Badiyat esh-Sham and North Arabia. *Paléorient* 13 (1): 41-67.

Hellström B. 1953. The ground water supply of north-eastern Sinai. *Geografiska Annales* 35 (2): 61-74.

Hellwing S. and Agiman Y. 2000. Animal bones from the Aharoni fortress. In: Z. Meshel (ed.), *Sinai. Excavations and Studies*. BAR International Series 876. Oxford: Archeopress. Pp. 71-72.

Hellwing S. and Feig N. 1989. Animal bones. In: Z. Herzog, G. Rapp and O. Negbi (eds.), *Excavations at Tel Michal, Israel*. Minneapolis: University of Minnesota Press. Pp. 236-247.

Heneidy S.Z.1996. Palatability and nutritive value of some common plant species from the Aqaba Gulf area of Sinai, Egypt. *Journal of Arid Environments* 34: 115-123.

Henry D. O. (ed.) 1995. *Prehistoric Cultural Ecology and Evolution. Insights from Southern Jordan*. New York: Plenum Press.

Henry D.O., Cardova C., White J.J., Dean R.M., Beaver J.E., Ekstrom H., Kadowaki S., McCorriston J., Nowell and Scott-Cummings L. 2003. The early Neolithic site of Ayn Abu Nukhayla, southern Jordan. *Bulletin of the American Schools of Oriental Research* 330: 1-30.

Hershkovitz I., Kobyliansky E. and Arensburg A. 1982. *Cox vara* in a Chalcolithic population from the Sinai. *Current Anthropology 23: 320-322.*

Hershkovitz I., Ben-David Y., Arensburg B., Goren A. and Pichasov A. 1987. Rock engravings in southern Sinai. In: G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 1. Pp. 605-616. (Hebrew).

Hershkovitz I., Bar-Yosef O. and Arensburg B. 1994. The Pre-Pottery Neolithic populations of south Sinai and their relations to other circum-Mediterranean groups: An anthropological study. *Paléorient* 20: 59-84.

Hesse B. and Wapnish P. 1975/78. The gazelle from a shaft tomb at Bab edh-Dhra. *Bulletin of the American Schools of Oriental Research* 12: 4-15.

Hesse B. and Wapnish P. 1985. *Animal Bone Archaeology*. Washington DC: Taraxacum Manuals on Archeology No. 5.

Hillson S. 1992. *Mammal Bones and Teeth. An Introductory Guide to Methods of Identification*. London: Institute of Archaeology, University College London.

Hilzheimer H.K. 1961. *Die Altersbestimmung bei Haustieren, Peltztieren und beim jagdbaren Wild*. Berlin: Paul Parey.

Hobbs J.J. 1995. *Mount Sinai*. Austin: University of Texas Press.

Hoffmeier J.K. 2002. Tell el-Borg in north Sinai. *Egyptian Archaeology* 20: 18-20.

Holland, F.W. 1870. *Sinai and Jerusalem*. London.

Holland, F.W. 1871. *The Recovery of* Jerusalem. London.

Holzer A. 2002. *Desert Kites in the Southern Negev. Their Date and Function as Part of an Ancient Environmental System*. Unpublished MA thesis, Tel Aviv University. (Hebrew).

Hoogstraal H. 1963. A brief review of the contemporary land mammals of Egypt (including Sinai). 2. Lagomorpha and Rodentia. *Journal of the Egyptian Public Health Association* 38: 1-35.

Hoogstraal H. 1964. A brief review of the contemporary land mammals of Egypt (including Sinai). 3. Carnivora, Hyracoidea, Perissodactyla and Artiodactyla. *Journal of the Egyptian Public Health Association* 39: 205-239.

Horowitz A. 1992. *Palynology of Arid Lands*. Amsterdam: Elsevier.

Horwitz L.K. 1986-87. Faunal remains from the Early Iron age site on Mount Ebal, *Tel-Aviv* 13-14 (2): 173-189.

Horwitz L.K. 1987. Animal offerings from two Middle Bronze Age tombs. *Israel Exploration Journal* 37: 251-255.

Horwitz L.K. 1989. A reassessment of caprovine domestication in the Levantine Neolithic: Old questions, new answers. In: Hershkovitz I. (ed.), *People and Culture in Change*. Oxford: BAR International Series 508i. Pp. 153-181.

Horwitz L.K. 1993. The development of ovicaprine domestication during the PPNB of the southern Levant. In H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East vol. I*. Leiden: Universal Book Services. Pp. 27-36.

Horwitz L.K. 1996. The impact of animal domestication on species richness: A pilot study from the Neolithic of the southern Levant. *ArcheoZoologia*; Vol. 8/1,2: 53-70.

Horwitz L.K. 1997. Animal remains. In: E. Braun (ed.) *Yiftah'el. Salvage and Rescue Excavations at A Prehistoric Village in Lower Galilee, Israel*. Israel Antiquities Authority Reports 2, Pp. 155-172.

Horwitz L.K. 1999. The Contribution of archaeozoology to the identification of ritual sites. In: S. Pike and S. Gitin (eds.), *The Practical Impact of Science on Near Eastern and Aegean Archaeology*. Wiener Laboratory Monograph No. 3. London: Archetype Press. Pp. 63-69.

Horwitz L.K. 2001. Animal offerings in the Middle Bronze Age: Food for the gods, food for thought. *Palestine Exploration Quarterly* 133: 78-90.

Horwitz, L.K. 2002a. The development of archaeozoological research in Israel and the West Bank. *Archaeofauna* 11: 131-145.

Horwitz L.K. 2002b. The fauna from caves in the northern Judean Desert. *Atiqot* 41 (Part II): 257-280.

Horwitz L.K. 2003a. Early Bronze Age archaeozoological remains. In: I. Beit-Arieh (ed.), *Archaeology of Sinai. The Ophir Expedition*. Tel Aviv: Emery and Claire Yass Publications in Archaeology. Pp. 242- 257.

Horwitz L.K. 2003b. Temporal and spatial variation in Neolithic caprine exploitation strategies: A case study of fauna from the site of Yiftah'el, (Israel). *Paléorient* 21: 19-58.

Horwitz L.K. 2003c. Fauna recovered from caves in the vicinity of the Holyland Hotel, Jerusalem. Unpublished Report, Israel Antiquities Authority.

Horwitz L.K. 2003d Early Bronze Age animal exploitation at Qiryat Ata. In: A. Golani (ed.) *Salvage Exacavations at the Early Bronze Age Site of Qiryat Ata*. Israel Antiquities Authority Reports 18. Pp. 225-241.

Horwitz L.K. in press a. Animal remains. In: U. Avner (ed.), *Late Neolithic-Early Chalcolithic burial site in Eilat by the Red Sea*. Israel Antiquities Authority Reports.

Horwitz, L.K. in press c. Faunal remains. In: M. Kochavi, Y. Gadot and E. Yadin (eds.) *Aphek-Antipatris II: The Upper City of Aphek. Bronze Age and Iron Age remains from Areas X, A and G*. Tel-Aviv Monograph Series, Institute of Archaeology, Tel-Aviv University.

Horwitz L.K. and Ducos P. 1998. An investigation into the origins of domestic sheep in the southern Levant. In: H. Buitenhuis, L. Bartosiewicz and A.M. Choyke (eds.), *Archaeozoology of the Near East III*. Groningen: ARC Publicaties. Pp. 80-94.

Horwitz L.K. and Goring-Morris N. 2004. Animals and ritual during the Levantine PPNB: A case study from the site of Kfar Hahoresh, Israel. *Anthropozoologia* 39 (1): 165-178.

Horwitz, L.K. and Milevski, I. 2001. The faunal evidence for socio-economic change in the Middle and Late Bronze Ages of the southern Levant. In: S.R. Wolff (ed.) *Studies in Archaeology of Israel and Neibouring Lands in Memory of Douglas L. Esse*. Studies in Ancient Oriental Civilization. Chicago: Oriental Institute. Pp. 16-42.

Horwitz, L.K. and Rosen, B. 2005. A review of camel milking in the southern Levant. In J. Mulville and A.K. Outram (eds.), *The Zooarchaeology of Fats, Oils, Milk and Dairying*. Oxford: Oxbow Books. Pp. 121-131.

Horwitz L.K. and Studer J. 2005. Pig production and exploitation during the Classical periods in the Southern Levant. In: H. Buitenhuis, A.M. Choyke, L. Martin, L. Bartosiewicz and M. Mashkour (eds.) *Archaeozoology of the Near East vol. VI*. Groningen: ARC-Publicaties 123. Pp. 222-239.

Horwitz L.K. and Tchernov E. 1989a. Animal exploitation in the Early Bronze Age of the southern Levant: An overview. In: P. de Miroschedji (ed.), *L'urbanisation de la Palestine a l'age du bronze ancien*. Oxford: BAR International Series 527(ii). Pp. 279-296.

Horwitz L.K. and Tchernov E. 1989b. Subsistence patterns in ancient Jerusalem: A study of animal remains. In: B. Mazar and E. Mazar (eds.), *Excavations in the South of the Temple Mount*. Qedem 29, Jerusalem: Institute of Archaeology, The Hebrew University. Pp. 144-154.

Horwitz L.K. and Tchernov E. 1990. Cultural and environmental implications of hippopotamus bone remains in archaeological contexts in the Levant. *Bulletin of the Schools of Oriental Research* 280: 67-76.

Horwitz L.K. and Raphael O. 1995. Faunal remains. In: I. Beit-Arieh (ed), *Horvat Qitmit,* (Monograph Series of the Institute of Archaeology, Tel Aviv University), Tel-Aviv. Pp. 287-302.

Horwitz L.K., Cope C. and Tchernov E. 1990. Sexing the bones of mountain-gazelle (*Gazella gazella*) from prehistoric sites in the southern Levant. *Paléorient* 16 (2): 1-12.

Horwitz L.K., Tchernov E. and Hellwing S. 1996. Patterns of Animal Exploitation. In: R. Gophna (ed.), *Excavations at Tel Dalit*. Tel Aviv. Pp. 193–216.

Horwitz L.K., Tchernov, E., Ducos, P., von den Driesch, A., Becker, C., Martin L. and Garrard, A. 1999a. Animal domestication in the southern Levant. *Paléorient* 25 (2): 63-80.

Horwitz L.K., Tchernov E. and Weksler-Bdolah S. 1999b. The past biogeography of the Arabian oryx (*Oryx lecoryx* Pallas, 1777) in the southern Levant in the light of new archaeological data. *Mammalia* 63 (4): 465-474.

Horwitz L.K., Galili E., Sharvit J. and Lernau O. 2002a. Fauna from five submerged Pottery Neolithic sites off the Carmel coast. *Journal of the Israel Prehistoric Society* 32: 147-174.

Horwitz, L.K., Tchernov, E., Mienis, H.K., Hakker-Orion, D. and Bar-Yosef Mayer, D. E. 2002b. The archaeozoology of three Early Bronze Age Sites in Nahal Besor, north-western Negev. In: E.C.M. van den Brink and E. Yanai (eds.), *In Quest of Ancient Settlements and Landscapes. Archaeological Studies in Honour of Ram Gophna*. Tel Aviv: Tel Aviv University-Ramot Publishing. Pp.107-133.

Horwitz L.K., Tchernov E. and Hongo H. 2004. The domestic status of the early Neolithic fauna of Cyprus: A view from the mainland. In: E. Peltenburg and A. Wasse (eds.), *Neolithic Revolution. New Perspectives on Southwest Asia in Light of Recent Discoveries on Cyprus*. Levant Supplementary Series 1. Oxford: Oxbow Books. Pp. 35-48.

Horwitz, L.K., Avner U., Davis S.J., Feig N. and Mienis H.K. in prep. Early pastoralist communities (5th-3rd millennia BC) in the ‘Uvda Valley, southern Negev Desert: Archaeozoological and malacological evidence.

Houlihan P.F. 1996. *The Animal World of the Pharaohs*. London: Thames and Hudson.

Hovers, E. 1981. *The assemblages from nawamis and habitation sites of the fourth millennium in Sinai. (Lithics of Ein Huderah , Ein um Ahmed and Wadi Nasb).* Unpublished MA Seminar, The Hebrew University, Jerusalem. (Hebrew).

Hume, W.F. 1906. *The Topography and Geology of the Sinai (South--Eastern Portion).* Cairo: National Printing Department.

Ikram S. 1995. *Choice Cuts: Meat Production in Ancient Egypt.* Leuven: Peeters Press.

Ilan, O. and Sebbane, M. 1989. Copper metallurgy, trade and the urbanization of southern Canaan in the Chalcolithic and Early Bronze Age. In: Miroschedji, de P. (ed.), *L’urbanisation de la Palestine a l’age du Bronze ancien*. Oxford: BAR International Series 527(i). Pp. 139-162.

Ingold T. 1980. *Hunters, Pastoralists and Ranchers*. Cambridge: Cambridge University Press.

Isaac B. 1988. The meaning of the terms *Limes* and *Limitanei*. *The Journal of Roman Studies* 78: 125-147.

Issar A. 1985. Fossil water under the Sinai-Negev Peninsula. *Scientific American* 253 (1): 104-110.

Issar A. S. 1998. Climate change and history during the Holocene in the eastern Mediterranean region. In: A.S. Issar and N. Brown (eds.)*, Water, Environment and Society in Times of Climate Change.* Kluwer Academic Press. Pp.113-128.

Jabbur J.S. 1995. *The Bedouins and The Desert. Aspects of Nomadic Life in the Arab East*. Albany: State University of New York Press.

Jackson F.G.S. 1916. *The Use of Cowrie Shells for the Purpose of Currency, Amulets and Charms*. Manchester Memoirs 60 (13): 1-72.

Jaffe S. 1987. The climate of Sinai. In: Gvirtzman G., Shmueli, A., Gradud Y., Beit-Arieh I. and Han-El M. (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 1. Pp. 331-335.
(Hebrew).

James F.W. and McGovern P.E. (eds.). *The Late Bronze Age Egyptian Garrison at Beth Shan: A study of Levels VII and VIII.* University Monograph No. 85. Pennsylvania: The University Museum.

Janssen J.J. 1975. *Commodity Prices from the Ramessid Period*. Leiden**.**

Joffe A.H. 1993. *Settlement and Society in the Early Bronze Age I and II Southern Levant: Complementarity and Contradiction in a Small-Scale Complex Society*. Sheffield: Sheffield Academic Press.

Kahila Bar-Gal G., Khalaily H., Marder O., Ducos P. and Horwitz L.K. 2002. Ancient DNA evidence for the transition from wild to domestic status in Neolithic goats: A case study from the site of Abu Gosh, Israel. *Ancient Biomolecules* 4 (1): 9-17.

Kemp B.J., Delwen S. and Luff R. 1994. Food for an Egyptian City: Tell el-Amarna. In: R. Luff and P. Rowley-Conwy (eds.), *Whither Environmental Archaeology* ? Oxford: Oxbow Monographs 38. Pp. 133-170.

Kingdon J. 1990. *Arabian Mammals. A Natural History*. London.

Klein R.G. and Cruz-Uribe K. 1984. *The Analysis of Animal Bones from Archaeological Sites*. Chicago: University of Chicago Press.

Klenck J.D. 1995. Bedouin animal sacrifice practices: Case study in Israel. In: K. Ryan and P.J. Crabtree (eds.), *The Symbolic Role of Animals in Archaeology*. Philadelphia: MASCA Research Papers in Science and Archaeology Vol. 12. Pp. 57-72.

Klenck J.D. 2002. *The Canaanite Cultic Milieu. The Zooarchaeological Evidence from Tel Haror, Israel*. BAR International Series 1029. Oxford: Archaeopress.

Köhler-Rollefson I. 1988. The aftermath of the Levantine Neolithic Revolution in the light of ecological and ethnographic evidence. *Paléorient* 14: 87-93.

Köhler-Rollefson I. 1989a. Changes in goat exploitation at ‘Ain Ghazal between the early and late Neolithic: A metrical analysis. *Paléorient* 15/1: 141-146.

Köhler-Rollefson I. 1989b. Resoving the revolution: Late Neolithic refinements of economic strategies in the eastern Levant. *ArchaeoZoologia* 1: 201-208.

Köhler-Rollefson I. 1992. A model for the development of nomadic pastoralism on the Transjordan plateau. In: O. Bar-Yosef and A. Khazanov (eds.), *Pastoralism in the Levant*. Monographs in World Archaeology No. 10. Madison, Wisconsin: Prehistory Press. Pp. 11-18.

Köhler-Rollefson I. 1995. The animal bones. In: C-M Bennett and P. Bienkowski (eds.), *Exacavations at Tawilan in Southern Jordan*. Oxford: Oxford University Press. Pp. 97-100.

Kozlowski J.K. and Ginter B. 1989. The Fayum Neolithic in the light of new discoveries. In: L. Krzyaniak and M. Kobusiewicz (eds.), *Late Prehistory of the Nile Basin and the Sahara*. Studies in African Archaeology No. 2. Poznan Archaeological Museum. Pp. 157-180.

Kuijt I. and Bar-Yosef O. 1994. Radiocarbon chronology for the Levantine Neolithic: Observations and data. In: O. Bar-Yosef and R.S. Kra (eds.), *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean.* Tucson: Radiocarbon. Pp. 227-245.

Kuijt I. and Goring-Morris A.N. 2002. Foraging, farming and social complexity in the Pre-Pottery Neolithic of the southern Levant: A review and synthesis. *Journal of World Prehistory* 16: 361-440.

Lachish, I. and Meshel, Z. 1982. *South Sinai Researches, 1967-1982*. Tel Aviv. (Hebrew).

Lam Y.M., Pearson O.M., Marean C. and Chen X. 2003. Bone density studies in zooarchaeology. *Journal of Archaeological Science* 30:1701-1708.

Lancaster W. and Lancaster F. 1991. Limitations on sheep and goat herding in the eastern *badia* of Jordan: An ethno-archaeological enquiry. *Levant* 23: 125-138.

Lang C. 1998. Preliminary report on the faunal analysis for Tell Qedwa. *Journal of the American Research Center in Egypt* 36: 58-59.

Le Berre M. 1989. *Faune du Sahara. I. Poissons-amphibiens-reptiles*. Paris: Terres Africaines.

Legge A. 1996. The beginning of caprine domestication in Southwest Asia. In: D. R. Harris (ed.), *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. London: UCL Press. Pp. 238-262.

Legge, A.J. and Dorrington, E.J. 1985. The animal bones. In: F.R. Clark and I.K. Jones (eds.), *The Romano-British Temple at Harlow, Essex.* West Essex Archaeological Group. Pp.122-133.

Legge, A.J. and Rowley-Conwy P.A. 1987. Gazelle killing in Stone Age Syria. *Scientific American* 257: 76-83.

Leguilloux M. 1997. Quelques aspects de l'approvisionnement en viande des *praesidia* du désert oriental égyptien. In: A. Gautier (ed.), *Animals and People in the Holocene of North Africa. ArchaeoZoologia* 9/1.2: 73-82.

Lernau H. 1986/87. Subfossil Remains of Nile Perch (*Lates* cf. *niloticus*). First evidence from ancient Israel. *Israel Journal of Zoology* 34: 225-236.

Lernau H. 1988. Mammal remains. In: B. Rothenberg (ed.), *The Egyptian Mining Temple at Timna*. London: Institute for Archaeo-Metallurgical Studies and The Institute of Archaeology, University College London. Pp. 246-253.

Lernau H. and Lernau O. 1992. Fish remains. In: A. de Groot and D.T. Ariel (eds.), *Excavations at the City of David 1978-1985; Final report, Vol. III. Qedem* 33, Jerusalem: Institute of Archaeology, The Hebrew University. Pp. 131-148.

Lev-Tov J. 2000. *Pigs, Philistines, and the Ancient Animal Economy of Ekron from the Late Bronze Age to the Iron Age II*. Unpublished PhD Thesis, The University of Tennessee, Knoxville.

Lev-Tov J. S.E. and Maher E.F. 2001. Food in Late Bronze Age funerary offerings: Faunal evidence from Tomb I at Tell Dothan. *Palestine Exploration Quarterly* 133: 91-110.

Levi S. 1976. Sinai leopards: a tale of extinction. *Teva Va'aretz* 19 (1): 8-14. (Hebrew).

Levi S. 1987. *The Bedouines in Sinai Desert. A Pattern of Desert Society.* Tel Aviv: Schocken Publishing (Hebrew).

Levy T.E. 1995. Cult, metallurgy and rank societies – Chalcolithic period (ca. 4500-3500 BCE). In: T.E. Levy (ed.), *The Archaeology of Society in the Holy Land*. London; Leicester University Press. Pp. 226-244.

Levy Y. 1987. The Bardawil Lagoon and the surrounding sabkhas. In: G. Gvirtzman, A. Shmueli, Y. Gradus, I. Beit-Arieh and M. Har-El (eds.), *Sinai*. Tel-Aviv: Ministry of Defence. Pp. 257-262. (Hebrew).

Lev-Yadun S., Gopher A. and Abbo S. 2000. The cradle of agriculture. *Science* 288: 1602-1603.

Lewis R.E., Lewis J.H. and Atallah S.I. 1968. A review of Lebanese mammals. Carnivora, Pinnipedia, Hyracoidea and Artiodactyla. *Journal of Zoology, London* 154: 517-531.

Lewis-Williams D. 2003. Review feature: The mind in the cave: Consciousness and the origins of art. *Cambridge Archaeological Journal* 13 (2): 263-279.

Lindner H. 1979. *Zur Frühgeschichte des Haushuhns im Vorderen Orients*. Inaugural PhD Dissertation inVeterinary Medicine, Ludwig Maximilians University, Munich.

Lortet L. Ch. and Gaillard C. 1903. *La Faune Momifiee de l'Ancienne Egypte*. Archives du Museum d'Histoire Naturelle de Lyon.

Loyet M. A. 2003. Preliminary faunal report-2002. Tell el-Borg.
(online report at: http://www.tellelborg.org/report2002fanual.htm).

Luff R.M. 2001. New light on ancient Egyptian fishing and fowling. In: H. Buitenhuis and W. Prummel (eds.), *Animals and Man in the Past. Essays in Honour of Dr. A.T. Clason Emeritus Professor of Archaeozoology Rijksuniversiteit Groningen, The Netherlands*. Groningen: ARC-Publicaties 41. Pp. 357-363.

Lyman R. L. 1985. Bone frequencies: Differential transport, in situ destruction, and the MGUI. *Journal of Archaeological Science* 12: 221-236.

Lyman R. Lee. 1992. Anatomical considerations of utility curves in zooarchaeology. *Journal of Archaeological Science* 19 (1): 7-22.

Lyman R. Lee. 1994. *Vertebrate Taphonomy*. Cambridge: Cambridge University Press.

MacDonald K.C. 2000. The origins of African Livestock: indigenous or imported ? In: R.M. Blench and K.C. MacDonald (eds.), *The Origins and Development of African Livestock. Archaeology, Genetics, Linguistics and Ethnography*. London: UCL Press. Pp. 2-17.

Macfarlane W.V. 1968a. Adaptation of ruminants to tropics and deserts. In: E.S.E. Hafez (ed.), *Adaptation of Domestic Animals*. Philadelphia: Lea and Febiger. Pp. 164-182.

Macfarlane W.V. 1968b. Comparative functions of ruminants in hot environments. In: E.S.E. Hafez (ed.), *Adaptation of Domestic Animals*. Philadelphia: Lea and Febiger. Pp. 254-276.

Magurran A.E. 1991. *Ecological Diversity and its Measurement*. London: Chapman and Hall.

Maltz E. 1980. *Lactation and productivity of Desert Ruminants: Bedouin Goat, Ibex and Gazelle*. Unpublished PhD Thesis, Tel Aviv University. (Hebrew).

Maltz E. and Shkolnik A. 1980. Milk production in the desert: lactation and water economy in the Bedouin goat**.** *Physiological Zoology* 53: 12-18.

Manlius N. 2001. The ostrich in Egypt: Past and present. *Journal of Biogeography* 28: 945-953.

Manlius N. and Gautier A. 1999. Le sanglier en Egypte. *Compte de Rendu du Academie Scientifique de Paris, Sciences de la Vie* 322: 573-577.

Martin L.A. 1994. *Hunting and Herding in a Semi-Arid Region. An Archaeozoological and Ethological Analysis of the faunal Remains from the Epipalaeolithic amd Neolithic of the eastern Jordanian Steppe*. Unpublished PhD Thesis, University of Sheffield.

Martin L.A. 1998. The animal bones. In: Betts A.V.G. (ed.), *The Harra and the Hamad. Excavations and Explorations in Eastern Jordan*. Sheffield: Sheffield Academic Press. Pp. 159-184.

Martin L.A. 1999. Mammal remains from the eastern Jordanian Neolithic, and the nature of caprine herding in the steppe. *Paléorient* 25/2: 87-104.

Marx E. 1977. Communal and individual pilgrimage. The region of Saints' tombs in south Sinai. In: R. P. Werbner (ed.), *Regional Cults*. London: Academic Press. Pp. 29-51.

Marx E. 1980. Wage labour and tribal economy of the Bedouin in south Sinai. In: P. Salzman (ed.), *When Nomads Settle*. New York: J.F. Bergin. Pp. 111-123.

Marx E. 1999. Oases in south Sinai. *Human Ecology* 27 (2): 341-357.

Mashkour M., Lecomte O. and Eisenmann V. 1998. Le sacrifice animal dans le temple de L'E. Babbar de Larsa (Irak) à la période Hellenistique: Temoigage des vestiges osseux. *Anthropozoologica* 27: 51-64.

Maxfield V.A. 1996. The eastern desert forts and the army in Egypt during the principate. In: D.M. Bailey (ed.), *Archaeological Research in Roman Egypt. Journal of Roman Archaeology Supplementary Series* 19: 8-19.

Mazar A. 1992. *Archaeology of the Land of the Bible. 10,000-586 B.C.E.* New York: Doubleday.

Meadow R.H. 1989. Osteological evidence for the process of animal domestication. In J. Clutton-Brock (ed.), *The Walking Larder. Patterns of Domestication, Pastoralism and Predation.* One World Archaeology 2. London: Unwin Hyman. Pp. 80-90.

Melmet A. 1964. Military ration-tables in the Anastasi 1 Papyrus and the Bible. In: J. Liver (ed.), *The Military History of the Land of Israel*. Pp. 342-349. (Hebrew).

Mendelssohn H., and Yom-Tov Y. 1999. *Fauna Palaestina - Mammalia of Israel*. Jerusalem, The Israel Academy of Sciences and Humanities.

Mendelssohn H., Yom-Tov Y., Ilany G. and Meninger D.1987. On the occurrence of Blanford's fox, *Vulpes cana*, Blanford, 1877, in Israel and Sinai. *Mammalia* 51: 459-462.

Mendelssohn H., Yom-Tov Y., and Groves C.P. 1995. *Gazella gazella*. *Mammalian Species* 490: 1-7.

Meshel Z. 1976. Kuntillet 'Ajrud - An Israelite site on the Sinai border. *Qadmoniot* 9: 119-124. (Hebrew).

Meshel, Z. 1977a. Kuntilat 'Ajrud, 1975-1976. Notes and News. *Israel Exploration Journal* 27 (2-3): 52-53.

Meshel Z. 1977b. A lyre player drawing from Ajrud in Sinai. *Tatzlil* 17: 109-110. (Hebrew).

Meshel, Z. 1977c. Kuntilat 'Ajrud. *Revue Biblique* 84: 270-273.

Meshel Z. 1978. Kuntillet 'Ajrud. An Israelite religious center in northern Sinai. *Expedition* 20 (4): 50-54.

Meshel Z. 1979. Kuntillat-Ajrud. *Le Monde de la Bible* 10: 32-36.

Meshel Z. 1980. Were the rock inscriptions in Sinai written by Nabateans ? In: Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Tel Aviv: Hakibbutz Hameuchad. Pp. 379-384. (Hebrew).

Meshel Z. 1981. A religious center at Kuntillet 'Ajrud, Sinai. In: A. Biran (ed.), *Temples and High Places in Biblical Times*. Jerusalem: Israel Exploration Society. Pp. 5-9.

Meshel Z.1982. Probe excavation in Dahab fortress and its importance. In: I. Lachish and Z. Meshel (eds.), *South Sinai Researches 1967-1982*. Tel Aviv: Society for the Protection of Nature. Pp. 33-35. (Hebrew).

Meshel Z. 1982-3. The Israelite religious centre of Kuntillet 'Ajrud. *Bulletin of the Anglo-Israel Archaeological Association*: 52-55.

Meshel Z. 1987. Horvat Teiman (Kuntillet Ajrud) – An Israelite cultic center in Sinai. In: G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 2. Pp. 665-673. (Hebrew).

Meshel Z. 1993. Horvat Teman. In: Stern, E. (ed.), *The New Encyclopedia of Archaeological Excavations Vol. IV*. Jerusalem: Israel Exploration Society. Pp. 1458-1464.

Meshel Z. 2000. *Sinai. Excavations and Studies*. Oxford: BAR International Series 876. Archaeopress.

Meshel Z. and Finkelstein I. (eds.). 1980. *Sinai in Antiquity* .Hakibbutz Hameuchad. (Hebrew).

Metawi H.R., Kandil H.M. and El Shaer H.M. 1999. Sheep productivity under extensive and semi-intensive production systems in Egypt. In: R. Rubino and P. Mohrand-Fehr (eds.), *Systems of Sheep* *and Goat Production. Organization of Husbandry and Role of Extension Services*. CIHEAM: Cahiers Options Mediterraneannes No. 28.

Mienis H.K. 1995. Molluscs. In: I. Beit-Arieh (ed.), *Horvat Qitmit an Edomite Shrine in the Biblical Negev*. Tel Aviv: Monograph Series of the Institute of Archaeology, Tel Aviv University 11. Pp. 276-279.

Mienis H.K. 1998. Shells collected during the North Sinai archaeological survey: Some facts and figures. *Levantina* 83:13-21.

Milevski I. 2002. A new fertility figurine and new animal motifs from the Chalcolithic in the southern Levant: Finds from cave K-1 at Quleh, Israel. *Paléorient* 28 (2): 133-142.

Miller R.L. 1990. Hogs and hygiene. *Journal of Egyptian Archaeology* 76: 125-140.

Miller R.L. 1991. Counting calories in Egyptian ration texts. *Journal of the Economic and Social History of the Orient* 34 (3): 258-269.

Miller J. 1999. Excavations at Sinai-18, The Khasem El Taref Site, Zarnoq locality. In: F.W. Eddy and F. Wendorf (eds.), *An Archaeological Investigation of the Central Sinai, Egypt*. Boulder: University Press of Colorado. Pp. 181-192.

Miller Rosen A.M. 1993. Phytolith evidence for early cereal exploitation in the Levant. In: D. M. Pearsall and D.R. Piperno (eds.), *Current Research in Phytolith Analysis. Application in Archaeology and Paleoecology*. MASCA Research Papers 10. Philadelphia: University of Pennsylvania. Pp. 161-171.

Mintz E. and Ben-Ami D. 1977. Neolithic occurrences. In: O. Bar-Yosef and J.L. Phillips (eds.), *Prehistoric Investigations in Gebel Maghara, Northern Sinai*. *Qedem* 7. Jerusalem: The Hebrew University. Pp. 219-244.

Miroschedji de P. 1993. Cult and religion in the Chalcolithic and early Bronze Age. In: A. Biran and J. Aviram (eds.), *Biblical Archaeology Today, 1990. Pre-Congress Symposium: Population, Production and Power*. Jerusalem: Israel Exploration Society. Pp. 208-220.

Miroschedji de P., Sadeq M., Faltings D., Boulez V., Nagghar-Moliner L., Sykes N. and Tengberg M. 2001. Les fouilles de Tell es-Sakan (Gaza): Nouvelles données sur les contacts Egypto-Cananéens au IVe-IIIe millénaires. *Paléorient* 27 (2): 75-104.

Misak R.F. and Draz M.Y. 1997. Sand drift control of selected coastal and desert dunes in Egypt: case studies. *Journal of Arid Environments* 35: 17-28.

Moens M-F. and Wetterstrom W. 1988. The agricultural economy of an Old Kingdom town in Egypt's west delta. Insights from the plant remains. *Journal of Near Eastern Studies* 47 (3): 159-173.

Mueller D. 1975. Some remarks on wage rates in the Middle Kingdom. *Journal of the Near Eastern Society* 34 (4): 249-263.

Na'aman N. 1981. Economic aspects of the Egyptian occupation of Canaan. *Israel Exploraton Journal* 31 (3-4): 172-185.

Na'aman N. 1987. The Sinai Peninsula as understood within the Egyptian and the Biblical concept of borders. In: G. Gvirtzman, A. Shmueli, Y. Gradus, I. Beit-Arieh and M. Har-El (eds.), *Sinai*. Tel-Aviv: Ministry of Defence. Pp. 709-713. (Hebrew).

Najjar M., Abu Dayya A., Suleiman E., Weisgerber G. and Hauptmann A. 1990. Tell Wadi Feinan. The first Pottery Neolithic tell in the south of Jordan. *Annals of the Department of Antiquities of Jordan* 34: 27-56.

Nebel A, Landau-Tasseron E, Filon D, Oppenheim A, Faerman M. 2002. Genetic evidence for the expansion of Arabian tribes into the southern Levant and North Africa. *American Journal of Human Genetics* 70: 1594-1596.

Neev D., Bakler N. and Emery K.O. 1987. *Mediterranean Coasts of Israel and Sinai*. New York: Taylor and Francis.

Negev A. 1967. New dated Nabatean graffiti from the Sinai. *Israel Exploration Journal* 17: 250-255.

Negev A. 1977. A Nabatean sanctuary at Gebel Moneijah, southern Sinai. *Israel Exploration Journal* 27: 219-231.

Negev A. 1987a. The Nabateans in Sinai. In: G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 2. Pp. 745-750. (Hebrew).

Negev A. 1987b. Nabatean inscriptions and rock engravings in Sinai. G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 2. Pp. 751-764. (Hebrew).

Neuville R.1952. Station acheuléenne du Sinai septentrional- DGebel el Faleq. *Bulletin de la Société Préhistorique Francaise* 49: 77-80.

Nicholson R.A. 1993. A morphological investigation of burnt animal bone and an evaluation of its utility in archaeology. *Journal of Archaeological Science* 20: 411-428.

Nicolotti M. 1998. *Les Mammifères Sauvages de l'Ancien Égypte*. Unpublished PhD Thesis, Universite Lumiere Lyon 2.

Nisani R. 1974. *Geographic Variation of Partridges (Alectoris chukar, Gray) and Bergmanns Rule*. Unpublished MSc Thesis, The Hebrew University of Jerusalem. (Hebrew).

Nobis G. 1976-77. Zu den wild-und haustieren von Tamassos auf Zypern-eines Tempelbereichs aus archaisch bis klassisch-Hellenistischer zeit. *Acta Praehistoria et Archeologie* 7/8: 492-497.

Noddle B. 1974. Ages of epiphyseal closure in feral and domestic goats and ages of dental eruption. *Journal of Archaeological Science* 1: 195-204.

O'Connor T. 2000. *The Archaeology of Animal Bones*. Gloucestershire: Sutton Publishing.

Oren E.D. 1973a. The overland route between Egypt and Canaan in the Early Bronze Age. *Israel Exploration Journal* 23: 198-204

Oren E.D. 1973b. Bir el-Abd (northern Sinai). *Israel Exploration Journal* 23: 112-113.

Oren E.D. 1973c. An Egyptian fortress on the military road between Egypt and`Canaan. *Qadmoniot* 6: 101-103. (Hebrew).

Oren E.D. 1979. Landbridge between Asia and Africa: Archaeology of northern Sinai up to the Classical period. In: B. Rothenberg (ed.), *Sinai: Pharaohs, Miners, Pilgrims and Soldiers*. Berne: Kummerly and Frey. Pp. 181-191.

Oren E.D. 1980a. North Sinai survey 1972-1978. In: Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Hakibbutz Hameuchad. Pp.101-158. (Hebrew).

Oren E. 1980b. Egyptian sites from the days of the New Kingdom in Sinai. *Qadmoniot* 49-50 (1-2): 26-33.

