A prelude to agriculture: Game use and occupation intensity during the Natufian period in the southern Levant

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A PRELUDE TO AGRICULTURE: GAME USE AND OCCUPATION INTENSITY DURING THE NATUFIAN PERIOD IN THE SOUTHERN LEVANT

by

Natalie Dawn Munro

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and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy

Dr. Mary C. Stiner	12 Oct 2001 Date
Dr. Steven L. Kuhn	12 OCT. 2001 Date
O. Bar-Yosef Prof. Ofer Bar-Yosef	10/12/01 Date
	Date
	Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Dissertation Director Dr. Mary C. Stiner — 12 Oct 2001
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ABSTRACT

The origins of agriculture was one of the most significant turning points in human history, yet, no consensus has been reached on its causes. The most commonly cited precursors to agriculture include population pressure, intensive foraging, and sedentism. These critical factors play central roles in models of agricultural origins, yet have not been rigorously tested. In the Levant, the Natufian period (ca. 13,000-10,500 B.P.) immediately preceded agricultural origins. This research applies ecological models to the Natufian archaeological record to formally test whether population pressure, sedentism, and intensified resource use were major catalysts for economic change at the transition to agriculture. It reconstructs predator-prey relationships by recording the potential effects of human hunting on prey populations and examining how these effects change with varying degrees of hunting pressure.

The effects of human hunting on prey populations is governed by the ecological characteristics of prey species. Prey species vary in their cost of capture and their resistance to hunting pressure. The presence of some species and not others at archaeological sites may thus reflect changes in human population density. In archaeofaunal assemblages these changes are expressed in the relative abundance and age structures of prey species.

The prey composition and prey age profiles from four Natufian sites --Hayonim Cave, Hayonim Terrace, Hilazon Tachtit, and el-Wad Cave -- support three major conclusions. First, site occupation intensity reached unprecedented levels in the Early

Natufian in comparison to earlier Paleolithic periods in the region. Second, a substantial decrease in site occupation intensity back to virtually pre-Natufian conditions occurred during the Late Natufian in association with the Younger Dryas climatic event. Finally, the Natufians exerted constant, intensive pressure on their resources throughout the duration of the period. These trends have implications for human demography at the regional scale. During the Early Natufian period, human population densities in the Mediterranean zone peaked for the Paleolithic period. With the decline in site occupation intensity in the Late Natufian, human populations became more mobile and partial depopulation of the region occurred. The origins of agriculture thus emerged from a atmosphere of long-term resource stress, not as an immediate response to environmental deterioration in the Late Natufian phase.

CHAPTER 1: INTRODUCTION

OVERVIEW OF THE PROBLEM

The Natufian culture of the southern Levant inspires great anthropological interest because it immediately precedes the adoption of the first agricultural economy. In the Natufian period, we thus hope to find the roots of some of the important cultural changes associated with this adoption -- explosive population growth, the formation of permanent sedentary villages, a dependence on domestic plants and animals, and novel social structures. Though consensus on the causes of the agricultural revolution has not been reached, researchers consistently return to a few ecological themes to explain the emergence of the Natufian adaptation, and of subsequent agricultural economies. These include population pressure, or an imbalance between human population size and resources; intensified site occupation or sedentism; and intensified subsistence regimes based on cereals grains, nuts, and wild game (Bar-Yosef and Belfer-Cohen 1989, 1991; Belfer-Cohen and Bar-Yosef 2000; Binford 1968; Boserup 1965; Braidwood 1960; Childe 1951; Cohen 1977; Flannery 1969; Gebauer and Price 1992; Henry 1989; Hillman 1996; Keeley 1995; McCorriston and Hole 1991; Redding 1988; Smith and Young 1972, 1983). Despite their paramount status in models of agricultural origins, these factors are poorly understood, and have rarely been subjected to rigorous testing.

This research applies ecological models to zooarchaeological assemblages to test for evidence of population pressure and intensified resource use during the Natufian period. I also explore the role of these factors as catalysts for economic change at the transition to agriculture. The expected impact of varying degrees of human hunting pressure on prey populations is investigated with the aid of simple population simulations (following Stiner et al. 1999, 2000). Application of the simulations to the archaeological record allows us to estimate the relative degree of pressure exerted by Natufian hunters on key elements of their food supply. The method is based on the assumption that the effect of human hunting on prey populations is governed partly by the behavioral and population characteristics of prey species. Animals vary in their cost of capture, body size, population density, and resistance to hunting pressure, and as a result in the total energy returned for the predator. If animal communities are relatively constant the presence of some species and not others in archaeological assemblages should reflect the intensity of resource use. This in turn acts as a proxy measure of human population density at regional (population pressure) and local scales (site use intensity). In the archaeological record, hunting pressure is reflected in the prey type composition and in the mortality or body size profiles of faunal assemblages.

The Natufian fauna from Hayonim Cave, a multicomponent base camp in the northern Levant, is the centerpiece of a larger study that explores human game use in the Natufian period in general. Three additional Natufian sites -- Hayonim Terrace, Hilazon Tachtit, and el-Wad Cave -- are also evaluated to reconstruct patterns of human demography on a regional scale. Reconstructions of the relative density of human populations across Southwest Asia over the Late Pleistocene/Early Holocene transition are relevant to ideas about demographic imbalance in current explanations of agricultural origins.

HUMAN POPULATION PRESSURE AND SITE OCCUPATION INTENSITY

Population pressure stems from an imbalance between human population size and resource availability. Resource imbalances are caused by population growth or a reduction in habitat area through climatic change, environmental degradation, territorial circumscription, or a combination of these (Bar-Yosef and Belfer-Cohen 1989; Binford 1968; Boserup 1965; Cohen 1977; Flannery 1969; Henry 1989; Smith and Young 1972, 1983). Because the survival of human populations depends on access to adequate nutrition, population imbalances can affect processes of cultural evolution. Such change may manifest itself as a shift in foraging strategy or population mobility, or as a technological innovation. Yet models of agricultural origins based on population pressure have been criticized for their unicausal designs as well as for their failure to explain the sources of population imbalance (Bender 1978; Cowgill 1975; Hassan 1978; Hayden 1981, 1995). This research does not seek to explain the origin of population pressure; rather it aims to test the hypothesis that it was associated with revolutionary subsistence change at the Pleistocene/Holocene boundary. This does not imply that population pressure was the sole force behind subsistence change. In the presence of other factors such as climatic, environmental, or social disruption, however, it may have the potential to provoke cultural change.

Currently, scholars generally agree that the roots of human sedentism in the Levant can be traced back at least to the Natufian period, based largely on the presence of biological indicators such as the appearance of commensal species. The appearance of large habitation sites with thick cultural deposits and rich material remains, including architectural features, ornamentation, art, and conspicuous human cemeteries, also sets the Natufian apart from all preceding Paleolithic cultures (Bar-Yosef and Belfer-Cohen 1991; Henry 1989; Tchernov 1991). The large "base camps" of the western Mediterranean hills (cf. Bar-Yosef 1970) form the core of arguments for the appearance of sedentism and population pressure in the Natufian period; thus they are the focus of study here. Although many archaeologists would agree that sedentism, intensified resource use, and human population growth were present in the Levant by the Early Natufian phase, no adequate measure of their magnitude or implications for the emergence of agriculture has been developed.

By definition, sedentism refers to the settling down of human populations into permanent or semi-permanent residential camps (Hitchcock 1987; Kelly 1995). This study prefers the term "site occupation intensity" to the term sedentism, because the former is better suited for distinguishing relative differences in site use, both between cultural periods and within the Natufian period itself. The intensity of site occupation is undoubtedly one of the most enthusiastically studied archaeological questions of the Natufian period (Bar-Yosef and Belfer-Cohen 1989, 1991; Belfer-Cohen and Bar-Yosef 2000; Davis 1983; Edwards 1989; Kaufman 1989; Lieberman 1991, 1993; Rosenberg 1998; Tchernov 1984, 1991). Researchers want to determine if Natufian populations had settled down or not, and if so, whether they lived in permanent villages for the entire year or at least a significant portion of it. Most research focuses on indicators of long-term investment in a habitation site, such as the presence of architecture, and the presence of commensal animals. Though suggestive, the results of these studies remain inconclusive, because the indicators used are unable to prove year-round occupation or distinguish among degrees of site occupation intensity. Clarifying the degree of site occupation intensity during the Natufian period in demographic terms will also shed light on the role of other factors such as human subsistence strategies, population growth, social organization, and cultural complexity in the Natufian period.

If we are to reconstruct the human demographic and economic environment during the Natufian period and evaluate its role in the transition to agriculture, then new methods must be implemented to quantitatively test these questions. Although this study builds upon previously published concepts (Stiner, Munro and Surovell 1999, 2000), it differs in application because it focuses principally on site occupation intensity, spatial variation in the indications of predator pressure, and small-scale diachronic variation within a single cultural period.

PREDATOR-PREY POPULATION INTERACTIONS

This research applies ecological models to the Natufian archaeological record to test if population pressure, sedentism, and intensified resource use were already in existence, and hence possible catalysts for economic change prior to the transition to agriculture. The theoretical basis for the research is rooted in population ecology and draws heavily on the principles of foraging theory (optimization models) and predator-prey population dynamics (*sensu* Pianka 1978). Changes in human demography should directly translate into changes in the intensity with which humans use local resources, including wild animals. Higher densities of people mean that greater quantities of resources must be harvested each year. Sustained pressure on resources may eventually lead to the depression and restructuring of local plant and animal communities (e.g., Broughton 1994; Speth and Scott 1989). Humans must respond to self-induced disturbances in resource distribution and abundance by altering their foraging regimes to include less desirable resources.

This research predicts the potential effects of human hunting on prey populations -- specifically, the effect of varying degrees of hunting pressure upon prey availability and age structures -- and then seeks these signatures in the archaeological record. The relationship between predators and their prey has been studied in ecology for many decades (e.g., Berryman 1992; Blasco et al. 1986/87; Dye et al. 1994; Elton and Nicholson 1942; Lambert 1982; Pianka 1978; Solomon 1949), but this rich literature has rarely been applied to the reconstruction of past human/animal relationships (but see Botkin 1980; Broughton 1994; Christenson 1980; Earle 1980; Stiner et al. 1999, 2000; Winterhalder et al. 1988). Because the prey species hunted by humans in the Natufian period still exist today, modern ecological data provide an independent framework for interpreting patterns in the archaeological record.

Optimality Theory and Predator-Prey Simulations

Optimality models make predictions about the behavior of consumers according to the assumption that natural selection will lead individuals to make decisions that maximize fitness or reproductive success (Charnov 1976; Emlen 1966; Krebs et al. 1983;

MacArthur and Pianka 1966; Perry and Pianka 1997; Pyke et al. 1977; Schoener 1971; Stephens and Krebs 1986). In ecology, optimality models are most often incorporated within a body of research known as foraging theory, and are designed to predict the decisions made by living species during resource procurement. Although the formal conditions of foraging theory are not employed here, the basic principles are used to generate qualitative predictions about past human foraging behavior.

The energy equation that predicts which animals human hunters will prefer is a simple cost/benefit function measured in calories. Benefits are derived from the energetic returns of the animal captured, and costs include the relative energy expended by the hunters on search, pursuit, and handling (Charnov 1976; Pianka 1978; Stephens and Krebs 1986). Search costs refer to the energy expended while locating prey; pursuit costs concern energy spent on the capture of the animal once it is located; and handling denotes the energy required to prepare the animal for consumption (i.e., transport, processing, cooking). To maximize reproductive fitness, human hunters are expected to prefer animals that provide the highest net energy returns (high-ranked species) after the costs of search and capture are taken into account. Only when demand exceeds the availability of high-ranked resources are hunters expected to turn to species that provide lower net returns (low-ranked species).

Ranking prey

Understanding the conditions under which prehistoric animal assemblages were generated requires that common prey species be ranked relative to one another. In archaeological research, prey types are typically ranked by body size (Broughton 1994;

Griffiths 1975; Simms 1987; Szuter and Bayham 1989). The larger the animal, the higher its ranking since all are made of the same range of tissues. In most cases body size is an effective measure of rank because the caloric value of large animals tends to be high enough to substantially outweigh the cost of capture. However, these rankings are based entirely on the benefit part of the equation, and the role of cost is ignored. In cases where capture costs are quite low, animal resources should be collected when encountered, regardless of body size. In effect, these resources provide pure gains, especially if the search is embedded in other foraging agendas. This is underscored in recent work by Stiner et al. (1999, 2000), who argue that slow-moving animals such as tortoises and shellfish may be high-ranked species despite their small body sizes. As such, they are expected to regularly enter the diet when encountered. Both the escape strategy and body size of a prey species must be considered when ranking prey.

Despite the formality of the conditions required by many applications of foraging theory in modern settings, these models can be applied more loosely to generate qualitative or rank-ordered predictions about the types of small game that prehistoric humans are expected to capture under specific demographic conditions. Though foraging models assume that human hunters tend to maximize cost/benefits, they do not assume that human hunters consciously forage with efficiency in mind. Humans are intelligent social animals who make some foraging decisions based on economic criteria and some on seemingly noneconomic criteria. However, even if noneconomic decisions accounted for a large part of human subsistence activities, they still will not mask the signature of economically motivated decisions. Human survival requires adequate nutrition above all else, and though social factors have a role to play, recent studies consistently demonstrate that humans meet nutritional needs by taking advantage of the highest quality resources they can effectively and safely procure (e.g., Kelly 1995; O'Connell and Hawkes 1982; Smith and Winterhalder 1992; Winterhalder 1986).

Predicting Demographic Pressure from Human Prey Choice

Variability in the ecological characteristics of prey species allows the derivation of expectations about the effects of human hunting pressure. Each prey species possesses a distinctive suite of characteristics that constrain the energy and hunting techniques humans must invest in their capture. Prey species will also respond demographically in different though clearly predictable ways to human hunting pressure. Two characteristics in particular play a large role in determining the cost/benefits and demographic responses of prey populations. First, the escape strategy of the prey strongly influences the cost of procurement. Second, population turnover and individual growth rates determine the susceptibility of a species to hunting pressure, the rate of the population's recovery, and ultimately its future availability to human hunters.

Escape Strategy ("Catchability")

Variation in escape strategy is of considerable importance when ranking animals of similar body size. Unlike their large game counterparts, the small game species commonly hunted by Paleolithic foragers show great variability in predator evasion strategies ranging from rapid flight to freezing and hiding. Though technological solutions can be developed to overcome prey escape strategies, pursuit and handling costs and the cost of making and maintaining technology for the capture of fast-moving species such as partridges and hares, is higher than for slow-moving species such as tortoises. The latter can usually be captured by hand, clearly a much lower-cost technique than those usually employed in the capture of fast prey types.

Population Turnover (Regeneration) Rates

The reproductive characteristics of prey taxa determine the effects of human predation on their populations, irrespective of their food value in human eyes. Reproductive data on common small prey species from the Natufian period (tortoise, hare, and partridge) are the basis for predator-prey simulations originally presented by Stiner et al. (1999, 2000). These simulations explore the responses of different animal populations to human hunting (see Chapter 6 and Stiner et al. 1999, 2000 for details). The simulations demonstrate remarkable differences in the population resilience of high- and low-turnover species. High-turnover animals quickly replace their populations through rapid growth. They tend to produce many young, experience heavy juvenile mortality, and live relatively short lives. Rapid growth and development permits explosive population growth and give tremendous resilience to high-turnover populations, even under conditions of heavy hunting. In contrast, low-turnover populations (tortoise) regenerate slowly. Adults produce few to many young, but juvenile mortality is high, and most importantly, individual development is slow. Low recruitment combined with slow growth causes low-turnover populations to be particularly susceptible to depletion by overhunting. Differential population resilience in small game species means that they will respond differently to human hunting pressure: low-turnover species are more susceptible to depletion than are high-turnover populations.

Summary of Predator-Prey Interactions

Like other animals, humans are expected to maximize benefits relative to costs while foraging (Kelly 1995; Stephens and Krebs 1986; Winterhalder 1986). Furthermore, when human population density and hunting intensity are low, human hunters are expected to select resources that produce the greatest returns for the effort of search, pursuit, and capture; either the least expensive to take (e.g., tortoises), or those that provide the largest quantities of energy per hunting episode (e.g., ungulates). As hunting intensity increases, humans will eventually cross a threshold beyond which the most attractive resources will no longer be available in adequate numbers to meet energy requirements, because some highly ranked prey populations shrink as human harvesting rates increase. At this point humans must add less cost effective (low-ranked) resources to their diet. Such animals include fast-moving birds and hares, which are also notorious for their productivity and their ability to withstand much greater harvesting pressure (Stiner et al. 1999, 2000). These model predictions can be directly tested by examining the proportions of game animals in the archaeological record using skeletal remains.

SCALES OF INQUIRY

Recent work by Stiner et al. (1999, 2000) uses changes in human prey choice to trace broad regional trends in human demography from the Middle Paleolithic to the Natufian period in the Wadi Meged in Israel. Particular attention is given to small game species. This project expands upon that research by providing a detailed reconstruction of spatial and temporal variation within the Natufian period (ca. 13,000 -10,500 B.P.). The methods previously established to investigate broad regional trends are adapted here to address questions of site use intensity within a relatively short cultural period (see also Munro 1999; Surovell 1999). At issue are trends in prehistoric human demography on local and regional scales during a cultural period lasting about 2500 years. Understanding of these trends is based on faunal indicators of human hunting intensity. Local analyses monitor change in the intensity of site use, whereas regional analyses seek to gauge human hunting pressure in the Mediterranean Levant.

The regional analysis focuses on the intensity of human hunting pressure within the Mediterranean hill zone. Regional trends are investigated from both long- and short-term perspectives. First, changes in human demography from the Middle Paleolithic to the late Epipaleolithic are reviewed (Stiner et al. 1999, 2000) to pinpoint the conditions that set the Natufian apart from preceding cultural periods. Next, the level of inquiry is restricted to the Natufian period (Early versus Late phases). Results from the Natufian sites in the sample are combined to provide a more detailed picture of regional demography during both the Early and Late Natufian phases. Though the analyses center on prey relative abundance and mortality profiles, some prey species are better suited than others for addressing local versus regional variation in the distribution of human populations. These animals include gazelle, which are best suited for regional analyses, and small game species such as hare, partridge, and tortoise, which are especially informative on a local scale.

Localized effects can be distinguished from regional pressures by reference to the home range of prey species. Small game such as tortoises, hares, and partridges have small territories, thrive at high densities in the absence of predator pressure, and are expected to be captured close to home because they provide limited caloric returns and so are unworthy of search and transport over long distances. The relative proportions of different small game animals captured by humans thus record the local impact of human populations. In contrast, gazelle and other ungulate populations occupy large home ranges that are more likely to intersect with the seasonal rounds of multiple groups of human foragers. Changes in the intensity of gazelle hunting by humans are therefore expected to better reflect regional pressure on animal resources. This should be detectable in the relative proportions of gazelle to small game, and in the age profiles and butchering intensity of gazelle and other ungulate species.

Predicted Human Impacts on a Local Scale: Small Game

Site occupation intensity is a function of any or all of the following: length of stay, frequency of visits, and size of the resident population at a site per unit time. All else being equal, the impact of a site's inhabitants on local resources will increase with site use intensity. Short-term, ephemeral occupations are expected to lightly impact local prey populations, as newcomers should initially rely on more desirable (cost effective), high-ranked species and move away when they are no longer sufficiently abundant to meet the needs of the human population. As site occupation intensity increases and prey availability decreases with continued exploitation, the demand for alternative prey will also increase and ultimately alter the ratio of high- and low-ranked species captured and deposited at the site. That is, when high-ranked species are unable to satisfy the requirements of the local population, lower ranked species must be added to human diets. Different levels of site occupation intensity are thus expected to produce assemblages with varying proportions of key prey types. Low intensity occupations should create assemblages with higher proportions of high-ranked prey taxa than intensive occupations.

Because small game taxa possess a wide range of reproductive and escape strategies, they show great variation in their responses to predator pressure. Though small game are an under-studied component of Paleolithic and other assemblages (but see Davis 1989; Davis et al. 1994; Pichon 1984, 1991; Stiner et al. 1999, 2000; Tchernov 1984, 1991, 1993), they can greatly inform our interpretations of human settlement strategies and local hunting intensity.

Relative species abundance in Levantine archaeofaunas varies with time, but three small prey types dominate in Paleolithic faunal assemblages. The Mediterranean spur-thighed tortoise (*Testudo graeca*) is a slow-moving reptile (Chelonia) whose low population resilience is attested to by the population simulations presented in Chapter 6. The ease with which tortoises can be captured by humans earn them the highest rank of the small game species used in the Paleolithic Levant. Hares (*Lepus capensis*) and chukar partridges (*Alectoris chukar*) use rapid flight to evade predators. Without special tools, the capture of these animals requires a significant energy investment, and both species thus receive a low ranking. Once included in a predator's diet, however, both hare and partridge populations are noteworthy for their great resilience. They provide a reliable resource base under intense hunting conditions if capture costs can be overcome.

By coincedence, the highest ranked tortoise also has the lowest population turnover (recovery) rates, and low-ranked partridge and hare populations have the fastest population turnover rates. The pairing of these characteristics heightens the contrasting effects of human hunting pressure on small prey populations. Even low-turnover tortoise populations can comfortably sustain modest culls, and significant depletion is unlikely to occur under low hunting intensity. As hunting intensity increases, tortoise populations will soon decline. The depression of such high-ranked prey populations gives way to a shift to lower ranked partridges and hares by hunters. The relative abundances of tortoises, hares, and partridges in archaeofaunas provide a simple yet elegant gauge for detecting change in site use intensity. The small game index used here pits the absolute abundance (NISP) of the high-ranked tortoises against that of low-ranked partridges and hares (high-ranked species/high-ranked species + low-ranked species) on a scale from 0 to 1. Based on the predictions laid out earlier in this chapter, it is expected that under conditions of low site occupation intensity, the small game index will be rich in tortoises and closer to a value of one. The index value will decrease as the intensity of site occupation increases due to prolonged stays, increased population size, or a combination of the two and assemblages will be richer in partridges, hares, or both.

The small game index does not provide absolute answers. It cannot, for example, be used to compute for how many consecutive days and by how many people an archaeological site or prehistoric landscape was occupied. But it does have the power to trace the relative intensity of land use on a local scale across space and time. It can thus identify synchronic differences in site occupation intensity within a region, as well as diachronic change throughout the ca. 2500 years of the Natufian period. This lends a more quantitative dimension to current conceptions of sedentism and population pressure; moreover, it allows us to go beyond static interpretations of human demography; an important step toward refining models of agricultural origins.

Predicted Human Impacts on a Regional Scale: Hunting Pressure and Human Demography in the Mediterranean Zone

The region-level analyses investigate the impact that humans had on their environments across the Mediterranean hill zone, commonly considered the "core area" (cf. Bar-Yosef and Belfer-Cohen 1989) of the Natufian adaptation and home to the sites studied here. As explained above, regional pressure is best investigated via changes in preferred large-bodied species (e.g., ungulates). Such species occupy larger territories that are more akin to the scales at which humans use landscape than the territories of smaller-bodied mammals.

Relative changes in the impact of Natufian groups on regional resources are evaluated first by comparison to earlier Paleolithic cultures in the region, and then within the Natufian period itself. Regional pressure on ungulate resources should be expressed as "depression" of prey populations as a result of human hunting. Resource depression can be detected partly from a decrease in the ratio of low-ranked (small-bodied) to high-ranked (large-bodied) species selected by hunters but, more importantly, by distortions in the age structures of hunted prey populations. Region-level pressure is also explored with reference to the butchering intensity of gazelle carcasses and the average body size of low-turnover tortoise populations.

The proportion of large ungulates to small game reflects the availability of large game species. When large game populations are depressed by heavy exploitation, humans are forced to compensate by increasing their consumption of low-ranked prey, either smaller bodied animals or those with higher capture costs, or both. In the case of either a regional reduction in large game availability or increased human demands, hunters must increase their consumption of smaller animals in compensation. Thus, increased proportions of small game in archaeofaunas, in effect, what Flannery (1969) referred to as a "broad spectrum economy", are expected to result from the failure of large game sources to meet the demands of human populations.

The relationship between age profiles of gazelle and the average body size of tortoises hunted by the Natufians is a good indicator of regional hunting pressure. Both of these high-ranked species should be preferred by human hunters because they provide high returns in relation to pursuit costs. Both also have relatively low rates of population turnover, the tortoise having the lowest of all. Their population structures are more sensitive to human hunting pressure. If human exploitation exceeds annual recruitment, the prey population will destabilize, fall well below carrying capacity, and enter a protracted growth mode. The proportion of juveniles will be inflated in the population as females maximize productivity. For gazelle populations, this effect will be recorded in the age structure of the hunted population based on tooth eruption and wear and fusion data; the number of juveniles in the living population will increase as will their frequency in the hunted assemblage (see Chapter 8). For tortoises, which grow more continuously through life, an increase in the proportion of young individuals will be expressed as a decrease in the average body size of the hunted population. This impact will be magnified by human preferences for larger individuals, and should be expressed as a decrease in the average body size in the archaeological assemblages. Finally, gazelle butchery practices may also reflect the intensity with which the Natufians utilized animal carcasses in response to the degree of hunting pressure that human populations placed on ungulate populations. Though it can be more elusive than other indicators, butchering intensity is examined through the examination of body part representation and bone damage (see Chapter 5).

THE SAMPLE

This study centers on faunal remains from the Natufian layer of Hayonim Cave, a multicomponent site in the western Galilee of the southern Levant. Hayonim Cave is particularly appropriate for large- and small-scale diachronic comparisons because it contains Paleolithic assemblages from several cultural periods (Mousterian, Aurignacian and Kebaran), and because of the thick Natufian layer that preserves considerable temporal resolution. For practical reasons, taphonomic studies of the Natufian were limited to the approximately 20,000 specimens collected from both the Early and Late Natufian layers from Hayonim Cave. Archaeofaunal assemblages from three additional Natufian sites were examined to provide a broader regional representation of Natufian subsistence and settlement strategies in the core region of the southern Levant. Each of the sites -- Hilazon Tachtit, el-Wad Cave, and Hayonim Terrace -- is located in the Mediterranean zone of the western Galilee. This sample provides a platform from which broader shifts in Natufian demography can be assessed at site and regional levels. Though evidence from four sites is insufficient to build a complete composite picture of

Natufian settlement and subsistence, the data reveal provocative trends in site occupation intensity and shifts in regional human population density within the Natufian period. Published data from earlier Paleolithic occupations in the Levant and other Natufian sites in the Mediterranean region and beyond are consulted for comparison.

DISSERTATION STRUCTURE

This research is presented in ten chapters, commencing with the preceding discussion of the research problem and its general theoretical basis. Specifically, Chapter 2 presents a review of the paleoecology of the southern Levant during the Late Pleistocene/Early Holocene, with special emphasis on climatic change, the role of the Younger Dryas, and its implications for faunal reconstructions during the Natufian period. The sites in the study sample, their faunal assemblages, and the history of research for each site and the Natufian period in general are summarized in Chapter 3.

Chapters 4 and 5 examine the taphonomic histories of the archaeofaunal assemblages from Hayonim Cave, and to the extent that sample size allows from Hilazon Tachtit. Taphonomic studies are limited to these two sites because they are the only assemblages for which a thorough analysis of bone damage, body part representation, and fragmentation was feasible. Chapter 4 establishes which species were collected and used by humans as opposed to other bone collectors and addresses the impact of *in situ* attrition in assemblage formation. according to frequencies of bone damage and the differential representation of skeletal portions. This chapter is a crucial first step in the analysis of large-scale faunal trends presented in later chapters. The treatment of prey carcasses at Hayonim Cave and Hilazon Tachtit are detailed in Chapter 5. Prey body part profiles, fragmentation indices, and frequencies of bone damage are examined to establish the habitual methods of prey transport, butchery, and consumption by Natufian foragers. An evaluation of the intensity of prey carcass processing follows as an offshoot of these studies.

Next, the prey simulation models originally developed by Stiner et al. (1999, 2000) are reviewed in Chapter 6. Integral to this research, these simulations are used to demonstrate how relative differences in the growth rates of prey populations, affect their susceptibility to human hunting. Broad scale faunal patterns identified at site and regional levels are presented in Chapters 7 and 8, which investigate demographic trends in occupation intensity at each of the sampled sites and for the larger Mediterranean region, respectively. Chapter 7 outlines the relative abundance of broad prey types to investigate site use intensity and regional hunting pressure, reviewing first trends from the Middle Paleolithic to the Natufian, and then investigating these factors during the Early to Late Natufian transition. Chapter 8 tackles the question of hunting pressure from another angle by evaluating the mortality profiles of gazelles and the average body size measurements of tortoises to test for region-wide evidence for prey depression.

Finally, Chapter 9 summarizes the faunal data presented in earlier chapters. Along with a synthesis of published information for other material classes (e.g., lithics, groundstone and ornaments), this chapter outlines the implications of the zooarchaeological results for current interpretations of site use, settlement, and subsistence in the Natufian period that pertain to the transition to agriculture. Based on the results of this research some refinement of current models of Early and Late Natufian adaptive strategies and the origins of agriculture are suggested.

CHAPTER 2: PALEOENVIRONMENT AND PALEOCLIMATE IN THE NATUFIAN PERIOD

INTRODUCTION

Climates played important roles in shaping past environments and associated prey communities. Global climates affected the distribution, productivity, and geographic extent of the Mediterranean zone and, holding cultural adaptations constant, the human carrying capacity of the region. Paleoclimatic and paleoenvironmental change thus likely played a role in shaping Natufian demographic landscapes -- the issue under investigation here. Of particular importance are broad reconstructions of the climatic conditions, productivity, and geographic extent of the Mediterranean zone over the course of the few thousand years spanning the Pleistocene/Holocene boundary. Although high resolution climatic reconstructions are not available, warm and wet versus cool and dry cycles can be defined, and are more on par with the scales of change observable in the archaeological record. Climatic and environmental reconstructions will later be meshed with archaeological data to create broad-scale models of human demography for the Natufian period, and to address its implications for the origins of agriculture (Chapter 9).

Natufian populations exploited the full spectrum of available habitats. Their sites occur in each of the major geographic and environmental zones of the southern Levant, ranging from the arid Negev to the humid coastal plain. Still, it is the Mediterranean hills, the setting of the largest Natufian sites, that has been repeatedly defined as the

Natufian "homeland" or "core zone" (cf. Bar-Yosef and Belfer-Cohen 1989, 1991). Not surprisingly, the rich Natufian record of the Mediterranean hills has generated great interest in the archaeological community, creating a heavy research bias here at the expense of other areas. This study is no exception. Because Hayonim Cave, the centerpiece of this study, is located in the heart of the Mediterranean hills, the boundaries of this zone provide a practical spatial framework for sites sampled therein. Imposing these limits reduces the impact of environmental variation on the structure of prey communities, which is imperative since this research depends heavily on ecological models. As the home to the core of the Natufian population, the Mediterranean area is the natural place to seek answers to demographic questions of site use intensity, population packing (increased density per unit land area) and regional hunting pressure. The physiographic and ecological variability of the neighboring environmental zones of the Levant are also reviewed briefly and provide essential background to the questions to be addressed.

Each of the four Natufian sites -- Hayonim Cave, Hayonim Terrace, Hilazon Tachtit, and el-Wad -- is situated rather close to the coastal plain, either on hillside terraces or in caves in the limestone ridges that form the hilly backbone of the southern Levant. Open air Natufian sites also occur in the Mediterranean zone but, aside from Hayonim Terrace, these were either not available for study or did not preserve bone. Three of the four sites -- Hayonim Cave, Hayonim Terrace, and Hilazon Tachtit -- are located in the western Galilee, only a few kilometers from the modern town of Karmiel.

The fourth site, el-Wad, is located further south at the junction between the Carmel Ridge, the coastal plain, and Wadi el-Mughara (see Chapter 3).

CLIMATE HISTORY AND PALEOENVIRONMENTS

Reconstructions of past climatic and environmental conditions provide crucial building blocks for models of subsistence evolution. The schedule, abundance, and availability of local resources dictate human foraging decisions and have significant consequences for the organization of settlements, resource procurement strategies, and often the timing and location of sociocultural events. Much effort has been invested in reconstructing Late Pleistocene/Early Holocene climates in the southern Levant. Many data sets have been employed including those with fairly good resolution such as oxygen isotope ratios from dated ice cores, deep sea cores, and cave speleothems (Bar-Matthews et al. 1997, 1999; Frumkin et al. 1999), and pollen cores (e.g., Niklewski and van Zeist 1970; van Zeist and Bottema 1982; Baruch and Bottema 1991; Leroi-Ghouran and Darmon 1991; van Zeist and Bottema 1991; Baruch 1994). Faunal series and geomorphological observations also provide climatic evidence though on a much grosser scale (Begin et al. 1980; Macumber and Head 1991; Goldberg 1986, 1994).

Unfortunately, there are conflicting interpretations over the pollen cores primarily due to the scarcity of radiocarbon dates, and biases introduced by the readings themselves. Biases in the pollen cores became evident when Rossignol-Strick (1995, 1997) compared data from marine and terrestrial cores in the Levant. The results of her work and new evidence from dated stalagmites from Soreq Cave and a cave in Jerusalem (Bar-Matthews et al. 1999; Frumkin et al.1999), clarify the timing of environmental changes in the Late Pleistocene, and now correlate well with global climatic events in the northern hemisphere (i.e., Hillman 1996; Bar-Yosef 1998). To avoid problematic reconstructions in this study, only those climatic trends for which multiple lines of support are available and general agreement has been reached will be presented. The following reconstruction also correlates well with globally established climatic events (e.g., Kudrass et al. 1998).

Radiocarbon Date	Calibrated Date
16,000 BP ± 100	19,091
15,500 BP ± 100	18,516
15,000 BP ± 100	17,940
14,500 BP ± 100	17,365
14,000 BP ± 100	16,789
13,500 BP ± 100	16,214
13,000 BP ± 100	15,613
12,500 BP ± 100	15084, 14731, 14382
12,000 BP ± 100	14,065
11,500 BP ± 100	13,455
11,000 BP ± 100	12,999
10,500 BP ± 100	12,622, 12,472, 12,390
10,000 BP ± 100	11,545, 11,512, 11,400, 11,391,

Table 2.1: Radiocarbon dates and corresponding calibrated dates following Stuiver et al. (2000).

Though many archaeological contexts and pollen cores relevant to this research have been dated by radiocarbon, the oxygen isotope data obtained from speleothems are assigned TIMS dates, which are calendrical ages. To ensure consistency between climatic data sets, only calibrated radiocarbon dates are used only for the following discussion of paleoclimatic data. The calibrated C-14 dates are presented in Table 3.1, and the calibration curve from which these dates were obtained is presented in Figure 3.1 (data from Stuiver et al. 1998). Though, calibrated dates are used here to discuss the paleoclimatic data, the last paragraph in this section which links paleoclimatic events with the cultural periods of interest, and the remainder of this dissertation rely on traditional radiocarbon dates for discussions to ensure consistency with previous publications.

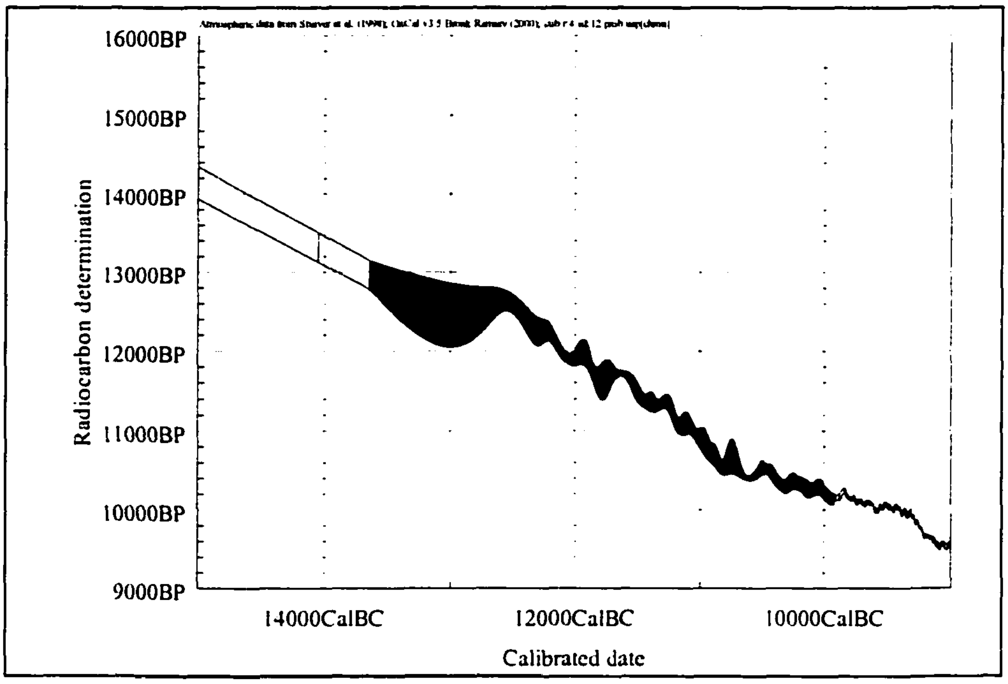


Figure 2.1: Calibration curve from Oxcal. Atmospheric data from Stuiver et al. (1998); Oxcal v. 3.5 Bronk Ramsey (2000); Cubr:4, sd:12 prob usp (chron).

An evaluation of several sources of paleoenvironmental data indicate three major climatic trends relevant to the Natufian and the periods leading up to it (see Table 2.1; Bar-Matthews et al. 1997, 1999; Baruch and Bottema 1991; Bar-Yosef 1996; Bar-Yosef and Meadow 1995; Frumkin et al. 1998; Hillman 1996; Macumber and Head 1991; Margaritz and Goodfriend 1987; Rossignol-Strick 1995, 1997; Yechieli et al. 1993). The story begins shortly after the termination of the extremely cold and dry Würm glaciation (oxygen isotope stage 3) ca. 19,000 B.P. Around 19,000 B.P. climates ameliorated as annual precipitation and mean temperatures began to rise. The warming trend (Bölling-Allerød) accelerated with the onset of the Natufian period, peaking ca. 13,500 years ago. By 13,000 B.P. the Younger Dryas, a brief, near global climatic event began and returned the Levant to almost glacial conditions (very cold and dry). The Younger Dryas terminated at the Pleistocene/Holocene boundary around 11,500 B.P., with a return to pluvial conditions just as the Natufian period came to a close and agriculture began.

Time Period and Climate	Indicator	Reference
ca. 19,000 – 13,000 B.P.	Increased arboreal pollen	Baruch and Bottema 1991
Wet and Warm	Expansion of Mediterranean forest	Colledge 1991; Henry and Turnbull 1985
	Increased water levels in Lake Lisan	Macumber and Head 1991; Yecheili et al. 1993
	High groundwater table	Macumber and Head 1991
	Paleosol formation in the Negev	Margaritz and Goodfriend 1987
	Freshwater lake existed in Sinai	Goldberg 1977
	Decrease in $\delta^{18}O$ in cave speleothems in Israel	Bar-Matthews et al. 1999; Frumkin et al. 1999
ca. 13,000 – 11,500 B.P.	Decreased arboreal Pollen	Baruch and Bottema 1991
Dry and Cool	Shrinking of Lake Lisan	Macumber and Head 1991; Yecheili et al. 1993
	Northward shift of arid-adapted snails	Margaritz and Heller 1980
	Increase in $\delta^{18}O$ in deep sea cores (global)	Kudrass et al. 1991
	Increase in $\delta^{18}O$ in cave speleothems in Israel	Bar-Matthews et al. 1999; Frumkin et al. 1999
ca. 11,500 - 7,000 B.P.	Increased arboreal pollen	Baruch and Bottema 1991
Wet and Warm	Decrease in $\delta^{18}O$ in Mediterranean sea cores	Luz 1982
	Decrease in $\delta^{18}O$ in cave speleothems in Israel	Bar-Matthews et al. 1999: Frumkin et al. 1999
	Standing freshwater in Jordan Valley	Tchernov 1994

Table 2.2: Summary of climatic indicators for time periods relevant to the Natufian period. Dates are calibrated.

After the Last Glacial Maximum: Warm and Wet Conditions

Several lines of evidence point to a warm, wet trend following the Last Glacial Maximum. This trend corresponds to the Bölling-Allerød, a significant warming event that saw temperatures and precipitation increase across the globe (Baruch and Bottema 1991). A wet, warm trend during this interval is indicated by a gradual increase in $\delta^{18}O$ values in cave speleothems at Soreq cave and at a cave near Jerusalem (Bar-Matthews et al. 1999; Frumkin et al. 1999). Pollen spectra from the Hula Lake core show dramatic increases in arboreal pollen ca. 17,000 B.P., indicating an expansion of the Mediterranean forest (Baruch and Bottema 1991). Forest expansion is further evidenced by high counts of Mediterranean tree pollens at Jordanian sites such as Wadi Hammeh 27 (Colledge 1991) and Wadi Judayid (Henry and Turnbull 1985; Sellars 1998). Today these sites sit firmly within the Irano-Turanian steppic zone and receive less than 400 mm of precipitation each year. Geomorphological data from the Wadi Hammeh reveal a long sequence of deposition in the wake of the steadily rising waters in Lake Lisan from the end of the Late Glacial Maximum to ca. 13,000 B.P. (Macumber and Head 1991). Pluvial conditions during this period are confirmed by high water tables evidenced by the highest recorded levels of groundwater discharge from the Wadi Hammeh. A bore hole in the alluvial fan of the Wadi Zeelim just south of the Dead Sea exhibits an erosional break in deposition after ca. 17,400 B.P. and before ca. 13,300 B.P., pointing to wet conditions (Yechieli et al. 1993). Finally, the formation of paleosols along the northern fringe of the Negev desert prior to ca. 13,000 B.P. indicates a period of high moisture beginning ca. 18,000 B.P. according to Margaritz and Goodfriend (1987).

The Younger Dryas

The Younger Dryas (ca. 13,000-11,500 B.P.) was a brief, yet intense cool and dry climatic event that interrupted a larger trend toward climatic amelioration (Overpeck et al.

1989). The Younger Dryas has been identified by spikes in the oxygen isotope ratios of deep sea cores (Kudrass et al. 1991) in diverse parts of the world. Local increases in $\delta^{18}O$ values are also preserved in the speleothems from caves in central Israel, attesting to the sudden onset of dry, cool conditions associated with the Younger Dryas (Bar-Matthews et al. 1999; Frumkin et al. 1999). Pollen spectra also record evidence for the Younger Dryas in Israel (Baruch and Bottema 1991) and across the globe (Engstrom et al. 1990; Heusser and Rabassa 1987). A reduction in the arboreal pollen in the Hula core reflects a contraction of the Mediterranean forest, signaling drier and colder conditions (Baruch and Bottema 1991). The Ghab pollen core from the Orontes region in Syria shows a similar cold, dry peak, however, the pollen data does not match up chronologically with that of the Hula core most likely due to problems with the dating of the Ghab sequence mentioned previously (Bar-Yosef and Valla 1991). According to Macumber and Head (1991) the rapid drying of Lake Lisan shown by the cessation of sedimentation, and the initiation of downcutting in the Wadi al-Hammeh at ca. 13,000 B.P. corresponds to increasing aridity associated with the Younger Dryas. Yechieli et al. (1993) also attribute the deposition of a thick salt layer in the former Lake Lisan to the shrinkage of the lake, which caused saturated salts to concentrate and precipitate. Finally, studies of the geographic ranges of land snails in the northern Negev indicate that the border between the desert and the Mediterranean zone shifted north after 13,000 B.P. (Margaritz and Heller 1980), attesting to an expansion of the arid steppes and deserts during the Younger Dryas.

The End of the Natufian: A Warm, Wet Trend

The Younger Dryas came to a close ca. 11,500 B.P., at the beginning of the Holocene. After this date, conditions in the Levant were warmer and wetter than today, but never reached temperatures of pre-Younger Dryas proportions (Bar-Yosef 1996). Significant decreases in the oxygen isotope ratios obtained from Mediterranean Sea cores and dating to the Early Holocene attest to improved conditions. Declines in the oxygen isotope ratios are attributed to an influx of glacial melt water and freshwater runoff from the continent in response to increased temperatures and precipitation (Luz 1982). The Hula pollen spectrum is marked by increased arboreal pollen counts in the Early Holocene, indicating a re-expansion of the Mediterranean forest. Even so, deciduous trees that prefer warmer climates never reached their full distribution, and more drought-resistant conifers continued to dominate. Finally, faunal assemblages from Pre-Pottery Neolithic A (PPNA) sites in the Jordan Valley, including Netiv Hagdud and Gilgal, are rich in freshwater bird and rodent species, indicating proximity to a substantial body of fresh water (Tchernov 1994). These observations are supported by the presence of pollen from several aquatic plant species at Netiv Hagdud (Leroi-Gourhan 1991; Leroi-Gourhan and Darmon 1987)

Paleoclimate and the Natufian Cultural Sequence

Clearly, the Natufian culture did not arise under a harsh climatic regime as was once thought, but during a period of mild climatic conditions (Baruch and Bottema 1991; Bar-Yosef and Valla 1991). During the Early Natufian, the Mediterranean zone, the richest of the Levantine habitats, was at its broadest extent, and precipitation and temperatures were at their post-glacial peak. Interestingly, the dramatic climatic changes of the Younger Dryas correspond to the beginning of the Late Natufian phase (ca. 11,500 B.P.). Populations living in the core Natufian area were faced with shrinking habitats, and probably associated declines in resource productivity per unit land area. The end of the Younger Dryas ca. 10,000 years ago correlates with the disappearance of the Natufian adaptation. Subsequent re-expansion of the Mediterranean forest and the return to warmer and wetter conditions coincides with the appearance of the first agricultural settlements in the Jordan valley, where rich alluvial soils provided a suitable setting for early agriculture.

The transitions, first from the Early to the Late Natufian, and then to the Neolithic period, both correspond to broad-scale climatic change. Although I do not imply that climate played the determining role in Natufian adaptations, it certainly had the potential to reshape habitats, redistribute resources, and alter productivity in the Mediterranean zone and surrounding regions. Fluctuating paleoclimatic and paleoenvironmental conditions undoubtedly contributed to the conditions selecting for cultural change.

THE ENVIRONMENTS OF THE SOUTHERN LEVANT

Geographically and ecologically the southern Levant is strikingly diverse, despite its small size. Topographic complexity in the region has created a rich mosaic of climatic and ecological zones (Zohary 1982). Today, the southern Levant occupies a strip along the Mediterranean coast south of Damascus. It includes much of modern-day day Israel, the Palestinian territories, Lebanon, and the Sinai as well as western Jordan and Syria.

Geographically, it represents the southwestern reaches of the so-called Fertile Crescent (Braidwood 1960), a great arc of rich habitats extending from the Levant to the Zagros mountains and the birth place of the earliest agriculture and animal husbandry. Ecological diversity also results from the region's geographic location at a major crossroads between two continental land masses -- Eurasia and Africa. Throughout prehistory, the Levant has been a "suture zone" for the Palearctic plant and animal communities of Eurasia and the tropical biotas of Africa, which shifted across the Levant in tandem with climatic change (Tchernov 1988).

Geographic and Vegetation Zones of the Southern Levant

The southern Levant is characterized by four distinct but narrow geographic belts which run in north/south bands paralleling the Mediterranean Sea. From east to west these include the coastal plain, the hilly zone, the rift valley, and the Jordanian plateau. Each of these zones was occupied with varying intensity by Natufian foragers between ca. 12,800 and 10,200 years ago. Temperature, humidity, and precipitation vary markedly between zones, tending to be highest in the west and declining to the east. Resulting variation in vegetation cover and resource availability had significant influence on food supplies of local foraging groups.

Three major vegetative communities occupy the undeveloped areas of the Levant today (Horowitz 1979; Zohary 1982), and their compositions appear to have changed very little since the Natufian period. The distribution of the three communities depends primarily on available moisture, and secondarily on elevation. Saharo-Arabian communities occur in the driest regions with Irano-Turanian and then Mediterranean communities in areas with progressively higher precipitation. During the Natufian period these habitats were all occupied by human foragers, though patterns of use shifted over time.

The Coastal Plain

The coastal plain is a narrow strip of flat land adjacent to the Mediterranean Sea. It is widest at its southernmost point near Gaza and narrows as it extends north to the Israel/Lebanon border, where the coastal hills descend directly into the Mediterranean Sea. The coastal plain is characterized by interlocking areas of fertile soil, marshes, and sand dunes. A series of calcareous sandstone ridges or kurkars run north south along the coast; these mark former beach transgressions created by fluctuating sea levels during the Pleistocene period (Klein 1988). In several periods, the kurkars blocked the flow of water from the wadis to the Mediterranean and created marshlands between the hills and the sea. These habitats were exploited by Late Pleistocene humans for resources such as fish and waterfowl. Humidity and precipitation are high on the coastal plain due to its proximity to the sea. Moisture is greatest in the north and diminishes to the south. North of Gaza the vegetation of the coastal plain is largely Mediterranean-type scrub forest (Zohary 1982), but the region is also home to a variety of small shrubs and grasses that thrive in dune and marshy environments. Saharo-Arabian communities characterize the southern half of the coastal sand dunes (Horowitz 1979).

Many Natufian sites, including those of interest here, are located at the edge of the Mediterranean zone within a few kilometers of the coastal plain. Few Natufian sites have been found on the coastal plain, contrasting with the preceding Geometric Kebaran

Period. Mediterranean shells and sandstone beads in Natufian deposits indicate that these populations exploited marine resources for ornaments, though at fairly low intensities (Bar-Yosef and Belfer-Cohen 1989, 1991; D. Bar-Yosef 1991; Reese 1991; Weinstein-Evron 1998). There is no evidence to suggest that the Natufians used marine mollusks for food.

The Hill Zone

Moving east, the hill zone rises from the coastal plain in a series of low but steep limestone ridges that reach a maximum elevation of 1,208 m in the Galilee and 1,010 m in the Negev. Running south to north, the Levant's hilly backbone stretches from the Sinai, through the Negev Desert into Samaria and Judea, and finally the Galilee and Lebanon where it joins with the Lebanon Mountains. Precipitation in the hill zone is partly determined by local elevation but generally declines from north to south. This cline in available moisture corresponds to a gradient in plant and animal community composition.

In the Levant, the amount of precipitation is most strongly determined by storm tracks originating over the Mediterranean Sea that send precipitation across the region in a cline that decreases from north to south (Margaritz and Goodfriend 1987). Precipitation is trapped according to elevation and local topography. Mediterranean summers tend to be hot and dry, averaging 28°C in August. Winters are cool and wet with an average January temperature of 12°C (Katsnelson 1966). Precipitation falls almost exclusively in winter, creating a sharp contrast between the winter and summer seasons. Mediterranean-type plant communities are found primarily in the north and central region in areas receiving between 400 and 1200 mm of rain each year. In the southern Levant, Mediterranean communities are located primarily in the hilly regions north of the Beer Sheva Basin, as well as in the Jordan Valley north of the Kinneret and the Mediterranean coast north of Caesarea.

The Mediterranean hills are composed of hard Upper Cretaceous limestones and dolomites as well as soft chalky limestones formed from Eocene and Senonian marls (Zohary 1982). The hard limestones produce terra rossa soils with high clay components, while the chalky limestones break down into brownish-grey rendzina soils that favor the growth of cereal grasses and forbs. The climax vegetation of the southern Levantine Mediterranean community is dominated by a maquis forest composed of trees and shrubs, including several species of oak (i.e., *Quercus calliprinos*, *Q. infectoria* and *Q. ithaburensis*), pistachio (*Pistachio palestina),* arbutus (*Arbutus andrachne*), Syrian maple (*Acer syriacum*), *Cercis siliquastrum* and *Platanus orientalis*. Pines, most notably *Pinus halepensis,* also grow at the highest elevations but only on rendzina soils (Horowitz 1979). Common shrubs include *Poterium spinosum*, *Salvia triloba*, *Phlomis viscosa*, *Teucrium divaricatum* and *Majorana syriaca*.

South of modern-day Beer Sheva, Irano-Turanian type vegetative communities occupy the hill zone. In the southern Levant the Irano-Turanian community thrives primarily in semi-arid steppic regions that receive between 200 and 400 mm of precipitation annually. Extreme temperatures and low moisture restricts the growing season to the spring and early summer months. Classic Irano-Turanian communities are dominated by grasses and herbs with scattered trees and shrubs.

Finally, like the southern coastal plain, the hilly regions of the southern Negev are occupied by Saharo-Arabian type communities. This zone is characterized by arid desert and limited by low precipitation which rarely exceeds 200 mm per annum. The seasonal cycle oscillates between hot dry summers and mild winters with all precipitation falling during the winter. Plants are arid-adapted and seed only in response to moisture, growing rapidly when conditions are wet enough for germination. Vegetation is extremely sparse and in some areas grows only in drainages. Dominant flora include *Zygophyllum dumosum* and *Anabasis articulata.*

The Jordan Rift Valley

East of the hills is the Jordan Valley, a fault system that is part of the northern extension of the Great Rift Valley, which originates in sub-Saharan Africa. In the Levant, the Rift Valley extends from the Gulf of Aqaba northward through the Arava to the Dead Sea, where plate tectonics have created the lowest elevation on earth (396 m below sea level). North of the Dead Sea, the Rift passes through the Jordan Valley to the Kinneret (Sea of Galilee), and finally into the Hula Valley at 200m above sea level. From there the Rift extends north to the Orontes Valley in Syria.

The Jordan Valley formed from strong downward tectonic movement and simultaneous uplift of the shoulders that flank its east and west sides (Horowitz 1988). The most recent episode of uplifting occurred 18,000 years ago. Despite being the southern Levant's primary water system, much of the Jordan River has a semi-arid to arid climate due to its location in a rain shadow of the western hills. The area is characterized by Mediterranean habitats in the north, Irano-Turanian communities in the central Jordan Valley, and Saharo-Arabian habitats south of the Dead Sea.

During the Natufian period the eastern hills adjacent to the Jordan Valley were dotted with small sites which have been interpreted as seasonal camps for the exploitation of rich stands of wild grasses (Bar-Yosef 1996). The alluvium in the valley is rich and fertile due to frequent replenishment by the Jordan River, and many areas are in close proximity to permanent water sources suiting the area for cultivation. In the Pre-Pottery Neolithic A (PPNA) period that followed, a number of sites were established in the Jordan Valley. Not surprisingly, it is at two of these sites, Gilgal and Netiv Hagdud, that the earliest evidence for the cultivation of wheat and barley in the Levant was recovered (Bar-Yosef 1989).

The Jordanian Plateau

The Jordanian Plateau was created by the uplifting of the Transjordanian block during the Oligocene and Miocene Eras (Henry 1989). The Plateau rises sharply from the Rift Valley and then levels off, sloping gradually eastward to the Syro-Arabian desert. Today the region is semi-arid to arid. It is covered primarily by a steppic Irano-Turanian vegetation, which gradually gives way to a desertic Saharo-Arabian regime to the east, though patches of Mediterranean maquis are present along the northwestern plateau overlooking the Jordan Valley.

Throughout the Natufian period, communities were firmly established on the Jordanian Plateau. Numerous recent surveys and excavations in Jordan have uncovered many sites ranging from large Natufian "base camps" to small activity areas (e.g., Beaver

2000; Byrd 1989a; Byrd and Rollefson 1984; Edwards et al. 1988; Garrard 1991; Garrard and Gebel 1988; Henry and Turnbull 1985; Sellars 1998).

RESOURCE AVAILABILITY, SEASONALITY AND SETTLEMENT

As stated earlier, the Mediterranean hill zone defines the boundaries of the region studied here. The Mediterranean hills zone is the richest of the Levantine habitats, particularly those areas receiving between 400 and 800 mm of annual rainfall. The region is home to the highest diversity of plant species and the greatest faunal biomass in the Levant, much of which is suited for human consumption (Bar-Yosef and Meadow 1995; Mendelssohn and Yom-Tov 1999; Uerpmann 1987). Potential food resources include a number of wild cereal grasses such as einkorn (*Triticum monococcum*) and emmer wheat (*T. dicoccum*), and barley (*Hordeum distichum*), which inhabit open areas within the forest. Legumes, such as lentils (*Lens culinaris*) and vetches (*Vicia sativa* and *V. ervilia*), and fruit- and nut-bearing trees including pistachio (*Pistacia* sp.) and oaks (*Quercus* sp.), are also naturally abundant (Harlan 1967; Zohary 1982).

Prior to the historic period, the Mediterranean community provided lush browse for several ungulate species, particularly gazelle (*Gazella gazella*), fallow deer (*Dama mesopotamica*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), aurochs (*Bos primigenius*). and wild goat (*Capra aegagrus*), though the relative abundance of these ungulates differed with habitat, and some species were always more common than others (i.e., gazelle and fallow deer). The abundance of ungulates fluctuated throughout the Pleistocene as a result of local climatic conditions. The open park forests also supported abundant, permanent populations of small animals such as the Mediterranean spur-thighed tortoise (*Testudo graeca*), cape hare (*Lepus capensis*), hedgehog (*Erinaeceus europaeus*), Persian squirrel (*Sciurus anomalus*), and game birds of the Phasinidae family (Mendelssohn and Yom-Tov 1999). The position of the Levant on a major flyway between Africa and Eurasia has created one of the most diverse avifaunas in the world. The region also provides a permanent home to many year-round resident species, in addition to summer and winter migrants (Yom-Tov 1988).

Resource productivity in the Mediterranean zone is seasonal, so the availability of consumable biomass fluctuates throughout the year. Most grasses ripen between April and June, and fruits and nuts are available between September and November, though a few species can be harvested during the winter months (Bar-Yosef and Meadow 1995; Flannery 1969). The availability of most seed-producing plant species is restricted to a short harvest period. For example, barley begins to ripen during the late spring and early summer months, but the seeds are mature in only a few short weeks. Human foragers clearly required tight scheduling to optimize their use of the energy offered by the Mediterranean community. The availability of fauna is less tightly linked to a seasonal schedule, with the exception of some avian species. Although herd composition changes, mountain gazelle populations, native to the Mediterranean zone in prehistory, occupy relatively stationary territories today (Mendelssohn 1974), and were likely similar in the past. Though the Persian gazelle (*Gazella subgutturosa)* which occupied the neighboring arid regions of the Levant in prehistory is a migratory species that congregated in large herds during certain seasons (Legge and Rowley-Conwy 1987), there is no evidence that the mountain gazelle engaged in similar behavior (*G. gazella*) (Mendelssohn 1974). Animal resources may undergo significant changes in the composition of body tissues (i.e., decrease in body fat during the lean season) in response to seasonal forage availability, which may alter their desirability to human hunters.

In the Levant, the staggered yet strict timing of resource availability (particularly of plant foods) tied prehistoric foragers to a seasonal cycle, while providing reliable access to a composite of resources throughout the year. Because the major ecological zones are so narrow and habitat contents so diverse, the foraging returns could be greatly improved by foraging in adjacent locales. Resources that became available in different seasons and habitats could be accessed from a single home base via logistical forays, particularly for those sites situated in ecotones (Bar-Yosef and Meadow 1995; Hillman et al. 1989). Residing in ecotones or in areas with high geographic diversity also potentially expanded the harvest season for widespread resources, since ripening schedules vary with temperature, precipitation and elevation.

Though similar geographic conditions existed for thousands of years, the special ecology of the Levant is of great significance, perhaps especially during the Natufian period. By the Natufian there is substantial evidence (e.g., groundstone and sickle blades) for high investment in the procurement and processing of small, expensive resources such as cereals and nuts that are generally inaccessible without the proper equipment (Unger-Hamilton 1989, 1991; Wright 1991, 1994). Accessibility to these new plant foods greatly expanded resource productivity per unit land. This point, as well as the paleoenvironmental reconstructions presented above, will be integrated later with changing patterns in game use in the Natufian period.

CHAPTER 3: THE SAMPLES: THE NATUFIAN SITES AND FAUNAL ASSEMBLAGES

HISTORY OF RESEARCH: THE NATUFIAN IN THE SOUTHERN LEVANT

The Natufian culture was first identified by Dorothy Garrod during her excavations at Shuqba Cave in the Wadi-Natuf in the 1920s (Garrod and Bate 1928). Garrod's (1932) definition of the Natufian culture was based on several features of the lithic industry: abundant lunate-shaped microliths; the presence of sickle blades and picks; and the use of the microburin technique to segment blades for microlith production. Further subdivision of the Natufian period into Lower and Upper phases resulted from Garrod's excavation at Shuqba and el-Wad in the Mount Carmel Ridge. The divisions were made according to differences in the average length of lunates, the frequency of bifacial Helwan retouch, and the presence or absence of the microburin technique (Garrod 1932; Garrod and Bate 1928, 1937). The Lower Natufian was characterized by significantly larger lunates and higher frequencies of Helwan retouch than the Upper phase. The microburin technique was attributed to the Upper but not the Lower Natufian phase.

Around this time, Neuville (1934, 1951) also discovered evidence for Natufian occupation in the Judean desert, confirming the distribution of the Natufian culture beyond the Mediterranean zone. In the 1950s Stekelis began excavations at Nahal Oren, and Perrot commenced work at the newly discovered open-air site of Ain Mallaha (Perrot

1966; Stekelis and Yizraely 1963). By the 1960s, a new era of Natufian research was initiated with the work of Bar-Yosef, Tchernov, and Arensburg, who introduced new excavation standards to Levantine archaeology in their quest to recover paleoenvironmental information at Hayonim Cave (Bar-Yosef and Tchernov 1967). An intense period of exploration in the 1970s and 1980s followed, with the initiation of several survey projects outside the traditional Mediterranean zone. Many new sites were identified in the Irano-Turanian and desertic zones of the Negev, Jordan, Lebanon, and Syria (Betts 1987; Byrd 1989a; Byrd and Rollefson 1984; Cauvin 1977; Edwards et al. 1988; Garrard 1991; Garrard and Gebel 1988; Goring-Morris 1987, 1991; Henry and Turnbull 1985; Henry et al. 1985; Marks and Larson 1977; Moore 1982). It soon became clear that the original definition of the Natufian culture was inadequate for addressing the cultural diversity of far-flung sites that extended from the Negev to the northern reaches of the Euphrates (Bar-Yosef 1983; Cauvin 1977). Although the sites were similar in the presence of lunates, they showed great variation in other cultural attributes that frequently corresponded to geographic and environmental variation (Byrd 1989b; Goring-Morris 1987; Henry 1977; Olszewski 1987, 1988, 1991, but see Belfer-Cohen 1991). These discoveries called for a refinement of the definition of the term Natufian, to account for cultural attributes other than stone tool forms.

Bar-Yosef and Belfer-Cohen (1989, 1991; Bar-Yosef 1981; 1983; Belfer-Cohen 1989; 1991) emphasize the importance of non-lithic attributes for defining the range of variation within the Natufian culture. They identify the Mediterranean zone of the southern Levant as the "core" Natufian area. Sites from the core area are characterized by a suite of attributes including the presence of architectural features, cemeteries, rich groundstone and worked bone traditions, ornaments, and mobiliary art. As a suite these features are found nearly exclusively in Natufian sites within the Mediterranean ecological zone, sites in neighboring areas possess some but not all of these traits.

The expansion of research also led to refinements in the Natufian chronology. Although the lunate remains the "fossile directeur" of the Natufian culture, variations in its average dimensions and the frequency of Helwan retouch have been used to differentiate the period into Early and Late phases (Bar-Yosef 1981, 1983; Bar-Yosef and Valla 1979), corresponding to the Lower and Upper phases that Garrod originally identified at Shuqba and el-Wad (Garrod and Bate 1937). Garrod's use of lunates as chronological markers was largely correct, though it is now clear that the microburin technique, which she originally attributed to the Upper Natufian, can be present in both Early and Late Natufian sites (Bar-Yosef 1983; Valla 1987). The Early Natufian phase dates between ca. 12,800 and 11,000 B.P. and is characterized by long lunates with high frequencies of Helwan retouch. Beginning ca. 11,000 B.P. and terminating by 10,200 B.P., the Late Natufian is characterized by shorter lunates and significantly lower frequencies of Helwan retouch. A variation on this chronology has been suggested by Valla (1987), who proposes that the last 300 years of the Late Natufian be attributed to a Final Natufian period (ca. 10,500 – 10,200 B.P.). This is marked by even shorter lunates than those of the Late Natufian phase. Because of the brevity of the phase and the small sample of sites assigned to it, the Final Natufian rarely appears in this study (see also Byrd 1987).

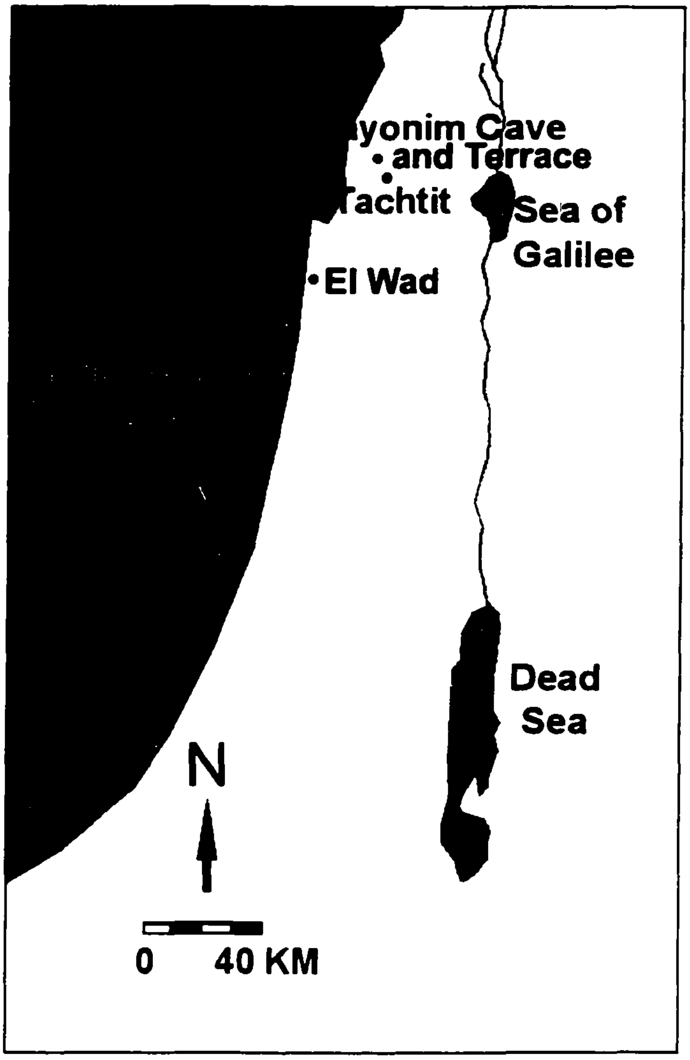


Figure 3.1: Map of Natufian sites in the study sample.

Site	Cultural Period	Excavator	References
Hayonim Cave	Early/Late Natufian	O. Bar-Yosef	Bar-Yosef 1991; Bar-Yosef and Goren 1973; Belfer-Cohen 1988
El-Wad	Early Natufian	M. Weinstein-Evron	Weinstein-Evron 1998
Hayonim Terrace	Late Natufian	F.R. Valla	Valla et al. 1989, 1991
Hilazon Tachtit	Late Natufian	L. Grosman	Grosman in prep

Table 3.1: Natufian sites and time phases investigated here, as well as the excavator and applicable references for the Natufian faunal assemblages.