Oren E. 1982. Excavations at Qasrawet in north-western Sinai. Preliminary Report. *Israel Exploration Journal* 32: 203-211.

Oren E.D. 1982-3. Ancient military roads between Egypt and Cana'an. *Bulletin of the Anglo-Israel Archaeological Society*. 20-24.

Oren E. 1983. Haruvit. *Excavations and Surveys in Israel* 2: 44-45.

Oren E.D. 1984. "Governors' Residences" in Canaan under the New Kingdom: A case study of Egyptian administration. *The Journal of the Society for the Study of Egyptian Antiquities* 14 (1): 37-56.

Oren E.D. 1987a. The "Ways of Horus" in north Sinai. In: A.F. Rainey (ed.), *Archaeological and Historical Relationships in the Biblical Period*. Tel Aviv: Tel Aviv University. Pp. 69-119.

Oren D.E. 1987b. Northern Sinai before the Classical period: History and archaeology. In: G. Gvirtzman, A. Shmueli, Y. Gradus, I. Beit-Arieh and M. Har-El (eds.), *Sinai Vol. 2*. Tel-Aviv: Ministry of Defence. Pp. 627-646. (Hebrew).

Oren E.D. 1993a. Northern Sinai. In: E. Stern (ed.) *The New Encyclopedia of Archaeological Excavations in Israel*. Israel Exploration Society. Pp.1386-1396.

Oren E.D. 1993b. Ethnicity and regional archaeology: The western Negev under Assyrian rule. In: A. Biran and J. Aviram (eds.), *Biblical Archaeology Today, 1990*. Jerusalem: Israel Exploration Society. Pp. 102-105.

Oren E.D. unpublished. *Gazeteer of North Sinai Sites*. Unpublished Mansucript.

Oren E.D. and Gilead I. 1981. Chalcolithic sites in northeastern Sinai. *Tel Aviv* 8: 25-44.

Oren E. and Yekutieli Y. 1990. North Sinai during the Early Bronze Age I – Pastoral nomadism and sedentary settlements. *Eretz-Israel* 21: 6-22. (Hebrew).

Oren E.D., A. Perevolotsky and R. Yizraeli (eds.). 1979. *Israel Guide. Sinai and Gaza Plain*. Jerusalem: Keter.

Orni E. and Efrat E. 1980. *Geography of Israel*, 4th edition. Jerusalem: Keter Publishing.

Osborn D.J. and Helmy I. 1980. *The Contemporary Land Mammals of Egypt (Including Sinai)*. Fieldiana, Zoology. New Series No. 5. Chicago: Field Museum of Natural History.

Osborn D.J. and Osbornová J. 1998. *The Mammals of Ancient Egypt. The Natural History of Egypt Vol. IV*. Warminster: Aris and Phillips.

Ozdogan M. and Basgelen N. (eds.). 1999. *Neolithic in Turkey. The Cradle of Civilization. New Discoveries*. Istanbul: Arkeolojive sanat Yayinlari.

Palmer, E.H. 1871. *The Desert of the Exodus*. Cambridge: Deighton, Bell and Co.

Parker S.T. 1987. *The Roman Frontier in Central Jordan: Interim Report on the Limes Arabicus Project 1980-1985.* Oxford: BAR International Reports 340.

Payne S. 1969. A metrical distinction between sheep and goat metacarpals. In: P.J. Ucko and G.W. Dimbleby (eds.), *The Domestication and Exploitation of Plants and Animals*. London: Duckworth. Pp. 295-305.

Payne S. 1973. Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale. *Anatolian Studies* 23: 281-303.

Payne S. 1975. Partial recovery and sample bias. In: A.T. Clason (ed.), *Archaeozoological Studies*. New York: Elsevier. Pp. 7-17.

Payne S. 1985. Morphological distinctions between the mandibular teeth of young sheep, *Ovis* and goats, *Capra*. *Journal of Archaeological Science* 12: 139-147.

Paz U. 1987. *The Birds of Israel*. Tel Aviv: Ministry of Defence Publishing House.

Perevolotsky A. 1980. "Desert kites" near Gebel Gunna. In: Z. Meshel and I. Finkelstein (eds.), *Sinai in Antiquity*. Tel Aviv: Kibbutz Hameuchad. Pp. 289-294. (Hebrew).

Perevolotsky A. 1981. Orchard agriculture in the high mountain region of southern Sinai. *Human Ecology* 9: 331-357.

Perevolotsky A. 1987. Territoriality and resource sharing among the Bedouin of southern Sinai: Aa socio-ecological interpretation. *Journal of Arid Environments*: 13: 153-161.

Perevolotsky A. and Baharav D. 1987. The abundance of desert 'kites' in eastern Sinai- an ecological analysis. In: G. Gvirtzman, A. Shmueli, Y. Gradus, I. Beit-Arieh and M. Har-El (eds.), *Sinai Vol. 2*. Tel-Aviv: Ministry of Defence. Pp. 595-603. (Hebrew).

Perevolotsky A. and Baharav D. 1991. The distribution of desert kites in eastern Sinai and sub-regional carrying capacity: an ecological perspective. *Journal of Arid Environments* 20: 239-249.

Perkins D. 1966. Appendix B. The fauna from Madamagh and Beidha. *Palestine Exploration Quarterly* 98: 66-67.

Perrot J. 1959. Statuettes en ivoire objects en ivoire et en os provenant des gisements préhistoriques de la region de Beersheba. *Syria* 36: 8-19.

Perrot J. and Gopher A. 1996. A Late Neolithic site near Ashkelon. *Israel Exploration Journal* 46 (3-4): 145-166.

Peters, J. 1993. Archaic Milet: Daily life and religious customs from an archaeozoological perspective. In: H. Buitenhuis and A. Clason (eds.), *Archaezoology of the Near East Vol. 1*. Leiden: Universal Books. Pp.88-96.

Peters J., Helmer D., von den Driesch A. and Saña Segui M. 1999. Early animal husbandry in the northern Levant. *Paléorient* 25: 27-48

Petrie W.M.F. 1906. *Researches in Sinai*. London: J. Murray.

Phillips J.L. and Gladfelter B.G. 1989. A survey in the upper Wadi Feiran basin, southern Sinai. *Paléorient* 15 (2): 113-122.

Pickering T.R., Marean C. W. and Dominguez-Rodrigo M. 2003. Importance of limb bone shaft fragments in zooarchaeology: A response to "On *in situ* attrition and vertebrate body part profiles" (2002), by Stiner. *Journal of Archaeological Science* 30: 1469-1482.

Prummel W. and Frisch H.-J. 1986. A guide for the distinction of species, sex and body side in bones of sheep and goat. *Journal of Archaeological Science* 13 (6): 567-577.

Prummel W. 1988. Atlas for the identification of foetal bones from archaeozoological contexts. Part I. *Archaeozoologia* 9/1: 32-40

Qumsiyeh M. B. 1996. *Mammals of the Holy Land*. Lubbock: Texas Tech University Press.

Rainey A.F. ed. 1987. *Egypt, Israel and Sinai*. Tel Aviv: Tel Aviv University.

Randall J.E. 1983. *Red Sea Reef Fishes*. London: Immel.

Raphael O. and Lernau O. 1996. Faunal remains from Bab-el-Hawa: An Iron Age-Byzantine site in the Golan Heights. *ArchaeoZoologia* 8/1.2: 105-118.

Rebholz W.E.R, Williamson D. and Rietkerk F. 1991. Saudi gazelle is not a subspecies of Dorcas gazelle. *Zoological Biology* 10: 485-489.

Redding R.W. 1984. The faunal remains. In: R.J. Wenke (ed.), *Archaeological Investigations at El-Hibeh 1980: Preliminary Report*. Malibu: Undena Publications. Pp. 38-49.

Redding R.W. 1992. Egyptian Old Kingdom patterns of animal use and the value of faunal data in modeling socioeconomic systems. *Paléorient* 18 (2): 99-107.

Redford D.B. 1990. *Egypt and Canaan in the New Kingdom*. *Beer-Sheva IV*. Beer-Sheva. Ben Gurion University of the Negev Press.

Redford D.B. 1992. *Egypt, Canaan, and Israel in Ancient Times*. Princeton: Princeton University Press.

Reese D.S., Mienis H.K. and Woodward F.R. 1986. On the trade of shells and fish from the Nile River. *Bulletin of the American Schools of Oriental Research* 264: 79-84.

Reitz E.J. and Wing E.S. 1999. *Zooarchaeology*. Cambridge: Cambridge University Press.

Richardson, J.E. 1997. An analysis of the faunal assemblages from two Pre-Pottery Neolithic sites in the Wadi Fidan, Jordan. In: H.G.K. Gebel, Z. Kafafi, and G.O. Rollefson (eds.) *The Prehistory of Jordan II. Perspectives from 1997*. Berlin: Studies in Early Near Eastern Production, Subsistence and Environment 4. Pp. 497-510.

Rollefson G.O. 1996. The Neolithic devolution: Ecological impact and cultural compensation at 'Ain Ghazal, Jordan. In: Seger J.D. editor. *Retrieving the Past*. Indiana: Eisenbrauns. Pp. 219-229.

Rollefson G.O. and Köhler-Rollefson I. 1989. The collapse of early Neolithic settlements in the southern Levant. In: Hershkovitz I. (ed.), *People and Culture in Change*. BAR International Series 508. Oxford: Archaeopress. Pp. 73-89.

Rollefson G.O. and Köhler-Rollefson I. 1993. PPNC adaptations in the first half of the 6th millennium B.C. *Paléorient* 19: 33-42.

Rosen B. and Perevolotsky A. 1998. The function of “desert kites”- hunting or livestock husbandry? *Paléorient* 24/1: 107-111.

Rosen A. 1989. Environmental change at the end of the Early Bronze Age Palestine. In: P. de Miroschedji (ed.) *L'Urbanisation de la Palestine a l'age du Bronze Ancien*. Oxford: BAR International Series 527 (ii).Pp. 247-254.

Rosen A. 1997. Environmental change and human adaptational failure at the end of the Early Bronze Age in the southern Levant. In: Dalfes, H. N., Kukla, G. & Weiss, H. (eds.) *Third Millennium BC Climate Change and Old World Collapse*. Berlin: Springer-Verlag. Pp. 25-37.

Rosen S.A. 1987. Demographic trends in the Negev Highlands: Preliminary results from the Emergency Survey. *Bulletin of the American Schools of Oriental Research* 266: 45-58.

Rosen S.A. 1988. Notes on the origins of pastoral nomadism fom the Negev and Sinai. *Current Anthropology* 29: 498-506.

Rosen S.A. 1992. Nomads in archaeology: A response to Finkelstein and Perevolotsky. *Bulletin of the American Schools of Oriental Research* 287: 75-85.

Rosen S.A. 1997. Beyond milk and meat: Lithic evidence for economic specialization in the Early Bronze Age pastoral periphery in the Levant. *Lithic Technology* 22: 99-109.

Rosen S.A. 1998. The development of pastoral nomadic systems in the southern Levantine periphery; an economic model based on archaeological evidence. In: M. Pearce and M. Tosi (eds.), *Papers from the EAA Third Annual meeting at Ravenna 1997. Vol. I: Pre- and Protohistory.* BAR International Series 717. Oxford: Archaeopress. Pp. 92-96.

Rosen S.A. 2002a. The evolution of pastoral nomadic systems in the southern Levantine periphery. In: E. van den Brink and E. Yannai (eds.), *In Quest of Ancient Settlements and Landscapes*. Tel Aviv: Tel Aviv University Press. Pp. 23-44.

Rosen S.A. 2002b. An economic model for Early Bronze Age pastoral nomadism. In: S. Ahituv and E.D. Oren (eds.), *Beer-Sheva* XV (Aharon Kempinski Memorial Volume). Pp. 344-359.

Rosen S.A. in press. The Nabateans as pastoral nomads: An archaeological perspective. In: K.D. Politis (ed.), *The World of the Nabataeans*. London: British Museum.

Rosen S.A., Savinetsky A.B., Plakht Y., Kisseleva N.K., Khassanov B.F., Pereladov A.M. and Haiman M. 2005. Dung in the desert: Preliminary results of the Negev Holocene ecology project. *Current Anthropology* 46: 317-327.

Rossignol-Strick M. 1997. Paleoclimat de la Mediterranee orientale et de l’Asie du sud-ouest de 15000 d 6000 BP. *Paléorient* 23: 175-186.

Rossignol-Strick M. 1999. The Holocene climatic optimum and pollen records of sapropel 1 in the eastern Mediterranean, 9000-6000 BP. *Quaternary Science Reviews* 18: 515-530.

Roth J.P. 1999. *The Logistics of the Roman Army at War (264 B.C.-A.D. 235).* Leidin: Brill.

Rothenberg B. 1961. *God’s Wilderness, Discoveries in Sinai.* London: Thames and Hudson.

Rothenberg B. 1969. Archaeological survey in southern Sinai. *Museum Ha-Aretz Bulletin* 11: 18-29. (Hebrew)

Rothenberg B. 1970. An archaeological survey of south Sinai. *Palestine Exploration Quarterly*: 2-29.

Rothenberg, B. 1972a. Sinai explorations 1967-1972. *Museum Ha'aretz Bulletin*: 37-45.

Rothenberg B. 1972b. *Timna, Valley of the Biblical Copper Mines*. London.

Rothenberg B. 1973. Preliminary summary of the sixth season of archaeological survey in Sinai. *Museum Ha-Aretz Bulletin* 15/16: 15-31. (Hebrew)

Rothenberg B. 1975. Two excavations in Sinai. *Museum Ha-Aretz Bulletin* 17/18: 36-42. (Hebrew).

Rothenberg, B. 1979. *Sinai: Pharaohs, Miners, Pilgrims*. Berne.

Russell K.W. 1988. *After Eden. The Behavioral Ecology of Early Food Production in the Near East and North Africa*. Oxford: BAR International Series 391.

Ryan K. and Crabtree P. J. (eds.) 1995. *The Symbolic Role of Animals in Archaeology.* MASCA Research Papers in Science and Archaeology vol. 12., Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Sade M. 1988. *Domestic Mammals in the Iron Age Economy of the Northern Negev*. Unpublished MA Thesis, University of Tel Aviv, Tel Aviv. (Hebrew).

Sade M and Milevski I. 2004. Faunal Remains. In: I. Milevski, A newly excavated tumulus in the Refa'im Valley, Jerusalem. '*Atiqot* 48: 51-62.

Saleh M.A. 1987. The decline of gazelles in Egypt. *Biological Conservation* 39: 83-95.

Saleh M.A. and Basuony M.I. 1998. A contribution to the mammalogy of the Sinai Peninsula. *Mammalia* 62 (4): 557-575.

Saleh M.A., Helmy I. and Giegengack R. 2001. The cheetah, *Acinonyx jubatus* (Schreber, 1776) in Egypt (Felidae, Acinonychinae). *Mammalia* 65 (2): 177-194.

Sanlaville P. 1999. Changements climatiques et évolution des sociétés humaines dans la region Levantine entre 17 000 et 7 000 BP (18 000-6 000 avant notre ère). *Les Annales Archéologiques Arabes Syriennes* 43: 23-36.

Sass B. 1980. Sinai between the 4th and 1st millennia BC. In: Z. Meshel and I. Finkelstein (eds.), *Qadmoniot Sinai*. Tel-Aviv: Kibbbutz Ha'Meuhad. Pp. 41-53. (Hebrew).

Schild R., Chmielewska M. and Wieckowska H. 1968. The Arkinian and Shamarkian industries. In: F. Wendorf (ed.), *The Prehistory of Nubia vol 2*. Dallas: SMU Press. Pp. 651-767.

Schmid S.G. 2001. The Nabataeans: travellers between lifestyles. In: B. MacDonald, R. Adams and P. Bienkowski (eds.), *The Archaeology of Jordan*. Sheffield: Sheffield Academic Press. Pp. 367-426.

Schmidt-Nielsen K. 1979. *Desert Animals: Physiological Problems of Heat and Water*. New York: Dover Publications.

Segal D. 1995. Appendix B. ^{14}C dates from Horvat Teiman (Kuntillet 'Ajrud) and their archaeological correlation. *Tel Aviv* 22 (2): 208-212.

Seger J.D. et al. 1990. The Bronze Age settlements at Tell Halif: Phase II Excavations, 1983-1987. *Bulletin of the American Schools of Oriental Research Supplement* 26: 1-32.

Sela Y. 1971. Saluki dogs in Sinai. *Teva Va'aretz* 13(3): 134-136. (Hebrew).

Semino O. et al. 2000. The genetic legacy of Paleolithic *Homo sapiens sapiens* in extant Europeans: A Y chromosome perspective. *Science* 290:1155-1159.

Semino O. et al. 2004. Origin, diffusion, and differentiation of Y-chromosome haplogroups E and J: inferences on the neolithization of Europe and later migratory events in the Mediterranean area. *American Journal of Human Genetics* 74: 1023-1034.

Shalmon B. 1993. *A Field Guide to the Land Mammals of Israel.* Jerusalem: Keter. (Hebrew).

Shipman P., Foster G. and Schoeninger M. 1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of Archaeological Science* 11: 307-325.

Shkolnik A., Borut A. and Choshniak I. 1972. Water economy of the Beduin goat. *Zoological Society of London Symposia* 31: 229-242.

Shkolnik A. Borut A., Choshniak I. and Maltz A.. 1974. Water economy and drinking regime of the Bedouin goat. In: *Ecological Research on Development of Arid Zones (Mediterranean Deserts) with Winter Precipitation*. Symposium Israel-France 11-14 March, Volcani Centre Special Publication No. 39. Pp. 79-90.

Silver I.A. 1969. The ageing of domestic animals. In: D.R. Brothwell and E.S. Higgs (eds.), *Science in Archaeology*. London: Thames and Hudson. Pp. 283-302.

Simmons A.H. 1997. Ecological changes during the Late Neolithic in Jordan: A case study. In: Gebel G-G., Kafafi Z., Rollefson G.O. (eds.), *The Prehistory of Jordan II. Perspectives from 1997.* Berlin: ex Oriente. Pp. 309-318.

Smith A.B. 1986. Review article: Cattle domestication in North Africa. *African Archaeological Review* 4: 197-203.

Smith P. 2002. The paleo-biological evidence for admixture between populations in the southern Levant and Egypt in the Fourth to Third millennia BCE. In: E.C.M. van den Brink and T.E. Levy (eds.), *Egypt and The Levant.* London: Leicester University Press. Pp. 118-128.

Smith P. and Horwitz, L.K. 1998. Human and animal remains from the burial cave at Sha'ar Ephraim central. *Tel Aviv* 25 (1): 110-115.

Sneh A., Weissbrod T. and Perath I. 1975. Evidence for an ancient Egyptian frontier canal. *American Scientist* 63: 542-548.

Speth J. and Spielmann C. 1983. Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Archaeologicsal* 2: 1-31.

Stager L. 1992. The periodization of Palestine from Neolithic through Early Bronze times. In: R.W. Ehrich (ed.), *Chronologies in Old World Archaeology vol I.* Chicago: University of Chicago Press. Pp. 22-41.

Stiner M.C. 2002. On *in situ* attrition and vertebrate body part profiles. *Journal of Archaeological Science* 29: 979-991.

Stiner M.A., Kuhn S.L., Weiner S. and Bar-Yosef O. 1995. Differential burning, recrystallization and fragmentation of archaeological bone. *Journal of Archaeological Science* 22: 223-237.

Stone M.E. (ed.). 1992. *Rock Inscriptions and Graffiti Project. Catalogue of Inscription, Vols 1-3*. Atlanta.

Studer J. 2002. Dietary differences at Ez Zantur Petra, Jordan (1st century BC-AD-5TH century). In: H. Buitenhuis, A.M. Choyke, M. Mashkoour and A-H Al-Shiyab (eds.), *Archaeozoology of the Near East Vol. V*. Groningen: ARC Publicaties 62. Pp. 273-281.

Studer J. in press. Animal exploitation in the Nabataean world. In: K.D. Politis (ed.), *The World of the Nabataeans*. London: British Museum.

Studer J. and Chenal-Velarde I. 2003. La part des dieux et celle des hommes: Offrandes d'animaux et restes culinaires dans l'aire sacrificielle nord. In: S. Heber (ed.), *Eretria XIV. L'Aire sacrificielle au nord du Sanctuaire d'Apollon Daphnephoros*. Montreux: Impremerie Corbaz SA. Pp. 176-185.

Tantawi M.A., El-Sayed E. and Awad M.A. 1998. Hydrochemical and stable isotope study of groundwater in the Saint Catherine-Wadi Feiran area, south Sinai, Egypt. *Journal of African Sciences* 28 (2): 277-284.

Taute W. 1981. Masad Mazzal, ein siedlungsplatz des präkeramischen Neolithkums südlich des toten Meeres (vorbericht). In: W. Frey and H-P. Uerpmann (eds.), *Beitrage zur Umweltgeschichte des Vorderen Orients (Contributions to the Environmental History of Southwest Asia).* Beihefte zum Tubinger Atlas des Vorderen Orients Reihe A (Naturwissenschaften) Nr. 8. Wiesbaden: Ludwig Reichert Verlag. Pp. 236-256.

Tchernov E. 1976. Some Late Quaternary faunal remains from the Avdat/Aqev area. In: A.E. Marks (ed.), *Prehistory and Palaeoenvironments in the Central Negev, Israel, Vol. I. The Avdat/Aqev Area*. Dallas: SMU Press. Pp. 69-73.

Tchernov E. 1979. The fauna. Meeting point of two continents. In: Rothenberg B. (ed.), *Sinai*. Washington: J. Binns. Pp. 93-99.

Tchernov E. 1988. The biogeographical history of the southern Levant. In: Y. Yom-Tov and E. Tchernov (eds.), *The Zoogeography of Israel*. Dordrecht: Dr. W. Junk Publishers. Pp. 159-250.

Tchernov E. 1993a. From sedentism to domestication - a preliminary review for the southern Levant. In: A.T. Clason, S. Payne, and H-P. Uerpmann (eds.), *Skeletons in Her Cupboard: Festschrift for Juliet Clutton-Brock.* Oxford: Oxbow Monograph 34. Pp. 189-233.

Tchernov E. 1993b. The impact of sedentism on animal exploitation in the southern Levant. In: H. Buitenhuis and A.T. Clason (eds.), *Archaeozoology of the Near East Vol. 1.* Leiden: Universal Book Services. Pp. 10-26.

Tchernov E. 1995. Environmental and socioeconomic background to domestication in the southern Levant. In: D.V. Campana (ed.), *Before Farming: Hunter-Gatherers Society and Subsistence*. MASCA Research Papers in Science and Archaeology Vol 12. Pp. 39-77

Tchernov E. and Bar-Yosef O. 1982. Animal exploitation in the Pre-Pottery Neolithic B period at Wadi Tbeik, southern Sinai. *Paléorient* 8 (2): 17-37.

Tchernov, E. and Horwitz, L.K. 1991. Body size diminution under domestication: unconscious selection in primeval domesticates. *Journal of Anthropological Archaeology* 10: 54-75.

Tchernov E., Dayan T. and Yom-Tov Y. 1986/87. The paleogeography of *Gazella gazella* and *Gazella dorcas* during the Holocene of the southern Levant. *Israel Journal of Zoology* 34: 51-59.

Thomas D.H. 1971. On distinguishing natural from cultural bone in archaeological sites. *American Antiquity* 36: 366-371.

Toplyn M. R. 1994. *Meat for Mars: Livestock, Limitanei, and Pastoral Provisioning for the Roman Army on the Arabian Frontier (A.D. 284-551).* Unpublished PhD Thesis, Harvard University.

Toynbee J.M.C. 1973. *Animals in Roman Life and Art.* London: Thames and Hudson.

Tristram H.B. 1884. *The Survey of Western Palestine. The Fauna and Flora of Palestine.* Palestine Exploration Fund, London, Commission.

Tsoar H. 1987. The sand dunes of northern Sinai. In: G. Gvirtzman, A. Shmueli, Y. Gardos, I. Beit-Arieh and M. Harel (eds.), *Sinai*. Tel Aviv: Defence Ministry Vol. 1. Pp. 241-246. (Hebrew).

Ucko P.J. 1969. Ethnography and archaeological interpretation of funerary remains. *World Archaeology* 1: 261-280.

Uerpmann H-P. 1979. *Probleme der Neolithisierung des Mittelmeerraums*. Beihefte zum Tubinger Atlas des Vorderen Orients, Reihe B. Wiesbaden: L. Reichert.

Uerpmann H-P. 1987. *Ancient Distribution of Ungulate Mammals in the Middle East.* Beihefte zum Tubinger Atlas des Vorderen Orients. Wiesbaden: L. Reichert Verlag.

Van Berg P-L., Vander Linden M., Lemaitre S., Cauwe N. and Picalause V. 2004. Desert-kites of the Hemma plateau (Hassake, Syria). *Paléorient* 30 (1): 89-100.

Van Neer W. 1997. Archaeozoological data on food provisioning of Roman settlements in the eastern desert of Egypt. In: A. Gautier (ed.), *Animals and People in the Holocene of North Africa. ArchaeoZoologia* 9 (1.2): 137-154.

Van Neer W. and Ervynck A. 1998. The faunal remains. In: S.E. Sidebotham and W.Z. Wendrich (eds.), *Berenike 1996. Report on the 1996 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert.* Leiden: Research School CNWS. Pp. 349-390.

Van Neer W. and Sidebotham S. 2002. Animal remains from the fourth-sixth century AD military installations near Abu Sha'ar at the Red Sea coast, Egypt. In: Jennerstrasse (ed.), *Tides of the Desert- Gezeiten der Wuste. Contributions to the Archaeology and Environmental history of Africa in Honour of Rudolph Kuper. Africa Praehistorica* 14: 171-195.

Van Neer W., Lernau O., Friedman R., Mumford G., Poblome J. and Waelkens M. 2004a. Fish remains from archaeological sites as indicators of former trade connections in the Eastern Mediterranean. *Paléorient* 30: 101-148.

Van Neer W., Linseele V. and Friedman R. 2004b. Animal burials and food offerings at the elite cemetery HK6 of Hierakonpolis. In: Hendricks, S., Friedman R.F., Cialowicz K.M. and Chlodnicki M. (eds.), *Egypt at its Origins*. Leuven: Peeters. Pp. 67-130.

Vermeersch P.M. (ed.). 1978. *L'Elkabien, Epipaléolithique de la Vallee di Nil Egyptien*. Leuven: Leuven University Press.

Vermeersch P.M. 1992. The Upper and Late Paleolithic of Northeastern and eastern Africa. In: F. Klees and R. Kuper (eds.), *New Light on the Northeast African Past. Africa Praehistorica* 5: 99-153.

Vermeersch P. M., Van Peer P., Moeyersons J. and Van Neer W. 1994. Sodmein Cave site, Red Sea Mountains (Egypt). *Sahara* : 6: 31-40.

Vigne J-D. 2001. The large mammals of early Aceramic Neolithic Cyprus: Preliminary results from Parekklisha Shilourokambos. In: S. Swiny (ed.), *The Earliest Prehistory of Cyprus: From Colonization to Exploitation*. Cyprus American Archaeological Research Institute Monograph Series 12. Boston: American Schools of Oriental Research. Pp. 55-60.

Vigne J-D. 2003. Unstable status of early domestic ungulates in the Near East: The example of *Shilourokambos* (Cyprus, IX-VIIIth millennia cal. B.C.). In: J. Guilaine and A. Le Brun (eds.), *Le Neolithique de Chypre. Actes du Colloque International*. Nicosia 17-19 May 2001.

Vigne J-D. and Buitenhuis H. 1999. Les premiers pas de la domestication animale a l'ouest de l'euphrate: Chypre et l'Anatolie centrale. *Paléorient* 25 (2): 49-62.

Vila E. 2004. Survey of the remains of mammals recovered in the Middle Bronze Age burials at Sidon (Lebanon). *Levant* 36: 167-180.

Wapnish P. 1982. Archaeozoology at Tell Jemmeh: Taphonomy and paleoeconomy in historic archaeology. Unpublished research Report, National Geographic Society.

Wapnish P. and Hesse B. 1991. Faunal remains from Tel Dan. *ArchaeoZoologia* 4 (2): 9-86.

Wapnish P. and Hesse B. 1993. Pampered pooches or plain pariahs? The Ashkelon dog burials. *Biblical Archaeologist* 56 (2): 55-79.

Wapnish P. and Hesse B. 2000. Mammal remains fom the Early Bronze sacred compound. In: I. Finkelstein, D. Usshiskin and B. Halpern (eds.), *Megiddo III: The 1992-1996 Seasons*. Tel Aviv: Institute of Archaeology Monograph, Tel Aviv University. Pp. 429-462.

Warburton D.A. 1997. *State and Economy in Ancient Egypt. Fiscal Vocabulary of the New Kingdom*. Fribourg: University Press Fribourg.

Warburton D.A. 2000. Before the IMF: The economic implications of unintentional structural adjustment in ancient Egypt. *Journal of the Economic and Social History of the Orient* 43 (2): 65-131.

Warburton D.A. 2001. Officials. In: Redford D.B. (ed.), *The Oxford Encyclopedia of Ancient Egypt Vol 2*. Oxford: Oxford University Press. Pp. 576-583.

Wasse A.M.R. 2000. *The Development of Goat and Sheep Herding During the Levantine Neolithic*. Unpublished PhD Thesis, University of London.

Wattenmaker P. 1982. Fauna. In: D.S. Whitcomb and J.H. Johnson (eds.), *Quseir al-Qadim 1980. Preliminary Report*. Malibua: Udena Publications. Pp. 347-353.

Weissbrod L. and Bar-Oz G. 2004. Caprines and toads: taphonomic patterning of animal offerings practices in a Late Bronze Age burial assemblage. In: S. Jones O'Day, Van Neer W. and Ervynck A. (eds.), *Behaviour Behind Bones. The Zooarchaeology of Ritual, Religion, Status and Identity*. Oxford: Oxbow Books. Pp. 20-24.

Wendorf F. and Schild R. 1976. The *Prehistory of the Nile Valley*. New York: Academic Press.

Wendorf F. and Schild R. 1994. Are the early Holocene cattle in the eastern Sahara domestic or wild? *Evolutionary Anthropology* 3: 118-128.

Wendorf F. and Schild R. 1998. Nabta playa and its role in northeastern African prehistory. *Journal of Anthropological Archaeology* 17: 97-123.

Wenke R.J., Long J.E. and Buck P.E. 1988. Epipaleolithic and Neolithic subsistence and settlement in the Fayyum Oasis of Egypt. *Journal of Field Archaeology* 15: 29-51.

Werner Y.L. 1973. *The Reptiles of the Sinai Peninsula*. Department of Zoology, The Hebrew University of Jerusalem. (Hebrew).

Werner Y.L. 1980. Preliminary results of the herpetofaunal survey of Sinai (1956-57; 1967-79) with emphasis on the southern mountains. *Israel Journal of Zoology* 29: 209 (Abstract).

West, B. and Zhou B-X. 1988. Did chickens go north ? New evidence for domestication. *Journal of Archaeological Science* 15: 515-533.

Wetterstrom W. 1993. Foraging and farming in Egypt. The transition from hunting and gathering to horticulture in the Nile Valley. In: T. Shaw, P. Sinclair, B. Andah and A. Okpoko (eds.), *The Archaeology of Africa: Foods, Metals and Towns*. London: Routledge. Pp.104-121.

White R. 1989. Husbandry and herd control in the Upper Paleolithic. *Current Anthropology* 30 (5): 609-671.

Whitcher S. 1999. *Animals, Environment and Society: A Zooarchaeological Approach to the Late Chalcolithic – Early Bronze I Transition in the Southern Levant*. Unpublished PhD thesis, University of Edinburgh.

Wiegand T. 1920. *Sinai*. Berlin: Walter de Gruyter.

Wilmsen E.N. and Durham D. 1987. Food as a function of seasonal environment and social history. In: I De Garine and G.A. Harrison (eds.), *Coping with Uncertainty in Food Supply.* Oxford: Clarendon Press. Pp. 52-87.

Yagil R. 1984. The adaptation of domesticated animals to arid zones with special reference to the camel. *Refuah Veterinarith* 41 (4): 144-156.

Yehieli A. 1993. *The Camel Herd Management and its Place in Bedouin Life*. Jerusalem: Society for the Protection of Nature. (Hebrew).

Yeivin E. and Olami Y. 1979. Nizzanim – A Neolithic site in Nahal Evtah: Excavations of 1968-1970. *Tel Aviv* 6: 99-135.

Yekutieli Y. 1998. *The Early Bronze Age I of North Sinai: Social, Economic and Spatial Aspects*. Unpublished PhD Thesis, Ben Gurion University of the Negev. (Hebrew).

Yekutieli Y. 2002. Settlement and subsistence patterns in north Sinai during the Fifth to Third millennia BCE. In: E.C.M. van den Brink and T.E. Levy (eds.), *Egypt and The Levant.* London: Leicester University Press. Pp. 422-433.

Yom-Tov Y. 1987. Vertebrates of the Sinai Peninsula. In: G. Gvirtzman, A. Shmueli, Y. Gradud, I. Beit-Arieh and M. Han-El (eds.), *Sinai (Human Geography) Part II*. Tel-Aviv: Eretz, Ministry of Defence. Pp. 341-374. (Hebrew).

Yom-Tov Y. and Mendelssohn H. 1988. Changes in the distribution and abundance of vertebrates in Israel during the 20th century. In: Y. Yom-Tov and E. Tchernov (eds.), *The Zoogeography of Israel*. Dordrecht: Dr. W. Junk Publishers. Pp. 515-548.

Yom-Tov Y., Mendelssohn H. and Groves C.P. 1995. *Gazella dorcas*. *Mammalian Species* 491:1-6.

Zahran M.A. and Willis A.J. 1992. *The Vegetation of Egypt*. London: Chapman and Hall.

Zeder M.A. 1996. The role of pigs in Near Eastern subsistence: A view from the southern Levant. In: Seger J.D. (ed.), *Retrieving the Past*. Cobb Institute of Archaeology. Pp. 297-312.

Zeitler J.P. 1990. Houses, sherds and bones: aspects of daily life in Petra. In: S. Kerner (ed.), *The Near East in Antiquity Vol. 1*. Goethe Institute, Amman: Al Kutba Publishers. Pp. 39-51.

Zohary D. and Hopf M. 1994. *Domestication of Plants in the Old World*. Oxford: Oxford University Press.

Zohary D., Tchernov E. and Horwitz L.K. 1998. The role of unconscious selection in the domestication of sheep and goats. *Journal of Zoology, London* 245: 129-135.

Table 1.1: Sites studied listed by period

Site Name	**Site Type**	**Period**	**Area in Sinai**	**Excavator/s**
Abu Madi III	Open	PPNB	south	O. Bar-Yosef
Gebel Rubsha	Open	PPNB	south	O. Bar-Yosef
Bir Sawaneh	Tumuli	Late Neolithic/Chalcolithic	south-east	U. Avner
Hadj I	Tumuli	Late Neolithic/Chalcolithic	south-east	U. Avner
Wadi Zalaqa M306	Tumuli	Late Neolithic/Chalcolithic	south-east	U. Avner
Wadi Zalaqa M306	Tumuli	Late Neolithic/Chalcolithic	south-east	U. Avner
Wadi Sa’al	Shrine	Chalcolithic	south-east	U. Avner
Wadi Daba’iyah	Shrine	Chalcolithic	south-east	U. Avner
Gebel Gunna	Nawamis	Chalcolithic-EBI	south	O. Bar-Yosef & A. Goren
Ein Huderah	Nawamis	Chalcolithic-EBI	south	O. Bar-Yosef & A. Goren
Moyat Dabaiyah	Habitation	Chalcolithic-EBI	south	A. Goren
Gunna 50	Habitation	Chalcolithic/EB I	south	O. Bar-Yosef & A. Goren
R45, R46, R48, R79	Camps	Chalcolithic	north	O. Oren
Gunna 25	Habitation	EB I/II	south	O. Bar-Yosef & A.Goren
Gunna 50	Habitation	EB I/II	south	O. Bar-Yosef & A. Goren
Gunna 32	Habitation	EB II	south	O. Bar-Yosef & A. Goren
Sheikh Muhsen	Habitation	EB II	south	I. Beit-Arieh
Nabi Salah	Habitation	EB II	south	I. Beit-Arieh
A-289 (Haruvit/Harouba)	Fortress	New Kingdom	north	E. Oren
A-345	Administration Center	New Kingdom	north	E. Oren
A-343	Temporary encampment	New Kingdom	north	E. Oren
BEA-10 (Bir el-Abd)	Fortress & Administration Center	New Kingdom	north	E. Oren
Kuntillet ‘Ajrud	Way Station/ Sanctuary	Iron Age II	north-east	Z. Meshel
Gebel Serbal	Sanctuary	Nabataean	south-east	U.Avner

Table 2.1: Presence/absence of the main wild taxa in the Sinai Peninsula until the 20th century.