THE SITES

The Natufian layer from Hayonim Cave is central to this study, though assemblages from several other sites play important supporting roles, Hayonim Terrace, Hilazon Tachtit, and el-Wad Cave (Figure 3.1; Table 3.1). Though the assemblages from the latter three sites are limited in size, they provide breadth to the Natufian sample and enable the reconstruction of broader trends in human demography and subsistence change just prior to the transition to agriculture. Ideally, the sample of sites would be larger, encompassing all available Natufian faunal assemblages from the Mediterranean Levant. However, the kind of detailed information required for this study is simply not available from many published Natufian sites.

Pre-Natufian Assemblages

Assemblages from earlier occupations in the area of Hayonim cave, including the Kebaran, Levantine Aurignacian, and Early Mousterian from Hayonim Cave and the Late Upper Paleolithic and early Kebaran from Meged Rockshelter provide the evolutionary context for the Natufian analysis (Kuhn et al. in prep; Rabinovich 1997; Stiner and Tchernov 1998; Stiner et al. 2000). Temporal gaps are filled using published data from Natufian and earlier sites where appropriate data are available (e.g., Bar-Oz et al. 1999; Bouchud 1987; Crabtree et al. 1991; Davis 1978, 1980a, 1981, 1982, 1983; Davis et al. 1994; Horwitz n.d.; Pichon 1984, 1991; Speth and Tchernov 1998, 2000; Tchernov 1993a; 1993b).

Hayonim Cave

Hayonim Cave is a multicomponent site that sites 230 meters above sea level in

Figure 3.2: View of Hayonim Cave.

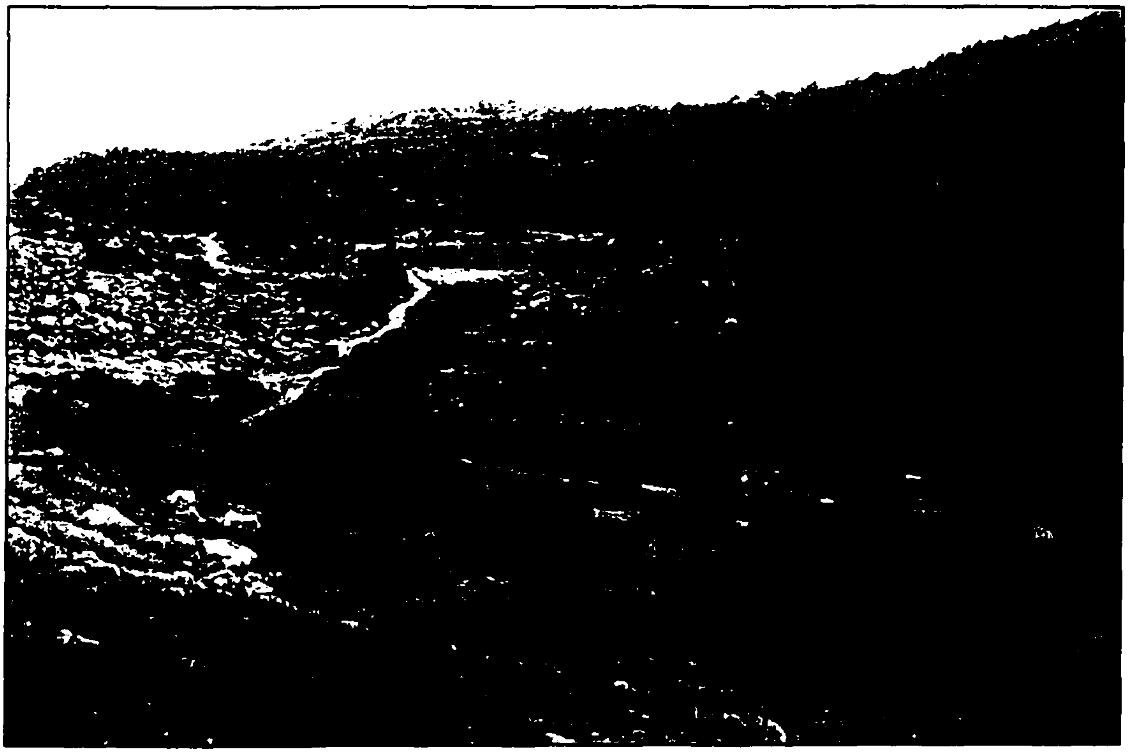


Figure 3.3: View of local environment from Hayonim Cave. Olive and pine trees are recently planted.

the Mediterranean foothills (see Figure 3.2 and 3.3). The site is located 13 kilometers east of the Mediterranean Sea in the Wadi Meged, close to the juncture of the Mediterranean foothills and the coastal plain. The cave's multiple chambers were formed by karstic activity in a Cretaceous limestone ridge. The surrounding countryside is composed of fairly steep limestone hills vegetated by classic Mediterranean maquis forest. Today, the site receives between 500 and 600 millimeters of precipitation annually.

The archaeological potential of Hayonim Cave was first brought to the attention of Ofer Bar-Yosef during a geological survey of the area in the early 1960s (Bar-Yosef 1991). Bar-Yosef joined forces with Eitan Tchernov and Baruch Arensburg to test the site in 1965. Testing revealed a long Paleolithic sequence in the cave's easternmost chamber (Figure 3.4) and plans were made to begin excavations the following year. Paleoenvironmental reconstruction -- a major goal of the investigators -- required the recovery of microscopic materials including pollen, microfauna, sediment, and botanicals that had not been collected by earlier excavators in the region. Since its inception, the project has maintained consistent high standards of recovery, providing a faunal assemblage that represents the full size spectrum of fauna deposited in the site via both natural and cultural processes.

Hayonim Cave was home to multiple human occupations during the Paleolithic periods. The primary cultural layers have been labeled from A to G. Layers A to E are described fully by Bar-Yosef (1991), and only a brief summary is presented here (Table 3.2). Layer A is a thick layer of deposits that has accumulated since the end of the

Pleistocene. At its base is a Byzantine glass furnace constructed roughly 2000 years ago. The furnace is capped by a series of thin burned layers approximately three meters thick, formed when shepherds set fires to rid the cave of goat dung and associated vermin that accumulated while it was used as a winter shelter for local goat herds. The burned layers were covered with additional dung that accrued in recent years.

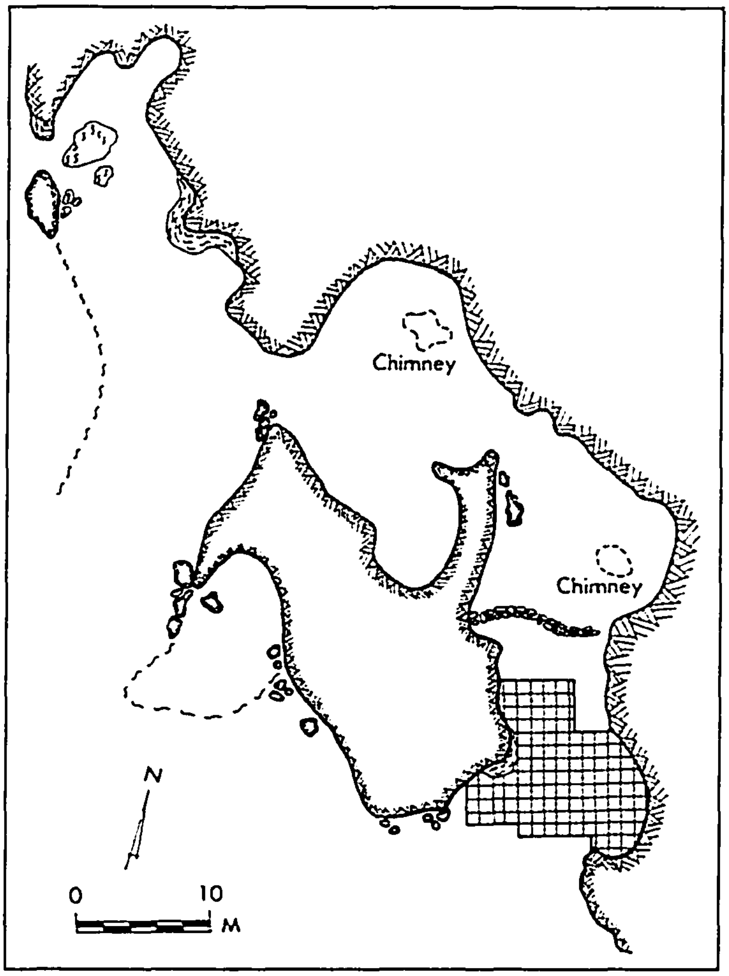


Figure 3.4: Plan of Hayonim Cave with Natufian excavation units indicated in the main chamber. Adapted from Bar-Yosef and Goren (1973).

LAYER	CULTURAL PERIOD	TIME RANGE
A	Byzantine and Recent	ca. 2,000 B.P. - recent
B	Early and Late Natufian	ca.12,500-11,000/10,700 B.P.
C	Kebaran	ca. 16,000-20,000 B.P.
D	Aurignacian	ca. 27,000-29,000 B.P.
E	Mousterian	ca. 70,000- 200,000 B.P.
F	Early Mousterian	>200,000 B.P.

Table 3.2: Archaeological layers and time ranges at Hayonim Cave.

Layer B, the primary subject of this dissertation is the Early/Late Natufian horizon. The majority of the deposits are located near the mouth of the cave, and can be distinguished from earlier layers by a high density of unmodified limestone blocks that were brought into the cave as building materials. Two burned lupine seeds from the Natufian layer have been dated by AMS and yield radiocarbon dates of 12,010 ± 180 B.P. and 12, 360 ± 160 B.P. (Bar-Yosef 1991; Hopf and Bar-Yosef 1987).

The Kebaran period Layer C, also situated near the entrance of the cave and directly beneath the Natufian layer, ranges between 1 and 2.3 meters in thickness. The Aurignacian Layer D is a thinner deposit located only toward the back of the cave in a depression formed in the top of earlier Mousterian sediments by dripping water. Layer E is a thick early Mousterian deposit with comparatively low artifact density. This layer covers a huge area extending from just outside the mouth of the cave across most of the cave's interior. Most of the deposits are brecciated, but the quality of preservation is surprisingly good in much of the cave. Layer F, an even older Mousterian layer, is differentiated from Layer E by changes in sediment and lithic technology. Finally, Layer G has only recently been discovered in the deep sounding at the entrance of the cave. Though only a small volume of sediment has been excavated, numerous hand axes have been recovered. Faunal remains are well preserved in all but the lower Mousterian (F) levels and Layer G. This provides a remarkable sequence for comparative analyses.

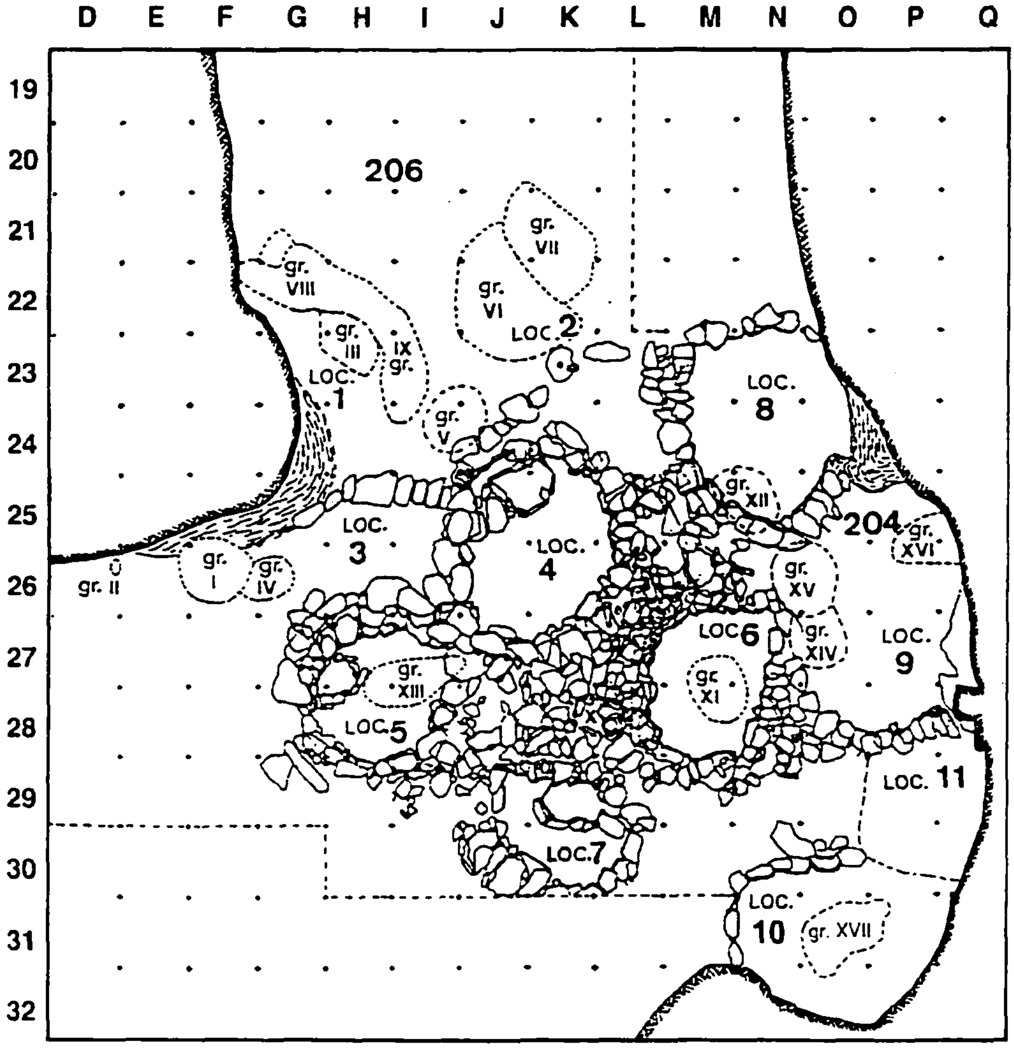


Figure 3.5: Plan of the excavations of the Natufian layer at Hayonim Cave, showing circular loci (Loc.) constructed from undressed limestone, and graves (Gr.). Adapted from Bar-Yosef and Belfer-Cohen (1999).

The Natufian Layer of Hayonim Cave

The Natufian layer at Hayonim Cave is marked by a high concentration of undressed limestone manuports taken from the surrounding hillside (see Figure 3.5).

These stones were used to build architectural features, primarily circular structures referred to as loci (see Figure 3.6). There are at least ten loci just behind the drip line of the cave. These structures comprise the main area of the Natufian layer, which ranges in thickness from a few centimeter to one meter near the entrance of the cave (Bar-Yosef 1991; Bar-Yosef and Belfer-Cohen n.d.).

Figure 3.6: View of Locus 8 at Hayonim Cave following excavation. Note built hearth at top, center of photo, and walls of undressed limestone constructed by the Natufian inhabitants.

The Natufian stratigraphy and features of Hayonim Cave is assigned to five temporal phases (Bar-Yosef and Belfer-Cohen n.d; Bar-Yosef 1991; Belfer-Cohen 1988). The phases correspond to a chronological sequence of building and occupation events and link deposits from spatially segregated areas in the cave. Spatially, the site is divided into

Loci, Graves, and Areas, each with its own stratigraphic sequence. Loci are bounded by low circular walls of undressed stone. Nine loci (3-11) have been identified, but Loci 9, 10, and 11 have only been partly excavated. Open spaces, designated Areas 201–206, are situated between and on top of the loci. Though areas lack the spatial integrity and distinct architecture of loci, they are characterized by independent sequences of archaeological layers. Most but not all of the areas cap deposits in the loci, and most represent later stages of Natufian occupation in the cave. Seventeen graves were also excavated, but faunal remains from only a few are included in this study (Graves X-XII and XIV-XVII). Several graves were dug into earlier Mousterian, Aurignacian, and Kebaran deposits in the cave causing mixing in the fill. Those graves with potentially mixed fills are excluded from the sample.

Each layer from loci, areas, and graves is assigned to one of five chronological phases (Belfer-Cohen 1988). The phases are used here mainly to examine relative change in the use of the site over time. The phase assignments are based purely on stratigraphic relationships between archaeological layers and are independent of cultural markers recovered from the fill. The Phases are numbered from I to V, with Phase I representing the earliest Natufian occupation in the cave and Phase V the latest. The temporal relationship between the phases is relative, as they have not been dated using absolute methods. Thus, attempts to link spatially segregated areas of the site may prove difficult. As a final note, the stratigraphy of Locus 10 and Grave XVII, which were excavated during a renewed field project in the cave during the 1990s, have not yet been linked with deposits uncovered during the original excavations. They certainly belong to the Early

Natufian occupation, but to which of the first three phases is unclear. The layers from these two areas therefore receive a phase designation of I-III, and will be collapsed with data from the Early Natufian phases of occupation in some later analyses.

Besides loci and graves, the Natufians built other kinds of features at Hayonim Cave. Built hearths were found in most fully excavated Loci (see Figure 3.6). Slab-lined floors were laid in Loci 4, 5, and 7 and Graves V and XI, and a small lime kiln was identified in Locus 4 (Bar-Yosef 1991). Three caches dating to the Late Natufian phase were also found along the easternmost wall of the cave. One cache contained a stash of large bovid ribs, several of which had been worked into preforms for sickle handles; the second held groundstone pestles; and the third was filled with numerous unworked male gazelle horn cores and *Dentalium* shells (Bar-Yosef 1991).

The Natufian layer at Hayonim Cave contains one of the richest, most diverse Paleolithic assemblages in the southern Levant (see Table 3.3). The lithic assemblage is characterized by single platform cores used primarily for flake production, though most Natufian tools were manufactured from blades. The microburin technique is exceedingly rare. Common tool types include burins, notches, denticulates, geometrics, borers, backed pieces, bifacial tools, sickle blades, and picks (Belfer-Cohen 1988). The bone tool assemblage is also diverse. It is primarily comprised of awls, spatulates, bone points, and gorgets used for a variety of activities including hide-working, sewing and weaving, hunting, and possibly even fishing (Campana 1991). Several modified bones also served ornamental or possibly ritual functions. Recovered primarily from human burials, beads were most commonly manufactured from the compact bone of ungulate long bone shafts, the distal tibiotarsi of partridges, and fox canines (Belfer-Cohen 1988; Pichon 1983). Decorative plaquettes with hatched incisions were manufactured from thin, flat bones and antler fragments. Flat limestone slabs incised with geometric, ladder-like patterns were also found in both loci and graves (Bar-Yosef and Belfer-Cohen 1999; Belfer-Cohen 1988).

Natufian Phase	Vol. Exc. (M^3)	Lithic Tools	Dentalium	Bone Tools	Groundstone	Fauna NISP
I	7.08	930	256	91	87	2634
II	5.51	513	160	47	72	1376
III	9.21	667	421	64	92	1854
IV	10.2	948	811	157	161	3626
V	15.15	1094	626	127	150	2788
Total	**47.15**	**4152**	**2274**	**486**	**562**	**12278**
Early Natufian	21.8	2110 (96.8)	837 (38.4)	202 (9.27)	251 (11.5)	**5584 (269.0)**
Late Natufian	25.35	2042 (80.6)	1437 (56.7)	284 (11.2)	311 (12.3)	**6414 (253.0)**

Table 3.3: Table of major artifact classes for five phase of occupation at Hayonim Cave. Data from all artifact classes except fauna compiled from Belfer-Cohen (1988). The counts include only material recovered from the original Natufian excavations during the 1960s and 1970s. For the Early and Late Natufian summary, the numbers outside of parentheses are total frequencies for each artifact class, while the numbers in parentheses are density values (n/m^3 excavated sediment). The lithic tool class includes only selected categories, which are shown in more detail in Chapter 9.

Hayonim Terrace

Hayonim Terrace is a large open-air site covering more than 1000 square meters (Bar-Yosef and Goren 1973). Both Early and Late Natufian occupations are present at the site, which is located directly outside the mouth of Hayonim Cave. Hayonim Cave and Terrace have usually been treated as separate entities, because there is no continuous stratigraphy linking the two areas. They also have different excavation histories. Typological analysis of the respective faunal assemblages indicates that at least portions of the two sites were occupied during the Late Natufian, though the main occupation phase at Hayonim Cave was in the Early Natufian phase (Bar-Yosef and Belfer-Cohen n.d.; Valla et al. 1991).

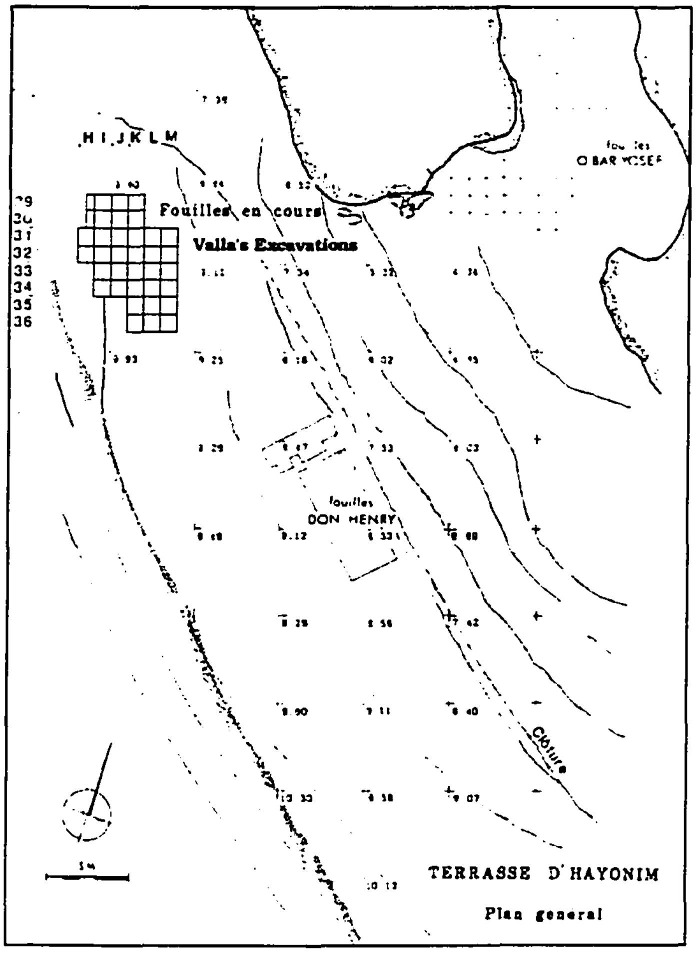


Figure 3.7: Plan of Hayonim Terrace and Cave showing the location of Bar-Yosef's Natufian excavations at Hayonim Cave, and Henry and Valla's excavations on the Terrace (adapted from Valla et al. 1991).

Hayonim Terrace was excavated on three separate occasions by different teams. The first work there was done by Bar-Yosef, Arensburg, and Tchernov in association with the testing of Hayonim Cave in 1966 and 1969. Two test trenches on the upper terrace revealed evidence for a Natufian occupation. Although both were unquestionably Natufian in character, the assemblages recovered from the two trenches differed from one another (Bar-Yosef and Goren 1973). Following testing, Bar-Yosef and his team opted to excavate the cave, and invited Donald Henry from the University of Tulsa to excavate the Terrace (Bar-Yosef 1991).

Henry began a formal excavation at Hayonim Terrace in 1974, and completed the project the following season (Henry and Davis 1974; Henry and Leroi-Gourhan 1976; Henry et al. 1981). His objectives included the reconstruction of environmental conditions, subsistence strategies, and cultural chronology, and establishment of the relationship between the Natufian and the preceding Geometric Kebaran Period. Henry first opened an 8 x 1 meter trench and subsequently a larger 5 x 7 meter area (Area A) that was separated from the test trench by a 1 meter baulk (Henry and Davis 1974; see Figure 3.7). Both the trench and Area A contained Early Natufian deposits and an underlying Geometric Kebaran component.

The most recent excavations at Hayonim Terrace, which provided the data for this study, were initiated by François Valla in 1980. Work continued for seven seasons between 1980 and 1989 (Valla et al. 1989, 1991). Valla's 36 square meter sounding was located at the northwestern end of the Terrace, approximately 10 meters from Henry's trench (see Figure 3.7). The excavations exposed three layers of archaeological deposits, Niveaux (Levels) I-III. Niveau I represents mixed material from Natufian and probably a later PPNA occupation on the Terrace. Niveau II is a clean layer of Natufian deposits, and Niveau III is predominantly Natufian. The latter, however is partially mixed with a small Geometric Kebaran component, likely an extension of the much larger concentration found in Henry's trench. Although no built-up hearths or slab-lined floors

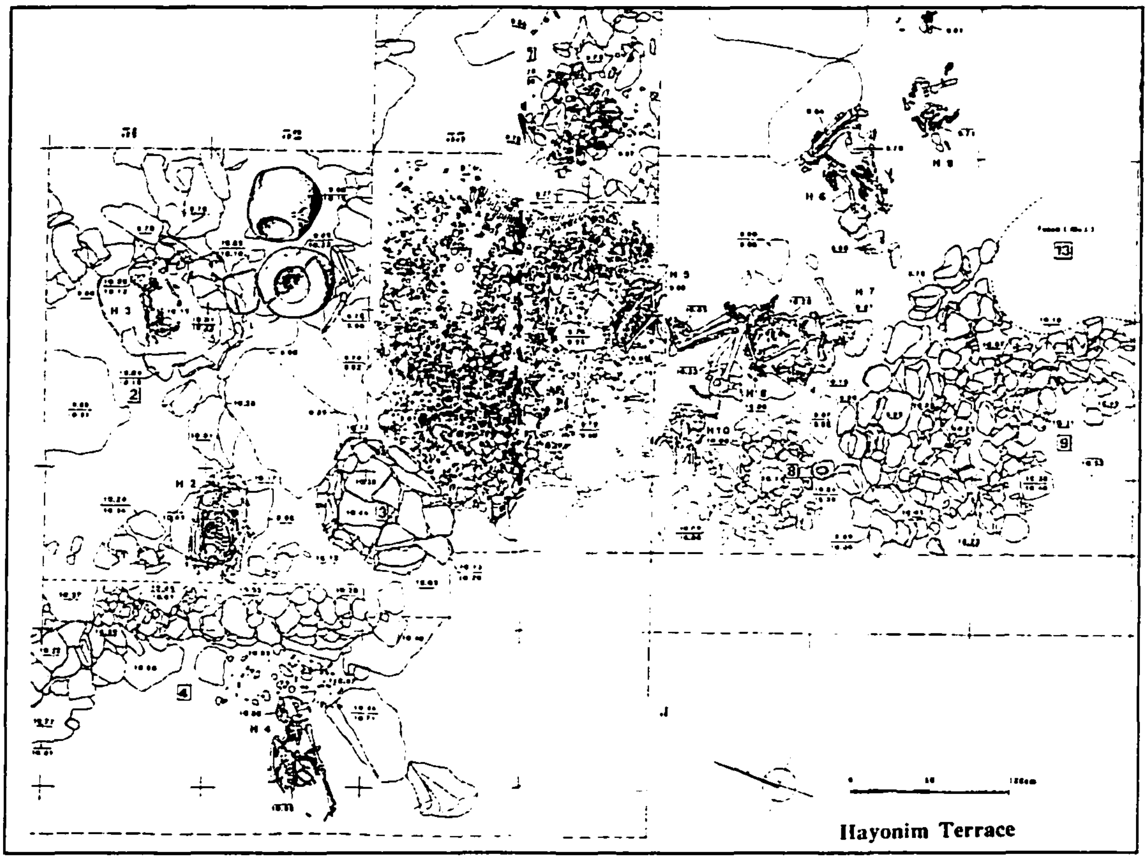


Figure 3.8: Plan of François Valla's excavations of Hayonim Terrace (adapted from Valla et al. 1991).

those from the cave were found on the terrace, a few walls and structures as well as a single slab-lined pit interpreted as a storage chamber were identified (Valla et al. 1989; see Figure 3.8). Valla's excavations also uncovered six shallow graves, some with multiple individuals. Of particular interest is one that contained two humans, two canids, two tortoise shells, and two gazelle horn cores; this grave is frequently cited as evidence of dog domestication in the Natufian period (Tchernov and Valla 1997). No ornaments were recovered from any of the Hayonim Terrace burials. The lithic assemblage from Valla's excavations on the Terrace is rich in notches, denticulates, burins, and geometric microliths, particularly backed lunates. Incidence of Helwan retouch on lunates is rare, but this is not unlike the Late Natufian in Hayonim Cave; microburin technique, on the other hand, is much more common on the Terrace than in the Cave (Bar-Yosef and Belfer-Cohen n.d.).

Hilazon Tachtit

Hilazon Tachtit is a Natufian cave site located approximately 7 kilometers southeast of Hayonim Cave. Only 14 kilometers west of the Sea of Galilee, and a few kilometers east of the coastal plain, the site is situated within the Mediterranean zone. The site is located in the middle of a steep limestone ridge 150 meters above the Wadi Hilazon (Figures 3.9 and 3.10). The cave itself is comprised of two small intact chambers formed by karstic activity within the Yanuch limestone formation, dating to the Cenomanian of the Cretaceous Era (Grosman n.d.). Evidence of prehistoric occupation in the Wadi Hilazon was noted by Bar-Yosef and Valla during a survey of the valley in the late 1960s. In 1994 Berger and Khalaily returned to the site and collected artifacts of Mousterian, Kebaran, and Natufian origin from colluvial deposits just below the mouth of the cave (Grosman n.d.). The first excavations took place in the summer of 1995 under the direction of Grosman and Berger. Two additional field seasons were undertaken in the summers of 1997 and 2000 under the sole direction of Grosman. A fourth field season in the summer of 2001 is not reported here. A radiocarbon date on charcoal from Natufian layer has recently yielded a date of 10,750±150 B.P. The presence of short lunates and a low incidence of Helwan retouch, also suggests that the site dates to the end of the Late Natufian phase.

Figure 3.9: View of Hilazon Tachtit Cave.

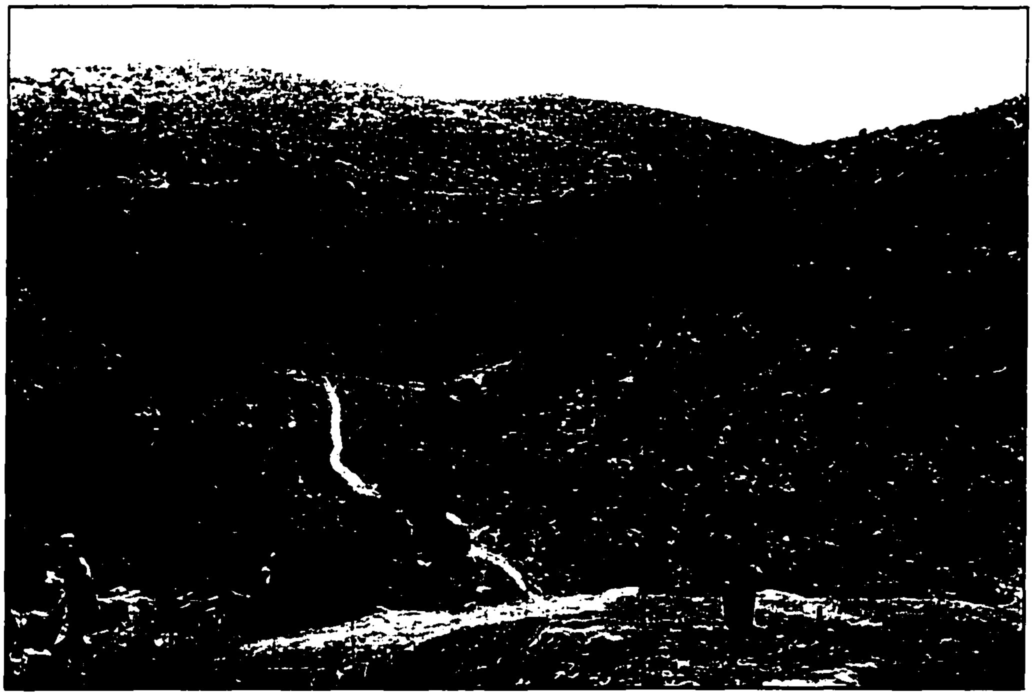


Figure 3.10: View looking east from the mouth of Hilazon Tachtit Cave.

The archaeological deposits at Hilazon Tachtit were capped by a 1.3 meter-thick layer of dung, that had been deposited by goat herds wintering at the site in recent years. During the 1997 season, the site was vandalized and the dung set on fire. The fire smoldered through the winter, and the team returned the following year to find the thick dung layer reduced entirely to ashes. Fortunately, the fire did not affect the archaeological deposits, which were protected by an additional 1.5 meter thick deposit containing the residue of past burns by historic herders. Some ceramic sherds, probably of Byzantine origin, were recovered from these burned layers, and some migrated into the Natufian deposit below. At the base of the dung layer a thin, black, greasy layer of sediment sealed the top of the Natufian deposits. Fourier-transform Infrared (FTIR) analysis indicates that this layer is extremely rich in organic matter, deposited after the Natufian occupation but before use of the cave by herders (L. Grosman, personal communication 2000). The top of the Natufian layer at Hilazon Tachtit begins at a depth of approximately 2.95 meters and is characterized by a homogenous dark, oily sediment and very good macroscopic bone preservation. A number of human burials are distributed throughout the fill. Many are disturbed, perhaps due to leveling of the Natufian deposits by visitors to the cave in historic times. Though architectural features on the scale of those found at Ain Mallaha or Hayonim Cave have not been recovered at Hilazon Tachtit, two distinct circular structures (Loci 1 and 2; see Figures 3.11 and 3.12) enclose areas rich in lithic and faunal debris. Human remains are found both within these areas and outside of them.

The lithic assemblage from Hilazon Tachtit is comprised primarily of geometric and non-geometric microliths, retouched flakes, and notches. The microburin technique is absent, as are lunates with Helwan retouch. The lunates at Hilazon Tachtit are backed and very short on average (16.4 millimeters). The small groundstone assemblage (n = 17) is composed of mullers, pestles, and a single mortar. Although, the bone tool industry is dominated by awls and bone points, a needle was also recovered. A single unusual animal tooth pendant was also found. It is the lower carnassial tooth of a canid pierced through both roots. The tooth is of special interest due to claims for the domestication of the dog in the Natufian period. *Dentalium* from the Mediterranean Sea and other typical Natufian ornaments were also recovered at Hilazon.

Figure 3.11: Natufian layer at Hilazon Tachtit, at the close of the summer 2001 excavations. Photo courtesy of L. Grosman.

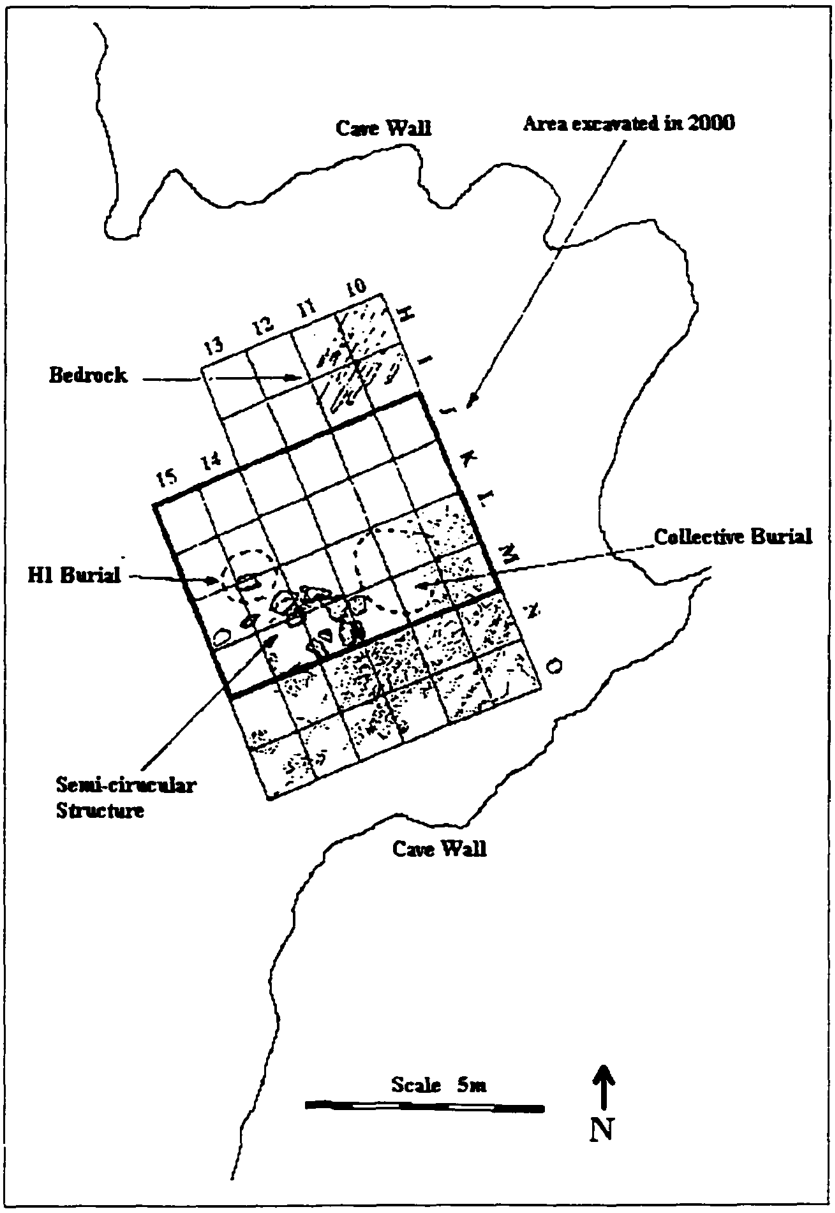


Figure 3.12: Plan of 2000 excavations at Hilazon Tachtit, courtesy of L. Grosman.

el-Wad

el-Wad Cave is the largest of the three large caverns in the Mount Carmel cave group. The caves are situated at the southern extent of the Mount Carmel ridge, a limestone formation rising from the coastal plain 3.5 kilometers east of the modern

Mediterranean Sea shore (see Figure 3.13). This area is an ecotone located at the junction between the coastal plain and Mediterranean zones. el-Wad sits 45 meters above sea level on a 12.5 meter escarpment just above the coastal plain and adjacent to the Wadi el-Mughara (Garrod and Bate 1937). Behind the cave, the limestone ridge rises to the north and west to a maximum height of 546 meters. The ridge and wadi host a thriving canopy of Mediterranean maquis and pine forest (Weinstein-Evron 1998). Today, the climate at el-Wad is much the same as it is further north at Hayonim Cave, but with slightly heavier seasonal precipitation each year (600 to 800 millimeters). el-Wad is a multi-chambered cavern widest at its entrance but quickly narrowing into a long passage that extends 70 meters into the hillside. Though the passage is generally narrow it widens into "chambers" at locations numbered from I to V by Garrod in 1929 (see Figure 3.14).

el-Wad has a long excavation history that began in the Fall of 1928, when the site was tested by Charles Lambert. Lambert sunk two trenches on the terrace and one in the cave. His discovery of rich Natufian deposits both in and outside of the cave saved the Mount Carmel caves from plans to open a limestone quarry there (Bar-Yosef and Callander 1999; Weinstein-Evron 1998). One year later, Dorothy Garrod began an intensive excavation of the site that lasted five full seasons (1929-1933). Over the course of these excavations Garrod completely removed the fill from Chambers I, II, and part of Chamber III in the cave. Her team opened 270 square meters on the terrace and talus slope, digging until bedrock was reached (Garrod and Bate 1937). She discovered that el-Wad was a multicomponent site with few areas of clearly superimposed stratigraphy. Garrod identified Mousterian, Levantine Aurignacian, and both Early and

Figure 3.13: View of the Carmel Caves from the coastal plain. el-Wad is the cavern on the far left.

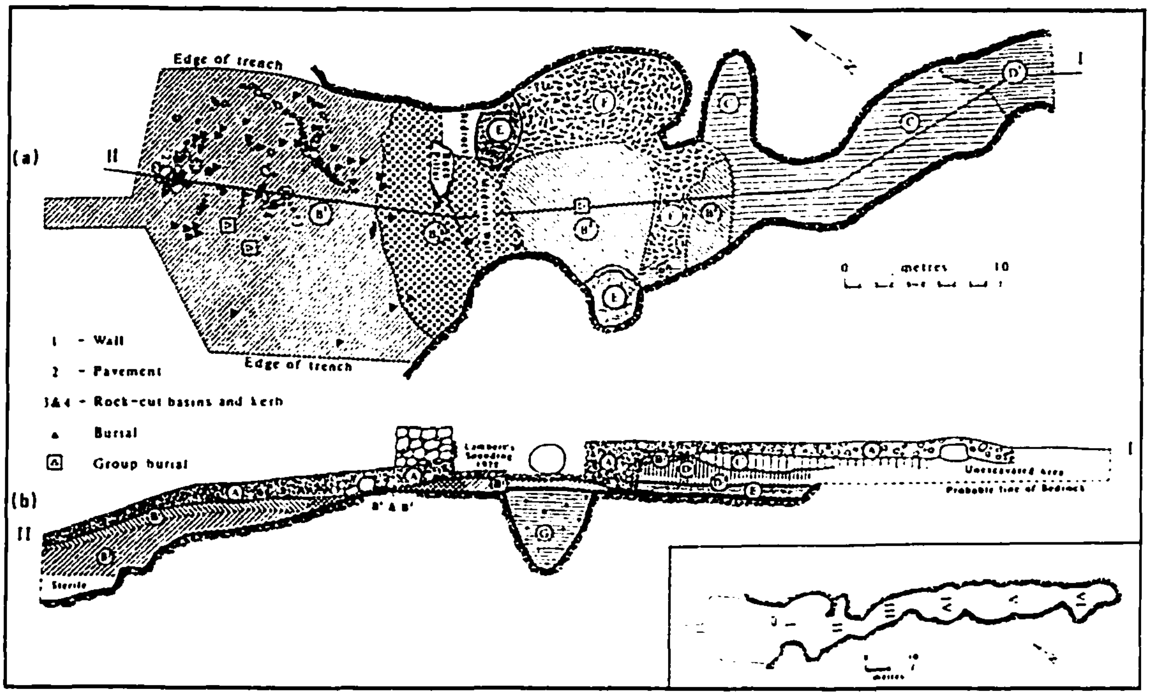


Figure 3.14: Garrod's original map of el-Wad Cave and Terrace (originally from Garrod and Bate 1937, but adapted from Weinstein-Evron 1998), showing the extent of the excavations, layers and stratigraphy. Layer A is recent, Layer B1 is Early Natufian, B2 is Late Natufian, C, D, E and F are Upper Paleolithic and G is Middle Paleolithic.

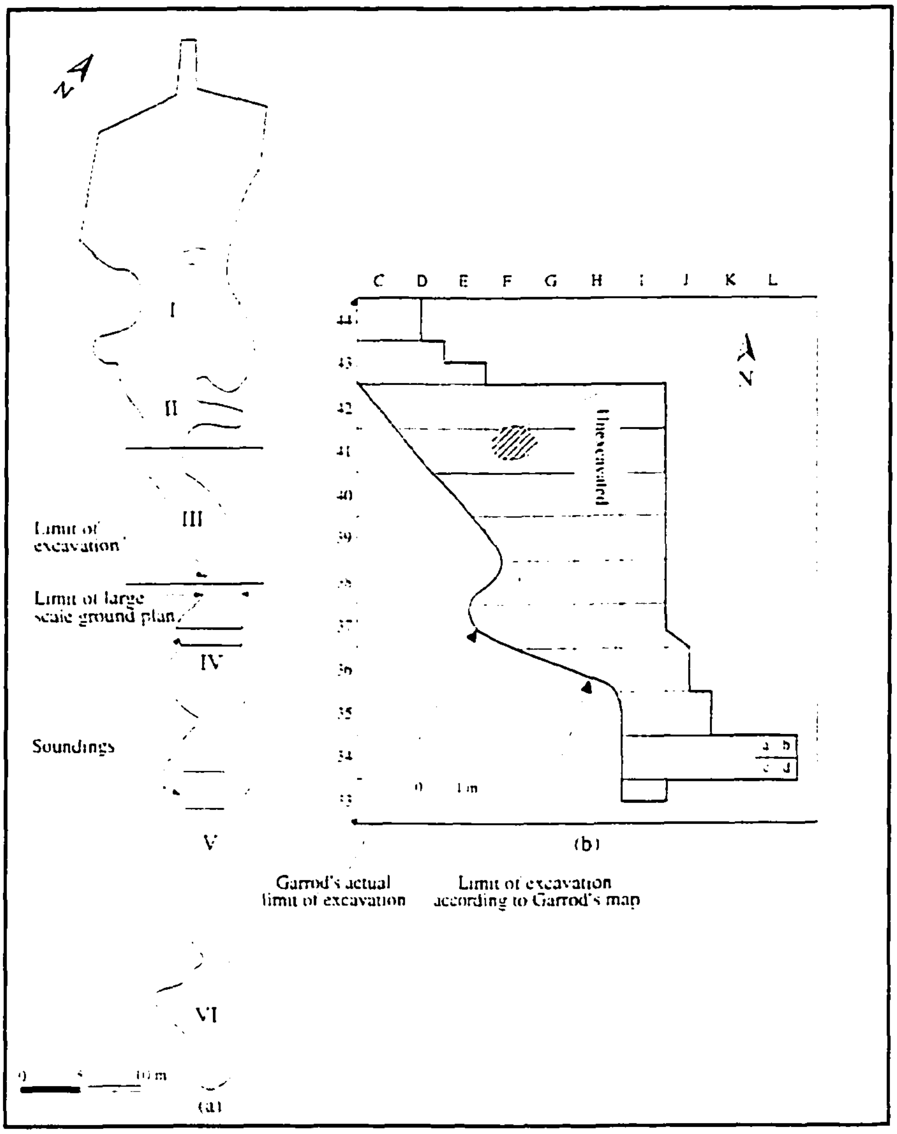


Figure 3.15: Map of area excavated during Weinstein-Evron's salvage project in Chamber III of el-Wad Cave. Adapted from Weinstein-Evron (1998).

Late Natufian deposits in various patches within the cave, but only Natufian deposits on the terrace (Figure 3.15).

Garrod's excavations exposed extremely rich Natufian deposits, particularly those of the Early Natufian. She uncovered numerous features, including bedrock cup marks, a stone curb, a stone wall, a built hearth, and a slab pavement at the base of Layer B1 on the terrace. Layer B1 was also rich in bone tools, ornaments (stone and bone beads), and mobiliary art, including two sculpted objects: a cervid carved from a large animal long bone and a roughly shaped human head manufactured from calcite. Though Layer B2 included many of the same classes of material objects as Layer B1, their diversity and abundance was much reduced in comparison to the preceding Early Natufian phase (Garrod and Bate 1937).

Bar-Yosef and Valla returned to the terrace at el-Wad in the 1980s to check and refine the stratigraphy using modern excavation methods. Valla et al. (1986) confirmed the presence of Garrod's Layers B1 and B2, and the assignment of B2 to the Early Natufian, but they further divided Layer B1 into Late and Final Natufian components. The presence of Early, Late, and Final industries makes el-Wad the only Natufian site other than Ain Mallaha to contain the full temporal sequence of the Natufian. According to archaeological indicators, the Early Natufian occupation at el-Wad was the most intensive, extending over the entire excavated area on the terrace and into Chambers I, II, and III in the cave (Garrod and Bate 1937; Valla et al. 1986). The thinner Late and Final deposits are limited to the terrace, and cover less area than the Early Natufian layer. Although, the only Paleolithic inhabitants of the terrace at el-Wad were the Natufians, the stratigraphy in the cave is much more complex. Deposits in the cave have formed in pockets that extend unevenly across its floor. This means that several cultural deposits may be present at any given depth inside the cave, although the areal extent of each layer is limited. Likewise, a trench at one end of a chamber may reveal a very different sequence of layers than one excavated only a few meters away. Because of close contact between the layers and confusion over exactly where each begins and ends, some mixing between layers in the cave has undoubtedly occurred.

Although Garrod removed most of the deposits from Chambers I and II in the cave, Chamber III was not completely excavated, and some Early Natufian deposits were left intact. It is from these deposits that the el-Wad sample analyzed in this study was obtained (Figure 3.16). In 1988 a team led by Mina Weinstein-Evron of Haifa University initiated a salvage effort in Chamber III. Soon after, a walkway was constructed in the area to facilitate access to the cave for visitors (Weinstein-Evron 1998). Though most of the deposits in Chamber III have been assigned an Early Natufian age, the assemblage is characterized by much lower frequencies of lunates, sickle blades, and awls than the Early Natufian assemblages from Chambers I and II in the cave. The Chamber III deposits do, however, contain typical Natufian groundstone, artwork, and faunal remains, as well as some lunates. The latter led Weinstein-Evron (1998) to interpret the deposits as a specialized activity area from the Early Natufian phase. A second archaeological deposit in Chamber III causes some uncertainty. This layer underlies and extends beyond the Early Natufian layer in several directions. The lithic assemblage is virtually indistinguishable from the one assigned to the Early Natufian, except that no lunates and only a small proportion of microliths are represented. Although Weinstein-Evron (1998) suggests that the layer may be of Late Upper Paleolithic origin, she does not discount the possibility that it may also be associated with the Early Natufian layer above. This as yet unresolved issue does not affect the sample studied here, which originates solely from the overlying Early Natufian layer.

In the past few years, another excavation has been opened on el-Wad Terrace, under the direction of Weinstein-Evron and Kaufman. The new excavations are located on the north end of the terrace just beyond the extent of Garrod's original excavations. Because the Natufian deposits on the terrace have been disturbed, some mixing has occurred, making it difficult to isolate Early and Late Natufian assemblages (Guy Bar-Oz, Personal Communication, 2001).

THE FAUNAL ASSEMBLAGES

The four Natufian assemblages analyzed for this study were collected by different teams of excavators who, fortunately, shared high standards of data recovery. Each assemblage was dry screened using 2 millimeter mesh, wet-sieved, and "picked" in some if not all stages of data recovery. The importance of high standards of recovery cannot be overemphasized because this project uses the relative abundance of small game faunas to address some major questions. In general, the preservation in each assemblage is very good, particularly in the three samples that originated from caves (Hayonim Cave, Hayonim Terrace, and Hilazon Tachtit). The fauna from Hayonim Terrace were coated in a calcareous outer sheath. Once removed, the underlying fauna is in remarkably good condition, yet there is no doubt that the strength of the concretions had the potential to crush small, fragile bones. This may explain the poor recovery of avian specimens from Hayonim Terrace.

Hayonim Cave

Portions of the Hayonim Cave Natufian fauna have been studied by several researchers with a range of research goals. Tchernov (Bar-Yosef and Tchernov 1967) undertook the first analysis, studying the sample recovered from the 1965 test excavations. The assemblage was small, but provided an accurate preview of some broad trends that would emerge later. Davis' (1978) dissertation research focused on the ungulates and carnivores excavated during the first field seasons at Hayonim Cave up to 1975. The excavations during these seasons were concentrated at the back of the cave where several graves were located (Rows 19, 20, 21, 22). Much of this area is excluded from the present analysis for fear of contamination, because the Natufians dug several of these graves into the underlying Aurignacian deposits. Although Davis' study was insightful, particularly his identification of a temporal change in the age composition of gazelle populations, much of the fauna he examined is excluded from this study due to potential mixing of the deposits with earlier layers. Davis mentions the presence of diverse small game species, he did not quantify them in his study.

In 1984, Pichon completed her dissertation on the avifauna of the Natufian layer from Hayonim Cave. Like Davis, she studied the birds recovered only in the first few excavation seasons, as the fauna excavated in the final seasons had not yet been sorted. Pichon's study provides a thorough analysis of the wide spectrum of avian species deposited at Hayonim Cave, from the microfauna to the largest raptors. Pichon's avian sample and her identifications are clearly labeled in the Hayonim Cave assemblage. A portion of this sample came from potentially mixed contexts and was thus excluded here.

In areas where the current sample overlapped with Pichon's, her identifications of rare species were checked against the comparative avian collection in the Department of Evolution, Systematics and Ecology at the Hebrew University and were then adopted here. The avian sample was bolstered significantly by fauna excavated in the late 1970s and 1990s.

Other, more specialized analyses of the Hayonim Cave fauna were undertaken by Cope (1991a, 1991b) who reanalyzed the ungulates from the sorted assemblage and argued for a specialized Natufian gazelle economy that preferentially targeted adult males. In the late 1980s Lieberman (1991, 1993) examined cementum from gazelle teeth to determine the seasonality of site occupation. Most recently, Bar-El and Tchernov (2001) sampled the hare assemblage as part of a region-wide examination of *Lepus* exploitation in the Natufian period.

Despite the plethora of research on the Hayonim fauna, the assemblage has never before been examined in its entirety or treated as a complete unit. This has precluded any comparative analyses between taxonomic groups, and has prevented researchers from detecting broad scale changes within the Natufian period itself. All faunal samples that have been examined to date were treated as a single Natufian component, masking both temporal and spatial variation within the site. For this study, the entire Hayonim Cave assemblage was analyzed, with the exception of fauna from potentially mixed contexts, or fauna with incomplete provenience information, and microfauna. This required the study of collections that had been sorted and curated by taxonomic group in Eitan Tchernov's lab at the Hebrew University, as well as a re-sort of the original excavation bags, which contained a large sample of identifiable material that had not yet been removed (ca. 5000 pieces).

The Natufian layer from Hayonim Cave is in direct contact with other cultural layers (including Byzantine, Kebaran, Aurignacian, and Mousterian). The Natufians excavated many of their graves into older cultural deposits, and later occupants disturbed the surface of the Natufian layer, particularly the Byzantines, who dug a glass furnace into Late Natufian layer. By "potentially mixed context" I refer to deposits that are stratigraphically assigned to the Natufian, due to their proximity to deposits from other layers, but have a greater chance of containing intrusive materials. Potentially mixed contexts are expected to contain predominantly Natufian-aged faunas, but they are excluded from analyses of relative species abundance to ensure that the patterns reported in upcoming chapters are clean and accurate. Secure cut-off depths for the Natufian deposits were determined in consultation with Ofer Bar-Yosef and Anna Belfer-Cohen and based on field maps, notes, and firsthand knowledge of the complex stratigraphy of the Natufian layer. The upper and lower cutoff depths for each square and subsquare from the Natufian excavations are presented in Appendix 2. At 15,000 NISP, the sample from secure contexts is ample, and each phase is represented by roughly equal numbers of bones, eliminating the potential for sample size bias (Table 3.4). Comparisons indicate that the fauna analyzed from potentially mixed contexts before the final cut-off points were determined (NISP = 3000), closely resembles those from secure contexts (see Chapter 7). Although, the sample from potentially mixed contexts is excluded in any analyses requiring data on relative species abundances, it is drawn upon for more general taphonomic discussions.

Natufian Phase	Natufian Period	Fauna NISP
I	Early	2430
II	Early	2202
III	Early	2005
I-III	Early	1459
IV	Late	3425
V	Late	2048
Phase Unknown	n/a	1489
Total	n/a	**14998**

Table 3.4: Size (NISP) of faunal samples by Natufian phase at Hayonim Cave.

Hayonim Terrace

The fauna recovered from the original test pit dug by Bar-Yosef (Bar-Yosef and Tchernov 1967) and Henry's excavation have been analyzed in part (Henry et al. 1981). In addition to the Hayonim Cave fauna, Davis (1978) reported on the ungulates and carnivores from Henry's excavation in his dissertation. Cope (1991a, 1991b) and Lieberman (1991, 1993) also sampled the ungulates from Henry's excavations in their dissertation research. More recently, Horwitz (n.d.) studied the fauna from Valla's mixed Niveau I, and attempted to separate the PPNA and Natufian components using taphonomic indicators. Aside from an in-depth study of the *Canis* sp. burials (Tchernov and Valla 1997), no other analyses on the Natufian faunal assemblage from Niveau II have been undertaken.

The sample from Hayonim Terrace studied here was recovered entirely from Niveau II of the main trench excavated by F. Valla, and dates to the Late Natufian phase.

Preliminary work on the assemblage was completed under the direction of Rivka Rabinovich. This included cleaning the bones with weak acetic acid to remove concretions, and sorting identifiable fragments into drawers organized by element. For this study, the NISP of the Terrace collection was calculated by tallying the taxon and element of all identifiable fauna, excluding microfauna from the sorted drawers.

To ensure that the exclusion of identifiable fragments in the unidentifiable fraction would not bias the results presented here, a sample of "unidentifiable splinters" was examined and all identifiable material was counted and compared to the species represented in the sorted fraction (Figure 3.16). The resulting profiles differ significantly because of a large quantity of tortoise carapace and plastron fragments that remain mixed in with the unidentifiable splinters. Because Figure 3.16 compares proportions of major game groups, the large discrepancy in the number of tortoises make it appear as if the remaining groups are underrepresented in the unidentifiable fraction. In Figure 3.17 the tortoises have been removed from the analysis, and the resulting proportions from the sorted and splintered fractions are virtually identical. Clearly, it is only a significant difference in the abundance of tortoises that causes the discrepancy in Figure 3.16, and I am confident that the relative proportions of all taxa other than tortoises reported here are accurate, even without additional sorting of the splintered material. The tortoise fraction is, however, underrepresented, as are corresponding proportions of small game. Because both tortoises and small game are already common in the Terrace assemblage, this discrepancy only serves to strengthen the results presented later (see Chapter 7).

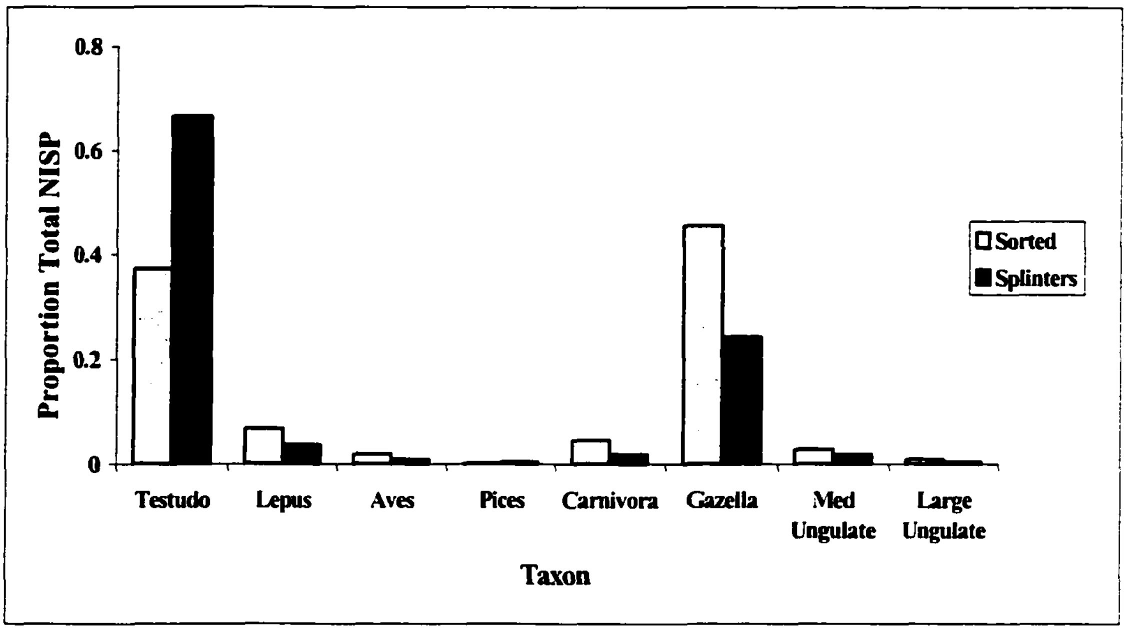


Figure 3.17: Relative abundance of major game groups from the Late Natufian occupation at Hayonim Terrace. "Sorted" bars represent identifiable bones that were removed from the "unidentifiable" splinters prior to this analysis. "Splinter" bars represent identifiable bones removed from a sample sorted from the "unidentifiable" fraction.

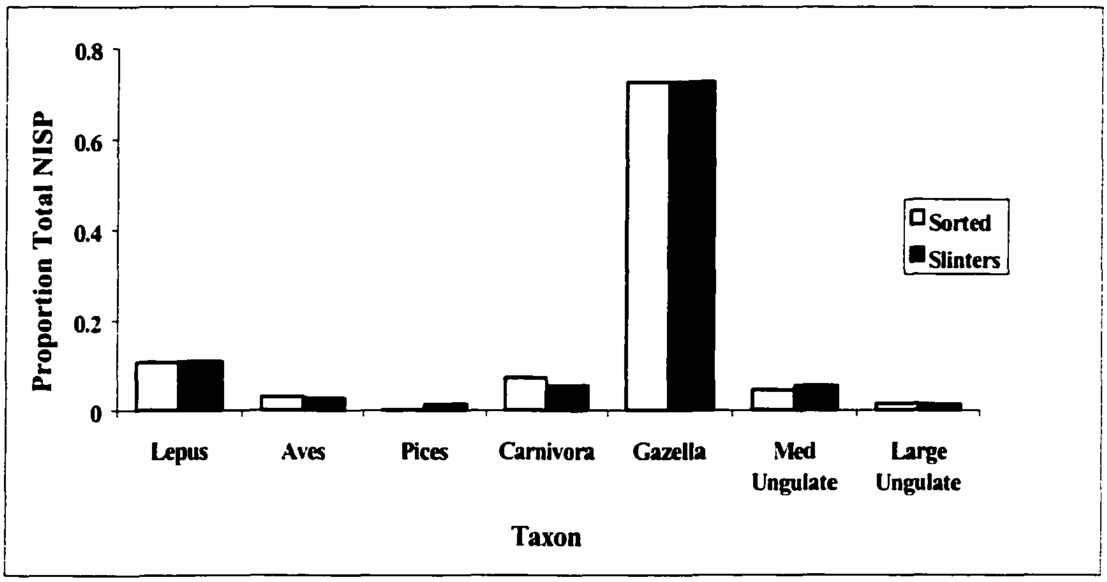


Figure 3.18: Relative abundance of major game groups from the Late Natufian occupation on Hayonim Terrace after the tortoise fraction has been removed. "Sorted" bars represent identifiable bones that were removed from "unidentifiable" splinters prior to this analysis. "Splinter" bars represent identifiable bones removed from a sample sorted from the "unidentifiable" fraction.

Other potential biases in the Hayonim Terrace data may have been introduced by the rapid analytical methods employed in the compilation of the data. Because elements were counted quickly, rare ungulate species such as roe deer and wild goat may be underrepresented in the sample. Moreover, because the assemblage is highly fragmented, and the portions of other small ungulate elements are morphologically similar to gazelle, it is possible that some rare taxa were mistakenly classified as gazelle. Again, because the proportions of these species are so low to begin with, this is not expected to introduce any significant bias to the results reported here. Roughly 10,000 identifiable specimens were tallied from the Hayonim Terrace collection.

Hilazon Tachtit

Thorough excavation procedures were followed at Hilazon Tachtit, including, proveniencing in 50 by 50 centimeter units in 5 centimeter spits; piece plotting significant finds in three dimensions; dry screening through 2 millimeter mesh; and wet sieving and picking of washed sediments for additional artifacts and microfauna. A sample of 2000 identifiable bones was recovered from the first three seasons of excavations. The assemblage is described here for the first time, but will continue to grow as excavations continue at the site. Though the microfauna is excluded from this analysis, a sizable sample has also been recovered.

el-Wad

The history of archaeofaunal research at el-Wad is as long as its excavation record. Dorothy Bate, an original member of Garrod's team, analyzed the assemblage from the caves in the Mount Carmel sequence (Garrod and Bate 1937). Bate's famous gazelle/fallow deer index originated from the study of the el-Wad assemblage as well as from the fauna recovered from at other Mt. Carmel Caves including the Tabun and Jamal Caves. Bate employed changes in the ratios of fallow deer to gazelle through time as an indicator of climatic shifts from wet (higher proportions of fallow deer) to dry conditions (higher proportions of gazelles). Though widely used during succeeding decades, Bate's index is not as popular today, because it fails to consider the cultural filter and its influence on ungulate ratios in archaeological sites. Unfortunately, the large faunal sample from Garrod's excavations cannot be considered here, largely because of the standards of excavation and recovery favored at the time. Until at least the 1950s, excavations in the Near East were consumed with reconstructing cultural sequences; thus, as was the norm for the day, only diagnostic bones from large mammals were collected by Garrod and analyzed in Bate's study.

Valla and Bar-Yosef's test excavations in the mid 1980s were carried out with much greater precision, and though recovery was excellent, sample sizes from each of the three Natufian layers are simply too small to use for comparison. The sample was fully analyzed by Tchernov, with the exception of the avifauna, which have not been identified to species (Valla et al. 1986). The full spectrum of common Natufian species are present, and gazelle and hare are especially common. A report on the fauna from the current excavations on el-Wad Terrace is included in a recent dissertation by Guy Bar-Oz (2001).

A larger sample of identifiable fauna was recovered by Weinstein-Evron during her excavations in Chamber III in the late 1980s. This assemblage was analyzed by Rivka Rabinovich (1998), with the exception of the reptiles, fish, and birds, which were identified and counted by myself for inclusion in this study. During the analysis of the small game fraction, additional hare bones were found mixed in with the other small game species. These were added to Rabinovich's (1998) counts, and explain any inconsistencies between the totals reported here and those in her original report. In total roughly 2600 identifiable specimens were examined.

CHAPTER 4: TAPHONOMIC PROCESSES: ASSEMBLAGE COLLECTORS AND *IN SITU* ATTRITION

INTRODUCTION

This research uses faunal remains as a tool to address the economic decisions and predator-prey population dynamics of Natufian foragers. Before human behavior can be examined, it must be established that the patterns observable in the archaeofaunal record were, in fact, generated by past human actions. Both the collectors of faunal assemblages and the effects of *in situ* attrition will be documented in this chapter. The collectors are those agents that transported and deposited bones in the sites of interest. Bone collectors include animals such as rodents, but are most often predatory animals such as raptors, mammalian carnivores, and humans, who capture prey and transport carcasses to a safe place for consumption. *In situ* attrition refers to the decomposition of skeletal materials by chemical or mechanical processes following their deposition. These processes may selectively remove bones or portions thereof from an assemblage. The range of processes encompassed by the term "*in situ* attrition" as it is defined here include chemical decomposition, weathering, root etching, and rodent or carnivore activity. Human-caused bone attrition including trampling, burning, and other activities, will be discussed independently in the next chapter. Only after establishing that prey skeletons were collected by humans and eliminating biases following human disposal, can accurate analyses of human prey choice, transport decisions and butchery patterns begin.

The field of taphonomy is based largely on observations from actualistic research, including but not limited to ethnographic analogy and experiments. Actualistic research explores potential links between taphonomic agents and the damage they leave on animal remains. Analogues drawn from actualistic studies can then be compared with a skeletal blueprint to derive expectations for archaeofaunal assemblages under a specific range of conditions. Comparisons of natural standards to archaeological data allow the analyst to determine what bones are missing from an archaeological assemblage and which processes most likely removed them. Despite the strength of recent research and a growing comparative database, taphonomic methods are far from infallible, due largely to the fact that a variety of processes acting alone or in combination can produce similar end results (equifinality). Because, it is easy to get lost in the mass of taphonomic information, or be misled by a false sense of precision, this chapter focuses on questions whose resolution is most relevant to the research problems at hand. They include identification of the collectors of prey bones and the processes and effects of *in situ* attrition, as well as basic information pertinent to understanding human transport and butchering activities discussed in the next chapter. Each questions is addressed using a series of independent tests to limit problems of equifinality.

Of the four assemblages examined here, detailed taphonomic information was recorded only for the Hayonim Cave and Hilazon Tachtit assemblages. The other assemblages were included in the study to test a narrower range of questions. The majority of the following discussion thus focuses on these two cave sites. Limestone caves are often good environments for preservation, providing shelter and a rain of sediment that may cover and protect bones. However, other properties of cave sediments and their potential inhabitants create their own biases that may confound interpretations of archaeofaunal remains. The origin of very small animals is particularly problematic because some species inhabit caves and also die there (Andrews 1990; Brain 1981). Predators of small animals, such as foxes, raptors, and owls, also commonly roost or den in caves and may contribute bones to the archaeological record by transporting prey or depositing their remains in pellets or scats.

GENERAL STATE OF BONE PRESERVATION

Though the high clay content of sediments in the Mediterranean hills is destructive to carbonized plant remains, it is conducive to the preservation of bone in most Natufian open air and cave sites. Over the course of this research I analyzed fauna from the Hayonim Cave and Hilazon Tachtit assemblages in detail, excavated a portion of the Natufian layer at both sites, and viewed the depositional conditions firsthand. Overall, the quality of preservation is very good at these sites. Bones representing a full range of structural densities (*sensu* Lyman 1984, 1994), sizes and forms have been recovered intact from Natufian deposits. Bone specimens appear fresh, with crisp, clean features that are easy to recognize. Still, the bones do have a distinctly "archaeological" appearance, primarily due to manganese oxide blackening on much of the Hilazon assemblage (ca. 50%), and patchy staining on bones from Hayonim Cave.

The bone assemblages are extensively fractured. Most complete elements are naturally small and compact. The exceptional quality of preservation nonetheless permits the identification of even the smallest fragments, provided they retain anatomically diagnostic features. In general, the color of the fracture surfaces matches that of the bone's exterior, indicating that breakage took place in antiquity. The much lighter coloration of new breaks (those occurring during excavation or later) are immediately obvious but uncommon. At both caves the sediment matrix is loose and soft and adheres only lightly to bone surfaces. Bones were easily cleaned of sediment by gentle scrubbing with either dry or wet brushes. In sum, the Natufian cave assemblages are in fine macroscopic condition, their surfaces are easily viewed, and despite heavy fragmentation yield a high proportion of identifiable pieces.

Only the fauna from the open air site Hayonim Terrace differs from this pattern. Bones from this assemblage were encased in a concreted carbonate matrix that adhered tightly to bone surfaces. The concretions were removed in a bath of weak acetic acid under the supervision of R. Rabinovich in the Department of Ecology, Systematics and Evolution at the Hebrew University, though there were many instances where they could not be completely dissolved. Because bone mineral is also susceptible to acids, the benefits of this cleaning method are limited and not without risks. When present, the concretions on the Hayonim Terrace material entirely obscure the bone's exterior. Removal of concretions revealed remarkably well preserved surfaces and clear bone features.

METHODS

Questions of *in situ* attrition are posed at the assemblage level, but questions about collecting agents must be addressed independently for specific prey taxa. Both large and small animals are suspected to have been captured by human hunters, yet body size plays a major role in their differential treatment by bone collectors. Since a predator's choice of prey is partly affected by body size and carcass treatment is influenced by the size of prey bones, the collection of large game (ungulates and carnivores) and small game (reptiles, birds, fish and small mammals) are addressed separately. This chapter thus investigates biases in the representation of animal taxa, skeletal elements, and bone portions in a multi-stage process. It is possible to determine which agents were the primary collectors of the assemblages by comparing categories of bone damage that are most clearly diagnostic of humans and non-human carnivores. The impact of *in situ* attrition is evaluated by examining natural categories of bone damage, as well as the representation of skeletal parts relative to differential bone mineral densities.

Primary and Derived Counting Units

Several quantification methods are employed in the following analyses, depending on the nature of the question, and include both primary and derived measures. NISP, or the number of identifiable specimens, is a primary counting unit representing the number of bones in an assemblage that can be classified to taxon and element. A specimen refers to any bone or tooth fragment, complete or not (Grayson 1984), and is not to be confused with the term element, which refers only to complete bones or teeth. The use of NISP can be problematic if used to compare the relative abundances of taxa and body parts within a single assemblage. Complete skeletons from different animal classes are represented by varying numbers of bone elements and teeth, and some bones are more subject to fragmentation than others (Grayson 1978, 1984). Because NISP does not account for fragmentation or taxonomic variation in skeletal composition, comparisons of the relative abundances of taxa and body parts may be biased. On the other hand, this problem can be largely circumvented if the taxonomic composition and fragmentation histories of the assemblages being compared are similar, as is the case here. In this study, specimens were identified to the most specific taxonomic level possible, and maximum length was measured. If a bone could not be identified to genus or species, it was assigned to a broader taxonomic group, defined according to general taxonomic and body size criteria (e.g., small ungulate, large mammal). Articulated elements are rare in the assemblages, but, when present, were recorded as separate units, with physical associations noted. This includes mandibles and maxillae with teeth intact. Because bones and teeth have distinct mineral properties, it is important to quantify them separately (Stiner 1994: 238), particularly in analyses of skeletal attrition. NISP values are used in this chapter to compare relative frequencies of bone damage, and later to compare the relative abundance of prey taxa.

Derived counting units include MNE (minimum number of skeletal elements), MNI (minimum number of individuals) and MAU (minimum number of animal units). Though these derived measures facilitate comparisons between taxa and body parts, they introduce their own quantitative biases due to the way they are derived from primary counting units. Moreover, tallies may vary depending on whether or not variables such as side, sex, body size, or age are taken into account, or how an assemblage is subdivided for analysis. The recombination of derived measures may be subject to significant aggregation error, since each value is rounded up to the next whole number, in accordance with complete biological structures (Grayson 1978, 1984). Because of the many techniques available to calculate derived measures, the methods used in this study are laid out below.

MNE is a derived counting unit representing the minimum number of elements that can account for all specimens of that element from a particular taxon. In this study MNE is calculated by counting morphologically unique bone portions and diagnostic landmarks specific to each element. The frequency of each bone portion or feature in the assemblage is tabulated and compared, and the most common portion defines the MNE. If more than one landmark or portion is present on a large specimen, each landmark was counted once. Age, side, sex, and body size were not taken into consideration when estimating MNEs. MNEs are used to compare the representation of body parts in the Natufian assemblages and to identify which parts may be missing due to attritional processes.

MAU (or standardized MNE following Stiner 1994) refers to the minimum number of animal units represented by a particular taxon (Binford 1978, 1981). MAU is a standardized measure that allows comparison of the abundance of bone portions or elements to a complete skeleton model. It is calculated by dividing the observed MNE by the number of times that element or portion is represented in the skeleton (expected MNE). MAUs derived from cranial bones and teeth are compared in this chapter, and a more detailed discussion on the derivation of MAU for the complete skeleton follows in Chapter 5.

Finally, MNI is the minimum number of individual animals required to account for all specimens of a given taxon in a faunal assemblage. The MNI is derived from the best represented skeletal portion or element for each taxon following standardization (i.e., the highest MAU). MNI estimates can vary considerably for an assemblage, depending on how they are calculated, and on how a faunal collection is divided. In this study, MNIs are derived without considering the side, sex, age, or size of each specimen in an effort to avoid compounding the effects of aggregation error.

BONE COLLECTORS AND MODIFIERS

As consumers of animal prey, the niches of many predators overlap with that of humans, and many prefer the same prey species. Humans and other predators kill, consume, and transport prey and sometimes even feed on the same animal carcass. Non-human predators also frequently prefer the same types of shelters as humans (e.g., dry caves and rock shelters with favorable exposure), and many species transport and leave bones in their dens or roosts. Because of the high potential for overlap in prey choice and feeding behavior, it is possible that bones collected by humans, particularly those recovered from caves or rock shelters, will become mixed with bones collected by other predator species. It thus can not be assumed that all bones recovered in association with lithics or other artifactual material are a product of human behavior by virtue of spatial association alone (Andrews 1990; Andrews and Nesbit-Evans 1983; Brain 1981; Dodson and Wexlar 1979; Hoffman 1988; Isaac 1983; Mondini 1995; Savage and Cooper 1982; Schmitt and Juell 1994; Stiner 1994). Before an assemblage can be attributed to human collectors, it is necessary first to establish whether or not other predators were contributing agents.

Three major groups of bone-collecting predators must be considered in this study: humans, mammals from the Order Carnivora, and diurnal raptors (Falconiformes) and nocturnal owls (Strigiformes). Each of these groups inhabited the Levant during the Natufian period, and each could have contributed to the Hayonim Cave and Hilazon Tachtit archaeofaunas. The most reliable method for distinguishing the effects of different bone collectors is to examine patterns of macroscopic damage on the bones. A wealth of research has been devoted to distinguishing the signatures of predators on bone assemblages. I will focus on broad types of damage that separate humans from mammalian and avian predators in general. If non-human predators are shown to have played a formative role in creating the Natufian assemblages, it will then be necessary to take a closer look for damage types that implicate specific predator species (i.e., species specific tooth marks on bones or prey body part representation). Though there is potential for overlap in the behavior and resulting bone damage caused by different predators, a combination of indicators have proven effective for separating the impact of humans from other bone collectors (Brain 1980; Cruz-Uribe 1991; Haynes 1983; Noe-Nygaard 1989; Stiner 1994). Human signatures such as cut marks, percussion marks, and burning, typical carnivore damage such as punctures, scoring, and cone fractures, as well as body part representation all help in distinguishing bones collected by humans from other carnivore species.

Collectors of Large Game

Only two groups of collectors, humans and large carnivores, could have contributed to the ungulate assemblages from Hayonim Cave and Hilazon Tachtit. Raptors of the Levant rarely capture ungulates because the prey are too large (Paz 1987). In the southern Levant, a narrow group of bone-collectors potentially contributed to the ungulate remains. Some of these species, including panthers (*Pantherus pardus*), jackals (*Canis aureus*), wolves (*Canis lupus*), and hyenas (*Hyaena striata* and *Crocuta crocuta*), inhabited the Levant during the Natufian period, but their bones are extremely rare or nonexistent at the sites studied here. Remains of small cats (*Felis* cf *chaus*), foxes (*Vulpes vulpes*) and badgers (*Meles meles*) are much better represented at Natufian sites. Though wild cats regularly hunt gazelles and other ungulate species, foxes and badgers consume them only opportunistically, usually via scavenging. Despite variation in the behavior of these collectors, the assemblages they create share many characteristics in common, and they differ in similar ways from assemblages accumulated by humans. Diagnostic damage types left by carnivores on ungulate bones are described below.

Damage on Large Mammal Skeletons

Three categories of damage provide evidence for human activity, while others inform us about the activities of carnivores.

Cut marks are left on bone surfaces following contact with the sharp cutting edge of human tools. Though cut marks may be created by a variety of activities, including dismemberment, butchering, and filleting, most processing activities do not leave any trace. Thus the absence of cut marks does not prove the absence of human activity.

Actualistic studies reporting the frequencies of cut marks on butchered bone are few (but see Binford 1978; 1981; Bartram et al. 1991; Gifford-Gonzales 1989; Lupo 1994, O'Connell et al. 1988; Shipman and Rose 1983; Yellen 1991a), but it can be assumed that bones bearing cut marks represent only a subset of the greater assemblage that was actually butchered by humans. This should surprise no one, since cut marks are undesirable byproducts of butchering activities and contact with bone generally dulls the edges of tools. In this study, the number, orientation (transverse, vertical and diagonal), average length, and the location of cut marks were recorded.

Percussion marks or cone fractures are created when bone is impacted by a highly concentrated force, in much the same way that flakes are produced during stone tool manufacture (e.g., Blumenschine and Selvaggio 1988). The force of impact dislodges a cone-shaped bone fragment (usually halved), which flares outward from its apex (the striking point) on the exterior surface of the bone (Figure 4.1).

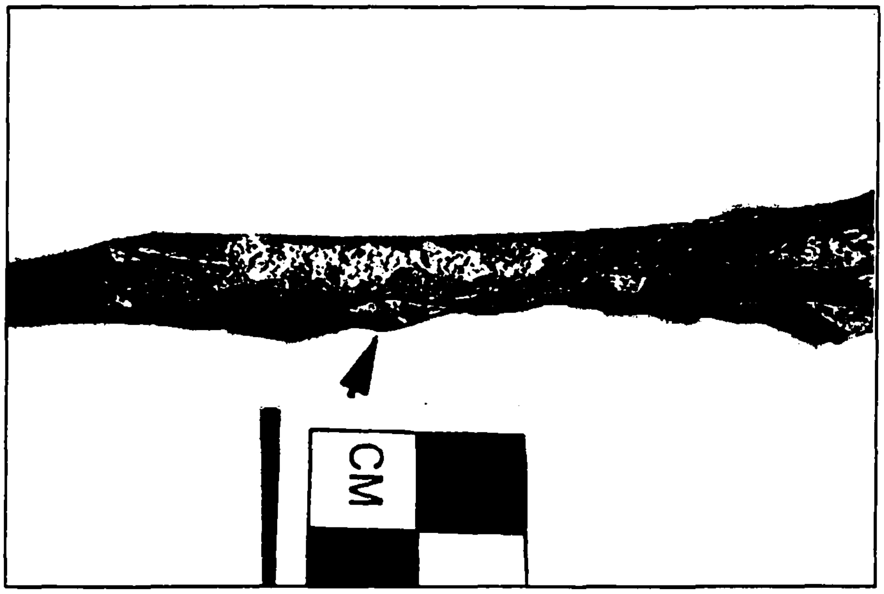


Figure 4.1: Cone fracture on gazelle tibia from Hayonim Cave. The arrow indicates the cone which is still attached.

Humans create percussion marks on bones when a hammerstone is used to open large bone cavities for marrow. Cone fractures occur most often on long bones with large medullary cavities. The thick cortical bone of long bone shafts is most likely to fracture in this way due to its relatively dense, uniform structure. Carnivores may also create cone fractures resembling percussion marks by compressing bones between their jaws, though they are rare in comparison to human-modified faunas and most commonly form in opposing pairs due to the action of both the upper and lower teeth (Stiner 1994: 106).

Burning is not an infallible indicator of deliberate human activity, despite the fact that humans are the only species that make fire and cook food. Bones may be burned at a number of stages in their depositional history, either as a byproduct of cooking, by disposal in active hearths, or by secondary burning from the heat of hearths build atop older debris. Buried bones with no direct contact with fire may be carbonized if they are buried within roughly 6 cm of an active hearth (Stiner et al. 1995). The shades of discoloration caused by burning on bone directly reflect the intensity of heat to which the bone was exposed (from gray to black to white; Shipman et al. 1984; Figure 4.3). Stiner et al. (1995) show that bones do not become calcined unless they come in direct contact with red heat. If shallowly buried beneath a hearth they will at most turn black.

Despite the difficulties of distinguishing bones burned as a direct result of human activity from those burned accidentally, the presence of burning provides at minimum, general evidence for human activity in the area where the bones are found. Establishing which part of the assemblage humans were responsible for collecting is more problematic. Assemblages must therefore be examined to determine the frequency of burning on specific portions, elements, and taxa. The repeated use of a cooking technique may result in higher frequencies of burning on some elements or bone portions than others. Localized patches of burning on long bone ends may also provide evidence for activities such as roasting, since articular ends are less likely to be protected from the heat source by flesh, if disarticulation of the animal occurs at the joints. Higher frequencies of burning on some taxa may indicate hearth-centered consumption.

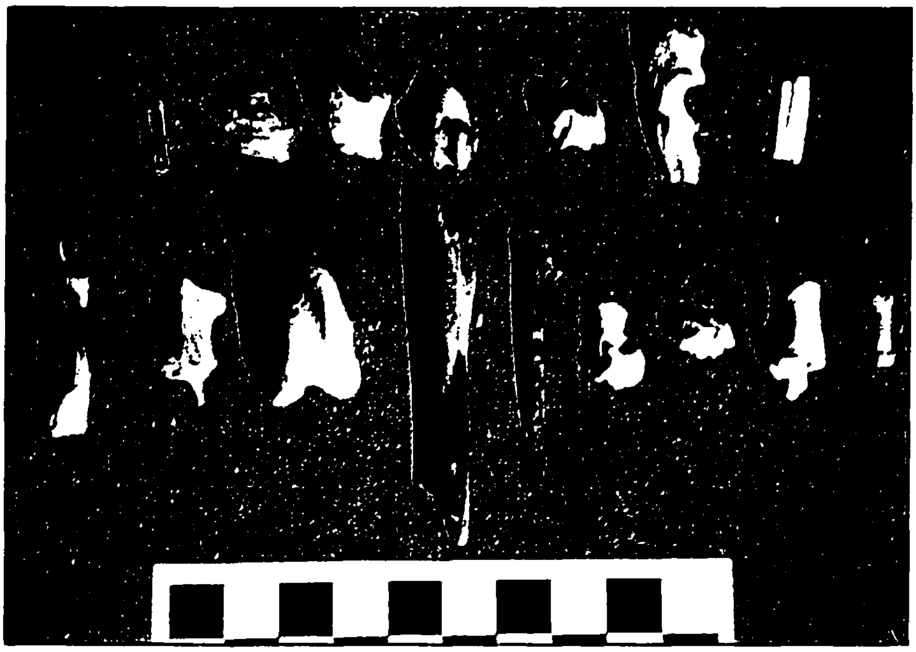


Figure 4.2: Variation in burning intensity on *Lepus* elements from Hayonim Cave. The selection includes several completely calcined bones (white), as well as those depicting varying intensities of burning on a single fragment.

In this study, burning was recorded conservatively, primarily because manganese staining is common in the assemblages from Hayonim Cave and Hilazon Tachtit, and its black color is often difficult to distinguish from burning. Burning therefore was noted only when it clearly was not staining; otherwise black bones were recorded as stained rather than burned. Burning was recorded using codes ranging on a scale from 1 to 6, with one representing the least intensive burning (i.e., less than half of bone carbonized) and 6 indicating the most intensive burning (i.e., bone completely calcined), using temperature associated criteria established by Stiner et al. (1995). The position of localized burning was noted when present.

Carnivore Ravaging occurs during feeding, when carnivores imprint bones with tooth marks, including punctures, scoring, and crenelation. Carnivores that consume meat, but avoid skeletal tissues sometimes mark bones with their teeth when gripping or tearing flesh from the bone. Those that often consume bone leave more obvious signatures, such as distinctly ragged edges, pitting, and scoring (Binford 1981; Haynes 1980; Haynes 1983; Maguire et al. 1980; Shipman 1981; Stiner 1994). Those bones that have been breached may display opposing cone fractures created by the joint action of a carnivore's upper and lower teeth (Lyman 1994; Stiner 1994). Finally, some bones are passed through the animal's digestive system, where they are bombarded by gastric acids that corrode, pit, polish, or thin skeletal tissue (Andrews 1990; Brain 1981; Horwitz 1990).

Results of Damage on Large Game Skeletons

Table 4.1 shows the frequencies of bone damage on ungulate remains from Hayonim Cave and Hilazon Tachtit. Despite the potential suitability of the two sites for carnivore dens, evidence for carnivore activity on ungulate and carnivore bones is virtually nonexistent. Only 8 ungulate and 3 carnivore bones from Hayonim Cave, and no bones from Hilazon Tachtit, were damaged by puncturing or scoring. In four cases punctures were suspected, but questionable, and the source of the mark unclear. In the remaining cases gnawing damage was restricted to a single puncture or score mark. A few bones from Hayonim Cave may provide evidence for digestion, but all are questionable: two have small patches of polish; two bear an eroded appearance that resembles corrosion from digestive acids; and two show high polish and pitting. Even if all six of these bones were digested by non-human predators, their frequency in the assemblage is exceedingly low and of little consequence considering the immense size of the assemblage.

UNGULATES	**Hayonim Cave**		**Hilazon Tachtit**	
	n Damaged	**% Damaged**	**n Damaged**	**%Damaged**
Cut Marks	78	1.5	8	1.2
Cone Fractures*	55	10.4	7	1.0
Burning	820	15.6	32	4.8
Carnivore Damage	8	0.2	0	0.0
Total Ungulate NISP	**5263**		**663**	

CARNIVORES	**Hayonim Cave**		**Hilazon Tachtit**	
	n Damaged	**% Damaged**	**n Damaged**	**%Damaged**
Cut Marks	6	0.8	1	1.1
Cone Fractures*	1	0.3	0	0.0
Burning	182	24.7	13	15.1
Carnivore Damage	3	0.4	0	0
Total Carnivore NISP	**736**		**86**	

Table 4.1: Frequency of bone damage caused by humans and carnivores on ungulate and carnivore remains from the Natufian layers of Hayonim Cave and Hilazon Tachtit. *The percent of bones damaged by cone fractures is calculated only out bones that have the potential to preserve cone fractures (i.e., ungulate long bone fragments).

Damage inflicted by humans is prevalent on ungulate and carnivore remains from both assemblages. Cut marks were identified on 1.5% of ungulate bones and 0.8% of carnivore bones from Hayonim Cave and in similar proportions at Hilazon Tachtit (1.2%

for ungulates and 1.1% for carnivores). Abundant cone fractures (10.4% of ungulate long bones from Hayonim Cave) indicate that much of the assemblage was broken by humans while fresh. Overall, the damage to bones by tool-bearing humans is more than 100 times more common than the damage left by other carnivore species. Burning, much of it heavy (40.1% of burned bone is at least partially calcined), is present on 15.6% of the Hayonim Cave ungulate remains, indicating that bone was deposited in or around hearths.

It is impossible to reconstruct the history of every bone in an assemblage, but the evidence from bone damage unequivocally points to humans as the dominant bone collectors of both the Hayonim Cave and Hilazon large game faunas. Frequencies of several categories of bone damage provide a strong argument for human activity, and suggest that carnivores contributed little to assemblage formation. This is rather interesting in light of the inferred presence of domestic dogs in Natufian sites. Although burning may only indicate secondary human activity at a site, high proportions of calcination, the greatest extreme of burning, the presence of cut marks and cone fractures, and the rarity of carnivore damage unequivocally demonstrate that humans were the primary collectors and users of the ungulates and carnivores whose remains were recovered from the Natufian deposits at Hayonim Cave and Hilazon Tachtit.

Collectors of Small Game

Determining the origin of small game is more challenging than establishing the collectors of ungulates and carnivores in the Natufian assemblages. The small game category includes fish, amphibians, reptiles, birds, and small mammals. Though small animals represent less biomass per individual than ungulates, their living density per unit area is much greater than that of large game, increasing the likelihood that they may live or die naturally at archaeological sites. Many types of small animals are actually attracted to caves which provide shelter for nesting or burrowing. Several small animal species are also drawn to the niche created by human habitations due to the presence of food scraps, crevices and disturbed sediment and in the case of the Natufian, dry wall architecture. Finally, cave sites also attract a range of small predators including mammalian carnivores and predatory birds, that may feed on small animals and deposit their remains as pellets or scats in cave sites.

This analysis seeks to narrow the list of small animals in Natufian cave sites to those species potentially collected by humans. Very small species were excluded from consideration from the start, as they lack any evidence for human activity other than very low incidences of burning. These species include small Passeriforme birds, all rodents except squirrels, amphibians, and reptiles smaller than the lizard *Agama stellio*. The recovery of articulated skeletons of microfauna and concentrations of their bone elements beneath long-term roosts of barn owls within Hayonim Cave (E. Tchernov, personal communication 2000), suggest that these species are intrusive in the two sites as victims of natural death or deposition by predators, most likely barn owls (*Tyto alba*). Thus only species with an average body mass weighing more than one half kilogram, but less than two or three kilograms are considered as likely small prey of humans and systematically investigated for signs of human activity. At Hayonim Cave and Hilazon Tachtit, species in this size range include fish, three species of reptiles (*Testudo graeca, Agama stellio,* *Ophisaurus apodus*), a variety of avian species (except small perching birds), hares (*Lepus capensis*), hedgehogs (*Erinaceus europaeus*) and squirrels (*Sciurus anomalus*). A few avian species are larger than the 2-3 kg upper weight cutoff, including the large raptors such as eagles and vultures, as well as several species of waterfowl (e.g., *Grus grus, Otis tetrax, O. tarda, Ardea cinerea* and *Anser albifrons)*, but are also incorporated within the small game group.

Potential Collectors of Small Prey Skeletons

It is possible to construct a list of potential bone-collectors based partially on their dietary preferences. A predator's body size and feeding strategies limits the size of the prey that it can kill or consume, an important factor governing prey species choice. Many of the common predators in the southern Levant during the Natufian were small or medium-sized and focused primarily on small to medium-sized prey. The list of potential collectors of small game thus greatly exceeds that for ungulates or carnivores.

Birds of prey merit more thorough consideration here. The Levantine Falconiformes vary dramatically in size from the lesser kestrel (*Falco naumanni*, 95-130 grams) to the black vulture (*Aegypius monachus*), the latter can grow as large as 13 kilograms (Paz 1987). Upward of thirty varieties of falcons, hobbies, merlins, hawks, eagles and vultures nest and/or migrate annually through the southern Levant, the west Palearctic's most important Falconiforme spring and autumn migration route (Paz 1987). Falconiformes that live in or regularly visit the Levant including three vultures (*Aegypius monachus, Gyps fulvus, Neophron monachus*) and two eagles (*Aquila chrysaetos, Haliaetus abicilla*) are large enough to capture the prey of interest here. The three vultures are scavengers and feed primarily on carrion but may transport bones with adhering flesh to young in the nest. Of the two eagles, the golden eagle (*A. chrysaetos*) is the only likely contributor to the two cave assemblages, since *H. abicilla* hunts and nests close to major water sources. Though the large raptors commonly nest and perch on rocky crags and cliff faces, which are available near Hayonim Cave and Hilazon Tachtit, they are unlikely to nest inside caves unless appropriate open ledges are available. Most of these species make enormous nests, averaging 1.5 meters in both width and height but reaching dimensions up to 5 meters wide and 3 meters high (Paz 1987), eliminating most cave interiors as suitable locations.

Ten species of owl inhabit the southern Levant today, but the only species large enough to have collected the prey of interest here are the eagle owl (*Bubo bubo*) and the barn owl (*Tyto alba*). The eagle owl is the largest owl in the southern Levant, weighing between 1 and 3 kilograms (Paz 1987). It feeds on small to medium-sized game, including partridges, doves, crows, waterfowl, fish, hedgehogs, bats, and rodents, and even several species of diurnal raptors. Barn owls are much smaller (250-310 g) and prefer correspondingly smaller prey, primarily rodents, songbirds, and insects, though they generally avoid reptiles and amphibians. What barn owls consider prey is determined more by prey body size than taxonomic affiliation (Tchernov 1993a). A rich database of pellet studies from Israel shows that modern barn owls repeatedly favor sparrows, voles and shrews (Paz 1987). Both barn and eagle owls are common in Mediterranean habitats and roost and nest in crevices in rocks and caves. They are therefore the most likely collectors of microfauna in the Natufian cave sites.

Criteria for Separating Collectors

Although only limited work on the composition and condition of bones deposited by avian predators has been undertaken in Southwest Asia, comparable data are available for similar and in some cases the same species in many other parts of the world (e.g., Andrews 1990; Cruz-Uribe and Klein 1998; Hockett 1996; Hockett and Bicho 2000; Sampson 2000; Schmitt 1997). Though the owls inhabiting these diverse areas may not have identical diets, it is expected that they will target prey of similar body size, and generally leave the same types of damage on prey skeletons despite differences in the species consumed.

Large owls (*Bubo bubo* and *Tyto alba*) typically swallow their prey whole, digest the meat and then regurgitate the inedible bones and fur in a dense pellet. As noted earlier the size of prey they consume is limited by their own body size, and specifically by the dimensions of their throat. The eagle owl consumes larger prey than the barn owl and may first prepare larger species by plucking or skinning before swallowing the remaining animal whole. Smaller, barn owls consume correspondingly smaller prey types. The owl's strategy of swallowing prey whole limits bone fragmentation, so that skeletal elements are regurgitated largely intact (Andrews 1990; Hockett 1996; Kusmer 1990; Saavedra and Simonetti 1998). Owls have relatively weak gastric acids, suited for the digestion of flesh but not bone, the latter of which is regurgitated (Andrews 1990; Hockett 1996). Bones from owl pellets thus exhibit only weak if any corrosive damage and are at most marked by patches of polish and light pitting. In sum, the bones of animals consumed by owls are expected to (a) belong to small, or juvenile game, (b) be largely complete, (c) display only light corrosion or polish if any, and (d) be represented by a high degree of skeletal completeness.

Falconiformes strip flesh from animal bones and consume carcasses in chunks. The size of their prey is limited to species they are strong enough to kill and carry in flight, unless the prey is scavenged. In the Levant large eagles regularly kill and consume prey on the larger end of the small game spectrum (e.g., adult hares). Vultures consume carrion and therefore prey choice is not limited by prey body size. Small and medium-sized raptors target the same general types of small prey as barn owls. By stripping meat, raptors ingest fewer bones, particularly large ones (Hockett 1996), and thus fewer bones are exposed to digestive acids. Those that are swallowed are subject to intensive digestion, however the gastric acids of Falconiformes are very potent, especially in comparison to those of owls, and can heavily scar, pit, and thin the walls of prey bones (Andrews 1990; Brain 1981; Hockett 1996; Hockett and Bicho 2000; Schmitt 1997). Raptors may also damage prey skeletons during capture, transport, or consumption by puncturing bones with their talons or beaks. Prey assemblages collected by raptors are expected to yield punctured crania, but fewer imprints on elements of the post-cranial skeleton (Cruz-Uribe and Klein 1998; Hockett 1991, 1996; Schmitt 1997). Golden eagles frequently behead their prey before transporting the carcass to the nest, and thus collect inflated proportions of postcranial body parts there. A few studies on the bone collecting behaviors of the golden eagle in North America show that the representation of prey body parts is significantly biased against heads and forelimbs, unlike those collected by owls (Cruz-Uribe and Klein 1998; Hockett 1991, 1995, 1996). Assemblages collected by raptors are thus expected to (a) be composed of small to medium sized prey, depending on the strength and size of the predator, (b) include high proportions of fragmented bones, (c) be frequently scarred by high incidences of corrosion, polish, and thinning from digestive acids, (d) be possibly biased toward the representation of prey hind limbs, and (e) exhibit punctures.

Though several carnivores may have played roles in the collection of the Hayonim Cave and Hilazon Tachtit faunas, and much work has been done to separate their signatures from those of humans, only general criteria that characterize carnivores as a group (Andrews and Nesbit-Evans 1983; Mondini 1995; Stallibrass 1984) and separate them from Falconiformes, Strigiformes and humans are relevant here. Much variation in the behavior of carnivores exists, especially in the range of prey body parts, taxa and age groups that they collect, but the skeletal damage caused by carnivores is more easily summarized than that of raptors or owls. Carnivore tooth marks include punctures, scoring (drag marks), crenelation, and percussion marks. Some carnivores like hyenas intentionally consume bone, but most of the carnivores of interest here ingest only small to medium-sized fragments and small compact elements as riders with the flesh they eat. The bones of small prey are often consumed whole, even by small carnivores such as foxes and jackals. The digestive acids of most carnivores are strong enough to "polish", corrode, pit, and thin the walls of bone fragments, but only the gastric acids of hyenas can entirely dissolve bone (Horwitz 1990; Stiner 1994; Sutcliffe 1970). Bones collected by smaller carnivores (e.g., foxes, jackals) are therefore expected to show intermediate degrees of digestive etching on small to medium-sized fragments, and exhibit a variety of small tooth marks including punctures, scoring and crenelation. Distinct patterns in the representation of prey body parts and fragment size are also expected in assemblages generated by carnivores, but these vary by species and often overlap, and thus will not be discussed here.

Humans are obvious contenders for the role of bone collector, particularly when assemblages are recovered from sites rich in cultural remains, as is the case here. Still in general, the collection of small prey species by humans tends to be more contentious than for bones of large game, since small taxa are less likely to preserve obvious signatures of human processing such as cut marks and percussion fractures. Humans also tend to be more opportunistic and omnivorous than their carnivorous counterparts, employing a broader definition of what constitutes prey, particularly with respect to body size.

Figure 4.3: Compression fracture on a modern tortoise (*Testudo graeca*) plastron.

Despite their generalist ways, humans do leave telltale signs on small animal remains. Cut marks, the classic indicators of human butchery, are sometimes left on small animal bones, but usually in such low frequencies that their absence is not sufficient to eliminate humans as potential collecting and modifying agents. Small animal bones rarely preserve evidence of percussion damage, due to the small size and gracility of bone structure. One exception is the tortoise, whose thick carapace and plastron segments fracture according to the same principles as mammalian cortical bone when struck with a hammer (see Figure 4.3). Though not infallible, burning is one of the most common human signatures on small animal remains, particularly localized burning on specific elements. Though burning may also result from indirect associations between bones and fire after deposition, variation in the frequencies of burning among small game taxa may enable the separation of taxa burned post-depositionally from those cooked or disposed of in hearths.

Because humans are less likely to adhere to a single hunting and carcass processing routine than other predators, it is difficult to construct generalized expectations about their impact on small game skeletons. According to ethnographic research, human hunters tend to transport complete small game carcasses regardless of distance, since they represent easily transportable packages (e.g., Hudson 1991; Yellen 1991b). Humans may also consume small animal carcasses during excursions away from a home base. In these cases they may also selectively return certain skeletal parts as raw materials valued for secondary use as tools or ornaments, a point that will be taken up later.

Damage on Small Game Assemblages

Many general statements can be made about the impact of predators on small animal prey, yet clearly there is much overlap in the patterns created by different predator species. As palimpsests, archaeological records are notorious for mixing the signatures of different collectors, leaving the archaeologist with the burden of separation. The most effective way to address this problem is to cross-reference multiple lines of evidence (Brain 1980; Cruz-Uribe 1991; Haynes 1983; Lyman 1994; Noe-Nygaard 1989; Stiner 1994). Prey body part representation, age structures, and bone fragmentation are summarized in Table 4.2 and provide general guidelines for the identification of the relative contributions of different collectors to archaeological assemblages. The observed damage and skeletal representation of several categories of small fauna from Hayonim Cave and Hilazon Tachtit are presented in Tables 4.3 and 4.4.

	AGENCIES			
DAMAGE CLASSES	**Falconiformes**	**Strigidae**	**Carnivora**	**Humans**
Punctures	Yes	Yes	Yes	No
Digestion	Yes, Heavy	Yes, Light	Yes, Variable	No (Very rare)
Burning	No	No	No	Yes
Cut Marks	No	No	No	Yes
Body Part Representation	Hind dominated	Complete	Complete	Variable
Proportion of Adults	Low	Low	Variable	Variable
Complete Elements	Fragmented	Complete	Fragmented	Fragmented
Preferred Prey Body Size	Small/Med	Small	Small/Med	Small to Large

Table 4.2: Damage bone collectors are expected to leave on small game prey elements.

The small prey taxa evaluated in Tables 4.3 and 4.4 can be divided into three groups, based on profiles of bone damage and skeletal representation. Hares, partridges, and tortoises are characterized by high incidences of burning, the presence of some tool

	SMALL GAME CATEGORIES					
HAYONIM CAVE				**Squirrel/**	**Med. Aves/**	**Diurnal**
DAMAGE CLASSES	**Tortoise**	**Lizards**	**Hare**	**Hedgehog**	**Partridge**	**Raptors**
Punctures	2 (<1.0%)	0 (0.0%)	2 (<1.0%)	0 (0.0%)	2 (<1.0%)	2 (<1.0%)
Digested	2 (<1.0%)	0 (0.0%)	2 (<1.0%)	0 (0.0%)	13 (<1.0%)	0 (0.0%)
Burning	905 (14.3%)	38 (13.6%)	629 (27.1%)	4 (8.0%)	311 (16.8%)	83 (18.4%)
Tool marks	413 (6.5%)	0 (0.0%)	3 (<1.0%)	0 (0.0%)	7 (<1.0%)	2 (<1.0%)
Body Part Represent.	Complete	n/a	Complete	n/a	Complete	Foot dom
Adults	n/a	n/a	1105 (83.9%)	11 (91.7%)	n/a	n/a
Complete Elements	1199 (19.0%)	132 (47.1%)	815 (35.2%)	28 (56.0%)	379 (20.5%)	247 (54.6%)
Body Size	Small/Med	Small	Medium	Small	Small/Med	Small/Med
NISP	**6331**	**280**	**2314**	**50**	**1849**	**452**

Table 4.3: Frequencies of damage on small game assemblages recovered from Natufian deposits at Hayonim Cave. n/a (not applicable) is used in cases of small sample size or when information collected from the assemblage was incomplete. Numbers outside of parentheses are NISP values. Those inside parentheses represent the percentage of the assemblage expressing each damage type. Percentage of adults was calculated for ageable specimens only.

	SMALL GAME CATEGORIES				
HILAZON TACHTIT					**Diurnal**
DAMAGE CLASSES	**Tortoise**	**Lizards**	**Hare**	**Partridge**	**Raptors**
Punctures	1 (<1.0%)	0 (0.0%)	0 (0.0%)	2 (<1.0%)	2 (<1.0%)
Digested	2 (<1.0%)	0 (0.0%)	0 (0.0%)	1 (2.3%)	0 (0.0%)
Burning	49 (5.8%)	0 (0.0%)	1 (2.3%)	1 (2.3%)	3 (13.0%)
Tool Marks	7 (0.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Body Part Repres.	Complete	n/a	Complete	Pectoral Girdle	Complete
Adults	n/a	n/a	16 (69.6%)	n/a	n/a
Complete Elements	190 (22.4%)	9 (64.3%)	16 (36.4%0	9 (20.9%)	6 (26.1%)
Body Size	Small/Med	Small	Medium	Small/Med	Small/Med
NISP	**848**	**14**	**44**	**43**	**23**

Table 4.4: Frequencies of damage on small game species recovered from Natufian deposits at Hayonim Cave. n/a (not applicable) is used in cases of small sample size or when information was unavailable. Numbers outside of parentheses are NISP values. Those inside parentheses are the percent of the assemblage expressing each damage type. Percentage of adults was calculated for ageable specimens only. The squirrel/hedgehog sample is eliminated from this analysis since sample sizes were inadequate (NISP = 3). Since there were no modified tortoise shells at Hilazon Tachtit, the tool mark values for the tortoise category refer to percussion marks only.

marks, intense fragmentation and fairly complete body part representation. The diurnal raptors also show high frequencies of burning and occasional tool marks, but their body parts are extremely biased in favor of foot phalanges (59.3% of Falconiforme NISP from

Hayonim Cave), in particular the terminal claws. The bones of raptors are also largely complete, but this is due primarily to the high frequencies of foot bones, which are small, compact, and less likely to fracture. Finally, bones of lizards, squirrels and hedgehogs are burned in lower frequencies, have lower rates of fragmentation, and lack secure indications of human inflicted damage, though some may have been eaten by humans.

Discussion of the Collectors of Small Game Assemblages

Though several agencies potentially contributed to the collection of the faunal remains from Hayonim Cave and Hilazon Tachtit, the conditions at the two sites point more to some collectors than others. To begin, there is clear evidence that humans occupied both sites in the Natufian period and brought meat there for consumption. The natural architecture of the caves prevented large raptors from roosting or nesting inside of them; the ledges and crevices in both caves are too small to have supported large eagle or vulture nests. The current ceiling morphology was not significantly different during the Natufian period at Hayonim Cave, as indicated by the lack of roof fall in succeeding layers, but at Hilazon Tachtit the Natufian layer may rest partially on top of roof collapse (Grosman n.d.).

Owls, however, are a different story, since they seek out dark crevices inside caves to roost and bear young, and they do not build elaborate nests. The barn owl in particular, has a long history of residence at Hayonim Cave (Tchernov 1993a; Pichon 1991). It's bones have been recovered from several archaeological levels, and individuals continue to inhabit the cave today, contributing microfauna to the sediments even during the excavation season when the cave is filled with people during the day.

Finally, it is likely that any collector responsible for a substantial portion of the fauna at either of the two caves will contribute some of its own remains to the site. The sizes of the bone accumulations at both sites are substantial and required repeated foraging trips over many years to amass. It is expected that over the course of accumulation a proportion of the predators or their young would have died at the site and thus some of the collectors' bones will be mixed in with the archaeological layers. At Hayonim Cave and Hilazon Tachtit, the bones of several predators were recovered (Table 4.5). It is likely that any non-human predator responsible for a portion of the Natufian faunas is included in this list. Though this evidence is largely circumstantial, it does help to narrow the range of potential collectors. It is the damage on the bones, however, that provides the most reliable evidence for the identity of the bone collectors.

ORDER	PREDATOR	HAYC NISP	HLZT NISP	ORDER	PREDATORS	HAYC NISP	HLZT NISP
Falconiformes	Indeterminate	225	18	Carnivora	Indeterminate	153	21
	Aquila chrysaetos	6	0		*Panthera pardus*	5	0
	Accipiter nisus	41	0		*Felis* cf *chaus*	130	12
	Buteo buteo	164	5		*Canis aureus*	5	0
	Falco tinnunculus	3	0		*Canis* sp.	6	6
	Falco subbuteo	1	0		*Vulpes vulpes*	311	30
	Gyps fulvus	3	0		*Meles meles*	43	1
	Aegypius monachus	2	0		*Martes foina*	45	10
	Neophron percnopterus	1	0		*Vormela peregusna*	24	2
	Indet. Vulture	6	0		Mustelidae	19	4
	Total Falconiformes	**452**	**23**		**Total Carnivora**	**741**	**86**
Strigiformes	Indeterminate	19	0		**TOTAL PRED.**	**1219**	**109**
	Asio otus	1	0				
	Athene noctua	1	0		**MNI HUMANS**	**60**	**12**
	Tyto alba	4	0				
	Otus scops	1	0				
	Total Strigiformes	**26**	**0**				

Table 4.5: NISP counts for predator species from the Natufian layer at Hayonim Cave and Hilazon Tachtit. Includes the MNI of humans represented in Graves.

Tortoises, Hares and Partridges. The body part representation and the damage sustained by tortoises, hares, and partridges (Tables 4.3 and 4.4) closely matches the predictions laid out in Table 4.2 for human predation, particularly at Hayonim Cave. The tortoises of Hayonim Cave show especially clear evidence of human processing activity, with 6.5% of the assemblage providing definite signs of modification, particularly on carapace fragments. Most tortoise body parts except for the most fragile and minute elements (e.g., vertebrae, cranial fragments, mandibles and phalanges) are well represented, and the assemblage was burned at a rate of 14.3%. Evidence for raptor or carnivore activity was recorded on only 4 tortoise shell fragments (<1%). Two cases of puncturing and two of corrosion, polish and pitting possibly caused by digestion were observed in the Hayonim assemblage, though no evidence of this was found on tortoises from Hilazon Tachtit.

Tool marks on hare bones (NISP = 3 at Hayonim Cave, NISP = 0 at Hilazon Tachtit) provide clear evidence for human use, but not surprisingly, are quite rare. Hares are also represented by a complete spectrum of body parts at both sites, though some elements (e.g., limb bones) are somewhat better represented than others (see Tables 5.6 and 5.7 and Figure 5.4 for details). At Hayonim Cave, burning provides the best evidence for the processing of hares by humans. The hare assemblage displays inflated frequencies of burning (27.1%), often at high intensities (52.6% of burned bones are at least partially calcined), in comparison to all other prey taxa. The frequency of burned hare bones greatly exceeds that of any other species at Hayonim Cave, and falls well outside of the range of random variation. Burning damage is therefore inferred to have resulted from human actions, either through cooking and/or habitual deposition in or near hearth areas (the unusual proportions of burning on hare bones will be discussed further in Chapter 5). Evidence for the activity of non-human predators on hare bones is limited to two punctures and two cases of corrosion, polishing and pitting, most probably caused by the digestive acids of carnivores or predatory birds.

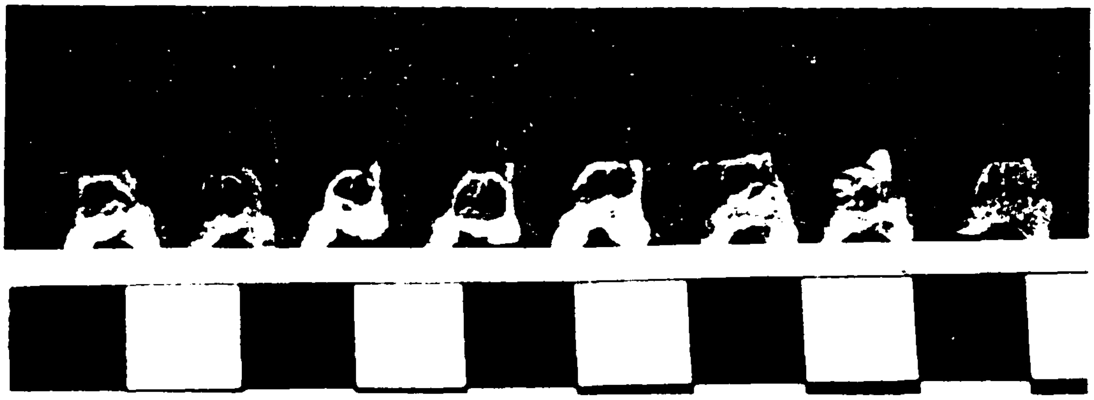


Figure 4.4: Distal partridge tibiotarsi from Hayonim Cave. These specimens were not cut, but were broken naturally, though they closely resemble beads cut from the distal end of the tibiotarsus shaft found at the site and cut from the distal end of the tibiotarsus shaft.

The Hayonim partridges also bear clear indications of human use. Cut marks are slightly more abundant on partridge bones than on any other small game category, but still constitute less than one percentage of the sample (NISP = 7). In many instances (NISP = 40), the distal tibiotarsi have been cut just above the condyle, apparently to take advantage of the natural foramen in the articular end (see Figure 4.4). The trimmed ends were then fashioned into beads, such as the bracelet composed of 20 distal tibiotarsi recovered from the wrist of Homo 25 in Grave VIII/IX (Belfer-Cohen 1988; Pichon 1983). Interestingly, while a full range of partridge body parts are represented at Hayonim Cave, there is a great overrepresentation of tibiotarsus elements, most of them unmodified. The potential secondary function of this element may have governed the zeal with which it was collected and curated by human foragers.

The partridge remains are burned at a frequency of 16.8%, exceeding the percentage of burning on some other taxa collected by humans, such as gazelle and tortoise, but not hare. Two puncture marks and 13 examples of digestive polish (<1% of assemblage) were also identified on partridge bones. Though the punctures may provide evidence for carnivore activity, there are no signs of digestive damage other than these few instances of polish. But polish may occur on bone as a result of several processes that involve repeated rubbing of a bone against a surface, either by wear from use, or abrasion by fine sediments following deposition. When "polish" results from gastric acids, other evidence for corrosion is expected to co-occur, including pitting and the thinning of compact bone, but is not the case here.

The partridge bones from Hilazon Tachtit are more problematic, particularly because of the smaller size of the sample (partridge NISP = 43). Even if partridges were collected by humans, they did not compose a significant portion of the diet. Approximately equal numbers (NISP = 50) of swift (*Apus* sp.) elements were recovered from Hilazon Tachtit. Swifts spend most of their adult life in flight, but nest and feed in steep cliff environments such as those around Hilazon Tachtit. Swifts are still abundant in the area today as well as along other cliffs of the Mediterranean rim. Swift bones occur throughout the burned deposits lying above the Natufian layer in Hilazon Tachtit, which accumulated at a time when humans were not living in the cave. Swift bones are entirely absent from the historic and prehistoric deposits of Hayonim Cave (Pichon

1984), apparently because there are no suitable nest sites nearby. At Hilazon there is a mixed layer between the burned dung layer and the Natufian cultural layer. Some artifacts and bones migrated between the layers forming a transition zone which becomes clearly Natufian only by a depth of approximately 2.95 m (Grosman n.d.). Because the division of the layers was initially unclear, sieving and data collection began at a depth of approximately 2.30 m.

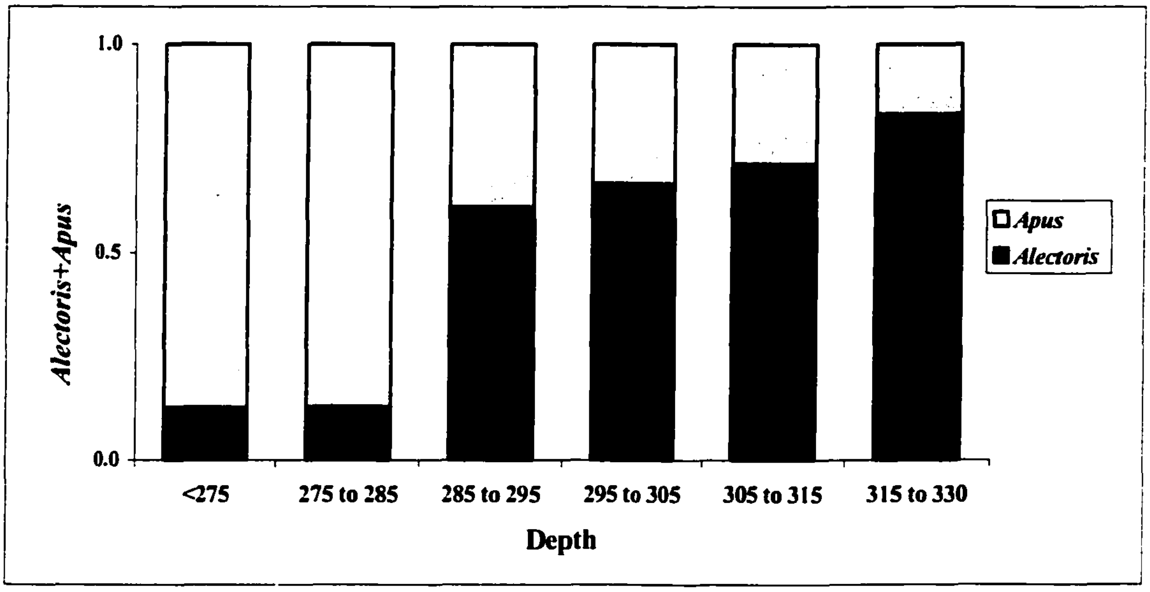


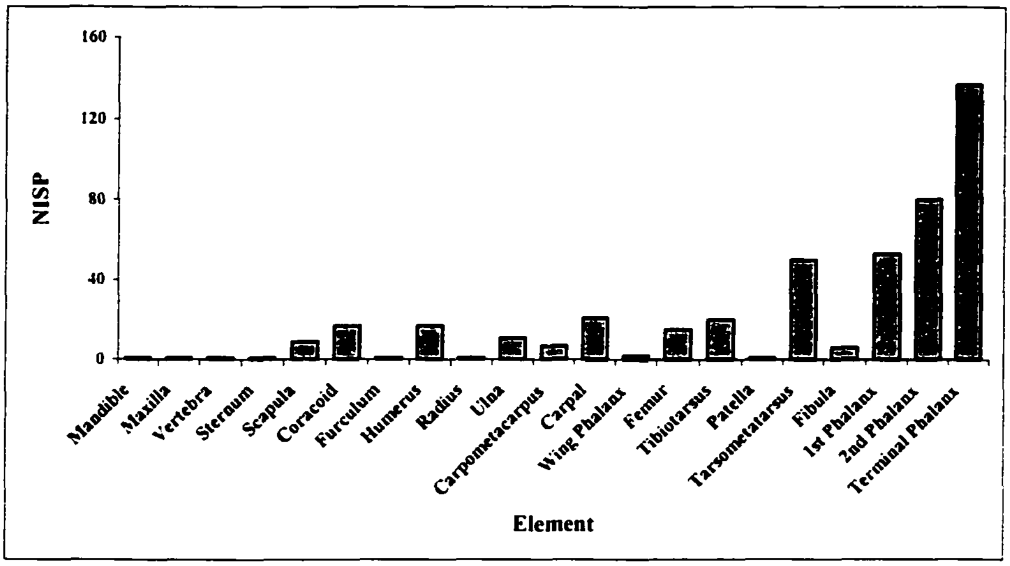
Figure 4.5: Proportion of swift (*Apus* sp.) versus partridge (*Alectoris chukar*) remains from Hilazon Tachtit by arbitrary level. Sample sizes for the two species are similar (swift NISP = 50, partridge NISP = 43).

It is possible to compare the representation of swifts and partridges recovered from the burned deposits, the transition zone, and the Natufian layer. Figure 4.5 shows a clear reversal in the relative frequencies of swifts and partridges, with swift dominated assemblages in the burned layers and transition zone to the partridge-rich Natufian layer. This shift underscores the behavioral association between partridge remains and human activity in the Natufian layer. A small percentage of elements may have migrated into the Natufian layer from above, but the abrupt change in avian species composition indicates that the taxa preferred by humans are not the same as those that were naturally attracted to the site when humans were not present or rarely present.

In addition to frequent evidence for human modification on tortoise, partridge and hare bones from Hayonim Cave and Hilazon Tachtit, each of these species are also much more abundant in the Natufian layer of Hayonim Cave. The evidence for human collection and use of these three prey types is widespread and clear, while evidence for collection by raptors and carnivores is virtually absent. It is therefore with certainty that I conclude that these three species were collected and consumed nearly if not exclusively by humans.

Diurnal Raptors (Falconiformes). The remains of raptors from Hayonim Cave and Hilazon Tachtit meet many of the same criteria that identify partridges, hares and tortoises as animals collected by humans. Raptor bones are burned at high frequencies (18.4%) comparable to or greater than the burning rates for human-collected gazelles and tortoises. A few Falconiforme elements also bear cut marks (NISP = 2 at Hayonim Cave), directly attesting to use in rare cases. Falconiforme body part representation, however, is strongly biased in favor of toe elements. While NISP is used in Figure 4.6 to illustrate the overrepresentation of all toe elements, it should be kept in mind that, if anything, the use of NISP de-emphasizes the dominance of toe elements, since Falconiforme toes in the assemblage are nearly always complete whereas limb bones are nearly always fragmented. This pattern differs substantially from that of other species

a) Hayonim Cave



b) Hilazon Tachtit

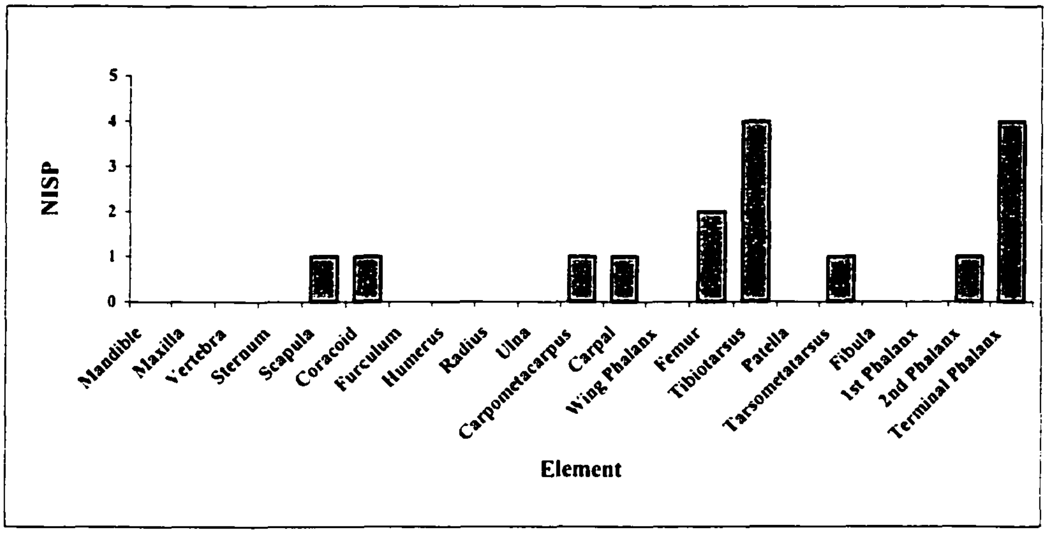


Figure 4.6: The representation of Falconiforme elements from Hayonim Cave (a) and Hilazon Tachtit (b).

collected by humans, but implicates humans as the most likely collector. No other predator is expected to transport lower limb and especially toe bones of Falconiformes to a central place, particularly terminal phalanges, since these elements are not associated with any meat. The toes of Falconiformes are frequently overrepresented in Levantine Paleolithic sites (Kuhn et al. n.d.; Pichon 1984; Rabinovich 1997; Tchernov 1993a), and were often used as ornaments or talismans. There is no clear evidence (i.e., modification) for the ornamental use of raptor toes in the Natufian sites examined here, but the unusual body part profile is most likely the product of human selectivity. Carnivores can be dismissed as collectors, as gnawing on Falconiforme bones is limited to only two punctures, and natural deaths can be ruled out due to incomplete body part representation and the high fragmentation of elements other than small compact toes. It is therefore concluded that the majority of the Falconiforme assemblage was collected by humans, though their function was significantly different than that of tortoises, partridges, or hares (see Chapter 5).

Lizards, Hedgehogs and Squirrels. The collectors of lizards, squirrels and hedgehogs are less easily determined. Although 13.6% of lizard bones and 8.0% of squirrels and hedgehog remains from Hayonim Cave are burned, these rates are somewhat lower than for other small animal species from the site. Though, these percentages may seem high compared to many faunal assemblages, all taxa at Hayonim Cave, including intrusive microfauna, is burned at fairly high frequencies as a result of secondary burning events within the cave (see Chapter 5). These percentages are thus low in comparison to more unequivocal food species at Hayonim Cave. Though some burning is likely to have occurred as a result of secondary processes, the results can not be fully dismissed. Unfortunately, no other damage categories show clear evidence for human collection. All of these species except *Agama stellio* are present in the assemblages in low frequencies and they all have some potential to naturally inhabit or die in caves, particularly those that are well lit such as Hayonim Cave and Hilazon Tachtit. These species are also on the smaller end of the potential game size continuum, increasing the possibility that they were consumed by small to medium-sized diurnal raptors or barn owls. Overall, the evidence for the collector of these four species is ambiguous, and not enough data are available to demonstrate or disprove that humans ate them. For this reason, as well as their low frequencies, they are omitted from further analyses. Because their abundance is low, particularly in the case of hedgehogs and squirrels, their removal from further consideration has no significant impact on the total representation of species at the sites.

Summary of Large and Small Game Assemblage Formation Histories

There is no question that the Hayonim Cave and Hilazon Tachtit assemblages were collected almost entirely by humans. Ungulates, mammalian carnivores, tortoises, hares, partridges, and Falconiformes all bear strong evidence of human modification. The only problematic species are a few relatively rare small animals, including the two lizards *Agama stellio* and *Ophisaurus apodus* and the squirrel and hedgehog. These rare animals are excluded from further analysis.

IN SITU ATTRITION

After disposal, bone is subject to structural and chemical breakdown through natural and cultural processes. Chemical decomposition occurs mainly through interaction with the surrounding sediment, and may lead to fossilization at one extreme or the complete leaching of bone at the other. Mechanical decomposition is caused by physical processes that alter the macrostructural properties of bone (see Lyman 1994). Mechanical processes of decomposition include abrasion, water transport, and gnawing by rodents and carnivores; and to some extent also weathering. Here, the term *in situ* decomposition is limited to breakdown by chemical processes and non-human mechanical agents. Human effects will be examined separately in the next chapter.

Bone Decomposition and Surface Damage

Each bone in an archaeological assemblage may record clues to its taphonomic history through damage sustained from attritional processes. Here, damage likely to have been caused by non-human mechanical and chemical forces after deposition is considered at the individual specimen and assemblage level.

Root Etching

After human activity ceases at a site, plants and animals quickly recolonize disturbed deposits and frequently leave traces of their presence on bones. In less than a year between excavation seasons at Hayonim Cave and Hilazon Tachtit, the caves were rapidly revegetated by a blanket of weeds and grasses, as well as large plants such as young fig trees. The rootlets of growing plants often come into contact with buried bones. As they grow, roots secrete chemicals with the strength to dissolve bone mineral, and leave squiggled etchings on bone surfaces (Lyman 1994). Root etching may vary significantly in intensity from light imprints to the complete destruction of bone, depending on the size and species of the plant and the amount of time roots are in direct contact with the bone. Root etching can also affect bones resting on the surface shortly after discard. In this study, root etching was recorded as a presence/absence variable, with an additional note on its severity (light, moderate, heavy).

Weathering

Weathering is caused by the prolonged exposure of bone or other materials to some combination of air, sunlight, moisture, and changing temperatures. Weathering causes the breakdown of bone in predictable ways as the fibrous collagen component of its structure decomposes (Behrensmeyer 1978; Gifford 1981; Miller 1975). Mild mineral recrystallization may also occur as weathering progresses (Stiner et al. 1995). Behrensmeyer (1978) divides the weathering process into six stages, defined by straightforward changes in the condition of the bone's outer surface. In the initial stages, bones become bleached and begin to crack in lines parallel to their main axis or grain. Next, cracks expand and separate, and the exterior layer begins to exfoliate. Cracks eventually widen, their edges become rounded, and fragments of bone break away from the surface. Severely weathered bone can be reduced to dust *in situ* and may completely disappear. Weathering can also blur and distort diagnostic features on a bone's surface such that the element and species are no longer recognizable. Burial beneath the ground surface generally arrests the weathering process. A bone's weathering stage may therefore provide a rough, relative gauge of how long a bone was exposed on the surface before it was buried (Lyman and Fox 1989). Here, weathering was recorded on a scale from 0 to 5 following Behrensmeyer (1978).

Rodent Gnawing

Rodents are one of only a few groups of animals with ever-growing teeth.

Though continuous growth prevents their incisors from dulling, they must be honed to a practical length to prevent dysfunction and injury. Most rodents keep their teeth in check by gnawing on hard substances and prefer bone if available, especially dense, compact fragments (Brain 1980; Lyman 1994). Gnawing produces deep double grooves on bone surfaces, the impressions of pairs of upper and lower incisors working in opposition. Rodents rarely completely consume a bone, but they can obscure diagnostic features or cause structural instability that may encourage decomposition by other processes. The frequency of gnawing reflects the extent of rodent activity at a site either immediately or long after human occupation. It can be a useful indication of the level of disturbance caused by rodent burrowing. When present on bones in the Natufian assemblages, the intensity and location of gnaw marks were also noted. Intensity was recorded as very light, light, moderate, heavy or breaching the bone's cavity.

Results on Surface Damage

The results on the frequency of damage from root etching, weathering and rodent gnawing in the Natufian faunas are presented in Table 4.6. Root etching was present on 5.4% of ungulate bones from Hayonim Cave and 5.3% from Hilazon Tachtit. Root etching is heavy in less than one twentieth of these cases, and severe enough to erode holes in only two instances at Hayonim Cave. In no case was the identifiability of recovered bone compromised by root etching. The impact of weathering is even less severe. Though 3.9% of the Hayonim and 1.9% of the Hilazon ungulate assemblage displayed evidence of weathering reached only stage 1, light cracking, in more than three-quarters of the cases at both sites. Only five bones from Hayonim Cave were weathered to stage 3, and one to stage 4. Rodent gnawing is even less common, affecting 1.4% of the ungulate assemblage; gnawing damage on only one bone from each assemblage was considered heavy. In all macroscopic categories bone damage is very light. The low intensity of *in situ* macroscopic damage caused by non-human agents confirms observations made previously that the assemblage is in a very good state of preservation. Though only ungulate frequencies are reported here (accounting for greater surface areas on bone), the proportions of such damage on carnivore and small game bones are similar.

UNGULATES	**HAYONIM CAVE**		**HILAZON TACHTIT**	
	n Damaged	**% Damaged**	**n Damaged**	**% Damaged**
Rodent Gnawing	78	1.4	9	1.4
Root Etching	284	5.4	35	5.3
Weathering	206	3.9	13	1.9
Total Ungulate NISP	**5263**		**663**	
CARNIVORES				
	n Damaged	**% Damaged**	**n Damaged**	**% Damaged**
Rodent Gnawing	2	0.3	1	1.1
Root Etching	22	3.0	7	8.0
Weathering	16	2.1	1	1.1
Total Carnivore NISP	**736**		**86**	

Table 4.6: Frequencies of damage caused by natural mechanical processes of *in situ* decomposition on ungulate and carnivore remains from the Natufian layer of Hayonim Cave (HAYC) and Hilazon Tachtit (HLZT).

In Situ Attrition and Mineral Density of Skeletal Tissues

Many methods for isolating the influence of *in situ* attrition caused by non-human forces of decomposition compare relative differences in the mineral density of skeletal elements. The mineral density of bone has been shown to correlate reasonably well with skeletal survivorship under a variety of conditions (Binford and Bartram 1977; Brain 1981; Lyman 1984; see Lyman 1994 for a review). The effects of a number of post-depositional taphonomic processes including carnivore ravaging (Brain 1969; Haynes 1980; Marean et al. 1992), chemical decomposition (Lyman and Fox 1989), trampling (Nicholson 1992), and water transport (Boaz and Behrensmeyer 1976; Voorhies 1969), may be mediated in part by skeletal density. Dense bones have lower porosity, and lower surface area to volume ratios, and are therefore argued to be less vulnerable to attack from sources of attrition (Lyman 1994). Teeth are most resistant of all because they are highly mineralized. Skeletal tissues incorporate a diverse range of mineral densities ranging from dense teeth to compact bone, cancellous bone and paper-thin cranial sinuses and turbinals. By examining the relative representation of bone portions with known densities, it is possible to gauge the influence of post-depositional attritional processes (Lyman 1984; 1994: 235-258).

Tooth- and Cranial Bone-Based MNI Comparisons

Stiner (1994: 99-103) introduced a test of *in situ* attrition that capitalizes on differences in the mineral density of teeth and cranial bones. As the densest component of the vertebrate skeleton, teeth are more resistant to decomposition and fragmentation than any bone, no matter how dense. By comparing tissues of different densities in the same anatomical unit (the skull), Stiner's test provides one relative measure of *in situ* attrition that should be independent of transport decisions. The test assumes that crania and possibly mandibles are deposited in the archaeological record with the teeth intact, so the MNI represented by both teeth and bone was potentially equal at the time of deposition. The intensity of attrition is measured by comparing the MNI of a species represented by teeth to its MNI calculated from cranial compact bone features. In cases of ideal preservation, the excavated assemblage is expected to mimic the deposited assemblage, and the ratio of bone- to tooth-based MNIs should be one. In cases where *in situ* bone loss has occurred, the ratio of bone- to tooth-based MNIs will drop below one, depending on the severity of decomposition. Values close to one indicate relatively good preservation. As conditions worsen the slope approaches zero.

This test is applied to all mammalian species from Hayonim Cave and Hilazon Tachtit that naturally possess both teeth and cranial bones. Gazelles provide the largest sample sizes. The only other ungulates with adequate representation are fallow deer and wild boar at Hayonim Cave, though samples for both of these groups are much smaller than for gazelles. Also considered are fox, wild cat and hare representing smaller mammal categories.

The tooth- versus bone-based MNIs for all taxa in the sample are listed in Table 4.7. In no instance does the MNI based on bone exceed that calculated from teeth, in keeping with the fact that teeth are more resistant to post-depositional processes than bone. In most cases, however, the tooth-based counts only slightly exceed bone-based counts. Figure 4.7 is a scatterplot of the tooth and bone-based MNIs listed in Table 4.7. The slope of the line demonstrates that for most species the ratios of tooth- versus bone-based MNIs are close to 1, and that the results are consistent across taxa with the exception of hare. The MNI represented by hare teeth (27) from Hayonim is greater than for cranial bones (18). This may be caused by human processing of hare skulls for their brains. Also, hares have exceptionally light frames and thus their fenestrated cranial bones may be particularly fragile. Overall, the results of this test indicate that the quality of preservation of compact bone at both sites is very good.