Northern Sinai includes the northern part of the Gulf of Suez.
Data from Yom-Tov 1987, Saleh & Basuony 1998; Osborn & Helmy 1980
+ probably extinct since the early 19th century
++ probably became extinct in late 20th century

	Northern Sinai	**Southern Sinai**
Artiodactyla		
Nubian ibex	X	X
Dorcas gazelle	X	X
Arabian oryx +	?	X
Hartebeest +	X	?
Hyracoidea		
Rock hyrax	X	X
Carnivora		
Cheetah ++	?	X
Leopard	?	X
Wild cat	X	X
Sand cat	X	-
Red fox	X **+**	X
Blanford's fox	-	X
Fennec	X	-
Golden jackal	X	-
Marbeled polecat	X	-
Striped hyaena	X	X
Lagomorpha		
Cape hare	X	X
Rodentia		
Porcupine	X	-
Greater Egyptian gerbil	X	X
Wagner's gerbil	-	X
Bushy tailed jird	X	X
Sundevall's jird	X	X
House mouse	X	X
Golden spiny mouse	-	X
Egyptian spiny mouse	-	X
Insectivora		
Ethiopian hedgehog	X	X
Lesser white-toothed shrew	X	X

Table 3.1: Species representation in PPNB sites from Sinai

Sites	**Abu Madi 3**		**Gebel Rubsha**		**Ujret el-Mehed**		**Wadi Tbeik**	
Species	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**
Aurochs ** (*Bos primigenius*)	-	-	-	-	(1)	0.03	(2)	0.1
Gazelle cf. Mountain gazelle (*Gazella* cf. *gazella*)	70	15	20	16	37	1	80	7
Goat (*Capra ibex*)	217	48	45	36	2271	69	229	21
Goat/Gazelle (*Capra/Gazella* sp.)	128	28	53	42	651	20	98	9
Wild horse (*Equus caballus*)	-	-	-	-	-	-	2	0.1
Wild ass (*Equus hemionus/africanus*)	-	-	-	-	-	-	18	2
Equus sp.	-	-	-	-	1	0.03	-	-
Undet. large mammal	-	-	3	3	-	-	-	-
Red fox (*Vulpes vulpes*)	5	1	-	-	12	0.3	2	0.1
Fennec (*Fennecus zerda*)	-	-	-	-	-	-	1	0.1
Wild cat (*Felis sylvestris*)	-	-	-	-	-	-	2	0.1
Striped hyaena (*Hyaena hyaena*)	-	-	-	-	-	-	2	0.1
Leopard (*Panthera pardus*)	-	-	-	-	1	0.03	-	-
Large felid	1	0.4	-	-	-	-	-	-
Hare (*Lepus capensis*)	6	1.5	4	3	156 (176 #)	5	605 (1395 #)	55
Sundevall’s jird (*Meriones crassus*)	-	-	-	-	-	-	2	0.1
Bushy-tailed jird (*Sekeetamys calurus*)	-	-	-	-	-	-	1	0.1
Sand rat (*Psammomys obesus*)	-	-	-	-	-	-	3	
Undet. rodents	1	0.4	-	-	-	-		

Table 3.1: Species representation in PPNB sites from Sinai (continued….)

Sites	Abu Madi 3		Gebel Rubsha		Ujret el-Mehed		Wadi Tbeik	
Species	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**
Ethiopian hedgehog (*Paraechinus aethiopicus*)	1	0.4	-	-	-	-	4	0.3
Undet. Reptiles	4	1	-	-	-	-	5	0.4
Roughtail rock agama (*Laudakia stellio*)	4	1	-	-	23	1	5	0.4
Ostrich eggshell frags. (*Struthio camelus*)	-	-	-	-	-	-	5	0.4
Houbara bustard (*Chlamydotis undulata*)	-	-	-	-	-	-	2	0.1
Purple gallinule (*Porphyrio porphyrio*)	-	-	-	-	-	-	4	0.3
Sand partridge (*Ammoperdix hayi*)	-	-	-	-	26	1	9	1
Chukar partridge (*Alectoris chukar*)	5	1	-	-	60	2	15	1
Quail (*Coturnix coturnix*)	-	-	-	-	5	0.1	-	-
Buzzard (*Buteo buteo*)	-	-	-	-	3	0.09	-	-
Falcon sp. (*Falco* sp.)	1	0.4	-	-	1	0.03	-	-
Brown-necked raven (*Corvus ruficollis*)	-	-	-	-	1	0.03	-	-
Passeriformes	1	0.4	-	-	-	-	-	-
Undet. Bird	5	1	-	-	-	-	9	1
Catfish (Clarias sp.)	-	-	-	-	-	-	1	0.1
Undet. Fish	2	0.4	-	-	7	0.2	3	0.2
Total Identified	**452**	**100**	**125**	**100**	**3257**	**100**	**1077**	**100**

** the identification of aurochs is discussed in the text

\# = alternative NISP counts taken from Bar-El and Tchernov 2001

References: Ujret el-Mehed (Banana I) – Dayan *et al*. 1986, Bar-El and Tchernov 2001; Abu Madi III – this study; E. Tchernov unpublished data; Bar-El and Tchernov 2001; Wadi Tbeik – Tchernov and Bar-Yosef 1982; Bar-El and Tchernov 2001

Table 3.2: Goat bone fusion data for PPNB sites
Age categories are based on bones which fuse within the same time range; N = NISP counts

	Abu Madi 3			**Gebel Rubsha**			**Ujret el-Mehed**			**Recent herd composition as %***
Age Range (months)	**F N**	**UF N**	**% F**	**F N**	**UF N**	**% F**	**% UF**	**% F**	**bone**	
0-12	11	3	78.5	1	0	100	0 11	100 89	dist. humerus 2nd phalanx	c.28
12-24	8	2	80	3	0	100	28 10	72 90	dist tibia 1st phalanx	c.26
24-36	7	6	54	-	-	-	34 53 61	66 47 39	dist. metapodials prox. femur prox. tibia	
36-48	2	2	50	0	1	50				c.46
48-60	3	0	100	1	0	100	55 39	45 61	dist. radius dist. femur	
Total NISP	**30**	**14**		**4**	**1**		**None Given**			

Bones included in age classes for feral goat (based on Noddle 1974)
(UF = unfused; F = fused; dist. = distal, prox. = proximal):
0-12 months = dist. scapula, dist. humerus, prox. radius, 2nd phalanx.
12-24 months = prox. 1st phalanx; dist. tibia.
24-36 months = dist. metapodials; prox. femur, prox. tibia.
36-48 months = prox. calcaneum.
48+ months = prox. humerus, dist. radius; prox. ulna; dist. femur.

Data for Ujret el-Mehed (Banana I) – Dayan et al.1986. Bones labelled by them as fusion line showing have been counted here as fully fused.
* data from G. Ilani presented in Dayan et al. 1986: Figure 3.
c. - circa

Table 3.3: Gazelle bone fusion data for PPNB sites
(Age categories are based on bones which fuse within the same time range)

	Abu Madi 3			**Gebel Rubsha**		
Age Range (months)	**F**	**UF**	**%F**	**F**	**UF**	**%F**
0-2	3	0	100	1	0	100
3-8	-	-	-	-	-	-
8-10	0	1	50	2	1	67
10-16	2	1	67	-	-	-
10-18	1	2	33	-	-	-
Total	**6**	**4**		**3**	**1**	

Bones included in age classes for *Gazella* (based on data in Davis 1980a)

(UF= unfused; F = fused; dist. = distal, prox. = proximal):

0-2 months = dist. humerus, prox. radius.
3-8 months = dist. scapula, prox. phalanges.
8-10 months = dist. tibia.
10-16 months = dist. metapodials, prox. femur, prox. calcaneum.
10-18 months = prox. humerus, dist. radius, prox. ulna, dist. femur, prox. tibia.

Table 3.4a: Skeletal element representation – Goat (NISP counts)

Sites **Bone Element**	**U el Mehed MNI= 80**	**W Tbeik MNI=8**	**Abu Madi 3 MNI = 2**	**J. Rubsha MNI=2**
Horncore	34		3	14
Skull	6		13	3
Maxilla	8	2	1	
Lower jaw	63	6	5	
Loose Teeth	120	25	71	2
TOTAL CRANIA	**231**	**33**	**93**	**19**
Axis				1
Atlas				1
Rib prox.			2	3
Rib frags.			16	2
Cervical vertb.			6	
Thoracic vertb.			4	
Lumbar vertb.			4	1
Caudal vertb.			2	
Vertb.				4
TOTAL TRUNK			**34**	**12**
Scapula dist.	39		2	
Scapula blade	9		3	1
Humerus prox.	5		1	
Humerus dist.	99	10	3	
Humerus shaft			4	
Radius prox.	39		3	1
Radius dist.	79			
Radius shaft			3	
Ulna prox.	53		3	1
Ulna shaft			3	1
Metacarpal prox.	92		2	2
Metacarpal shaft		9		
Metacarpal dist.			6	
Carpals			2	
TOTAL FORELIMB	**415**	**19**	**35**	**6**

Table 3.4a: Skeletal element representation – Goat (continued…..)

Sites **Bone Element**	**U el Mehed MNI= 80**	**W Tbeik MNI=8**	**Abu Madi 3 MNI = 2**	**J. Rubsha MNI=2**
Pelvis acetab.	64		2	
Pelvis frag.	13		1	
Femur prox.	53	1		
Femur dist.	27	3		
Patella			1	
Tibia prox.	11		1	
Tibia shaft			2	
Tibia dist.	67	6	3	2
Metatarsal prox.	97		3	
Metatarsal shaft			1	
Metatarsal dist.			2	
Tarsals			7	1
Astragalus	154	16		
Calcaneum	33	5	7	1
TOTAL HINDLIMB	**519**	**31**	**30**	**4**
1st phalanx +prox	154	59	7	3
1st phalanx dist	91			
2nd phalanx +prox.	174	40	6	1
2md phalanx dist.	30			
3rd phalanx	144	25	6	
TOTAL FEET	**593**	**124**	**19**	**4**
Undet. Metapodials*	513	18	6	
Total	**2271**	**229**	**217**	**45**

* These are metapodials that could not be assigned to either the forelimb or hindlimb

Table 3.4b: % MAU (Minimum Animal Units) for goat and gazelle from PPNB sites and the %MGUI (Modified General Utility Index) for sheep (after Binford 1978).
Table based on data given in Table 3.4a.
dist. = distal; prox. = proximal; vertb.= vertebra

	Capra	***Capra***	***Capra***	***Gazella***	
Sites **Bone Element**	**U. el Mehed %MAU**	**W. Tbeik %MAU**	**Abu Madi 3 %MAU**	**Abu Madi 3 %MAU**	**SHEEP %MGUI**
Horncore	22.0		42.8		1.03
Ribs				100.0	100.0
Axis				50.0	18.68
Cervical vertb.			34.2		55.33
Thoracic vertb**.**			8.5	3.5	46.49
Lumbar vertb.			17.1	25.0	38.90
Scapula dist.	25.3		28.5		45.0
Scapula blade	5.8		42.8	50.0	45.0
Humerus prox.	3.2		14.2	50.0	37.28
Humerus dist.	64.2		42.8	75.0	32.79
Radius prox.	25.3	62.5	42.8		24.30
Radius dist.	51.2			25.0	20.06
Metacarpal prox.	59.7		28.5	50.0	10.11
Metacarpal dist.			85.7	25.0	8.45
Carpals			2.8		13.43
Pelvis acetabulum	41.5		28.5		81.5
Femur prox.	26.5	6.2			80.58
Femur dist.	17.5	18.7			80.58
Tibia prox.	7.1		14.2		51.99
Tibia dist.	43.5	37.5	42.8	25.0	37.70
Metatarsal prox.	62.9		42.8	100.0	15.77
Metatarsal dist.			28.5		12.11
Astragalus	100.0	100.0			23.08
Calcaneum	21.4	31.2	100.0	25.0	23.08
1st phalanx	24.9	91.2	22.8	10.0	8.22
2nd phalanx	28.1	62.5	20.0	35.0	8.22
3rd phalanx	23.3	38.7	20.0	10.0	8.22

Table 3.5: Skeletal element representation- Gazelle (NISP counts)

Sites **Bone Element**	**U Mehed MNI =5**	**W Tbeik MNI =5**	**Abu Madi 3 MNI=2**	**J. Rubsha MNI=2**
Horncore	11			5
Skull			1	1
Maxilla	1		1	
Upper teeth				
Lower jaw			1	2
Loose teeth	8		8	2
TOTAL CRANIA			11	**10**
Axis			1	
Rib prox.			2	2
Rib frags.			10	1
Cervical vertb.				
Thoracic vertb.			1	
Lumbar vertb.			3	1
Vertb.			8	
TOTAL TRUNK			**25**	**4**
Scapula dist.	2			
Scapula blade			2	1
Humerus prox.			2	
Humerus shaft				
Humerus dist.	1	3	3	
Radius prox.				1
Radius dist.			1	
Radius shaft			4	
Ulna prox.		1	1	
Metacarpal prox.			2	
Metacarpal dist	3	2	1	
Carpals				
TOTAL FORELIMB	**6**	**6**	**16**	**2**

Table 3.5: Skeletal element representation- Gazelle (continued…….)

Sites **Bone Element**	**U Mehed MNI =5**	**W Tbeik MNI =5**	**Abu Madi 3 MNI=2**	**J. Rubsha MNI=2**
Pelvis acetab.				
Pelvis ilium				
Femur shaft			1	
Femur prox.				
Femur dist.				
Patella				1
Tibia dist.		5	1	
Tibia shaft			1	
Metatarsal prox.	4		4	
Metatarsal dist.	2			
Tarsals				
Astragalus		3		
Calcaneum			1	
TOTAL HINDLIMB	**6**	**8**	**8**	**1**
1st phalanx+prox	1	13	2	2
2nd phalanx	3	37	6	1
3rd phalanx	1		2	
TOTAL FEET	**5**	**13**	**10**	**3**
Undet. Metapodial*	**-**	3	**-**	
Total	**37**	**80**	**70**	**20**

* These are metapodials that could not be assigned to either the forelimb or hindlimb

Table 3.6: *Capra* measurements
(Measurements in mm, definitions after von den Driesch 1976 and Horwitz et al. 1990; X = mean; SD = std. deviation; N = NISP)

Distal humerus	**Bd**											
Abu Madi III	36.2											
Radius dist	**Bd**											
Abu Madi III	29.8											
Metacarpal dist.	**MCHDW**				**MCSC**				**MCLC**			
	N	**X**			**N**	**X**			**N**	**X**		
Abu Madi III	**1**	**11.3**			**1**	**9.1**			**1**	**14.8**		
Metacarpal prox.	**Bp**				**Dp**							
	N	**X**			**N**	**X**						
Abu Madi III	-				1	15.1						
Gebel Rubsha	1	24.9			1	13.3						
Metatarsal dist.	**MTHDW**				**MTSC**				**MTLC**			
	N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**
Abu Madi III	3	11.0	10.1-11.8	0.86	3	10.0	8.6-11.0	1.24	3	14.9	13.5-16.2	1.34
Tibia dist.	**Bd**											
	N	**X**	**Range**	**SD**								
Abu Madi III	3	20.8	18.9-22.4	1.77								
1st phalanx					**Bd**				**Bp**			
					N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**
Abu Madi III					5	11.6	10.8-12.8	0.84	3	13.3	12.3-14.9	1.36
U el Mehed									73	12.5	10.5-16.2	1.38
Wadi Tbeik									49	12.5	9.1-16.1	1.67
Recent Nubian ibex									39	13.0	9.9-15.5	1.66
2nd phalanx	**GLpe**				**Bd**				**Bp**			
	N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**
Abu Madi III	4	25.6	22.0-28.5	2.87	5	9.6	8.6-10.4	0.71	4	12.5	11.5-13.0	0.67
3rd phalanx	**BF**				**DLS**				**Bp**			
	N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**
Abu Madi III	4	13.7	12.6-14.6	0.85	3	28.6	27.6-30.5	1.64	3	16.1	15.7-17.0	0.72

Table 3.7: Bone mineral density (BMD) values for *Capra*
(using averaged values for sheep taken from Lyman 1994:Table 7.6)

% for each bone group are calculated from the sum of NISP counts for these bones
prox. = proximal; dist. = distal

Sites	**Mean BMD values for Sheep**	**U el Mehed**		**W Tbeik**		**Abu Madi 3**		**J. Rubsha**	
Bone Element		**NISP**	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**
Humerus prox.	0.17	5	5	0	0	1	25	0	
Humerus dist.	0.35	99	95	10	100	3	75	0	
Tibia prox.	0.18	11	12	0	0	1	25	0	
Tibia dist.	0.32	67	88	6	100	3	75	0	
1st phalanx	0.46	245	41	59	47.5	7	37	3	75
2nd phalanx	0.38	204	34	40	32	6	31.5	1	25
3rd phalanx	0.30	144	24	25	20	6	31.5	0	0

Table 3.8: *Gazella* measurements
(Measurements in mm, definitions after von den Driesch 1976 and Horwitz et al. 1990; X = mean; SD = std. deviation; N =NISP)
prox. = proximal; dist. = distal; N = NISP counts

Metacarpal dist.	**MCLC**				**MCSC**							
	N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**				
Abu Madi III (UF)	2	15.4	14.7-16.1	0.98	2	10.5	9.4-11.6	1.55				
Metacarpal prox.	**Bp**				**Dp**							
Abu Madi III	20.4				14.7							
Distal tibia	**Bd**				**Dp**							
Abu Madi III (UF)	22.8				19.3							
Calcaneum	**GL**				**CAW**							
Abu Madi III	58.8				21.9							
2nd ph	**GLpe**				**Bd**				**Bp**			
	N	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**	**N**	**X**	**Range**	**SD**
Abu Madi III	3	21.6	19.4-25.0	2.9	5	8.3	7.9-8.8	0.36	3	7.4	6.9-7.8	0.49
Recent Mnt. Gazelle* M	12	22.2	21.1-24.5	1.0	11	7.2	6.5-7.8	0.4	12	9.3	8.9-10.0	0.3
Recent Mnt. Gazelle* F	14	20.9	19.1-23.4	1.3	14	6.7	6.2-7.2	0.3	14	8.7	8.2-9.4	0.3
3rd ph	**DLS**				**Bp**							
Abu Madi III	26.5				15.2							

* data from Horwitz et al. 1990

Table 3.9: Bone mineral density (BMD) values for *Gazella*
(using averaged values for sheep taken from Lyman 1994:Table 7.6)

% for each bone group are calculated from the sum of NISP counts for these bones
prox. = proximal; dist. = distal

Bone Element	**Mean BMD values for Sheep ***	**U el Mehed**		**W Tbeik**		**Abu Madi 3**		**J. Rubsha**	
		NISP	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**
Humerus prox.	0.17	0		0		2	40	0	
Humerus dist.	0.35	1	100	3	100	3	60	0	
Tibia prox.	0.18	0		0		0		0	
Tibia dist.	0.32	0		5	100	1	100	0	
1st phalanx	0.46	1	20	13	26	2	20	2	67
2nd phalanx	0.38	3	60	37	74	6	60	1	33
3rd phalanx	0.30	1	20	0	0	2	20	0	0

Table 3.10: Biotopes Exploited.

(AM=Abu Madi 3; JR=Gebel Rubsha; UM= Ujret el-Mehed; SH = Sheikh III; WA= Wadi Ahmar; WT=Wadi Tbeik).

Rocky habitats:
ibex (AM, JR, UM, SH, WA, WT)
sand partridge (UM, WT)
Ethiopian hedgehog (AM, WT)
bushy-tailed jird (WT)
roughtail rock agama (AM,UM,WT)
leopard (AM?, UM)

Open plains:
gazelle (AM, JR, UM, SH, WA, WT)
equids (UM, WA, WT)
Sundevall’s jird (WT)
houbara bustard (WT)

Sandy plains
fennec (WT)
sand rat (WT)

Ubiquitous except for forests:
Cape hare (WT, UM, AM, JR),
chukar partridge (AM,UM,WT)

Ubiquitous:
red fox (AM, WT, UM)
wild cat (WT)
brown-necked raven
striped hyaena (WT)
Indian crested porcupine (Sh)

Passage migrant:
quail (UM)
buzzard (UM)
falcon (AM, UM)

Running freshwater:
catfish (WT)
purple gallinule (WT)
freshwater mollusc -*Theodoxus jordanii* (WT)

Red Sea: fish (AM, UM. WA, WT)

Table 3.11: Seasonality scheme for PPNB sites in Sinai

Species		**Hare**	**Quail**	**Ibex**	**Gazelle**
Herd Structure *		Solitary	Flocks	F+young M only Solitary old M	F+young Young M only Adult M only Territorial M
PPNB Sites	**Suggested time of occupation**				
Ujret el-Mehed Abu Madi 3 Gebel Rubsha	**Summer** June-October			herd near water/ oases and in deep ravines for shade	
	Autumn October-November			mating	mating
Wadi Tbeik	**Winter** November-April	births- 1 month nursing		herds in the desert plains pasturing on annuals	
	Spring April -June	births- 1 month nursing	early spring	births (late March-early April)	peak births - 3 months suckling

M = Male; F = Female

Data on herd structure from Mendelssohn and Yom-Tov (1999)

Table 4.1: Radiocarbon dates of Late Neolithic/Pottery Neolithic sites discussed in the text.
For sites with several dates, only the earliest and latest are cited here.
Calibration by www.calpal-online.de

Region/Site	**Lab No.**	**14C uncal. BP**	**14C cal. BP**	**Reference**
Jordanian Eastern Desert				
Burqu 27-2	OxA-2764	7270±80	8094±75	Martin 1999
Dhuweila 2	OxA-1729	7450±90	8269±83	Martin 1999
Dhuweila 2	OxA-1728	7140±90	7969±92	Martin 1999
Dhuweila 2	OxA-1636	7030±90	7851±88	Martin 1999
Gebel Naja	OxA-375	7430±100	8239±104	Martin 1999
Mediterranean South Coast				
Nizzanim	Hv-8509	6740±90	7599±72	Yeivin and Olami 1979
Givat Haparsa	KN-3537	6100±1200	6820±1322	Garfinkel 1999b
Qatif Y3	Pta-2968	6040±80	6908±107	Gilead 1988
Southern Jordan Valley				
Tell Wadi Feinan	HD-10567	6410±118	7317±110	Najjar et al. 1990
Tell Wadi Feinan	HD-12336	5375±30	6193±65	Najjar et al. 1990
Negev Highlands				
Ramon I, level VIII		7213±84	8056±84	Rosen et al. 2005
Ramon I, level VIII		6050±118	6936±161	Rosen et al. 2005
Southern Negev				
Nahal Issaron	RT-1640	7135±95	7964±96	Carmi et al. 1994
Nahal Issaron	RT-1691	7100±70	7923±62	Carmi et al. 1994
Nahal Issaron	RT-1606	6680±85	7554±66	Carmi et al. 1994
Nahal Issaron	Pta-2999	6460±80	7373±67	Carmi et al. 1994
Nahal Issaron	Pta-3486	6130±70	7033±102	Carmi et al. 1994
Nahal Issaron	RT-1608	5690±55	6492±67	Carmi et al. 1994
Nahal Issaron	RT-1518	4990±50	5758±88	Carmi et al. 1994
Sinai				
Qadesh Barnea 3	SMU-662	7530±100	8324±94	Bar-Yosef 1980
Qadesh Barnea 3	Pta-3362	7350±80	8176±106	Bar-Yosef 1980

Table 4.2: Radiocarbon dates for Chalcolithic and EBI-EB III sites discussed in the text.
For sites with several dates, only the earliest and latest are cited here.
Calibration by www.calpal-online.de

Region/Site	Lab No.	14C uncal. BP	14C cal. BP	Reference
Tombs				
Ein Um Ahmed	RT-1856	5815±50	6618±63	Carmi and Segal 1994
Ein Um Ahmed	RT-1857	5575± 60	6371±50	Carmi and Segal 1994
Ein Um Ahmed	RT-1851	5130±55	5858±76	Carmi and Segal 1994
Wadi El Abar	RT-1854	3335±50	3569±66	Carmi and Segal 1994
Abu Khalil	RT-1853	5200±70	6003±95	Carmi and Segal 1994
Wadi Zalaqa T2	Pta-3633	5590±70	6387±63	Avner et al. 1994
Wadi Zalaqa T2	RT-648E	5440±80	6210±94	Avner et al. 1994
Elat Burial Site IV/16	RT-989	6470±80	7380±69	Avner et al. 1994
Elat Burial Site IV/1	Rt-926	5400±100	6164±117	Avner et al. 1994
Shrines/*Masseboth*/ Sanctuaries				
‘Uvda Valley -124/ IV *	RT-1419	4370±100	5039±162	Avner et al. 1994
‘Uvda Valley -124/ IV *	RT-3173	4010±45	4489±48	Avner 2002
‘Uvda Valley -124/XVII	Rt-70D	7960±200	8857±255	Avner et al. 1994
Uvda Valley - 124/XVII	Pta-3646	6960±70	7803±80	Avner 2002
Uvda Valley - 124/XVII	RT-336	4130±90	4662±125	Avner 2002
Wadi Daba’iyeh	RT-2186	6045±65	6904±88	Avner 2002
S-18 (H. al-Taref)	ETH-17505	6575±65	7493±52	Eddy and Wendorf 1999
S-18 (H. al-Taref)	ETH-17506	6160±85	7057±107	Eddy and Wendorf 1999
Habitation Sites				
S-1	DRI-3269	5518±121	6310±127	Eddy and Wendorf 1999
S-1	DRI-3272	4639±91	5326±160	Eddy and Wendorf 1999
S-1	DRI-3273	3290±78	3534±87	Eddy and Wendorf 1999
S-25	DRI-3126	5721±63	6530±80	Eddy and Wendorf 1999
S-32	Gd-11319	6230±140	7118±162	Eddy and Wendorf 1999
S-32	Gd-10603	3910±120	4344±171	Eddy and Wendorf 1999
S-32	Gd-9751	3100±220	3290±271	Eddy and Wendorf 1999
Gunna 25	SMU-659	4056±72	4604±139	Bar-Yosef et al. 1986
Gunna 100	SMU-659	4373±64	5001±110	Bar-Yosef et al. 1986
Moyat Daba’iyeh	RT-1855	5355±60	6140±96	Avner 2002
Serabit el Khadim	RT-1807	5250±55	6050±91	Avner 2002
Sheikh ‘Awad	RT-1806	4325±55	4920±58	Avner 2002
Sheikh Muhsein	HV-5296	4710±50	5454±98	Beit-Arieh 2003a
Desert ‘Kites’				
S-10	Gd-7948	4530±60	5183±105	Eddy and Wendorf 1999
S-10	Gd-7953	4420±80	5074±151	Eddy and Wendorf 1999
S-10	Gd-11317	4390±80	5052±151	Eddy and Wendorf 1999

Table 4.3: Species and sketelal elements represented in Chalcolithic sites in North Sinai (numbers given = NISP counts)

SITE R45	**SITE R46**	**SITE R-48**	**SITE R-79**
Sheep/Goat = 2 1 left upper M1 and M2 – adult		***Sheep/Goat = 5*** 1 occipital fragment 1 left mandibular symphysis 1 left lower M3- wear stage 12 1 left proximal calcaneum UF - burnt 1 left astragalus fragment	***Sheep/Goat = 9*** 1 radius shaft 1 right proximal ulna-burnt 1 right distal femur –UF-burnt 1 right femur proximal -UF-burnt 1 tibia shaft-burnt 1 left proximal calcaneum UF - burnt 1 left navicullo-cuboid 1 proximal rib 1st phalanx - UF
		Medium Mammal = 5 1 cranial fragment 2 rib shaft fragments 1 vertebral body fragment 1 metapodial fragment sheep/goat	***Medium Mammal = 3*** 1 scapula blade 2 vertebral body fragment
Cattle = 2 1 right upper M1- adult 2nd phalanx whole		***Cattle = 2*** 1 left cattle distal humerus fragment 1 left cattle upper M2- adult	***Cattle = 1*** 1st phalanx fragment
Donkey =1 1 right calcaneum fragment	***Donkey =4*** Lower PM4-M2 Upper M2	***Large Mammal = 1*** 1 humerus shaft –burnt	***Large Mammal = 1*** 1 rib fragment
			Pig= 2 1 ascending ramus -burnt 1 right distal scapula- UF
Snake = 4 4 vertebrae			***Hare =1*** 1 phalanx
Total Id Bones = 9 **Total Fragments = 5**		**Total Id Bones = 13** **Total Fragments = 6**	**Total Id Bones = 17** **Total Fragments = 23**

Table 4.4: Taxa represented in the 4th millennium BC *Masseboth* sites and shrines from Southern Sinai

NISP = bone counts

Species Sites	**Goat** **NISP**	**Sheep/Goat** **NISP**	**Medium Mammal NISP**	**Hare** **NISP**	**Quail** **NISP**	**Rodent** **NISP**	**Total Diagnostic NISP**	**Total Non-diagnostic NISP**
Hadj I			5				5	
Bir Sawaneh 6		2	1				3	1
Wadi Zalaqa M306								2
Wadi Zalaqa M308						1		2
Wadi Sa'al		2		1	1		4	19
Wadi Daba'iyeh	4	13	1	3	4		25	65
Totals	**4**	**17**	**7**	**4**	**5**	**1**	**37**	**89**

Table 4.5: Sheep/goat skeletal element representation at the shrines of Wadi Sa’al and Wadi Daba’iyeh

NISP = bone counts; UF = unfused

Sites **Bone Element**	**Bir Sawaneh 6 NISP**	**Wadi Sa’al NISP**	**Wadi Daba’iyeh NISP**	**Total NISP**
Horncore			1	
Loose teeth (fragments)	1	1		
Molar tooth			1	
Total Crania				4
Humerus shaft		1		
Radius prox.			1	
Total Forelimb				2
Femur shaft	1			
Tibia shaft			1	
Metatarsal prox.			1	
Metatarsal dist.			2 -UF	
Tarsals			3	
Astragalus			1 left 1 left-neonate	
Calcaneum			2 (*Capra*) 1 left neonate	
Total Hindlimb				13
Unidentified Metapodials*			1 dist 1 shaft-neonate	2
Total	**2**	**2**	**17**	**21**

* These are metapodials that could not be assigned to either the forelimb or hindlimb

Table 4.6a: *Capra* bone measurements from Chalcolithic-EB I sites
UF = unfused; Measurements in mm, taken after von den Driesch 1976 and Horwitz et al. 1990.

Wadi Daba'iyeh Shrine	**GL**	**AW**	**Bd**	
right calcaneum (UF) (? ibex)	51.7	23.0	-	
right calcaneum F	29.6	-	17.8	
	MTHDW	**MTSC**	**MTLC**	
distal metatarsal (UF)	9.2	9.4	14.1	
distal metapodial (UF)	-	8.2	13.1	
Sawawin Nawamis	**GL**	**Bd**	**SD**	**Dp**
1st phalanx	31.5	9.9	9.2	10.6
Ein Um Ahmed Nawamis	**BG**	**SD (neck)**		
distal scapula	14.4	15.3		
Gunna 25	**Bd**	**BT**	**HDH**	
distal humerus	30.7	28.7	14.6	
	L	**B**		
patella	25.6	20.9		
	MCHDW	**MCSC**	**MCLC**	
distal metacarpal (UF)	12.2	9.3	14.9	
	GLI	**Bd**	**Dm**	
astragalus	27.2	16.7	13.7	
Gunna 50	**Bd**	**BT**	**HDH**	
distal humerus	29.2	28.1	11.7	
	MCHDW	**MCSC**	**MCLC**	
distal metacarpal (UF)	12.2	9.3	14.9	
	GL	**Bd**	**SD**	**Dp**
1st phalanx	**-**	9.8	9.2	
2nd phalanx	20.6	-	-	12.0
2nd phalanx	23.6	9.2	8.0	11.9
R-79	**GL**	**GB**		
navicullo-cuboid	20.9	17.2		

Table 4.6b: Other species bone measurements from Chalcolithic-EB I sites
Measurements in mm, taken after von den Driesch 1976 and Horwitz et al. 1990.

Equid				
Gunna 50	Midpoint Length	Midpoint Breadth		
lower M2	29.5	17.9		
Bos				
Site R 45	**GL**	**Bd**	**Bp**	**Dp**
2nd phalanx	35.5	21.4	26.1	29.4
Gazelle				
Gunna 50	**Lad**	**Bp**	**BF**	
3rd phalanx	24.2	14.3	11.7	

Table 4.7: Faunal remains from the *nawamis* tombs (given as NISP counts)
frag. = fragment; prox. = proximal; dist.= distal ; UF = unfused; numbers given = NISP counts.

* number cited in Bar-Yosef et al. 1977: Table 2, minus the three identified horncores listed here

Species **Sites**	**Cattle** ***Bos***	**Gazelle** ***Gazella***	**Gazelle/ Caprine**	**Goat/Ibex** ***Capra***	**Hare** ***Lepus capensis***	**Rodent**	**Reptile**	**Shark**	**Total ID**	**Total Non-Id**
Ein Um Ahmed				1upper 2nd molar 3 tooth frags. 1 right scapula dist.-UF 2 humerus shaft frags.	1 rib				7	2 frags.
Ein Huderah	1 worked pelvis	1 horncore 1 horncore tip		1 goat horncore					3	35 bones*
Wadi El Abar			10 tooth frags.	1 left prox. humerus-UF 1 patella frag. 1 premaxilla frag. 9 tooth frags. 1 left jaw corpus frag. 5 rib shafts 10 prox. rib frags. 1 cervical vertebra - UF 1 thoracic vertebra - UF 2 vertebral frags.	1 sacrum 1 lumbar vertebra 1 rib	1 incisor - *Meriones* sp. 1 longbone	1 jaw - *Uromastyx*	tooth	49	
Hzeimeh (Upper Wadi Nasb)									0	13 frags.

Table 4.7: Faunal remains from the *nawamis* tombs (continued…….)

Species **Sites**	**Cattle** ***Bos***	**Gazelle** ***Gazella***	**Gazelle/Caprine** **Med. mammal**	**Goat/Ibex** ***Capra***	**Hare** ***Lepus capensis***	**Rodent**	**Reptile**	**Shark**	**Total ID**	**Total Non-Id**
Wadi Sawawin			2 longbone frags.	1st ph F 1 tooth frag. 1 upper molar 1 metapodial shaft	1left & 1 right jaw 1 dist humerus 2 radius shafts 1 rib frag.	1 femur 1 tibia	1 jaw *Uromastyx*		15	
Abu Halil			7 tooth frags.	5 tooth frags.	1 pelvis					6 burnt 7 frags.
Nakb Hibran			1 tooth frag.		1 dist. humerus 1 pelvis 1 femur dist. 5 longbone frags. 1 rib	1 incisor *Meriones* sp.				