SITE AND TAXON	TOOTH-BASED MNI	BONE-BASED MNI
HAYC *Gazella*	14	14
HAYC *Dama*	1	1
HAYC *Sus*	2	1
HAYC *Vulpes*	4	3
HAYC *Felis*	4	3
HAYC *Lepus*	27	18
HLZT *Gazella*	4	2
HLZT *Vulpes*	1	1
HLZT *Felis*	1	1
HLZT *Lepus*	1	1

Table 4.7: Tooth- and bone-based MNIs of ungulate, carnivore, and small mammal cranial bone and teeth from the Natufian layer at Hayonim Cave (HAYC) and Hilazon Tachtit (HLZT).

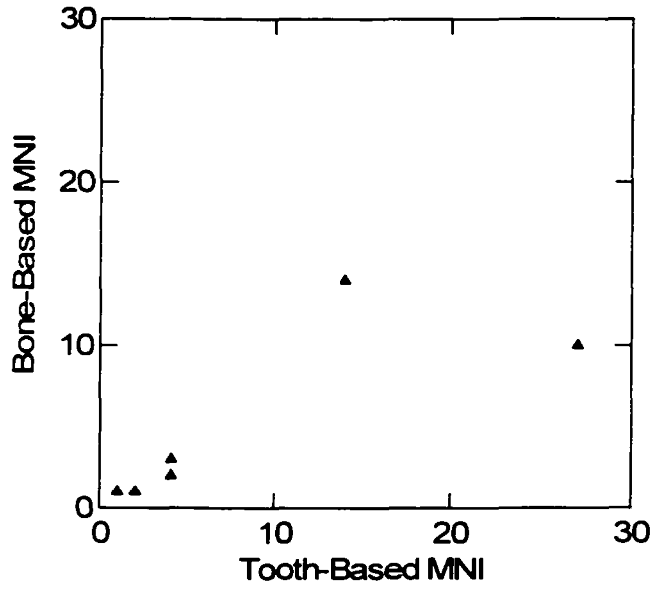


Figure 4.7: Scatterplot of tooth- versus bone-based MNIs for ungulate, carnivore, and small mammal taxa from the Natufian layers at Hayonim Cave and Hilazon Tachtit.

Though the MNIs based on cranial bone and teeth are closely matched, there is significant variation in the representation among the bony parts of the crania and mandibles. The best represented portions (e.g., the petrous) are also the most dense (sensu Lyman 1984, 1985, 1994) and tend to be most resistant to decomposition. Compact bone features also occur in many other elements of the skeleton, thus there is a good chance that MNE estimates for the full skeleton will be accurate representations of the number of elements that were originally deposited (Stiner n.d.). The high quality of bone preservation at Hayonim Cave and Hilazon Tachtit is not surprising given the freshness of specimens on visual inspection.

Density-Mediated Attrition and the Postcranial Skeleton

Like the preceding tests comparing tooth- and bone-based MNIs, postcranial tests examine the relative representation of bone portions within an element, or between elements according to variation in mineral density. Here bone density is defined as grams per cubic meter following Lyman (1984, 1994), who measures bone density using a nondestructive technique called photon densitometry (or photon absorptiometry). This technique calculates density by directing a beam of photons through a predetermined location on a bone (scan site) and measuring its strength as it emerges from the bone (Lyman 1984, 1994). Lyman has published density standards for scan sites on sheep, antelope, and marmots, derived from the average bone density of a few individuals from each species (Lyman 1984; Lyman et al. 1992). Since then, other researchers have applied his methods to other mammals, providing standards for species including bison, deer (Kreutzer 1992), and hares (Pavao and Stahl 1999). Some of these standards are used here.

Tests of postcranial attrition highlight which elements or bone portions are missing from an assemblage, and to what extent bone loss may be explained by structural density (*sensu* Lyman 1984, 1994). Bone density varies significantly within the mammalian postcranial skeleton and even within individual elements (Kreutzer 1992; Lyman 1984; Lyman et al. 1992; Pavao and Stahl 1999). Though most elements contain at least some dense compact bones portions, the bones of the vertebral column are dominated by cancellous bone and thus have low overall density. Thick compact bones are more resistant to many attritional processes. The mineral density of most appendicular bones, including the long bones can be much greater, but still varies considerably within elements. Some articular ends are composed of spongy, cancellous bone, which is less dense than the thick cortical bone of long bone shafts and certain other articular ends such as the distal tibia and humerus. To compare the survivorship of portions of variable densities within the same element, the MNE for gazelle long bones is calculated independently for the shaft and the distal and the proximal ends (Stiner 1994: 238-240). Under ideal conditions, the MNE derived from each portion is expected to be equal. Underrepresented portions are assumed to be either missing from the assemblage or fragmented beyond recognition. The NISP and MNE data for the shaft, and articular ends of gazelle long bones, including the scapula, humerus, radius, ulna, femur, and tibia from Hilazon Tachtit and Hayonim Cave are presented in Table 4.8.

The results from the two sites are similar. Both show unequal representation of shaft, proximal and distal portions of gazelle long bones. MNEs derived from the proximal ulna and scapula (glenoid fossa) far outweigh those calculated from shafts and distal ends. The opposite is true for the humerus and tibia, which are represented by significantly higher quantities of distal ends. MNEs derived from the proximal and distal ends of the radius and femur are nearly equal, except in the case of the radii from Hilazon Tachtit. Finally, in no case was the MNE calculated from shafts the highest for an element (see Table 4.8). In general, the representation of long bone ends seems to be explained by differences in bone density (following Lyman 1984, 1994: 235). Portions known to have low densities such as the proximal humerus are underrepresented by up to ten times in comparison to the opposite and denser end.

MNE	Scapula	Humerus	Radius	Ulna	Femur	Tibia	Calcaneum	Astragalus
HAYC								
Complete	2 (2)	0 (0)	2 (2)	0 (0)	0 (0)	4 (4)	42 (42)	59 (59)
Proximal	16 (26)	8 (22)	41 (66)	36 (55)	17 (36)	25 (45)	24 (26)	2 (3)
Shaft	10 (33)	14 (32)	19 (41)	23 (15)	15 (42)	17 (72)	n/a	n/a
Distal	10 (12)	80 (103)	24 (30)	6 (6)	20 (41)	45 (74)	11 (13)	6 (7)
Total MNE	**16 (67)**	**80 (157)**	**41 (133)**	**36 (76)**	**20 (119)**	**45 (183)**	**66 (81)**	**65 (69)**
HLZT								
Complete	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(1)	6(6)
Proximal	8(8)	1(1)	4(8)	5(9)	3(9)	3(5)	1(2)	0(0)
Shaft	2(11)	3(6)	2(11)	1(1)	3(23)	3(11)	n/a	n/a
Distal	0(0)	9(5)	1(1)	1(1)	3(3)	7(7)	2(2)	0(0)
Total MNE	**4(19)**	**9(22)**	**4(20)**	**5(11)**	**3(36)**	**7(23)**	**3(5)**	**6(6)**

Table 4.8: MNE counts of complete, proximal, shaft and distal limb portions of gazelle elements from Hayonim Cave (HAYC) and Hilazon Tachtit (HLZT). NISP values are indicated in parentheses.

The results presented in Table 4.8 summarize the probable influence of density-mediated processes over postcranial attrition in the Natufian layers from both Hayonim Cave and Hilazon Tachtit. The strength of the influence of mineral density on skeletal representation is probed further using Spearman's rank-order correlation coefficient. Proxy mineral density values (in g/cm^3) for gazelle postcranial bones are taken from Lyman's (1984) measures for pronghorn antelope (*Antilocapra americana*). Density values from pronghorn are preferred over those of sheep because antelope have long, gracile bones similar to gazelles, and, although they are somewhat larger in overall stature, density is expressed on a relative scale ranging from 0 to 1. Lyman obtained his values by measuring structural density at a series of scan sites on each element. Scan sites were chosen to represent the range of variation in bone density within a single element and often correspond to unique markings or features (see Lyman 1994: 240-241 for illustrations of scan sites and a review). The coding system used in this study divides bones primarily into shaft, distal, and proximal regions that are not always directly comparable to Lyman's scan sites, but they are close. Instead the maximum rather than the average value of the density measures taken from each of the portions used here is adopted (see Table 4.9). For the tests that follow, additional elements with high density (astragalus and calcaneum) are added to the long bone sample to maximize the range of bone densities considered. Teeth are excluded from this analysis, since their mineral composition greatly exceeds any bone, and is thus much less affected by attritional processes than bone.

The relative representation of bone portions in the assemblage was determined by calculating each portion's survivorship in relation to the most common portion (following Lyman 1994: 239). This method assumes that the bone portion providing the highest MAU for any bone element in the assemblage represents the absolute number of that bone originally deposited in the assemblage. The percent survivorship of each bone portion is calculated by dividing its MNE first by the number of times the portion is represented in a complete skeleton, and then by the MAU of the most common bone element (% survivorship = [MNE of portion/# of that portion in a complete skeleton]/MNI, in other words MAU/MNI). The maximum MNE for gazelle in both assemblages (Hayonim Cave MNE = 80, Hilazon Tachtit MNE = 10) is derived from the distal humerus and is used as a baseline against which the survivorship of all other portions in the assemblage are measured (see Table 4.9).

		HAYONIM CAVE		**HILAZON TACHTIT**	
PORTION+ELEMENT	**Bone Density**	**MNE**	**%Survivorship**	**MNE**	**%Survivorship**
Shaft Ulna	n/a	23	28.8	1	11.1
Distal Ulna	n/a	6	7.5	1	11.1
Proximal Humerus	0.12	8	10.0	1	11.1
Proximal Tibia	0.18	25	31.3	3	33.3
Scapular Blade	0.21	10	12.5	2	22.2
Proximal Femur	0.21	17	21.3	3	33.3
Shaft Humerus	0.25	14	17.5	3	33.3
Proximal Radius	0.26	41	51.3	4	44.4
Distal Femur	0.27	20	25.0	3	33.3
Proximal Ulna	0.28	36	45.0	5	55.5
Proximal Scapula	0.30	16	20.0	8	88.9
Shaft Femur	0.33	15	18.9	3	33.3
Distal Radius	0.34	24	30.0	1	11.1
Distal Tibia	0.40	45	56.3	7	77.7
Distal Humerus	0.44	80	100.0	9	100.0
Shaft Tibia	0.48	17	21.3	3	33.3
Calcaneus	0.55	66	82.5	3	33.3
Shaft Radius	0.57	19	23.8	2	22.2
Astragalus	0.57	65	81.3	6	66.6
Maximum MNE		**80**		**9**	

Table 4.9: Bone density and percentage survivorship values for shaft, proximal, and distal end portions of gazelle limb bones from Hayonim Cave and Hilazon Tachtit. Bone density for gazelle is approximated using Lyman's (1984) density values for pronghorn antelope (*Antilocapra americana)*. The maximum rather than the average density value for the scan sites found on each portion are used here. Percent survivorship is calculated by dividing a portion's MNE by the maximum MNE. In this case MNEs were not standardized since all portions are represented in pairs in the skeleton .

The significance of the relationship between bone density and survivorship is determined using Spearman's rank-order correlation coefficient (r_s). Although absolute density values are provided here, these measures are averaged from only a few individuals and do not account for the range of variation within a species caused by differences in age, nutrition, and other factors (Lyman 1994). However, among mature adults, mineral density gradients are similar among Artiodactyl and Perissodactyl species (Lam et al. 1999). Here, density values from one species are considered analogous for a different though structurally similar species. Spearman's correlation coefficient ranks and then compares the density and survivorship values. The scatter diagram in Figure 4.8 plots bone density against percent survivorship for the portions of gazelle long bones from Hayonim Cave (data in Table 4.9). The relationship is significant at the .05 level of probability ($r_s = 0.546$, $P<.05$, $n = 17$), but the correlation is not very strong. A second scatterplot (Figure 4.9) presents the same data but with the bone shafts removed. In this case the correlation between bone density and survivorship is stronger and significant at the .001 level of probability ($r_s = 0.759$, $P<.001$, $n = 13$). Both tests show that density-mediated attrition played a role in shaping the Hayonim Cave ungulate assemblages. However, the question concerning the causes of the attrition remains unanswered.

Though none of the true bone eaters (e.g., hyenas) were a serious problem at the Natufian sites, the Natufians possessed sophisticated groundstone technology and may have kept dogs, both of which may preferentially destroy low density bone. The decomposition of bone by chemical dissolution following its deposition in the archaeological record is another possible source of density-mediated attrition but indications of this are few. The extreme rarity of evidence for carnivore activity indicates that dogs were not a major destructive agent in Natufian assemblages, though human activities, such as bone grinding, butchering, and trampling, may have been.

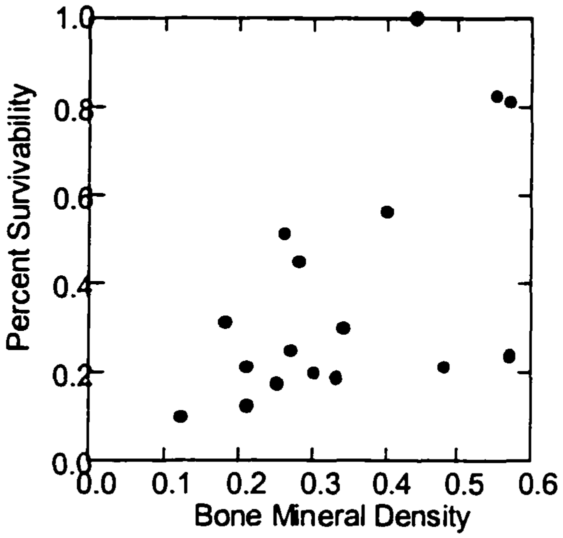


Figure 4.8: Scatterplot of bone mineral density versus percent survivorship of shaft, proximal and distal end portions of gazelle limb bones from Hayonim Cave. Bone density for gazelle is approximated using Lyman's (1984) density values for pronghorn antelope (*Antilocapra americana*). $r_s = 0.546$, $P<.001$ (n = 17).

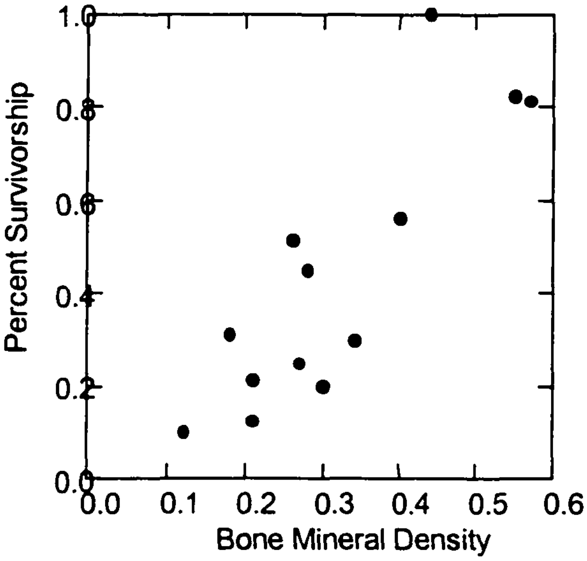


Figure 4.9: Scatterplot of bone density versus percent survivorship of proximal and distal end portions of gazelle limb bones from Hayonim Cave. The long bone shafts are excluded from analysis. Bone density for gazelle is approximated using Lyman's (1984) density values for pronghorn antelope (*Antilocapra americana*). $r_s = 0.759$, $P<.001$ (n = 13).

Gazelle long bone shafts are well represented in the Hayonim Cave assemblage, but the relationship between structural density and bone survivorship is stronger when shafts are removed from analysis. Though in many cases, the cortical bone of shaft fragments is denser than one or both articular ends of the same element, there are several taphonomic processes that contribute to the fragmentation and destruction of long bone shafts, an important factor is bone processing by humans since shafts encase the energy-rich marrow cavity. The fragmentation of long bone shafts and patterns of density-mediated attrition will be explored further in the discussion of game processing and butchering in Chapter 5.

The low intensity of damage on bone surfaces discussed earlier suggests that the Hayonim assemblage was not greatly biased by non-human processes of *in situ* decomposition. But can these factors be eliminated as causes of density-mediated attrition in the gazelle assemblage? Because *in situ* processes as defined by this study operate following disposal, they are not expected to discriminate between taxonomic categories. If non-human causes of *in situ* decomposition are responsible for density-mediated attrition, the body part representation of taxa other than ungulates should be affected as well. To test this prediction, the relationship between bone density and survivorship is presented for the hares from Hayonim Cave. Though hares differ significantly from gazelles in body size, their skeletal density varies more within and between elements, particularly in the cranium which includes several regions of low density fenestrated bone (e.g., maxilla, occipital).

ELEMENT PORTION	Bone Density	MNE	MAU	Percent Survivorship
Proximal Scapula	.240	30	15	45.5
Scapular Blade	.070	13	7	21.2
Proximal Humerus	.450	11	6	18.2
Shaft Humerus	.220	4	2	6.1
Distal Humerus	.320	66	33	100.0
Proximal Radius	.180	59	30	90.9
Shaft Radius	.210	5	3	9.1
Distal Radius	.280	32	16	48.5
Proximal Ulna	.160	39	20	60.6
Shaft Ulna	.001	2	1	3.0
Distal Ulna	.001	3	2	6.1
Proximal Femur	.330	44	22	66.7
Shaft Femur	.330	4	2	6.1
Distal Femur	.540	41	22	66.7
Proximal Tibia	.560	25	13	39.4
Shaft Tibia	.320	24	12	36.4
Distal Tibia	.430	41	21	63.6
Calcaneus	.430	34	17	51.5
Astragalus	.190	31	16	48.5
Atlas	.140	4	4	12.1
Axis	.270	5	5	15.2
MNI		**66**	**33**	

Table 4.10: Bone density and percent survivorship values of the shaft, proximal and distal portions of hare limb bones from Hayonim Cave. Bone density for hare is approximated using Pavao and Stahl's (1999) density values for California jackrabbit (*Lepus californicus*). Maximum density values are used for each portion. Percent survivorship is calculated by dividing the MAU of a portion by the maximum MNI.

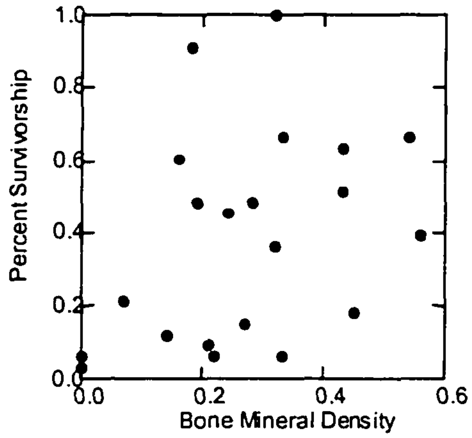


Figure 4.10: Scatterplot of bone density versus the percent survivorship of shaft, proximal and distal end portions of hare limb bones from Hayonim Cave. Bone density for hare is approximated using Pavao and Stahl's (1999) density values for California jackrabbit (*Lepus californicus*). The relationship is not significant ($r_s = 0.393$, n = 21).

Bone density values for hare were adapted from Pavao and Stahl's (1999) measurements for the black-tailed jackrabbit (*Lepus californicus*), which is closely related to the cape hare (*Lepus capensis*) of the Levant and similar in body size and locomotor structure. Density and percent survivorship values for the Hayonim hares are presented in Table 4.10. The correlation between survivorship and bone density is insignificant both when bone shafts are included ($r_s = 0.393$, $n = 21$; see Figure 4.11) and when they are not ($r_s = 0.271$, $n = 15$). If the shaft and distal end of the ulna are excluded from the analysis due to their inordinately low densities, the relation between bone density and survivorship diminishes even further ($r_s = 0.198$, $n = 19$). A comparison between the scatter plot for hare (Figure 4.10) and those for gazelle (Figures 4.9 and 4.10), emphasizes the difference in the relationship between bone density and survivorship for the two taxa. The survivorship of gazelle bone portions appear to have been strongly mediated by bone density, while the survival of hare bones not at all. A dichotomy in the relationship between bone survivorship and mineral density among taxa indicates that, though forces of density-mediated attrition were at work in the Hayonim assemblage, they are not strongly determined by chemical decomposition or other non-human *in situ* processes that are expected to affect taxa equally.

Conclusions for *In Situ* Bone Attrition

In sum, low incidences and intensities of surface damage and good agreement between MNIs calculated from teeth and cranial bones from several mammalian species indicate that the faunal assemblages from Hayonim Cave and Hilazon Tachtit are relatively well preserved. Though the mineral density of skeletal tissues is shown to correlate with the survivorship of gazelle body-parts, this is not true for another commonly represented mammal, hares. Some taxa (e.g., gazelle) were subjected to processes mediated more by bone density than others. All, however, were collected by humans, eliminating the possibility that the biases among species were caused by non-cultural *in situ* processes of decomposition. It is likely that variation between taxa was caused primarily by their differential treatment by human consumers during activities such as body transport, butchering, bone processing, and trampling. This conclusion is explored in greater detail in the next chapter.

CHAPTER 5: THE TRANSPORT AND BUTCHERY OF NATUFIAN PREY

INTRODUCTION

This research on animal remains addresses broader questions about human site use intensity, taking archaeozoological data a step beyond traditional economic analyses. It is first necessary to establish the function of prey species and their various body parts within the human economic and social system. This chapter reconstructs the passage of prey species through the Natufian cultural filter, from the time they were hunted to their deposition in the archaeological record.

Transport decisions, butchering, cooking, and the use of skeletal tissue for raw materials all potentially result in the fracture of and damage to archaeological bone. Following disposal, humans may further modify bones by trampling them, moving fill, or by building fires close to trash. This discussion sequentially examines the transport, butchering, and consumption of key prey species as food and as sources of raw materials during the Natufian. The evidence from Chapter 4 points overwhelmingly to humans as both the bone-collectors and the major sources of attrition in both the Hayonim Cave and Hilazon Tachtit assemblages.

This chapter is divided into two sections. The first deals with the transport of prey body parts from the kill to the living site and the second with the butchery and consumption of animal carcasses once they reached Hayonim Cave and Hilazon Tachtit. Both sections rely heavily on the results of body part analysis, but also draw on food-utility and fragmentation indices and frequencies of bone damage.

PREY TRANSPORT BY HUMANS

Many animals transport food to gain important energetic advantages that can not be had at the kill or collection site. Food is most often transported to monopolize or protect it, to optimize reproduction by provisioning young, to share with other group members, or to gain a processing advantage through access to special equipment (Binford 1978, 1981; Brain 1981 Gifford-Gonzales 1993; Isaac 1983; O'Connell et al. 1988; Stiner 1993). Most models of prey transport are based on principles of cost/benefits. They assume that a predator's transport decisions are constrained by the weight of the prey, and the distance over which it must be transported (Binford 1978, 1981; Perkins and Daly 1968, and others). Secondary factors, such as the time of day, the number of human carriers, the season of capture, and other plans a hunter may have when prey is encountered also figure into the transport equation (Bartram et al. 1991; Bunn et al. 1988; Kent 1993; O'Connell and Marshall 1989; O'Connell et al. 1988; Oliver 1993). If the weight of the prey exceeds what can be transported to camp by available carriers, hunters must be selective about which parts to carry and are expected to maximize returns by selecting portions with the highest energetic yields. Principles of cost/benefits do not yield infallible predictions about human transport decisions, but provide a scale for assessing behavioral variation. Recent research on the transport and field processing behaviors of modern hunter-gatherer and agricultural groups also indicate that the hypothesis holds up well in many parts of the world (Bunn et al. 1988; Binford 1978;

Kent 1993; O'Connell et al. 1988; O'Connell and Marshall 1989; Oliver 1993).

Because prey skeletal parts are most often transported with soft tissues, it is possible to assess the role of human transport on prey assemblage formation by examining the skeletal representation of prey at archaeological sites. Transport decisions can thus be studied by assigning relative values to prey skeletal parts according to the caloric yields of associated products, including meat, marrow, and bone grease. If restrictions (high costs) on transport were imposed, the body part profiles of affected species are expected to be biased toward high-utility skeletal remains (those associated with high energy body tissues; *sensu* Binford 1978). If carcasses were carried in complete units, or if prey were collected for purposes other than food, there should be no significant correlation between the energetic value of prey body parts and their representation at archaeological sites. Though the value of prey body parts is often at least partially determined by the demand or perceived value of raw materials such as bone, skin, sinew, or antler, the value of these materials are difficult to assess in calories, and thus raw materials are generally left out of transport equations. The importance of the latter products in determining transport decisions is discussed in more detail below.

Binford (1978) refined the link between prey skeletal portions and their energetic value by measuring the caloric yield of consumable body parts associated with prey skeletal elements. The result was the Modified General Utility Index (MGUI) which assigns relative energetic values to the skeletal portions of caribou and sheep the main prey of the Nunamiut groups he studied. The MGUI provides utility values for bone portions likely to be recovered from archaeological assemblages (e.g., proximal humerus, calcaneum) by summing the energy derived from the meat, marrow, and bone grease in a complete animal. The utility values are then normed on a scale from 0 to 100, and each is divided by the energetic value of the highest utility part. Low-utility elements likely to accompany high-utility parts as riders (e.g., carpals, tarsals, and phalanges) are assigned intermediate values. In the absence of density-mediated attrition of bone, a strong negative correlation indicates a "high-utility" transport strategy, or selection for body parts with high caloric yields. Strong positive correlations indicate reverse utility strategies, or assemblages rich in low-utility parts, and are most commonly interpreted as butchering stations. Finally, insignificant correlations indicate that transport did not exert a significant role in assemblage formation, that food utility was not the main influence on transport, or that other more influential processes subsequently distorted its signature.

Since the development of the MGUI, many researchers have recommended adjustments and refinements (i.e., the food utility index and transport indices; Jones and Metcalfe 1988; Metcalfe and Jones 1988; O'Connell et al. 1988). Utility indices have also been determined for new species such as guanaco, bison, and phocid seals (e.g.., Borrero 1990; Lyman et al. 1992). All of this attention attests to the general strength of the method for predicting human transport decisions, yet the utility indices also have their share of problems. In 1984 Lyman published an important cautionary statement on utility indices. His work showed that the utility value and mineral density of skeletal portions are negatively correlated. Utility indices thus correlate significantly with bone survivorship in assemblages biased by density-mediated attrition, regardless of the role transport played in their formation (Lyman 1985, 1994; Grayson 1988, 1989). This issue is of particular relevance here, since the survivorship of gazelle body parts from Hayonim Cave was shown to correlate significantly with bone mineral density in Chapter 4.

Food Transport in the Natufian Period

Prior to the Natufian, there is good evidence that hominid foragers of the Levant transported prey carcasses to central places for consumption (Bar-Oz et al. 1999; Rabinovich 1997; Speth and Tchernov 1998, 2001; Stiner 1994; Stiner and Tchernov 1998). Free from competition and with easy access to site facilities and tools, humans were able to invest additional time to extract energy from animal carcasses. Flint tools were used to deflesh and dismember carcasses, and hammerstones used to smash long bones and access marrow cavities. Still, it is not until the Epipaleolithic period, and the Natufian in particular, that the innovation and subsequent diversification of groundstone technology greatly increased the potential yields that could be extracted from available foods.

Groundstone artifacts opened an entirely new niche for human foragers, who gained affordable access to plant resources that were previously unavailable due to high processing costs. Though less important, groundstone technology may have also facilitated greater extraction of grease from the microstructure of mammalian bone, thus increasing the value of animal bones to human consumers. Innovations and diversification in processing equipment including groundstone and sickle blades, gave the Natufians unprecedented potential to extract energy from the local environments (Wright 1994). This undoubtedly also altered the value of plant and animal resources to human foragers and thus their food transport decisions.

Methods

Prey transport is addressed by examining prey body part profiles from Natufian sites. Body part analysis begins here with the division of the skeleton into anatomical regions likely to have been transported to campsites as quasi-articulated units. For larger prey (gazelle), the distribution of bone portions is also compared to the MGUI.

Body part analysis was undertaken for all prey species for which adequate samples were available, including gazelle (*Gazella gazella*), fox (*Vulpes vulpes*), felids (*Felis* cf. *chaus*), hare (*Lepus capensis*), partridge (*Alectoris chukar*), and diurnal avian raptors (Falconiformes). The gazelle category includes specimens assigned to both gazelle and small ungulate categories. Because gazelles represent 99% of the small ungulates identified to species in the Hayonim Cave and Hilazon Tachtit assemblages (see Chapter 7), it can safely be assumed that virtually all of the small ungulates originate from gazelles even those specimens that do not permit species-specific attribution. Combining the two fractions ensures that all elements, not just the most diagnostic ones, are included in the body part profiles. Likewise, the partridge sample from Hayonim Cave includes a subset of specimens from the medium-sized bird category. Unfortunately, in the case of hares and small carnivores, the same strategy could not be applied, since parts that could not be identified for these taxa were assigned by necessity to the same small mammal category. Elements identified to the small mammal category were thus omitted from the body part analysis, and it is likely that the neck, axial, and foot regions of hare and carnivore skeletons will be underrepresented in the profile as a result.

The relative representation of prey body parts is analyzed by dividing the prey carcass into anatomical regions and standardizing observed MNE frequencies against expected MNE for each region, following Stiner (1991; 1994: 240-242). Anatomical regions are defined based on the natural articulation of body parts and their potential for dismemberment into easily transportable units (e.g., head, neck, upper forelimb). The MAU for an anatomical unit is calculated by summing the MNE for each element in that unit in the archaeological assemblage. This total is then divided by the number of elements in that unit in a complete skeleton. For example, two complete gazelle lower forelimbs are composed of 6 major elements; 2 radii, 2 ulnae and 2 metacarpals. The MNE for gazelle radii (41), ulnae (36), and metacarpals (27) from the Natufian layer at Hayonim Cave totals 104. This value is then divided by the number of lower forelimb elements in the complete skeleton (6) and rounded-up to the next whole number to give an MAU of 18 for the gazelle lower forelimb. Because the MAU for each anatomical region is standardized against an expected value, results can be compared among regions to identify discrepancies in the representation of different body parts.

Though each prey species is divided according to the same basic anatomical plan, some taxonomic groups required adjustments in expected MNE due to variation in skeletal structure (see Table 5.1). Elements that could not be identified to species are eliminated from analysis except as described above. Teeth are also excluded due to their greater likelihood of preservation (see Chapter 4). The anatomical divisions for each prey species, and the MNE for each region in a complete skeleton are outlined in Table 5.1.

MAMMALS	Gazelle	Carnivores	Hares	BIRDS	Partridge	Falconiformes
Horn	2	n/a	n/a	**n/a**	n/a	n/a
Head	4	4	4	**Head**	2	2
Neck	7	2	7	**Neck**	14	n/a
Axial	49	3	23	**Axial**	23	2
Upper Front	4	4	4	**Pectoral Girdle**	6	6
Lower Front	6	4	4	**Wing**	10	10
Upper Hind	4	2	2	**Upper Hind**	2	2
Lower Hind	8	8	6	**Lower Hind**	4	4
Feet	24	80	80	**Feet**	28	30
TOTAL	**108**	**107**	**130**	**TOTAL**	**89**	**56**

Table 5.1: Minimum number of elements in a complete skeleton for each of the anatomical units used in body part analysis. Note that ribs and vertebrae are excluded from the carnivore and Falconiforme groups, and ribs are excluded from the hare and partridge groups, since they could not be identified to species.

Carnivore and ungulate skeletons are divided following Stiner (1991; 1994: 240-242) into 8 and 9 anatomical units respectively (see Table 5.1). Two changes were made in the derivation of the carnivore anatomical regions. First, the metacarpals and metatarsals are included in the foot region rather than the hind leg unit. Second, most vertebrae are excluded from the analysis due to identification problems. The neck group of carnivores therefore contains only the atlas and the axis, and the axial region is limited to the sacrum and the two innominates. Hares are divided into the same basic categories as carnivores (see Table 5.1). Ribs are excluded from the analysis, since they are difficult to separate from small carnivore ribs, particularly when fragmented. Vertebrae of hares are included since these elements are more easily distinguished from those of small carnivores. For birds, a new category -- the pectoral girdle -- is created for the bones of the breast region (scapula, coracoid, furculum, and sternum). The pectoral girdle supports the flight muscles, and is associated with the largest meat mass in the avian body. The bones of the wing (humerus, radius, ulna, carpometacarpus, wing phalanges, and carpals) are tightly articulated with ligaments, associate with little meat, and are considered a single anatomical unit (the wing). The only wing phalanx counted for birds is the highly diagnostic 1st phalanx of digit 2. The skeletons of partridges and Falconiformes are represented by the same number of elements and are divided into the same basic units (see Table 5.1). Because I was unable to identify Falconiforme vertebrae to order, they were assigned to general avian categories based on body size (e.g., large bird) and will be underrepresented in Falconiforme body part profiles

The analysis of prey body parts centers on taxa from Hayonim Cave for which the largest samples are available. Profiles are presented for some common species from Hilazon Tachtit, but the sample sizes are often too small to show more than very basic information on anatomical units. The Early and Late assemblages from Hayonim Cave are collapsed into a single unit in this discussion to increase sample sizes. However, body part profiles from the Early and Late layers were checked for consistency and no major differences between them were found.

Results of Body Part Analysis

Gazelle (Gazella gazella)

The gazelle body part profiles from Hayonim Cave and Hilazon Tachtit are similar, though small differences in the representation of some anatomical regions may exist (Tables 5.2 and 5.3, and Figure 5.1). Both profiles are dominated by the limb regions, and axial elements are poorly represented. The bias against neck and axial elements can be partly explained by the action of density-mediated attritional processes discussed earlier, though the same cannot be argued for the underrepresentation of heads and horns. At Hayonim Cave, the MNE counts for heads and horns are based on dense bone portions including the petrous, the mandibular condyle and the base of the horn core. The bone-based head and horn counts agree with the MAU calculated from teeth (MAU = 14). The same is not true of the Hilazon Tachtit gazelles, whose teeth (MAU = 4) are as common as most limb elements. The horn and head regions are somewhat underrepresented, but not as seen for Hayonim Cave.

Hayonim Cave Gazelle	MNE in Skeleton	NISP	MNE	MAU	Hilzon Tachtit Gazelle	MNE in Skeleton	NISP	MNE	MAU
Horn	2	98	26	13	**Horn**	2	9	2	1
1/2 Cranium	2	133	24	12	**1/2 Cranium**	2	23	3	2
Mandible	2	124	24	12	**Mandible**	2	24	3	2
Atlas	1	24	4	4	**Atlas**	1	4	3	3
Axis	1	19	5	5	**Axis**	1	3	3	3
Cervical	5	106	21	5	**Cervical**	5	1	1	1
Thoracic	13	101	33	3	**Thoracic**	13	16	9	1
Lumbar	7	138	25	4	**Lumbar**	7	12	4	1
Sacrum	1	6	3	3	**Sacrum**	1	1	1	1
Ribs	26	394	95	4	**Ribs**	26	86	20	1
Innominate	2	87	11	6	**Innominate**	2	7	5	3
Scapula	2	67	14	7	**Scapula**	2	19	4	2
Humerus	2	157	90	45	**Humerus**	2	22	9	5
Radius	2	133	41	21	**Radius**	2	20	4	2
Ulna	2	76	36	18	**Ulna**	2	11	5	3
Metacarpal	2	106	27	14	**Metacarpal**	2	13	4	2
Femur	2	119	20	10	**Femur**	2	36	3	2
Patella	2	34	34	17	**Patella**	2	0	0	0
Tibia	2	184	45	23	**Tibia**	2	23	7	4
Astragalus	2	71	65	33	**Astragalus**	2	6	6	3
Calcaneum	2	87	66	33	**Calcaneum**	2	5	3	2
Metatarsal	2	165	33	17	**Metatarsal**	2	21	4	2
Phalanx 1	8	429	242	31	**Phalanx 1**	8	49	28	4
Phalanx 2	8	300	229	29	**Phalanx 2**	8	34	26	4
Phalanx 3	8	192	168	21	**Phalanx 3**	8	17	14	2
TOTAL	**108**	**3350**	**1381**	**45**	**Total**	**108**	**462**	**171**	**5**

Table 5.2: Elemental representation of gazelle (*Gazella gazella*) from the Natufian layer at Hayonim Cave and Hilazon Tachtit. Small ungulates are included in the gazelle category, since 99% of the small ungulates assigned to species at both sites are gazelle.

The underrepresentation of head parts at Hayonim Cave can not be explained by *in situ* attrition or by human processing activities, since at least the very dense portions of the skull and mandible are expected to endure under both circumstances; if skulls are bashed to extract the brains, dense portions such as the petrous will still preserve well, even if they are fragmented. Instead, the poor representation of dense head parts indicates that only about half as many gazelle heads as bodies were deposited at Hayonim Cave. Heads in general are underrepresented at Hayonim Cave, but the heads of females are nearly absent. Nearly all of the 26 (MNE) horn cores recovered from the site belong to males (92.3%). Thus females were either rarely hunted or their heads were rarely transported to Hayonim Cave during the Natufian period.

Hayonim Cave Gazelle	**MNE in Skeleton**	**NISP**	**MNE**	**MAU**	**Hilazon Tachtit Gazelle**	**MNE in Skeleton**	**NISP**	**MNE**	**MAU**
Horn	2	98	26	13	**Horn**	2	9	2	1
Head	4	257	48	12	**Head**	4	47	6	2
Neck	7	149	30	5	**Neck**	7	8	7	1
Axial	49	726	167	4	**Axial**	49	122	39	1
Upper Front	4	224	104	26	**Upper Front**	4	41	13	4
Lower Front	6	315	104	18	**Lower Front**	6	44	13	3
Upper Hind	4	153	54	14	**Upper Hind**	4	36	3	1
Lower Hind	8	507	209	27	**Lower Hind**	8	55	20	3
Feet	24	921	639	27	**Feet**	24	100	68	3
TOTAL	**108**	**3350**	**1381**	**27**	**TOTAL**	**108**	**462**	**171**	**4**

Table 5.3: Body part representation of gazelle (*Gazella gazella*) by anatomical region from Hayonim Cave and Hilazon Tachtit. Non-specific small ungulate remains are included within the gazelle category, since 99% of small ungulate remains that could be assigned to species in both assemblages are gazelles in both assemblages.

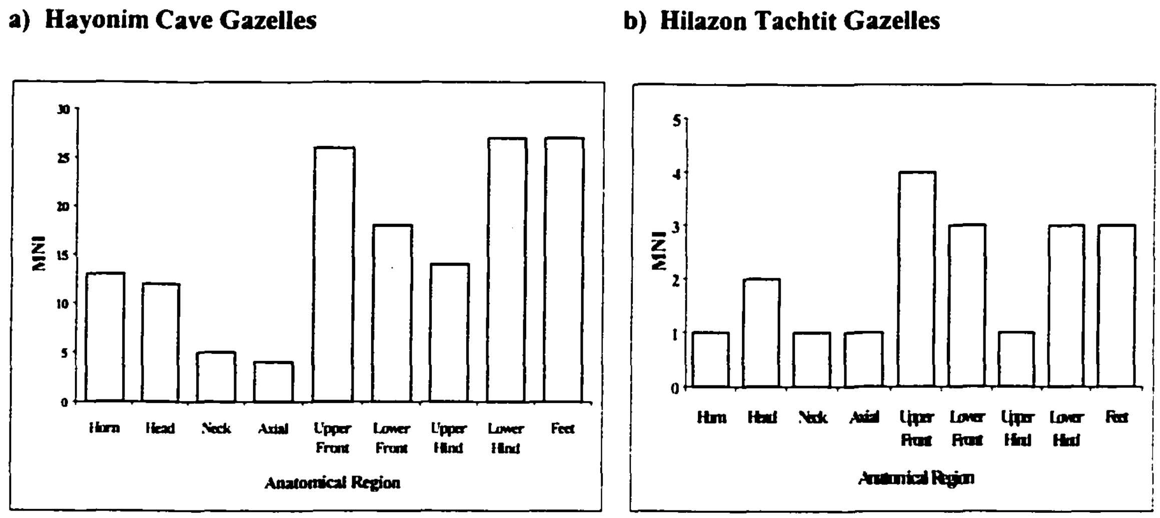


Figure 5.1: Gazelle (*Gazella gazella*) body part representation by anatomical region from the Natufian layer at Hayonim Cave (a) and Hilazon Tachtit (b). Non-specific small ungulate remains are included within the gazelle category, since 99% of small ungulate remains that could be assigned to species in both assemblages are gazelles in both assemblages.

Neck and axial parts are even less common than gazelle head parts in the Hayonim Cave assemblage. This is not surprising since vertebrae are composed mainly of low density, cancellous bone, and they are easily fragmented and difficult to identify to species when broken. It is difficult to determine whether the poor representation of gazelle heads and necks indicates a transport or a preservational bias. Gazelles may be large in comparison to most Natufian prey, but they fall on the small end of the ungulate body size spectrum in Eurasia (females average 15-18 kg and males average 20-25 kg; Baharav 1983a). This is not to suggest that their heads could not have been removed and consumed in the field.

A Spearman's rank-order coefficient is used to establish whether transport decisions played a significant influence over the gazelle body part representation.

Binford's (1978) MGUI values for sheep are used as analogues for gazelle based on similarities in their body mass and close taxonomic affiliation. Figure 5.2 shows the relationship between the survivorship of gazelle bone portions from Hayonim Cave and the MGUI derived for sheep. The relationship between bone survivorship and the MGUI is statistically significant only at the .05 level of probability (r_s = -0.502, n = 11, p<.05). In the previous chapter, however, it was shown that the observed representation of gazelle bone portions correlates strongly with bone mineral density (r_s = 0.546, n = 17, p>.001). Gazelle attrition at Hayonim Cave is clearly density-mediated. As argued by Grayson (1988, 1989) a relatively weaker correlation between the MGUI and bone survivorship suggests that the representation of body parts is unlikely to have been caused by utility-based transport decisions. Instead the correlation between the MGUI and gazelle bone survivorship at Hayonim Cave is more likely a byproduct of density-mediated processes, which preferentially destroyed high utility bone portions. This issue, and specifically its causes, will be taken up again later.

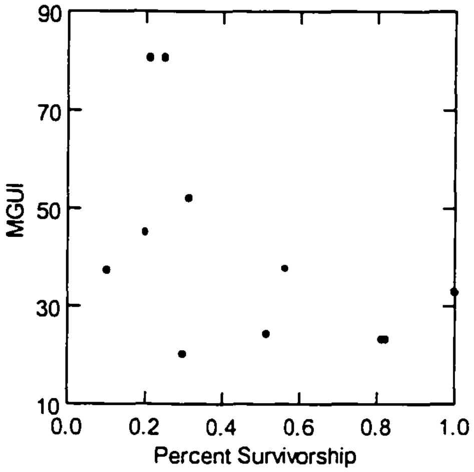


Figure 5.2: Percent Survivorship of gazelle long bones (shafts not included) versus MGUI (r_s = -0.502, n = 11, p<.05).

Carnivores

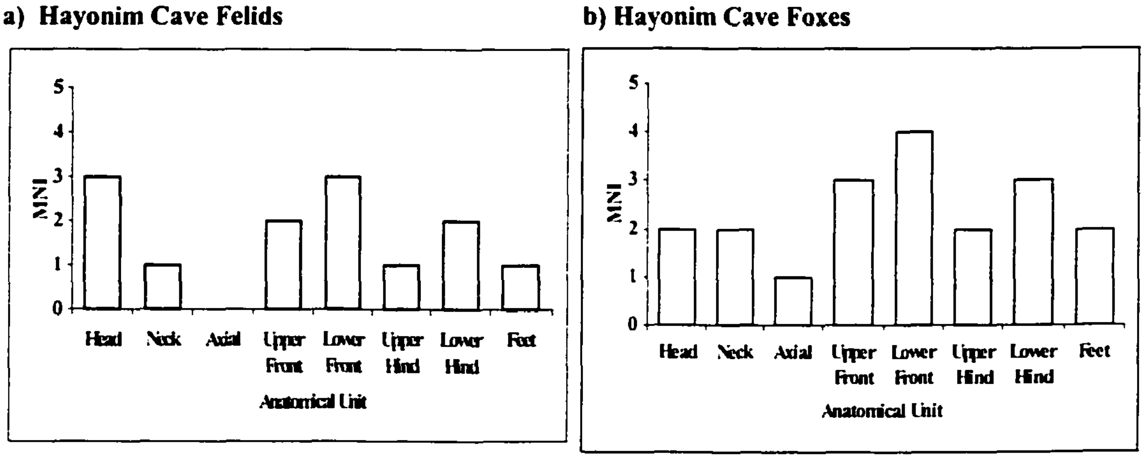
Carnivore sample sizes from the two sites are fairly small, but those for foxes (*Vulpes vulpes*) and felids (*Felis* cf. *chaus*) from Hayonim Cave are adequate for basic body part analysis (see Tables 5.4 and 5.5, and Figure 5.3). The body part profiles of the two carnivores are nearly identical, with the exception of the head which is better represented in the felids. Unfortunately, samples for mustelid species are too small to determine whether a similar pattern emerges for other fur-bearing carnivore species.

Hayonim Felids	MNE in Skeleton	NISP	MNE	MNI	Hayonim Foxes	MNE in Skeleton	NISP	MNE	MNI
Cranium	2	7	7	4	**Cranium**	2	15	3	2
Mandible	2	4	2	1	**Mandible**	2	8	3	2
Atlas	1	0	0	0	**Atlas**	1	3	2	2
Axis	1	1	1	1	**Axis**	1	2	2	2
Sacrum	1	0	0	0	**Sacrum**	1	1	1	1
Pelvis	2	0	0	0	**Pelvis**	2	3	2	1
Scapula	2	1	1	1	**Scapula**	2	3	3	2
Humerus	2	10	5	3	**Humerus**	2	19	8	4
Radius	2	13	7	4	**Radius**	2	13	9	5
Ulna	2	2	2	1	**Ulna**	2	7	6	3
Metacarpal	10	7	6	1	**Metacarpal**	10	14	14	2
Femur	2	1	1	1	**Femur**	2	5	3	2
Tibia	2	4	3	2	**Tibia**	2	11	6	3
Fibula	2	2	2	1	**Fibula**	2	4	4	2
Astragalus	2	3	3	2	**Astragalus**	2	6	6	3
Calcaneum	2	3	3	2	**Calcaneum**	2	6	5	3
Metatarsal	10	2	3	1	**Metatarsal**	10	15	12	2
Phalanx 1	20	22	21	2	**Phalanx 1**	20	13	13	1
Phalanx 2	20	19	19	1	**Phalanx 2**	20	28	28	2
Phalanx 3	20	1	1	1	**Phalanx 3**	20	15	16	1
TOTAL	**107**	**102**	**87**	**4**	**TOTAL**	**107**	**191**	**146**	**5**

Table 5.4: Representation of felid (*Felis* cf. *chaus*) and fox (*Vulpes vulpes*) elements in the Natufian layer from Hayonim Cave. Vertebrae and ribs (except atlas and axis) are eliminated from analysis since they could not be assigned to a category more specific than "small mammal".

Hayonim Felids	MNE in Skeleton	NISP	MNE	MNI	Hayonim Foxes	MNE in Skeleton	NISP	MNE	MNI
Head	4	11	9	3	**Head**	4	23	6	2
Neck	2	1	1	1	**Neck**	2	5	4	2
Axial	3	0	0	0	**Axial**	3	4	3	1
Upper Front	4	11	6	2	**Upper Front**	4	22	11	3
Lower Front	4	15	9	3	**Lower Front**	4	20	15	4
Upper Hind	2	1	1	1	**Upper Hind**	2	5	3	2
Lower Hind	8	12	11	2	**Lower Hind**	8	27	21	3
Feet	80	51	50	1	**Feet**	80	85	83	2
TOTAL	**107**	**102**	**87**	**3**	**TOTAL**	**107**	**191**	**146**	**4**

Table 5.5: Representation of felid (*Felis* cf. *chaus*) and fox (*Vulpes vulpes*) anatomical units in the Natufian layer from Hayonim Cave. Vertebrae and ribs (except atlas and axis) are eliminated from analysis since they could not be assigned to a category more specific than "small mammal".



a) Hayonim Cave Felids

b) Hayonim Cave Foxes

Figure 5.3: Representation of felid (*Felis* cf. *chaus*; graph a) and fox (*Vulpes vulpes*; graph b) anatomical units in the Natufian layer from Hayonim Cave.

The carnivore profiles do not differ significantly from those of the gazelles except in the ratio of upper to lower forelimb bones, and the abundance of foot elements. At both sites gazelle upper forelimbs are represented in higher frequencies than the lower forelimb, while the reverse is true for the foxes and felids from Hayonim Cave. This discrepancy corresponds directly to differences in the distribution of muscle mass and probably also how animals were used; gazelles are better represented by the meaty upper limbs, and carnivores by the non-meat bearing lower limbs, which are expected byproducts of fur collection. The interpretation is opposed by the underrepresentation of felid foot bones at Hayonim Cave. Because the foot elements of fox and wild cat are often very small and difficult to identify to species, greater loss during recovery (i.e., small foot bones may have been sorted out as microfauna) and identification is expected than in the case of ungulates.

The variation in the relative representation of fox and felid body parts at Hayonim Cave is partly attributable to sample size, but overall the profiles show fairly complete body part representation, indicating that they were most often carried to the site as intact bodies. Foxes and felids have fairly small body masses (foxes up to 4 kg; *Felis* sp. range between 3-7 kg; Silva and Downing 1995), and it is nearly as easy to transport them whole, as to butcher them and selectively discard parts in the field.

Hares (Lepus capensis)

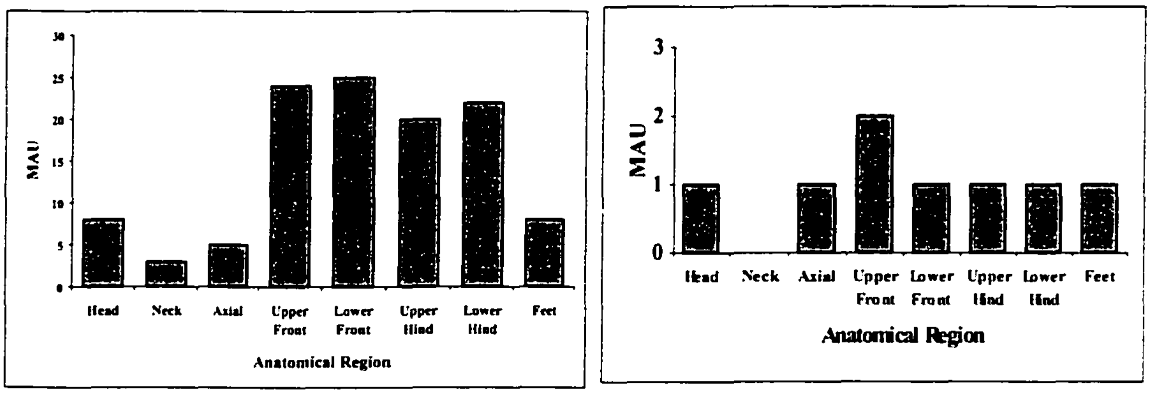
The body part representation of hares from Hayonim Cave and Hilazon Tachtit (Tables 5.6 and 5.7, and Figure 5.4) is biased against the axial regions (head, neck and vertebral column) and foot elements. This pattern is more likely the result of identification and preservation biases than differential transport. Though the head region appears to be underrepresented as well, this is true only of the cranial and mandibular bones. Teeth MAUs are similar (MAU = 25) to those of the appendicular regions, and thus skulls must have originally been deposited in frequencies similar to the postcranial skeleton. The underrepresentation of the neck and axial regions, composed primarily of vertebrae, is likely a joint product of their fragile structure and lower inherent identifiability (see Chapter 4). As was the case for carnivores, hare foot bones are underrepresented in the Hayonim assemblage probably because they include large numbers of very small elements (20 per foot), which are difficult to identify to species and are easily lost during excavation and sorting. Also, the first phalanges of hares and foxes are similar in form and were most often assigned to a more general small mammal category.

Hayonim Hares	**MNE in Skeleton**	**NISP**	**MNE**	**MAU**	**Hilazon Hares**	**MNE in Skeleton**	**NISP**	**MNE**	**MAU**
1/2 Cranium	2	60	11	6	**1/2 Cranium**	2	1	1	1
Mandible	2	54	18	9	**Mandible**	2	3	3	2
Atlas	1	6	3	3	**Atlas**	1	0	0	0
Axis	1	8	6	6	**Axis**	1	0	0	0
Cervical	5	12	9	2	**Cervical**	5	0	0	0
Thoracic	13	51	36	3	**Thoracic**	13	0	0	0
Lumbar	7	62	35	5	**Lumbar**	7	3	2	1
Sacrum	1	2	2	2	**Sacrum**	1	0	0	0
Innominate	2	75	22	11	**Innominate**	2	0	0	0
Scapula	2	103	30	15	**Scapula**	2	5	3	2
Humerus	2	105	66	33	**Humerus**	2	3	2	1
Radius	2	145	59	30	**Radius**	2	0	0	0
Ulna	2	65	39	20	**Ulna**	2	0	0	0
Metacarpal	10	152	142	15	**Metacarpal**	10	3	3	1
Femur	2	122	39	20	**Femur**	2	1	1	1
Tibia	2	157	41	22	**Tibia**	2	3	1	1
Astragalus	2	44	38	19	**Astragalus**	2	4	4	2
Calcaneum	2	64	49	25	**Calcaneum**	2	1	1	1
Metatarsal	10	134	107	11	**Metatarsal**	10	4	3	1
Phalanx 1	20	125	109	6	**Phalanx 1**	20	3	3	1
Phalanx 2	20	124	116	6	**Phalanx 2**	20	2	2	1
Phalanx 3	20	102	102	6	**Phalanx 3**	20	0	0	0
TOTAL	**130**	**1772**	**1079**	33	TOTAL	**130**	**36**	**29**	**2**

Table 5.6: Representation of hare (*Lepus capensis*) elements in the Natufian layer from Hayonim Cave and Hilazon Tachtit. Ribs are omitted since they were not assigned to species but to the small mammal category.

Hayonim Hares	MNE in Skeleton	NISP	MNE	MAU	Hilazon Hares	MNE in Skeleton	NISP	MNE	MAU
Head	4	114	29	8	**Head**	4	4	4	1
Neck	7	26	18	3	**Neck**	7	0	0	0
Axial	23	190	95	5	**Axial**	23	3	2	1
Upper Front	4	208	96	24	**Upper Front**	4	8	5	2
Lower Front	4	210	98	25	**Lower Front**	4	3	3	1
Upper Hind	2	122	39	20	**Upper Hind**	2	1	1	1
Lower Hind	6	265	128	22	**Lower Hind**	6	8	6	1
Feet	80	637	576	8	**Feet**	80	9	8	1
TOTAL	**130**	**1772**	**1079**	**25**	**TOTAL**	**130**	**36**	**29**	**2**

Table 5.7: Representation of hare (*Lepus capensis*) by anatomical region in the Natufian layers at Hayonim Cave and Hilazon Tachtit.



a) Hayonim Cave Hares

b) Hilazon Tachtit Hares

Figure 5.4: Hare (*Lepus capensis*) body part representation by anatomical region in the Natufian layer from Hayonim Cave (a), and Hilazon Tachtit (b).

That crania, toes, vertebrae, and ribs are underrepresented in the hare and carnivore profiles due to an identification bias is attested to by the body part profiles of the small mammal taxonomic group. All small mammal specimens that could not be identified to species were assigned to this general category. With the exception of the vertebrae component, the MNE values for small mammals elements in Table 5.8 are the opposite and therefore complement of the profiles shown previously for hares and carnivores. The underrepresentation of crania, ribs, and toes in the hare and small carnivore profiles is clearly linked to identification issues rather than their absence in the assemblage. Hare carcasses were thus transported to Hayonim Cave whole, which is hardly surprising given their small body size of ca. 2-3 kg (Silva and Downing 1995).

Hayonim Cave Small Mammals	**NISP**	**MNE**	**Element**	**NISP**	**MNE**
Cranium	17	6	**Humerus**	1	1
Mandible	1	1	**Ulna**	1	1
Atlas	1	1	**Metacarpal**	1	1
Axis	1	1	**Femur**	1	1
Cervical	2	2	**Tibia**	1	1
Thoracic	3	3	**Metatarsal**	1	1
Rib	337	68	**Phalanx 1**	157	132
Lumbar	4	4	**Phalanx 2**	18	18
Pelvis	1	1	**Phalanx 3**	1	1
Scapula	1	1	**TOTAL**	**556**	**244**

Table 5.8: NISP and MNE values for elements from the small mammal category from the Natufian layer at Hayonim Cave. The small mammal category includes animals the size of a fox or smaller, that can not be assigned to a specific taxonomic affiliation.

The hare assemblage from Hilazon Tachtit is small (NISP = 36), but all anatomical regions, with the exception of the neck, are represented. What few animals were brought to the site were carried back whole to the site as well.

Partridges (Alectoris chukar)

Figure 5.5 shows that the peak of the lower hind limb in the Hayonim Cave partridge profile dwarfs even the second most common anatomical region (the pectoral girdle) by a factor of two (data in Tables 5.9 and 5.10). This figure is much higher when the elements are examined independently (Table 5.9). The high frequency of the lower limb is explained nearly entirely by the abundance of partridge tibiotarsi in the assemblage. This bias was identified previously by Pichon (1983; 1984) and Tchernov

(1993a), who relate the abundance of tibiotarsi with the manufacture of partridge bone beads at Hayonim Cave. Beads made from the distal ends of partridge tibiotarsi have been recovered from only three Natufian sites but include at least 40 specimens from Hayonim Cave, 6 from Ain Mallaha, and 2 from Erq-el Aqmar in the Judean Hills (Belfer-Cohen 1988). Despite their known ornamental function, most of the tibiotarsi are not actually modified (only 17.1% are cut, NISP = 246), but perhaps were stockpiled or curated for future use. A significant bias in the representation of partridge tibiotarsi does

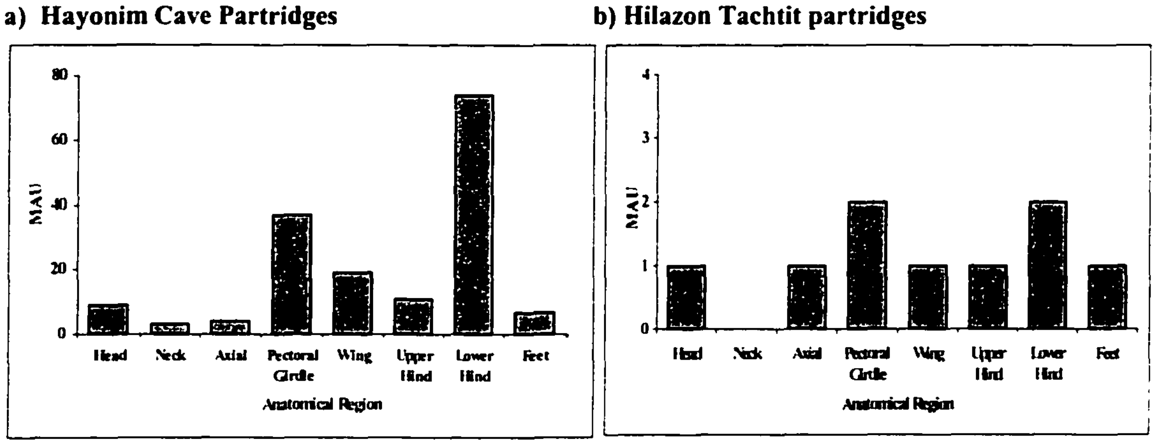
Hayonim Element	MNE in Skeleton	NISP	MNE	MAU	Hilazon Element	MNE in Skeleton	NISP	MNE	MAU
Cranium	1	11	8	8	**Cranium**	1	1	1	1
Lower Beak	1	13	10	10	**Lower Beak**	1	1	1	1
Atlas	1	0	0	0	**Atlas**	1	0	0	0
Axis	1	3	3	3	**Axis**	1	0	0	0
Cervical	12	34	26	3	**Cervical**	12	0	0	0
Thoracic	6	16	16	3	**Thoracic**	6	0	0	0
Synsacrum	1	7	3	3	**Synsacrum**	1	1	1	1
Ribs	14	13	6	1	**Ribs**	14	0	0	0
Innominate	2	72	48	24	**Innominate**	2	2	1	1
Sternum	1	63	40	40	**Sternum**	1	0	0	0
Coracoid	2	170	82	41	**Coracoid**	2	7	4	2
Furculum	1	35	34	34	**Furculum**	1	2	2	2
Scapula	2	80	65	33	**Scapula**	2	5	5	3
Humerus	2	127	64	32	**Humerus**	2	7	3	2
Radius	2	22	10	5	**Radius**	2	2	2	1
Ulna	2	63	22	11	**Ulna**	2	2	2	1
Carpometacarpus	2	79	46	23	**Carpometacarpus**	2	0	0	0
Wing Phalanx	2	47	45	23	**Wing Phalanx**	2	2	2	1
Femur	2	63	22	11	**Femur**	2	4	1	1
Tibiotarsus	2	429	229	115	**Tibiotarsus**	2	4	3	2
Tarsometatarsus	2	159	66	33	**Tarsometatarsus**	2	1	1	1
Phalanx 1	8	53	45	6	**Phalanx 1**	8	1	1	1
Phalanx 2	12	78	71	6	**Phalanx 2**	12	1	1	1
Phalanx 3	8	79	78	10	**Phalanx 3**	8	0	0	0
TOTAL	**89**	**1716**	**1039**	**115**	**TOTAL**	**89**	**43**	**31**	**3**

Table 5.9: Representation of partridge (*Alectoris chukar*) elements in the Natufian layer from Hayonim Cave and Hilazon Tachtit.

not occur at sites where beads were not present (e.g., el-Wad and Hilazon Tachtit). The number of individual partridges accounted for by tibiotarsi is so much greater than any other element that foragers must have obtained tibiotarsi from many more partridges than were transported to the site. Perhaps some tibiotarsi were found or captured and eaten by human foragers off site.

Hayonim Element	MNE in Skeleton	NISP	MNE	MAU	Hilazon Element	MNE in Skeleton	NISP	MNE	MAU
Head	2	24	18	9	**Head**	2	2	2	1
Neck	14	37	29	3	**Neck**	14	0	0	0
Axial	23	108	73	4	**Axial**	23	3	2	1
Pectoral Girdle	6	348	221	37	**Pectoral Girdle**	6	14	11	2
Wing	10	338	187	19	**Wing**	10	13	9	1
Upper Hind	2	63	22	11	**Upper Hind**	2	4	1	1
Lower Hind	4	588	295	74	**Lower Hind**	4	5	4	2
Feet	28	210	194	7	**Feet**	28	2	2	1
TOTAL	**89**	**1716**	**1039**	**74**	**TOTAL**	**89**	**43**	**31**	**2**

Table 5.10: Representation of partridge (*Alectoris chukar*) anatomical units in the Natufian layer from Hayonim Cave and Hilazon Tachtit.



a) Hayonim Cave Partridges **b) Hilazon Tachtit partridges**

Figure 5.5: Representation of partridge (*Alectoris chukar*) anatomical units in the Natufian layer from Hayonim Cave (a) and Hilazon Tachtit (b).

Though, the pectoral girdle is second in abundance to the lower hind limb, its representation is economically important. The bones of the pectoral girdle are connected to the primary meat source in the partridge body (see also Pichon 1984; Tchernov 1993a). The high frequency of partridge pectoral elements at Hayonim Cave attests to the bird's importance as a food source and the refuse directly links it to consumption on site.

The small sample size of the Hilazon Tachtit assemblage precludes quantitative analysis of the anatomical units, but the full spectrum of body parts are represented with the exception of the neck. The sample shows only a minor bias toward the tibiotarsus, despite its prevalence in the Hayonim Cave assemblage, most likely because partridge beads were not manufactured or curated at Hilazon Tachtit.

Diurnal Raptors (Falconiformes)

At Hayonim Cave and Hilazon Tachtit the Falconiforme assemblages are dominated by leg elements, especially the terminal phalanges (see Tables 5.11 and 5.12, and Figure 5.6). In birds, the lower legs are encased in a protective covering of scales and skin, but bear no meat except at the base of the thigh (the proximal tibiotarsus). The anatomical pattern strongly indicates that Falconiforme foot and lower leg elements were selectively transported to the site to the near exclusion of other parts. The Falconiforme body part profile differs significantly from that expected for a game bird such as the partridge. The Natufians clearly preferred the non-meat bearing parts of raptors. Among modern human groups, raptors are rarely captured for meat, presumably due to their high trophic position which reportedly lends an unpleasant taste to their flesh. The most common skeletal element in the raptor assemblage, the third phalanx, forms the basis of a powerful claw and shows up in many Upper and Epipaleolithic sites, frequently as ornaments or talismans (Kuhn et al. 2001, n.d.; Rabinovich 1997).

Hayonim Cave Falconiformes	MNE in Skeleton	NISP	MNE	MAU	Hilazon Tachtit Falconiformes	MNE in Skeleton	NISP	MNE	MAU
Lower Beak	1	1	1	1	**Lower Beak**	1	0	0	0
Synsacrum	1	0	0	0	**Synsacrum**	1	0	0	0
Innominate	2	0	0	0	**Innominate**	2	0	0	0
Sternum	1	1	1	1	**Sternum**	1	1	1	1
Coracoid	2	17	11	6	**Coracoid**	2	3	3	2
Furculum	1	1	1	1	**Furculum**	1	0	0	0
Scapula	2	9	8	4	**Scapula**	2	2	2	1
Humerus	2	17	7	4	**Humerus**	2	0	0	0
Radius	2	1	1	1	**Radius**	2	0	0	0
Ulna	2	11	6	3	**Ulna**	2	1	1	1
Carpometacarpus	2	7	5	3	**Carpometacarpus**	2	1	1	1
Wing Phalanx	2	2	2	1	**Wing Phalanx**	2	0	0	0
Femur	2	15	6	3	**Femur**	2	2	2	1
Tibiotarsus	2	20	14	7	**Tibiotarsus**	2	4	3	2
Tarsometatarsus	2	50	27	14	**Tarsometatarsus**	2	3	3	2
Tarsal	2	21	21	11	**Tarsal**	2	1	1	1
Phalanx 1	8	52	46	6	**Phalanx 1**	8	0	0	0
Phalanx 2	12	80	70	6	**Phalanx 2**	12	1	1	1
Phalanx 3	8	137	126	16	**Phalanx 3**	8	4	3	1
TOTAL	**56**	**442**	**353**	**16**	**TOTAL**	**56**	**23**	**21**	**2**

Table 5.11: Representation of Falconiforme elements in the Natufian layer from Hayonim Cave and Hilazon Tachtit. Vertebrae and ribs are eliminated from analysis since they could not be assigned to a category more specific than medium or large bird.

Hayonim Cave Falconiformes	MNE in Skeleton	NISP	MNE	MAU	Hilazon Tachtit Falconiformes	MNE in Skeleton	NISP	MNE	MAU
Head	2	1	1	1	**Head**	2	0	0	0
Axial	2	0	0	0	**Axial**	2	0	0	0
Pectoral Girdle	6	28	21	4	**Pectoral Girdle**	6	6	6	1
Wing	10	38	21	2	**Wing**	10	2	2	1
Upper Hind	2	35	6	3	**Upper Hind**	2	2	2	1
Lower Hind	4	71	62	11	**Lower Hind**	4	8	7	2
Feet	30	269	242	9	**Feet**	30	5	4	1
TOTAL	**56**	**442**	**353**	**11**	**TOTAL**	**56**	**23**	**21**	**2**

Table 5.12: Falconiforme body part representation by anatomical unit in the Natufian layer from Hayonim Cave and Hilazon Tachtit.