Table 4.8: Faunal remains from the *nawamis* habitation sites

Sites	**Moyat Daba'iyeh**	**Gunna 25**			**Gunna 50**		
Species	**NISP**	**NISP**	**%**	**MNI**	**NISP**	**%**	**MNI**
Goat/ibex (*Capra* sp.)	7 tooth frags.	33	9	2	60	32	3
Gazelle (*Gazella* sp.)	-	7	2	1	8	4	1
Medium mammal	-	105	29	3	109	58	2
Equid (*Equus* sp.)	-	-	-	-	2	1	1
Large mammal	-	-	-	-	3	2	1
Hare (*Lepus capensis*)	2	31	9	3	5	3	1
Jird sp. (*Meriones* sp.)	-	122	33	14	-	-	-
Desert monitor (*Uromastyx* sp.)	-	4	1	1	-	-	-
Bird sp.	-	4	1		-	-	-
Sand partridge (*Ammoperdix hayi*)	-	2	0.5	1	-	-	-
Quail (*Corturnix coturnix*)	-	28	8	2	-	-	-
Raptor cf. sparrowhawk	-	1	0.4	1	-	-	-
Passerifomes	-	24	7	3	-	-	-
Total Identified	**9**	**361**	**100**	**33**	**187**	**100**	**9**
Unid. fragments	21	188			165		
Burnt unid. fragments	4	84			70		
Total Unidentified	**25**	**272**			**235**		

Table 4.9: Age based on bone fusion of goats and ibex
F = fused ; UF = unfused; N = NISP

Age Range (months)	**Gunna 25** **F N**	 **UF N**	 **% F**	**Gunna 50** **F N**	 **UF N**	 **% F**
0-12	3	1	75	4	1	80
12-24	1	1	50	3	2	60
24-36	2	3	40	-	-	-
36-42	0	2	0	0	3	100
Total	**6**	**6**		**7**	**6**	

prox. = proximal; dist. = distal

Bones included in age classes for sheep/goat (dist. = distal, prox. = proximal):
0-12 months = scapula, dist. humerus, prox. radius;
12-24 months = prox. phalanges; dist. tibia, dist. metapodia;
24-36 months = prox. ulna; prox. femur, calcaneum;
36-42 months = prox. humerus, dist. radius; dist. femur, prox. tibia.

Removed: tibia dist., femur prox., ilium, ischium, ulna shaft, scapula blade, humerus, cervical vertebrae, upper pre-molar, atlas, axis, metatarsal dist.

Table 4.10a: Skeletal elements represented at Gunna 25 and 50 (NISP counts)

Sites	**Gunna 25**			**Gunna 50**		
Bone Elements/ Species	**Goat/Ibex**	**Medium Mam.**	**Gazelle**	**Goat/Ibex**	**Medium Mam.**	**Gazelle**
Horncore	1			1		
Cranial frags.		1		2		
Petrous bone			2			
Mandible frags.	2	1 neo-nate		2		4
Upper molars	2			1		1
Lower molars				4		1
Lower premolars				3		
Incisors			2	3		
Tooth enamel frags.	9	83		8	72	
TOTAL CRANIAL	**14 42%**	**85 81%**	**4**	**24 40%**	**72 66%**	**6**
Hyoid			1			
Thoracic Vertebrae				1	1	
Lumbar Vertebrae	1			1		
Vertebrae frags.				2	2	
Rib prox.	2			6	1	
Rib shaft frags.		7		3	18	
TRUNK	**3 9%**	**7 7%**	**1**	**13 22%**	**22 20%**	
Scapula Dist				1		
Humerus Prox.	1					
Dist.	1			3		
Shaft	2	2		1	5	
Radius Prox.				1		
Dist.	1			2		
Shaft			1			
Ulna Prox.	3	1 neo-nate				
Metacarpal Prox.				1		
Dist.				2		
FORELIMB	**8 24%**	**3 3%**	**1**	**11 18%**	**5 4.5%**	

Table 4.10a: Skeletal elements represented at Gunna 25 and 50 (continued……)

Sites	**Gunna 25**			**Gunna 50**		
Bone Elements/ Species	**Goat/ibex**	**Medium Mam.**	**Gazelle**	**Goat/Ibex**	**Medium Mam.**	**Gazelle**
Acetabulum		1 neo-nate		1	1	
Femur Dist.				1		
Femur Shaft	1	1			6	
Tibia Prox.	1			1		
Tibia Shaft	2	2	1	1	3	
Metatarsal Prox.		1		2		
Tarsals				1		
Astragalus	1	1				
Calcaneum	1					
HINDLIMB	**6 18%**	**6 6%**	**1**	**7 12%**	**10 9%**	
Metapodial Dist.		1		1		
Prox	1					1
Shaft		2				
whole		1 neo-nate				
METAPODIAL	**1 3%**	**4 3%**		**1 1%**		
1st Phalanges	1			2		
2nd Phalanges				2		
3rd Phalanges						1
TOTAL FEET	**1 3%**			**4 7%**	**0**	**1**
TOTAL NISP	**33**	**105**	**7**	**60**	**109**	**8**

Table 4.10b: Values for goat from Gunna Sites 25 and 50:
% Completeness (based on an MNI estimate of 5 animals); % MAU (Minimum Animal Units),
%MGUI (Modified General Utility Index) and Bone Mineral Density (BMD) (based on summed scan values).

Sheep %MGUI after Binford (1978); Mean BMD values for each sheep element after Lyman (1994:Table 7.6).

Table based on data given in Table 4.10a.

Site Skeletal Element	**Goat Gunna 25+50 Expected**	**Goat Gunna 25+50 %Completeness**	**Goat Gunna 25+50 %MAU**	**SHEEP %MGUI**	**SHEEP Mean BMD Values**
Thoracic vertb.	65	1.5	4.6	46.4	0.21
Lumbar vertb.	30	6.6	22.0	38.9	0.24
Scapula Dist.	10	10.0	33.3	45.0	0.29
Humerus Dist.	10	40.0	100.0	32.7	0.35
Humerus Prox.	10	10.0	33.3	37.2	0.17
Humerus. Shaft			100.0		0.42
Radius Dist.	10	30.0	100.0	20.0	0.20
Radius Prox.	10	10.0	33.3	24.3	0.35
Ulna Prox.	10	30.0	100		0.22
Metacarpal Dist.	10	20.0	66.6	8.4	0.44
Metacarpal Prox.	10	10.0	33.3	10.1	0.47
Pelvis acetabulum	10	10.0	33.3	81.5	0.26
Femur Dist.	10	10.0	33.3	80.5	0.23
Femur Shaft	10	10.0	33.3		0.36
Tibia shaft	10	30.0	100.0		0.59
Tibia Prox.	10	20.0	66.6	51.9	0.18
Metatarsal Prox.	10	20.0	66.6	15.7	0.48
Astragalus	10	10.0	33.3	23.0	0.59
Calcaneum	10	10.0	33.3	23.0	0.50
1st phalanx	40	7.5		8.22	0.46
2nd phalanx	40	5		8.22	0.38

Table 4.11: Previously published species lists for the EBII Sinai assemblages

Sites **Species**	**Site 1014**[1]	**Wattiya North**[1]	**Feiran I**[2] **NISP**	**Sheikh ‘Awad**[3]	**Wadi Gunna 32**[4]	**Wadi Gunna 100**[5]	**Sheikh Muhsein**[1]	**Nabi Salah**[1]
domestic goat	X	X	9	X *	-	-	X *	X *
ibex	-	-	-	X	-	-	X	X
goat/ibex	-	-	-	-	X	X		
cattle	-	-	1	-	-	-	X	-
dorcas gazelle	-	-	1	X	-	-	-	X
dog	-	-	1	X	-	-	-	-
hare	-	-	-	X	X	-	X	-
hyrax	-	-	-	X	-	-	-	X
rodent	-	-	-	-	-	-	X	-
dove/pigeon	-	-	-	-	-	-	X	-
ostrich eggshell	X	X	X	X	X	-	X	X
TOTAL NISP	-	-	15	-	-	-	-	-

Notes to Table 1

X = Taxon present but no numerical data given.
* most common taxon in assemblage.
1 = Analysis of the fauna from Site 1014 and Wattiya North was carried out by Dr. D. Hakker-Orion and reported in Beit-Arieh (1977).
2 = Analysis of the Feiran I fauna was carried out by Dr. S. Hellwing and reported in Beit-Arieh (1982).
3 = Analysis of the Sheikh ‘Awad fauna was carried out by Dr. S. Hellwing and reported in Beit-Arieh (1981).
4 = Fauna from this site were briefly described in Horwitz and Tchernov (1989a) who analysed the remains.
5 = Data on Gunna 100 are reported in Bar-Yosef et al. (1986: 132).

Table 4.12: Species representation at Sheikh Muhsein based on the re-analysis of the fauna

Unit **Species**	**Unit A NISP**	**Unit B NISP**	**Unit C NISP**	**Unit F NISP**	**Site Total NISP**	**%**	**MNI**
goat	698	160	17	53	928	86.0	9
ibex	109	25	-	1	135	12.0	3
gazelle	7	1	-	1	9	1.0	1
equid	1	-	-	-	1	0.1	1
carnivore sp.	1	3	-	-	4	0.3	1
hare	4	1	-	-	5	0.4	1
hyrax	-	1	-	-	1	0.1	1
sand partridge	2	-	-	-	2	0.1	1
Total ID	**822**	**191**	**17**	**55**	**1085**	**100**	**18**

Table 4.13: Comparative measurements of *Capra* bones from EB II sites in the Sinai and in the Southern Levant
Data used: Grar - Grigson (1995b); Halif Terrace Whitcher (1999); Qiryat Ata and Tel Aphek (L.K. Horwitz, unpublished data).

(a) Humerus		***BT***	***HT***
S. Muhsein		30.3	12.9
		34.1	12.3
		31.8	13.3
	number	**3**	**3**
	mean	**32.0**	**12.8**
	range	**30.3-34.1**	**12.3-13.3**
N. Salah		27.0	12.0
		25.4	11.3
		23.0	10.6
	number	**3**	**3**
	mean	**25.1**	**11.3**
	range	**23.0-27.0**	**10.6-12.0**
Grar Chalcolithic	**number**	**2**	-
	mean	**30.1**	-
	range	**28.8-31.4**	-
Halif Terrace EBI	**number**	**5**	-
	mean	**33.2**	-
	range	**30.6-36.4**	-
Tel Aphek LBII	**number**	**4**	**4**
	mean	**29.6**	**14.5**
	range	**28.8-30.8**	**14.1-14.7**

(b) Astragalus		**GLI**
S. Muhsein		24.7
		28.5
		24.5
	number	**3**
	mean	**25.9**
	range	**24.5-28.5**
N. Salah		26.4
		27.8
? ibex		30.7
	number	**3**
	mean	**28.3**
	range	**26.4-30.7**
Halif Terrace EBI	**number**	**3**
	mean	**28.6**
	range	**27.3-29.8**
Tel Aphek LBII	**number**	**2**
	mean	**30.4**
	range	**29.8-31.0**

Table 4.13: continued

(c) 1st phalanx		***GLpe***	***Bd***	***Bp***
Sheikh Muhsein		35.8	13.4	13.6
		36.0	10.8	11.9
		36.8	12.5	12.7
		38.2	14.8	13.5
		33.3	10.1	11.1
?ibex		41.4	16.2	14.8
?ibex		41.9	15.0	16.9
	number	**7**	**7**	**7**
	mean	**37.6** **(36.0)***	**13.2** **(12.3)**	**13.5** **(12.5)**
	range	**33.3-41.9**	**10.1-16.2**	**11.1-16.9**
Nabi Salah		39.8	11.8	12.7
		39.2	12.1	12.7
		37.9	13.6	11.8
	number	**3**	**3**	**3**
	mean	**38.9**	**12.5**	**12.4**
	range	**37.9-39.8**	**11.8-13.6**	**11.8-12.7**
Gunna 32		34.4	12.5	13.2
		-	12.6	-
	number	**1**	**2**	**1**
	mean	**34.4**	**12.5**	**13.2**
	range	**-**	**12.5-12.6**	**-**
Grar Chalcolithic	**number**	**6**	**-**	**6**
	mean	**34.5**	**-**	**11.9**
	range	**32.0-37.9**	**-**	**10.9-13.2**
Qiryat Ata EBII	**number**	**3**	**3**	**3**
	mean	**35.4**	**13.0**	**13.1**
	range	**34.7-36.1**	**12.3-13.9**	**13.1-13.2**
Tel Aphek LBII	**number**	**6**	**6**	**6**
	mean	**39.3**	**13.4**	**13.8**
	range	**37.4-42.2**	**11.9-16.5**	**12.6-15.8**

Samples include both anterior and posterior phalanges
* calculated without suspected ibex bones

Table 4.14: Age based on bone fusion of goats and ibex from EBII sites

	Sheikh Muhsein Goat			**Sheikh Muhsein** Ibex			**Nabi Salah** Goat			**Gunna 32** Goat/Ibex		
Age Range (months)	F N	UF N	% F	F N	UF N	% F	F N	UF N	% F	F N	UF N	% F
0-12	25	5	83	10	1	91	23	2	92	0	0	-
12-24	25	15	62	5	0	100	37	16	70	3	3	50
24-36	10	9	53	1	0	100	10	11	48	0	0	-
36-42	6	6	50	1	0	100	11	13	46	0	0	-
Total	**66**	**35**		**17**	**1**		**81**	**42**		**3**	**3**	

Bones included in age classes for *sheep/goat* (dist. = distal, prox. = proximal):
0-12 months = scapula, dist. humerus, prox. radius; 12-24 months = prox. phalanges; dist. tibia, dist. metapodia; 24-36 months = prox. ulna; prox. femur, calcaneum; 36-42 months = prox. humerus, dust. radius; dist. femur, prox. tibia.

Table 4.15: Ageing of caprines from EBII sites based on dental attrition for individual lower teeth.

Numbers refer to the quantity of teeth with a particular attrition score.

		Sheikh Muhsein				**Nabi Salah**			
Attrition Stages (Payne 1973)	Age (years)	decid. m3	M1	M2	M3	decid. m3	M1	M2	M3
A	0-2 mnth								
B	2-6 mnth								
C	6-12 mnth	1				1	1	2	
D	1-2	1		1		2	2	4	
E	2-3		2				6	1	1
F	3-4		1	3			8	10	6
G	4-6		6		3		4		2
H	6-8				2		2	2	
I	8-10								

Table 4.16a: Skeletal element representation for goat from Sheikh Muhsein.
% Completeness (based on an MNI estimate of 9 animals using the distal humerus); % MAU (Minimum Animal Units),
%MGUI (Modified General Utility Index) and Bone Mineral Density (BMD) (based on summed scan values).
Sheep %MGUI after Binford (1978); Mean BMD values for each sheep element after Lyman (1994:Table 7.6).

Skeletal Element	**N Goat**	**N Expected**	**% Completeness**	**%MAU**	**%MGUI**	**Mean BMD Values**
Scapula Dist.	10	18	55.5	0.25	45.0	0.29
Scapula Blade	16	18	88.8	0.41		0.25
Humerus Dist.	10	18	55.5	0.25	32.7	0.35
Humerus Prox.	2	18	11.1	0.05	37.2	0.17
Humerus. Shaft	31	18	172.2	0.79		0.42
Radius Dist.	3	18	16.6	0.07	20.0	0.20
Radius Prox.	19	18	105.5	0.48	24.3	0.35
Radius Shaft	39	18	216.6	1		0.52
Ulna Prox.	10	18	55.5	0.25		0.22
Ulna Shaft	4	18	22.2	0.10		
Metacarpal Dist.	10	18	55.5	0.25	8.4	0.44
Metacarpal Prox.	16	18	88.8	0.41	10.1	0.47
Metacarpal Shaft	2	18	11.1	0.05		0.60
Femur Dist.	1	18	5.5	0.02	80.5	0.23
Femur Prox.	3	18	16.6	0.07	80.5	0.21
Femur Shaft	30	18	166.6	0.76		0.36
Tibia Dist.	4	18	22.2	0.10	37.7	0.32
Tibia Prox.	3	18	16.6	0.07	51.9	0.18
Tibia Shaft	27	18	150.0	0.69		0.35
Metatarsal Dist.	4	18	22.2	0.10	12.1	0.59
Metatarsal Prox.	22	18	122.2	0.05	15.7	0.48
Metatarsal Shaft	4	18	22.2	0.10		
Metapodia Prox.	4	18	22.2	0.10		
Total	**284**	**450**				

Table 4.16b: Skeletal element representation for ibex from Sheikh Muhsein.

% Completeness is based on an MNI estimate of 3 animals using the distal humerus

Skeletal Element	**N Ibex**	**N Expected**	**%Completeness**
Scapula Dist.	2	6	33.3
Humerus Dist.	3	6	50.0
Radius Dist.	1	6	16.6
Radius Prox.	6	6	33.3
Radius Shaft	2	6	33,3
Ulna Prox.	2	6	33.3
Ulna Shaft	1	6	16.6
Metacarpal Prox.	2	6	33.3
Tibia Dist.	2	6	33.3
Metatarsal Prox.	2	6	33.3
Total	**23**	**150**	

Table 4.17: Skeletal element breakdown by anatomical groupings

	Sheikh Muhsein				**Nabi Salah**				**Gunna 32**	
	Goat		**Ibex**		**Goat**		**Ibex**		**Goat/Ibex**	
	NISP	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**	**NISP**	**%**
cranial	452	50	73	54	734	56	47	68	68	73
forelimb	161	17	16	12	160	12	5	7	4	4
hindlimb	134	14	7	5	164	12.5	6	9	7	8
trunk	133	14	33	24	217	16.5	4	6	10	11
feet	48	5	6	4	37	3	7	10	4	4
Total	928	100	135	100	1312	100	69	100	93	100

Table 4.18: Species representation at Nabi Salah based on the re-analysis of the fauna

Unit **Species**	**Unit A/B NISP**	**Unit C NISP**	**Unit D NISP**	**Unit E NISP**	**Unit F NISP**	**Site Total NISP**	**%**	**MNI**
Goat	857	26	400	8	21	1312	92.0	12
Ibex	42	-	23	4	-	69	5.0	4
Gazelle	5	-	-	-	-	5	0.3	1
Hare	21	-	4	-	-	25	1.7	
Hyrax	8	-	4	-	-	12	0.8	
Sand partridge	2	-	-	-	-	2	0.1	1
Total ID	**935**	**26**	**431**	**12**	**21**	**1425**	**100**	

Table 4.19a: Skeletal element representation for goat from Nabi Salah
% Completeness (based on an MNI estimate of 12 animals using the proximal +distal radius); % MAU (Minimum Animal Units),
%MGUI (Modified General Utility Index) and Bone Mineral Density (BMD) (based on summed scan values).
Sheep %MGUI after Binford (1978); Mean BMD values for each sheep element after Lyman (1994:Table 7.6).

Skeletal Element	N Goat	N Expected	% Completeness	%MAU	%MGUI	Mean BMD Values
Scapula Dist.	2	24	8.3	7.2	45.0	0.29
Scapula Blade	10	24	41.6	37.2		0.25
Humerus Dist.	9	24	37.5	3.3	32.7	0.35
Humerus Prox.	2	24	8.3	7.2	37.2	0.17
Humerus. Shaft	23	24	95.8	86.3		0.42
Radius Dist.	7	24	2.6	26.3	20.0	0.20
Radius Prox.	11	24	45.8	40.9	24.3	0.35
Radius Shaft	22	24	91.6	82.7		0.52
Ulna Prox.	5	24	20.8	18.1		0.22
Ulna Shaft	7	24	2.6	26.3		
Metacarpal Dist.	4	24	16.6	14.5	8.4	0.44
Metacarpal Prox.	8	24	33.3	30.0	10.1	0.47
Metacarpal Shaft	2	24	8.3	7.2		0.60
Femur Dist.	6	24	25.0	22.7	80.5	0.23
Femur Prox.	5	24	20.8	18.1	80.5	0.21
Femur Shaft	28	24	116.6	100.0		0.36
Tibia Dist.	5	24	20.8	18.1	37.7	0.32
Tibia Prox.	9	24	37.5	33.6	51.9	0.18
Tibia Shaft	26	24	108.3	90.9		0.35
Metatarsal Dist.	1	24	4.1	3.6	12.1	0.59
Metatarsal Prox.	20	24	83.3	75.4	15.7	0.48
Metatarsal Shaft	6	24	25.0	22.7		
Metapodia Dist.	20	24	83.3	75.4		
Metapodia Prox.	23	24	95.8	0.86		
Metapodia Shaft	2	24	8.3	7.2		
Total	**263**	**600**				

Table 4.19b: Skeletal element representation for ibex from Nabi Salah

% Completeness (based on an MNI estimate of 4 animals from the proximal metatarsal)

Skeletal Element	**N Ibex**	**N Expected**	**% Completeness**
Scapula Dist.	2	8	25.0
Humerus Dist.	1	8	12.5
Humerus. Shaft	1	8	12.5
Radius Prox.	2	8	25.0
Radius Shaft	1	8	12.5
Metacarpal Dist.	2	8	25.0
Femur Shaft	2	8	25.0
Tibia Dist.	1	8	12.5
Tibia Shaft	1	8	12.5
Metatarsal Dist.	2	8	25.0
Metatarsal Prox.	4	8	50.0
Total	**20**	**200**	

Table 4.20: Species representation at Gunna 32

	NISP	**%**	**MNI**
domestic goat	8	8	1
goat/ibex	85	85	3
hare	6	6	1
jird	1	1	1
Total Identified	**102**	**100**	**6**
Unidentified frags.	**189**		

Table 4.21: Skeletal element representation for goat/ibex from Wadi Gunna 32

% Completeness (based on an MNI estimate of 4 animals from teeth)

Skeletal Element	**N**	**N Expected**	**% Completeness**
Humerus. Shaft	2	8	25
Radius Shaft	1	8	12.5
Metacarpal Prox.	1	8	12.5
Femur Shaft	2	8	25
Metatarsal Dist.	1	8	12.5
Metatarsal Prox.	1	8	12.5
Metatarsal Shaft	1	8	12.5
Metapodia Dist.	1	8	12.5
Metapodia Prox.	1	8	12.5
Metapodia Shaft	1	8	12.4
Total	**12**	**200**	

Table 5.1: Comparison of mammalian remains from New Kingdom sites

Sites **Species**	**A-343** **NISP**	**%**	**A-345** **NISP**	**%**	**BEA-10 Bir el-Abd** **NISP**	**%**	**A-289 Haruvit (sample)** **NISP**	**%**
Domestic								
Sheep/goat	32	55	216	77	9	5	220	39
Cattle	7	12	37	13	-	-	90	16
Pig	-	-	10	4	2	1	18	3
Donkey	13	22	-	-	-	-	-	-
Equid sp.	5	9	-	-	-	-	-	-
Camel	1	2	-	-	-	-	-	-
Wild								
Gazelle	-	-	1	0.5	-	-	-	-
Bird	-	-	1	0.5	-	-	-	-
Rodent	-	-	3	1	-	-	3	0.5
Fish	-	-	11	4	187	94	238	41.5
Total Id	**58**	**100**	**279**	**100**	**198**	**100**	**569**	**100**
Total Non-id	**30**		**220**		**4**		**142**	

Table 5.2a: Skeletal element representation at New Kingdom sites studied here (NISP counts)
dist. = distal; prox. = proximal; vertb.= vertebra

Sites	**A-343**		**A-345**		**BEA-10**	**A-289**	
Bone element/ Species	**Sheep/Goat**	**Equid**	**Sheep/Goat**	**Cattle**	**Sheep/Goat**	**Sheep/Goat**	**Cattle**
Horncore			7			9	
Skull	2	1	11	2	1	9	5
Upper teeth	5	4	15	1	1	15	4
Lower jaw	3	6	6	1		5	3
Lower teeth	1		5	1		7	
TOTAL CRANIA	**11**	**11**	**44**	**5**	**2**	**45**	**12**
Atlas						1	
Axis			1			2	
Rib prox.			3			4	5
Rib frags.	2	1	34	10	1	37	26
Cervical vertb.			3			3	
Thoracic vertb.			9	2		13	1
Lumbar vertb.			10	1		3	1
Caudal vertb.							2
Vertebrae			9	2		12	3
TOTAL TRUNK	**2**	**1**	**69**	**15**	**1**	**75**	**38**
Scapula dist.			2	1	1	3	2
Scapula blade	1		4			3	
Humerus prox.			2			3	
Humerus shaft	1		10			10	2
Humerus dist.	1		7			8	
Radius prox.	1						
Radius dist.		1					
Radius shaft	2		6			6	
Ulna prox.		1	2			2	
Metacarpal prox.	1						
Metacarpal dist.	1			1			3
Metacarpal shaft	2		1			1	
Carpals		1	3	3		3	5
TOTAL FORELIMB	**10**	**3**	**37**	**5**	**1**	**39**	**12**

Table 5.2a: Skeletal element representation at New Kingdom sites studied here (NISP counts) (continued….)

Sites	A-343		A-345		BEA-10	A-289	
Bone element/Species	**Sheep/Goat**	**Equid**	**Sheep/Goat**	**Cattle**	**Sheep/Goat**	**Sheep/Goat**	**Cattle**
Pelvis acetab.	1		5	1		6	3
Pelvis ilium			2	1		1	3
Femur shaft			3		1	2	2
Femur prox.			4			6	
Femur dist.			5			6	
Patella	1						
Tibia prox.			4			3	
Tibia dist.	1		4			3	
Tibia shaft		1	12			9	
Metatarsal prox.			5			2	2
Metatarsal shaft						1	
Metatarsal dist.				1			
Tarsals	1	1	2	1	1	2	3
Astragalus	2		2	1	1	2	3
Calcaneum			3		1	3	
TOTAL HINDLIMB	**6**	**2**	**51**	**5**	**4**	**46**	**16**
1st phalanx	1		8	4		9	7
2nd phalanx	2		7	1	1	5	2
3rd phalanx		1		2		1	3
TOTAL FEET	**3**	**1**	**15**	**7**	**1**	**15**	**12**
Total	**32**	**18**	**216**	**37**	**9**	**220**	**90**

Table 5.2b: % MAU (Minimum Animal Units) for sheep/goat remains from New Kingdom sites and the %MGUI (Modified General Utility Index) for sheep (after Binford 1978). Table based on data given in Table 5.2a . dist. = distal; prox. = proximal; vertb.= vertebrae

Sites **Bone element**	**A-343** **%MAU**	**A-345** **%MAU**	**A-289** **%MAU**	**SHEEP** **%MGUI**
Horncore		58.3	90	1.03
Atlas		0	20.0	18.68
Axis		16.6	40.0	18.68
Ribs	3.5	23.3	30.0	100.0
Cervical vertb.		10.0	12.0	55.33
Thoracic vertb.		10.0	20.0	46.49
Lumbar vertb.		26.6	10.0	38.90
Scapula dist.		16.6	30.0	45.0
Scapula blade	50.0	33.3	30.0	45.0
Humerus prox.		16.6	30.0	37.28
Humerus dist.	50.0	58.3	80.0	32.79
Radius prox.	50.0			24.30
Metacarpal prox.	50.0			10.11
Metacarpal dist.	50.0			8.45
Carpals		3.3	4.0	13.43
Pelvis acetab.	50.0	41.6	60.0	81.5
Pelvis ilium		16.6	10.0	81.5
Femur prox.		33.3	60.0	80.58
Femur dist.		41.6	60.0	80.58
Tibia prox.		33.3	30.0	51.99
Tibia dist.	50.0	33.3	30.0	37.70
Metatarsal prox.		41.6	20.0	15.77
Astragalus	100.0	16.6	20.0	23.08
Calcaneum		25.0	30.0	23.08
1st phalanx		16.6	22.0	8.22
2nd phalanx		13.3	12.0	8.22
3rd phalanx			2.0	8.22

Table 5.3: Sheep/goat bone fusion data for New Kingdom period sites
F= fused; UF = unfused; N = NISP

Sites	**A-343**			**A-345**			**A-289**		
Age Range (months)	**F N**	**UF N**	**% F**	**F N**	**UF N**	**% F**	**F N**	**UF N**	**% F**
0-12	2	2	50	8	1	89	8	1	89
12-24	2	3	40	9	6	60	9	6	60
24-36	-	-	-	3	4	43	4	5	44
36-42	-	-	-	5	6	45	5	8	38
Total	**4**	**5**		**25**	**17**		**26**	**20**	

Bones included in age classes for sheep/goat (dist. = distal, prox. = proximal):
0-12 months = scapula, dist. humerus, prox. radius.
12-24 months = prox. phalanges; dist. tibia, dist. metapodia.
24-36 months = prox. ulna; prox. femur, calcaneum.
36-42 months = prox. humerus, dist. radius; dist. femur, prox. tibia.

Table 5.4: Cattle bone fusion data for New Kingdom period sites
F= fused; UF = unfused; N = NISP

Sites	**A-345**			**A-289**		
Age Range (months)	**F N**	**UF N**	**% F**	**F N**	**UF N**	**% F**
0-12	0	1	0	2	2	50
12-24	3	4	43	2	5	28
24-36	-	-		0	2	0
36-42	-	-		-	-	
42-48	-	-		-	-	
Total	**3**	**5**		**4**	**9**	

Bones included in age classes for cattle (dist. = distal, prox. = proximal):
0-12 months = scapula, dist.
12-24 months = humerus, prox. radius; prox. phalanges.
24-36 months = dist. tibia, dist. metapodia..
24-36 months = prox. femur, calcaneum;.
36-42 months = prox. ulna; prox. humerus, dist. radius; dist. femur, prox. tibia.

Table 6.1: Faunal Remains from Kuntillet ‘Ajrud
X = each X indicates the number of loci in which material was present. Note- this does not represent the number of finds per locus.

Species	**This Paper Identified Material (NISP)**	**Hellwing List**
Domestic Sheep	1 almost complete skeleton	-
(*Ovis aries*)	1	
Domestic Goat (*Capra hircus*)	1	X
Sheep/Goat (*Ovis/Capra*)	3	X
Cattle (*Bos taurus*)	-	X
Dog (*Canis familiaris*)	-	XX
Rueppell’s Sand fox (*Vulpes rueppellii*)	1 almost skeleton & cranial remains	-
Cape Hare (*Lepus capensis*)	6	X
Rodentia		
Unidentified Rodent Species	1	X
House Mouse (*Mus musculus)*	-	X
Sundevall's jird (*Meriones crassus*)	5	XXX
Aves		
Ostrich (*Struthio* camelus)	-	X
Bird sp.	1 (feather)	
Reptilia		
Unidentified Snake Species	6	-
Unidentified Reptile Species	-	X
Pisces		
Unidentified Fish Species	-	XXXX
Nile Perch (*Lates niloticus)*	4	-
Grouper sp. (*Epinephelus* sp.)	1	-
Gilt-head Sea Bream (*Sparus auratus*)	2	-
Mollusca		
Glycymeris insubrica	-	X
Monetaria moneta	-	XXX
Stramonita haemastoma	-	X

Table 6.2: Measurements of *Vulpes* from Kuntillet ‘Ajrud and modern specimens of *Vulpes*
(all measurements in mm; as defined in von den Driesch 1976; modern samples comprise both sexes)

		Measurements			Measurement
	N specimens	lower M_1 length	lower M_1 breadth	N specimens	tibia distal breadth
Kuntillet ‘Ajrud	1	11.1	4.2	1	10.6
Vulpes vulpes (Red fox)	6	13.3	7.7	6	12.9
Vulpes rueppellii (Rueppell’s Sand fox)	1	13.2	4.8	1	11.3
Vulpes cana (Blanford’s fox)	2	8.8	3.9	1	11.5

Table 6.3: Comparison of Species Represented in Iron Age II Sites from the Desert Regions of the Southern Levant (data given as frequency of total identified remains)

Key to Table 3:

Data on Iron Age II Fortresses - Quseima 'The Aharoni Fortress' from Hellwing and Agiman (2000).
Qadesh Barnea, Ein Kadeis & Nahal Sirpad from Hakker-Orion (2004:Table1).
* In an earlier report in Cohen (1986: 399-400), the 3 bones from Ein Kadeis are identified as those of ibex while the 25 gazelle bones from Qadesh Barnea are split into 13 gazelle bones and 12 ibex bones. In the 1986 report, the gazelle species is identified as the dorcas gazelle.

Data on Iron Age II cultic sites - Horvat Qitmit from Horwitz and Raphael (1995), the temple at Tel Arad from Sade (1988) and podium adjacent to gate at Horvat 'Uza from Sade (1988). Data are summarised in Horwitz and Raphael (1995: Table 8.3).

Data on Iron II domestic sites – Tel Arad VI-XI, Uza Strata 1-4 (Sade 1988) & Tel Ira from Sade (1988); Tawilan from Köhler-Rollefson (1995).
+ the function of the site of Tawilan, Southern Jordan is unclear – according to Köhler-Rollefson (1995) it may have been a seasonal agro-pastoral settlement, permanent agricultural village or administrative/trading center.
++ small ruminants include gazelle, roe deer and sheep and goat sized animals. However, according to Köhler-Rollefson (1995), the majority of these remains belong to sheep and goats such that the total sheep/goat frequency is probably in the 80% range.