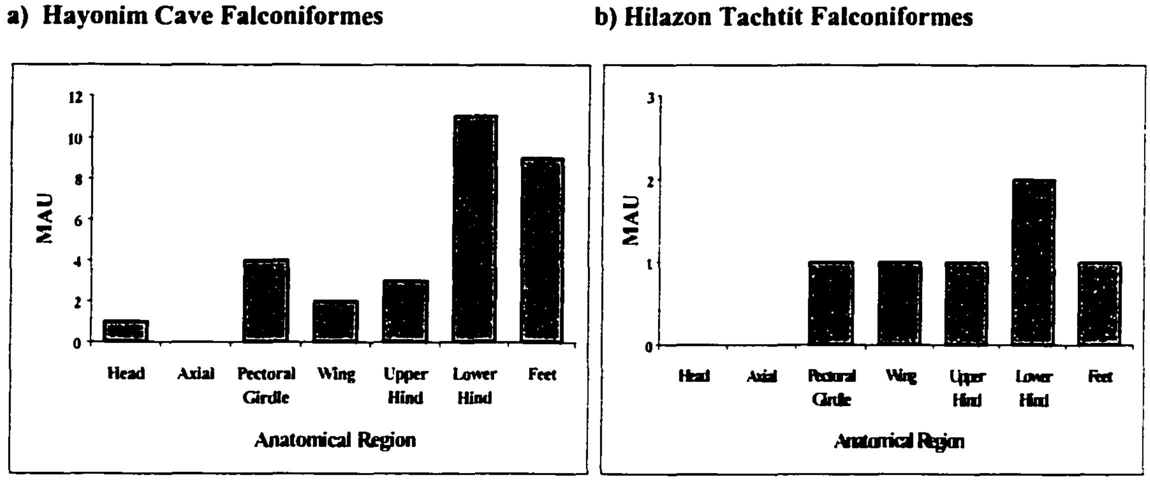


Figure 5.6: Falconiformes body part representation by anatomical unit in the Natufian layer from Hayonim Cave (a) and Hilazon Tachtit (b).

Summary of Human Transport Decisions

Body size was the primary constraint for transport decisions at Hayonim Cave and Hilazon Tachtit. Small-bodied animals such as hares, partridges, foxes, and felids are represented by the full range of body parts. Certain elements of partridge and raptors are greatly overrepresented, but this is explained by their function as raw material for ornaments and tools. Due to difficulties quantifying portions of the carapace and plastron, the body part representation of tortoises was not presented, yet tortoise carapace, plastron, and limb elements are also abundant at the two sites, while the head elements are missing due to their fragility or because they are simply too difficult to recover. All of the small animals discussed come in easy to manage packages that rarely exceed 1 kg and can be transported over long distances by a single person. With the exception of the carnivores, small game species commonly hunted by the Natufians can live at high population densities, and were most likely obtained close to home. Of the small animals, only the body parts of the avian species were selectively transported. It is difficult to establish whether raptors were captured primarily to acquire raw materials (e.g., bones and possibly feathers), or if valued elements were opportunistically scavenged when encountered.

Though gazelles are relatively small ungulates, they are the largest of the common prey species in the Natufian assemblages, and they are the only species other than the Falconiformes that may have been partially butchered in the field. At Hayonim Cave, the heads of gazelle are only half as common as the appendicular regions. Of the heads that were transported, most are males possessing large horn cores. The sex-biased transport of gazelle heads may have been caused by a few factors acting alone or in combination, including the distance transported, but more importantly the sex of the animal and perhaps the season of capture.

When female gazelles were captured far from home, their heads may have been removed to be eaten immediately or to ease the burden of transport. Only a relatively small portion of the head's weight is edible in comparison to other body parts, and it can easily be separated from the body of the animal and roasted. The main edible portions of the cranium, the brains and the tongue, could also have been removed and consumed at the kill site. Still, the removal of the head is not expected to reduce the weight of a carcass by much -- the head weighs less than one kilogram in females and less than two kilograms in males (Cope 1991a).

The animal's sex appears to have determined whether or not heads were transported to camp. Male heads differ from females primarily in the size of their horns, which are several times thicker and longer. Though female horn cores may be more sensitive to post-depositional processes, MNE counts for horn cores are based on its junction with the frontal bone, which is quite dense in both males and females.

A bias in favor of male heads can be caused by preferential selection of males when hunted (as suggested by Cope 1991a, 1991b), or preferential transport of male heads, horn cores and/or keratinous sheaths to camp for use as raw materials. That male horn cores were valued by Natufian foragers is clear, based on the presence of several modified pieces at Hayonim Cave, as well as a cache of at least 18 (MNE) male horn cores recovered from the Late Natufian deposits close to the east wall of the cave (see Figure 5.7). There is, however, no clear evidence that the male postcranial assemblage was also dominated by males as suggested by Cope (1991a, 1991b). It is extremely difficult to sex the gazelle's postcranial skeleton, yet plotting measurements from the archaeological population can at least indicate the overall size distribution of the culled population for any given skeletal element. A scatterplot of the breadth versus height of the distal trochlea of gazelle (*G. gazella*) humeri (in mm), reveals a large range of variation, extending well beyond the range for modern males and females combined (see Figure 5.8; measurements of modern gazelle populations courtesy of Guy Bar-Oz). Regardless of whether Natufian gazelles were smaller or larger on average than modern gazelles, it is difficult to believe that the male population alone could encompass such broad variation in body size. This line of evidence agrees with MAU/sexed horn data – since heads are about half as common in comparison to postcranial skeletons in the assemblage, and these heads are nearly exclusively male. Females may well be represented in the postcranial material, hunters just didn't bring their heads home much of the time.

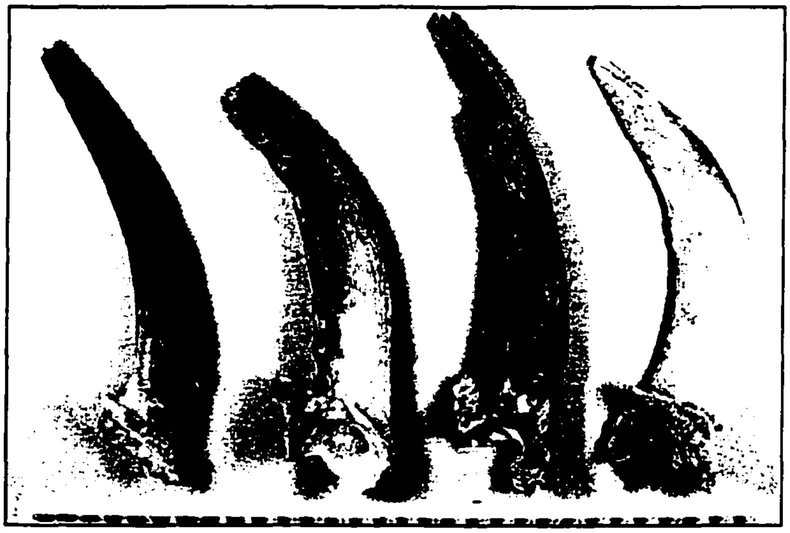


Figure 5.7: Sample of male gazelle horn cores recovered from Late Natufian cache at Hayonim Cave. All specimens are burned but with varying intensities.

The season of capture may also have influenced human decisions to transport head parts. The availability of fat in Mediterranean environments fluctuates on a seasonal basis: during the winter and early spring in the Levant the fat stores of animals become depleted. Mammals store fat under their skin, in their bones, and as permanent structures in the nervous system. The first fat store to be tapped during periods of shortage is the subcutaneous layer, followed by the marrow. The nervous system requires fat for its operation and can not be metabolized, thus even animals on the brink of starvation retain fat in their central nervous system (Stiner 1991a, 1994: 228). The brains of animal provide a dependable source of fat during the lean season, and the heads of gazelles may only have been transported during this period. Alternatively, and typical of arid environments (Stiner 1994: 228) gazelles' brains were eaten, some in the field and some at home.

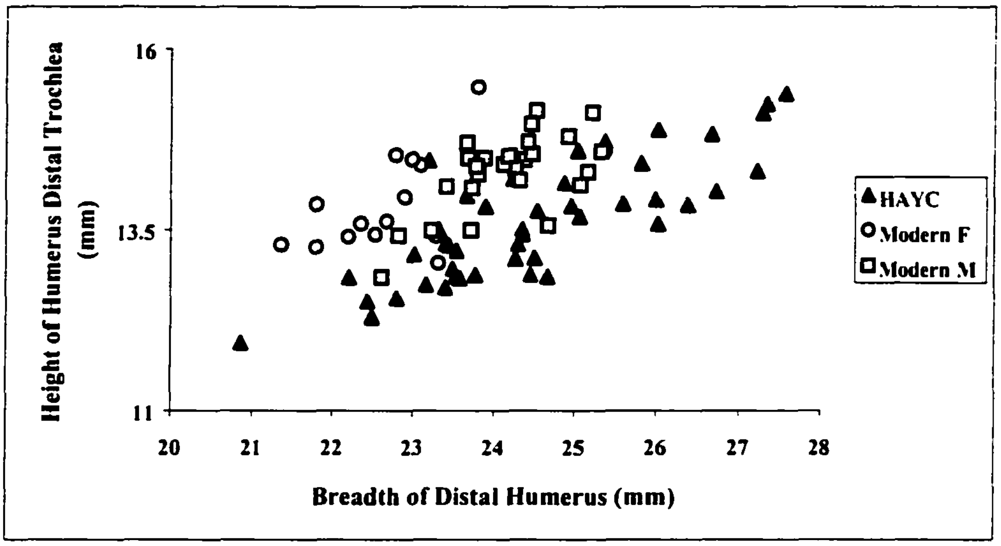


Figure 5.8: Measurements of gazelle distal humeri from the Natufian layer at Hayonim Cave, and modern gazelles of known sex from the faunal collection in the Department of E.S.E. at the Hebrew University. Modern gazelle measurements are courtesy of Guy Bar-Oz.

In summary, the gazelles transported to Hayonim Cave arrived as essentially complete carcasses, with the exception of the heads in nearly half the cases, most of them female. Perhaps, the heads of females were removed and eaten at kill sites, since they were not needed for secondary materials (e.g., horn cores). Female heads may have been roasted and brains eaten prior to transport as suggested by modern studies of hunter-gatherers who tend to snack on easily prepared parts between the time of the kill and the return to camp (e.g., Binford 1978; Bunn et al. 1991; O'Connell et al. 1988).

Transport and Curation of Certain Skeletal Elements as Raw Materials

In several instances, the body part profiles of Natufian game species at Hayonim

Cave are marked by inflated proportions of a just a few skeletal elements that served distinct secondary functions as raw materials for tool and ornament manufacture at Hayonim Cave (see also Campana 1989, 1991). Cervid antlers, gazelle metapodials, partridge tibiotarsi, and terminal raptor phalanges are among the most common elements for their taxon. Fallow deer and red deer are uncommon in the Natufian assemblages, yet antler fragments are abundant (21.8% of NISP). The metapodials of gazelles (MAU = 36), the most common raw material for the manufacture of bone awls, beads and other tools at Hayonim Cave, are the second most abundant element in the gazelle assemblage (MAU = 36). Also, as mentioned above, though gazelle heads are underrepresented at Hayonim, those that were transported belong nearly exclusively to males possessing large horns.

The bias toward raw materials is even more pronounced in the body part profiles of avian species. Partridge tibiotarsi (MNE = 229) are nearly three times more common than the second most frequent element (the coracoid, MNE = 82), and the third phalanx (the claw) of all raptor species are the most abundant in the Falconiforme assemblage by a factor of two.

The caches at Hayonim Cave, one of gazelle horn cores and another of large ungulate ribs (some modified, but most unworked), attest to the perceived value of certain bones by the Natufians, who stockpiled them for later use. The Natufian inhabitants of Hayonim Cave unquestionably recognized the value of these elements as raw materials and made a concerted effort to transport and curate them, even when their abundance exceeded demand.

CARCASS PROCESSING BY NATUFIAN FORAGERS

Animal carcasses provide high-quality edible products such as meat, marrow, and bone grease, and contain most or all of the nutrients essential for human survival and nutrition. Animals also provide secondary resources in the form of skin, feathers, sinew, and bone, staples for the production of clothing, shelter, tools, and ornaments. The activities undertaken to extract these products are collectively known as carcass processing and include skinning, dismembering, defleshing, marrow and grease extraction, and cooking.

Butchering methods and other forms of processing often leave traces on skeletal materials in the form of cut marks, fractures, burning, and fragmentation, and provide a basis for the reconstruction of the history of faunal remains. Processing techniques often vary by taxa, thus a species-specific reconstruction of the butchery sequence is undertaken to identify the relative value of prey taxa in Natufian society. This step is important for upcoming interpretations of prey abundance. How did Natufians render prey carcasses into useable products. Of principle interest are activities aimed at the isolation of meat, grease, and marrow. The discussion therefore focuses on three major carcass processing activities: (1) the initial stages of butchering including skinning, dismembering, and defleshing the carcass to isolate the tissues into usable components such as meat, viscera, blood, bone, skin, and sinew; (2) the breakage of bones to extract marrow housed in the cavities of long bone shafts, and bone grease from the bone's spongy microstructure; (3) the heating and cooking of animal tissues to facilitate butchery and preparation as food. The bulk of the discussion is directed at ungulate species, especially gazelle, which outstrip all other animal taxa as sources of animal protein and raw materials at Hayonim Cave and Hilazon Tachtit. Despite smaller body sizes, other prey species certainly made important contributions to the Natufian economy (e.g., carnivores, hares, partridges, Falconiformes and tortoises) follows the more detailed analysis of gazelles below.

Skinning, Dismembering and Defleshing

In the Natufian period the separation and removal of soft tissues were most probably undertaken with the aid of sharp flint tools used to cut skin, tendons, ligaments, and flesh, and to separate the carcass into manageable portions. Skinning, disarticulation, and defleshing are thus expected to occasionally leave cut marks on skeletal elements during the removal of soft tissues close to the bone. Each of the three butchering activities should leave distinct patterns of cut marks on the prey skeleton, with minimal overlap between activities (see Binford 1981).

The removal of the skin and associated fur or feathers from a prey carcass can be performed neatly with minimal damage to the skeleton. Animal skins are removed essentially by turning the skin inside out. The skin peels away easily from the animal's flesh and requires cutting only in areas where if adheres tightly to the bone, such as the distal limbs, the mandible, and the cranium, particularly around the eyes and ears. Skinning is thus expected to leave cut marks on the skull, the base of the mandible, the distal half of the metapodials, the astragalus, calcaneum, and in some cases the toe elements. Thus, there is potential for overlap between skinning marks and those caused by skeletal dismemberment only on the distal limbs.

Dismemberment of the carcass into manageable portions for transport, cooking or the extraction of raw materials tends to affect areas of the skeleton connected by networks of ligaments, tendons, and muscles. These must be severed to separate the body into parts. Some joints, such as the ankle and hip, are more tightly articulated than others and may be more difficult to separate, thus require more intensive butchering and transverse breaks through the bone. Frequent disarticulation of these parts are more likely to leave cut marks than other joints (Lyman 1994). Dismemberment therefore is expected to leave cut marks close to major joints, in particular the proximal and distal epiphyses of long bones and the junction between the crania and neck, depending on the disarticulation method.

Defleshing or removing meat from the skeleton involves cutting muscle insertions and other direct attachments to bone visible on the bone's surface as roughened or raised areas. Cut marks created during defleshing activities are expected to occur at these muscle attachments, such as on the shafts of long bones and on the elements of the postcranial axial skeleton. Cut marks created by defleshing are expected to occur frequently on the shafts of bones associated with rich meat sources (e.g., ribs, vertebrae, scapula, pelvis, humerus, femur), and less often on those that are not (e.g., metapodials, tarsals, carpals, phalanges, crania, mandibles).

Results for Skinning, Disarticulation and Defleshing Activities

The proportion of cut marked specimens by taxa or group from Hayonim Cave and Hilazon Tachtit are presented in Table 5.13. The frequency of cut marks increases with body size. Large animals are difficult to dismember by hand because attachments are stronger. Prey are much easier to manage once divided into smaller anatomical units. Still, regardless of body size, cut marks are extremely rare in both Natufian assemblages (<0.1% at Hayonim Cave and <0.1% at Hilazon Tachtit). The only taxa for which cut marks occur on more than 2.0% of the elements, are large taxa or those that are rare in the assemblage, and thus most likely inflated by small sample sizes. Cut marks are sufficiently abundant only in the case of the Hayonim gazelles to warrant further analysis.

Broad Taxonomic Group	Taxon	HAYC Cut Marks	HLZT Cut Marks
Ungulates	*Capreolus capreolus*	1 (10.0%)	n/a
	Dama mesopotamica	6 (6.8%)	n/a
	Cervidae	1 (1.2%)	n/a
	Gazella gazella	64 (1.4%)	8 (1.2%)
	Medium Ungulate	3 (2.0%)	n/a
	Large Ungulate	1 (3.0%)	n/a
Carnivora	*Felis cf chaus*	1 (0.8%)	n/a
	Vulpes vulpes	2 (0.7%)	n/a
	Martes foina	n/a	1 (10.0%)
	Vormela peregusna	3 (12.5%)	n/a
Small Game	*Lepus capensis*	2 (0.1%)	n/a
	Alectoris chukar	5 (0.4%)	n/a
	Buteo buteo	1 (0.6%)	n/a
	Otis taida	1 (5.3%)	n/a
	Large Aves	1 (0.9%)	n/a
General Categories	Medium mammal	11 (1.6%)	1 (0.8%)
	Large mammal	1 (1.6%)	1 (16.7%)
	TOTAL	**105 (<0.1%)**	**11 (<0.1%)**

Table 5.13: Proportion of cut marks on select taxa from Hayonim Cave and Hilazon Tachtit. Only taxa bearing cut marks are listed. Cut marks on bone tools are not included. Numbers outside of parentheses are NISPs of cut marked specimens. The number in parentheses represents the proportion of cut specimens for that taxa. n/a means that no specimens for that taxon bore cut marks.

Table 5.14 shows the distribution and frequency of cut marks on gazelle elements from Hayonim Cave. Each cut mark is attributed either to processes of skinning, defleshing or disarticulation based on its anatomical location following Binford (1981).

Though evidence for each of the three butchering processes exists, cut marks are infrequent and distributed almost randomly over a wide range of skeletal elements and portions. Though the Natufians undoubtedly skinned, disarticulated, and defleshed much of their prey, the intensity of these behaviors cannot be addressed using cut marks alone, as their butchering techniques rarely left evidence on the prey carcasses.

Skinning	Defleshing	Disarticulation
(1) Cranium	(2) Rib Shaft	(1) Axis
(4) Base of Mandible	(1) Scapular Blade	(1) Proximal Rib
(2) First Phalanx	(1) Humerus Shaft	(4) Innominate (Acetabulum)
(2) Second Phalanx	(4) Femur Shaft	(11) Distal Humerus
	(5) Tibia Shaft	(2) Distal Radius
		(3) Proximal Ulna
		(1) Proximal Femur
		(1) Patella
		(3) Proximal Tibia
		(3) Distal Tibia
		(3) Proximal Metapodial
		(5) Distal Metapodial
		(1) Astragalus
		(4) Calcaneum

Table 5.14: Location and frequency of cut marks most likely created during the skinning, defleshing, and disarticulation of ungulate taxa from the Natufian layer at Hayonim Cave (following Binford 1978). Numbers in parentheses represents the NISP of cut marked specimens.

Marrow Extraction

Yellow marrow is a rich, fatty substance stored primarily within the hollow interiors of mammalian long bones, mandibles, and phalanges (Currey 1984). Marrow storage in adult skeletons may compensate for boom/bust cycles in resource availability; it is stored in mammalian long bone cavities during rich seasons and metabolized by the animal when dietary fat is scarce (Speth 1987; Stiner 1994: 226-227). Thus, in most seasons, marrow supplies a concentrated energy source that can be accessed by humans using cold-processing techniques including simple technologies such as hammerstones and anvils. Once bones are broken to breach the interior cavity, concentrated (medullary) marrow stores can be pushed out using a stone tool or stick. Cold marrow extraction involving the fracture and breakage of compact bone can be detected in the archaeological record by the presence of cone fractures, green breaks, and fragmentation rates. Medullary marrow content varies significantly from bone to bone and is expected to correlate positively with the incidence of cone fracture and bone fragmentation. Cancellous marrow on the other hand is stored within the airy matrix of spongy bones, and is more difficult to process using cold techniques. Though, like bone grease, cancellous marrow can be consumed by pounding the bone into a pulp, it is more easily extracted using hot processing techniques, namely boiling. Because cancellous bone requires the same processing techniques as bone grease and its extraction leaves the same signature on bone, it is included within the discussion on bone grease that follows.

The marrow content of various skeletal elements has been measured for a few ungulate species (e.g., sheep, bison, caribou; Binford 1978; Brink and Dawe 1979). Though gazelle is not among them, relative rankings of marrow rich bones in other small bovids provide suitable analogues. Here Binford's marrow utility index for domestic sheep is used as a model for gazelle, owing to similarities in body size and relatively close taxonomic affiliation.

Five tests are performed in search of evidence for marrow extraction practices during the Natufian period at Hayonim Cave and, where possible, at Hilazon Tachtit. Each test assumes that the bones processed for marrow must be fractured, and that percussion marks and frequencies and fragmentation indices will be positively correlated with independent estimates of marrow content. First, the frequency of cone fractures among prey taxa ranked by total marrow yield (body size) are compared. Next, completeness indices for long bone shafts originating from taxa with significantly different marrow yields are presented (gazelle, hares, and partridges). Third, the relationship between marrow content and the frequency of cone fractures and fragmentation indices for the Hayonim Cave gazelles are examined using a Spearman's rank-order correlation coefficient. Fourth, the fragmentation (NISP:MNE) of gazelle marrow-rich long bone shafts is compared to their marrow-poor articular ends. A test for the intensity of marrow extraction is presented last and examines the relative completeness of compact gazelle elements containing small to no marrow yields.

Results for Marrow Extraction

The frequency and location of cone fractures on archaeological bone provide general rather than absolute indications of the intensity of human processing. Overall, the frequency of cone fractures in the Hayonim Cave and Hilazon Tachtit assemblages are low (see Table 5.15) and increase directly with prey body size, as do bulk marrow yields and bone thickness; big animals that store greater quantities of bone marrow therefore display more evidence for percussion. The only exception is the tortoise, whose shells often exhibit cone fractures. In this case people were after meat not marrow. Impact fractures form on tortoise shell due to its relatively thick, sandwich structure, not unlike the bones of the human braincase. Because tortoise shells are fractured to access meat, the high incidence of percussion marks is not relevant here, but will be taken up in a later discussion.

Broad Taxonomic Group	Taxa	HAYC Cone Fractures	HLZT Cone Fractures
Ungulates	Large Ungulate	2 (5.9%)	n/a
	Cervus elaphus	2 (4.8%)	n/a
	Medium Ungulate	2 (1.4%)	n/a
	Gazella gazella	55 (1.2%)	6 (0.9%)
Carnivora	General Carnivora	1 (0.7%)	n/a
Small Game	*Testudo graeca*	61 (1.0%)	8 (0.9%)
	Total	**123**	**14**

Table 5.15: Frequency of taxa bearing cone fractures in the Natufian layer from Hayonim Cave and Hilazon Tachtit. Taxa are ranked in descending order of body size. Value in parentheses is the percentage of long bone shafts bearing cone fractures of that taxa.

Completeness indices for long bone shafts for gazelle, hare, and partridge are compared in Table 5.16. Partridges produce no marrow, hares store small quantities, and gazelles provide rich sources of bone marrow. The results indicate that the intensity of shaft fragmentation is positively correlated with marrow concentration. Despite their fragility, partridge long bone shafts from Hayonim Cave have consistently high completeness indices. In contrast, hare and gazelle long bones, have reduced completeness percentages, indicating greater incidences of breakage. Interestingly the degree of completeness is negatively correlated with bone fragility (i.e., mineral density). Although, partridges have thin-walled, delicate bones, at least 50% of the shafts of each of their long bones are complete. Hares and gazelles have higher bone densities and much lower completeness indices; the completeness of gazelle shafts ranges from 16.7% at best for femur shafts, to only 1.4% of tibia shafts at the other extreme.

	Gazelle	Hare	Partridge
Humerus	3.1% (32)	33.3% (9)	72.2% (79)
Radius	12.5% (40)	7.5% (53)	80.0% (5)
Ulna	5.9% (17)	8.3% (12)	55.6% (36)
Femur	16.7% (42)	16.7% (12)	51.2% (43)
Tibia	1.4% (70)	23.3% (73)	51.4% (144)
Metapodial	14.6% (178)	35.7% (8)	62.4% (85)
TOTAL	**10.8% (379)**	**17.9% (167)**	**58.4% (229)**

Table 5.16: Percentage of complete gazelle, hare and partridge long bone shafts from the Natufian layer at Hayonim Cave.

Element	Cone NISP (Proportion)	Marrow Index	NISP/MNE
Scapula	0.0% (0)	6.23	3.3
Humerus Shaft	4.5% (7)	34.8	2.3
Radius Shaft	3.8% (5)	52.2	2.2
Ulna Shaft	2.6% (2)	n/a	1.5
Innominate	1.2% (1)	9.57	7.9
Femur Shaft	2.5% (3)	47.34	2.8
Tibia Shaft	4.9% (9)	78.52	4.2
Metapodial Shaft	3.0% (19)	68.2	4.5
Astragalus	0.0% (0)	1.0	1.2
Calcaneum	<0.1% (1)	23.11	1.2
First Phalanx	0.0% (0)	33.77	1.8
Second Phalanx	0.0% (0)	25.11	1.3
Third Phalanx	0.0% (0)	1.0	1.1

Table 5.17: Frequency of cone fractures, marrow utility indices and fragmentation indices (NISP:MNE ratios) for gazelle marrow bearing elements from the Natufian layer at Hayonim Cave. Values outside of parentheses in the cone fracture column, represent the proportion of that portion bearing cone fractures. Numbers in parentheses are the NISP of fractured specimens. Only elements capable of receiving cone fractures are listed here. Non-marrow bearing elements are included to fill out the variation in marrow content. Marrow utility values are based on Binford's (1981) index for domestic sheep.

Next, fragmentation indices and the frequency of cone fractures in the Hayonim gazelle assemblage are compared against bone marrow yields derived from Binford's (1978) values for domestic sheep using a Spearman's rank-order correlation coefficient (see Table 5.17 for data). Fragmentation indices are calculated as NISP to MNE ratios for the complete element in the case of mandibles and phalanges, and for shafts only in the case of long bones. All elements that store bone marrow are evaluated, as are a few non-marrow bearing elements (e.g., astragalus and terminal phalanx) to round out the range of the sample. Both cone fractures and fragmentation indices are strongly and positively correlated with bone marrow yields (for cone fractures $r_s = 0.686$, $p<.01$, $n = 12$; for fragmentation $r_s = 0.688$, $p<.01$, $n = 12$). Mammal bones with high marrow contents are significantly more fragmented and contain cone fractures more often than those of other animals with minimal or no marrow stores (Figure 5.9).

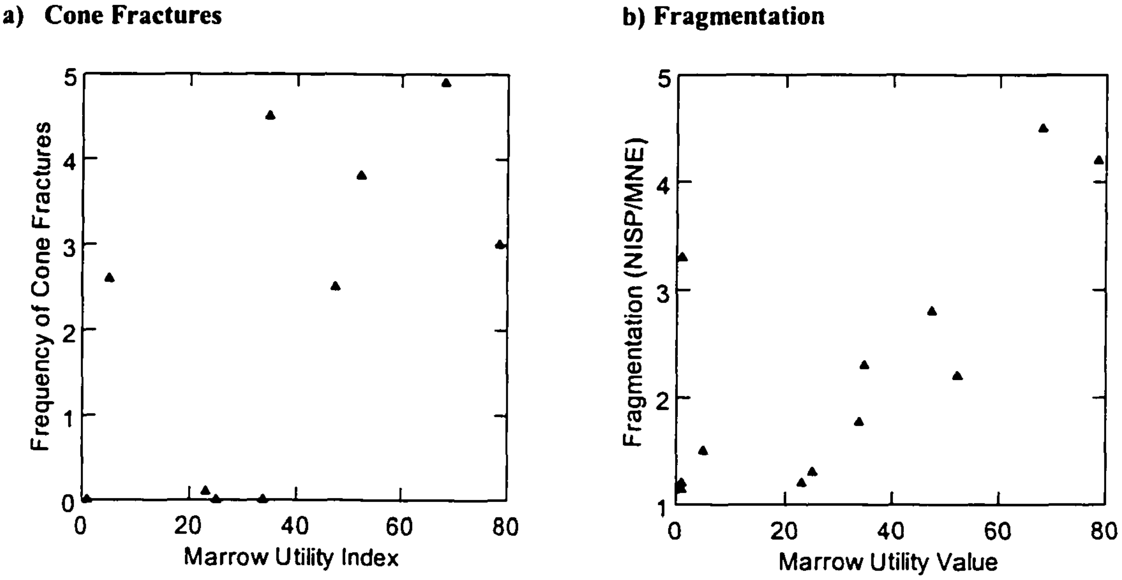


Figure 5.9: Scatterplots depicting the relationship between marrow utility and frequency of cone fractures (graph a), and marrow utility and fragmentation indices (graph b) for gazelle long bones from the Natufian layer at Hayonim Cave. Data is presented in Table 5.17. A few non-marrow bearing bones are included to fill out the range of variation in marrow content. Spearman's rank-order correlation coefficient is significant at the .001 confidence level for both relationships (cone fractures and marrow: $r_s = 0.686$, $p<.001$, $n = 12$, fragmentation and marrow: $r_s = 0.688$, $p<.001$, $n = 12$).

The next test compares the fragmentation (NISP:MNE) indices of marrow-rich long bone shafts versus marrow-free articular ends from the same element. This comparison may be confounded by density-mediated processes of bone destruction such as trampling, which preferentially fragment low density bone portions, including some of the marrow-poor articular ends (Nicholson 1992). Table 5.18 shows that gazelle long bone shafts from Hayonim Cave are consistently more fragmented than their corresponding articular ends, except in the case of the proximal humerus, the lowest density portion of the gazelle long bones (0.12 g/cm^3). Fragmentation and medullary marrow content are thus positively correlated in this example.

NISP:MNE HAYONIM	**Scapula**	**Humerus**	**Radius**	**Ulna**	**Femur**	**Tibia**	**Calcaneum**	**Astragalus**
Proximal	1.6	2.8	1.7	1.5	2.1	1.8	1.1	1.5
Shaft	3.3	2.3	2.2	1.5	2.8	4.2	n/a	n/a
Distal	1.2	1.3	1.3	1.0	2.1	1.6	1.2	1.2
NISP:MNE	**6.7**	**2**	**3.2**	**2.1**	**5.6**	**4.1**	**1.2**	**1.1**

Table 5.18: NISP:MNE ratios of gazelle long bone portions in the Natufian layer at Hayonim Cave.

Though long bones provide the primary source of marrow, ungulate mandibles and toes also house concentrated fat stores. In the mandible, marrow is stored in a hollow in the base of the horizontal ramus, which can be accessed by breaking the ramus into transverse sections and splitting off the base. Stiner (1994: 140) noted this breakage pattern in ungulate mandibles processed by Paleolithic hominids in Italy, and similar patterns are found in the gazelle assemblage from the Natufian layer at Hayonim Cave. The mandibles from Hayonim are highly fragmented, with no examples of complete or nearly complete specimens. Gazelle horizontal rami (NISP = 91) are consistently split transversely and vertically (67.0%), providing easy access to marrow from three exposed sides. Finally, the ascending ramus is nearly always detached from the horizontal ramus and the mandibular condyle, perhaps in an effort to remove the tongue (Stiner 1994:

140), though these breaks are also encouraged by weak points in the mandibular structure.

The smaller bones of gazelle hind legs require more effort to crack despite low returns, thus providing a simple gauge of extraction intensity. Of the three ungulate phalanges, the first and second contain marrow, though the first phalanx holds about twice as much as the second (Binford 1978). The calcaneum also contains small marrow stores, similar in weight to the second phalanx. A rough measure of extraction intensity is provided by comparing the percent completeness of the first and second phalanges, and the calcaneum against the non-marrow bearing compact bones of the lower leg (the astragalus and third phalanx). In the Hayonim Cave gazelle assemblage, the first phalanx has the lowest completeness index (30.5%). The index for the second phalanx is much higher (56.9%), and also exceeds the calcaneum though the latter contains slightly less marrow (48.3%). Both the astragalus and third phalanx have significantly higher completeness ratios than the other elements (see Table 5.19). In general, the completeness ratios for the compact elements correspond directly to bone marrow yields. The low rate of completeness for the first phalanx indicates that though small, this source of bone marrow was usually tapped, and effort consistent with lower medullary content was invested into cracking the second phalanx and calcaneum less than half the time. The Natufians intensively exploited marrow stores in gazelle carcasses, as attested to by the fragmentation of nearly all marrow bearing bones including the first phalanx, they stopped short of thorough exploitation only at the smallest of marrow stores.

Element	NISP	Competeness Index	Marrow Content
Phalanx 1	429	30.5%	33.77
Phalanx 2	299	56.9%	25.11
Calcaneus	87	48.3%	23.11
Phalanx 3	192	71.4%	1.0
Astragalus	71	80.3%	<1.0

Table 5.19: Completeness indices for select gazelle foot bones including the astragalus, calcaneum and phalanges from the Natufian layer at Hayonim Cave. Elements are ranked in order of marrow content. The completeness index is the percentage of each element which is complete or nearly complete.

To summarize, the results of the preceding tests for marrow extraction are in strong agreement. In every case bone fragmentation and/or cone fractures are more common on portions associated with abundant, concentrated marrow stores. This pattern holds up convincingly across taxa, elements, and bone portions within the same element.

The strong correlation between marrow content and fragmentation contradicts, to some extent, the signature of density-mediated attrition pointed out in Chapter 4. In two of the tests presented above bone density and marrow content were negatively correlated across taxa. In both tests fragmentation correlated strongly with marrow content, but inversely with bone density across different taxa (gazelles, hares and partridges). For example, fragile partridge long bone shafts which contain no marrow were complete more than 50% of the time although they have extremely low mineral density, while high density gazelle long bone shafts were complete less than 10% of the time. The shafts of gazelle long bones were also fragmented more often than their epiphyses though the shafts usually have higher bone mineral densities (see Table 5.18). It can thus be concluded that fragmentation and density-mediated attrition at least in marrow rich areas of prey skeletons, was most likely caused by intentional human efforts to extract bone marrow rather than secondary causes such as trampling or chemical break-down, factors also expected to preferentially destroy bones with low mineral density (e.g., Lyman 1994; Nicholson 1992).

Grease and Trabecular Marrow Extraction

Bone grease and trabecular marrow is dispersed in tiny pockets within the microstructure of bone (Brink 1997) and must be rendered using more elaborate techniques than medullary marrow extraction. Grease is stored in both cancellous and cortical bone, but it is easier to extract from cancellous bone, since the latter's porous structure facilitates its escape when heated and also reduces the energy required to crush bones when processed cold. This point is underscored by studies of modern hunter-gatherers, who process cancellous bones for grease more often than cortical bone (Binford 1978; Lupo and Schmitt 1997; Vehik 1977; Yellen 1991a). Grease is usually freed in a multi-step process by crushing cancellous bone using stone hammers or groundstones, immersing the pulp in boiling water to release the grease, and skimming the fat from the surface (Brink 1997; Vehik 1977).

Evidence for boiling of animal products during the Natufian period is inconclusive. The Natufians did not manufacture ceramics, and though they are as likely or even more likely to have made watertight animal skin or vegetal containers suited for stone boiling, fire cracked rock is rare in most Natufian sites. The possibility that the Natufians boiled water is not excluded here in the absence of evidence, but signs of "cold" methods for grease extraction are easier to find in the Natufian record. Grease does not need to be separated from bone for consumption. Instead, grease rich bones, particularly cancellous parts, may be crushed into a fatty pulp and consumed as is, or mixed with edible plant or animal products. The mortars, pestles, and grinding slabs common at Hayonim Cave and other Natufian sites are massive and can easily smash cancellous elements (Laure Dubreuil, personal communication 2001).

Ethnographic sources indicate that grinding, smashing, and chopping activities are central to grease extraction if one is to reduce cancellous grease-rich bones to a mixture of small digestible fragments and bone meal powder (Binford 1978; Lupo and Schmitt 1997; Vehik 1977). Modern ethnographically documented groups limit grease extraction primarily to low-density, easy-to-grind bone structures. Grease extraction is thus expected to be expressed archaeologically as a density-mediated bias, or more specifically by low survivorship of cancellous bone. The bone portions with low survivorship are also expected to have high fragmentation indices.

Results for Grease Extraction

To test for grease extraction, a Spearman's rank-order correlation coefficient is used to examine the relationship between survivorship and fragmentation. Bone shafts are eliminated from the comparison, since their breakage patterns and survivorship was argued to be the result of medullary marrow extraction. The articular epiphyses of long bones encompass a substantial range of bone densities, thus the omission of shafts should not be a biasing factor. Bone portions, associated fragmentation indices, and survivorship values (% MNE) are listed in Table 5.20, while the relationship between survivorship and fragmentation is shown in Figure 5.10. The results of the test are significant at the .001

level of probability ($r_s = -0.511$, $n = 13$, $p > .001$), indicating that articular ends with low survivorship potentials, are also more intensively fragmented than those that normally survive better in assemblages. The loss and fragmentation of low density bone at Hayonim Cave is restricted to gazelle, which is the only well represented mammal that yields a significant quantity of bone grease. The cancellous articular ends of gazelle long bones have consistently higher NISP:MNE ratios than hare bones despite similar bone mineral density ranges (see Table 5.21). Overall these results, and the substantial density-mediated bias in the Hayonim gazelle assemblage, meet the expectations for grease extraction. Other mechanical processes, namely trampling, may produce similar results, but should affect different taxa equally, which is not the case here. This complex issue will be taken up again below.

Element and Portion	NISP/MNE	Survivorship
Proximal Scapula	1.6	0.20
Scapular Blade	3.3	0.13
Proximal Humerus	2.8	0.10
Shaft Humerus	2.3	0.18
Distal Humerus	1.3	1.00
Proximal Radius	1.7	0.51
Shaft Radius	2.2	0.24
Distal Radius	3.2	0.03
Proximal Ulna	1.5	0.45
Proximal Femur	2.1	0.21
Shaft Femur	2.8	0.19
Distal Femur	2.1	0.25
Proximal Tibia	1.8	0.31
Shaft Tibia	4.2	0.21
Distal Tibia	1.6	0.56
Astragalus	1.1	0.83
Calcaneum	1.2	0.81

Table 5.20: Fragmentation indices and survivorship values for gazelle long bone portions from Hayonim Cave. Survivorship is calculated following Lyman 1994: 239. These variables are used in the scatterplot and Spearman's test presented in Figure 5.11.

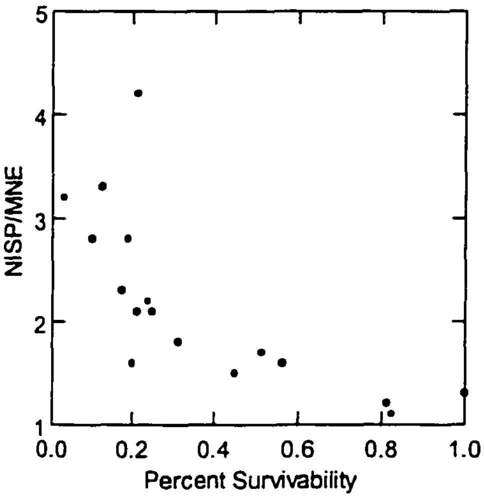


Figure 5.10: Percent survivorship versus fragmentation (NISP/MNE) of gazelle long bone articular ends from the Natufian layer at Hayonim Cave ($r_s = -0.847$, $n = 17$, $P>.001$).

Element	Hare NISP/MNE	Gazelle NISP/MNE
Proximal Humerus	1.8	2.8
Distal Humerus	1.2	1.3
Proximal Radius	1	1.7
Distal Radius	1	1.3
Proximal Ulna	1.3	1.5
Proximal Femur	1.3	2.1
Distal Femur	1.2	2.1
Proximal Tibia	1.4	1.8
Distal Tibia	1.2	1.6

Table 5.21: Fragmentation indices for hare and gazelle long bone ends from the Natufian layer at Hayonim Cave.

Cooking

In the Paleolithic periods animals were most often cooked by roasting. Roasting is defined here as cooking without containers, and includes heating meat directly above an open flame or on hot coals, either by direct or indirect exposure (i.e., through the burial or packing of meat in organic material). Boiling may have been in use by the early

Upper Paleolithic, yet no firm evidence for this exists in southwest Asia until the Neolithic ceramic period. The most obvious archaeological indicator of cooking is burning, though bone often does not burn even when roasted or boiled for prolonged periods (e.g., Kent 1993).

Bones burned as a result of cooking may be confounded by the effects of burning by natural occurrences, secondary human activities, or disposal in hearths. These processes must be separated as much as possible before interpretations of human cooking can be made. Indirect exposure to fire results from the protection of bone by an intervening substance such as sediment or meat, the first being intentional and the second not. Burning experiments by Stiner et al. (1995) indicate that bone buried within 6 cm of a hot coal bed by a bonfire on the ground surface can be charred. The intensity with which bone is burned, and whether or not it was in direct contact with the flame can often be partly evaluated from its color in the absence of diageneic processes that may cause discoloration (Shipman *et al.* 1984; Stiner et al. 1995). When burned, bone first turns black as the organic content carbonizes, then gray to bluish-gray to white with progressively more heating as oxidization of the carbonized organics occurs (Brain 1981). Calcination occurs only if bone comes in direct contact with the heat source. Bone that is protected from the heat source by a few centimeters of insulation may turn a grayish color, though it never reaches the full calcination stage. Unfortunately, several other taphonomic processes can discolor bones and frequently mimic burning. At Hayonim Cave and particularly at Hilazon Tachtit black-blue staining from manganese oxides is common. Burning was recorded in this study only when it was certain, thus burning counts are likely underrepresented, particularly in the Hilazon Tachtit assemblage.

Much information on cooking and burning is anecdotal. To be more useful this information needs to be integrated for systematic analysis. The first step is to compare frequencies of burning at the taxon, element, and portion levels to determine if burning is randomly distributed across the prey anatomy (more likely natural or secondary processes) or biased toward certain parts (more likely intentional). Non-random patterns can then be examined more closely for regularities in the coloration and intensity of burning to identify cooking techniques by prey species.

Results for Cooking

At Hayonim Cave and Hilazon Tachtit there is significant variation in the proportion of burned specimens by taxon (Table 5.22), though at least 14.0% of all prey taxa from Hayonim Cave are burned. These proportions are high in comparison to ethnographically derived figures from cooked bone, regardless of whether the animals were roasted or boiled (Kent 1993). They are thus interpreted as partly, if not largely the result of secondary burning following deposition. This point is underscored by data in Table 5.23, which lists the spatial distribution of burning in Hayonim Cave. There is much variation in the frequency of burned bone among Loci, Areas, and Graves, regardless of the relative abundance of taxa present, confirming that spatial context is a primary determinant of burning frequency. Burning frequencies vary across space due to differentiation in the use histories of each area. For example, a large space along the eastern cave wall, centered in Locus 9 and 11, is extensively burned. The area is rich in calcined bone and ash. The fill is a light gray color, a stark contrast to the surrounding brown sediments. This is an extreme example and, with the exception of hearth features, differential burning in sediments is rarely so obvious. However, this example does illustrate the complicated stratigraphic and variable spatial history of the Hayonim Cave deposits. Repeated use of fire, as well as small scale displacement of sediments undoubtedly exerted secondary damaging effects on bones (including intrusive species) and other materials previously deposited in the fill, influencing the frequency of burning on bones in the immediate vicinity.

High rates of secondary burning likely reflect the intensity of site and/or feature use, since the longer a site is occupied, the more likely bones will be burned through secondary processes. The high rate of burning thus suggests regular reuse of Hayonim Cave in comparison to Hilazon Tachtit, the latter of which has much lower rates of burning across the board (5.9%). This is most likely a combined effect of the conservative approach used to identify burning at Hilazon, but also an overall lower frequency of burning.

TAXON	Total NISP	Total Burned	% Burned
Tortoise	6193	905	14.6
Lepus	2314	629	27.2
Partridge/Medium Aves	1629	311	19.1
Falconiformes	428	80	18.7
Carnivores	725	178	24.6
Gazelle	3890	728	18.7
Med/Large Ungulate	333	77	23.1
TOTAL	**15512**	**2908**	**18.7**

Table 5.22: Frequency of burning on common prey taxa from the Natufian layers at Hayonim Cave.

HAYONIM CAVE SPATIAL DIVISION	Total NISP	NISP Burned Specimens	% Burned Specimens
Locus 3	569	50	8.8%
Locus 4	2210	410	18.6%
Locus 5	696	82	11.8%
Locus 6	1178	195	16.6%
Locus 7	863	159	18.4%
Locus 8	3499	447	12.7%
Locus 9	1934	670	34.6%
Locus 10	1248	339	27.2%
Locus 11	189	88	46.6%
Grave XVI	60	15	25.0%
Grave XVII	1094	252	23.0%
Area 201	840	194	23.1%
Area 202	194	27	13.9%
Area 203	242	30	12.4%
Area 204	956	197	20.6%
Area 205	93	4	4.3%
Area 206	49	8	16.3%
Total	**17309**	**3352**	**19.3%**

Table 5.23: Proportion of burned bone specimens by spatial region (Loci, Areas and Graves) from the Natufian layer at Hayonim Cave.

Despite the strong influence of localized secondary burning events in Hayonim Cave, it is clear that the taxonomic differences in burning frequencies shown in Table 5.22 crosscut spatial boundaries, and are not determined only by localized depositional histories or changes in the relative abundance of species from one area to another. This point is clarified in Table 5.24, which compares variation in the frequency of burned hares and tortoises across space at Hayonim Cave. Although the rates of burning for the two species vary with spatial location, differences in burning frequencies between the two species are consistent throughout, with hares burned more often than tortoises regardless of spatial location.

Other differences in burning frequency between taxa shown in Table 5.22 hold true across space. Hares (27.2%), carnivores (24.6%), and medium/large ungulates

(23.1%) are burned in significantly higher frequencies than are tortoises (14.6%) and gazelles (18.7%). Distinctive treatment of prey species during processing, cooking, or disposal therefore clearly had a secondary yet significant impact on the taxonomic distribution of burning at Hayonim Cave.

HAYONIM CAVE SPATIAL DIVISION	Hare NISP	% Hare Burned	Tortoise NISP	%Tortoise Burned
Locus 3	167	9.0%	204	6.9%
Locus 4	395	26.3%	538	9.9%
Locus 5	141	12.1%	172	5.8%
Locus 6	101	29.7%	495	14.1%
Locus 7	269	31.2%	147	4.1%
Locus 8	342	21.3%	1196	8.2%
Locus 9	81	55.6%	981	29.2%
Locus 10	243	46.5%	206	13.6%
Locus 11	13	38.5%	52	28.8%
Grave XVI	0	n/a	27	25.9%
Grave XVII	210	42.4%	166	16.3%
Area 201	44	27.2%	488	22.7%
Area 202	40	25.0%	40	10.0%
Area 203	6	16.7%	154	7.8%
Area 204	19	21.1%	697	14.5%
Area 205	9	11.1%	49	4.1%
Area 206	12	0.0%	11	18.2%
TOTAL	**2092**	**28.8%**	**5623**	**15.0%**

Table 5.24: Proportion of burned hare and tortoise elements by spatial region within Hayonim Cave. Note that though the frequency of burning for the two species rise and fall in tandem with changes in space. In all cases, hares are burned in higher frequencies that tortoises.

Separating out differences in the treatment of prey proves problematic. Little can be said of cooking techniques for gazelle, since burning is evenly distributed across gazelle elements and bone portions. The high frequency of burned carnivore bones is provocative, but closer investigation of their spatial and elemental distribution reveals that the inflated frequency of burning is largely determined by the spatial location of fox bones. Higher than expected numbers of fox foot bones were recovered from the burned area along the east side of the cave wall. All bones from this area were intensely burned and covered in a light gray matrix of ash.

The burning damage on hare bones is unusual not only for its frequency, but also its coloration. A substantial sample of hare bones (23.3% of burned NISP) are burned a faint grayish blue color in localized patches. Comparisons with bones burned in experimental conditions by Stiner et al. (1995), indicate that the color does not match the blue shade a bone passes through just prior to calcination, but is close to the faint greyish-blue color that occurs only as a result of indirect contact with a heat source. A significant portion of the hare bones were most likely burned while protected from the heat source either by a thin layer of dirt or perhaps by the flesh of the animal itself during cooking. Post-depositional burning is a less likely cause since hares are the only species that exhibit this unusual coloration, even though their bones were interspersed in the fill with all other species.

ELEMENT	Shaft NISP	Prop Shaft Burned	Ends NISP	Prop Ends Burned
Scapula	52	0.50	51	0.37
Humerus	9	0.33	96	0.26
Radius	53	0.47	91	0.22
Ulna	12	0.50	51	0.26
Femur	13	0.62	105	0.23
Tibia	60	0.52	110	0.34
Total	**199**		**504**	

Table 5.25: Frequency of burned hare long bone shafts and long bone articular ends from the Natufian layer at Hayonim Cave. Prop = proportion.

Burning is evenly distributed across hare elements, but, at the portion level of comparison, long bone shafts are burned in consistently greater frequencies than the corresponding articular ends (see Table 5.25); the exception is the humerus but the sample size is small (NISP = 9). On average, hare long bone shaft fragments are burned more than 50.0% of the time, much higher than the average rate of 27.2% for the complete hare sample. Shafts are also highly fragmented, and burning may have occurred as part of a more general human activity that also involved bone breakage (see below).

TRANSPORT AND BUTCHERING SUMMARY BY TAXON

Gazelles

The representation of gazelle body parts in Hayonim Cave was determined predominantly by human-mediated processes. The Hayonim gazelle assemblage provides some evidence for skinning, disarticulation, and defleshing, and, more vividly, intensive marrow extraction. The question of grease rendering is more problematic due to the potentially confounding influences of other mechanical processes, namely trampling. A few other lines of evidence (i.e., attrition of the hare assemblage is not density-mediated and fragile partridge long bone shafts are much less fragmented than those of gazelles) however, suggest that, though trampling probably played a role in assemblage formation, processing activities such as grease extraction were more influential. Trampling is expected to preferentially destroy low-density bone following deposition via periodic, repetitive mechanical loading on bones lying on or just below the living surface. Bones with low mineral density are less resistant to mechanical loading and thus more subject to destruction than denser bone. Unlike human processing effects, however, trampling is expected to differentially affect bones according to variation in bone density independent of taxonomic variation. On the other hand, destruction associated with grease extraction activities is obviously mediated by variation in bulk bone grease yields and is expected only in animals of suitable body size (e.g., ungulates).

In the Hayonim Cave assemblage, density-mediated destruction occurs in the gazelle assemblage only. Smaller prey species (e.g., partridges and hares) show less pronounced attrition by density-mediated sources, as indicated by high completeness ratios for partridge long bone shafts (see Table 5.16) and the insignificant correlation between hare bone mineral density and survivorship (see Table 4.10). The fact that gazelle bones are interspersed with the bones of other taxa throughout the Hayonim Cave deposits means that density-mediated processes were not spatially localized but are specific to gazelle.

Though the relationship between bone survivorship and mineral density was shown to be significant for gazelle, the relationship is stronger when dense long bone shafts are removed from the equation. Bone survivorship was thus also influenced by other processes that crosscut bone tissue density boundaries. This pattern is exactly that expected from the combined effects of grease and marrow extraction. Grease rendering preferentially destroys soft, low-density long bone ends and vertebrae, and cold marrow extraction tends to fragment long bone shafts, though dense articular long bone ends are expected to survive. It has also been shown that, regardless of bone density, gazelle bone portions with poor survivorship are highly fragmented in the Hayonim Cave assemblage. Cancellous bone and shaft fragments are therefore not entirely missing from the assemblage, but have simply been smashed to pieces and suffered some loss of identifiability as a result. Though this pattern is precisely that expected to result from marrow and grease extraction, it does not preclude trampling from playing a role.

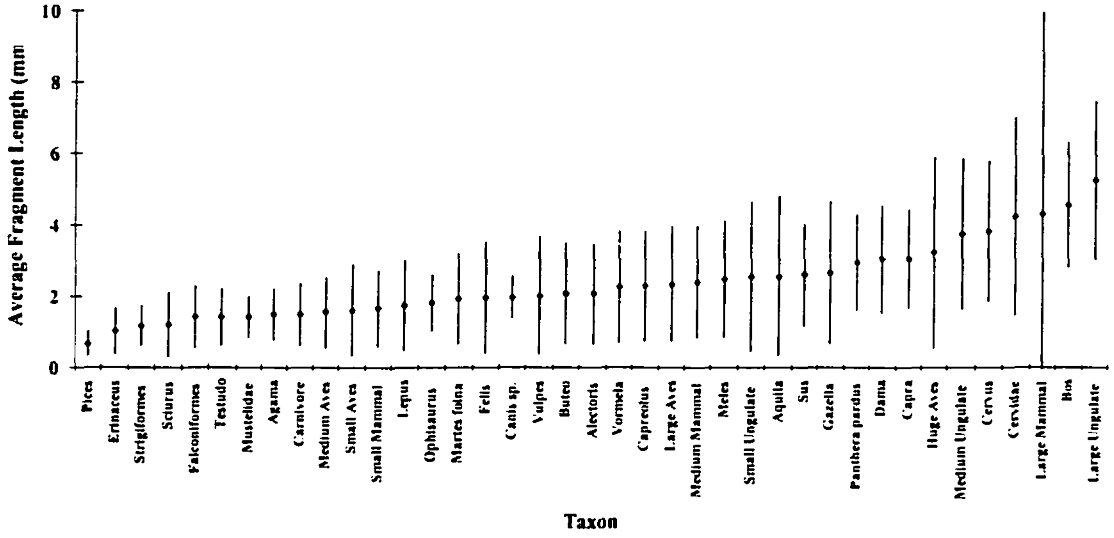


Figure 5.11: Average fragment size for all taxa at Hayonim Cave. Taxa in descending order of average fragment size.

In combination, these results point strongly to human processing activities as the single most important determinant of skeletal part frequencies in the Hayonim Cave gazelle assemblage. Trampling likely played an unspecified secondary role, as indicated by the small average fragment size for all taxa (Figure 5.11). On average, the Hayonim Cave assemblage is fragmented, but some bone portions are far more fragmented than others. The influence of in-bone nutrients likely began well before assemblage formation, playing a major role in prey transport decisions, particularly after the advent and proliferation of groundstone technology during the Upper and Epipaleolithic periods. Increasing site permanence during the Epipaleolithic associates with increasing investment in heavy, efficient groundstone equipment. The milling stones of the

Natufian required much work to manufacture but also offered significant bone processing advantages, undoubtedly increasing the value of what were previously considered low-utility prey bones.

Overall the evidence for processing activities from Hayonim points to very intensive use of gazelle carcasses. Natufians made thorough use of all components of the gazelle carcass, stopping only at very small marrow sources in compact elements, which were still extracted close to 50% of the time. Gazelle were transported to the site whole or nearly whole, stripped of meat, processed for marrow and grease and even used for raw materials for the manufacture of bone tools and ornaments. The faunal assemblage is highly fragmented overall, with an average fragment size of only 2.1 cm, attesting to the tendency of Natufian foragers to bash things up.

Carnivores

Foxes and felids were brought to Hayonim Cave and Hilazon Tachtit as complete carcasses. An overrepresentation of lower limb bones in comparison to the meaty upper limbs, suggests that these species were preferred for non-meat products, such as skins, which are often removed with the meatless lower limbs. High rates of burning in both the fox and felid assemblages is partly attributable to a high concentration of foot bones located in the burned region in Locus 9 and 11. Why these foot bones were concentrated here is a separate question, perhaps relating to the removal of the feet from fox furs and their subsequent disposal or ritual use. Because the burned area in Hayonim Cave is located in proximity to an intrusive glass furnace constructed close to 2000 years ago, it is unclear if the patch was burned during the Natufian or at a much later date.

The mustelid remains, including *Martes foina, Meles meles* and *Vormela pergusna* provide the clearest evidence for fur processing. There are few remains from Hayonim Cave (NISP = 133) and Hilazon Tachtit (NISP = 17), yet body parts are dominated by cranial bones (47.3% in Hayonim Cave, 76.4% in Hilazon Tachtit), which may find their way to the site as riders on furs. Although cut marks on complete bones are extremely rare in the Hayonim assemblages, three virtually intact *Vormela* crania were identified in the assemblage, and all three them have cut marks on the premaxilla. The premaxilla is expected to be cut when detaching skin from the bone, so that it an be peeled away from the rest of the body. The possibility that these animals were used for other purposes cannot be ruled out, but it is very that they were exploited for their fur.

Tortoises (*Testudo graeca*)

Robust evidence, including percussion marks, burning, body part representation, and breakage patterns, point to the regular transport and consumption of tortoises by Natufian foragers at Hayonim Cave and Hilazon Tachtit. The tortoise assemblage from Hayonim Cave also reveals unprecedented, yet habitual use of the tortoise carapace as tools by humans. Modification and use wear were observed on a sample of tortoise carapace fragments (7.5%, NISP modified segments = 475) from the Hayonim Cave Natufian assemblage. The function of the modified tortoise carapaces, which take the form of shallow concave palettes or containers remains largely speculative.

Modified Tortoise Bones from Hayonim Cave

Some Natufian tortoise carapaces or segments therefrom, from Hayonim Cave were intentionally modified by piercing and grinding (see Table 5.26), they exhibit clear signs of use wear in the form of striations and polish. Several types of modification exist and appear nearly exclusively on particular carapace elements. Some nuchal scutes are pierced, peripheral segments are cut and rounded by abrasion, and the lateral edges of many pleural segments are ground to a fine polish. Use wear in the form of grooves, striations and polish is limited to the interior face of pleural and neural carapace segments. Overall, use wear and modification are found exclusively on carapace segments; with only a few incidents of polish (most likely natural) on plastron fragments.

T.G. ELEMENT	NISP	Burn	%	Striation	%	Ground	%	Polish	%
Carapace	1346	214	15.9	17	1.3	2	0.0	16	1.0
Nuchal Scute	57	10	17.5	4	7.0	0	0.0	10	18.0
Neural	497	73	14.7	69	13.5	1	0.0	61	12.0
Pleural	1874	255	13.6	277	14.8	79	4.0	280	15.0
Peripheral	676	91	13.4	1	0.1	11	2.0	14	2.0
Peripheral Hinge	192	20	10.4	1	0.5	1	1.0	2	1.0
Epiplastron	59	11	18.6	0	0.0	0	0.0	0	0.0
Entoplastron	56	10	17.9	0	0.0	0	0.0	0	0.0
Hyoplastron	39	3	7.7	0	0.0	0	0.0	0	0.0
Hypoplastron	62	7	11.3	0	0.0	0	0.0	0	0.0
Xiphiplastron	36	3	10.5	0	0.0	0	0.0	0	0.0
Plastron	388	60	15.4	6	1.5	0	0.0	3	1.0
Carapace/Plastron	684	105	15.3	8	1.2	0	0.0	7	1.0
Pelvis	38	6	15.8	0	0.0	0	0.0	0	0.0
Scapula	87	14	16.1	0	0.0	0	0.0	0	0.0
Humerus	148	12	8.1	0	0.0	0	0.0	0	0.0
Femur	76	8	10.5	0	0.0	0	0.0	0	0.0
Tibia	12	3	25.0	0	0.0	0	0.0	0	0.0
3rd Phalanx	3	0	0.0	0	0.0	0	0.0	0	0.0
Total	**6330**	**905**	**0.1**	**384**	**0.1**	**94**	**0.0**	**393**	**6.0**

Table 5.26: Distribution of tortoise elements and associated modifications and damage. Terminology for tortoise elements follows Olsen (1968).

Pierced elements. Eight pierced tortoise specimens were recovered (Figure 5.12), only one of which was previously identified (A. Belfer-Cohen, personal communication 2000). Piercings are found exclusively on nuchal scutes, a one-of-a-kind element centered on the anterior edge of the tortoise carapace (see Figure 5.13), with the exception of one pierced pleural segment. The nuchal bone is distinguished by its pentagonal shape and symmetrical linear markings. Of the seven pierced nuchal bones, only two are complete, the remaining five are broken across the pierced hole, a weak point in the shell. The pierced pleural is also split across the hole, and the other half was not recovered. It is unclear whether these elements were broken during or after manufacture. The piercings are small and placed in the center of the scute, with the exception of one nuchal bone which has an extremely large hole with a diameter of approximately 5 mm.

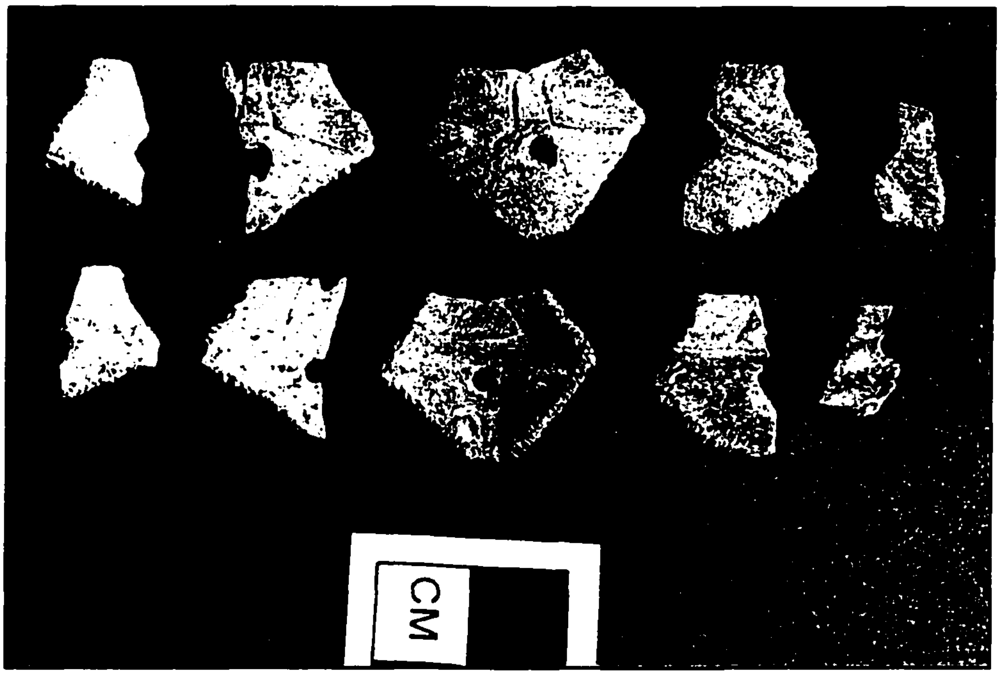


Figure 5.12: Pierced nuchal scutes from tortoises carapaces in the Natufian layer at Hayonim Cave. External and interior views.

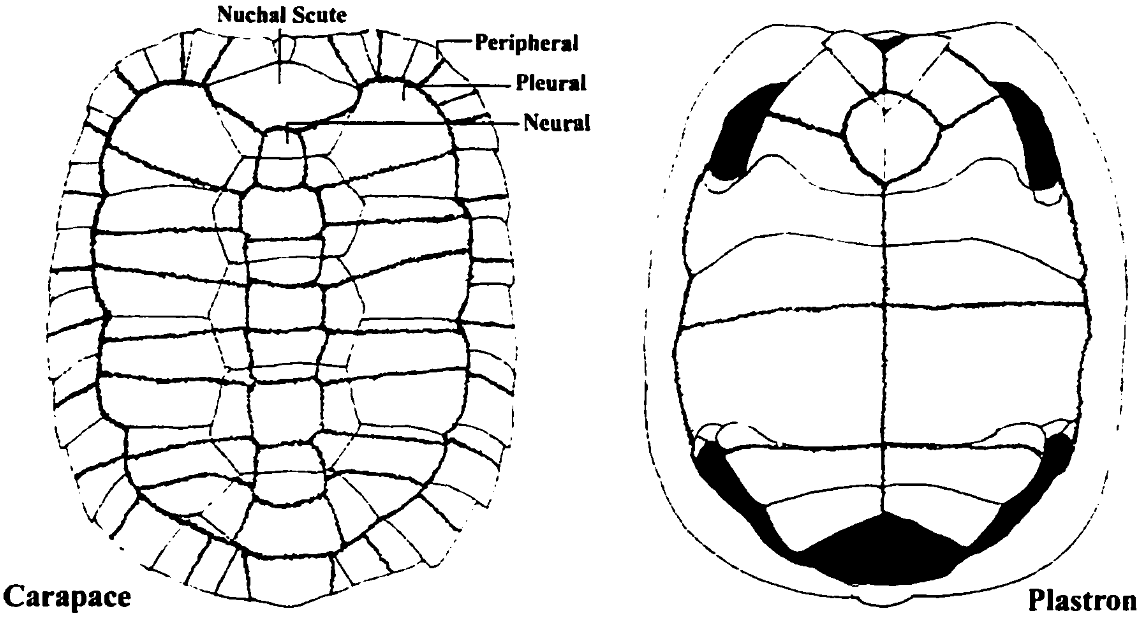


Figure 5.13: Sketch of the tortoise (*Testudo graeca*) plastron and carapace. Courtesy of Gideon Hartman.

Figure 5.14 Cut and ground tortoise (*Testudo graeca*) peripheral segments. Note the artificial groove on the segment on the far right. Grooves on the other segments are natural. The first segments is cut and rounded on its left edge, the second and third are ground on their left edge.

Cut and Ground Peripheral Segments. Twelve peripheral segments were cut in half across their vertical axis and were then ground until the cut edge became rounded (see Figure 5.14). In all cases, only the cut edge was ground, and the natural sutures were left intact. It is possible that these segments were articulated with other peripheral segments at the time of modification. Some of the modified peripherals (NISP = 4) are also grooved with deep vertical incisions on the exterior face. The association between the ground peripherals and the other modified pieces is unclear.

Ground Pleurals. The distal edges of many pleural segments were ground to a light polish on their exterior faces (NISP = 94). The result is a refined, gentle sloping edge (see Figure 5.15). The abraded edges are found on all types of pleural segments regardless of their shape and position within the pleural row, but only on the distal edge. The grinding is found nearly exclusively on pieces which also have striations and/or polish on their interior surfaces (96.0%). The ground edge appears to be ornamental and is clearly associated with evidence of use wear.

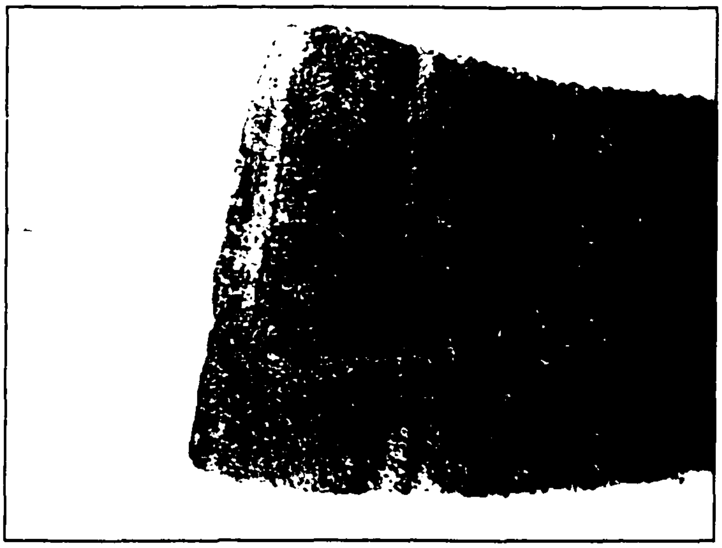


Figure 5.15 Detail of the ground distal edge of a tortoise pleural segment.

Striated Segments. The most common modifications on the Natufian tortoise elements are striations on the interior of carapace segments (NISP =384), and most likely were created by use wear. The striations are fine shallow grooves (Figure 5.16) most often associated with polish (80.5% of cases). They are commonly oriented in a single direction across the horizontal axis of the segment, although several pieces also exhibit more irregular marks in multiple directions. Striations are found nearly exclusively on neural segments (NISP = 69) which connect to vertebra along the saggital axis of the tortoise shell, and pleural segments (NISP = 277) which compose the main body and supporting rib structure of the carapace (Figure 5.13). Only two peripheral segments which circle the perimeter of the carapace, and articulate with the distal edge of the pleural segments (the ground edge) exhibit light striations and polish.

It is highly unlikely that the striations on the tortoise segments were created by postdepositional processes. The striations are most often unidirectional, and in the case of pleurals, are frequently associated with intentionally ground edges. The specimens with striations are recovered from many contexts within the cave, and are interspersed with unmodified specimens in all types of fill. The striations are also limited to specific elements of the carapace shell and do not occur on flat bones from any other taxa. Finally, the inner surface of both neural and pleural segments is slightly concave, thus striations were most likely created by activities contained within the shell itself. It is argued that the striations represent instances of human induced use wear, created while the neurals and pleurals were still articulated.

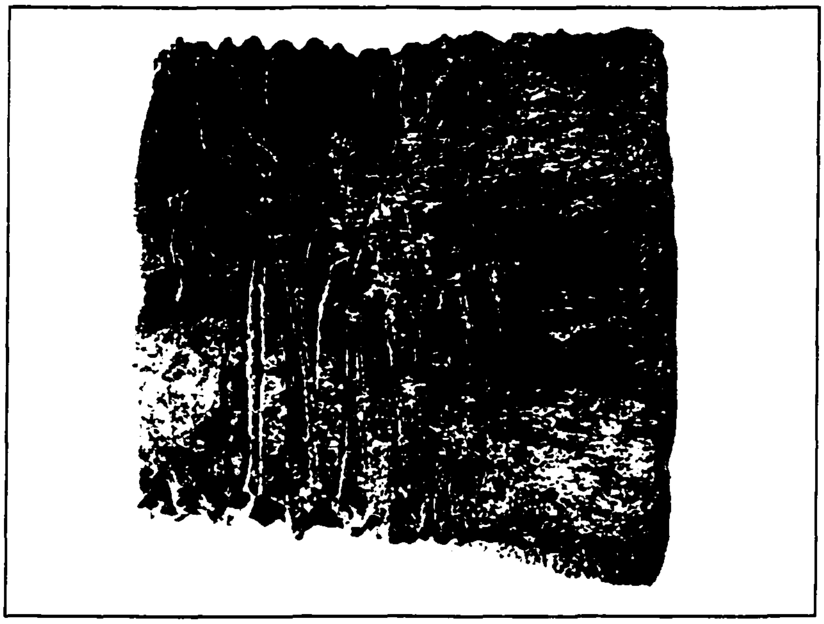


Figure 5.16 Detail of the striations on the interior of a tortoise pleural fragment.

Polished Segments. Polish was also identified on the interior faces of carapace segments, most often in association with striations and/or grinding damage, though some specimens only bear signs of polish (NISP = 62). Polish was recorded on the exterior of the carapace in only one instance and on plastron segments in seven cases. Neural and pleural segments are by far the most commonly polished elements. However, a few peripheral segments including nuchal scutes, also exhibit polish on their interiors. This occurs nearly exclusively on the raised horizontal edge found on the interior face of most peripheral segments and may have been created by natural abrasion in the sediments.

Discussion of Tortoise Modifications

The evidence for modified tortoise shells can be assembled to reconstruct the form of an articulated "vessel" used by the Natufians. There is strong evidence that segments were modified prior to the disarticulation of the center of the carapace (i.e., the neurals and pleurals, see Figure 5.13). When articulated, the pleural and neural segments form an oval, concave basin, with peripheral bone segments ringing the outside edge. While in use the modified carapaces probably had the form of a shallow vessel with a ground ornamental perimeter. To obtain this portion of the carapace it is necessary first to remove the exterior peripheral segments and the plastron. This is easily done, as there is a natural ring of sutures extending around the entire circumference of the carapace, between the distal edge of the pleurals and the peripherals proximal edge. These sutures form a weak point, from which the center of the carapace can be removed intact. Figure 5.17 shows an exterior view of a modern tortoise carapace following the removal of the outer keratin sheath by boiling. The weak point between the peripherals and pleurals is

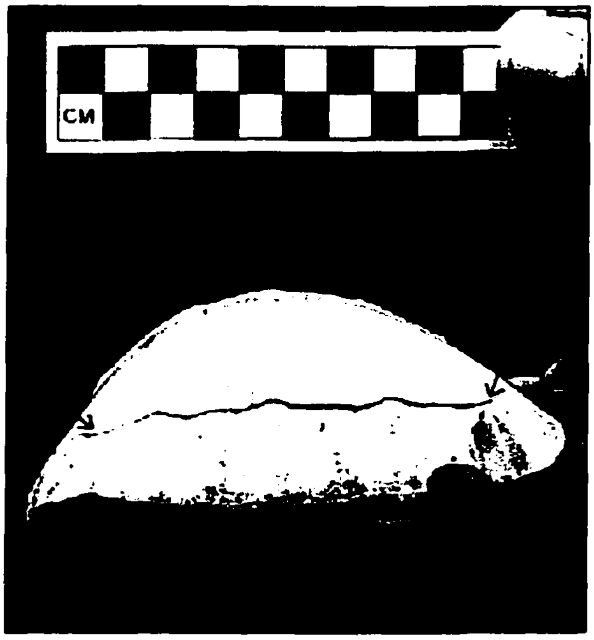


Figure 5.17: Side view of modern tortoise (*Testudo graeca*) carapace and plastron with the keratinous covering removed. Note the separation of the distal pleurals from the proximal peripheral segments (indicated by arrows). This is the suture along which the tortoise carapace containers are divided from the rest of the shell.

already beginning to separate. Figure 5.18 depicts the remnants of a modern tortoise shell with the keratin still intact. The remaining shell contains only the plastron, and the peripheral segments of the carapace, and represents the inverse of the modified carapace vessel. The shell of this tortoise had been dealt two blows when fresh. This loosened the sutures between the pleurals and the peripherals so the tortoise meat could be removed while still attached by the ligaments and bony connections of the vertebral column o the pleural and neural bones. The nuchal scute and other anterior peripheral segment would also be removed in articulation with the inner shell.

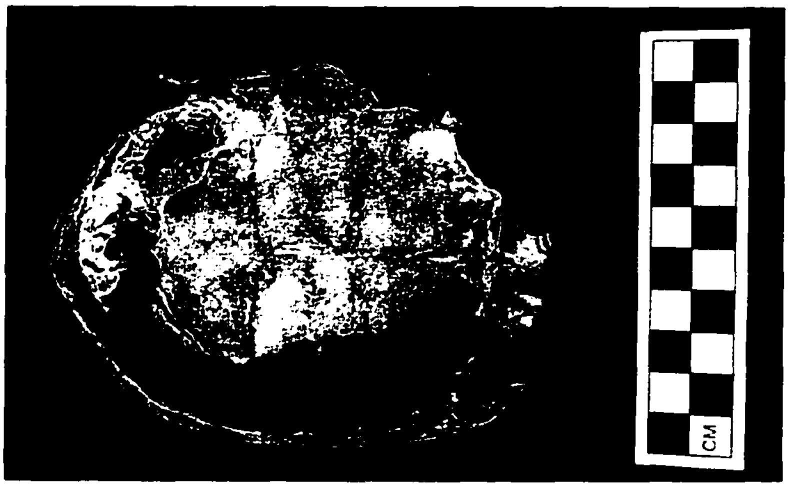


Figure 5.18: Dorsal view of modern tortoise carapace with neurals and pleurals removed. The inverse of the tortoise vessels from the Natufian period at Hayonim Cave.

Overall, it seems likely that tortoises were butchered by striking the carapace with a hammerstone, often near the hinge between the carapace and plastron. The meat could then be removed with the center of the carapace still intact. In some cases this natural vessel was separated from the meat, ground around the periphery to provide a refined edge, and then used by the Natufians as a small flat container or palette of some kind.

The evidence for tortoise shell vessels or palettes at Hayonim Cave is very similar to the reconstruction of a modified tortoise carapace from a much more recent (circa 705 ± 45 B.P.) midden deposit at the South African site of Elandsbay Open (Horwitz 1979). The reconstructed vessel consists only of the neural and pleural segments, as well as the nuchal scute and two adjacent peripheral segments. The exterior edge of the palette (the distal edge of the pleural segments) is ground in exactly the same manner as the Natufian elements discussed above.

That the shells were used is not at issue, as they are clearly marked by striations and polish; how they were used is more difficult to know. Unmodified tortoise shells could provide an easy source of containers for Paleolithic foragers. However, the vessels described lack the outer rim, which provides much of the depth to the shell. The remaining carapace is only slightly concave, and diminished greatly in volume, leaving only a shallow bowl. The modified carapace segments most commonly belonged to gracile tortoises of intermediate body size, thus the manufacturers definitely were not going for volume; many larger unmodified individuals were recovered from the site. It is unlikely that the modified carapaces reached more than 1 or 2 cm in depth. No residues or pigments are visible in the striated grooves, though many fragments were not washed in anticipation of residue analysis. Finally, there is no evidence that the shells were used to heat their contents. Burning is no more common on modified fragments than it is in the unmodified tortoise assemblage (12.6% of modified tortoise elements, Modified NISP = 475), and in many instances seems to have occurred postdepositionally (i.e., segments are just as likely to be burned on their interior as their exterior surfaces).

The tortoise specimens from the four Natufian assemblages studied here were all checked for modification. No modified elements were identified from Hilazon Tachtit or el-Wad Cave, and only seven striated fragments (out of 3347) were recovered from the Hayonim Terrace assemblage. The modified tortoise assemblage from Hayonim Terrace is most striking in its rarity relative to unmodified tortoise remains, and has implications for the relationship between the occupation at Hayonim Cave and the Terrace. This issue is taken up again in Chapter 9.

CHAPTER 6: PREDATOR-PREY ECOLOGY AND PREY POPULATION SIMULATIONS

INTRODUCTION

The interaction between predators and their prey may strongly affect the size and structure of their populations. Of particular interest in this study is the effect of human hunting on the availability of prey species, and how prey availability feeds back to influence subsequent human hunting decisions. Unraveling the nature of human-prey relationships requires a good working knowledge of its demographic complexities. To begin, it is necessary to define the major variables that determine the rate at which prey populations grow, shrink, and respond to changes in predator pressure. Likewise, we must understand how humans make hunting decisions and what determines the relative costs and benefits of these decisions. Though general perceptions of the population characteristics for some of the species of interest here are well known (e.g., tortoises and hares), the key variables must be defined in empirical terms, before testable expectations for predator-prey interactions can be derived.

This chapter summarizes information on prey simulations published previously by Stiner et al. (1999, 2000), and adds results for one new prey type – the gazelle. The prey simulations were originally undertaken to model the range of variation in the growth rate and sustainability of common Mediterranean small prey populations (tortoises, hares, and partridges) when subjected to varying degrees of hunting pressure. Annual growth rates determine how quickly populations can rebound following intensive culls. Sustainability refers to how much annual off-take prey populations can withstand without undermining the population's long-term viability. Realistic reconstructions of prey population growth rates and hunting sustainability can be used to predict variation in the relative abundance of small prey taxa in the archaeological record to infer changes in the degree of hunting pressure exerted by humans on local environments.

This chapter also presents the results of a new simulation for gazelle (*Gazella gazella*), the most common ungulate species in Natufian assemblages, using the same methods employed for small game predator-prey simulations. In the gazelle case, the population models are used to monitor the impact of human harvest pressure on living age structures. As in the small prey models, simulated gazelle populations are subjected to incremental increases in hunting pressure. However, the proportion of juveniles in the population, in particular. is tracked, rather than population resilience. While the living age structures of prehistoric prey populations are not directly preserved in the age profiles of archaeological assemblages -- potential distortions are imposed by the human cultural filter -- it is possible to estimate the degree of hunting pressure prey were exposed to when hunted. Distortions of gazelle living structures caused by human hunting and/or other factors such as seasonality in the Natufian are addressed in Chapter 8. The simulation results for small game are employed in an analysis of these animals in Natufian assemblages in Chapter 7. The objective here is to use faunal data to test ideas about site occupation intensity within the Mediterranean hill zone during two phases of the Natufian period.

THE PREDATOR-PREY SIMULATIONS

The following discussion summarizes the mechanics of the simulations presented by Stiner et al. (1999, 2000). The population characteristics of prey taxa were obtained from wildlife population studies on Mediterranean and closely related species. When available, longitudinal studies or those focusing on non-hunted wildlife populations were preferred, as they are likely to capture a more complete range of the natural variation in prey population cycles which fluctuate, often dramatically, in response to changes in food supply, climatic conditions, and other factors. To capture the full range of variation, best case (High Growth Model) and worst case (Low Growth Model) scenarios were modeled for each simulated population.

The simulations were written by Todd Surovell using Visual Basic macros in Microsoft Excel 7.0. The populations were simulated as a group of individuals, each assigned a sex and an age that increased by a fixed amount with each iteration of the model. The prey simulations operate according to a series of fertility and mortality parameters that determine rates of population growth and recovery. The fertility parameters include the age of females at first reproduction, and the minimum and maximum number of offspring produced per female each year. Once a female reaches reproductive age she adds infants to the populations at the beginning of each iteration of the model, until she dies. The number of babies a female produces each year is randomly selected from within a range defined by the minimum and maximum number of offspring variables. Minimum and maximum values are used instead of averages to account for natural fluctuations in the number of offspring produced from year to year or female to female, as some proportion of females may not bear young in any given year.

Mortality is determined by the combined influence of juvenile mortality; adult mortality; and maximum potential lifespan variables. The shift from youth to adulthood also determines the age of onset of adult mortality. All individuals below this age are subjected to a generalized juvenile mortality rate, and those above it to adult mortality. The mortality values determine the proportion of adults and juveniles that are randomly removed from the population in each iteration. Individuals are also removed once they attain the maximum potential lifespan.

The growth rate of the prey populations was modeled by plugging taxa-specific values for the preceding parameters into the simulation, and allowing a small randomly generated population (n = 25) to grow to carrying capacity. Carrying capacity was set so that in the absence of human hunting, the stable population size for each species equaled approximately 800 individuals in the high growth (HGM) and 400 in the low growth models (LGM). Once carrying capacity was reached, the model was cycled for at least an additional 100 iterations to ensure that the structure had stabilized. Population size was then plotted from year 0 to 100 to depict the growth rate for each population.

The stable populations created by the growth simulations are used as starting points for the models investigating the impact of human hunting pressure on prey population structure. Hunting pressure is introduced as a mortality variable that preferentially removes a fixed percentage of adults from the population with each iteration. The rationale is simply that adults are the largest individuals and may also contain the most fat in some seasons. If there are not enough adults in the population to fill the hunting quota, older juveniles are also hunted. In each successive run of the model, the proportion of hunting is increased incrementally to find the crash threshold of the prey population under HGM and LGM conditions. The results of the HGM and LGM simulations for each prey species thereby provide the upper and lower limits of hunting pressure that can be sustained by its population.

The gazelle simulations introduced below follow the same methods developed previously for tortoises, hares, and partridges. Parameters derived from modern gazelle populations were plugged into the model to generate a stable age structure at carrying capacity. Hunting was then introduced and increased incrementally with each succeeding run. When hunting pressure is added, the populations first begin to shrink and then restabilize at a lower population size.

The Small Game Simulations : Population Growth and Resilience

	Gazelle		**Tortoise**		**Hare**		**Partridge**	
Fertility Parameter	**HGM**	**LGM**	**HGM**	**LGM**	**HGM**	**LGM**	**HGM**	**LGM**
Female min age of reproduction (years)	1	1	8	12	0.75	1	0.75	1
Birth spacing (days)	365	365	365	730	365	365	365	365
Min number of young per year	1	0.7	7	7	9	7	11	9
Max number of young per year	1.4	1	14	14	11	9	13	11
Mortality Parameter	**HGM**	**LGM**	**HGM**	**LGM**	**HGM**	**LGM**	**HGM**	**LGM**
Max life span (years)	12	12	60	60	12	12	8	8
Age of onset of adult mortality (years)	1	1	1	1	0.5	0.5	0.2	0.2
Annual adult mortality	0.2	0.2	0.053	0.093	0.4	0.5	0.5	0.6
Base-level Juvenile mortality	0.30	0.45	0.7	0.85	0.6	0.7	0.42	0.6

Table 6.1: Population parameters used in tortoise, hare, partridge, and gazelle population simulations. See Stiner et al. (2000) for explanation of parameter definition for tortoises, hares, and partridges.

Stiner et al. (1999, 2000) present the results of the predator-prey simulation models for the most common small game species from Paleolithic Mediterranean archaeofaunas, the tortoises, partridges, and hares. The derivation of the parameters used in the HGM and LGM for each of these species is discussed in detail in Stiner et al. (2000), and summarized in Table 6.1. The table emphasizes the salient differences in the reproductive capacities and resilience of the prey species.

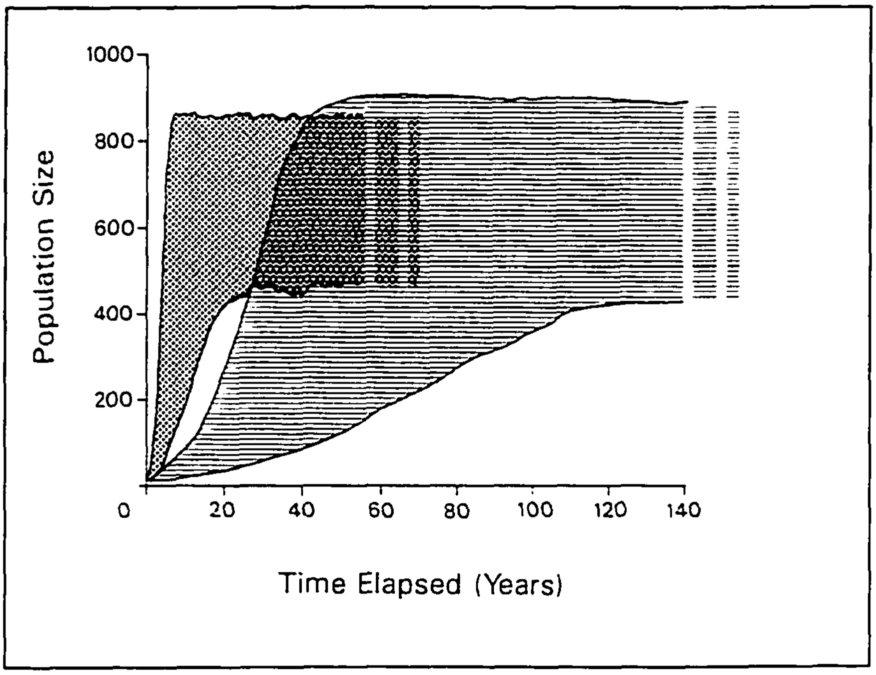


Figure 6.1: Growth curves of tortoise and hare populations created by LGM and HGM simulations. Growth rates for partridge populations are not included, but are nearly identical to hares. Partridge populations grow slightly faster than hare populations. Note, there is no overlap in the growth ranges of tortoises and hares. Figure reprinted from Stiner et al. (2000: 56).

Figure 6.1 diagrams the growth of the tortoise and hare populations from a size of 25 individuals to carrying capacity as determined by the LGM and HGM. Although, partridge populations are not depicted here, their growth potential is virtually identical to that of hares; if anything they can grow slightly faster, widening the gap between the slow- and fast-growing populations further still. One point is of great importance: though partridges and hares race to carrying capacity in 25 years or less even under the most unfavorable conditions, the tortoise take at least 7 times longer. Despite the broad extremes afforded by the HGM and LGM models, there is no overlap whatsoever in the growth rates of tortoise populations versus partridge and hare populations.

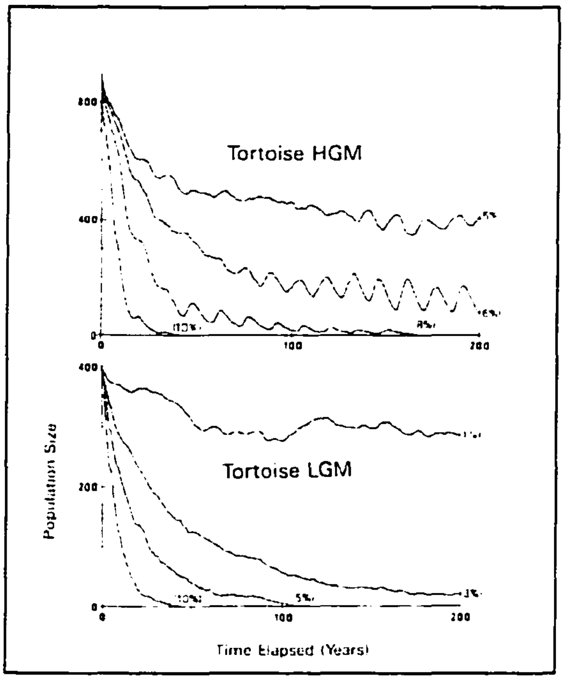


Figure 6.2: The response of the tortoise HGM and LGM populations to incremental increases in hunting pressure. Each line in the series represents population size when subjected to a set percentage of hunting each year. The proportion of the population hunted in each run is indicated by the numbers in parentheses at the right side of the graph. The lowermost line that extends to 200 years, indicates the maximum percentage of hunting pressure the population can sustain each year without crashing. Figure reprinted from Stiner et al. (2000: 53).

Figures 6.2 to 6.4 illustrate the affects of increasing hunting intensity on the sizes of tortoise, hare, and partridge populations for the HGM and LGM simulations. Whether at the low or high range of their reproductive capacity, tortoise populations can sustain a much lower percentage of annual off-take (between 3 and 8%) than hares and partridge populations. The sustainability of hare and partridge populations is great, with partridges showing slightly greater resilience (between 20% and 65% off-take per annum) than hares (between 18% and 50% off-take per annum; Figure 6.5).

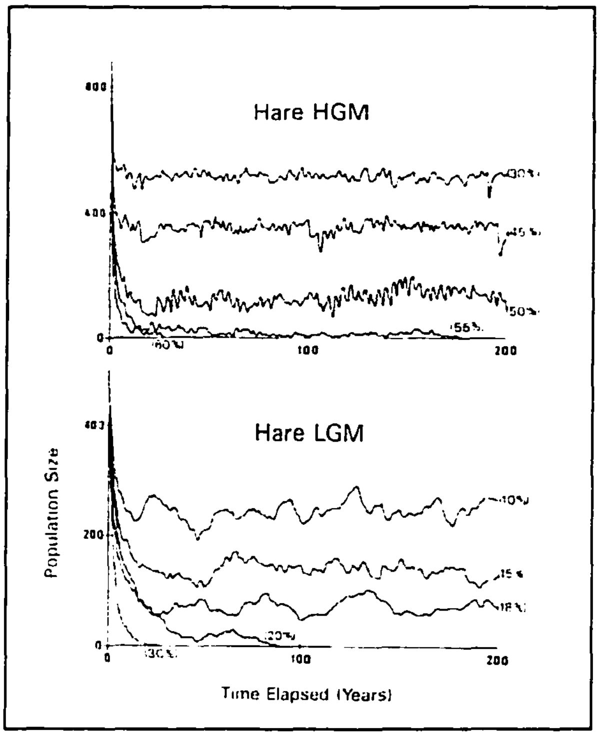


Figure 6.3: The response of hare HGM and LGM populations to incremental increases in hunting pressure. Each line in the series represents the population size when subjected to a set percentage of hunting each year. The proportion of the population hunted in each run is indicated by the numbers in parentheses at the right side of graph. The lowermost line that extends to 200 years, indicates the maximum percentage of hunting pressure the population can sustain each year without crashing. Figure reprinted from Stiner et al. (2000: 55).

The results of the simulations highlight two important points. First, the reproductive potential of tortoises is significantly lower than for either partridges or hares. Tortoise populations grow slowly, whereas hares and partridges quickly return to carrying capacity after periodic disturbances. Second, tortoise populations show poor overall resilience and can be put at risk from much lower intensities of hunting pressure.

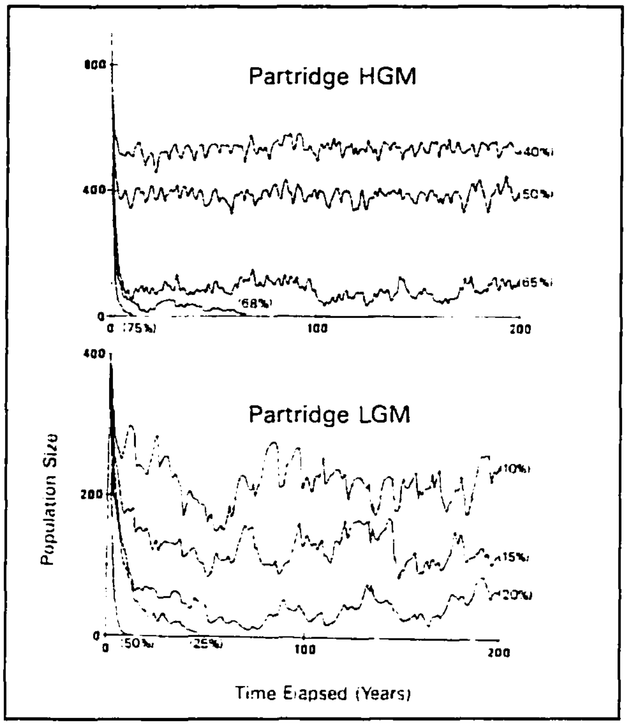


Figure 6.4: The response of partridge HGM and LGM populations to incremental increases in hunting pressure. Each line in the series represents the population size when subjected to a set percentage of hunting each year. The proportion of the population hunted in each run is indicated by the numbers in parentheses at the right side of graph. The lowermost line that extends to 200 years, indicates the maximum percentage of hunting pressure the population can sustain each year without crashing. Figure reprinted from Stiner et al. (2000: 54).

Tortoises replace themselves slowly and thus have low-turnover populations. This is largely the product of slow maturation rates (age of first reproduction in females is on average 10 years) and high juvenile mortality, which prevent most young recruits from reaching reproductive age and contributing to future generations. Those tortoises that do reach reproductive maturity live extremely long lives (up to 60 years) however, and experience low adult mortality. Hares and partridges have high population turnover, mostly due to rapid maturation (the majority of females begin reproducing in their first year of life), and extremely high reproductive rates (see Table 6.1). While many individuals may reach reproductive maturity, they may reproduce only a few times on average before they die, owing to high adult mortality rates and short lifespans (12 years for maximum for hares and 8 years for partridges).

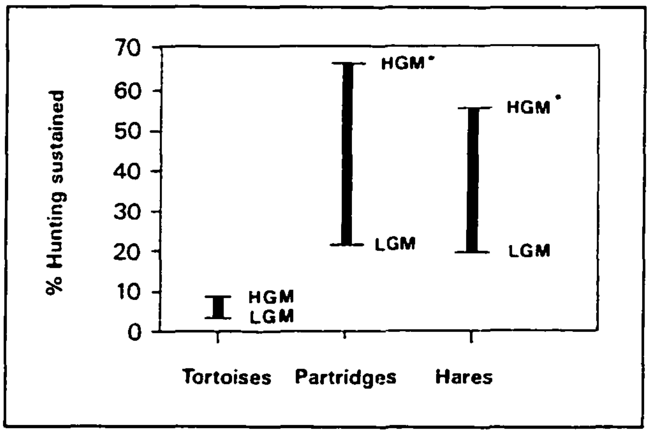


Figure 6.5: Range of tolerance of tortoise, hare, and partridge populations to hunting pressure. Lower bar represents maximum percentage of hunting sustained by the LGM populations and the upper bar indicates the maximum percentage of hunting sustained by the HGM populations. Figure reprinted from Stiner et al. (2000: 56).

Differences in rates of population turnover for tortoises versus hares and partridges are of great significance for archaeologists, as they provide a baseline from which to predict the relative availability of prey species under a range of hunting conditions. Because hunting intensity differentially affects the abundance of prey species due to variation in prey population resilience (i.e., tortoises are affected more than hares and partridges), it is possible to predict the impact of increased hunting intensity on the relative availability of these three small game types. For example, when human hunting pressure increases, tortoise populations will decline sooner than those of hares and partridges, and thus the relative availability of the three species should change and tortoise abundance will decrease in relation to hares and partridges. Human preference for some prey species over others (i.e., high- versus low-ranked prey), also enters the equation, allowing the generation of even more precise predictions about past hunting behavior (see Chapter 7).

THE GAZELLE SIMULATION

Two gazelle species, the mountain gazelle (*Gazella gazella gazella*) and the Dorcas gazelle (*G. dorcas*) occupy the modern day Levant. Though there is a small zone of sympatry between the two species, their niches are roughly separated by the boundary separating regions which receive more and less than 150mm of precipitation *per annum* (Mendelssohn 1974). The mountain gazelle lives in the wetter areas, primarily in the hilly Mediterranean zone of Lebanon and Israel, and much of the steppic Irano-Turanian belt throughout Israel, Jordan, and Syria, while the Dorcas gazelle is arid-adapted, occupying desertic areas including the Negev and the Arava Valley of Jordan and Israel. The Dorcas gazelle also occurs across the Arabian peninsula and northern Africa (Al-Hazmi and Ghandour 1992; Grettenberger 1988; Loggers 1992; Marraha 1996). Tchernov et al. (1987) re-examined elements attributed to *G. dorcas* from Levantine Paleolithic and early Neolithic sites, concluding that there is no good evidence for Dorcas gazelles in the Levant until after the Pre-Pottery Neolithic B period, and reassigning all *G. dorcas* specimens from sites recovered before this date to *G. gazella*. Priority for the simulation parameters was thus given to studies on mountain gazelle, though reports on

Dorcas gazelles were consulted when the literature on the mountain gazelle proved inadequate. A perusal of the literature on several gazelle species indicates that, despite some variation, most species share similar reproductive parameters (Baharav 1974, 1983a, 1983b; Dittrich 1972; Loggers 1992; Zhaowen et al. 1998).

Pristine gazelle populations are non-existent today. Though many modern herds are protected, most are managed and live in reserves or areas inhabited by humans. In Israel, three well-studied mountain gazelle populations provide the bulk of the information provided here. The populations inhabit the Golan Heights, the lower Galilee (Ramat Yissakhar), and the Hula Valley (Ramat Qedesh; Ayal and Baharav 1983; Baharav 1974,1983a, 1983b, 1988; Frankenburg 1992; Mendelssohn 1974; Shy et al. 1998). The Ramat Yissakhar population provides an excellent example of high population growth. It occupies an agricultural landscape with an unnaturally rich distribution of food and water available year round due to agricultural activity. Permanent food and water sources have increased both the survivorship and fertility of the Ramat Yissakhar gazelle population (Ayal and Baharav 1983; Baharav 1988), and thus its reproductive parameters represent the upper range of gazelle productivity. In contrast, the Ramat Qedesh population lives under more seasonal conditions and has a significantly lower rate of annual increase, if it grows at all. It is representative of a low growth situation, and thus well suited for application to the LGM. The following presents the parameters chosen for the gazelle simulations based on information available from modern gazelle wildlife studies, primarily those on the Israeli populations.

Age at First Reproduction in Gazelles

Female gazelles reach reproductive maturity during either their first or second year of life (between 6 and 18 months of age; Ayal and Baharav 1983; Baharav 1983a, 1983b; Shy et al. 1998). Gestation lasts for 6 months, and does bear their first fawn by the age of one or two years. The Ramat Yissakhar females become reproductively active at 6 months (Ayal and Baharav 1983; Baharav 1983b) and produce their first fawn at 12 months of age, while those from Ramat Qedesh often do not become pregnant until they reach 18 months of age. The discrepancy between the two populations is caused largely by differential access to permanent water sources. Other populations also report pregnancy in 6 month old does, though a relatively high percentage of these pregnancies were unsuccessful (e.g., 30%; Shy et al. 1998). Variation in the reproductive success of one year old gazelles is incorporated within the number of offspring variable, and an age of one year is adopted as the age of first reproduction in both the LGM and HGM

Number of Gazelle Fawns Per Female Per Year

Gazelle pregnancies most often lead to the birth of a single fawn (Ayal and Baharav 1983; Baharav 1983b). Twin births have never been observed in mountain gazelles, though they make up between 2.5 and 8.2% of live births in *G. Subguttorosa* Zhaowen et al. 1998), a closely related species. The gazelle birthing season is limited by the availability of standing water (Baharav 1983b). In well-watered locations, breeding is known to occur throughout the year, but peaks during the wettest months (Nowak 1991). In mountain gazelle parturition is most often limited to a single discrete period in the late spring, though a second but less productive birthing season may also occur in the autumn.

The second birth season most likely represents a last attempt at reproduction by does who did not conceive in the spring. If water is abundant, does may produce more than one fawn per year. Under unusually favorable conditions (i.e., access to abundant standing water), mountain gazelle abandon rigid birthing seasons and increase productivity.

High productivity has been observed in mountain gazelles inhabiting the well-watered regions of Ramat Yissakhar where recruitment reaches as many as 1.4 fawns per adult female each year (Ayal and Baharav 1983). Conversely, in neighboring regions, annual production is often less than a single fawn per female, depending on the proportion of failed pregnancies and access to water during the critical season. The lowest recorded birth rates in the studies examined here were 0.42 fawns per female per year in populations living in highly seasonal environments, however these rates were recorded in years when populations were in decline and may not be typical (Marraha 1996; Baharav 1983b).

While access to water clearly influences gazelle productivity, predicting the availability of standing water in the past is problematic. Artificial landscapes created by intensive agriculture inflate gazelle productivity in some cases by providing year round access to food and water. The lowering of the water table in recent years may have also reduced the availability of water to levels below those typical of the past. It is thus difficult to assess whether the reproductive rates of either of the two well-studied gazelle populations from Israel provide accurate representations of populations in the past. The extremes modeled in the HGM and LGM therefore are designed to cover the full range of potential gazelle productivity, circumventing the problem of trying to create precise reconstructions of the past.

In the simulation, the minimum and maximum number of fawns produced per female per year are set at 0.7 and 1 fawn per female per year for the LGM, and at 1 to 1.4 fawns per female per year for the HGM. The number of fawns selected for the LGM is higher than some of the figures available for recent gazelle populations, because these populations were in decline. Using them for the simulations, thus creates an unviable population. The higher rate of 0.7 to 1 fawn per female per year is thus chosen as the minimum number of fawns required to maintain a stable population in accordance with the other LGM parameters.

Age of Onset of Adult Mortality

The age of onset of adult mortality was derived in consideration of three points. First, gazelle reach close to full body size by one year of age, although their bones continue to fuse until approximately 18 months of age (Davis 1980a). Second, gazelle reach reproductive maturity between 6 and 18 months of age. Finally, based on years of field observations, Baharav (1983b) estimates that gazelles are subject to adult mortality by the time they reach 1 year of age. The age of onset of adult mortality is thus set at 1 year for both models.

Mortality

Mortality data for both juvenile and adult gazelles are seldom found in studies of gazelle population ecology. Fortunately, the longitudinal studies by Baharav (1974, 19831, 1983b, see also Ayal and Baharav 1983) provide high quality mortality data on the mountain gazelles from Ramat Yissakhar and Ramat Qedesh.

Juvenile Mortality

The juvenile mortality rates for gazelles living under well-watered conditions at Ramat Yissakhar is 0.32 and is rounded down to 0.30 for use in the HGM. The juvenile mortality rate was much higher for the gazelle population surviving on natural resources at Ramat Qedesh (0.47) and is also rounded down slightly to 0.45 for use in the LGM model.

Adult Mortality

The adult mortality values from the Ramat Yissakhar and Ramat Qedesh populations are recorded as 0.20 and 0.25 per annum respectively. In this case, the more productive Ramat Yissakhar population has a higher rate of adult mortality than the Ramat Qedesh population. This is the natural outcome of Ramat Yisshakhar's low rate of juvenile mortality. Because the simulations aim to model the extremes of population growth the lower rate (0.20) is used in the HGM simulation, but must also be used in the LGM simulation, since the higher mortality rate (0.25) outweighs annual fertility, and the population will not be viable in the long run.

Maximum Life Span

Gazelles exceeding the age of 12 years of age have rarely been reported in the wild. Jones (1982) reports a *G. dorcas* that survived to the age of 17 in captivity. Gazelle are not expected to live this long in natural populations, except under extraordinary circumstances. Thus an maximum age of 12 years will be used for both the HGM and LGM models.

Results of the Gazelle Simulations: Age Structures and Hunting Pressure

The gazelle population parameters were used to create stable LGM and HGM populations. Hunting was applied to these populations in gradual increments and the proportion of juveniles was recorded after each population stabilized. Juveniles are defined as individuals 18 months of age or younger to correspond to the oldest age for fusion of long bones, which are used to age Natufian gazelles in this study (see Chapter 8). The proportion of juveniles in the HGM and LGM populations subjected to incremental intensities of hunting pressure are plotted in Figures 6.6 and 6.7.

Three important observations can be made from these graphs. First the proportion of juveniles in the population increases gradually with hunting intensity in both the HGM and LGM populations (see Chapter 8). Second, the steepness of the graph slopes, representing the proportion of juvenile remains in the population, is greater for the HGM than it is for the LGM, since the HGM population is subjected to higher culls (up to 15% in comparison to 6% for the LGM). Third, and most importantly the models provide empirical estimates of the potential effects of hunting pressure on the living structures of viable gazelle populations. When no hunting is added to the simulations, the proportion of juvenile gazelles in both the HGM and LGM populations is about 30% (28% for the LGM and 31% for the HGM). This is the similar to the average proportion of juveniles reported by Baharav (1983b) for the real Ramat Qedesh population.

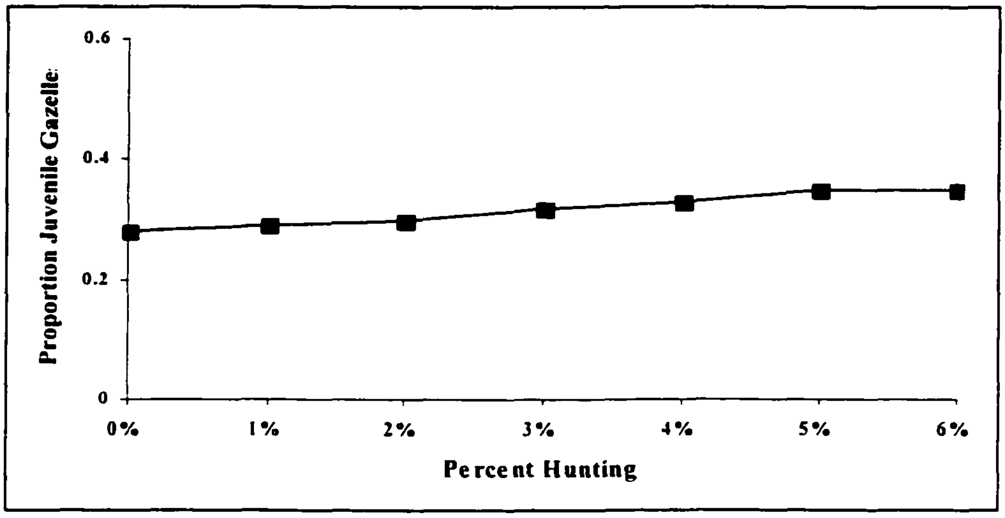


Figure 6.6: Proportion of juvenile gazelles (18 months or less) in the HGM gazelle population when subjected to increasing hunting pressure.

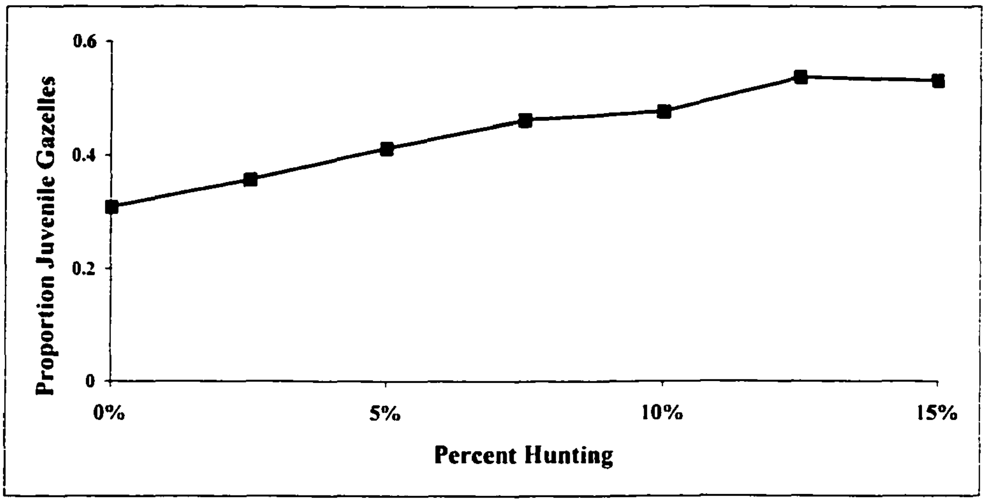


Figure 6.7: Proportion of juvenile gazelles (18 months or less) in the LGM gazelle population when subjected to increasing increments of hunting pressure.

Implications of the Gazelle Simulations for Monitoring Human Hunting Intensity

The preceding simulations have defined the range of potential sustainable impact human hunters can exert on the living structures of gazelle populations. Because the mortality profiles of hunted prey populations can be obtained by aging animal bones and teeth collected by prehistoric hunters, the simulated ratios of juveniles to adults can be used as proxy measures of past human hunting pressure. Other factors -- such as seasonality and hunting strategies -- also influence the age structures of prey death assemblages. Defining the range of potential influence of each factor provides, however, a starting point for separating their role in assemblage formation. The simulations show that hunting pressure alone may inflate the proportion of juveniles in a stable gazelle population from approximately 30% to as high as 50% or perhaps even 60% in the case of heavily hunted high growth populations. Hunting at higher rates will crash the population, since like tortoises, gazelle populations have low rates of turnover. Finally, defining the living structure of prey populations means that hunted assemblages with percentages of juveniles outside of this range were most likely created by selective human hunting for specific age groups. The results of the gazelle simulations will be applied to Paleolithic gazelle assemblages in Chapter 8.

CHAPTER 7: RELATIVE ABUNDANCE OF MAJOR PREY TYPES: SITE OCCUPATION INTENSITY AND HUNTING PRESSURE IN THE NATUFIAN

INTRODUCTION

Questions of human demography -- such as population pressure and sedentism-- are difficult to test, yet they are of central interest in current Natufian research. This chapter presents a new method (following Stiner et al. 2000) for discerning finer-grained information about the intensity of site occupation. Tracking the proportions of small prey (tortoise, partridges, and hares) provides considerable resolution for detecting relative differences in the intensity of site use from one place to the next and across two Natufian phases. Moreover, the abundance of small game relative to ungulate remains reveals the degree of pressure exerted by human populations on their environment at a regional scale (see Chapter 1).

METHODS

To facilitate comparison between sites and time periods, assemblages are first grouped into three broad prey categories: ungulates, carnivores, and small game. Although carnivores and predatory birds may not be "prey" *senso stricto* they were caught and used by humans. The small game fraction includes a variety of reptiles, birds, and small mammal species weighing no more than two kilograms. Only prey types demonstrably modified by humans, as evidenced by cut marks, burning, body part representation, fragmentation, and other taphonomic criteria, are included in this comparison (see Chapter 4).

Next, the small game index is applied (see Chapter 1). The small game fraction of each Natufian assemblage is subdivided into small mammals, birds, and reptiles based on arguments presented earlier in Chapter 4. Microfauna, including most rodents, small passerine birds, and the majority of small reptiles and amphibians have been shown to be intrusive, and thus are not included in the analysis. Specimens classified into general taxonomic groups such as small, medium, and large mammal are also excluded, because they could belong to any of two or more prey groups.

To address variation in hunting intensity across time and space in the Natufian, broad taxonomic and small game comparisons are presented. A summary of the Paleolithic faunal sequence at Hayonim Cave and Meged Rockshelter (Stiner et al. 1999, 2000) places the Natufian fauna in chronological and ecological perspective. The subdivision of the Natufian fauna from Hayonim Cave into five phase, allows the study of changes in the intensity of site occupation within the Natufian at this site. Finally, comparison of an expanded sample of Natufian sites including Hayonim Terrace, el-Wad Cave, and Hilazon Tachtit, with the Natufian of Hayonim Cave enables examination of regional trends within the Natufian period. This kind of temporal and regional framework is the foundation for discussing human demography at the Pleistocene/Holocene boundary. It also allows for more precise reconstruction of the distribution of Natufian populations at large sites at a time when imbalances between humans and their resources may have contributed to the onset of an agricultural revolution.

The large Natufian faunal sample from Hayonim Cave (NISP = 19,000) is subdivided to address questions posed on three different time scales. First, the Natufian fauna are treated as a single assemblage in order to bring out differences between the Natufian and preceding cultural adaptations, and allow examination of long-term change at Hayonim Cave beginning in the Middle Paleolithic (Stiner et al. 1999, 2000). Although the Natufian layer is broken into more temporally refined units in subsequent analyses, the major differences that distinguish this assemblage from earlier Paleolithic layers are sustained. More fine-grained variation within the Natufian period at Hayonim Cave is discernible, however, when the assemblage is divided into a series of five consecutive phases (as defined by Bar-Yosef and Belfer-Cohen n.d.; Belfer-Cohen 1988; and see Chapter 3). To strengthen the reliability of the Natufian analysis, fauna from problematic contexts and taxa were removed from the database, reducing the NISP count to 15,000 (see Chapter 3 for discussion of potentially mixed contexts, and Appendix 1). Finally, for inter-site analysis of the Natufian, the five phases from Hayonim Cave are collapsed into Early and Late Natufian categories. The Early Natufian is comprised of Phases I-III at Hayonim Cave, and the Late Natufian is equivalent to Phases IV and V (cf. Bar-Yosef and Belfer-Cohen n.d.; Belfer-Cohen 1988).

THE LONG PALEOLITHIC SEQUENCE AT HAYONIM CAVE

Hayonim Cave was repeatedly occupied by Paleolithic foragers throughout

The late Middle and Upper Pleistocene. Layers from the Early Middle Paleolithic (Mousterian), Upper Paleolithic (Levantine Aurignacian), and Epipaleolithic (Kebaran and Natufian) periods provide an ideal sequence for the examination of long-term change. Faunal analyses of the early occupations at the site were undertaken by Mary Stiner of the University of Arizona (Stiner and Tchernov 1998; Stiner et al. 1999, 2000) and Rivka Rabinovich of the Hebrew University in Jerusalem (Rabinovich 1997, Kebaran and Aurignacian only). Because Rabinovich did not quantify the small game remains of the Aurignacian assemblage, they were later counted by Stiner and combined with Rabinovich's figures for ungulates and carnivores. The revised counts appear in Stiner et al. (1999, 2000). Fauna from the earlier layers were collected according to the same standards as the Natufian sample, thus the assemblages are directly comparable. With the exception of the Natufian component, which is greatly expanded in the current study, the figures reported here follow Stiner et al. (2000: Table 4, Table 5).

Minor changes to the small game criteria set forth in Stiner et al. (2000) are the removal of two reptilian species, snakes (*Calubra* sp.) and the lizard, *Agama stellio*, because these species could not be unequivocally linked to humans. The small game species include the Mediterranean spur-thighed tortoise (*Testudo graeca*); the legless lizard (*Ophisaurus apodus*); a diverse category of avifauna composed primarily of ground birds (mainly Phasinidae), raptors (Falconiformes and Strigiformes), and waterfowl (Ralliformes, Gruiformes, and Anseriformes); and the small mammals, hare (*Lepus capensis*), Persian squirrel (*Sciurus anomalus*), and hedgehog (*Erinaceus europaeus*).

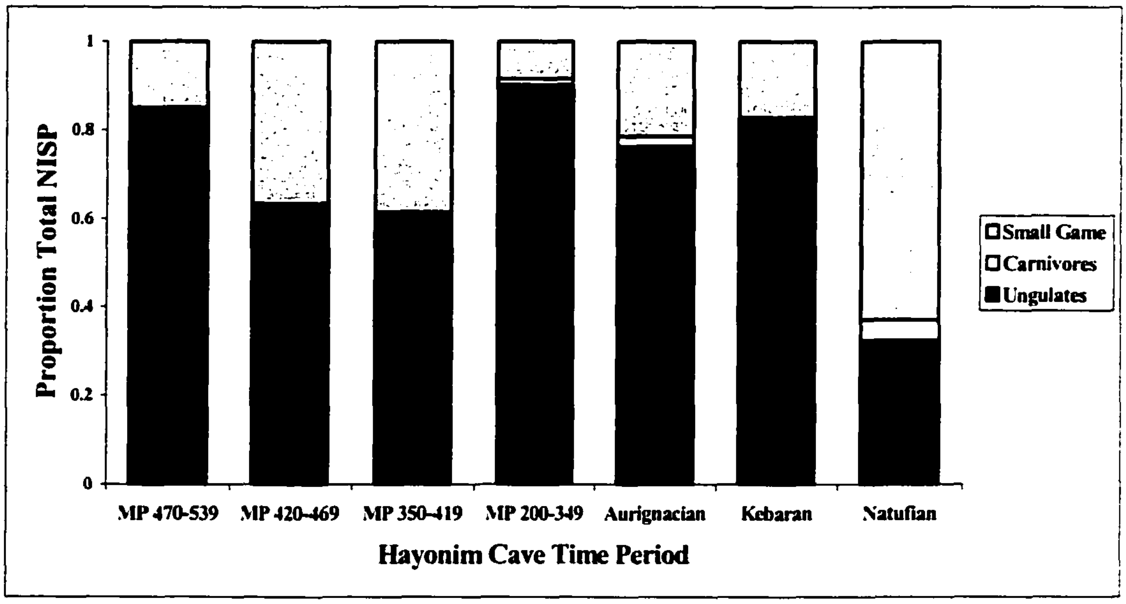


Figure 7.1: Relative abundance of broad taxonomic groups from Mousterian, Aurignacian, Kebaran, and Natufian layers at Hayonim Cave. Phases are ordered from oldest to most recent. The Mousterian or Middle Paleolithic (MP) layer is divided into four phases that are designated by the depths of the deposits, which in turn correspond to climatic and technological changes. Faunal data for pre-Natufian layers from Stiner et al. (1999, 2000).

Ungulate Taxa	**MP 470-539**	**MP 420-469**	**MP 350-419**	**MP 200-349**	**Aurignacian**	**Kebaran**	**Natufian**
Capreolus capreolus	0 (0.0%)	1 (<1.0%)	5 (1.2%)	0 (0.0%)	77 (1.0%)	16 (1.2%)	8 (<1.0%)
Dama mesopotamica	50 (18.1%)	565 (32.6%)	127 (30.7%)	12 (26.7%)	798 (10.5%)	161 (12.5%)	80 (2.7%)
Cervus elaphus	7 (2.5%)	95 (5.5%)	18 (4.4%)	2 (4.4%)	236 (3.1%)	70 (5.4%)	39 (1.3%)
Cervidae	27 (9.7%)	193 (11.1%)	44 (10.7%)	2 (4.4%)	3 (<1.0%)	86 (6.7%)	81 (2.7%)
Gazella gazella	129 (46.6%)	674 (38.8%)	174 (42.1%)	23 (51.1%)	6253 (82.3%)	827 (64.1%)	2602 (88.1%)
Capra aegegrus	0 (0.0%)	1 (<1.0%)	4 (1.0%)	0 (0.0%)	103 (13.5%)	37 (2.9%)	26 (<1.0%)
Bos primigenius	36 (13.0%)	137 (7.9%)	26 (6.3%)	5 (11.1%)	77 (1.0%)	43 (3.3%)	19 (<1.0%)
Sus scrofa	28 (9.7%)	61 (3.5%)	13 (3.1%)	1 (2.2%)	52 (<1.0%)	51 (4.0%)	98 (3.3%)
Equus cf. caballus	0 (0.0%)	8 (<1.0%)	2 (<1.0%)	0 (0.0%)	3 (<1.0%)	0 (0.0%)	1 (<1.0%)
Subtotal	**277**	**1735**	**413**	**45**	**7602**	**1291**	**2954**
Small Ungulate	100	649	209	38	nd	618	1716
Medium Ungulate	209	1417	313	33	nd	491	151
Large Ungulate	92	202	65	16	nd	102	33
Total	**678**	**4003**	**1000**	**132**	**7602**	**2502**	**4854**

Table 7.1: Taxonomic abundance of ungulate species from all Paleolithic layers at Hayonim Cave. Numbers outside of parentheses are NISP counts. Numbers in parentheses represent the proportion of the subtotal for that layer. "Subtotal" refers to the NISP of ungulates assigned to species for each layer, and "Total" refers to the NISP of ungulates for each layer, including those assigned to broad categories based on size. "nd" means no data. Data for pre-Natufian layers from Stiner et al. (2000).

Figure 7.1 compares the relative abundance of ungulates, carnivores, and small game for Hayonim Cave's four Paleolithic cultural periods. The ungulate fraction in the Natufian is comprised almost exclusively of gazelles (88%), whereas earlier assemblages contain notably higher quantities of large-bodied species such as fallow deer, red deer, wild boar, and wild cattle (see Table 7.1). The carnivore fraction is relatively stable throughout the Paleolithic sequence and represents only a small proportion of identifiable specimens (1- 5%).

The ratio of small game to ungulates is high but variable throughout the Paleolithic sequence, although it is highest in the Natufian period, at 63% (NISP = 14,998). Ungulates continued to provide a significant meat source for the Natufians, but their remains are surpassed by small game in sheer numbers for the first time in the Natufian period. The investment required to capture such large numbers of small animals is significant and would have involved increased efforts in pursuit and/or investment in technology by Paleolithic hunters.

Significant differences in the composition of the small game fraction over the course of the Paleolithic set the Natufian faunal assemblage apart from all previous occupations at Hayonim Cave. Figure 7.2 focuses on the relative abundances of small game types only for the Hayonim Cave series. Unlike earlier Paleolithic occupations, the Natufian small game fraction is represented by more even proportions of each of the three small game groups. Middle Paleolithic small game assemblages are dominated by slow-moving tortoises; in fact, tortoises appear to have been a staple throughout the entire Hayonim sequence, but gradually decline in frequency as fast-moving species were added to the diet (see Stiner et al. 2000). Moreover, a wide array of birds appears in abundance in the Aurignacian period, and increases even further during the Natufian period. Hare, another fast-escape type, appears in large numbers only during the Natufian period. Though the Natufians continued to hunt tortoises, proportions of this prey type are significantly reduced relative to the rapidly increasing frequencies of partridge and hare.

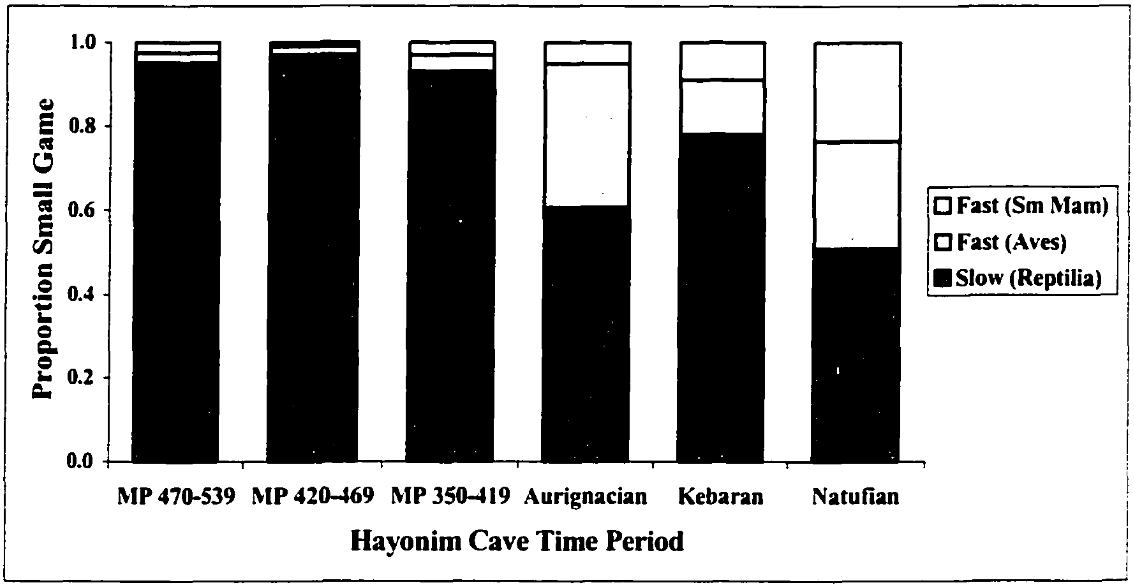


Figure 7.2: Relative abundance of small game groups from Mousterian, Aurignacian, Kebaran, and Natufian layers at Hayonim Cave. Phases are ordered from oldest to most recent. The Mousterian or Middle Paleolithic (MP) layer is divided into four phases that are designated by the depths of the deposits, which correspond to climatic and technological changes. Data from pre-Natufian assemblages from Stiner et al. (2000).

Changes in the composition of small game faunas across the Paleolithic from predominantly high- to predominantly low-ranked animals, signal shifts in human population densities (demography) and human adaptations. It is inferred that in the Middle Paleolithic, human population densities were lower, and hunters could afford to focus exclusively on tortoises, a profoundly unproductive species, and to ignore quicker small prey. Changing species composition indicates that this was no longer possible throughout the Upper Paleolithic, and even less so in the Natufian (Stiner et al. 2000). In general, the increasing use of quick-moving small prey (partridges and hares) favored immediately prior to the agricultural transition can be related to higher availability as tortoises declined. Partridges and hares have short life spans, reach reproductive maturity within a year, and produce multiple litters per year. Such populations can rebuild quickly and withstand comparatively intense predation (see Chapter 6). Ungulates and tortoises, by contrast, reach reproductive maturity at a much older age (about two and ten years, respectively). They have greater difficulty reestablishing their populations after heavy losses, and as a result, their populations are much more sensitive to predation (Stiner et al. 1999, 2000). Overall, the significantly higher proportions of hares and partridges in relation to tortoises during the Natufian indicates that this period witnessed the most intense levels of predation of the Levantine Paleolithic sequence. This observation serves as the main premise for the pan-Natufian analysis; the focus of this dissertation.

Changes in the proportions of high- versus low-ranked animals clearly mirror shifts in human adaptations, shifts that are argued to be linked to increased population density at the regional scale. The sequence in which small game taxa were introduced to Paleolithic diets indicates evolutionarily significant changes in hominid foraging strategies and increased human population densities culminating in the Natufian period just prior to the transition to agriculture.

INTRASITE COMPARISON: THE NATUFIAN LAYER AT HAYONIM CAVE

Tracking relative prey abundances across the five phases of occupation at Hayonim Cave reveals trends in site use intensity (see Bar-Yosef 1991 and Belfer-Cohen 1988 for phase divisions). Here, the small game group is pared down in comparison to the previous analyses to ensure that only those prey unambiguously captured by humans are evaluated; these are tortoises, hares, partridges, waterfowl, and Falconiformes. This rather extreme measure is taken to exclude species with somewhat equivocal taphonomic histories and any possibility of ambiguous stratigraphic association. The taphonomic histories of the small game species from Hayonim Cave discussed in Chapter 4 form the basis for these decisions. The elimination of squirrels, legless lizards, and hedgehogs is statistically insignificant in terms of overall results, because these small game animals are only represented in very small numbers in the Natufian assemblages.

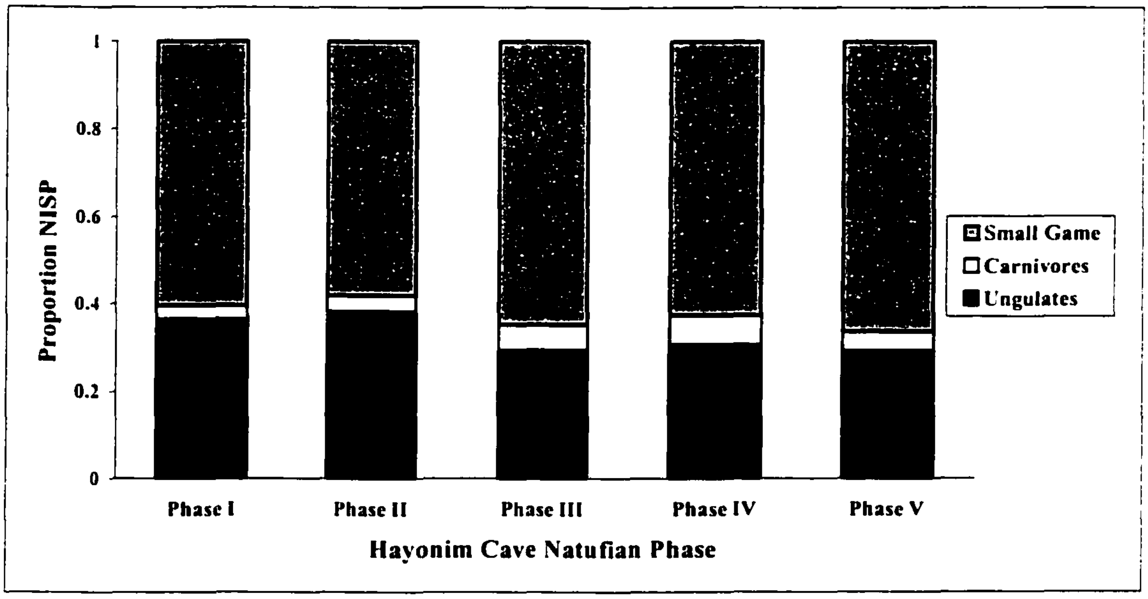


Figure 7.3: Relative abundance of broad taxonomic groups from five phases of Natufian occupation at Hayonim Cave. Phases are ordered from oldest to most recent.

Figure 7.3 shows the relative proportions of ungulates, carnivores, and small game for each of the five Natufian phases at Hayonim Cave. Two patterns immediately emerge. First, the consistency in the relative proportions of the three groups through time is remarkable, indicating stability in the basic hunting strategy throughout the occupation. Second, the small game fraction consistently outnumbers the large game component, confirming a categorical increase in small game use for the Natufian period relative to earlier cultural periods.

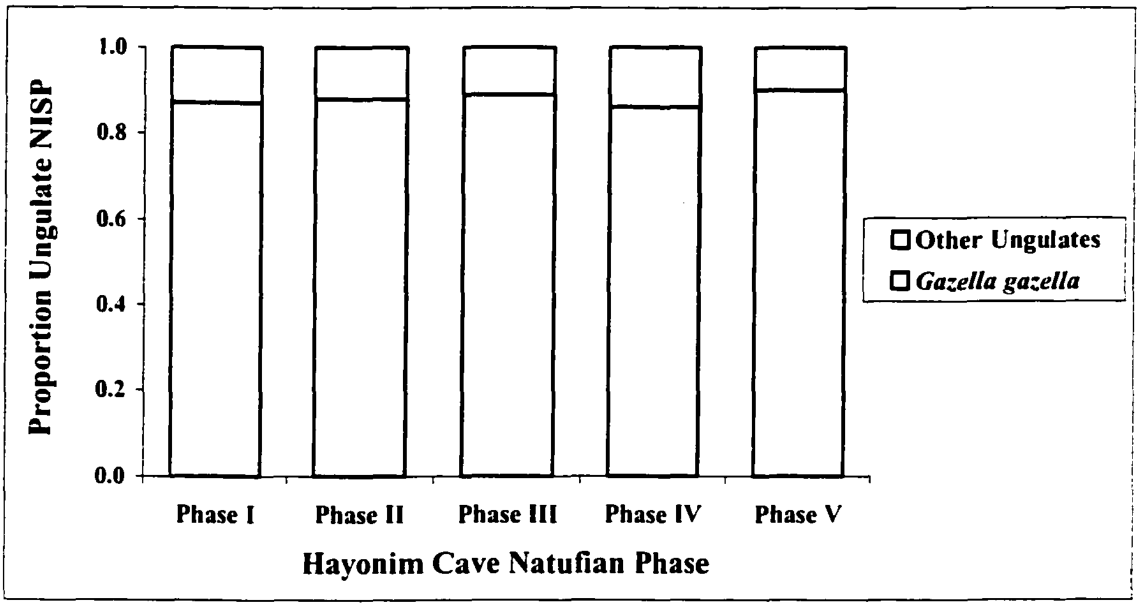


Figure 7.4: Relative abundance of gazelle in comparison to total ungulate species from five phases of Natufian occupation at Hayonim Cave. Phases are ordered from oldest to most recent. The "Other Ungulate" category includes roe deer, fallow deer, red deer, wild boar, wild goat, and wild cattle.

Figure 7.4 compares the proportions of gazelles relative to all other ungulate species in the five Natufian phases at Hayonim Cave. The results are entirely consistent with what has been reported in earlier analyses of fauna from both Hayonim Cave and other Natufian sites located in the Mediterranean zone (Bar-Yosef and Tchernov 1967;

Bouchud 1987; Cope 1991a, 1991b; Davis 1978, 1981; Davis et al. 1994; Henry et al. 1981; Rabinovich 1998; Valla et al. 1986). Gazelles were hunted almost exclusively in each of the five phases, with wild boar, fallow deer, roe deer, red deer, wild goat, and aurochs playing distinctly minor roles.

The fauna from Hayonim Cave appears "typically Natufian" with the usual array of species. However, some qualities of the Natufian faunas of Hayonim Cave are anything but static. Figure 7.5 illustrates substantial changes in the small game index across the five phases of occupation. Here, small game are divided into "slow" (high-ranked) and "fast" (low-ranked) types, based on the animals' escape mechanisms. Phases I-III (Early Natufian) of the Natufian period show consistently higher proportions of fast to slow small game animals, with the fast types outnumbering the slow types. During Phase IV, at the onset of the Late Natufian, a reversal occurs, and the slow-moving small game fraction increases markedly, to the point where it surpasses the proportion of fast game. The trend continues through Phase V when slow, small prey constituted almost the entire small game fraction (83%).

Figure 7.5 tracks proportions of slow- versus fast-moving small game animals through time, but with small mammal and avian prey as separate categories. Both types of quick small prey clearly decrease. The importance of absolute changes in Natufian diets for current interpretations necessitates independent verification of observed patterns in the small game fraction. As Figure 7.3 illustrates there is marked stability in the proportions of small game relative to ungulates across the five phases of the Natufian occupation at Hayonim Cave. The frequency of ungulates in each phase can therefore be used as an independent standard for determining if the shifts in small game use represent absolute or only relative changes. If use of slow game was, in fact increasing, and fast game decreasing in absolute terms, then these trends will also be apparent when slow and fast game are plotted against the ungulates by phase.