Table 6.3: Comparison of species represented in Iron Age II Sites from the desert regions of the Southern Levant (data given as frequency % of total identified remains)

		Fortresses				**Cultic Sites**			**Domestic Sites**			
Species	**‘Ajrud**	**Quseima**	**Qadesh Barnea**	**Ein Kadeis**	**Nahal Sirpad**	**Horvat Qitmit**	**Horvat Uza**	**Tel Arad**	**Tawilan +**	**Tel Arad**	**Horvat Uza**	**Tel Ira**
Sheep/Goat (*Ovis/Capra*)	6	74	61	96.5	97	93	91	96	43	92	90	81
Small ruminant									40 ++	-	-	-
Cattle (*Bos taurus*)	X	4	3	2	0.5	7	7	4	9	7	6	12
Pig (*Sus scrofa*)	-		-	-	-	-	2	-	1	-	0.3	1
Ibex (*Capra ibex)*	-		-	-	-	-	-	-	-	0.1	0.3	-
Gazelle sp. (*Gazella* sp.)	-		10*	0.2*	-	-	-	-	1	-	1	0.5
Deer (Cervid sp.)	-		-	-	-	-	-	-	-	0.6	1	1
Equid sp. (*Equus* sp.)	-	7	-	-	0.5	-	-	-	1	0.2	-	-
Camel (*Camelus dromedarius*)	-		15.5	1	-	-	-	-	0.5	-	-	0.1
Large mammal	-		-	-	-	-	-	-	4.5	-	-	-
Unidentified Carnivores	-		-	-	-	-	-	-	-	-	-	0.2
Dog (*Canis familiaris*)	X		2	0.1	0.5	-	-	-		-	0.1	0.5
Rueppell’s Sand fox (*Vulpes rueppellii*)	1		-	-	-	-	-	-		-		
Cape Hare (*Lepus capensis*)	6		3	-	1	-	-	-		-	0.1	
Rodent sp.	6		-	0.2	-	-	-	-			1	
Bird sp.	1	15	5.5	-	0.5	-	-	-	*X*	0.1	0.1	2
Reptile sp.	6					-	-	-		-	-	
Fish	7					-	-	-		-	-	0.5
Total NISP	**(33)**	**27**	**251**	**1298**	**182**	**317**	**521**	**797**	**548**	**3083**	**4761**	**578**

Appendix A: List of Taxa at Kuntillet ‘Ajrud by Locus

Material from loci denoted by an asterisk * indicates material listed by Hellwing which was not re-examined

Locus	Taxon	Skeletal Element
8	fish- *Lates niloticus*	5th abdominal vertebra
13*	shell-*Glycymeris insubrica*	
14*	rodent-*Meriones crassus*	
	shell- *Monetaria moneta*	
	Fish	
16*	shell- *Monetaria moneta*	
	feathers	
	carnivore scats	
18	snake	vertebrae and ribs (with skin)
	rodent	1 femur
19*	hare	
	shell- *Monetaria moneta*	
	rodent-*Meriones crassus*	
	unidentified bone fragments	
41*	dog	1 phalanx
	unidentified hair	
50	rodent-*Mus musculus**	
	rodent-*Meriones crassus**	
	fish – *Sparus auratus*	1 left premaxilla
51	carnivore-*Vulpes rueppellii*	almost complete skeleton with: 2 cranial fragments, left maxilla, upper canine, left zygoma, left jaw with M1, right humerus, left pelvis, thoracic vertebra, 4 lumbar vertebrae, 3 caudal vertebrae, 4 ribs, 1st phalanx) and carnivore scats
	sheep-*Ovis aries*	1 horn sheath
	sheep- *Ovis aries*	almost complete post-cranial skeleton with: left & right scapula, left & right humerus, left & right ulna-radius, right pelvis, left distal tibia-unfused, left distal metatarsal-unfused., sacrum, cervical vertebra, axis
	sheep/goat	pair of scapula-unfused
	hare -*Lepus capensis*	3 distal tibia, 1 pelvis, 1 metapodial unfused
	rodent-*Meriones crassus*	occipital, 1 right jaw, 1 humerus, 1 tibia, 1 pelvis
	fish-unidentified*	pharyngeal teeth
	reptile*	scales
	bird	feathers
	unidentified hair*	-
65*	goat	1 femur
	bird	-
	hare	1 molar
67*	goat	
	sheep/goat	
68*	carnivore scats	
71*	unidentified bone fragments	
73*	rodent	
	bird	

80*	bird	feathers
81*	ostrich unidentified bone fragments	fragments of eggshell
90*	ivory fragment	
101*	feathers	
104*	Feathers carnivore scats fish	
153*	unidentified bone fragments	
162*	Fish	
251	fish – *Sparus auratus*. sheep/goat* unidentified bone fragments* shell-*Stramonita haemastoma**	1 left maxilla 1 rib
252*	Cattle unidentified bone fragments	
256*	Dog	
262	fish-*Lates niloticus*	4th and 6th abdominal vertebrae
264	fish - *Epinephelus* sp.	1 left dentale
266	fish- *Lates niloticus* unidentified bone fragments*	1 left neurocranial element
270*	unidentified bone fragments	

Table 7.1: List of faunal remains from the Gebel Serbal Sanctuary

Species	**Loci 2-4 NISP**	**Loci 8-9 NISP**	**Bone Totals**
Gazelle	1 left astragalus 1 left tarsal		2
Sheep/goat/ibex	1 astragalus 2 long bone shafts	1 left ascending ramus 1 femur shaft 1 tibia shafts 2 ribs	8
Chicken	1 left carpometacarpus 1 left ulna 1 rib.	1 whole left humerus 1 right distal humerus, 1 right and 1 left ulna 1 whole left carpometacarpus 1 left distal femur 1 left distal tibiotarsus	9
Total identified bones	8	11	19
Total unidentified fragments	12	39	51
Total Bones	20	50	70
Burnt Bones			
Identified burnt bones	2	3	
Unidentified burnt fragments	12	39	
Total Burnt	14	42	

Table 7.2: Galliformes remains from Gebel Serbal compared to modern taxa and archaeological specimens from the Southern Levant. Measurements in mm, taken after von den Driesch (1976).
N = NISP, X = mean.
1. Modern chukar partridge data from Southern Sinai (13 males M and 12 females F) from Nisani (1974)
2. Chukar partridge from Tel Hesban from von den Driesch and Boessneck (1995)
3. Mons Claudianus from Hamilton-Dyer (1997)
4. Tel Hesban data from Lindner (1979)

Bones	**Gebel Serbal**		**Chukar Partridge**[1]	**Chukar Partridge**[2]	**Mons Claudianus**[3]	**Tel Hesban**[3]	**Chicken**	
	Loc 3 (left)	**Loc 8 (left)**	**Modern**	**Tel Hesban**	**Roman Chicken**	**E. Roman**	**Roman**	**L. Roman**
Humerus	***Left***	***Right***	**X Mean**	**N X Range**	**N X Range**	**N X Range**	**N X Range**	**N X Range**
GL	-	58.6	25 50.3	7 50.0 47.2-53.5	6 71.0 55.5-86.0	2 66.5 66.3-66.8	3 66.6 63.8-70.3	1 64.1 -
Bp	-	14.2	-	9 14.1 13.2-14.6	3 20.0 15.0-23.5	3 17.0 16.2-17.8	3 17.4 16.7-18.2	2 17.1 16.3-17.9
SC	-	5.1	-	14 4.6 4.2-4.9	8 6.1 4.9-7.5	4 5.8 5.1- 6.5	3 6.0 5.5- 6.6	- - -
Bd	9.4	10.9	-	14 10.5 10.0-11.3	8 13.7 11.3-18.0	5 13.9 12.6-16.0	3 13.7 12.8-14.6	4 14.0 12.0-15.7
Ulna	***Left***	***Right***						
GL	50.4	(52.6)	25 47.7	4 49.5 46.5-52.5		1 72.9	2 68.0 65.1-71.0	9 68.6 60.0 79.5
Bd	3.8	4.4						
Bp	-	6.1		5 6.7 6.0-7.0				
Carpometacarpus								
GL	-	30.9	25 28.9	4 30.7 30.0-31.3		7 36.8 33.3-41.4		4 37.3 35.1-39.8
Bd	8.6	(7.6)						
Femur	***Left***							
Bd	11.5			6 10.9 10.2-11.6		6 15.5 14.1-17.1	2 13.8 13.3-14.3	6 14.2 12.8-16.1
Tibiotarsius	***Left***			**N Means for M/F**				
Bd	9.1		25 7.6	2 9.9/8.6				
SC	6.0			2 4.5/5.6	23 11.1 8.4-13.3	6 5.6 5.3-6.6	3 5.7 5.5-6.0	4 5.7 5.3-6.2

FIGURE 1.1: Satellite photograph of the Sinai Peninsula and surrounding regions

FIGURE 2.1: Satellite photograph showing the different regions of the Sinai Peninsula. **Features of Note**: dune fields in the north; drainage channels of Wadi el-Arish in the central region; the dividing valley between central & southern regions; high massif in the south and the broad sandy Plain of Qa at the southern end of the Gulf of Suez.

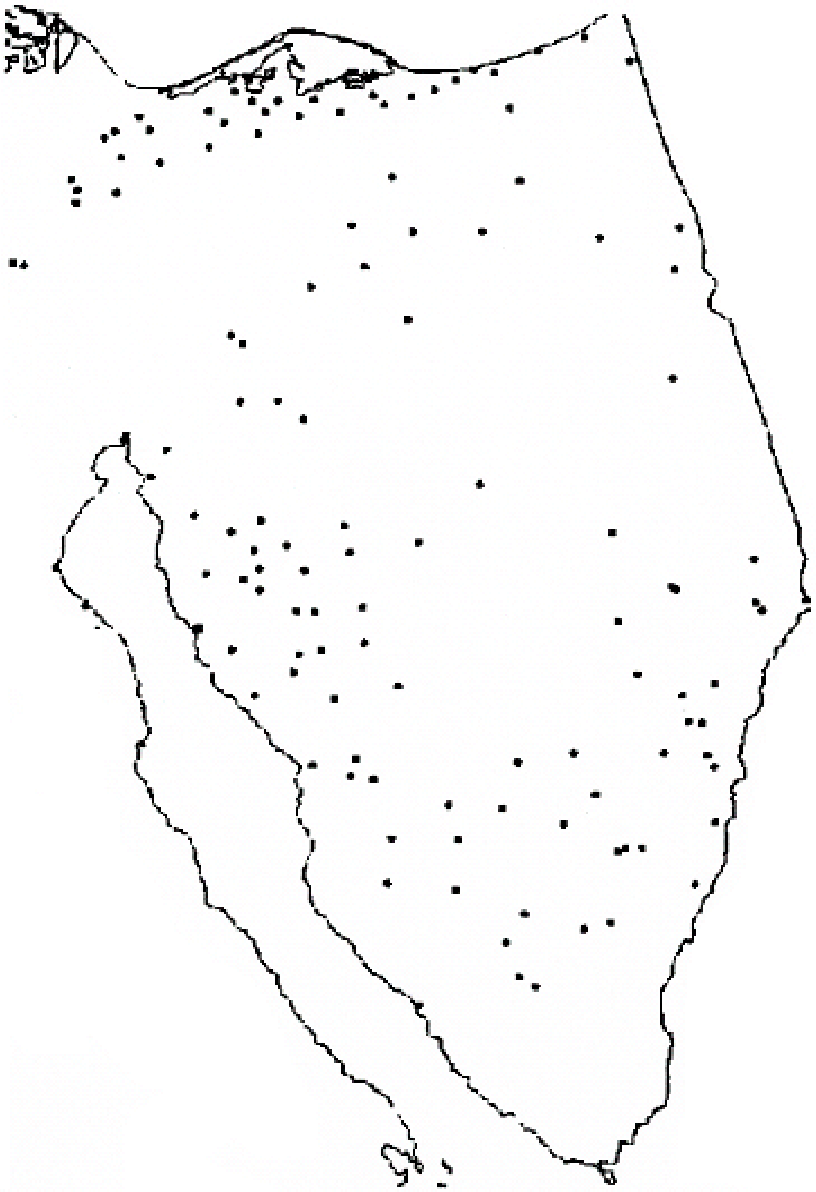
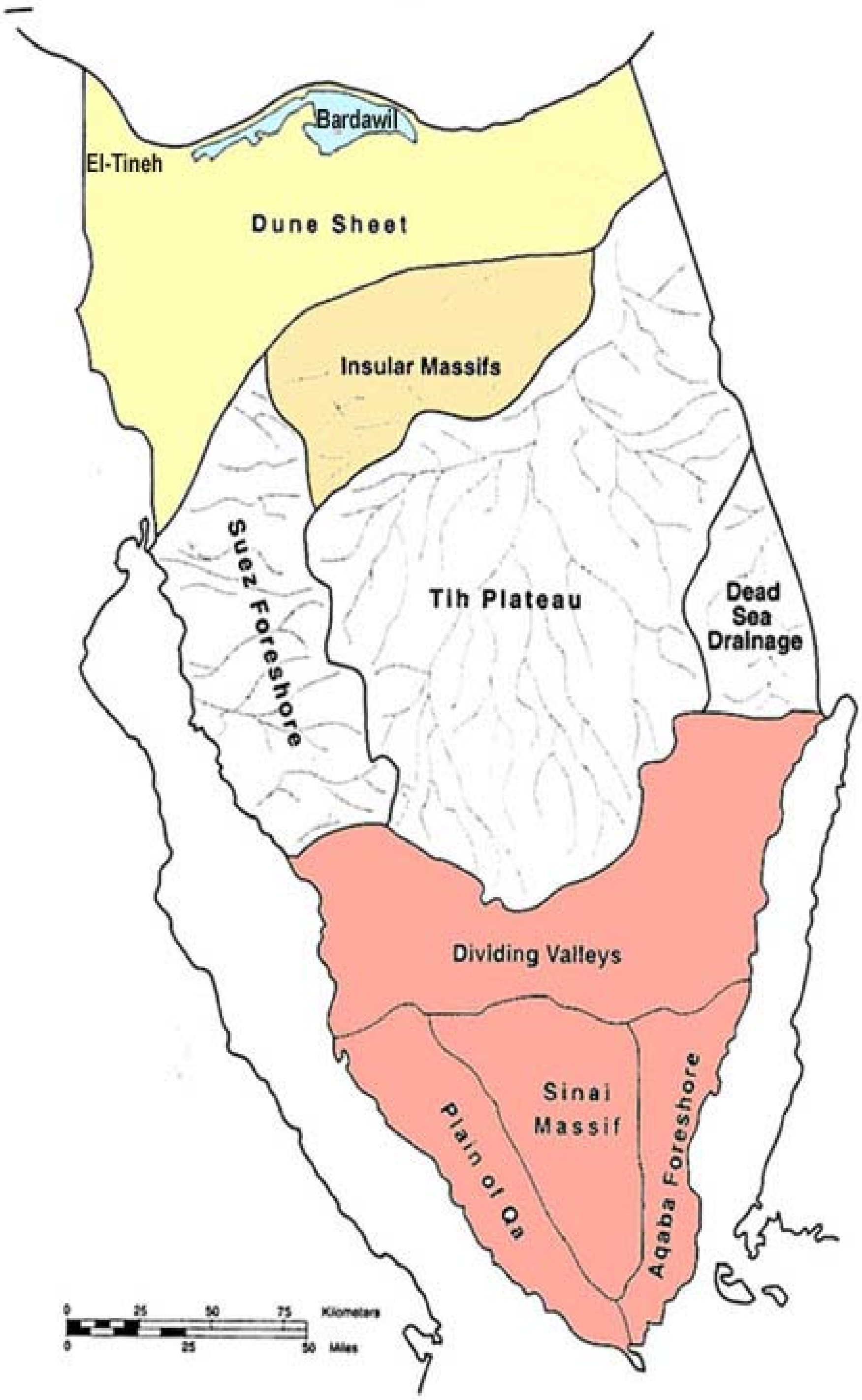


FIGURE 2.2: Location of water wells and springs in Sinai (after Abou Rayan et al. 2001)

FIGURE 2.3: Map of Sinai showing main geographic regions (after Greenwood 1997: Figure 3.1).



Yellow / Brown = northern Sinai; White = central Sinai; Pink = southern Sinai

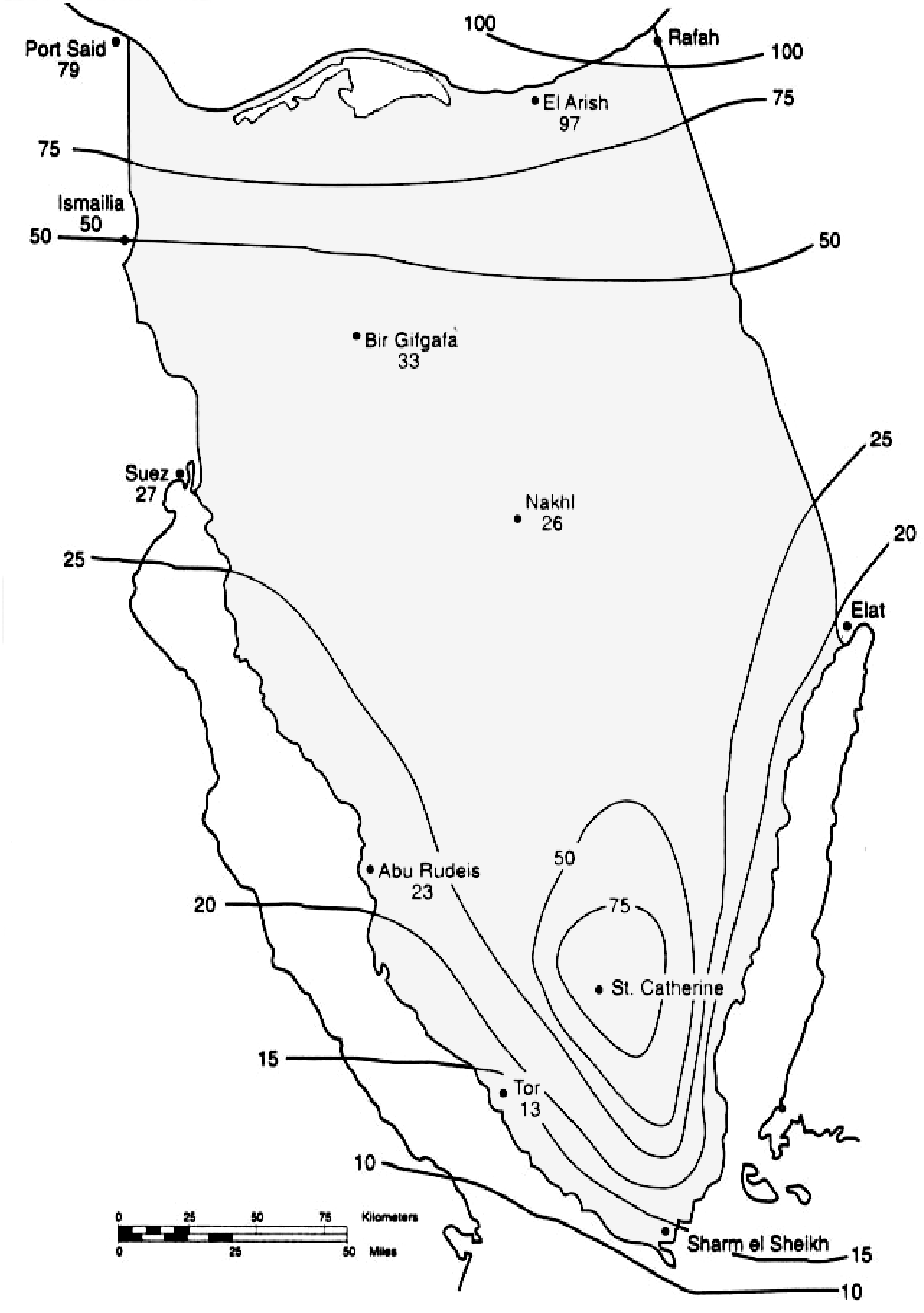


FIGURE 2.4: Mean annual rainfall in Sinai in mm (after Greenwood 1997: Figure 4.5)

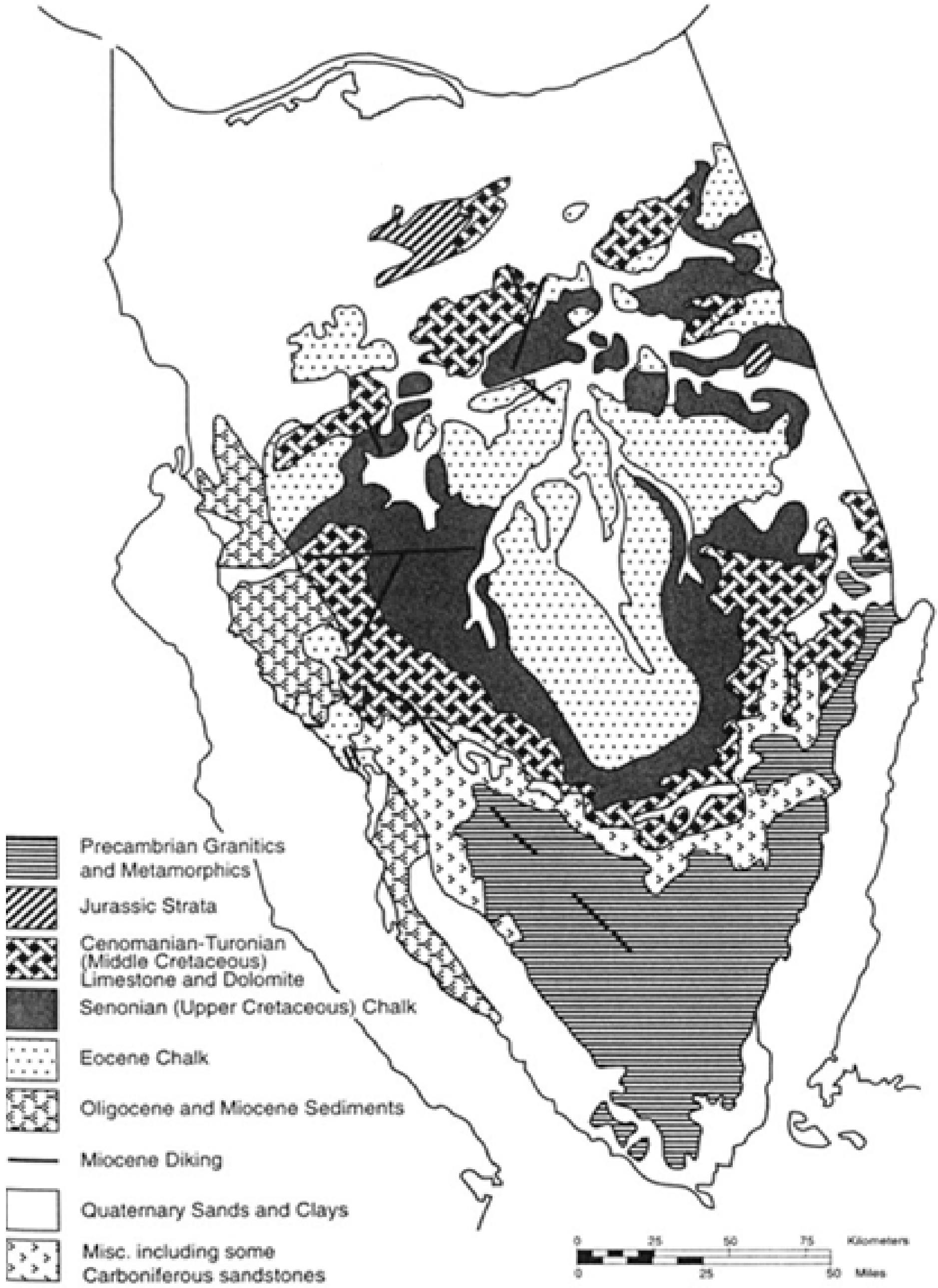


FIGURE 2.5:
Surface geology of Sinai (after Greenwood 1997: Figure 2.4)

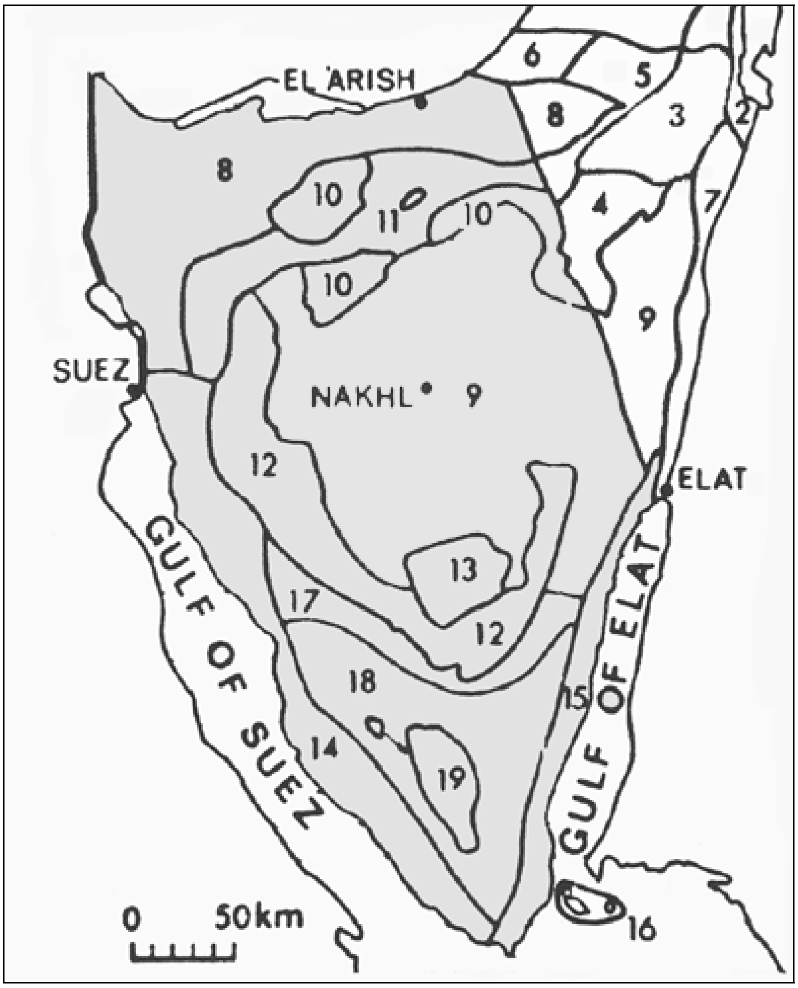


FIGURE 2.6: Vegetation of Sinai (after Danin 1983).

NORTH SINAI
8= Mediterranean sands and salt marshes
10= Transition zone between 8+9
11= Anticlines of north Sinai
CENTRAL SINAI
9= Gravelly plains of central Sinai
12= Table mountains of central and western Sinai
13= Jebel Egma
SOUTH SINAI
14= Gulf of Suez coastal plain (also part of central Sinai)
15= Gulf of Aqaba coastal plain and foothills (also part of central Sinai)
17= Sandstone belt
18= Lower Sinai massif
19= Upper Sinai massif

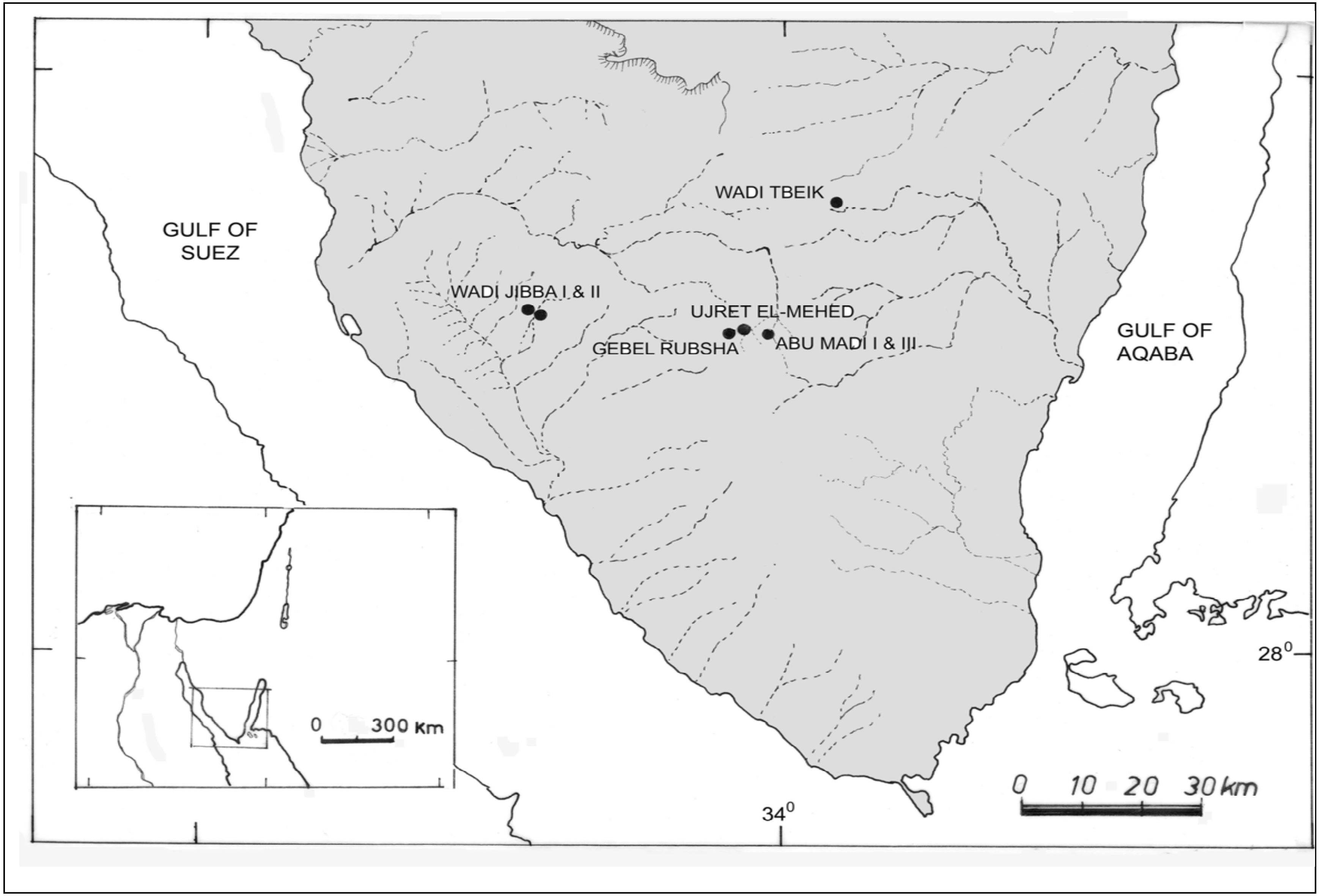
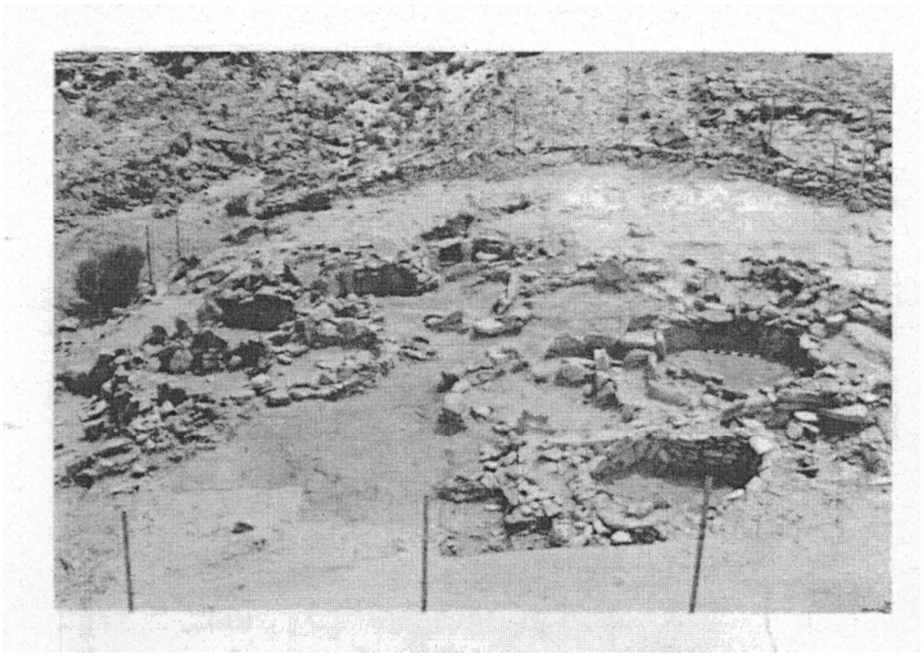


FIGURE 3.1: Map showing Neolithic sites in southern Sinai



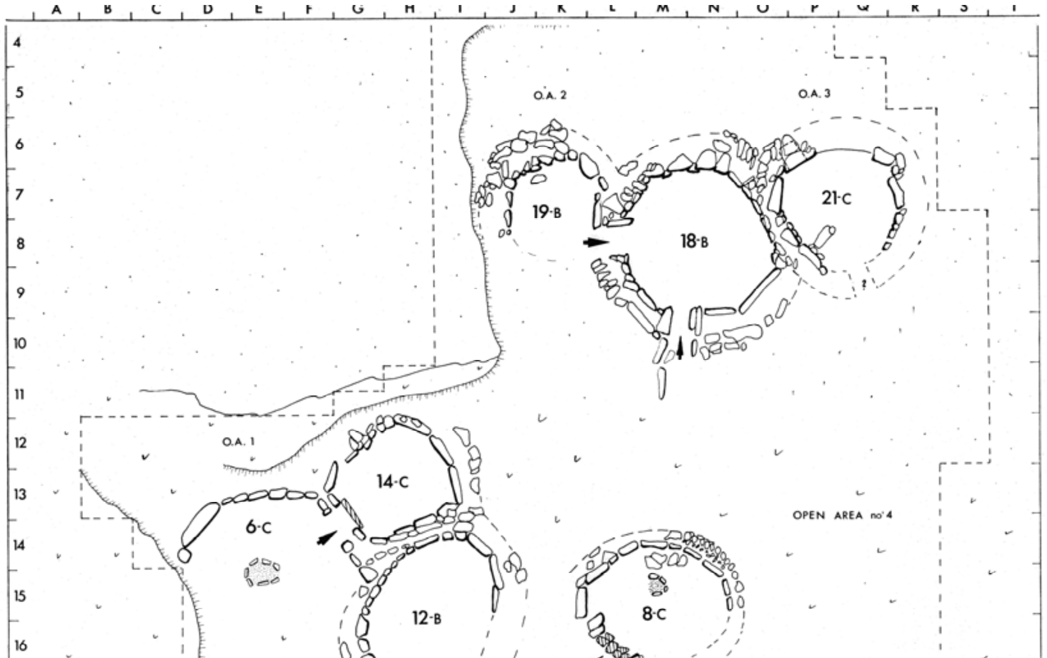
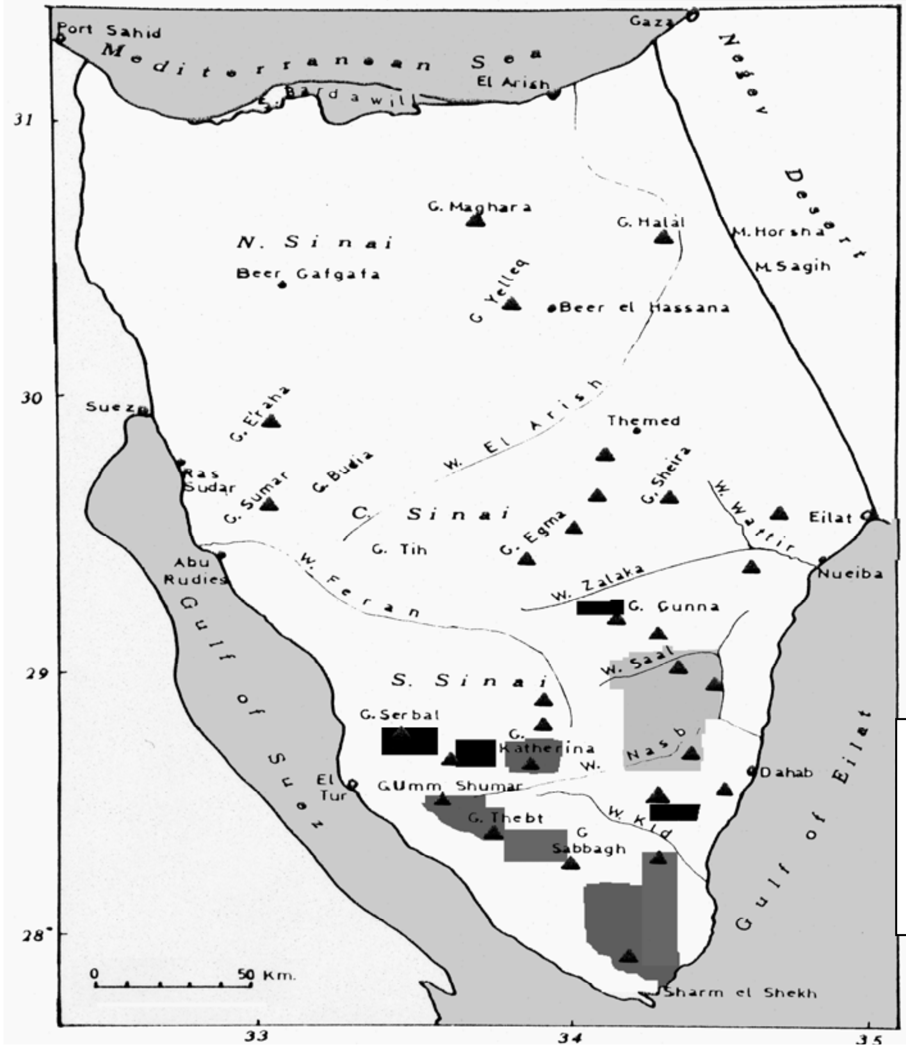


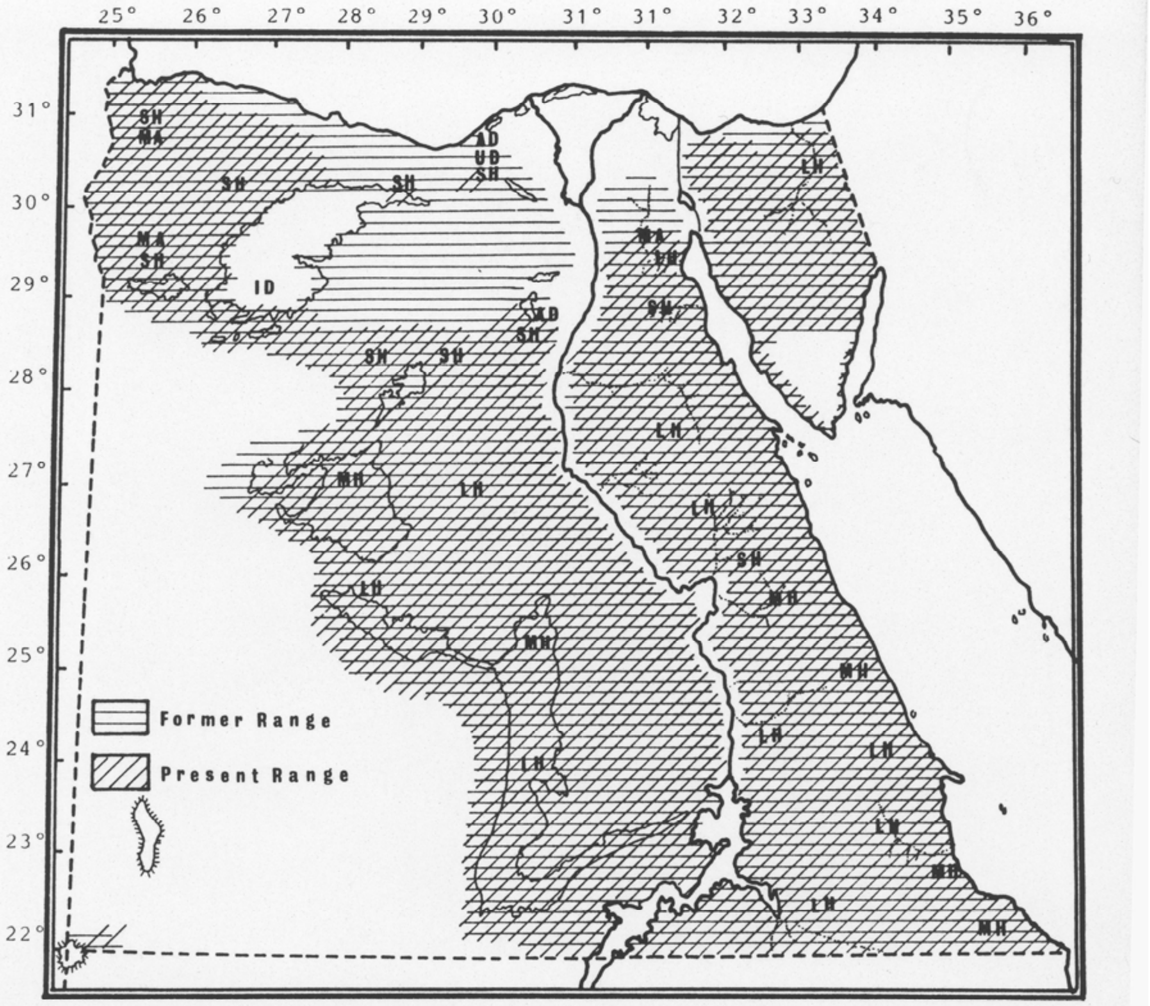
FIGURE 3.2: Plan of PPNB Wadi Tbeik (top) and a photograph of the same site (bottom) (after Bar-Yosef 1981b,c)

FIGURE 3.3: Distribution map of modern ibex in southern Sinai (based on Baharav and Meiboom 1981: Figs. 1 & 2)



No. Ibex
>50 (light grey)
25-50 (dark grey)
<25 (black)
triangle = sighting

FIGURE 3.4: Male ibex skull and horns from the PPNA site of Abu Madi I.



Present and former distribution of *Gazella dorcas* in Egypt (*G. d. dorcas* in the Western Desert, *G. d. littoralis* in the Eastern Desert and both subspecies in the Sinai), and human activities affecting its populations. AD, agricultural development; ID, industrial development; UD, urban development; MA, military activity; LH, limited hunting; MH, moderate hunting; and SH, severe hunting.

FIGURE 3.5: Historic distribution of dorcas gazelle (after Saleh 1987: Fig. 3). Note absence of gazelle in the high mountains of southern Sinai.

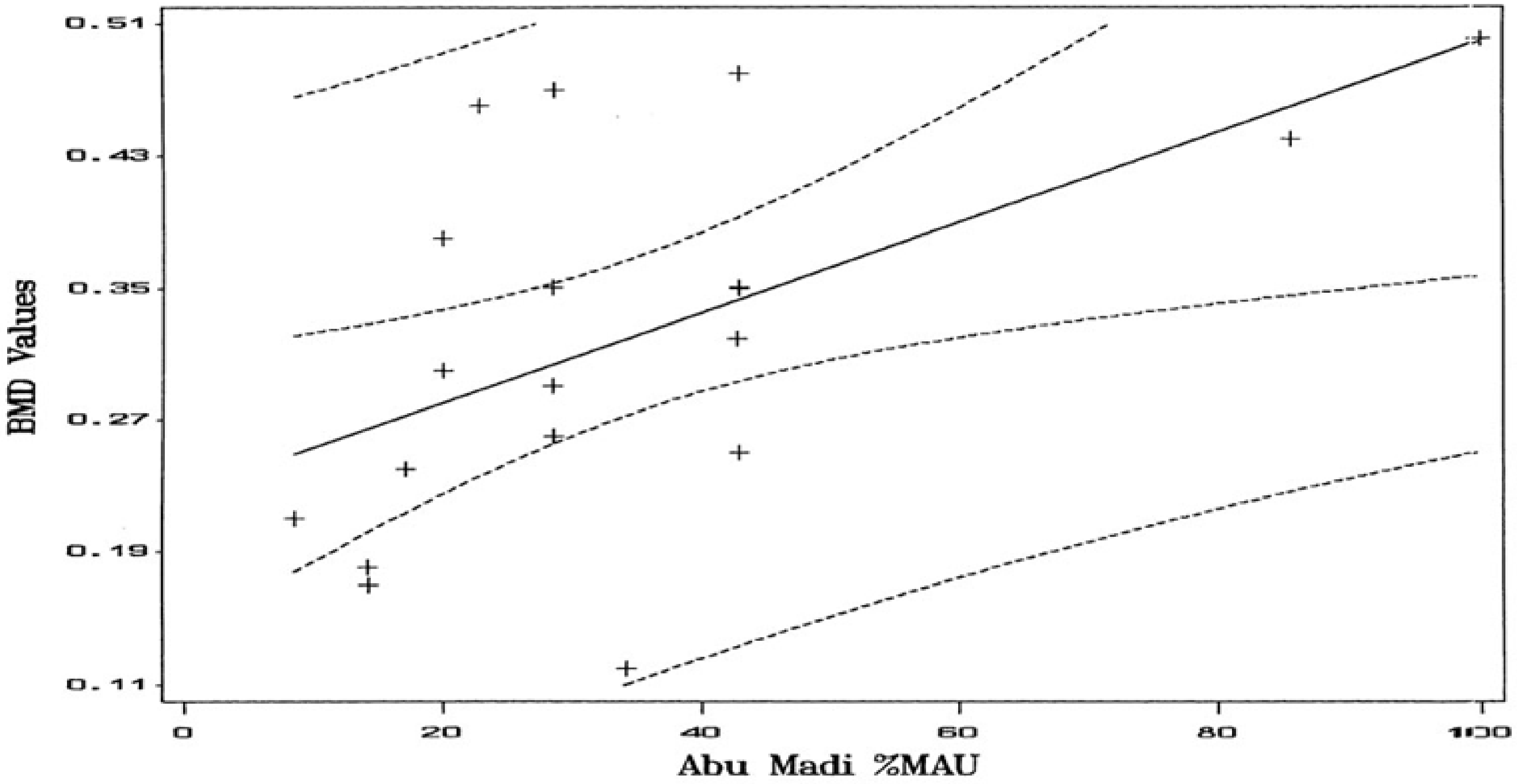


FIGURE 3.6: Bivariate plot showing regression line and 95% confidence limits for Bone Mineral Density values (BMD) of sheep against %MAU for goats from
(a) Abu Madi III

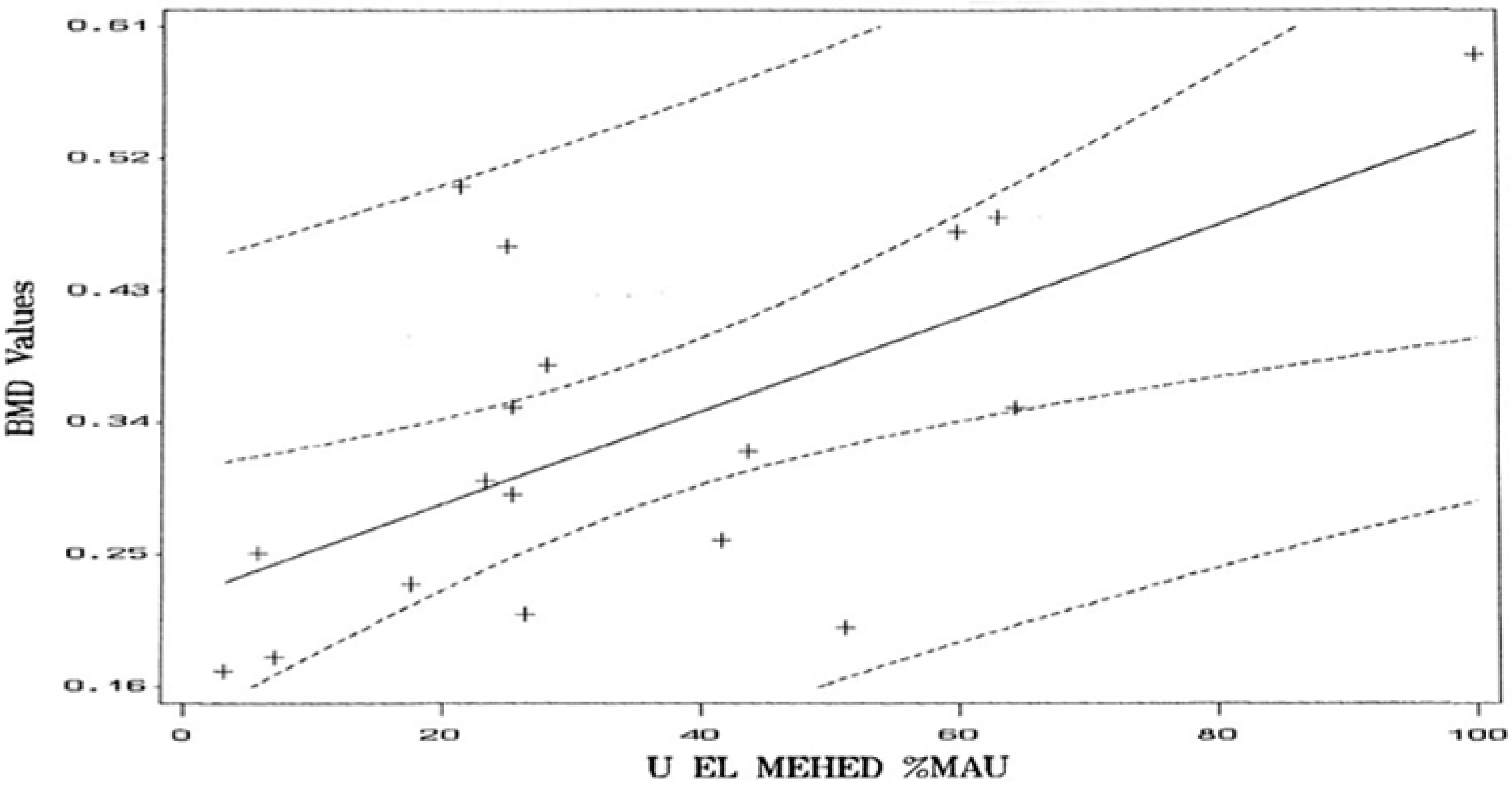


FIGURE 3.6: Bivariate plot showing regression line and 95% confidence limits for Bone Mineral Density values (BMD) of sheep against %MAU for goats from
(b) Ujret el-Mehed

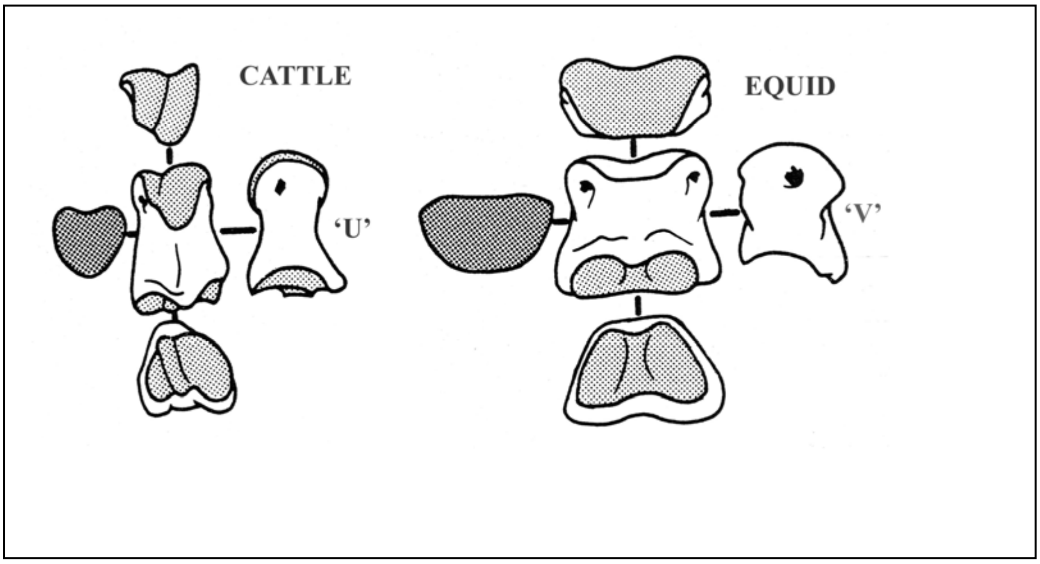
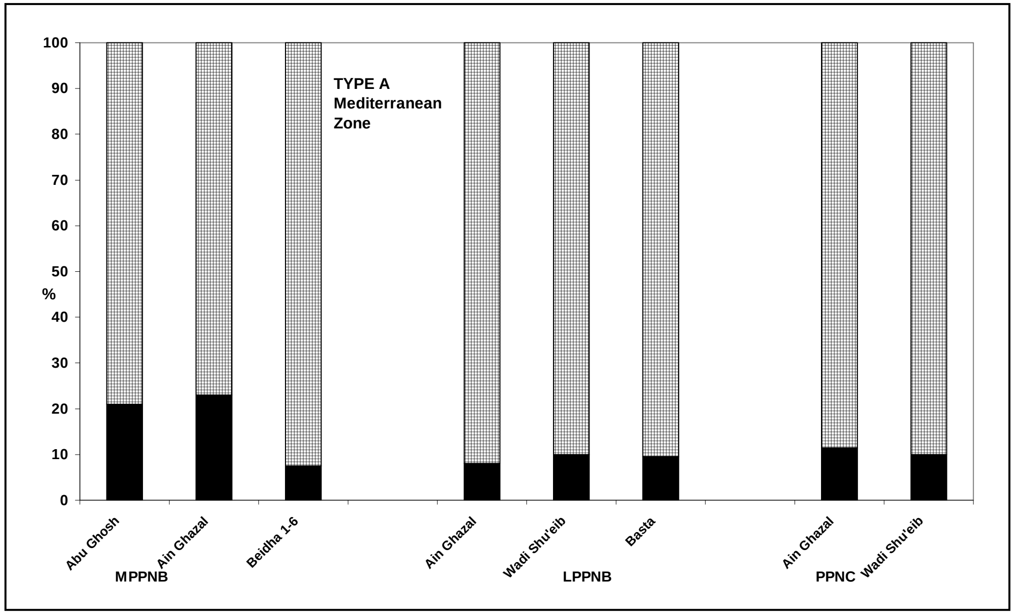


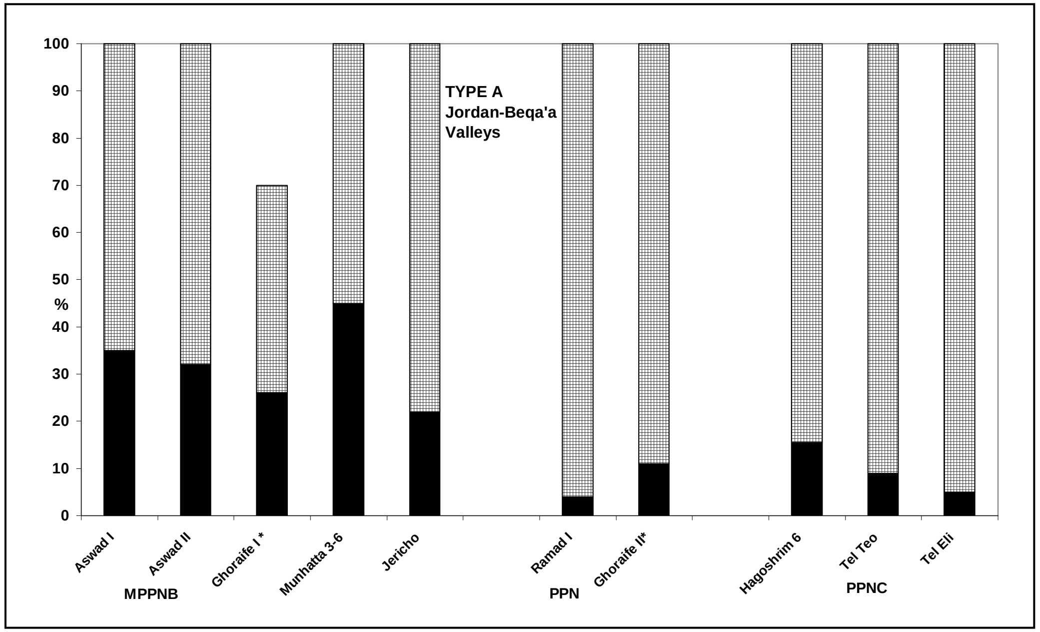
FIGURE 3.7: Abaxial view of 2nd phalanges
(top) Wadi Tbeik and (middle) Ujret el-Mehed compared to modern domestic donkey and cattle.
(bottom) drawing showing morphology of modern cattle and equid 2nd phalanges (after Hillson 1992)

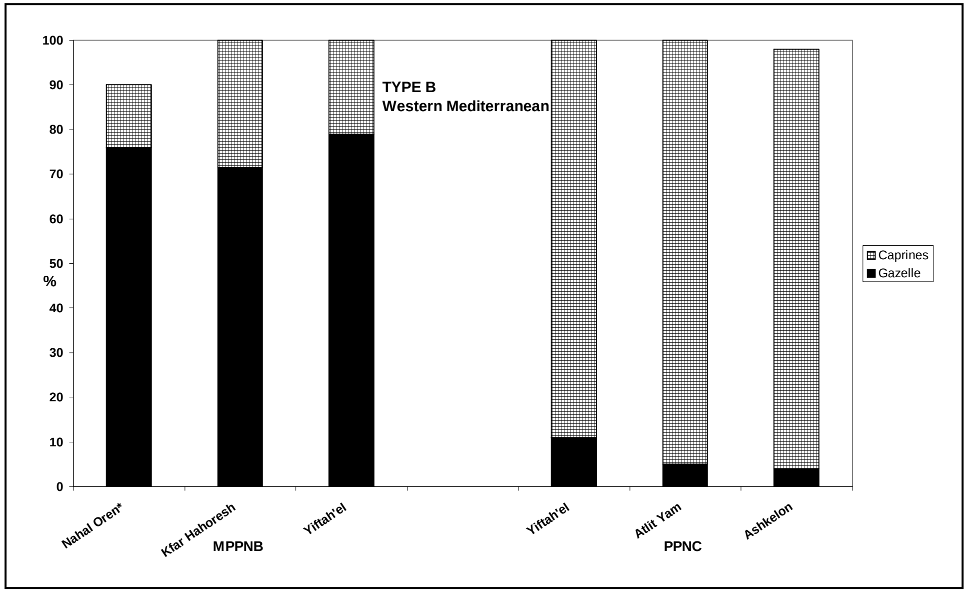
FIGURE 3.8: Histograms showing MPPNB to PPNC gazelle to caprine frequencies in southern Levantine sites by region.

Sites denoted by an asterisk are those for whom frequencies out of 100% could not be calculated.

(Data sets used are cited in Horwitz 1989, 1993, 1996, 2003b)

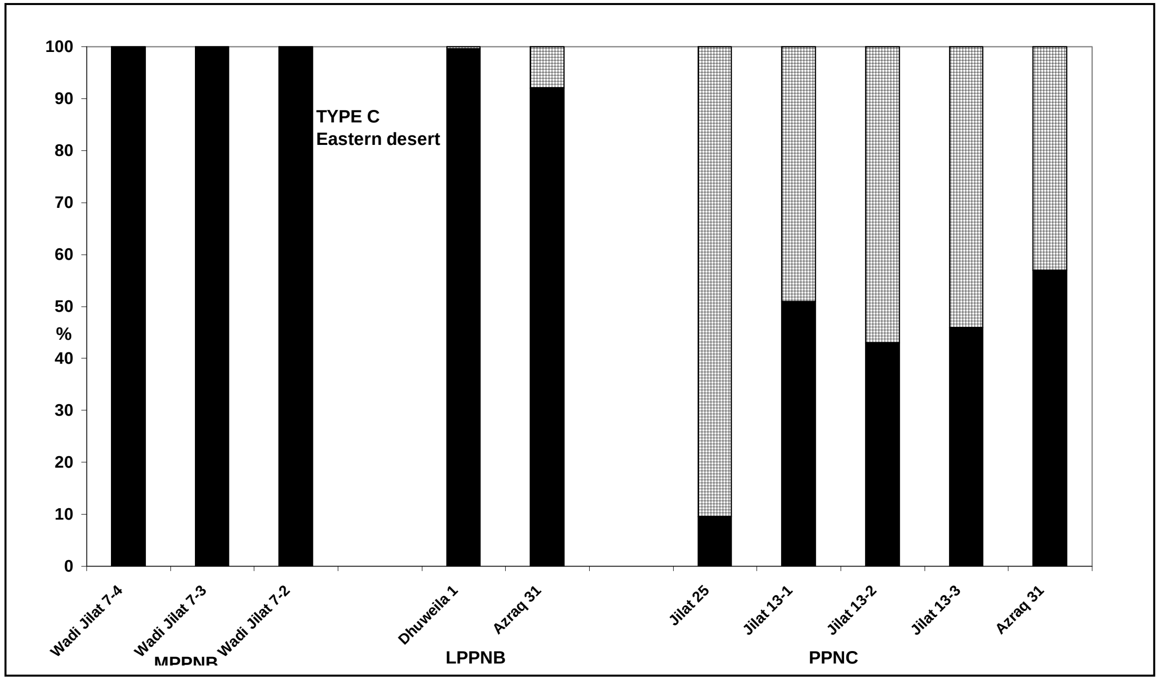






■ GAZELLE

▦ GOATS



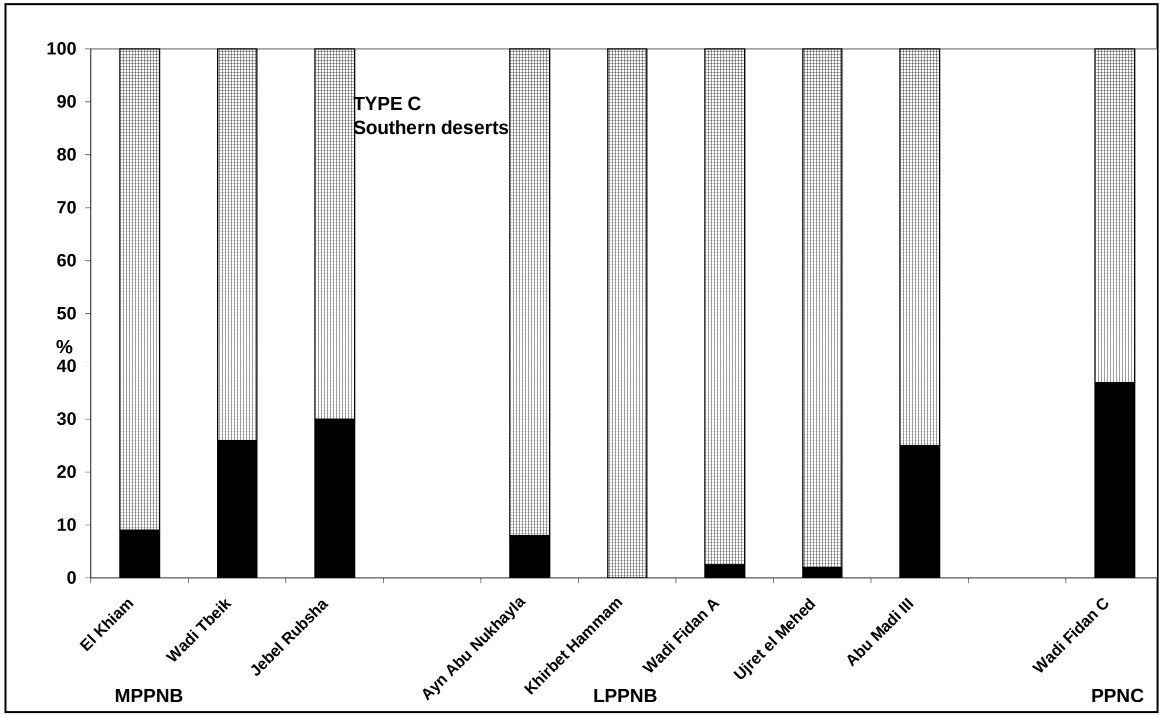


FIGURE 3.8 continued:

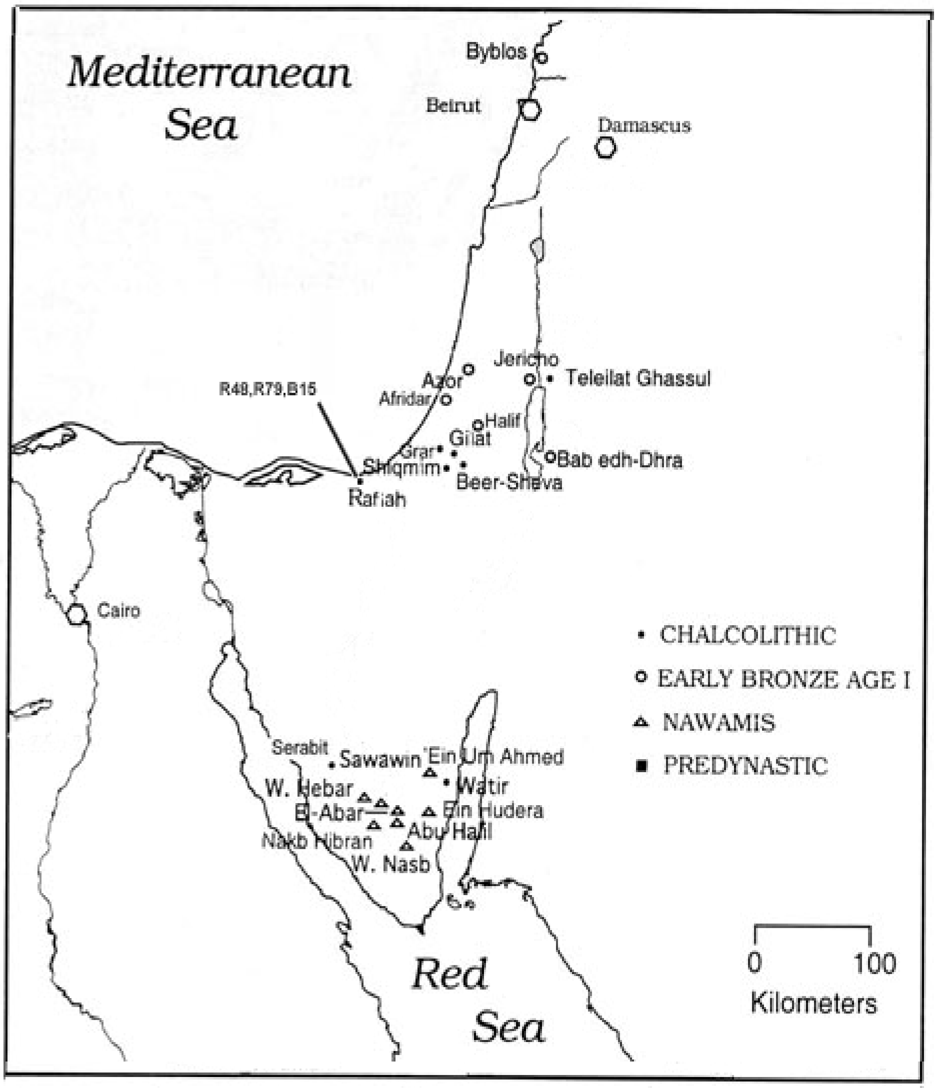
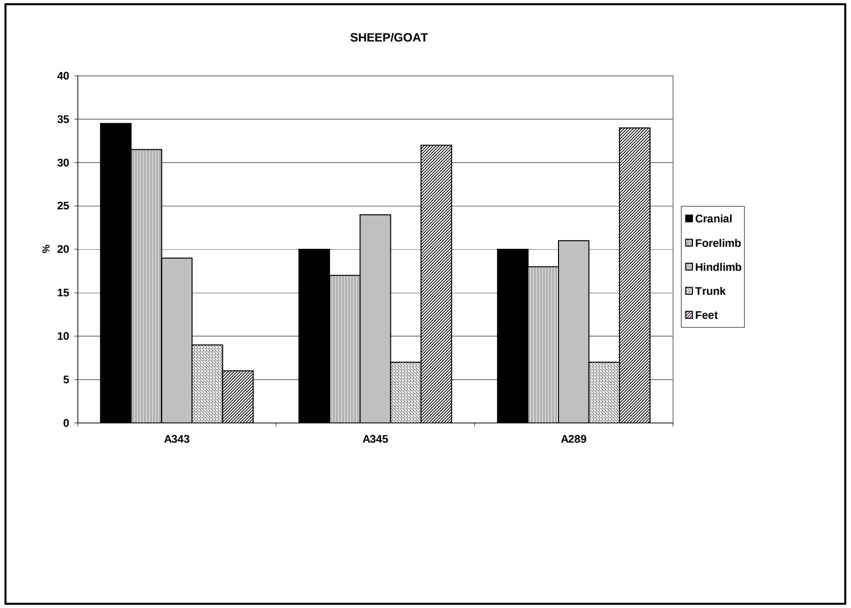
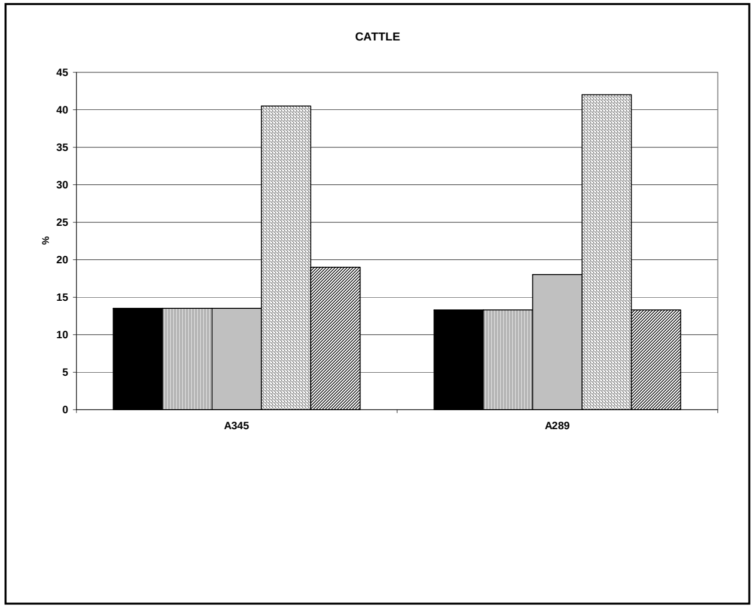


FIGURE 4.1: Map showing Chalcolithic and EBI sites mentioned in the text

FIGURE 4.2: Tumuli
Top-Bir Sawaneh tumulus
Bottom- Hadj I tumulus
(Photo U.Avner)

FIGURE 4.3: Shrines
Top- Wadi Daba'iyeh
Bottom-Wadi Sa'al
(Photo: U. Avner)





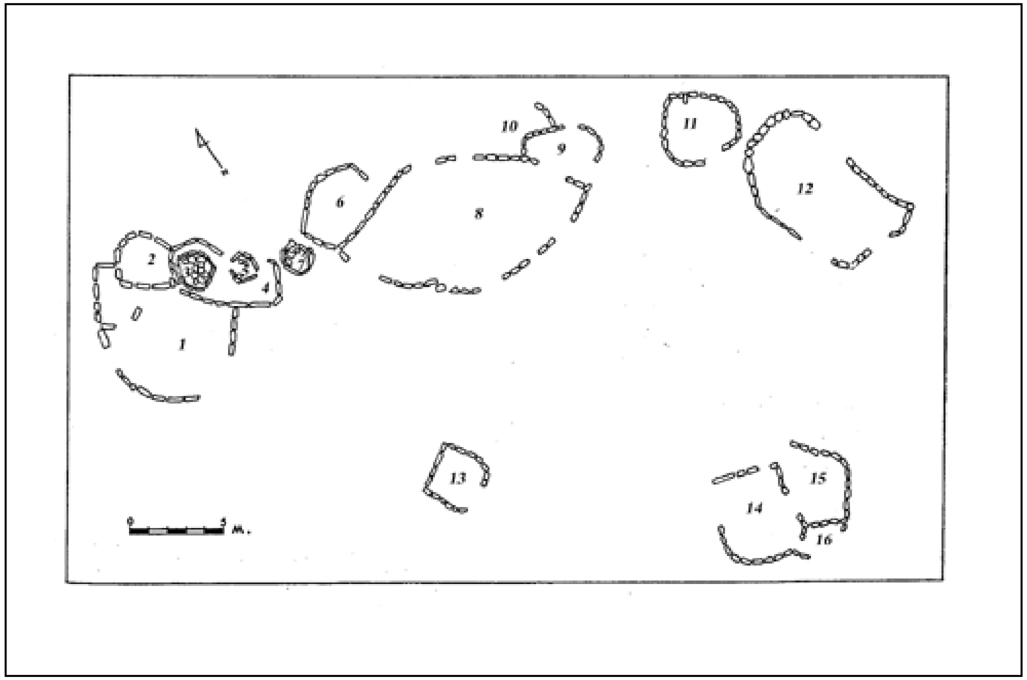
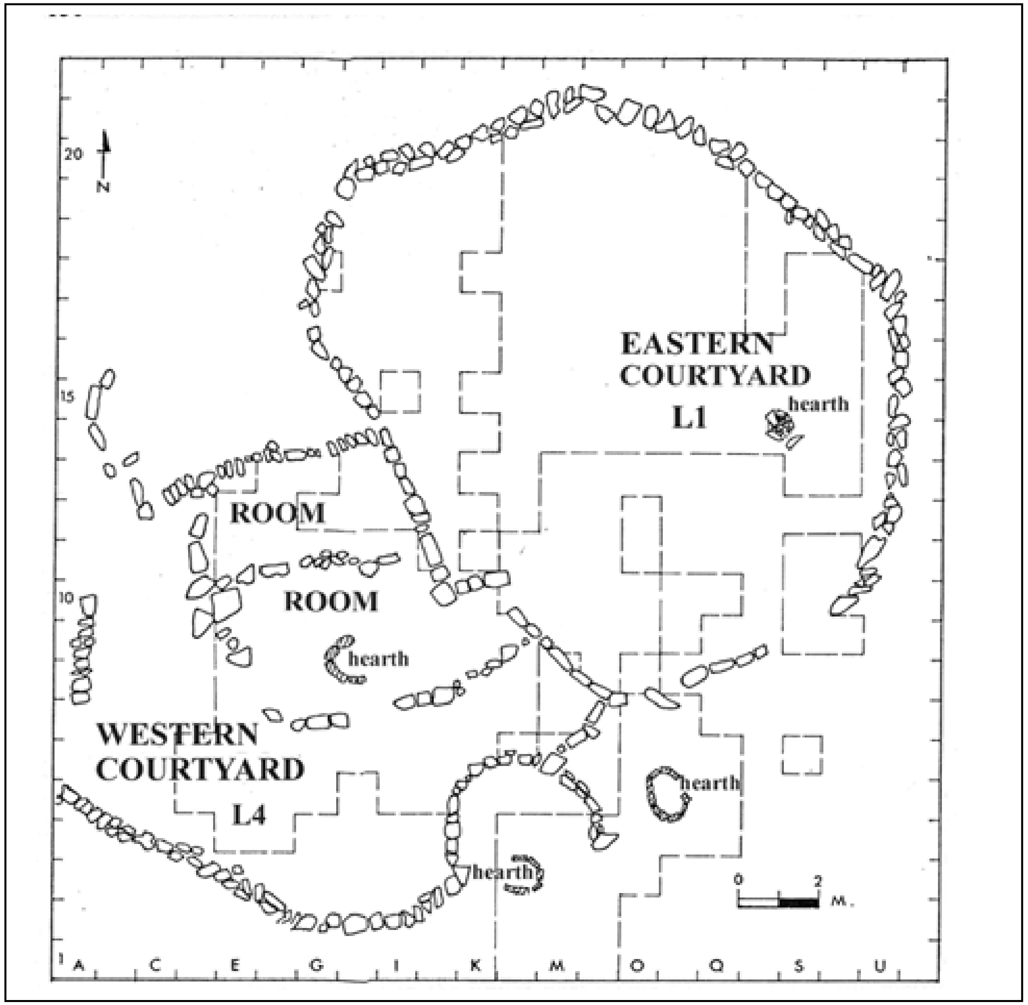


FIGURE 4.4: Plan of Gunna 25 showing different structures, and histograms showing frequencies of remains recovered.