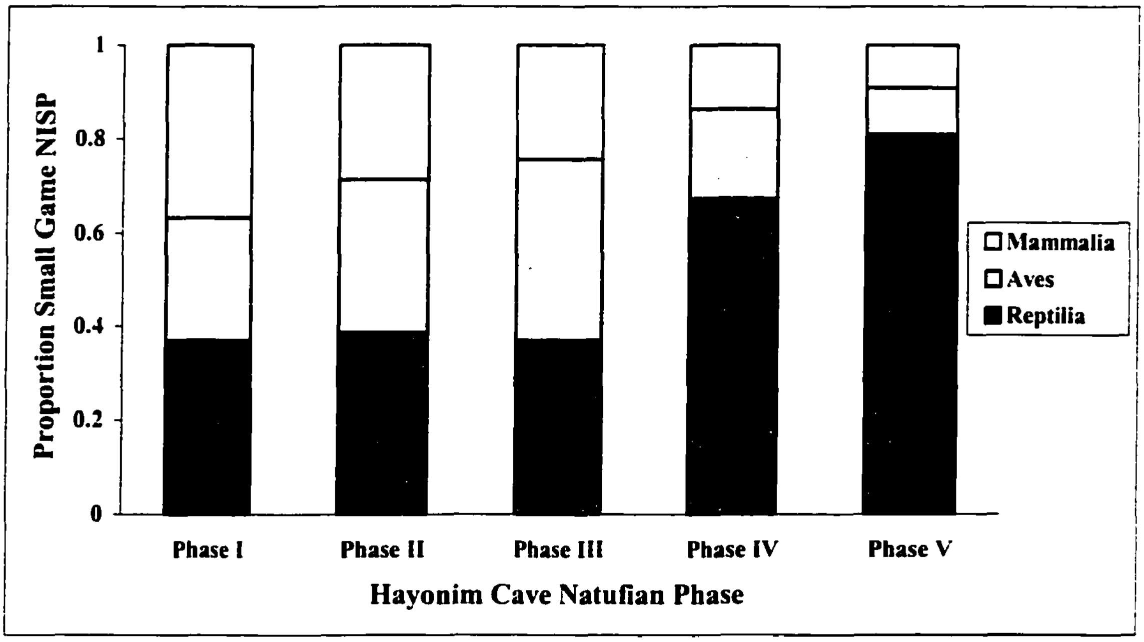


Figure 7.5: Relative abundance of small game types from the five phases of Natufian occupation at Hayonim Cave. Phases are ordered from oldest to most recent. The Reptilia category includes only tortoises; Aves includes Phasinidae, Falconiformes, and waterfowl; and Mammalia includes only hares.

Figures 7.6 and 7.7 compare the proportion of slow and fast small game types in comparison to ungulates for each of the five Natufian occupation phases. Figure 7.6 reveals a clear increase in the proportion of slow small game in the Late Natufian, and Figure 7.7 indicates a decline in the use of fast small game. These trends confirm that Natufian hunters from Hayonim Cave increased their off-take of slow small game, and hunted less fast small game in the Late Phase. In other words, hunting emphasis on small

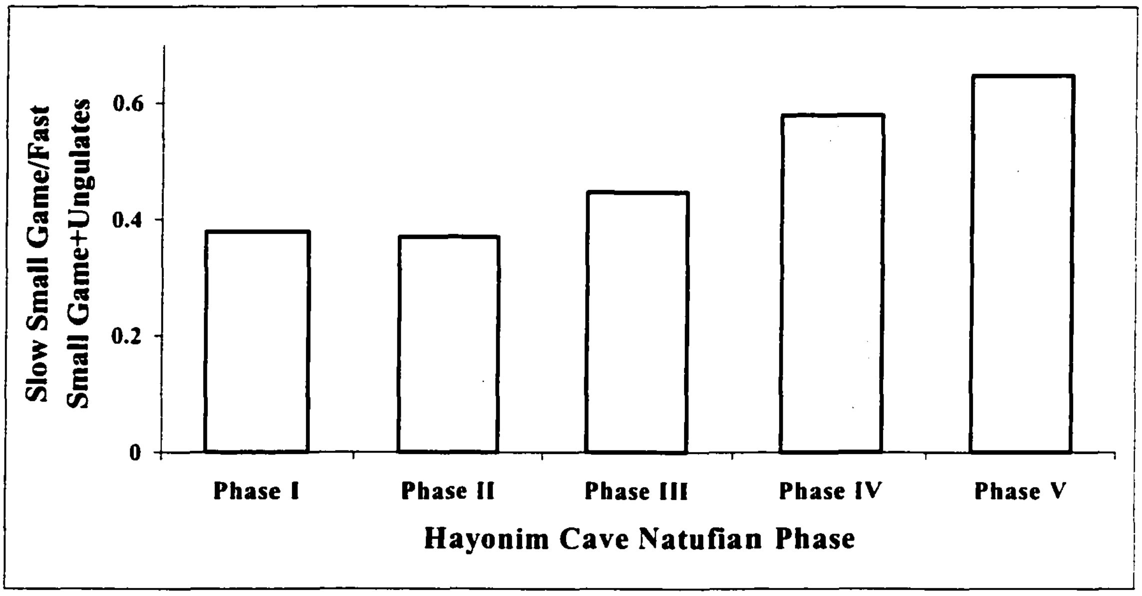


Figure 7.6: Proportion of slow small game in relation to ungulates during the five phases of Natufian occupation at Hayonim Cave. Phases are ordered from oldest to most recent. "Slow small game" includes only tortoise. Ungulates include gazelle, roe deer, fallow deer, red deer, wild boar, wild goat, and wild cattle.

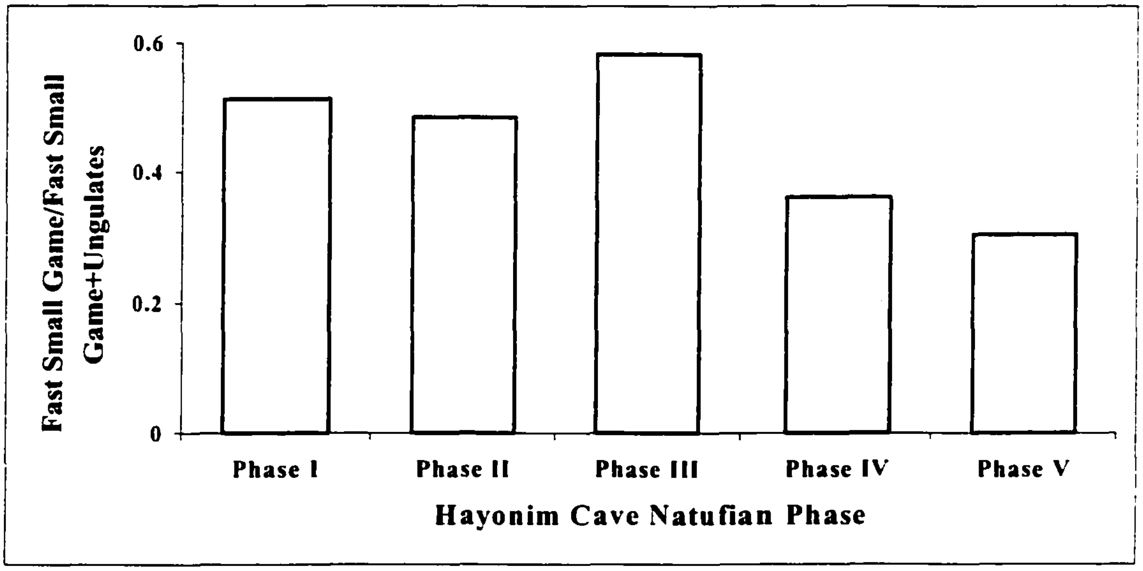


Figure 7.7: Proportion of fast small game in relation to ungulates during the five phases of Natufian occupation at Hayonim Cave. Phases are ordered from oldest to most recent. "Fast small game" includes hare, partridge, waterfowl, and Falconiformes. Ungulates include gazelle, roe deer, fallow deer, red deer, wild boar, wild goat, and wild cattle.

prey types was more even in the Early Natufian, the period of greatest pressure on easily collected small prey, and less even in the Late Natufian, when pressure lessened, albeit to an as yet undetermined degree.

Although, these patterns are intriguing, there is some difficulty linking stratigraphic layers to their associated temporal phases throughout the cave (see Chapter 3). Thus there may be some question over the accuracy of the phase divisions and the apparent trends. The reliability of the phase subdivisions can be tested to determine if the small game pattern is upheld in those areas of the cave that have the best spatial integrity, with clearly superimposed layers representing multiple phases of occupation. Locus 4 and Locus 8 are ideal candidates for this purpose, because each is clearly bounded by a

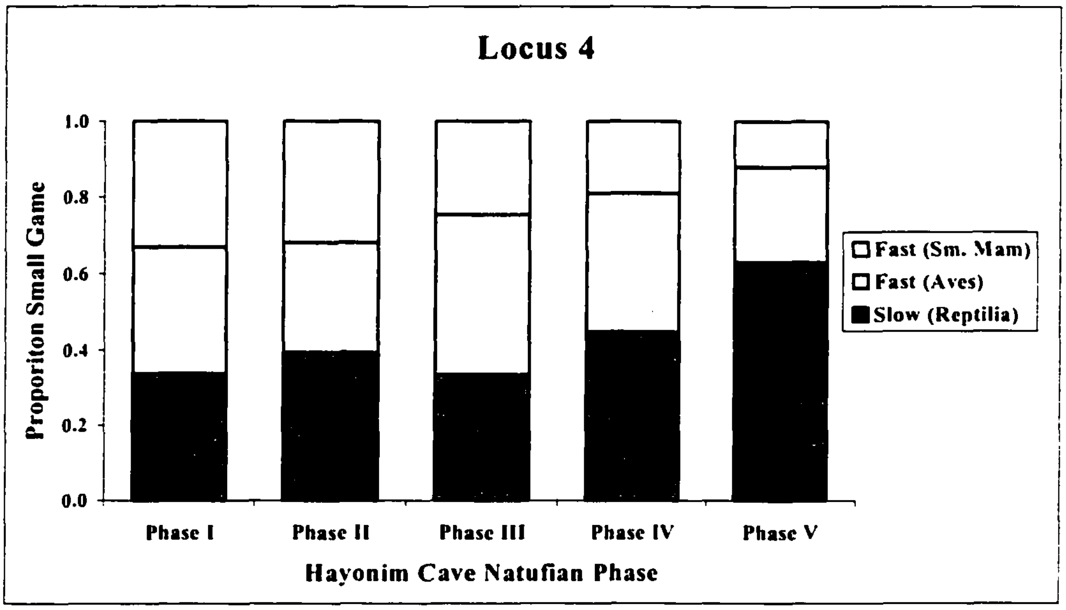


Figure 7.8: Relative abundance of small game types from four phases of Natufian occupation in Locus 4 at Hayonim Cave. Phases are ordered from oldest to most recent. Slow small game (Reptilia) includes only tortoise. Fast small game (Aves and Small Mammals) include partridge, waterfowl, Falconiformes, and hares.

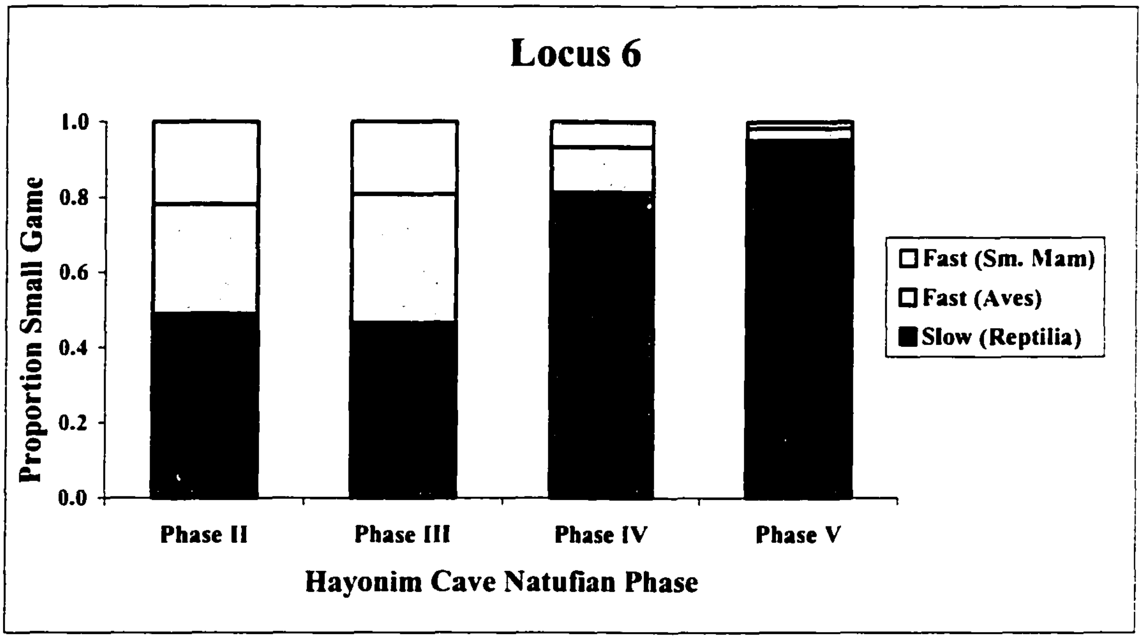


Figure 7.9: Relative abundance of small game types from Locus 6 of the Hayonim Cave Natufian. Phases are ordered from oldest to most recent. Slow small game (Reptilia) includes only tortoise. Fast small game (Aves and Small Mammals) include partridge, waterfowl, Falconiformes, and hares.

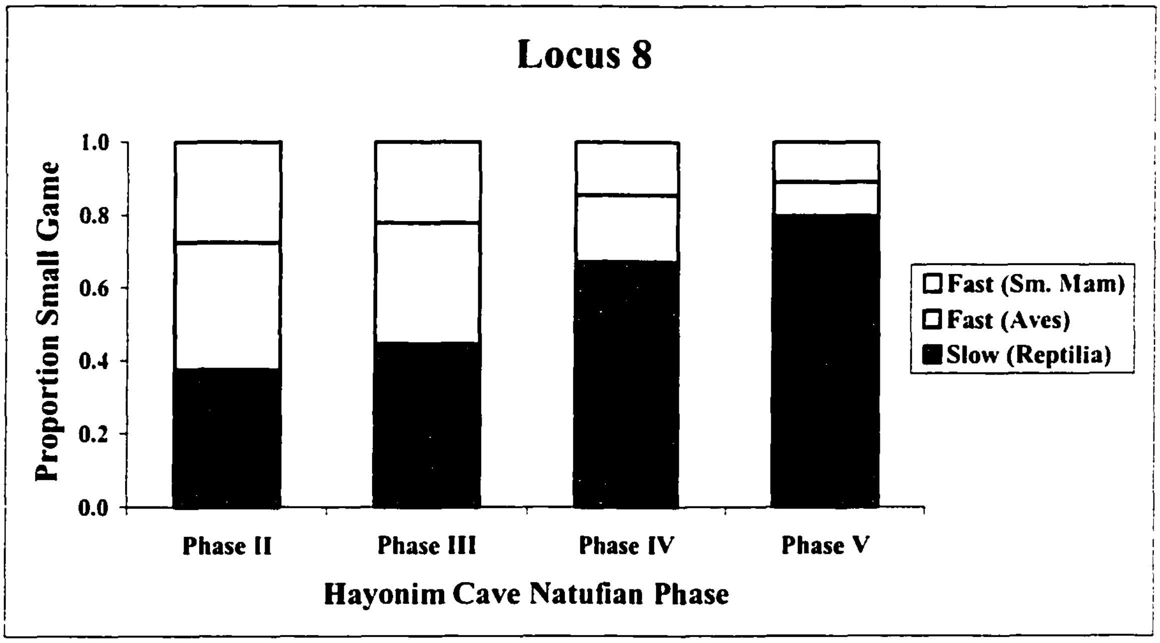


Figure 7.10: Relative abundance of small game types from Locus 8 of the Hayonim Cave Natufian. Phases are ordered from oldest to most recent. Slow small game (Reptilia) includes only tortoise. Fast small game (Aves and Small Mammals) include partridge, waterfowl, Falconiformes, and hares.

circular stone wall and contains evidence of discrete building sequences of layers representing at least four consecutive occupation phases. Locus 6 also contains intact layers belonging to four phases, but the samples from the upper two phases (IV and V) are small due to the removal of fauna from potentially mixed contexts. The fauna quantified from potentially mixed contexts in Locus 6 are thus, included only for this analysis. Figures 7.8, 7.9, and 7.10 compare the relative proportions of slow versus fast small game for each consecutive phase in Locus 4, 6, and 8, respectively. Once again, the patterns described for the site as a while stand out with only minor variations.

With the partial exception of the sample from Locus 6 presented in Figure 7.9, these results are based only on material from undisturbed contexts at Hayonim Cave. The removal of fauna from potentially mixed contexts significantly reduced the sample sizes of the Phase IV and V (Late Natufian) deposits at the top of the layer. The use of only the most reliable of all contexts slightly diminishes the trend in small game use, patterning is stronger when fauna from potentially mixed contexts are included in the sample, but the trend is still very clear and consistent with the results of site-wide comparisons. Figures 7.11 and 7.12 show the differences between the small game fraction represented in good contexts from Phases IV and V and those from some good and some potentially mixed contexts. Small game from potentially mixed contexts dating to the Late Natufian contain even higher proportions of tortoises than the "cleanest" assemblage. The removal of these potentially mixed faunas reduces only the intensity of the trends, but does not negate them.

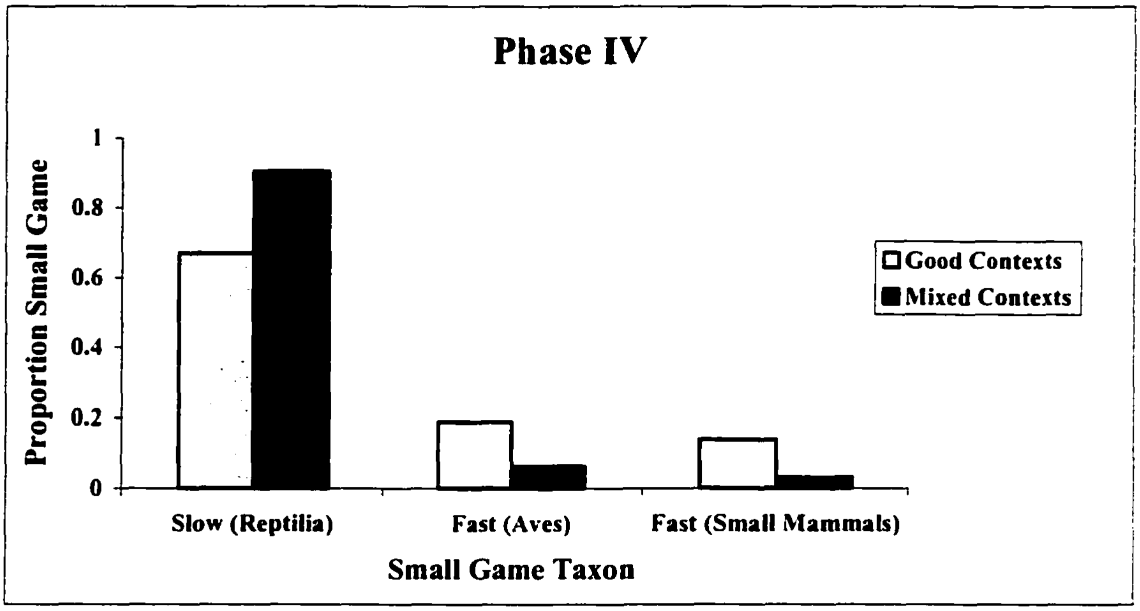


Figure 7.11: Relative abundance of small game taxa from "good contexts" (contexts from secure Natufian contexts) versus those from potentially mixed contexts (those originating in areas with high potential for mixing with non-Natufian layers) from Phase IV of the Natufian deposits at Hayonim Cave.

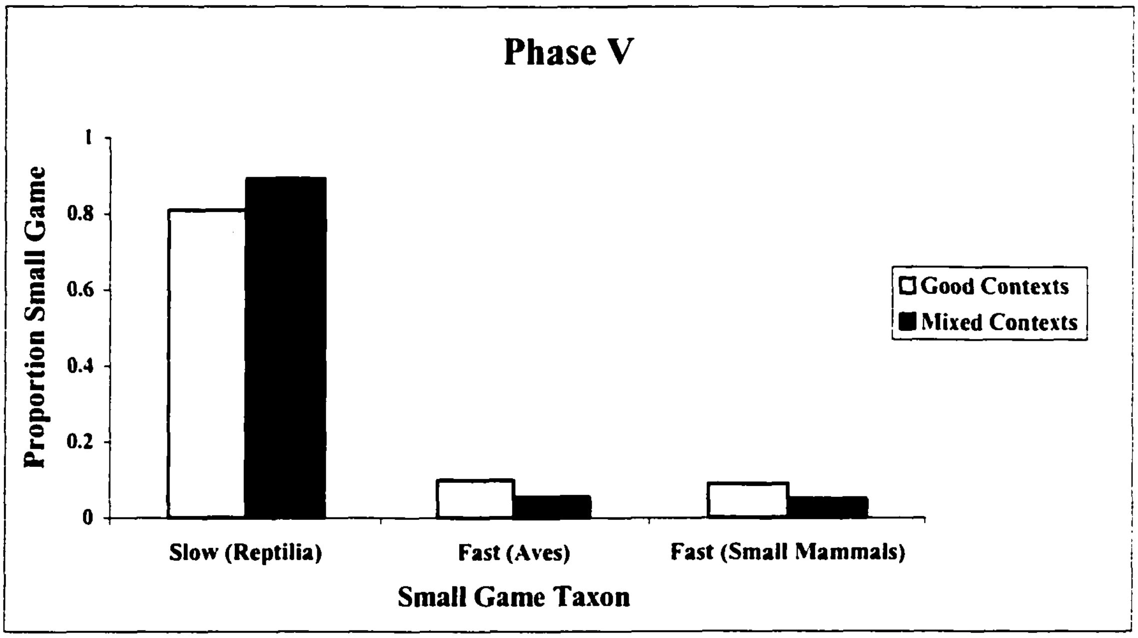


Figure 7.12: Relative abundance of small game taxa from "good contexts" (contexts from secure Natufian contexts) versus those from potentially mixed contexts (those originating in areas with high potential for mixing with non-Natufian layers) from Phase IV of the Natufian deposits at Hayonim Cave.

The trends described for the small game fraction in the Hayonim Cave fauna are real. Even in the face of problematic contexts, a very distinct trend emerges from the data: fast small game were most abundant in human diets during the Early phase of occupation at Hayonim Cave (Phases I-III),but much less abundant relative to slow small game during the Late Natufian phase (Phases IV and V).

Discussion of Results on Hayonim Cave Natufian

High proportions of fast small game animals in Early Natufian deposits of Hayonim Cave indicate that encounter rates with high-ranked species were insufficient to meet human demands for animal resources. Natufian foragers compensated for this by bringing more low-ranked hares and partridges into their diets. Hunters continued to capture tortoises when encountered, but the increased demand for animal products may have been sufficient to deplete tortoise populations. After low-ranked species were added to human diets, the foraging system stabilized; human demands for small game did not grow beyond the reproductive capacity of hares and partridges.

By the Late Natufian a significant shift in human foraging strategies occurred. This was essentially a return to greater dependence on tortoises, implying that previously depleted high-ranked resources were able to recover at least to levels observed for the Kebaran period. Though the continuing presence of hares and partridges attests to the Natufian's recognition of these animals as potential food sources, they did not invest as much energy in their capture. This suggests that human needs were greatly reduced in comparison to earlier periods, that higher-ranked game populations were sufficiently abundant to meet these needs, and that Late Natufian population densities in the areas were lower than those of the Early Natufian.

Following the expectations of the small game index presented earlier, trends in the relative abundance of small game from Hayonim Cave appear to reflect a dramatic change in the intensity of site use from the Early to the Late Natufian. The integration of low-ranked animals into the Early Natufian hunting repertoire suggests more mouths to feed per unit foraging habitat, and thus greater hunting pressure on the surrounding ecosystem than any earlier Paleolithic inhabitants. Furthermore, increased demands for animal resources and associated increases in hunting pressure point to more intensive site use; that is, greater numbers of Cave occupants per unit time. In the Late Natufian people seemed to have exerted significantly less hunting pressure on the surrounding ecosystem than their Early Natufian predecessors, implying a substantial reduction in the number of people occupying Hayonim Cave per unit time and/or reduced number of visits, and perhaps in the Mediterranean hills in general.

These results are corroborated by independent reconstructions of the occupation sequence at Hayonim Cave by Bar-Yosef and Belfer-Cohen (n.d.; Belfer-Cohen 1988). These authors argue for three major stages of building and occupation during the Natufian period. The earliest stage (Phase I) was marked by the construction of the first and largest of the stone structures (Locus 3) at the entrance of the cave. The second stage (Phases I-III, with the exception of Locus 3) was characterized by the construction of all loci, with the exception of Locus 3, and several episodes of structural refurbishment. Loci 4, 6, 7, 8, and probably also 9, 10, and 11, were built in a large open space behind the drip line of the cave. Each of these loci with the exception of 6 and possibly 9, 10, and 11, which have not been fully excavated, contain formal occupation floors and stone-lined hearths, reflecting significant energy investment. These observations along with other artifactual evidence indicate that the loci served primarily as domestic structures during their initial occupation (Bar-Yosef and Belfer-Cohen n.d.; Belfer-Cohen 1988). Some ritual paraphernalia are also present, suggesting that both ritual and domestic activities were integrated into daily life. After its initial construction, each locus followed an independent trajectory of rebuilding and reuse. During the same time span, burials were separated from living areas, and the dead were primarily interred in graves behind the loci, toward the rear of the cave. Bar-Yosef and Belfer-Cohen (n.d.) interpret this second period of building in Hayonim Cave as the most intensive Natufian occupation phase. Their interpretation is independently supported by the faunal data.

During the final stage of occupation (Phases IV and V), a large continuous area opened up along the eastern wall of the cave. Some of the archaeological deposits in this area have since been disturbed by the construction of a Byzantine glass furnace, but a general picture of activities in this area can still be constructed. There is a general lack of formal features in the open area, and there are three unusual caches against the cave wall, as described earlier. Evidence for the last Natufian occupation at Hayonim Cave (Phase V) also comes primarily from this area, where several graves were dug into the fill of earlier loci. The presence of these graves clearly indicates that loci ceased to be used for domestic purposes, though some domestic activities still took place along the cave's eastern wall. Bar-Yosef and Belfer-Cohen (n.d.) interpret Phase V as a less intensive and more sporadic occupation, in contrast to the Early Natufian. Their interpretation is based on the apparent lack of formal architectural features, the presence of caches with intentionally stockpiled materials for later use, and the addition of several graves to the fill of the loci. This assessment is independently corroborated by the faunal evidence, which indicates a much less intensive occupation of the cave during the Late Natufian Phase.

INTER-SITE COMPARISONS

A sample of Natufian sites are compared to examine the relative intensity of occupation at each site, a proxy for evaluation of regional patterns of Natufian demography and subsistence change. The size of the comparative sample is limited by both time constraints on data collection and the lack of other published assemblages of Natufian small game fauna. Although researchers working with Levantine assemblages have occasionally reported the frequencies of one or two small game species such as hares (Bar-El and Tchernov 2000; Bouchud 1987; Davis et al. 1994; Pichon 1984; Rabinovich 1998; Tchernov 1984), complete quantification of all major groups of small prey have been done only in a few cases and for small samples (Bar-Yosef and Tchernov 1967; Crabtree et al. 1991; Valla et al. 1986). Bouchud (1987) analyzed the full range of food species from two structures at Ain Mallaha but did not quantify materials from areas outside these structures noting only that the proportions were markedly different. Thus we are left with the data collected specifically for this study from Hayonim Cave, Hayonim Terrace, Hilazon Tachtit, and el-Wad. An inadvertent advantage is, however, that the data meet a nearly ideal standard of comparability because the analyst is the same for all cases to be compared. Presentation will follow the same analytical format used for Hayonim Cave.

The fauna from Hayonim Cave are collapsed into two groups for this comparison corresponding to the Early (Phase I-III) and Late (Phase IV and V) phases of the Natufian period. Otherwise, the sample is identical to that used in the preceding intra-site comparison of Hayonim Cave. The Hayonim Terrace, Hilazon Tachtit, and el-Wad assemblages are as described in Chapter 3.

Results of Inter-Site Natufian Comparison

Figure 7.13 shows the relative proportions of three broad taxonomic groups at each site. Although the results indicate some variation, there is no trend in the relative abundance of ungulates and small game among the sites. The high proportion of small game, which comprises between 40 and 60% of each assemblage, is an exclusively Natufian phenomenon, uniformly exceeding proportions of small game from preceding Paleolithic cultures in the Levant.

Analysis of small game proportions alone confirms that much of the diversity in Natufian faunas occurs within the small end of the dietary spectrum. Figure 7.14 reveals dramatic differences in small game type frequencies in the Natufian samples. Both of the Early Natufian assemblages, el-Wad and Hayonim Cave, are rich in low-ranked small game. The situation reverses in the Late Natufian assemblages from Hayonim Cave, Hayonim Terrace, and Hilazon Tachtit, when high-ranked species resurge on par with the preceding Kebaran period.

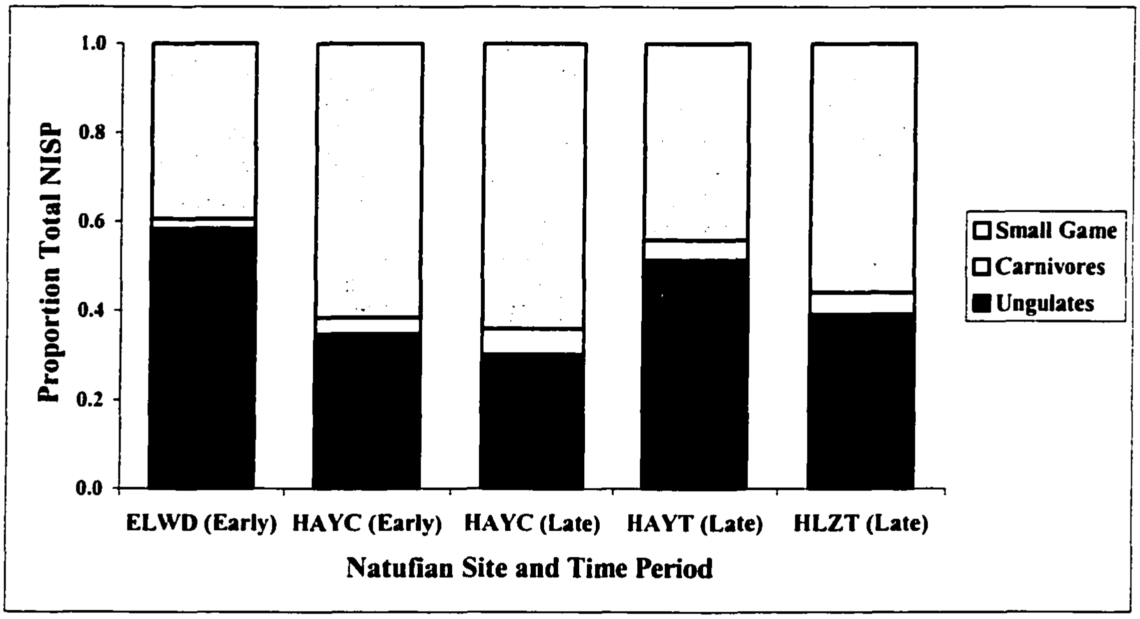


Figure 7.13: Relative abundance of three broad taxonomic groups from five Natufian occupations in northern Israel. ELWD = el-Wad, HAYC = Hayonim Cave, HAYT = Hayonim Terrace, and HLZT = Hilazon Tachtit. Early and Late refer to temporal phase divisions within the Natufian period.

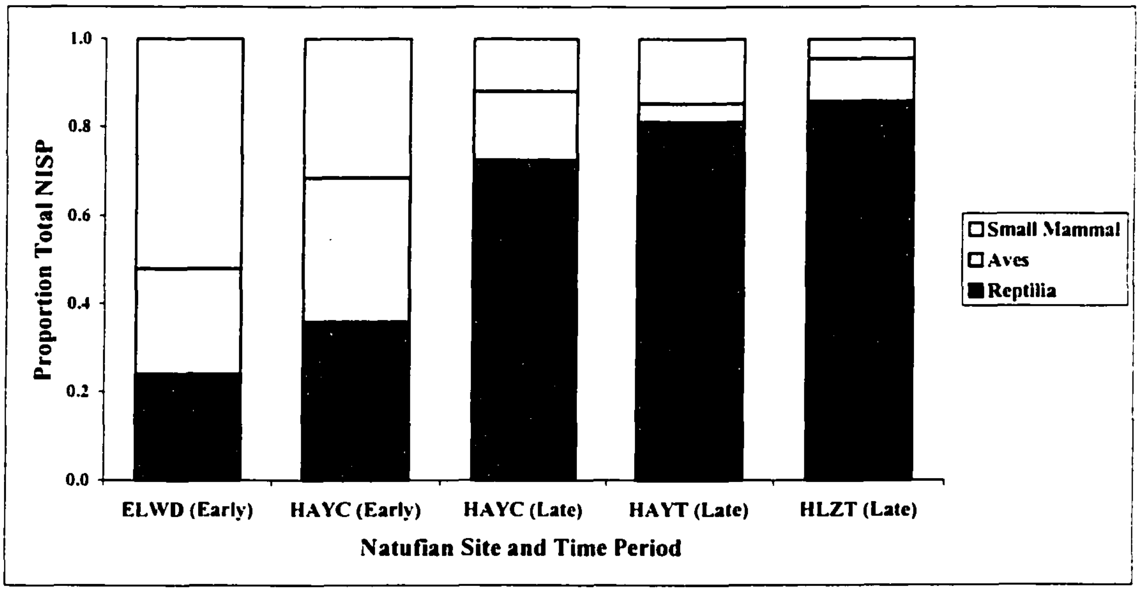


Figure 7.14: Relative abundance of small game taxa from five Natufian occupations in northern Israel. ELWD = el-Wad, HAYC = Hayonim Cave, HAYT = Hayonim Terrace, and HLZT = Hilazon Tachtit. Early and Late refer to temporal phase divisions within the Natufian period.

These data comment on both regional patterns of game use (broad taxonomic groups) and the site occupation intensity of each site (relative proportions of small game). The high proportions of small game remains at Natufian sites indicate both increased human predation pressure and associated decreases in human foraging efficiency on a regional scale compared to earlier periods. This pattern clearly contrasts with that observed by Stiner et al (1999, 2000) for earlier cultural periods in the Levant, although the scale of contradiction is only noticeable if confined to variation within the Epipaleolithic, and is of great interest for dynamics within the Natufian in particular. As discussed in Chapter 1, a shift from high-ranked, large-bodied ungulate species to small, low-ranked ones suggests that ungulates were no longer sufficiently abundant to meet the demands of the human population. This condition typifies all Natufian phases. Increased reliance on small, locally available animals points to a decrease in encounters with large mammals or an increase in human demands for meat due to larger population sizes, or both. As a result of depletion, environmental deterioration, or increased demand, hunting efforts were intensified in the Natufian period. Natufian populations in the Mediterranean zone likely exerted sufficient pressure to depress, though never entirely deplete ungulate resources. When researcher biases are eliminated (Chapters 1 and 3), the proportions of small to large game are similar at the four Natufian sites, regardless of time period, suggesting that human pressure on large game populations was constant on a regional scale throughout the Natufian period.

At the local scale, the changing compositions of small game assemblages (Figure 7.14) provide subtler indications of predation intensity, almost certainly relating to site occupation intensity. The Early Natufian occupations at Hayonim Cave and el-Wad provide the clearest indications of intensive site use (Garrod and Bate 1937; Valla et al. 1986). Foragers at both sites hunted large quantities of low-ranked prey, but continued to capture high-ranked species when encountered, particularly tortoises and gazelles. In fact, large sites generally date to the Early Natufian phase.

Like the story at Hayonim Cave, the Early Natufian layer at el-Wad (Garrod's Layer B1) is both thicker and larger in area than the Late Natufian deposits of this site. Moreover, el-Wad Terrace exhibits several architectural features attributed to the Early Natufian (Garrod and Bate 1937). The Early Natufian bone assemblages are also much richer and more diverse than those from earlier Paleolithic periods. These characteristics meet the criteria established by Bar-Yosef (1970) for Natufian base camps. Variation in the types of features present in Early versus Late Natufian phases signals an important difference in the intensity of site occupation, which was clearly greatest in the Early phase. The high proportion of low-ranked game in the faunal assemblage from inside el-Wad Cave supports this interpretation of the Early Natufian occupation; however, the Late Natufian sample from el-Wad was insufficient for comparison, due to the mixing of site deposits.

We have already seen that the Late Natufian occupation at Hayonim Cave was much more ephemeral and sporadic than the Early phase. The likelihood that Hayonim Cave and Terrace represent one very large site makes it essential to compare the Late Natufian deposits from both sites. It is important to clarify whether changes in the Cave sample represent an overall change in hunting intensity, as argued here, or a change in the function of the Cave versus the Terrace during the Late Natufian as has been suggested by other researchers.

The Hayonim Terrace small game fauna is dominated by high-ranked tortoises. Hares and birds are also present, but in less significant numbers (see Figure 7.14). The emphasis on tortoises indicates that encounter rates with these animals were high, that exploitation was not excessive, and that humans could thus afford to rely mainly on this species for their small game needs. Overall, the small game proportions for the Terrace are very similar to those from the Late Natufian phase inside Hayonim Cave, but they are markedly different from those of the Early Natufian in the cave (Figure 7.14). The only notable difference between the Late Natufian assemblages from the Cave and Terrace concerns the proportion of birds, particularly partridges, which are much better represented inside the cave. This may be a result of differential preservation, because bird bones are thin-walled and hollow, and thus more susceptible to crushing in the concreted sediments on the Terrace than in the soft deposits inside the cave.

Bar-Yosef and Belfer-Cohen (n.d.) use archaeological indicators to argue that Late Natufian occupation on the Terrace was shorter than the occupation in the Cave. They cite the absence of slab-lined floors and built-up hearths on the Terrace as an indication of reduced energetic investment into architectural features. Still, the Terrace is interesting because it contains several features associated with Natufian "base camps", including burials, heavy grinding stones, and fragments of stone walls backed into the natural slope of the terrace (Valla et al. 1991). Affinities in the relative proportions of small game types from the Terrace and those from the Late phase of occupation inside

Hayonim Cave suggest that the intensity of use of the two areas was similar. Whether or not Hayonim Cave and Terrace were one site or two, it is clear that Late Natufian occupations in both locations were significantly less intensive than the Early Natufian occupations inside the Cave. Equivalence in the proportions of small fauna types from the Late Natufian in the Cave and on the Terrace indicates similar subsistence requirements and foraging conditions in both areas during this phase.

The small game proportions from the Late Natufian site of Hilazon Tachtit indicate that its inhabitants were the least constrained hunters of all. Of the sites sampled, Hilazon Tachtit yielded the highest proportions of tortoises, which constitute 86% of the small game types consumed there. The only other major prey type in the assemblage is gazelle, another high-ranked species. The types of game selected by the hunters that occupied Hilazon Tachtit suggest that the site was occupied only sporadically by small groups, and that the environment around the site was not so depleted of high-ranked resources that local demand could not be met.

Hilazon Tachtit is a small cave site with two circular structures (loci), constructed from low stone walls (Leore Grosman, personal communication 2001). Ornaments and artwork are present, but uncommon, and groundstone and bone tool assemblages are restricted to the more basic types (mortars and pestles, awls, gorgets, and sickle hafts). The site is rich, however, in primary and secondary burials, and the abundance of human remains raises questions about the ritual significance of the site. Was it a burial center to which humans came to inter their dead? The presence of so many human burials confirms that the site functioned as a cemetery during the Late Natufian, but the lithic and faunal assemblages also provide evidence for a full range of economic activities (see Chapter 5; Grosman n.d.). Hilazon Tachtit was a small Late Natufian base camp by the standard definition. The small game index corroborates the evidence for light, sporadic occupation.

In general, the largest Natufian sites with the greatest investment in site features have the highest proportion of highly-ranked small game animals (tortoise), indicating intensive use of the site and the surrounding environment. They are also the earliest Natufian sites in the Mediterranean Hills. The shift away from diets rich in low-ranked resources to those emphasizing more high-ranked species correlates strongly with time: the largest sites in the sample were occupied in the Early Natufian, the more ephemeral sites date to the Late Natufian phase. Though the small game index predicts relative site occupation intensity, the temporal trend must eventually be tested by including sites from outside the Mediterranean zone. Despite this qualification, it is appropriate to explore broader temporal trends in Natufian subsistence and demography on the basis of the faunal evidence (see Chapter 9). Before taking this final interpretive step, I use another line of evidence, the age structures of high-ranked prey (see Chapter 8), to examine the influence of human hunting pressure on Natufian prey populations.

CHAPTER 8: GAZELLE AND TORTOISE AGE STRUCTURES AND HUNTING PRESSURE IN THE NATUFIAN PERIOD

INTRODUCTION

Over the past four decades, mortality profiles have been adopted by archaeozoologists as a tool to solve a diverse range of problems. Effective methods have been proposed to answer questions on subjects ranging from human hunting strategies and preferences (i.e., scavenging versus hunting) to seasonality and resource depletion (e.g., Klein 1982; Lyman 1987; Stiner 1990, 1991, 1994). Most studies have been aimed at reconstructing human hunting behavior in particular. This requires the separation of the original living age structure of the prey population from the mortality profile potentially created by human hunting decisions, and subsequently deposited in the archaeological record. This discussion focuses not so much on mortality profiles as it does on simulating variation in the living age structure of populations from which prey were originally hunted. The ultimate goal is to gauge the intensity of human hunting pressure. To do so, nonetheless we must define the range of natural variability in prey living age structures, identify the expected outcome of human hunting pressure on prey populations, and pinpoint potential confounding influences (i.e., hunting strategies and preferences, and season of capture), and their anticipated effects on prey mortality profiles (Stiner 1990; 1994: 271-287).

Using living age structures to monitor hunting pressure certainly isn't new in biology, where the method is widely employed, particularly within the context of game management and conservation (i.e., Riney 1982; Solbrig and Solbrig 1979; Taber et al. 1982). Though less commonly applied in archaeological contexts, a few studies focus on the impact of hunting pressure on ungulate age structures (Broughton 1994; Davis 1983; Elder 1965; Lyman 1987; Koike and Ohtaishi 1985, 1987; Stiner 1990, 1994; Wolverton 2001). Most archaeological studies use life tables or living age structures of modern prey populations subjected to known hunting pressures, as analogues to interpret age profiles generated from archaeozoological assemblages. This research follows similar methods.

The discussion begins by outlining the range of natural variation in prey living age structures. The simulations introduced in Chapter 6 illustrated the impact of population growth rates and seasonal reproduction on the age composition of living prey populations. They also illustrated the potential impacts of human hunting behavior on prey living structures and archaeological mortality profiles. The expectations from predator-prey simulation modeling are now applied to the mortality profiles of archaeological prey to interpret the intensity of human hunting pressure during the Natufian period. Age profiles from the Middle and Upper Paleolithic Levant set the Natufian into evolutionary context, followed by a detailed examination of the Natufian period itself.

VARIATION IN LIVING POPULATION STRUCTURES OF PREY

The living age structures of animal populations can vary from season to season or year to year in response to environmental or biological perturbations. The living structure concept is a static representation of one instant in a dynamic population cycle, and provides only a glimpse of a population's age structure at any given time. In reality, population structure is under continual adjustment to internal and external variables, though it normally varies within predictable limits. The expected range of natural variation in prey population structures is reviewed below.

The living age structure of a stable vertebrate population display a step-like pattern in 2-D graphic format, descending from the youngest to the oldest age group in the population (Figures 8.1 and 8.2). The number of animals in a particular cohort is highest immediately after birth and diminishes over time as individuals succumb to a variety of mortality agents. Stable populations are at equilibrium, thus fertility and mortality rates are entirely complementary to one another, and the ratios among age cohorts remain constant through time (Caughley 1966, 1977). Despite great variation in reproductive strategies, the same basic population structure defines most or all vertebrate populations at equilibrium. This point is illustrated by the stable populations generated by the tortoise LGM (Figure 8.1) and the hare HGM (Figure 8.2) simulations, an exercise with strong empirical components. Despite differences between tortoises and hares in population parameters and the absolute ages of the cohorts, the stable structure of the two populations are virtually identical.

Although all stable population structures display the same basic pattern, the relative sizes of the steps in the age pyramid (the steepness of the slope) and thus the ratio of juveniles to adults in a population can shift if the system is destabilized in any way. The processes that shape living age structures according to knowledge gained from modern ecological studies are instructive here: the most influential factors relevant in this study include seasonality and the rate of population growth.

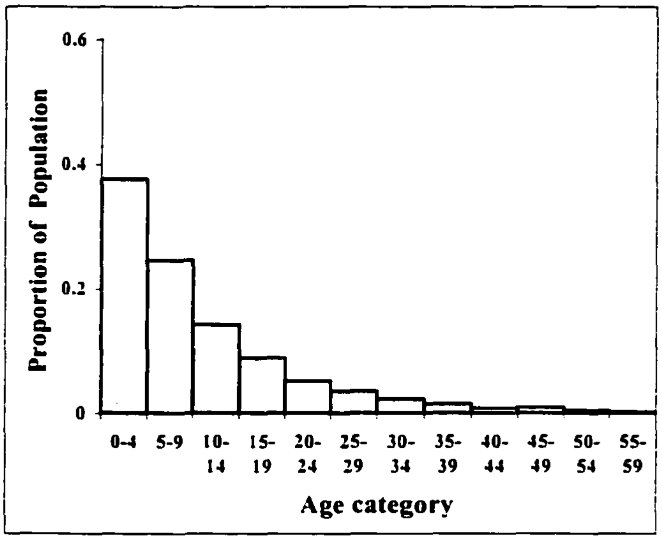


Figure 8.1: Age structure of a stable population under low growth conditions. Population created using the tortoise LGM parameters. Simulation was run at equilibrium for 200 years. Three runs were averaged to eliminate random variation.

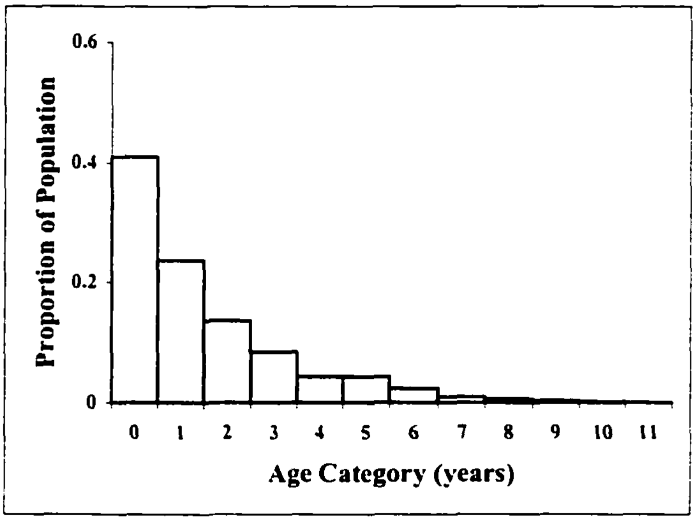


Figure 8.2: Age structure of a stable population under high growth conditions. Population created using the Hare HGM parameters (see Chapter 6). Simulation was run at equilibrium for 200 years to ensure stability. Three runs were averaged to eliminate random variation.

The Effect of Seasonality on Prey Living Structures

The adults of many animal species are reproductively active for only short periods each year. The young of these species are usually born in correspondingly restricted periods. The proportion of juveniles is thus highest immediately following the birth season, and then gradually declines until the cycle begins again. The impact of seasonally restricted reproduction on an animal population structure is illustrated by tracking monthly changes in the proportions of juveniles in a modern gazelle population from Ramat Qedesh in Israel. Mountain gazelles are seasonal breeders with one or two reproductive peaks per annum, depending on the favorability of conditions (Ayal and Baharav 1983; Baharav 1974, 1983a, 1983b). Gazelle populations in the Levant today, bear the majority of their young in late spring/early summer. The proportion of juveniles thus peaks first in early summer and occasionally a second time in early autumn, if conditions allow. The percentage of juveniles in the populations then gradually declines over the remainder of the year, reaching a low in spring just prior to the next reproductive season (Baharav 1974, 1983b).

Figure 8.3 illustrates variation in the proportion of juvenile gazelles in the Ramat Qedesh population over the course of three years (data adapted from Table 1 in Baharav 1983b). There was strong seasonal variation in the proportion of juveniles in the population ranging from 14.5 to 39.6% in 1975, and between 15.1% and 29.9% in 1976. Though other influences including population movements also have some influence over population composition.

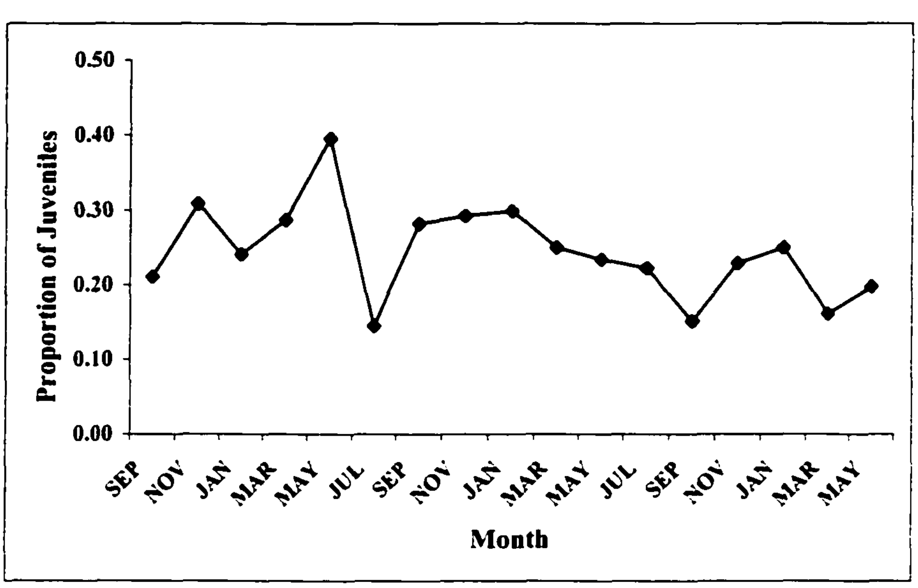


Figure 8.3: Bimonthly fluctuations in the proportion of juveniles in a population of mountain gazelles from Ramat Qedesh in Israel. Data from Baharav (1983b, Table 1).

As illustrated by the Ramat Qedesh gazelles, restricted reproductive seasons can cause fluctuations in a population's age composition throughout the year. Clearly an hunting a prey population in its natural proportions in winter would produce a different mortality profile than one collected in the summer. Seasonal birth patterns may have a significant impact on prey mortality profiles, particularly in hunted assemblages that are collected at restricted times of the year. Their signatures can thus be confounded with those resulting from human hunting strategies that favor the collection of specific age groups. The archaeological record averages this effect to a large extent in many situations. The length of stay is already interpreted to vary between phases of the Natufian, however, thus seasonal explanations must be considered when evaluating prehistoric change in prey age structures.

The Effect of Population Growth Rate on Prey Living Structures

Shifts in the relation between rates of fertility and mortality can also create fluctuations in population age structures. When mortality rates increase, the population may drop below carrying capacity and responds by shifting into growth mode, leading to inflation of the proportion of juveniles. The living structure of a growing population is thus concentrated on the younger age of the age axis in the typical 2-D graph, with a steep slope and lower mean and maximum ages in comparison to a stable population (Figure 8.4). The living structure of a typical growing population (Figure 8.4) was created by increasing the annual rate of mortality in the hare HGM simulation after that population had reached equilibrium.

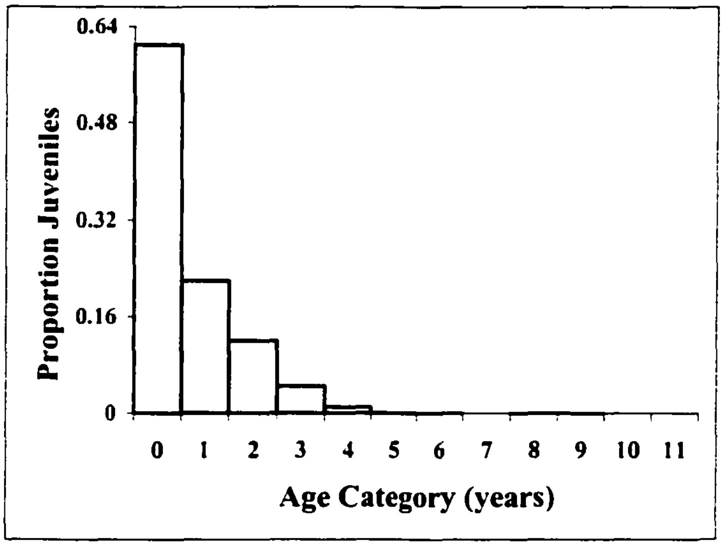


Figure 8.4: Age structure of a growing population under high growth conditions. Population created using parameters from hare HGM simulation. Population was encouraged to grow by increasing mortality.

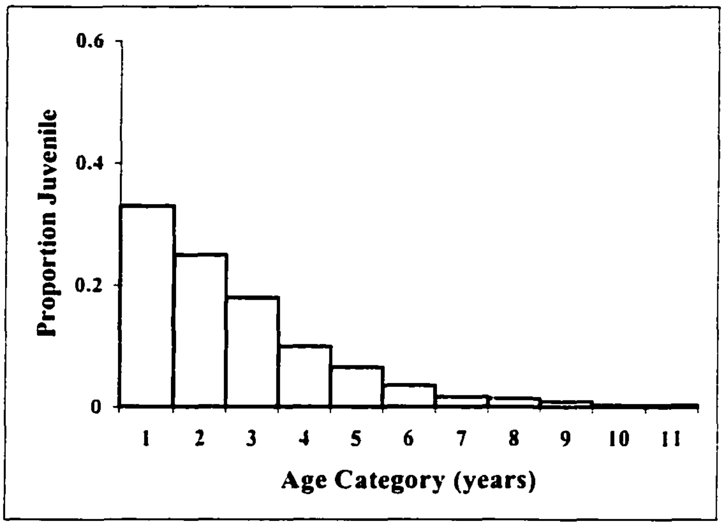


Figure 8.5 Age structure of the same outset population as in Figure 8.4, as it shrinks. Population created using parameters for the HGM hare simulation. Age structure created by reducing the number of babies produced per female each year so that mortality exceeded fertility. The population was allowed to shrink for a few years before the age structure was determined.

If fertility decreases but mortality remains the same, a population will shrink because it is no longer able to replace all deceased individuals. Since fewer babies are born per adult during each reproductive cycle, an adult bias develops in the overall age structure. Figure 8.5 depicts the age structure of a typical shrinking population, created by reducing the productivity of female hares in a stable HGM population. The living structure is characterized by a shift to the right end of the age axis, a more gradual slope, and an increase in the average and maximum ages of the population in comparison to stable populations.

Changes in mortality and fertility may be caused by a variety of external and internal factors including, but not limited to, predation, disease, environmental degradation, interspecific competition, and climatic change. These factors can cause a living structure to depart from the stable forms presented in Figures 8.1 and 8.2 and may confound seemingly straightforward archaeological interpretations. Fortunately, living structures tend to depart from the ideal in predictable ways. Thus, if we know something about the basic ecological characteristics of the species, and have access to information on the archaeofaunal assemblages under investigation, it is possible to rule out some explanations.

The Effect of Human Hunting Pressure on Living Age Structures of Prey

Human hunting pressure can be a major source of prey mortality. Increased hunting pressure by humans can push prey populations into growth mode, increasing the proportion of juveniles in the population, just like certain other mortality factors. The living structure of a population exposed to heavy hunting pressure is thus the same as depicted for a growing population (Figure 8.4). The power of hunting pressure to restructure prey living structures was demonstrated by the gazelle simulations in Chapter 6 (see Figures 6.6 and 6.7). The simulations showed gradual increases in the proportions of juveniles in the living age structures of the gazelle population with increased hunting pressure, and associated decreases in the average age of the population. In the gazelle simulation, adults and juveniles were hunted indiscriminately. If adults were preferentially selected, the bias toward juvenile animals under conditions of heavy exploitation would only be more pronounced.

Hunting Pressure and Rate of Population Turnover

Although all populations exhibit the same basic responses to predator pressure, the intensity of a species response varies most closely with the rate of its population's turnover -- the amount of time required for a population to completely replace itself. As was shown in Chapters 6 and 7, populations with low rates of turnover (e.g., tortoises and gazelles) are easily depressed by hunting. These populations are much more sensitive indicators of hunting pressure than their more resilient counterparts. Populations with high rates of population turnover grow quickly and recover rapidly from bouts of even intensive hunting (Stiner et al. 1999, 2000). The living structures of these populations are not expected to change substantially except under extreme, prolonged exploitation. Examples of pressured populations of fast-reproducing animals, such as European rabbits, do exist in the wildlife literature; some populations experience astronomical annual death tolls from the shooting of thousands of individuals each year (e.g., Ferreira and Guimaraes 1996). On the other hand, it is remarkable that these fast-growing populations can withstand such heavy hunting. Their tremendous resilience precludes them from effectively monitoring the scale of hunting intensity that might reasonably be expected to occur in the Natufian or any other Paleolithic period. For this reason, high-turnover species (e.g., partridges and hares) do not figure in the remaining discussion on prey age structures.

SEPARATING HUNTING PRESSURE FROM OTHER FACTORS

Human hunting pressure, seasonality and other sources of prey mortality play influential, yet predictable roles in determining the age composition of animal populations. As noted previously, however, some of these processes may have similar results. Factors most likely to be confounded with signs of hunting pressure include the effects of seasonal hunting, hunting strategies, and deliberate preferences. A change in habitual hunting strategy, or a change in the mean size of the hunting group, may alter the age composition of archaeological death assemblage.

Seasonal Hunting

The impact of seasonal hunting on living age structures is dependent on the reproductive cycle of a prey species. If reproduction is seasonally restricted, the wildlife literature can be consulted to determine the timing of its reproductive cycle in the region of interest and to estimate its living structure in different seasons. When possible, the season of site occupation, or at least the relative duration of occupation should also be established using independent measures — not an easy task. The expected age profiles for the season of occupation can then be compared against the observed mortality profiles to determine whether seasonality played an influential role in assemblage formation. Multi-season occupation at a site may diminish the influence of seasonal biases by time averaging archaeological deposits, evening out biases introduced by seasonal factors. This may be most true for Natufian among Paleolithic periods, but most specifically the Early Natufian.

It should also be noted that seasonal explanations are ineffective in the face of large-scale synchronic or diachronic shifts in prey age structures. In most landscapes, human settlement patterns must incorporate occupations from the full spectrum of seasons, but some localities may be used only in certain seasons. If seasonality is a primary factor in assemblage formation, then some intersite variation is expected in the prey mortality profiles.

Human Hunting Preferences

The strategies and preferences of human foragers also shape prey mortality profiles. Human hunters often intentionally target prey sub-groups based on age or sex, but they may also favor particular age groups as an unintended byproduct of a hunting strategy. Some hunting strategies (i.e., communal or encounter ambush techniques) are indiscriminate in their selection of prey age groups and may thus produce age structures broadly representative of the living population (Caughley 1977; Lyman 1987; Klein 1978, 1982; Stiner 1990, 1994).

Despite their influence over the formation of mortality profiles, human hunting strategies are not expected to confound the signature of hunting intensity significantly. Hunting intensity will result in the inflation of juvenile individuals, resulting in juvenile-biased or U-shaped age structures (a.k.a. attritional, Caughley 1966; 1977). U-shaped age profiles display an inflated proportion of senile individuals and an underrepresentation of prime aged animals. When predation is the mortality factor, U-shaped patterns are created by hunting the weakest members of the population (the young and the old). This strategy is generally typical of cursorial predators; those that run down their prey. Human foragers, however, only produce U-shaped or juvenile-biased age profiles under rare and limited circumstances (i.e., Nunamiut skin-hunting in spring, Binford 1978; Stiner 1994). Following a thorough review of archaeological and anthropological data sets, Stiner (1991, 1994) concluded that hominids rarely if ever create U-shaped mortality patterns in ungulates. Scavenging, which is unknown as a dominant human foraging strategy after the Middle Paleolithic, and even after the early part of this period, can also produce U-shaped mortality profiles, but is not considered a reasonable option here. Instead, human hunters almost universally ambush their prey using communal or solitary techniques, and a tendency to selectively target prime-aged animals is evidenced in many cultures with diverse technologies (Stiner 1990, 1994). Ambush strategies can be indiscriminate hunting techniques that rely on the element of surprise, in which case the resulting age structure (catastrophic or living structure) reflects the living structure of the original prey population. Ambush techniques can produce prime adult or juvenile biases, but this is most likely to occur if the prey live in age-sex segregated groups and/or form temporary calving herds. In sum, the effects of human hunting strategies differ from the anticipated effects of human hunting pressure, in that the latter only produces juvenile-biased or U-shaped living structures. In other words, the bias is highly directional in the case of hunting pressure. Prime-dominated mortality profiles for high-ranked prey are largely erased under conditions of heavy hunting pressure. Given the early evolution of human's tendency to favor prime adult artiodactyl prey (Stiner 1990, 1994), if hunting pressure is great enough to inflate the proportions of juveniles in the living structure during the Natufian, then prime-aged animals should not be sufficiently abundant to meet human demands. In the face of intense hunting pressure during the Natufian, humans are expected to shift their emphasis to lower-ranked juvenile animals. Two species are of interest here, because of their substantive role in Natufian diets; tortoises and gazelles. Both reproduce slowly but they have very different ecological characteristics. Gazelles and tortoises are two of the highest ranked species in the Natufian diet and should have been the first to be affected when hunting intensified.

Hunting Pressure and Gazelle Living Age Structures

Gazelle populations have low rates of population turnover and slow population growth. These factors magnify the impact of hunting pressure on their populations. As simulated in Chapter 6 and demonstrated above, the proportion of juvenile gazelles should increase with the intensity of hunting pressure. Reconstructions of stable gazelle living structures cannot be directly applied to the archaeological record. The results of the gazelle simulations presented in Chapter 6 do, however, define the magnitude of change expected in the relative proportion of juveniles when their populations are subjected to increasing hunting intensity; the population is composed of up to two times as many juveniles when subjected to hunting, than when subject to only non-human agents of mortality. An intensification in gazelle procurement is thus expected to be recorded in the archaeological record as an increase in the relative proportion of juvenile gazelles.

Hunting Pressure and Tortoise Living Age Structures

Unlike mammalian species, tortoises grow throughout much of their adult lives. They invest more energy into growth during their first twenty years, but they continue to grow slowly thereafter (Blasco et al. 1986; Lambert 1982; Shine and Iverson 1995). Male and female tortoises have different otonogenic growth patterns. During the first ten years of life females devote much of their energy to growth, while males invest somewhat more in early reproduction. Due to their head start, females are consistently larger than males from the same age cohort, and males almost never reach the full body size of females. Because humans should favor large tortoises due to greater visibility and high energetic returns, large adult females were likely preferentially removed from tortoise populations by hunters. In fact they are more visible than young tortoises in the environments they inhabit.

Previously it was shown that tortoise populations are exceptionally sensitive to changes in human hunting pressure. Annual recruitment through natural growth and migration from adjacent populations can slow depletion, but it remains true that tortoise populations can withstand only low levels of hunting pressure, due to low productivity. As tortoise populations are pushed into growth mode, inflation in the proportion of juveniles results. This process may be accelerated by the selective removal of large adults, most often females, which form the population's long-lived reproductive core. Body size here serves as a proxy for individual age. Hunting pressure is expected to result in body-size diminution in tortoise populations due to the combined effects of inflated proportions of juveniles, selective removal of large females, and very slow individual growth/development rates (Klein and Cruz-Uribe 2000; Stiner et al. 2000).

Although tortoises reproduce seasonally, their age structures show surprising stability, because of low rates of population turnover, low adult mortality; and high rates of juvenile mortality. Females lay several eggs each year, but most hatchlings do not survive beyond their first month (Doak et al. 1994, for *Gopherus* populations). Low population turnover and long life spans translate into high proportions of adults in stable populations. Annual recruitment therefore comprises only a small proportion of the total tortoise population. Seasonal increases in the number of young are dampened by the bulk of the remaining population. Seasonal birth patterns in tortoises are thus not expected to cause significant fluctuations in tortoise body size.

Recently, Speth and Tchernov (n.d) have suggested that seasonality may influence tortoise living structures in a different way. They cite a study of a Spanish *T. gracea* population (Diaz-Paniagua et al. 1995, 1996) that displays seasonal variation in the activity rates of males and females; females are more active than males in the early summer, and males are more active in late winter and spring. If human hunters are more likely to capture active tortoises, then the sex ratio of the hunted population will differ by season. Because males and females differ significantly in size, assemblages captured in different seasons may also differ in average size (of course the differences in activity cycles cannot be too great, or males and females will never meet). Though no good evidence exists for differential activity patterns in Levantine tortoises (Speth and Tchernov n.d.), the potential for seasonal biases will be evaluated following the presentation of results. Seasonal biases can be largely ruled out in the face of universal or long-term unidirectional trends in tortoise body size that make very little sense as products of seasonal change.

AGE DETERMINATION TECHNIQUES FOR PREY SKELETAL REMAINS

How exactly will the above predictions be operationalized using less than precise archaeological data? First, it is essential to reconstruct the age structure of archaeological prey populations. A number of skeletal aging techniques with varying degrees of resolution have been applied to archaeological faunas. The predictions for detecting hunting intensity do not require elaborate aging systems. One only needs to divide the sample into adult and juvenile age groups. When the data allows, the adult component will also be separated into prime and senescent (old) groups. The intensity of hunting will be monitored by examining the proportion of juvenile gazelles and tortoises in archaeological assemblages. Because, reptilian and mammalian bone obey different patterns of growth, different methods must be applied to age them.

Age Determination for Gazelles

Ungulate skeletal remains can be effectively aged using tooth eruption and wear sequences, as well as bone fusion. Tooth eruption and wear provide the most discrete and precise age stages for adults, but the robusticity of the technique is often hampered by small sample sizes, and, in the Natufian, heads of some prey apparently never reached the site. Because tooth samples are often small, bone fusion data is examined as an additional line of evidence.

Tooth Eruption and Wear Sequences

Ungulate teeth erupt according to a genetically determined ontogenic plan and at species-specific rates. Through the study of individuals of known ages, the eruption sequence of the milk and adult dentition and their associated ages have been established for some ungulate species such as gazelles (Davis 1980a, 1983). The stage of development at the time of death can be determined most accurately if a complete tooth row is present, although individual teeth can also be evaluated using the degree of crown and root formation (Hillson 1986). The dentitions of ungulates are adapted for processing tough, herbaceous foods. The teeth are composed of intertwined layers of dentine and enamel that form peaks and troughs and provide a rough grinding surface for food processing. Enamel is a much denser, tougher structure than dentine, thus the two substances wear at different rates. Ungulate teeth retain a sharp, uneven grinding surface throughout their functional life.

Food processing results in gradual attrition of a tooth's occlusal surface, exposing a distinctive sequence of patterns in the folds of dentine and enamel, known as wear stages. By combining eruption sequences with tooth wear, teeth can be assigned to a series of relative age categories with considerable precision especially in the younger age groups. Attrition occurs at a variable but predictable constant rate within a species (e.g., Gifford-Gonzales 1991; Severinghaus 1949). Animals of the same age are expected to exhibit similar stages of wear if they consume the same basic diet. Some researchers have attempted to assign absolute ages to wear stages using modern specimens of known age for comparison. Though provocative, and perhaps possible under certain tightly controlled conditions, rates of wear can vary in response to many factors, including but not limited to climate, sex and amounts of dietary grit. For this reason, as well as the sample size issue, wear stages are best collapsed into broader yet more reliable groups representing the more basic stages of life (following Stiner 1990, 1994).