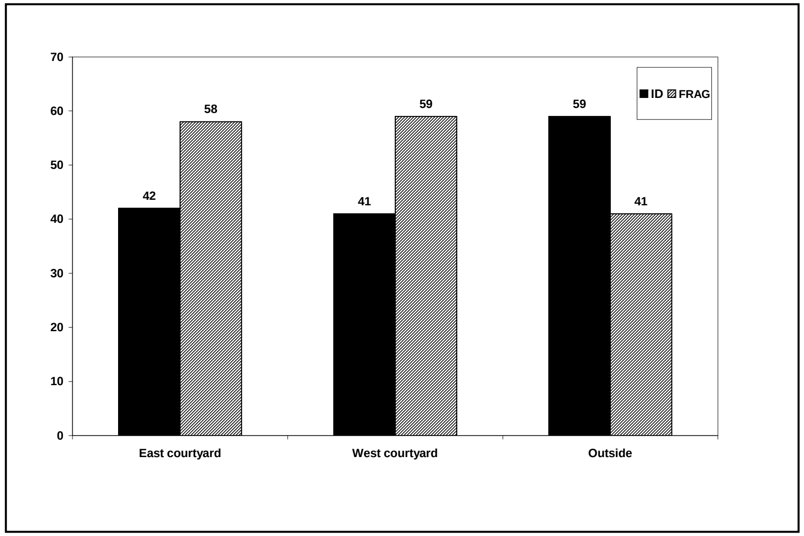
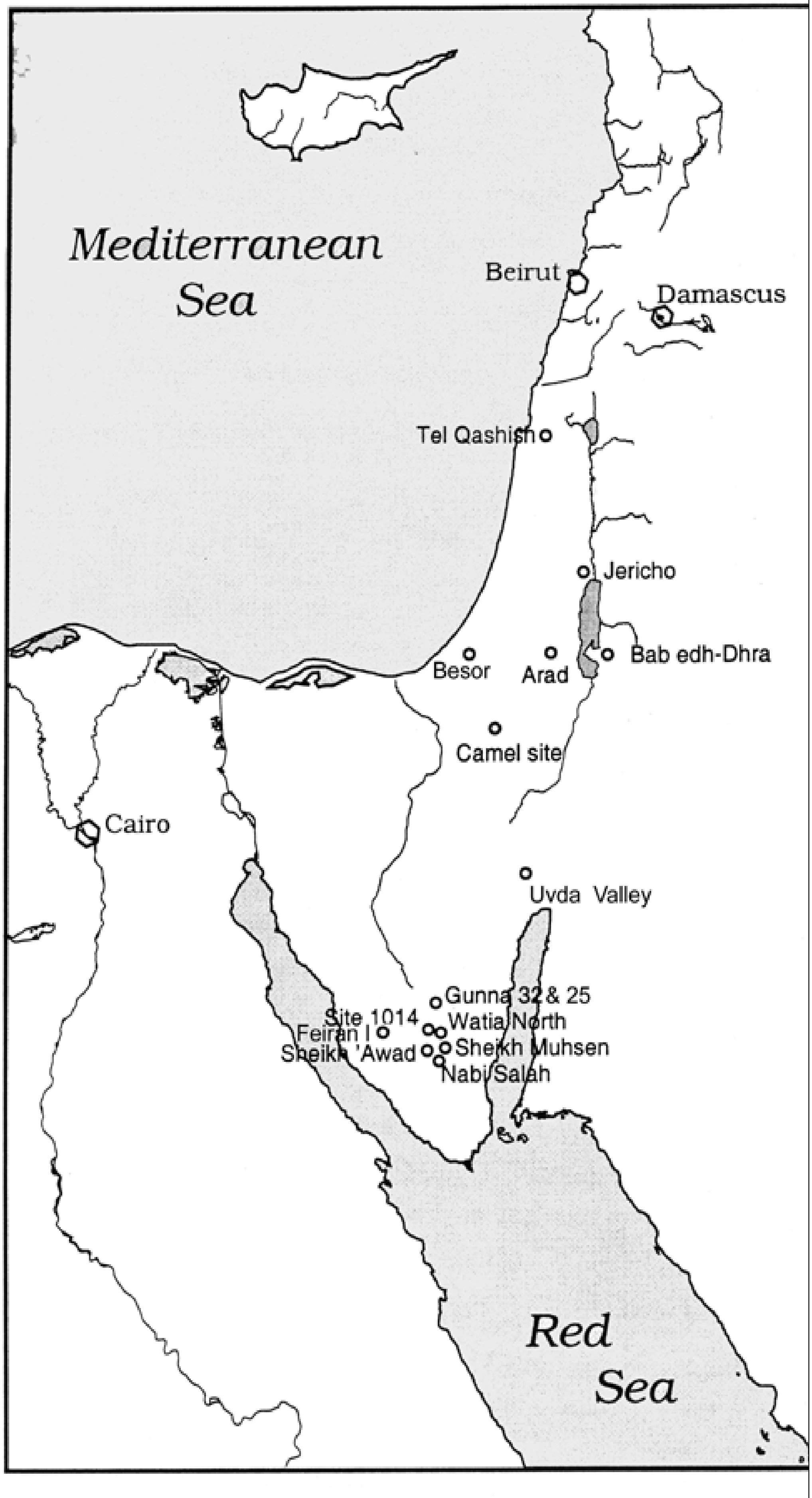
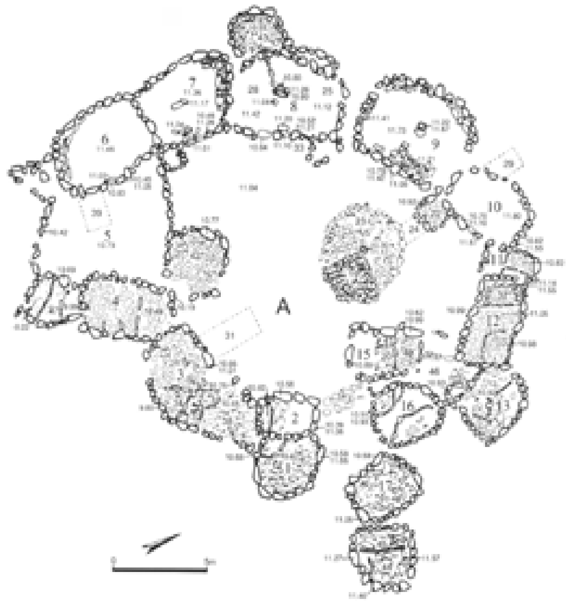


FIGURE 4.5: Plan of Gunna 50 showing different structures and histogram showing frequencies of remains recovered

FIGURE 4.6: EB II sites mentioned in the text





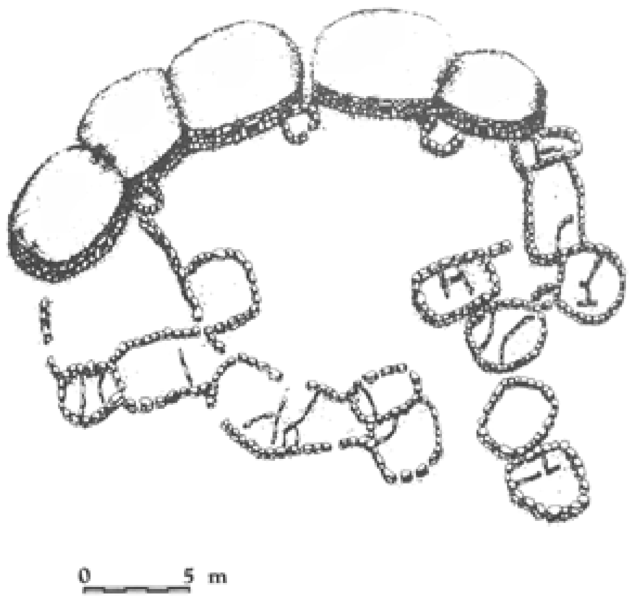


Fig. 4.7: Top – ground plan of Unit A at Nabi Salah
(after Beit-Arieh 2003a: Fig 2.4)

Bottom- Isometric reconstruction of Nabi Salah Unit A
(after Beir-Arieh 2003a: Fig. 3.6)

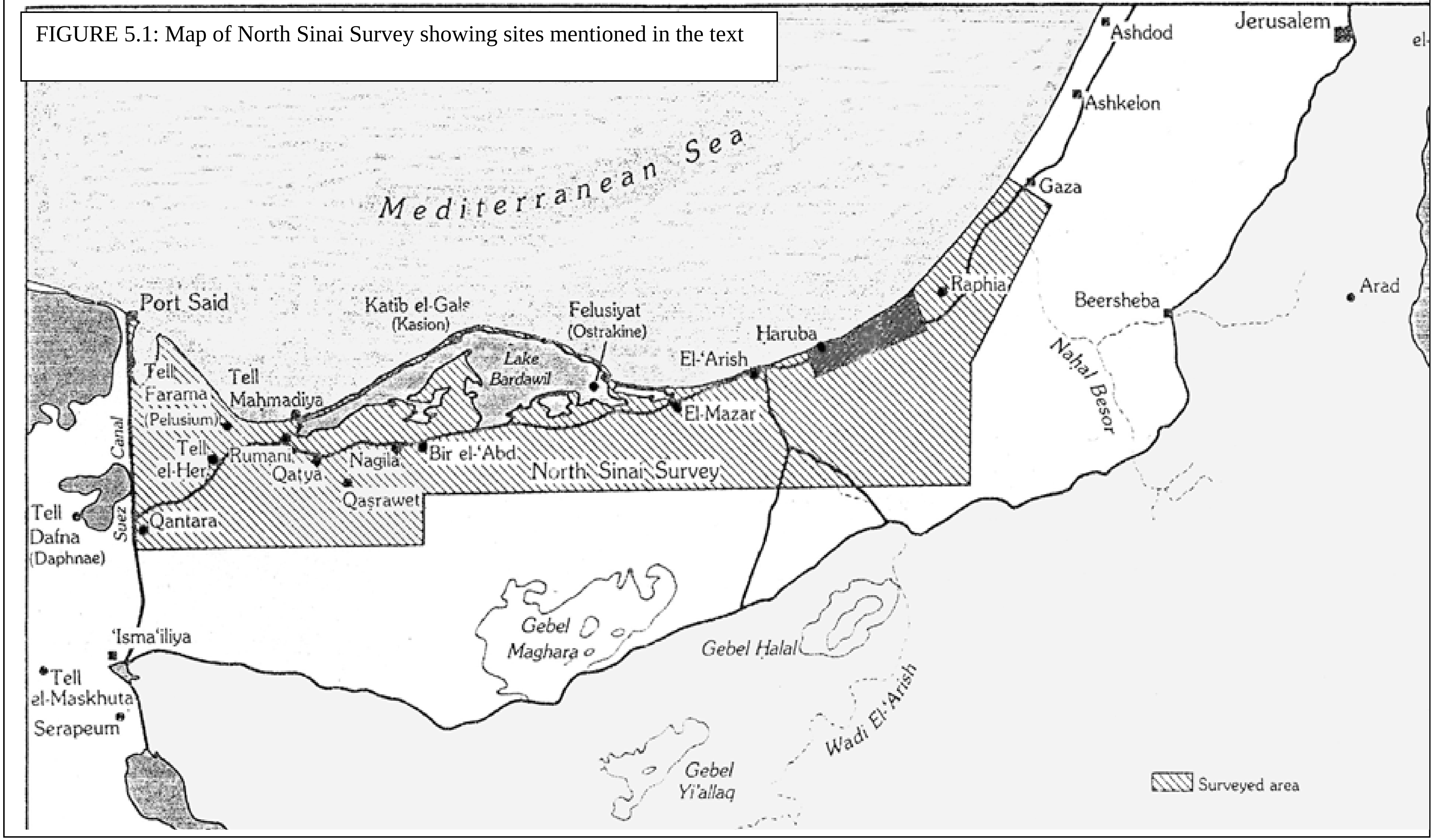
Fig 4.8: Goat horncores from Sheikh Muhsein

Left- domestic goat (*Capra hircus*); Right – ibex (*Capra ibex*)

Fig 4.9: Top – *Capra* 1st phalanges; Bottom-2nd phalanges from Sheikh Muhsein showing the presence of two size classes of goats

Fig 4.10: Two proximal metacarpals of leopard (*Panthera pardus*). Left- Sheikh Muhsein; Right – Modern comparative material

FIGURE 5.1: Map of North Sinai Survey showing sites mentioned in the text



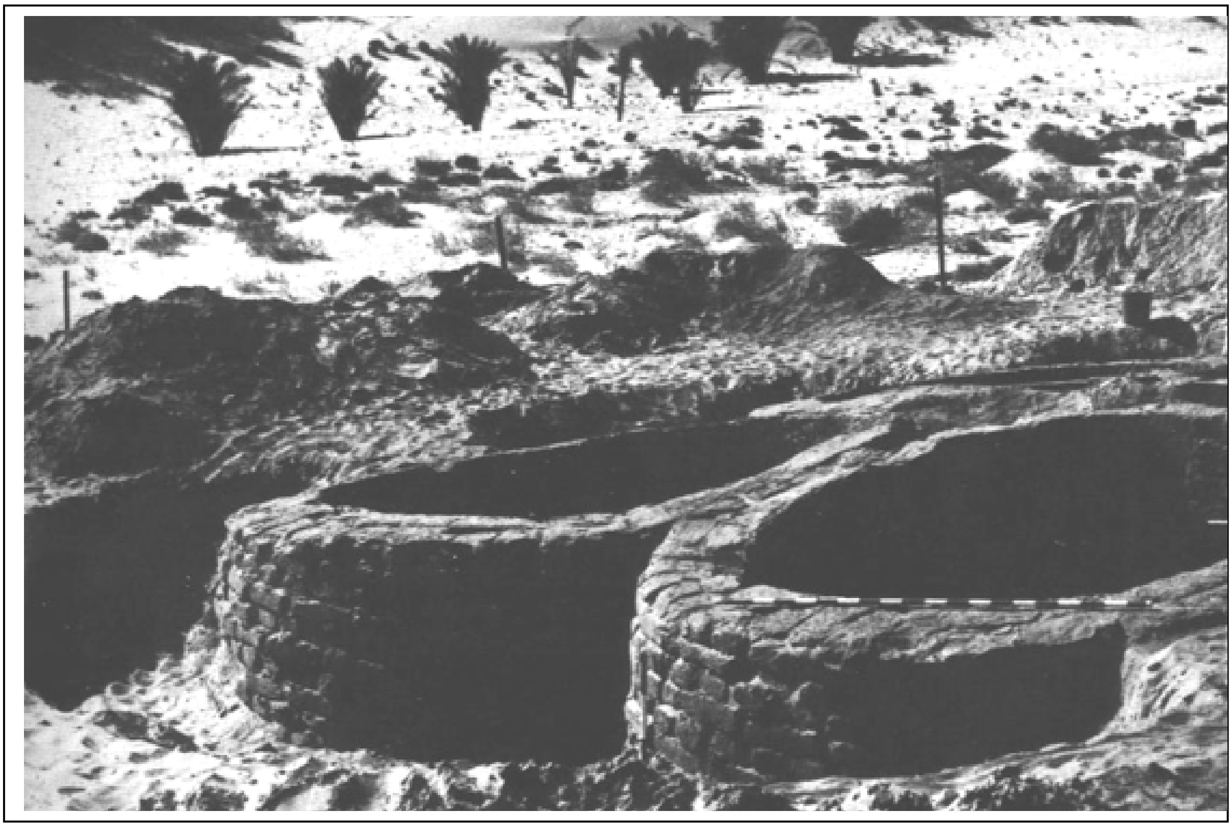
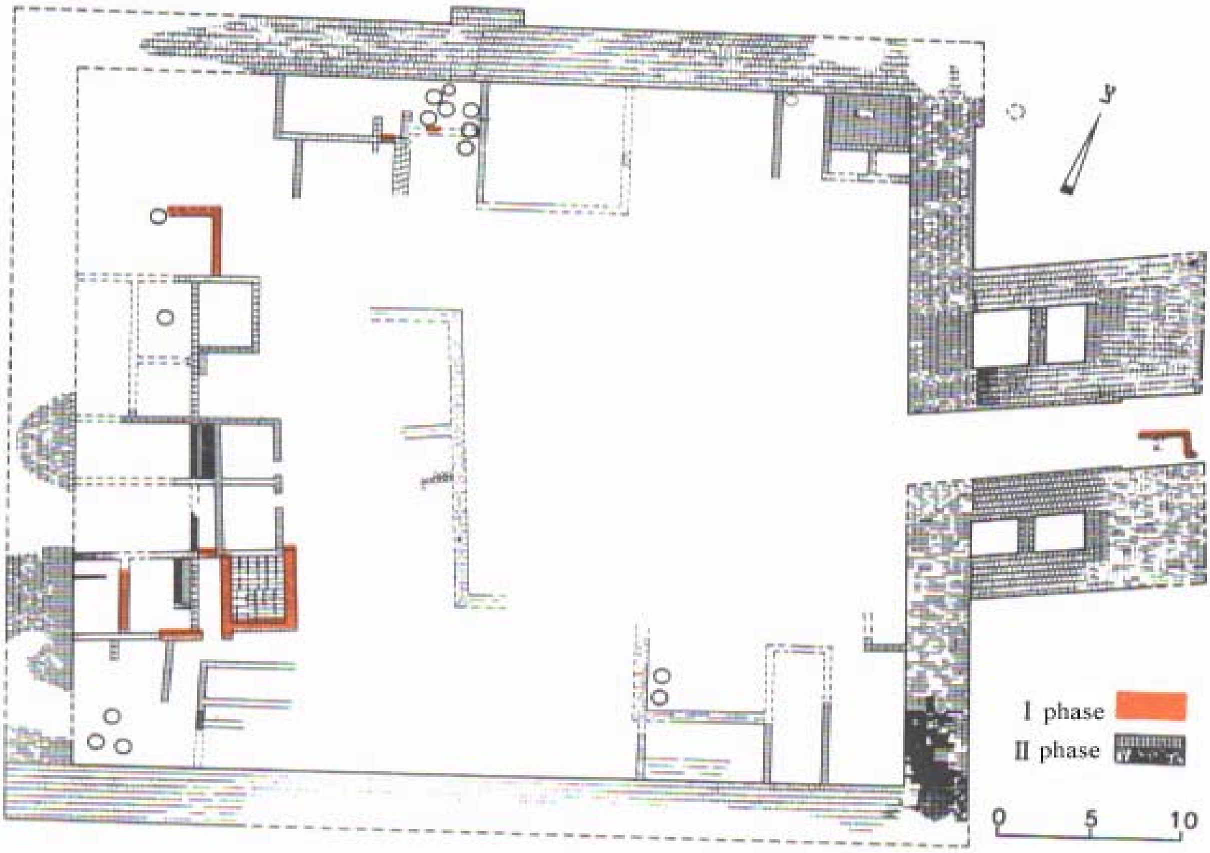
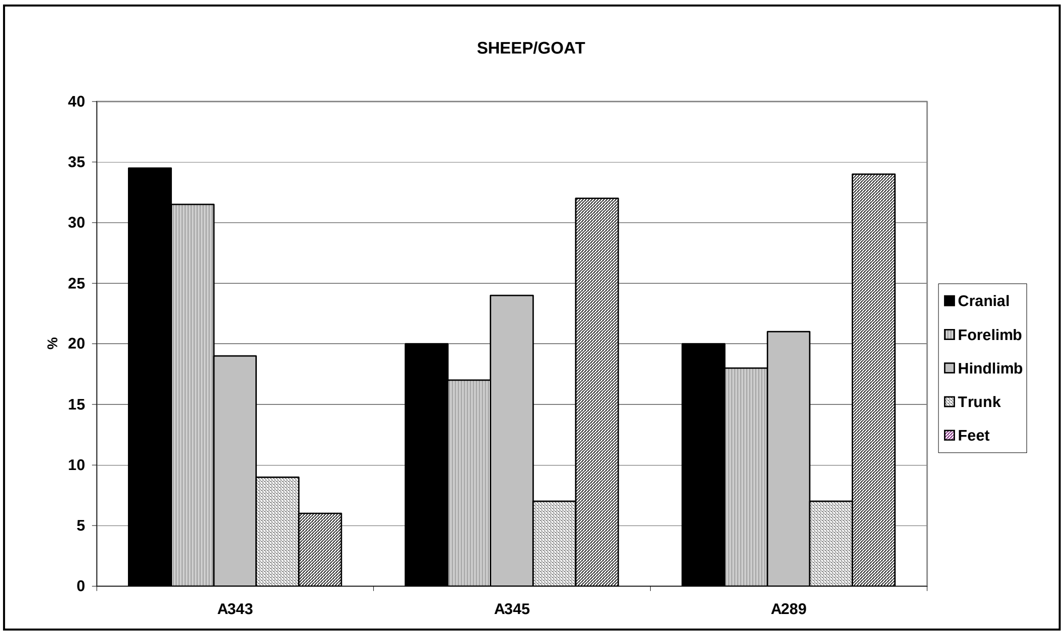


FIGURE 5.2: Above-Bir el Abd silos
Below-plan of A-289 (Haruvit)
(after Oren 1993a)





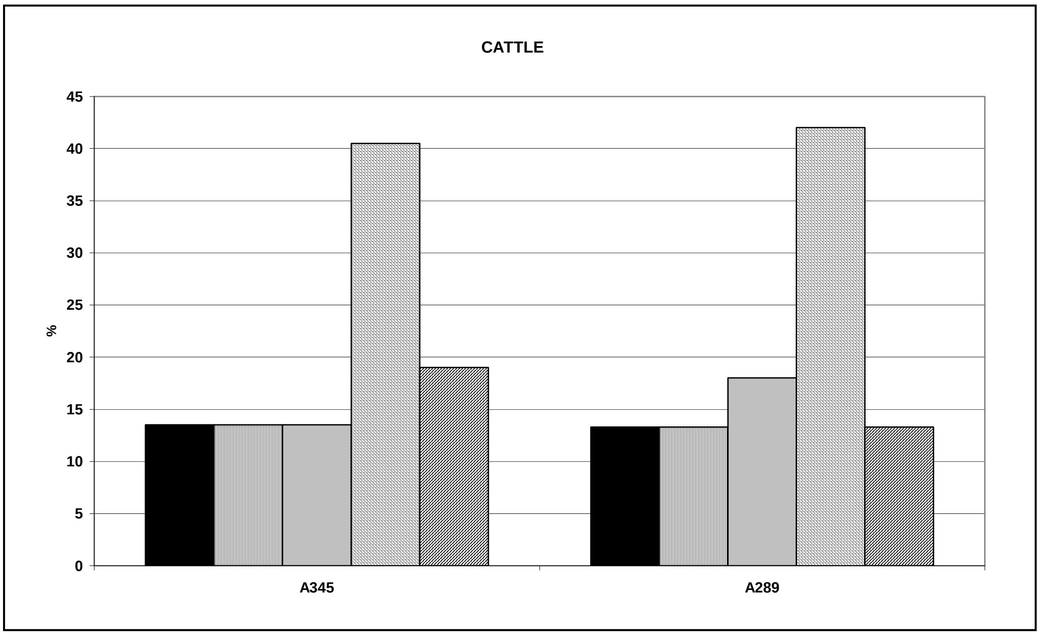


FIGURE 5.3: Comparison of body parts from New Kingdom sites in northern Sinai

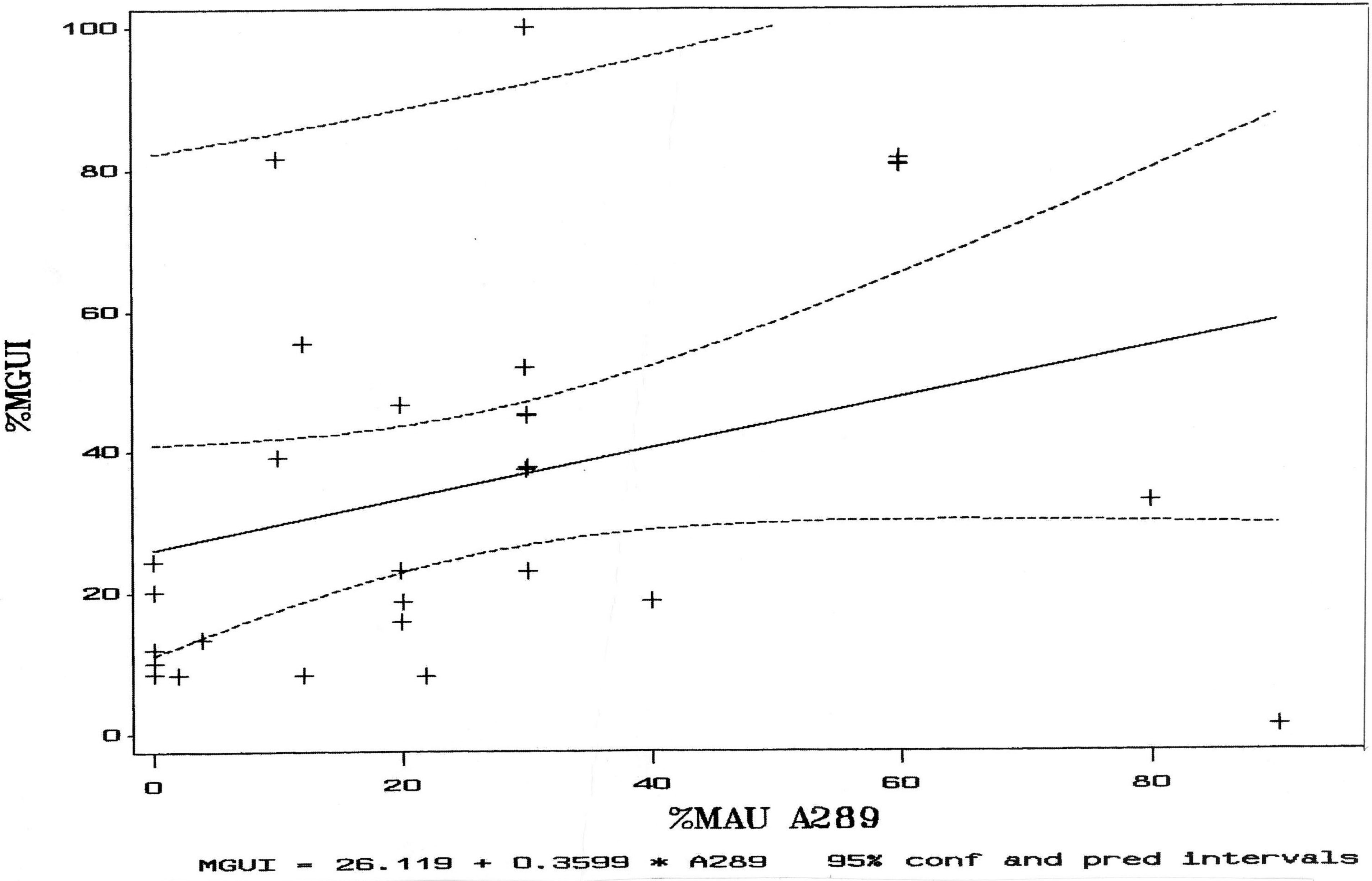
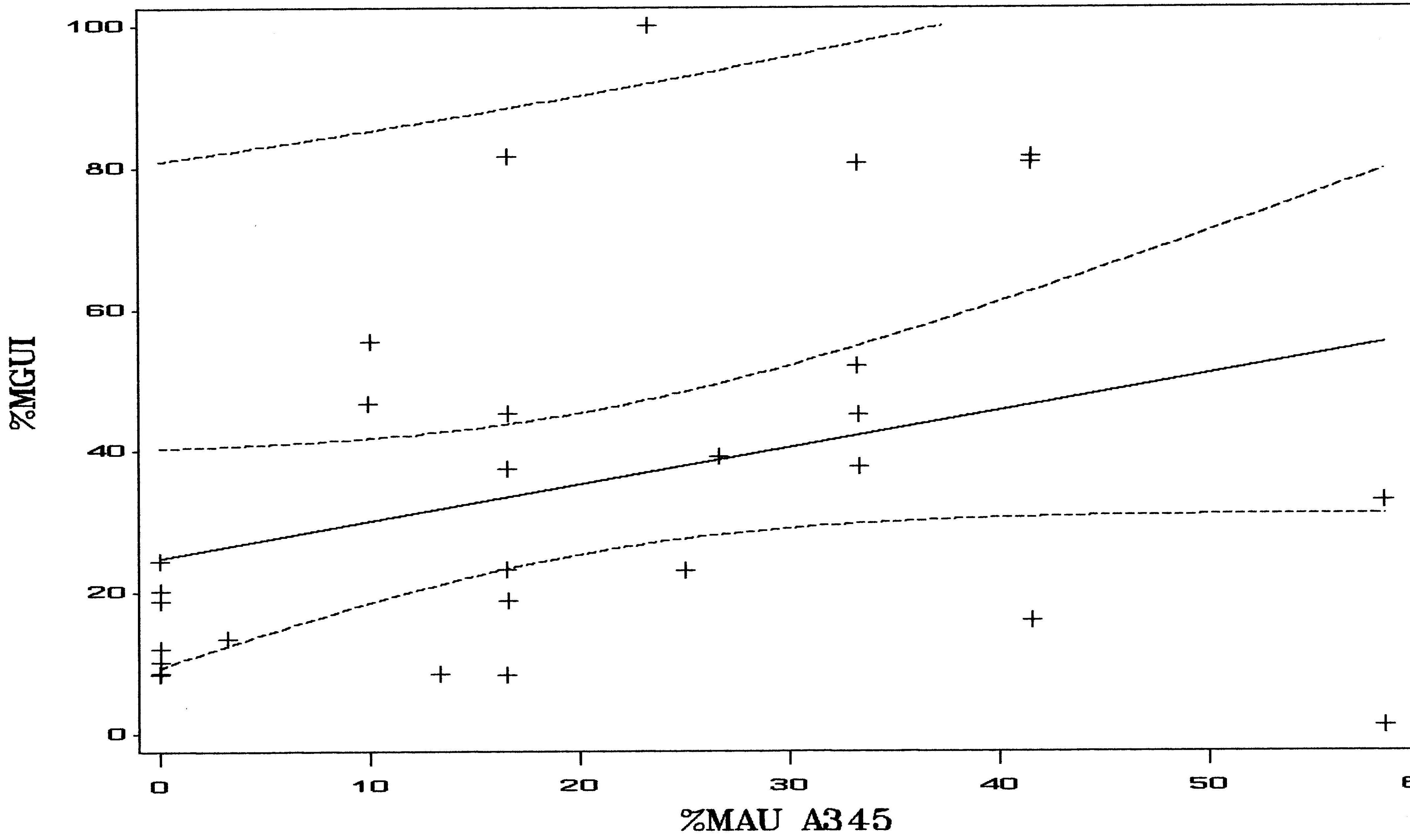


FIGURE 5.4: Bivariate plot of %MAU and %MGUI for (a) A-289 Haruvit (b) A-345



MGUI = 24.924 + 0.5212 * A345   95% conf and pred intervals

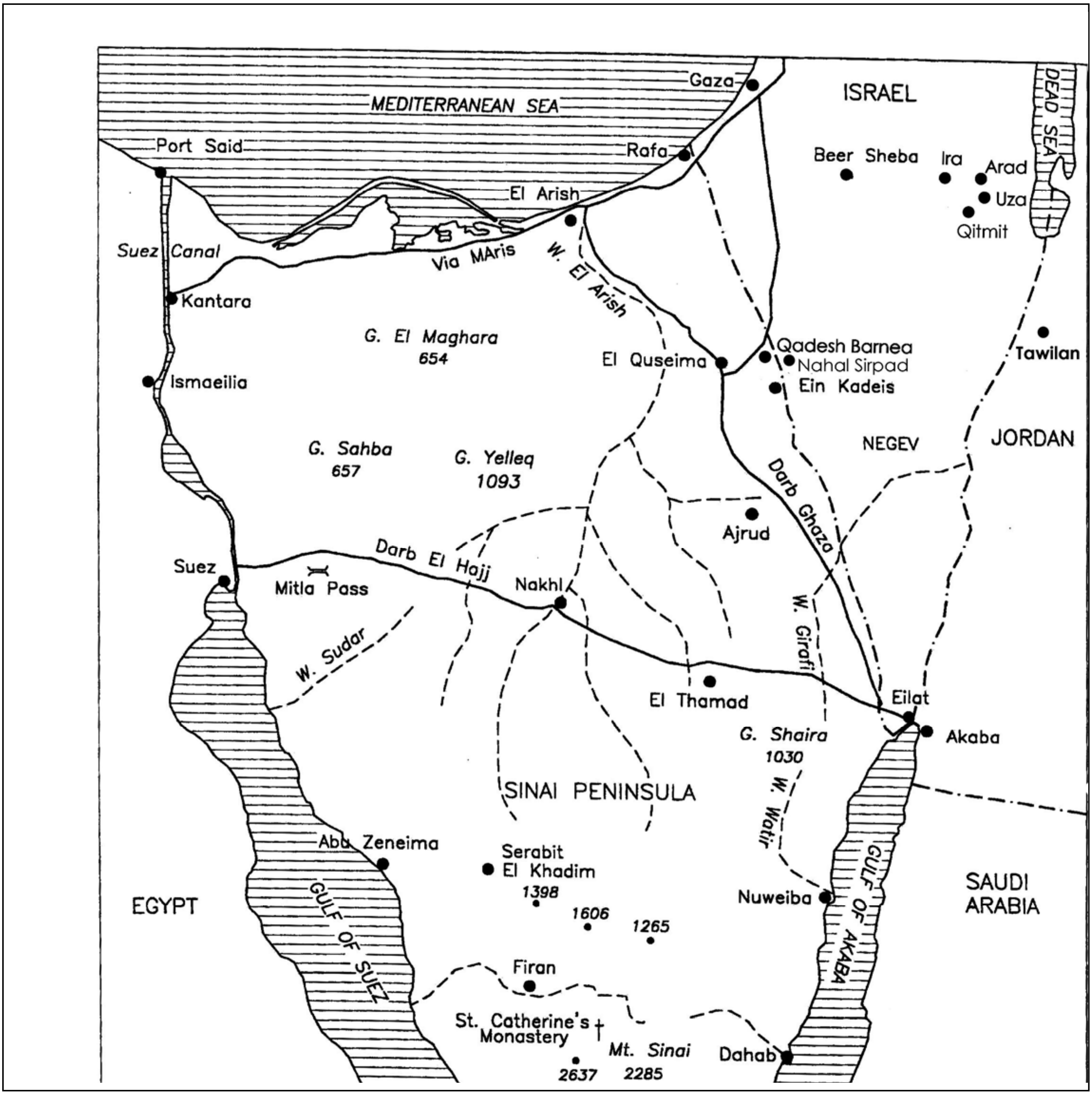


FIGURE 6.1: Map showing the location of Kuntillet ‘Ajrud and other Iron Age II sites mentioned in the text
(modified after Meshel 2000: Introduction).

FIGURE 6.2: Aerial photograph of Kuntillet ‘Ajrud (after Meshel 1987:Fig 3)

FIGURE 6.4: South storeroom with ceramics and other finds

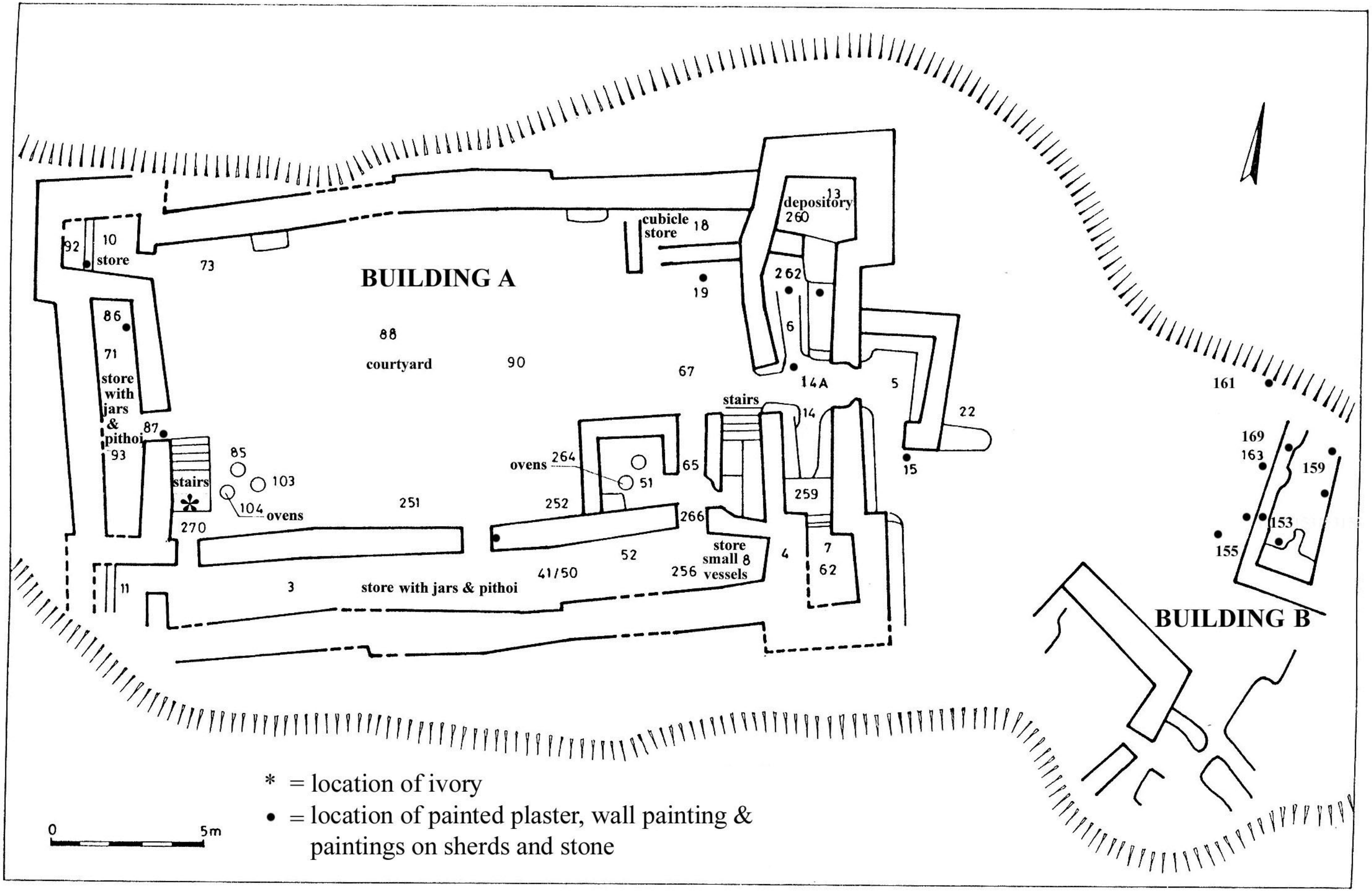


FIGURE 6.3: Site plan with loci numbers mentioned in the text and identifications of specific localities (based on Beck 1982: Figure 2 and Ayalon 1995: Figure 2).

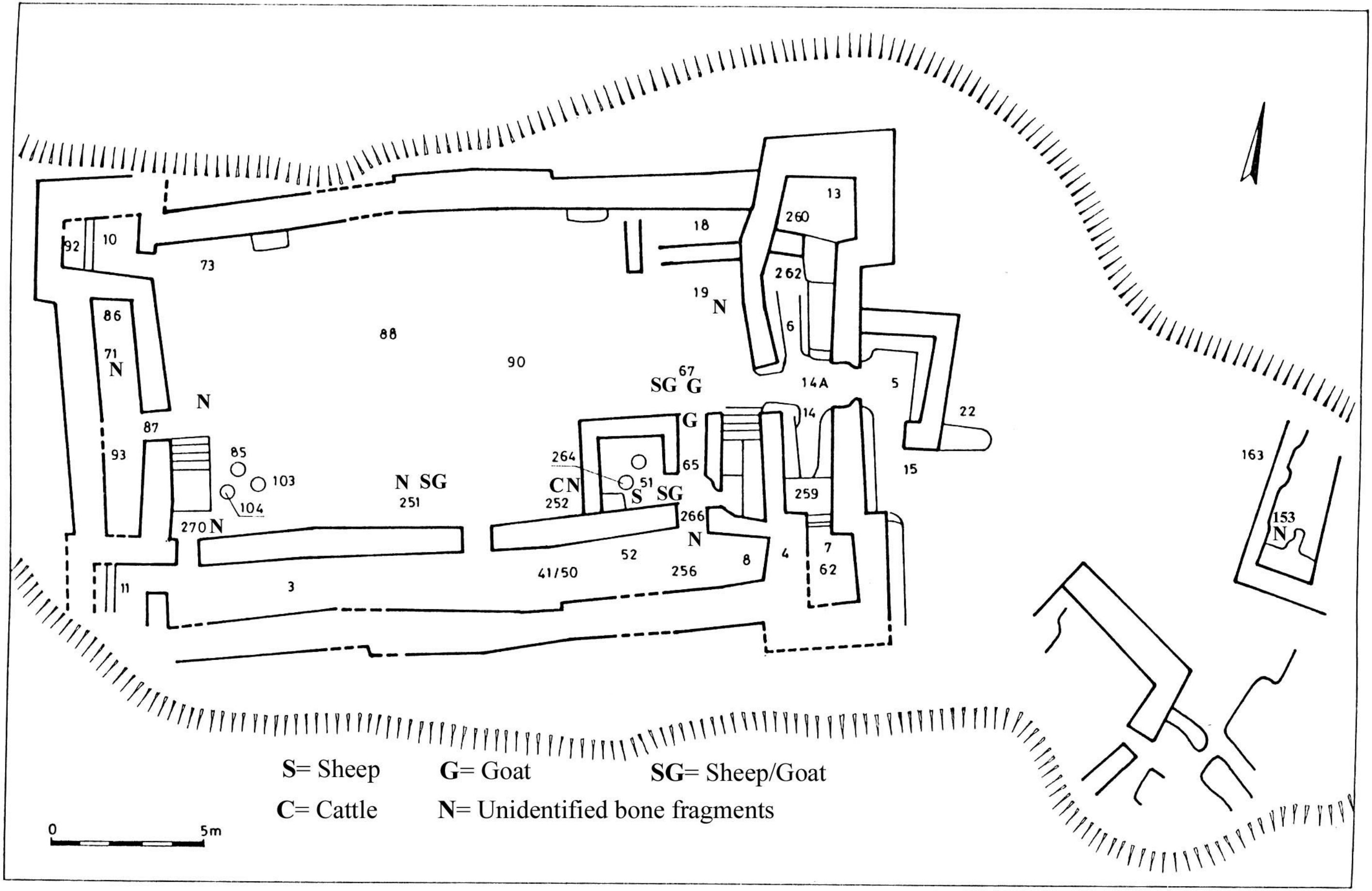


FIGURE 6.5.1: Spatial distribution of artiodactyls (species designated by capital letter)

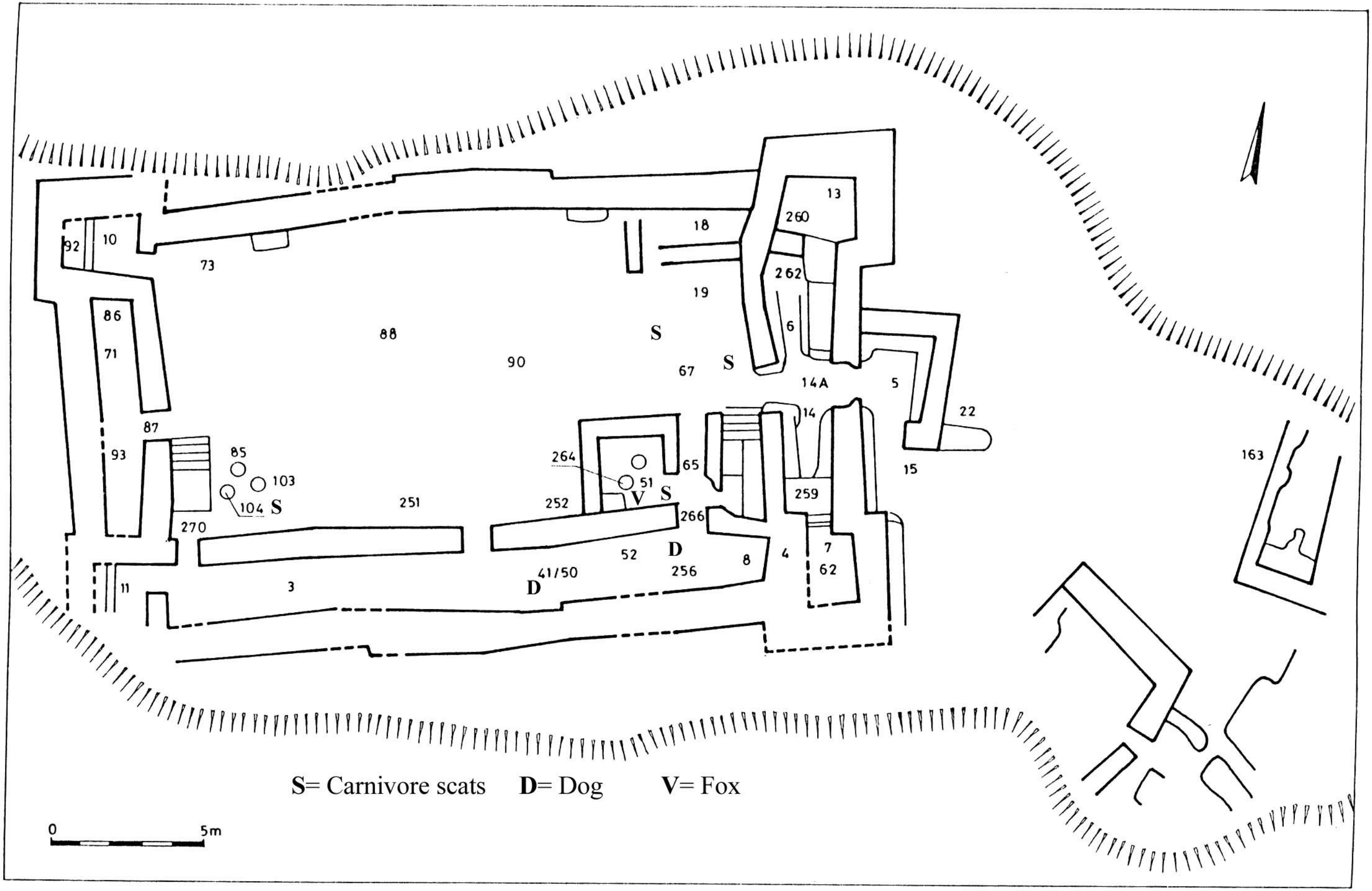


FIGURE 6.5.2: Spatial distribution of carnivores (species/item designated by capital letter)

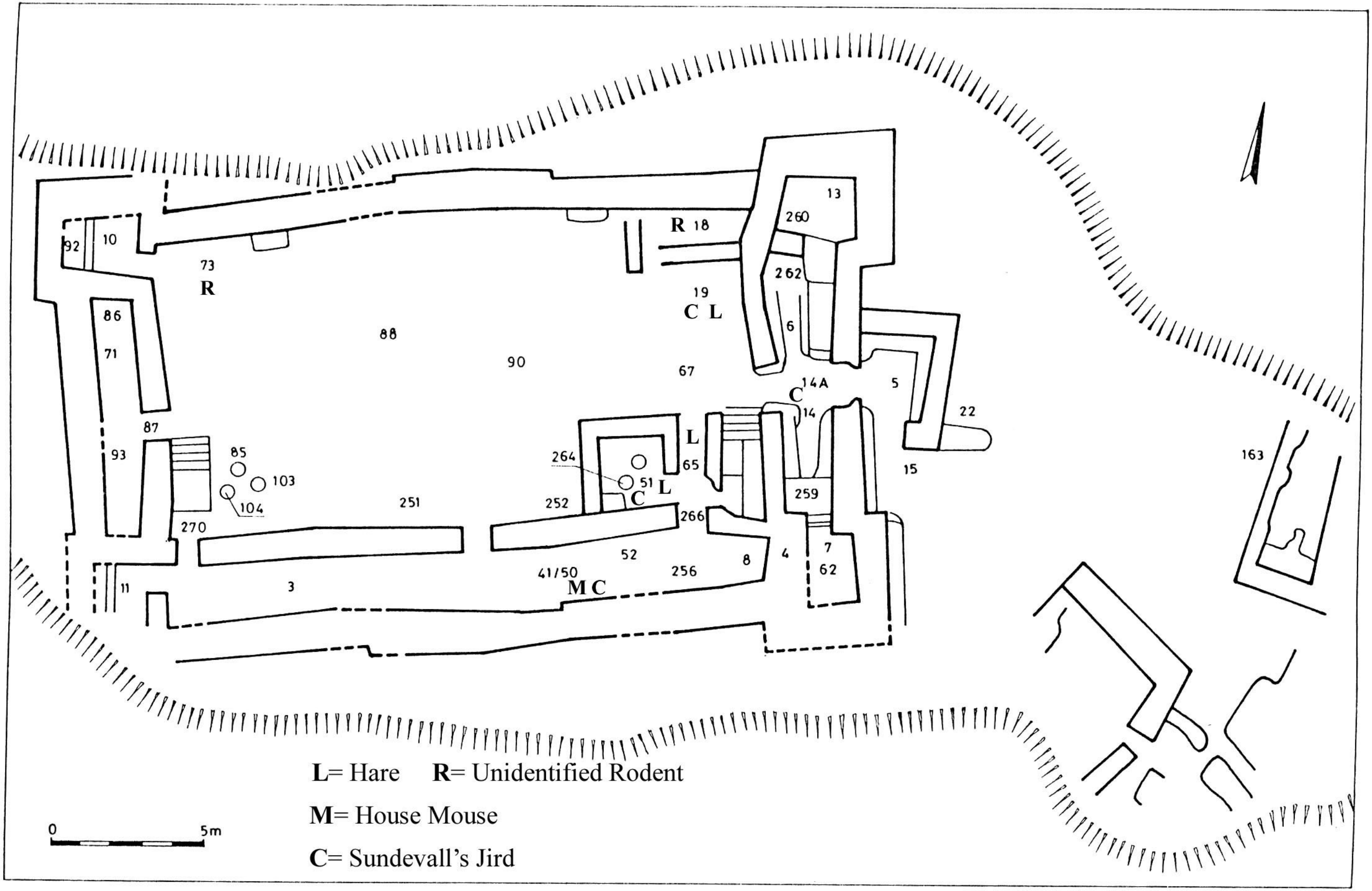


FIGURE 6.5.3: Spatial distribution of small mammals (species designated by capital letter)

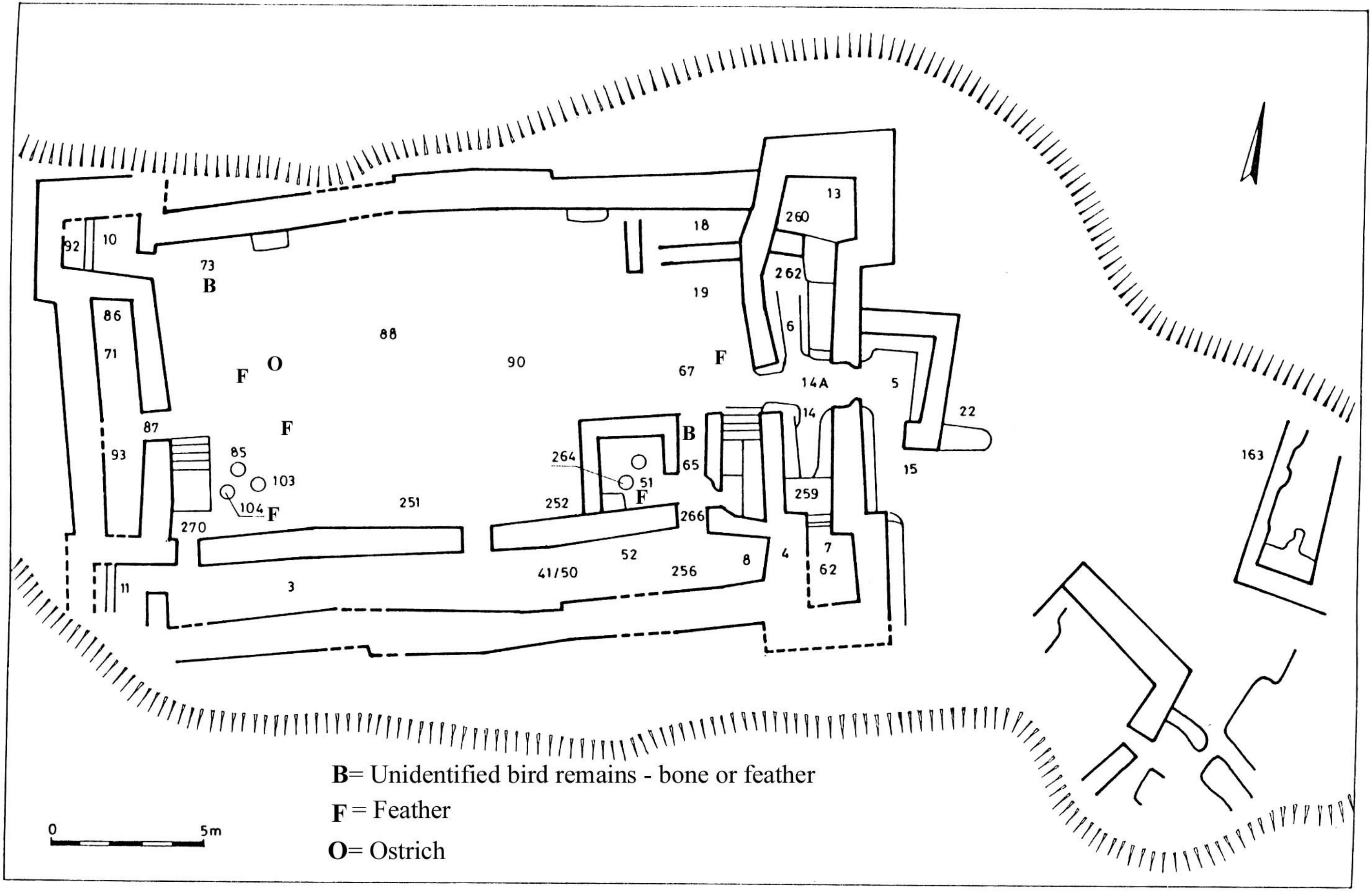


FIGURE 6.5.4: Spatial distribution of bird remains (item designated by capital letter)

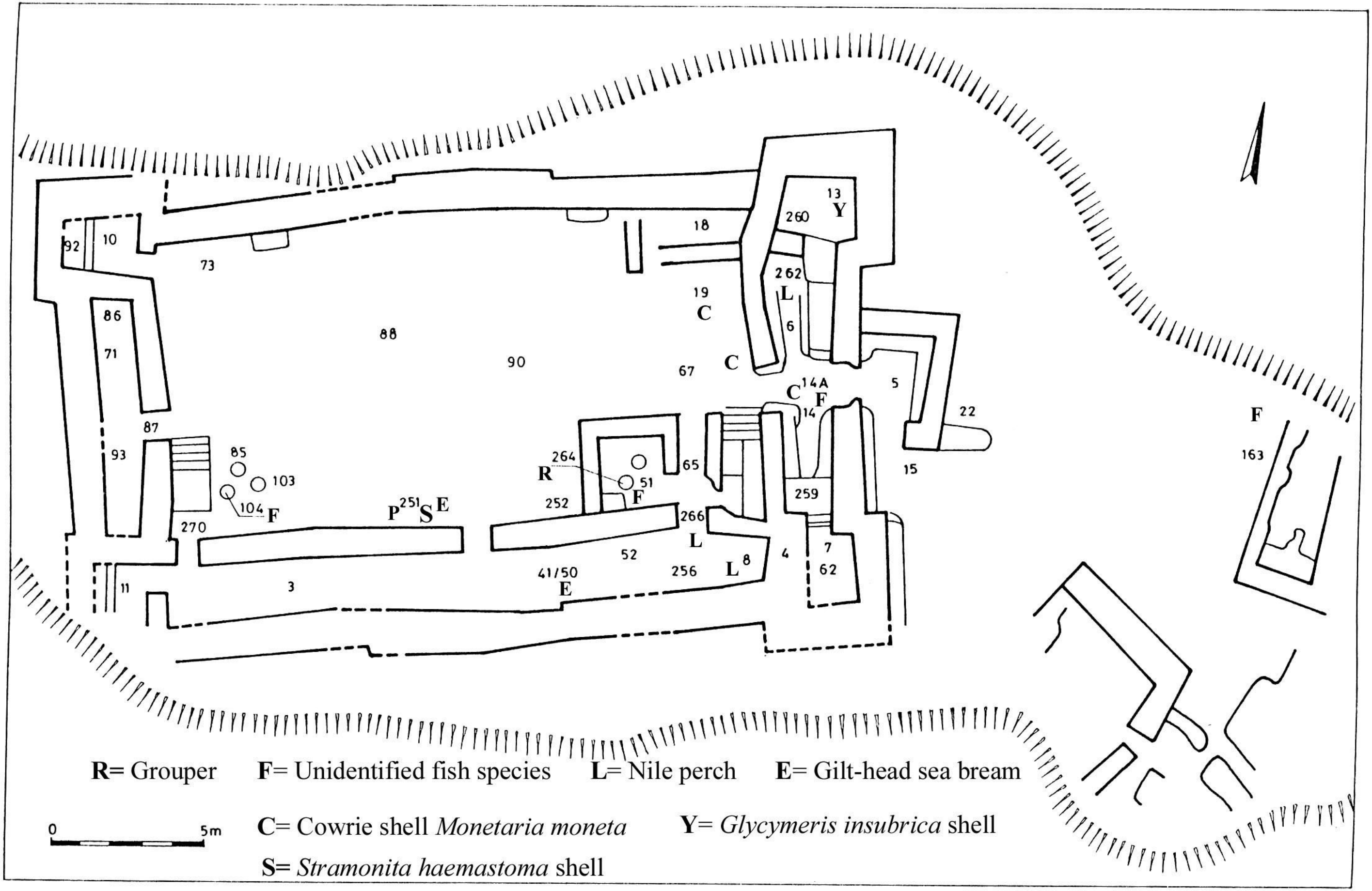


FIGURE 6.5.5: Spatial distribution of marine/freshwater fish and shells (species designated by capital letter)

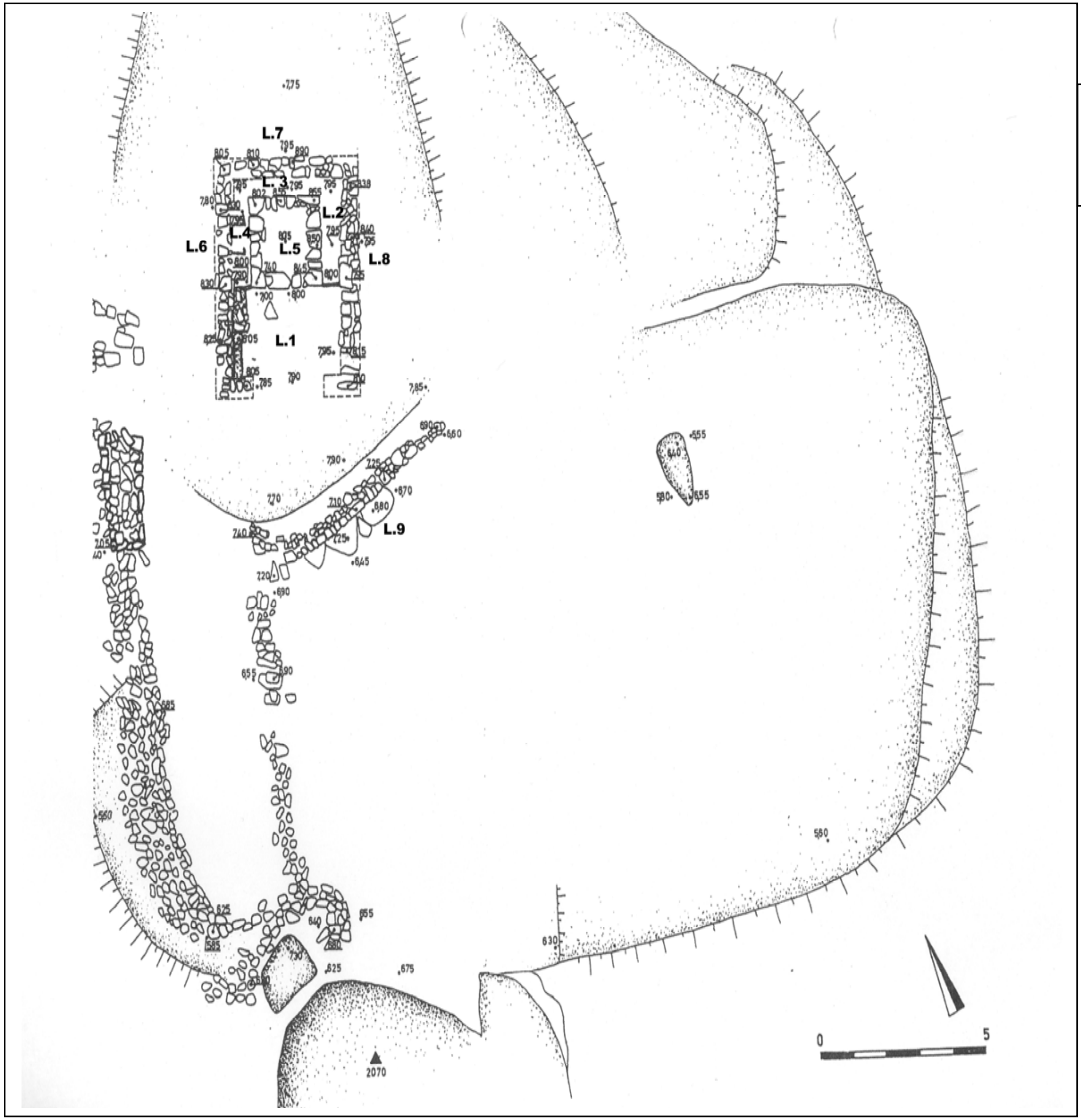


FIGURE 7.1: Plan of Gebel Serbal Sanctuary showing loci excavated
(from Avner in press)

FIGURE 7.2:
Photograph showing the Sanctuary.
Note the passage on left & right of main structure

Photo: U. Avner

אוניברסיטת תל אביב
הפקולטה למדעי- הרוח ע"ש לסטר וסאלי אנטין
בית הספר למדעי היהדות ע"ש חיים רוזנברג
החוג לארכיאולוגיה ותרבויות המזרח הקדום

דגמי ניצול דְיאַכְרוֹנִיים של בעלי חיים בחצי האי סיני

חיבור לשם קבלת תואר דוקטור לפילוסופיה
מאת

ליאורה רחל קולסקה הורביץ

בהדרכת

פרופ' איתן צרנוב (ז"ל) ו- פרופ' ישראל פינקלשטיין

הוגש לסנאט של אוניברסיטת תל אביב
דצמבר 2005

תקציר

במהלך חמש עשרה השנים שחלפו ממלחמת ששת הימים בשנת 1967 ועד הנסיגה מחצי האי סיני ב- 1982, נערכו באזור מספר רב של חפירות ארכיאולוגיות ומחקרים בהיקף רחב על ידי מכונים ארכיאולוגיים ישראלים.
אוסף הפאונה שנאסף במהלך חפירות אלו משמש כבסיס לתזה זו.
זה נותן הזדמנות נדירה להבהיר מודלים משתנים של עורך חיים באזור בלתי מוכר זה אשר שימש כגשר יבשתי וחזית בין מצרים והלבנט.

המאספים הארכיאוזואולוגיים מתייחסים למספר נושאים מרכזיים:

1) עצמת ההשפעה של המבנה הגיאוגרפי של סיני על הרכב הפאונה.
2) טבעם של השינויים התקופתיים בדגם ניצול בעלי החיים באזור תוך שימת דגש על נוודות לעומת התיישבות קבע.
3) השפעת שינויי האקלים על אסטרטגיות המחייה
4) מידת ורמת הקשר בין סיני, מצרים והלבנט.

שני הפרקים הראשונים מהווים את הבסיס למחקר זה.
הפרק הראשון מציג את מטרות המחקר ודן בחפירות ובמדגמים ששימשו למחקר זה. כמו כן מציג הפרק מידע אודות השיטות הארכיאוזואלוגיות שיושמו במחקר זה. נידונות מגבלות המדגמים כגון שימור לקוי ומספר זעום של ממצאים ומובאים פתרונות המאפשרים להתגבר על מגבלות אלה.

הפרק השני מתאר את הגיאוגרפיה הפיזית של האזור ואת הפלורה והפאונה של סיני בתקופתנו תוך התייחסות לשלושה אזורים עיקריים: צפון, מרכז ודרום סיני.
נתונים אלה מהווים בסיס לדיון בשינויי אקלים,משאבים זמינים ואסטרטגיות מחייה הנדונים בפרקים הבאים.

הפרקים שלוש עד שבע מתארים סדרה של מאספי פאונה מצפון ודרום סיני.
פרק שלוש מתייחס לתקופת הניאולית הקדם קרמי ב׳. תקופה זו באזור הים תיכוני של הלבנט מאופיינת על ידי הקמתם של ישובי קבע בקנה מידה גדול, במורכבות סוציו-

פוליטית, בגידול דגנים קטניות ופשתן. כמוכן, ביות כבשים ועיזים התחיל בתקופה זו. ואילו בסיני, תרבות הצייד והלקט נמשכה והייתה מאופיינת בנוודות עונתית.
עדרים מבויתים הגיעו לאזור רק בסוף תקופת הניאולית הקדם קרמי ב׳.
יתכן דגם הניצול של עדרי יעלים בתקופת הניאולית הקדם קרמי ב׳ שימשה מודל לניידות של רועי צאן שהתפתחה בהמשך.

פרק ארבע חוקר את התזמון, המקור והמכניזם של הופעת צאן מבוית ואת התפתחותו של אסטרטגיות שונות של ניצול העדרים במהלך הזמנים. כבשים ועיזים היו המבויתים הראשונים שהגיעו לחצי האי סיני מהלבנט ונפוצו לדרום סיני ולעמק הנילוס. לעמק הנילוס הם הגיעו כנראה דרך החוף הים תיכוני של סיני.
בתקופה הכלקוליתית ובתקופת הברונזה הקדומה א׳ היעד העיקר של ניצול העדרים הייתה לבשר לצריכה ביתית ודמה במידה רבה לצייד היעלים בתקופת הניאולית.
רק בתקופת הברונזה הקדומה ב׳ הפכו המוצרים המיישנים (חלב ,צמר ושיער) למטרה המרכזית בגידול העדרים, על מנת לסחור במוצרים בשווקים ומרכזי המסחר שמחוץ לחצי האי.

חשיבותם של מוצרים משניים יצר צורך בהתיישבות קבע וזרז את התפתחותה, אולם רועי הצאן נאלצו לנדוד עם העדרים בחיפוש אחר כרי מרעה ומקורות מים.
תפנית זו באסטרטגיות המחייה מיוחסת להתפתחות של רשתות מסחר והעניין הגובר במוצרים מאזור המדבר (נחושת, צדפים מהים האדום וכלי צור מיוחדים) והתחזקות הקשרים בין המדבר ובין האזור הים תיכוני.

פרק חמש מציע מודל ארכיאוזואלוגי לזיהוי אספקת מזון על ידי שלטון מרכזי , המתבסס על נתונים מתקופת הרומאי. לשם כך נבחנה פאונה מסדרת אתרים מצריים ששימשו כמרכזים צבאיים -אדמיניסטרטיביים בתקופת הממלכה החדשה. למרות שכלי האחסון באתרים אלה מקורם ממצרים, מדגים המחקר הארכיאוזואולוגי בוודאות שבשר ודגים הושגו במקום (יתכן בצורת מס או תרומה).

רעיון דומה נבדק בפרק שש העוסק בתקופת הברזל באתר קונטילת עזרוד שבצפון מזרח סיני. החופר זיהה את האתר כמרכז פולחני, בעוד אחרים סברו שהמקום שישמש כ״חאן״ לעוברי אורח. המסקנות המבוססות על הממצאים הפאוניסטים מהאזור מלמדות שהאתר שימש כנראה לשתי המטרות גם יחד ושחלק ממוצרי המזון הגיעו לשם מרחוק.

המחקר האחרון עוסק במאסף קטן ממקדש נבטי בדרום מזרח סיני ומאפשר הצצה לעולמם הטקסי.לאור העובדה שקיים מידע זעום אודות כלכת בעלי החיים הנבטי, זורה מחקר זה אור נוסף על הנושא.

פרק האחרון מסכם את השינויים העיקרים שחלו בבעלי חיים לאורך הזמן ומשתמש בהם כבסיס לענות על השאלות שנשאלו בהקדמה.

המסקנות המרכזיות ממחקר זה הנן:

(1) בכל תקופה שנבדקה היו ממצאי הפאונה מדרום וצפון סיני ייחודיים , וזאת בגלל טופוגרפיה, אקלים מקורות מים וצמחייה הייחודיים לשני האזורים .

(2) נתוני הפאונה משקפים את השינויים האתניים והפוליטיים של האזור. ניכרים שינויים בדפוסי הניצול של בעלי החיים במהלך התקופות בסיני המיוחסים להגירת בני אדם ובעלי החיים אל האזור. הייתה דמיון רב בין דגם הניצול של בעלי החיים בתקופות הכלקוליתי ותקופת הברונזה הקדומה א׳ לבין זו של הניאלית הקדם קרמי ב׳. לאומת זאת, בתקופת הברונזה הקדומה ב׳ התפתח דגם ממשק שונה המתבסס על מוצרים משיניים ששימשו לסחר חליפין. כתוצאה מזה, התפתח יישובי קבע.

מאספי הפאונה מתקופות המאוחרות יותר הינם מאתרים ייחודיים (מצודות, חאן, מקדשים) ששימשו כלוויינים סוציו-פוליטיים של מיצרים או כנען והיו תלויים באופן חלקי באספקת מזון על ידי גורמי חוץ. היה להם תפקיד מוגדר וכנראה היו מאוכלסים בזרים. אורח החיים של אתרים אלה היה קצר.

(3) האקלים אמנם השפיע על הגירת בני אדם אל האזור וגם השפיע על צורת חייהם.

(4) הממצאים הארכיאוזואולגיים מדרום סיני מראים דמיון רב יותר ללבנט מאשר למצרים בעוד שבצפון סיני ניכרת השפעה מעורבת המשתנה בהתאם לתקופה הנבדקת.