In archaeology the use of tooth wear and eruption techniques was pioneered by Sebastian Payne (1973), who developed a series of relative wear stages for domestic sheep and goat in Anatolia. His notation is widely used and has been adapted by researchers to derive age wear stages for many other species (Grant 1982; Levine 1982; Stutz n.d.). Here, I use wear stages developed for gazelle by Aaron Stutz (n.d., see

Appendix 3), based on comparative collections of mountain gazelle skulls of known ages housed in the mammalian collections at Tel Aviv University and the Hebrew University in Jerusalem, Israel. Stutz follows Payne's basic wear stages for sheep and goat but with attention to species-specific differences in attrition rate and the structural relationship between enamel and dentine for gazelle in particular. Due to small sample sizes and the simplicity of the data required to address questions of hunting intensity, Stutz's wear stages will be collapsed into three basic age categories following Stiner (1990: 312). These stages include juvenile, prime, and old categories and correspond to the three major phases of an animal's full potential life span. The juvenile stage is devoted to growth and includes the period between birth and reproductive maturity in females. The prime stage of life is dedicated to reproductive activity and corresponds with an animal's peak reproductive years. Senescent animals are those past their reproductive prime, in a state of decline towards death.

No tooth element in the dental row is in continuous wear throughout a gazelle's lifetime. The eruption and wear of the lower deciduous fourth premolar (dP_4) in combination with the fourth permanent premolar (P_4) or the third permanent molar (M_3), however, provide the closest approximation of a continuous sequence of wear spanning from an animal's birth to its death. The dP_4 and M_3 eruption and wear sequence is used here to construct gazelle age profiles. The M_3 is chosen in *lieu* of the P_4 since the division between prime and old animals is more difficult to assess using the wear stages for gazelle P_4s. The M_3 erupts just prior to the loss of the dP_4, thus there is only a short period when the teeth are in simultaneous use. To avoid double counting individuals, the wear stage and side of each tooth were cross-checked to ensure that no two teeth could have come from the same mandible. If an M_3 and dP_4 could have originated from the same individual, one was eliminated from the sample.

Stages of Bone Fusion

The fusion of bone elements corresponds loosely to the transition from youth to adulthood. In the first phase of a mammal's life, energy is primarily devoted to growth. As growth slows this energy becomes available for processes of maintenance and reproduction, the latter beginning in females around the time an animal reaches full size. Unfused bones provide secure markers of juvenile animals, while fused bones indicate that an animal is well on its way to adulthood, if not already there.

Fusion does not occur at the same time or in all long bone elements, but like teeth, it follows a predetermined species-specific sequence. Fusion sequences and ranges of absolute ages are provided for different species based on the study of modern individuals of known ages. Davis (1980a, 1983) estimated absolute ages for the fusion of gazelle long bones, obtained from a modern assemblage of wild mountain gazelle (*Gazella gazella gazella*) collected in Israel and curated in the Department of ESE at the Hebrew University of Jerusalem. Davis determined the ages of the skeletons using tooth wear and eruption stages that he developed from a second population of gazelles of known age in the Museum of Zoology at Tel Aviv University. This somewhat roundabout approach may involve minor errors, but Davis' data are of great value as a relative sequence of long bone fusion for mountain gazelles.

Element	Age of Fusion in Mountain Gazelle	Fusion Sequence
Proximal Radius	ca. 2 months	1
Distal Humerus	ca. 2 months	2
Proximal Phalanx 1	5-8 months	3
Distal Tibia	8-10 months	4
Distal Metacarpal	10-16 months	5
Distal Metatarsal	10-16 months	6
Distal Calcaneum	10-16 months	7
Proximal Femur	10-16 months	8
Distal Femur	10-16 months	9
Proximal Humerus	12-18 months	10
Proximal Tibia	12-18 months	11
Proximal Ulna	12-18 months	12
Distal Radius	12-18 months	13

Table 8.1: Age of fusion of gazelle long bone epiphyses, adapted from Davis (1980a: 132). Despite overlap in the age of fusion among elements, bones fuse in a pre-determined order, recorded here from 1 to 13.

The bone elements, their estimated age at fusion, and the relative order of fusion are presented in Table 8.1. Davis (1980a: 132, 1983) provides age ranges for the fusion of most bones, as well as the sequence in which the elements fuse. For example, it appears that the distal calcaneum and distal femur fuse at the same time, since they are both assigned an age of 10-16 months. However, in gazelle the tuber calcis of the calcaneum always fuses before the distal femur. There is no question that all unfused gazelle elements in the collection belong to animals younger than two years of age, by which point gazelles have ceased growing and females have reached reproductive maturity.

The following skeletal portions were selected to examine the age structures of gazelle populations following Davis (1983): distal tibia, tuber calcis of the calcaneum, distal femur, and distal radius. These portions all fuse between 10 and 15 months of age (Davis 1983: 58). Other elements with known ages of fusion are abundant in the assemblage, such as metapodials and phalanges, but the inclusion of these elements greatly increases the risk of double counting the same individual. For example, each gazelle skeleton contains eight of each of the three phalanges. It is possible that one individual could be represented by as many as eight times in the age profile of a single element. All of the elements selected for analysis here are represented by only two bones per skeleton, but data on metapodials are included to later check the consistency of the other results. To evaluate the reliability of the fusion results, the proportion of unfused specimens for each of the selected bone portions are determined. The results for each are then presented in the order that they fuse to check for consistency within the assemblage.

Elements identified as "gazelle" and "small ungulate" are included as gazelles in the age profile. It is assumed that the vast majority of small ungulate bones belong to gazelles, since they constitute 99% of all small ungulates identified to species in this study. It is possible that a few roe deer or wild goat bones were categorized as small ungulate and are erroneously included in the gazelle assemblage, but their rate of occurrence is so low (<1%) that they are expected to have no discernible effect on the final outcome of the analysis.

Age Determination for Tortoises

The growth of reptilian bone is sensitive to food availability and quality, thus growth does not occur at such predictable rates as those seen in mammals and birds. Ossification occurs from only a single center, leavings no lines of fusion or good visual indications that the bone belonged to a juvenile or a reproductively mature adult . Because tortoise bones grow throughout life, it is possible to use size as a proxy for age.

As explained earlier, hunting pressure not only increases the proportion of juveniles in a tortoise population, it also reduces the mean average age by decreasing the likelihood that an adult will complete it's potential life span. In continually growing animals, a decrease in the average age of the population should thus translate to a decrease in mean body-size. The fact that female and male tortoises grow at different rates may bias this assumption slightly if the relative proportion of males and females varies dramatically from assemblage to assemblage. At this point there is no evidence to suggest that this is the case here.

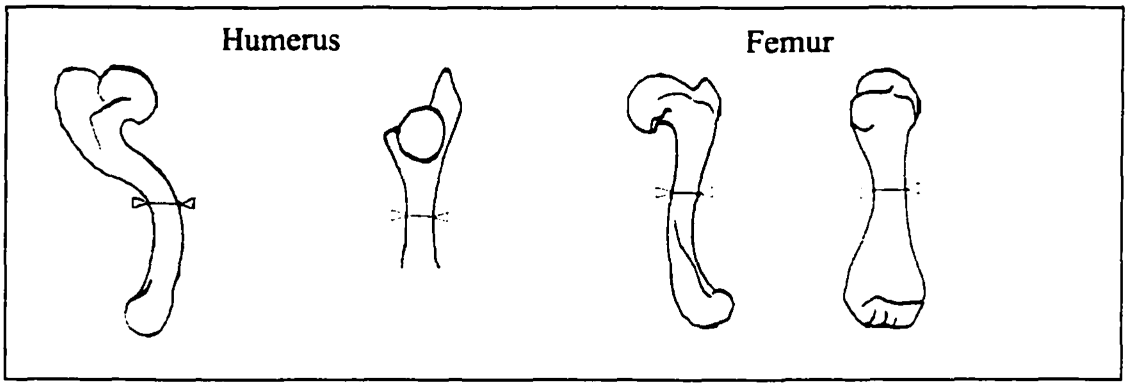


Figure 8.6: Tortoise (*Testudo graeca*) humerus and femur, with the narrowest point on the shaft indicated, where the medio-lateral breadth measurement is taken. Sketch is slightly modified, and courtesy of M. Stiner.

The humerus and the femur are the largest and most easily identified weight-bearing elements in the tortoise skeleton. The size of the limb bones correlates with body mass (Wainwright et al. 1976; Gideon Hartman personal communication 2001). The humerus and femur shafts are particularly resistant to destruction by archaeological processes, whereas the proximal and distal ends tend to snap off and are often missing or too damaged to measure accurately. Both shafts have roughly hourglass shapes when viewed anteriorly or posteriorly, and the narrowest point is easy to locate. The medial-lateral breadth is measured at the narrowest point along the shaft (see Figure 8.6; see also Klein 1994; Klein and Cruz-Uribe 2000; Stiner et al. 1999, 2000). The samples of humerus measurements are larger than those for femurs, probably because the femur shaft is narrower and breaks more often, close to the point where the measurement is taken. When available, the results for both elements are presented.

AGE STRUCTURES OF NATUFIAN GAZELLES AND TORTOISES

Age data from gazelle and tortoise populations are presented below to monitor hunting pressure in the Levantine Paleolithic with special reference to the Natufian period. To explore Natufian hunting intensity, long-term trends in hominid hunting strategies from the Middle Paleolithic period onward are explored to set the Natufian within a broader evolutionary framework. We will then delve into a more detailed investigation of the faunas from Natufian sites, and at Hayonim Cave in particular.

Long-Term Change in Gazelle Hunting in the Mediterranean Levant

To examine long-term change across the Paleolithic period in the Mediterranean Levant, published reports were consulted for data on gazelle age profiles and tortoise body size. Data on gazelle tooth eruption and wear is spotty for the Paleolithic period, most often due to small assemblage sizes and the lack of published material.

Gazelle Bone Fusion Results

Much of the pre-Natufian data on gazelle bone fusion presented here are adapted from Davis (1983), who first reported a gradual increase in the proportion of juvenile gazelles across the Paleolithic sequence in the Levant. Davis monitored the proportion of juvenile gazelles in faunal assemblages by tabulating the proportion of unfused epiphyses from five long bones that fuse between 10-15 months of age -- the distal tibia, the tuber calcis of the calcaneum, the distal femur, the distal radius, and the distal metapodial (Davis 1983). Though this method has its problems, not least of which is the potential to count an individual multiple times, it allows the combination of small, otherwise unusable databases to construct large samples. Davis' (1983) original Natufian sample is bolstered here with data from the current study and from recent publications (see Table 8.2). To maintain geographic consistency, only sites from the Mediterranean zone and the Jordan Valley are included here.

Difficulties arise when attempting to compile and compare data sets collected by different researchers using variable reporting techniques. The most serious problems with fusion data are the failure of the author to define the age of a juvenile animal or disclose which elements were used to age the assemblage. Some researchers calculate the proportion of juveniles based on the total number of unfused elements in the sample, mixing elements that fuse at different ages. To overcome various pitfalls associated with data reporting, and to maintain consistency, two aging procedures are followed here. Because small sample sizes are common in the comparative data, these procedures were chosen to favor sample robusticity over accuracy. First, the proportion of unfused metapodials are used to estimate the proportions of juvenile animals. Although metapodials may encourage double counting, they fuse within a tightly restricted time frame (Davis 1980a) and are the most commonly reported element in published sources.

A back-up method follows Davis' (1983) original strategy and includes a combined sample of several elements that fuse between the age of 10-15 months. These data were less commonly available in published literature, but they are used when present to cross-check results (see Table 8.2). These methods do have their pitfalls, but when used consistently across time periods, they can be used to discern broad synchronic and diachronic trends.

Site and Cultural Period	% UF Metapodials	% UF Combined	Reference
MP Kebara	18.0	16.9	Davis 1983
MP Hayonim Cave	21.0	17.6	Davis 1983
Middle Paleolithic Average	**19.5**	**17.3**	
UP Hayonim Cave	28.0	26.3	Davis 1983
UP Kebara	26.0	26.4	Davis 1983
UP Sephunim	18.6	15.9	Davis 1983
UP Fazael X	22.6	34.0	Davis 1983
UP Fazael IX	25.0	15.8	Davis 1983
Upper Paleolithic Average	**24**	**23.9**	
KEB Hayonim Cave	25.0	26.7	Davis 1983
KEB Ein Gev I	39.0	26.4	Davis 1983
KEB Fazael IIIA	n/a	25	Davis 1983
KEB Nahal Oren	54.5	n/a	Noy et al. 1973, Legge 1972
Kebaran Average	**39.5**	**26**	
NAT Hayonim Cave (Early)	41.7	34.3	This Research
NAT Hayonim Cave (Late)	50.9	35.5	This Research
NAT Hilazon Tachtit	41.2	37.0	This Research
NAT Hatoula	31.3	30.1	Davis 1985
NAT Mallaha	40.5	n/a	Bouchud 1987
NAT Hayonim Terrace (Early)	32.6	33.3	Henry et al. 1981
NAT Nahal Oren	54.7	n/a	Noy et al. 1973
NAT Salibiya	n/a	50.0	Crabtree et al. 1991
NAT El-Wad	n/a	37.0	Rabinovich 1998
Natufian Average	**41.8**	**36.7**	

Table 8.2: Proportion of unfused elements represented at Paleolithic sites from the Mediterranean zone in the Levant. "% UF Metapodial" refers to the proportion of gazelle distal metapodials that are unfused. "% UF Combined" refers to the combined percentage of unfused distal tibia, tuber calcis of the calcaneum, distal femur and distal radius for gazelle. Numbers outside of parentheses are percentages of unfused elements and numbers in parentheses are the NISP of total elements in each sample.

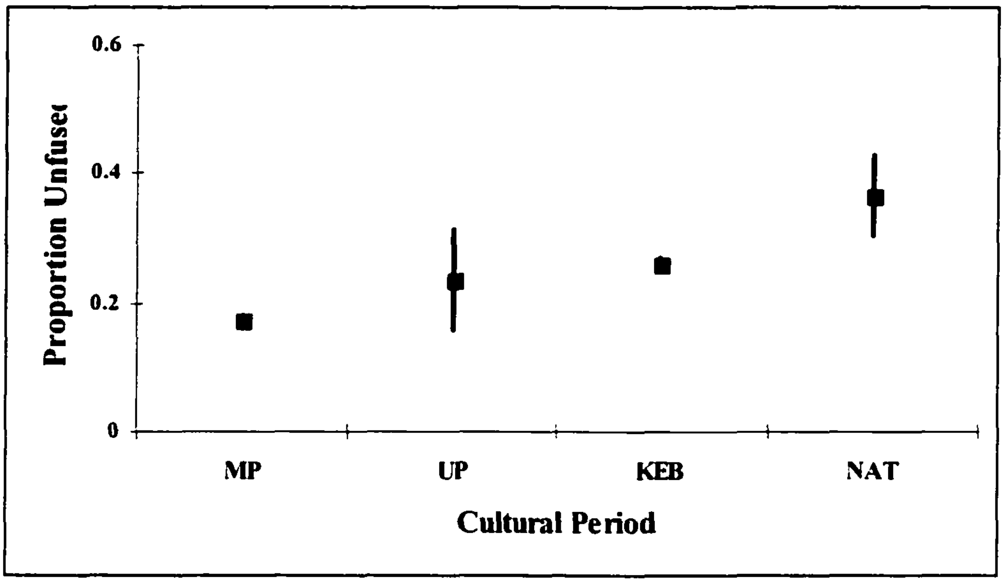


Figure 8.7: Average proportion of unfused distal metapodials from Middle Paleolithic (MP, n = 2), Upper Paleolithic (UP, n = 5), Kebaran (KEB, n = 3), and Natufian (NAT, n = 7) assemblages. Note that the number of sites sampled for each cultural period is small. Data sources summarized in Table 8.2.

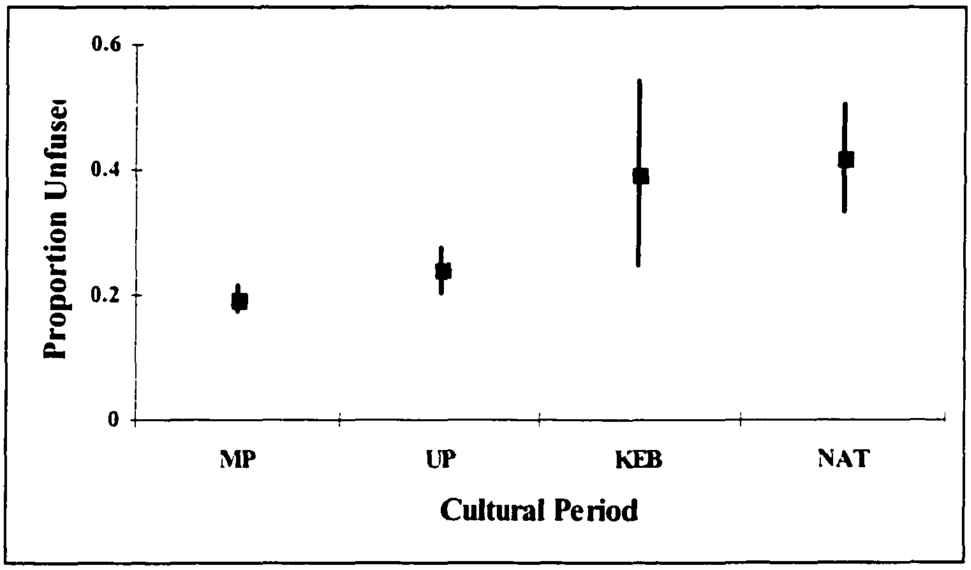


Figure 8.8: Average proportion of combined elements: distal tibia, tuber calcis of calcaneum, distal femur, and distal radius. Assemblages from Middle Paleolithic (MP, n = 2), Upper Paleolithic (UP, n = 5), Kebaran (KEB, n = 4), and Natufian (NAT, n = 7) sites from the southern Levant. Note that the number of sites sampled for each cultural period is small. Data sources summarized in Table 8.2.

The gradual long-term increase in the proportion of juvenile gazelle from the Middle Paleolithic to the Natufian originally observed by Davis (1983) is upheld in the expanded sample of fusion data presented in Table 8.2. Both the metapodial and combined long bone sample show clear unidirectional increases in the proportion of juvenile gazelles from the Middle Paleolithic through the Natufian period. The proportion of unfused metapodials does not exceed 30% in any Middle and Upper Paleolithic assemblage. The Kebaran assemblages are represented by less than 30% juvenile gazelles less in two of the three assemblages. Although the average for Natufian assemblages is not much higher, juveniles comprise more than 30% of the gazelle assemblage in all nine samples. The site samples for cultural periods other than the Natufian are fairly small, and each cultural period includes an occasional outlier, but the underlying trend for both metapodials (Figure 8.7) and the combined sample (Figure 8.8) is the same.

The Paleolithic Sequence from the Wadi Meged, Israel

Comparative data on gazelle tooth wear and eruption sequences, and tortoise body-size measures are available from M. Stiner (pre-Natufian cases only) for the Paleolithic occupation sequence in the Wadi Meged in the western Galilee of Israel. The Wadi Meged sites include Hayonim Cave where Mousterian, Aurignacian, Kebaran, and Early and Late Natufian components are preserved, a Late Natufian occupation on the terrace outside the cave (Hayonim Terrace), and Meged Rockshelter, which preserves late Upper Paleolithic and Early Kebaran deposits (Kuhn et al. n.d.; Stiner and Tchernov 1998). This sample provides a good, local representation of the major prehistoric phases of the Levantine cultural sequence that retains tight geographic control. The mortality data from the Early and Late Natufian layers in Hayonim Cave are collapsed and treated as one sample for the analysis on gazelle tooth wear and eruption, owing to small sample sizes and the apparent similarity in the gazelle age structures of in the two components.

Gazelle Tooth Eruption and Wear Results

Figure 8.9 shows the proportion of juvenile gazelles identified using tooth eruption and wear stages in the Wadi Meged assemblages. There is a stark contrast in the proportion of juveniles represented in the earlier Paleolithic periods in the sequence and those from the Natufian period. Just over 50.0% of the gazelles hunted at both Hayonim Cave and Terrace during the Natufian were juveniles, compared to a maximum of 26.0% in all earlier assemblages.

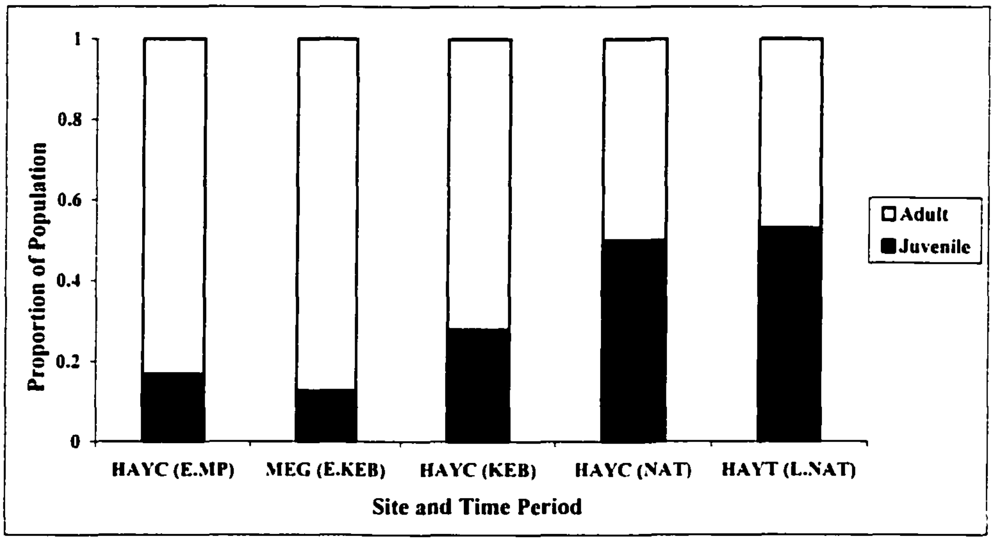


Figure 8.9: Relative proportions of juvenile and adult gazelles based on tooth wear and eruption data of the lower deciduous third premolar and the lower permanent third molar. Samples are from Paleolithic occupations in the Wadi Meged, Israel. HAYC is Hayonim Cave, MEG is Meged Rockshelter, and HAYT is Hayonim Terrace. Data from Middle Paleolithic and Kebaran components from Stiner et al. (2000).

When plotted on a triangular graph, the nature of the differences between the Natufian and earlier Paleolithic assemblages are clarified. The triangular plot allows one to quickly spot differences in the age mortality profiles of prey assemblages. The graph is composed of three axes representing the relative proportions of juvenile, prime, and senescent (old) animals in an assemblage. The resulting three-dimensional space is divided into areas referring to ranges of variation associated with distinct mortality patterns (see Figure 8.10). For example, the area on Figure 8.10 marked "living structure" represents prey age structures that mimic the expected proportions of age groups in stable, growing, and declining living populations. Living structures are characterized by high proportions of prime and juvenile animals and relatively low proportions of old individuals. All pre-Natufian assemblages are living structure patterns or biased toward prime adults. On the other hand, the mortality profiles of both Natufian assemblages are clearly U-shaped (attritional). U-shaped distributions have heightened proportions of the more vulnerable age groups (old adults and juveniles) in comparison to living structure patterns. In other words, prime aged animals are underrepresented in the Natufian death assemblages, the opposite of earlier culling practices. The Natufian pattern thus shows a marked departure from all earlier hunted assemblages in the Wadi Meged and Paleolithic hunted faunas in general it must reflect either a dramatic change in procurement strategy and/or in the natural composition of gazelle populations available to human hunters.

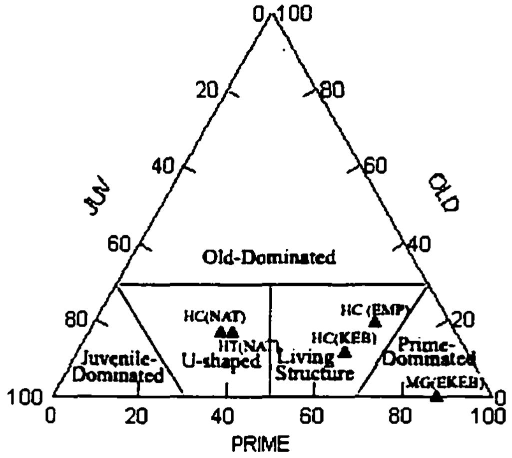


Figure 8.10: Age structures derived from tooth wear and eruption sequences of gazelle from Paleolithic sites in the Wadi Meged. HC(NAT) = Hayonim Cave Natufian, HT(NAT) = Hayonim Terrace Natufian, HC(KEB) = Hayonim Cave Kebaran, MG(EKEB) = Meged Early Kebaran, HC(EMP) = Hayonim Cave Early Mousterian.

Tortoise Body Size Results

Trends in body size reduction of Paleolithic tortoises in the Wadi Meged have been presented elsewhere (Stiner *et al.* 1999, 2000) and are only briefly summarized here. Stiner *et al.* (1999, 2000) present a sequence of tortoise humeral shaft breadth measurements from the Middle Paleolithic through Natufian periods in the Wadi Meged. Overall, the sequence shows a clear trend in tortoise body size diminution, despite minor fluctuations within the Middle Paleolithic period (Stiner *et al.* 1999, 2000: Figure 8.11). Variation in mean tortoise body size in the Middle Paleolithic is most probably linked to fluctuating food supplies, since the growth of tortoises is sensitive to availability and quality of forage, which is related to climate. Within the sequence, there is one major episode of diminution that is not explained by major climatic events (Figure 8.11). A dramatic drop in body size around the Late Middle Paleolithic to Upper Paleolithic transition (ca. 44 kya). This drop is substantiated by an enlarged tortoise sample from Kebara Cave for the late Middle Paleolithic and early Upper only.

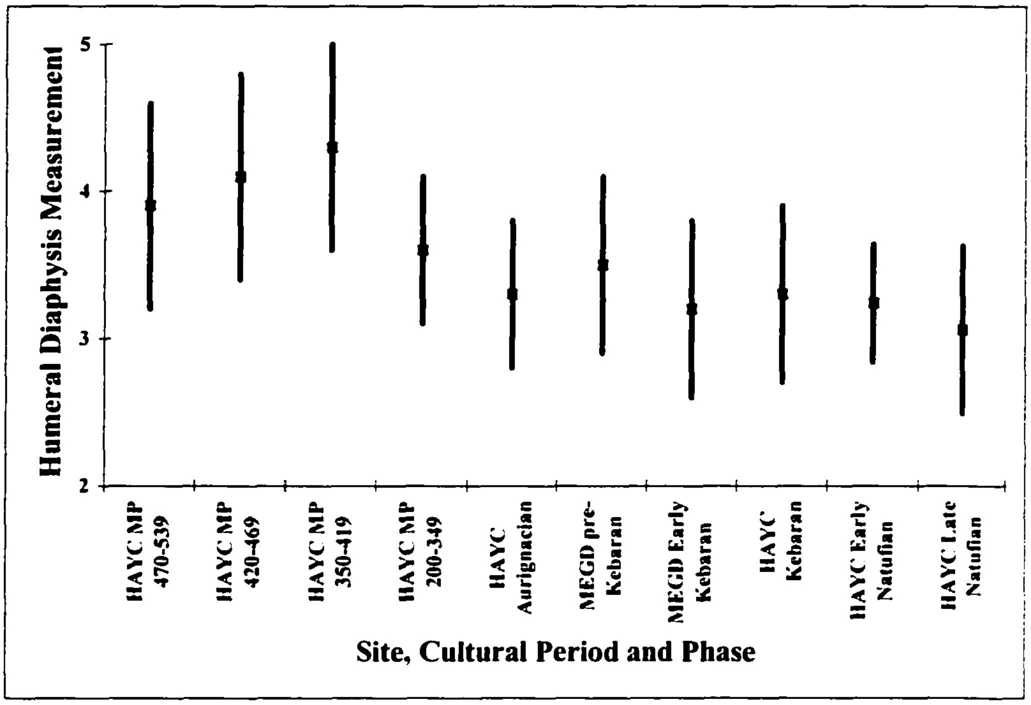


Figure 8.11: Average medio-lateral breadth measurement of narrowest point on tortoise humeral shaft plus and minus one standard deviation. Sites are all Paleolithic occupations in the Wadi Meged, Israel. HAYC is Hayonim Cave, MEGD is Meged Rockshelter. Pre-Natufian data from Stiner et al. (2000).

Variation Within The Natufian Period

Gazelle tooth wear and eruption sequences for the Natufian period are limited to Hayonim Cave and Hayonim Terrace and were reported in the preceding discussion on long-term change in the Wadi Meged. Detailed fusion data on multiple elements are limited to the Early and Late assemblages from Hayonim Cave. A larger sample of fusion data was also presented earlier in Table 8.2. Natufian tortoise measurements are available only from Hilazon Tachtit, Hayonim Terrace, and the Early and Late components from Hayonim Cave. The el-Wad sample is inadequate for comparison.

Gazelle Tooth Eruption and Wear Results

The tooth wear and eruption data reported earlier (Figures 8.9 and 8.10) reveal high proportions of juveniles at Hayonim Cave (50%) and Hayonim Terrace (53%). Published data for the distal metapodial, and where possible, the distal tibia, tuber calcis of the calcaneum, distal femur, and distal radius (see Table 8.2), support this trend. Though some variation is present, the proportion of unfused gazelle metapodials in Natufian sites is consistently high (ranging between 32.6 and 54.7%) in comparison to earlier Paleolithic periods. The dental eruption and wear data and fusion data for Natufian gazelles indicate a widespread change in the nature of the human-gazelle relationship in the Mediterranean zone by the Natufian period, which remained consistent through both the Early and Late Natufian phases.

Gazelle Bone Fusion Results from Hayonim Cave

Hayonim Cave is the only site with the temporal resolution and sample sizes sufficient to address diachronic change in gazelle population structure within the Natufian period. The fusion data is divided into Early and Late Natufian samples and the proportion of unfused elements is determined separately for the distal tibia, tuber calcis of the calcaneum, distal metapodial, distal femur, and distal radius. Figure 8.12 presents the results with the elements arranged in the sequence in which they fuse. Because each subsequent element fuses at a slightly later age, the proportion of unfused elements is not expected to be the same for each element, and the proportion of unfused specimens should be higher for elements that fuse at older ages.

The data presented in Figure 8.12 indicate that there are high proportions of unfused gazelle elements (between 25% and 57%) in both the Early and Late Natufian deposits at Hayonim Cave. A high percentage of gazelles were culled before they reached 18 months of age, regardless of phase. These results corroborate the tooth wear and eruption data from Hayonim Cave (50% juveniles approximately 18 months and younger). In general elements that fuse at older ages are represented by the highest proportions of unfused specimens, with the exception of the distal metapodial. The metapodials (metacarpals and metatarsals) are represented by much larger samples than the other elements, but also run a greater risk of double counting, and therefore must be

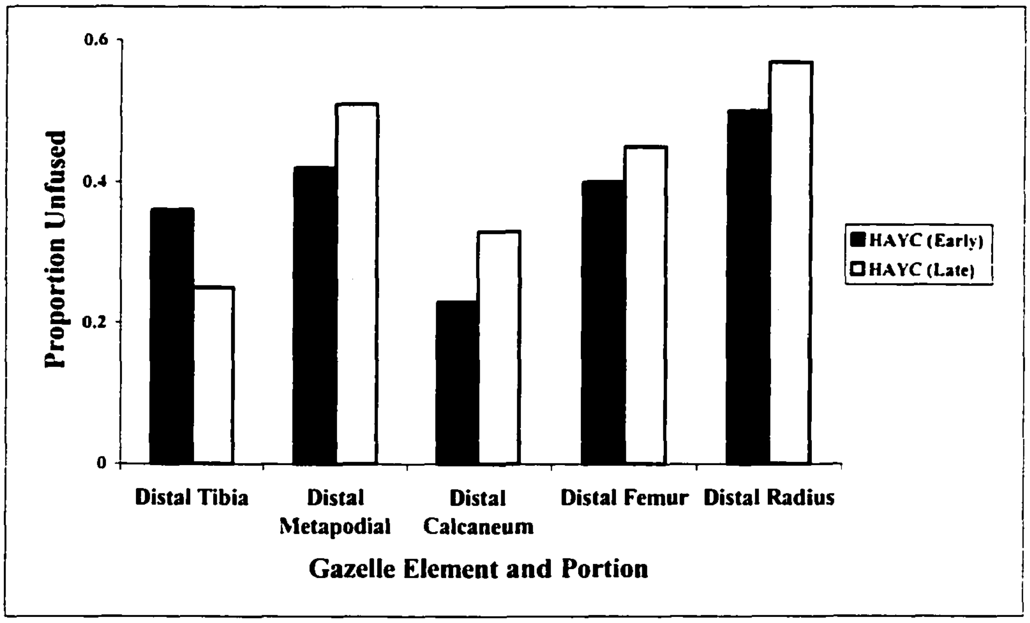


Figure 8.12: Proportion of select unfused gazelle elements from Late and Early Natufian assemblages from Hayonim Cave. Elements are listed in the temporal order in which they fuse.

treated with caution. Overall, the consistency of the results support the pattern discussed previously, despite small samples for some elements. There are no significant differences in the proportions of unfused gazelle elements between the Early and Late Natufian assemblages from the cave, but the Natufian is very different from earlier periods. Though differences between the Natufian phases exist, they range between only 5 and 10% of total sample sizes. Except for the distal tibia, the proportion of juveniles in the Late Natufian assemblage from Hayonim Cave is slightly greater than in the Early phase, but the difference is small and most likely explained by random variation.

Tortoise Body Size Results

The sample sizes of tortoise humeri from the Natufian assemblages are adequate for analysis (Hayonim Cave Early NISP = 27, Hayonim Cave Late NISP = 60, Hayonim Terrace NISP = 104 and Hilazon Tachtit NISP = 27). The average medio-lateral breadth of the narrowest point on the humeral shaft and associated standard deviations are plotted for each Natufian sample in Figure 8.13. Much overlap between the means and standard deviations of all of the samples indicates that tortoise populations had essentially the same mean body sizes throughout the Natufian period. The Natufian tortoises, are however, the smallest of any Paleolithic period. Sample sizes for the shaft breadth measurements of tortoise femurs are smaller (HAYC Early NISP = 7, HAYC Late NISP = 20, HAYT NISP = 37, HLZT NISP = 17), but reveal similar results, with no statistically significant differences between means (see Figure 8.14).

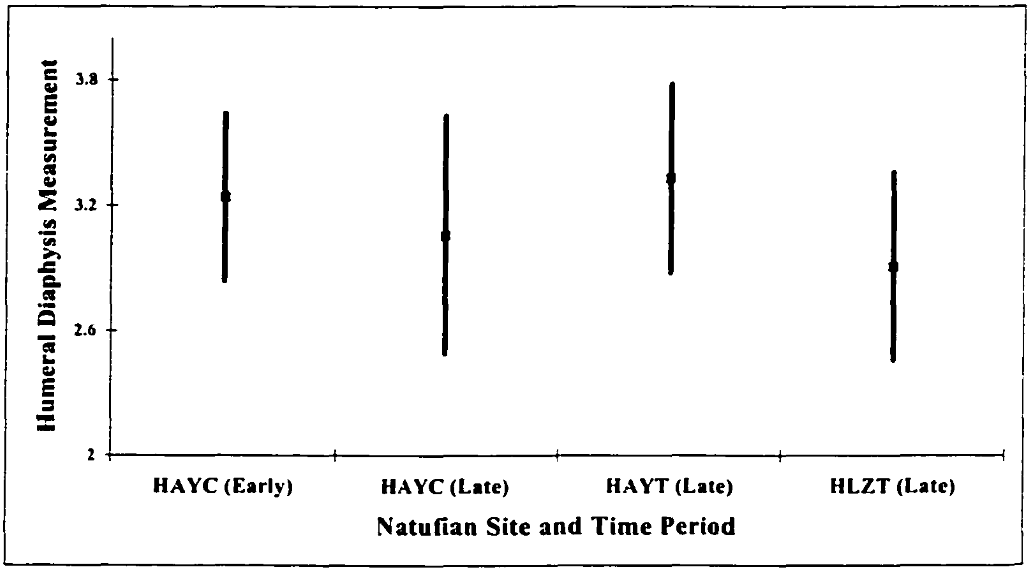


Figure 8.13: Average medio-lateral breadth of the narrowest point on the tortoise humerus shaft, plus and minus one standard deviation. Measurements of tortoise assemblages from Natufian sites in Israel. HAYC is Hayonim Cave, HAYT is Hayonim Terrace, and HLZT is Hilazon Tachtit.

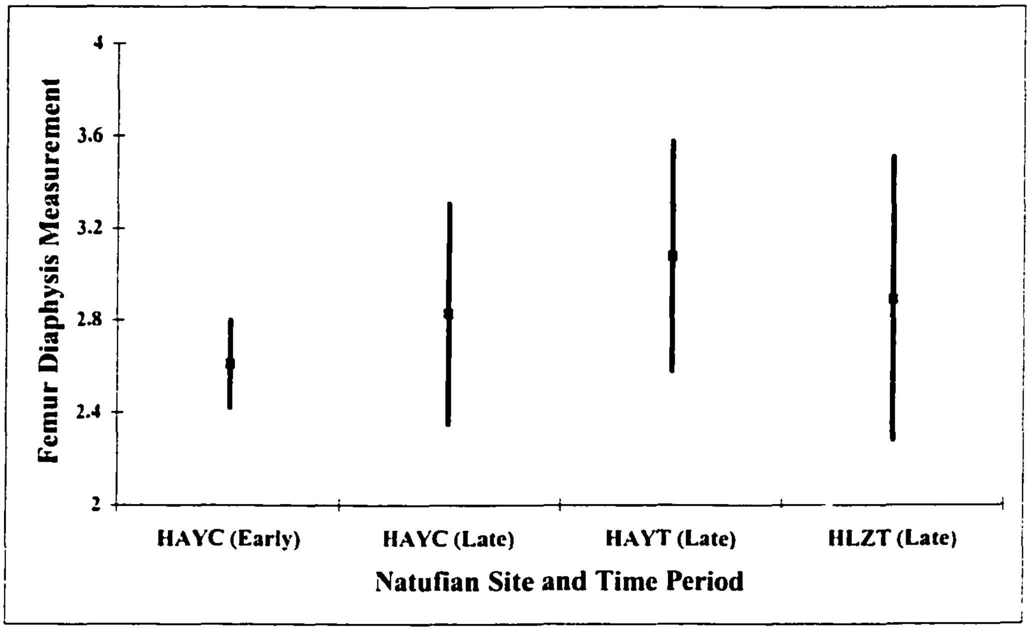


Figure 8.14: Average medio-lateral breadth of the narrowest point on the tortoise femur shaft, plus and minus one standard deviation. Measurements of tortoise assemblages from Natufian sites in Israel. HAYC is Hayonim Cave, HAYT is Hayonim Terrace, and HLZT is Hilazon Tachtit.

IMPLICATIONS OF PREY AGE STRUCTURES FROM NATUFIAN SITES IN THE MEDITERRANEAN ZONE

Gazelles

According to both tooth wear and fusion data, the proportion of juveniles in gazelle populations increased dramatically over time, reaching its highest level in the Natufian period in the Wadi Meged, and the greater Mediterranean region of the southern Levant. In general, pre-Natufian gazelle populations have living structure or prime-dominated profiles (see Figure 8.10). In the Natufian period the proportion of juveniles rises to between 30 and 50%. Gazelle mortality profiles are characterized by consistently high proportions of juvenile gazelles in both the Early and Late Natufian periods.

The sudden and dramatic increase in juvenile gazelles in the Natufian period seems to be the result of an increase in human hunting pressure. If correct, prime aged animals were no longer sufficiently abundant to meet human needs, due to age depression. Natufians would be forced to cull larger numbers of low-ranked juveniles to make ends meet. However, the Natufian assemblages are represented by proportions of juveniles above and beyond those expected in a stable gazelle living structure (see Chapter 6, Baharav 1974). Even if changes in prey age structures were created by a shift to less discriminatory hunting strategies (i.e., ambush, encounter, or communal hunting), the effect is exceptional relative to earlier Paleolithic periods. Increased hunting intensity is still implicated as the major determinant of juvenile-biased Natufian structures, but it would be a relationship on the very brink of overexploitation.

As mentioned previously, the interpretation of prey age structures may be hindered by equifinality, that is, the potential for more than one process to produce the same pattern. Seasonality remains a potential contributing factor. Though season may have contributed to the formation of the gazelle age profiles presented here, a purely seasonal explanation is difficult to accept given the patterning in the data. A seasonal explanation for the gazelle age structures must attribute all of the Natufian assemblages to hunting in late spring/early summer. The gradual increase in the proportion of juveniles throughout the Paleolithic could also only be explained as the gradual replacement of Middle Paleolithic winter and spring camps by spring and summer occupations during the Natufian. Though not impossible, the likelihood of this scenario is small, particularly since all sites belonged to a single period were unlikely to have been occupied only in a single season. If anything, the overall duration of site occupations increased during the Natufian. Unless Natufian foragers only hunted gazelles in spring, seasonal fluctuations can be discounted. In fact, the widespread distribution of juvenile-biased gazelle assemblages across Natufian sites of varying size, function and occupation intensity in the Mediterranean zone contradicts the latter possibility.

Tortoises

The long Paleolithic sequence from the Wadi Meged indicates clear diminution in average tortoise body size between the Middle Paleolithic and Upper Paleolithic periods. Slight decreases in body size occur across the Upper Paleolithic and Epipaeolithic periods, but are not statistically significant. There is no change in average tortoise body size between the Early and Late Natufian phases.

Stiner *et al.* (1999, 2000) interpret the major episode of tortoise body size diminution and sustained dimunition for the rest of the Upper Paleolithic and Epipaleolithic in the Wadi Meged sequence as a response to the effects of demographic increase. The diminution begins at approximately 44 kya, indicating at least one major pulse in human population density. Additional increases in human population density in the later Upper Paleolithic and through the Epipaleolithic periods are better indicated by other aspects of the small game data. Tortoise body size does fluctuate somewhat in response to climatic change. However, the scale of the diminution and its overall transgression of major climatic events after 44 kya, indicate that growing human populations exerted hunting pressure that sustained the depression of tortoise populations.

Speth and Tchernov (n.d) confirm a shift in tortoise diminution at Kebara Cave at the Middle/Upper Paleolithic boundary using an expanded tortoise sample of humeral shaft measurements. Though they agree that tortoise body size fluctuates loosely with climatic events, and that major changes are likely attributable to human demographic shifts, they also warn about the effects of seasonality and climate on body size. Seasonality could have contributed to small-scale fluctuations in tortoise body size across the duration of the Paleolithic sequence, but the overriding trend in tortoise diminution is unidirectional and lasts too long in the Wadi Meged sequence to be a product of differing seasons of site occupation.

Though climate also undoubtedly had some impact on tortoise body size, the diminution trend crosscuts several major climatic events in the Wadi Meged, particularly in the latter part of the Paleolithic sequence. These events include the Last Glacial

Maximum (LGM), general global warming after the LGM, and the Younger Dryas, and represent major oscillations between harsh cold and dry conditions and warm and wet climates. These climatic events go completely unregistered in the tortoise body size profiles which represent long accumulation times. The Younger Dryas coincided with the Late Natufian and this study is represented by tortoise assemblages from Hayonim Cave, Hayonim Terrace, and Hilazon Tachtit. Late Natufian tortoise populations show no difference in average body size from the Early Natufian sample from Hayonim Cave, which represents the peak of warm/wet conditions from ca. 16,000 B.P. to about 11,000 B.P. In sum, though it is probable that tortoise body size fluctuated somewhat in response to paleoclimatic change, other forces, most probably human predation, were strong enough to override all other signatures. This is particularly true of the late Paleolithic.

The tortoises are slightly smaller during the Natufian, and body size is remarkably consistent across the duration of the period. For reasons outlined above, climatic change has been ruled out as a major source of diminution at least in the late Paleolithic. The stability in tortoise body size is argued to reflect similar intensities of hunting pressure in both the Early and Late Natufian phase. This trend is of particular importance within a context of broader changes in settlement strategy and human demography that are associated with the Early to Late Natufian transition (see Chapter 9).

Implications of Prey Age Structures for Human Hunting Pressure

Given the predictions laid out earlier, changes in Paleolithic gazelle age structures signal a gradual intensification in hunting pressure throughout the Paleolithic sequence. By the Natufian period, hunters were exerting steady, yet comparatively intense pressure on high-ranked game, namely tortoises and gazelles. These long-term trends are argued to be determined primarily by increases in human population density. As human population density grew so did the pressure humans exerted on local animal populations, particularly high-ranked species with poor population recovery. Prey populations were never hunted to the point of depletion, but were hunted with greater pressure in each consecutive period. Though there were undoubtedly some shorter term fluctuations and intense localized periods of stress within each period, the site sample does not have the sensitivity to capture it.

The intensity of hunting pressure remained consistently high throughout the duration of the Natufian period, at least for the sites sampled here. This is important since hunting pressure remains constant despite major changes in climate (see Chapter 3) and site occupation intensity (see Chapter 7) at the Early/Late Natufian boundary. In summary, Natufian gazelle populations are characterized by substantially higher proportions of juvenile individuals than assemblages from earlier Paleolithic occupations in the region. The proportion of juveniles in Natufian gazelle and tortoise populations also demonstrate temporal and spatial consistency throughout the Natufian period. These observations and their distribution across the Mediterranean zone point to long-term increases in hunting pressure, which culminated and then stabilized in the Natufian period.

CHAPTER 9: THE EARLY TO LATE NATUFIAN TRANSITION AT HAYONIM CAVE

INTRODUCTION

The previous two chapters described several clear trends in Natufian game use in the Mediterranean hills of the southern Levant. Changes in the relative abundance of small game are argued to result from shifts in site occupation intensity, but also correlate directly with the temporal division between the Early and Late Natufian phases. Hayonim Cave presents a unique opportunity to examine the details of the Early to Late Natufian transition with precise geographic control. The site is one of the few that bridges the Early to Late Natufian transition and provides detailed contextual information from a rich, well-quantified database (see Belfer-Cohen 1988).

VARIABILITY IN ARTIFACTS AND ARCHITECTURE AT HAYONIM CAVE

A synthesis of the available data for this cave site is undertaken with two goals in mind. The first is to elucidate diachronic trends in site use intensity using multiple lines of evidence. This will clarify whether changes suggested by the faunal record in Chapters 7 and 8 are corroborated by other material classes. The second goal is to comment on site function and define its variability throughout the Natufian occupation insofar as possible using the faunal data. Bar-Yosef and Belfer-Cohen (n.d.) have suggested that temporal changes in material classes between the Early and Late Natufian phases at Hayonim Cave may reflect a shift in the function of the site from a multitask base camp to a special use site used primarily for the burial of the dead. In her doctoral thesis Belfer-Cohen (1988) presents detailed quantitative information on major artifact classes from the Early and Late Natufian phases at Hayonim Cave. Below, architectural features, settlement organization, lithics, groundstone, bone tools, ornaments, artwork, burials (from Belfer-Cohen 1988), and taphonomic and economic aspects of the faunal database are compared for the Early (Phase I-III) and Late (IV-V) phases.

MATERIAL CLASS	**ARTIFACT OR FEATURE**	**EARLY NATUFIAN**	**LATE NATUFIAN**
	Volume Excavated m^3	21.8	25.4
Architecture	**Rooms (Loci)**	9	0
	Built Hearths	6	0
	Slab-Lined Floors	5	0
	Slab-Lined Graves	2	2
Graves	**Total Graves**	8	8
	Human Burials	29 + 2 fetus	18 + 1 fetus
Bone Tools	**Bone Tools**	202 (9.3)	284 (11.2)
Ornaments/Art	**Decorated Bone**	1	3
	Bone Beads in Graves	123 (5.6)	2 (<1.0)
	Bone Beads Outside Graves	45	41
	Dentalium	837 (38.4)	1437 (56.7)
	Engraved Limestone	4	1
Groundstone	**Groundstone**	78 (3.6)	121 (4.8)
	Groundstone with Ochre	17	15
Stone Tools	**Lunates**	226 (10.4)	424 (16.7)
	Burins	794 (36.4)	663 (26.2)
	Sickles	32 (1.5)	91 (3.6)
	Bifaces	27 (1.2)	31 (1.2)

Figure 9.1: Frequency and density of features and major artifact classes from Early and Late Natufian deposits at Hayonim Cave. Numbers outside of parentheses are frequencies and numbers in parentheses are density values when sample size is large enough to warrant them. Figures derived from Belfer-Cohen 1988, and refer only to excavations from the 1960s and 1970s.

Site Organization

Throughout the Natufian occupation at Hayonim Cave graves and living areas were segregated, although the spatial relationship between the two shifts in the Late phase. During the Early phase domestic activities were concentrated in the circular structures (Loci) near the cave's entrance and the dead were buried behind the structures and primary living area. In the Late Phase domestic activities shifted to both a large open space on the east side of the cave's interior, and Locus 1 and 2 situated on top of Graves III, VI and VII at the back of the cave (see Figure 3.5). Human interments were later concentrated in the fill of abandoned Loci. By the end of the occupation the activity area in the east side of the cave was filled with new graves (e.g., XIV, XV, XVI), though faunal, lithic and other debris continued to accumulate in this area on a smaller scale.

Architecture: Energy Investment into On-site Features

Table 9.1 compares the frequency of built features constructed in the Early versus Late Natufian at Hayonim Cave. The site is home to features requiring significantly different energy investments. Built features, such as stone loci, slab pavements, slab-lined graves and built hearths, require planning, acquisition of heavy building materials, and construction. Other features, such as living floors and non-built hearths, provide evidence for spatially constrained activities, but the delineation of these areas is a cumulative byproduct of use rather than deliberate construction investment. With the exception of two slab-lined graves constructed in the final occupation phase, all built features in Hayonim Cave, including 9 loci, 6 built hearths, and 5 slab-lined floors, were constructed during the Early Natufian phase exclusively (with the possible exception of the slab-lined floor in Locus 7, see Bar-Yosef and Belfer-Cohen n.d.). The few features attributed to the Late Natufian include packed living floors and ash concentrations, which were delimited primarily by use and were not deliberately created.

Graves

Several changes in burial practices accompany the Early to Late transition at Hayonim Cave and are in agreement with diachronic trends for Natufian cemeteries from the Mediterranean region in general (Belfer-Cohen 1991b; Belfer-Cohen and Bar-Yosef 2000; Byrd and Monahan 1995; Garrod 1957; Stekelis and Yizraely 1963; Perrot 1966).

Variability in burial practices within the Early and Late Natufian phases is high and most temporal change is expressed as proportional rather than absolute differences. Early Natufian burials are characterized by higher percentages of primary interments (75.0%) and lower frequencies of individual (25.0%) versus group burials (75.0%) than those from the Late Natufian. Decorated burials (13.8%) and extended burial positions (33.3%) are restricted to Early Natufian contexts. In the Late Natufian, only burials in flexed or semi-flexed positions occur, primary interments (62.5%) decreased in favor of secondary burials (32.5%) and individual graves increase in frequency (37.5%) even though group burials remain the norm (62.5%). None of the Late Natufian burials are decorated, but some individuals (3 of 5 primary Late Natufian burials) were recovered without the cranium, and with mandibles left intact. This practice became much more common in succeeding Neolithic sites from the Levant, but was first introduced in the

Late Natufian (Belfer-Cohen 1988). Overall, these results are based on small sample sizes, and thus are not statistically significant. The trends are provocative, but can not be considered more than suggestive at this point.

Beads, Decorated Artifacts, Mobiliary Art, and Bone Tools

Apart from the decorated graves, minimal differences exist in the densities of bone tools, ornaments, and art objects throughout the Natufian occupation at Hayonim Cave (see Table 9.1). Trends are visible only in the abundance of *Dentalium* shells, whose relative numbers increase significantly during Phase IV of the Late Natufian, particularly in the open activity area at the eastern side of the cave interpreted as a workshop by Belfer-Cohen (1988: 294). Interestingly, during the Early Natufian *Dentalium* is most often recovered from graves, but in the later period its presence is restricted to domestic areas. The frequencies of bone tools and decorated bone objects, such as sickle hafts and antler are fairly consistent throughout the Natufian occupation. Bone tools are more common in the open activity areas of the Late Natufian, but the perception of abundance may be inflated by a large quantity of broken and unidentifiable bone tool fragments ($5/m^3$ in the Late Natufian versus $3/m^3$ in Early Natufian contexts, data from Belfer-Cohen 1988).

Plant Processing Equipment: Groundstone and Sickle Blades

Of the tool types that Belfer-Cohen calls "groundstone" in the Hayonim Cave assemblage, only mortars, pestles, and grinding stones are interpreted as plant processing equipment. All other groundstone categories, such as shaft straighteners, flaked limestone, and hammerstones, are excluded from the immediate discussion. Groundstone increase in density in the Late Natufian (Table 9.1) and are nearly exclusively distributed in the activity area on the east side of the cave. A cache of at least 10 pestles was found in a slab-lined pit abutting the east wall. Otherwise, the pestles were recovered primarily from small concentrations scattered throughout the activity area (Belfer-Cohen 1988). Ochre stains were noted on several groundstone tools, pestles in particular (see Table 9.1). The frequency of ochre-staining is fairly consistent through time, decreasing only slightly during the Late Natufian phase. Although never present in large numbers (0.8% and 4.8% of Early and Late Natufian assemblage), sickle blades are six times as common in Late Natufian lithic tool assemblages than they are in Early Natufian samples (Table 9.1). Like groundstone, the Late Natufian sickle blades are concentrated in the activity area adjacent to the eastern wall (Belfer-Cohen 1988).

Other Lithic Artifact Patterns

The density of lithic tools decreases in the Late Natufian deposits at Hayonim Cave (see Table 9.1). The most common lithic categories -- cores, lunates and burins -- are best represented in Loci 4 and 6 and to a lesser extent in Locus 8, which appear to have been hubs for domestic activity during the Early Natufian. Throughout the first four phases of Natufian occupation, most cores were the single platform variety. In Phase V multiplatform cores became the norm in more than 50% of excavated contexts (Belfer-Cohen 1988). The more random distribution of core types in Phase V suggests that knapping was more sporadic and unpatterned than in earlier phases, which Belfer-Cohen

(1988: 276) suggests may indicate less intensive core use and less systematic tool procurement.

VARIATION IN THE FAUNAL ASSEMBLAGES FROM HAYONIM CAVE

Faunal indicators are were used to gauge occupation intensity at Hayonim Cave, in particular the relative proportions of small game species, the frequency of natural and cultural damage on bone, and the intensity of carcass processing in the case of the most important food species. The Early and Late Natufian faunal assemblages are also examined for clues on site function by comparing patterns of human prey selection and use, with a special note on modified tortoise fragments, the only worked bone class from Hayonim Cave not previously examined by Belfer-Cohen (1988).

Relative Proportions of Small Game

The theoretical and empirical basis for using the relative abundance of small game as an indictor of site use intensity was presented in Chapters 1 and 7. The results from Hayonim Cave show an abrupt increase in the proportion of high-ranked small prey (tortoises) in relation to their low-ranked counterparts (partridges and hares), beginning with the Late Natufian occupation at Hayonim Cave and peaking in the last Phase of occupation in the cave (see Figure 7.5). This is the opposite of what is expected to result from long duration site occupation.

Taphonomic Summary of Natufian Faunas

The frequencies of natural and cultural taphonomic damage in Early and Late

Natufian assemblages from Hayonim Cave are summarized in Table 9.2. The categories of damage are alike in both the Early and Late Natufian assemblages indicating that they had similar depositional histories. This is not surprising given that the assemblages were created in the same general time period and were recovered from similar depositional environments. The only obvious difference between the assemblages is in the proportion of burning. The Late Natufian assemblage from Hayonim Cave is burned at substantially greater frequencies (21.2%) than that of the earlier Natufian phase (15.8%). This difference, however, can be explained by spatial patterning.

Taphonomic Variables	HAYC Early	HAYC Late
NISP	9267	7948
Density	269 per m3	253 per m3
Fragment Length	2.07+/- 1.68	1.88+/- 1.52
% Root Etch	170 (1.8%)	264 (3.3%)
% Weathering	182 (2.0%)	259 (3.3%)
% Rodent Gnawed	174 (1.9%)	58 (<1.0%)
% Carnivore Tooth Marks	13 (<1.0%)	7 (<1.0%)
% Possible Digestion	2 (<1.0%)	2 (<1.0%)
% Complete Elements	2334 (25.2%)	1753 (22.1%)
% Burn	1462(15.8%)	1683 (21.2%)
% Tool marks	355 (3.8%)	194 (2.4%)
% Cone Fractures	40 (<1.0%)	25 (<1.0%)

Table 9.2: Taphonomic summary of Early and Late Natufian assemblages from Hayonim Cave. Numbers in parentheses represent percentage of assemblage affected. Numbers outside of parentheses indicate the NISP of damaged specimens.

The high proportion of burning in the Late Natufian deposits is inflated by the presence of one large burned area packed with ash, burned slabs, and bone, and concentrated in squares Q26, P26 and P27. Very high percentages of bones recovered from these squares were burned (35.6%) and many of the bones were calcined (16.0%), thus exaggerating the total proportion of burned bones in the Late Natufian assemblage.

When the bones from these squares are eliminated from the sample, the frequency of burning on Late Natufian bone drops to 17.9% and does not differ significantly from that of the Early Natufian assemblage (15.8%).

Some of the more subtle taphonomic differences between the three assemblages are more informative (see Table 9.2). Many categories of taphonomic damage occur in such low frequencies (i.e., a few percentages or less) that the differences between assemblages appear less profound than the more common damage types. Still, a difference of only one or two percentage points can be important in certain damage categories. With this in mind, notable differences between the Early and Late Natufian layers exist in the proportions of weathering, root etching, and rodent gnawing. During the Early Natufian 2.0% of the Hayonim Cave assemblage displays evidence for weathering and 1.8% of bones were corroded by root activity. The frequency of both types of damage increase by approximately twofold during the Late Natufian (3.3% weathered, 3.3% root etched), implying relatively longer time for non-anthropogenic processes to damage bone. The implications of these results are discussed below.

The Distribution of Modified Tortoise Shells

The proportion of modified tortoise segments in comparison to total tortoise fragments decreases by nearly three times from 13.8% in the Early Natufian to 4.8% in the Late phase (see Table 9.3). This decline is not simply a byproduct of inflated tortoise shell abundance in the Late Natufian, as it is corroborated by the density of modified segments in Natufian sediments, which declines from 11.3/m^3 in the Early phase to 3.4/m^3 in the Late phase of the Natufian.

HAYONIM CAVE TIME PERIOD	NISP Mod Tortoise	Tortoise NISP	% Mod Tortoise	Volume Excavated	Modified Tortoise Bones (m3)
Phase I	55	540	10.2%	7.08	7.77
Phase II	63	493	12.8%	5.51	11.43
Phase III	90	482	18.7%	9.21	9.77
Phase I-III	38	266	14.3%	n/a	n/a
Phase IV	223	2015	5.6%	10.2	11.08
Phase V	54	1873	2.9%	15.15	3.56
TOTAL	**413**	**5669**	**7.3%**	**47.15**	**n/a**
Early Natufian	246	1781	13.8%	21.8	9.54
Late Natufian	187	3888	4.8%	25.35	7.38

Table 9.3: Proportion and density of modified tortoise scutes from Phases I through V at Hayonim Cave.

SITE OCCUPATION INTENSITY AT HAYONIM CAVE

The data summarized above illustrate changes in aspects of material culture at Hayonim Cave, some of which correspond directly to the Early (Phases I-III) to Late Natufian transition (Phases IV-V). Those shifts that correspond to the division between the Early to Late Natufian are also linked to changes in site use intensity. There is a stark contrast in the energy invested into built features, which, with the exception of two slab-lined graves, were constructed nearly exclusively in the Early Natufian phase. The permanence of shelter and other features such as hearths and floors are expected to correlate inversely with the degree of human mobility (e.g., Binford 1990; Kelly 1995). Mobile foragers that make frequent residential moves must make and break camp each time they move. Permanent architecture is energetic overkill for such brief occupations, unless a site is occupied multiple times each year, for significant periods each year, or both. The energy required for construction activities is better expended on other more immediate demands during short occupations. Though investing in architecture can result in certain kinds of long-term gains, this is likely only if one is reasonably sure to reoccupy the site for long enough periods to reap the benefits. The termination of major construction during the Late Natufian at Hayonim Cave suggests that it was no longer worthwhile to significantly invest in the site, most probably because of a decrease in site occupation intensity.

Increases in the number of secondary inhumations and the absence of decorated burials in Late Natufian graves at Hayonim Cave may indicate a decrease in site occupation intensity and associated increases in mobility during the Late Natufian phase. The skeletal remains of individuals who died elsewhere were later transported to Hayonim Cave for burial (cf. Belfer-Cohen and Bar-Yosef 2000; Perrot 1966). The absence of decorations in Late Natufian burials also supports the interpretation that individuals were already skeletonized at the time of burial, since ornaments are most likely to be associated with clothing or fully fleshed bodies (Belfer-Cohen 1991b; Belfer-Cohen et al. 1991). The few primary burials recovered from Late Natufian contexts suggest that the Natufians continued to occupy Hayonim Cave and that some individuals died while in residence at the site or nearby, but not to the extent seen in the Early Natufian.

Taphonomic indicators, such as *in situ* weathering and root etching, provide coarse-grained commentary on the intensity of site use. The frequencies of weathering and root etching roughly double during the Late Natufian at Hayonim Cave. Because weathering occurs after deposition but prior to burial, its intensity should vary directly with the amount of time a bone spends on the surface. Rapid accumulation of debris in tandem with anthropogenic activity, reduces the time a bone spends on the surface and its chance of becoming weathered. Bones are expected to be buried more rapidly during periods of occupation, and especially when rebuilding occurs. Root etching occurs as bones are lightly buried if plant growth is not checked by space clearing and human traffic. Some roots penetrate deeply into the soil, but in general, as the depth of burial increases, the chance of rootlet damage declines. Root etching is more likely to occur during periods when sites are not heavily occupied, since human activity causes disturbance which repress plant re-colonization. Weathering and root etching are thus expected to be most apparent during breaks in human occupation, or during periods of reduced occupation intensity. Of course some damage may also be much more recent, since the site was abandoned long ago.

Much of the faunal data indicates remarkable consistency in hunting and butchering strategies throughout the Natufian period at Hayonim Cave. The Natufians continued to hunt the same spectrum of animals and butchered their carcasses with the same intensity and using the same basic techniques in the Early and Late phases. The only major difference in hunting strategy is the dramatic increase in the capture of high-ranked tortoises in comparison to low-ranked small game species (birds and hares). The Late Natufian assemblage is marked by a return to high-ranked species. Considering the somewhat depleted state of tortoise and gazelle populations throughout the Natufian, this could only mean that Natufian people were more lightly distributed on the local landscape. Because the Natufians reverted from prey that require more technological sophistication to capture (i.e., birds and hares) in the Early phase to those that can be captured easily by hand in the Late phase, technological innovation could not have been a factor in this economic shift. The similarity in all other aspects of the Natufian faunal assemblages makes the shift in small game use even more significant from a demographic point of view, an interpretation supported by the other non-faunal lines of evidence discussed above.

In sum, it appears that there was a significant drop in the intensity of human occupation at Hayonim Cave beginning, with the onset of the Late Natufian, and becoming increasingly more ephemeral by the final stage of Natufian habitation in the cave. Despite the significant decrease in site use intensity during the Late Natufian phase, people continued to use the site on a reduced scale, for burial of their dead and as a base for the extraction of plant and animal resources. It must be noted that this interpretation does not account for the role of Hayonim Terrace which is located directly outside the mouth of Hayonim Cave. The cave and terrace were most likely utilized simultaneously at least at some stages during the occupation, perhaps for different purposes. The fauna from the Late Natufian occupations from both sites, however, are extremely similar in composition and taphonomy, and strongly suggest that the intensity of occupation in the two areas at least during the Late Natufian was also similar.

SITE FUNCTION AT HAYONIM CAVE

Some changes in material culture exist from the Early to Late Natufian at Hayonim Cave, but these do not seem to be the product of changing site function. The abundance of artifacts commonly associated with ritual activity, including ornaments, art, and ochre, show no increase in frequency in grave fill or activity areas during the Late Natufian. Ornaments disappear entirely from grave contexts during the latter part of the occupation, but this is probably linked to the rise in secondary burials. Decorated bone and other mobiliary art, such as engraved limestone slabs decrease in frequency during the Late Natufian phase, both in graves and domestic contexts. *Dentalium* shell beads are the only ornamental class that increases in the Late Natufian, however they are distributed nearly entirely within domestic refuse. *Dentalium* shells are scattered in great quantities in the open area along the east wall of the cave with the onset of the Late Natufian. Finally, the use of ochre is commonly associated with ritual activity in many prehistoric contexts, and it is present at Hayonim Cave in small chunks and as residues on groundstone implements. Over 30 ochre-stained groundstone tools have been found at Hayonim. They are more common in the Early than in the Late Natufian phase, but the context of their use is unknown. In summary, there is variation in the representation of artifacts with ritual association across the Natufian period, but there is no clear trend in the overall abundance of non-utilitarian objects, other than their reduction in grave contexts during the Late Natufian.

There is good evidence that despite the reduction in site occupation intensity during the Late Natufian, the full spectrum of domestic activities continued at the site, and in a few cases may have intensified. The diversity of forms in the lithic and bone tool assemblages persists across the duration of the Natufian cultural period at Hayonim Cave, providing evidence for a broad range of activities throughout the occupation. The frequencies of specialized plant processing tools, including mortars, pestles, and sickle blades, increased during the Late Natufian, such objects are concentrated along the eastern wall of the cave, the primary activity area during the formation of the Late Natufian deposits. Pestles were usually concentrated in small groups and caches. Sickle blades are at least two to three times more abundant in Late Natufian deposits than they were in any of the first three phases of occupation at the site, and they are also concentrated in the activity area along the caves eastern wall. There is clear evidence for resource intensification in both phases. However faunal evidence shows that fewer people could have been supported by it in the Late Phase.

The increased emphasis on plant processing equipment indicates that the Late Natufians continued to use Hayonim Cave as a platform for resource extraction. Belfer-Cohen (1988: 286) suggests that the increase in groundstone in the Late Natufian may be caused by their "specialised intrasite distribution rather than the association of grinding tools with a Late Natufian phase." The clumped distribution of pestles and simultaneous increases in the numbers of mortars could suggest a concentration of processing activities during the Late Natufian, as well as caching behavior, potentially by the occupants of

Hayonim Terrace. The nearly exclusive distribution of mortars and pestles in the open activity area along the eastern wall, and their virtual absence in the fill of Late Natufian graves, intergrave areas, or Loci indicate a patterned arrangement and intentional stockpiling for later use. Caching behavior is most likely if one must be away from a locality for longer periods. The spatial distribution of grinding tools indicates a direct relationship with domestic use areas, providing strong evidence that either the Cave or the Terrace was used for plant exploitation, though likely on a more seasonal basis.

Similar proportions of ungulates to small game taxa in the Early and Late Natufian faunal assemblages point to stability in the primary hunting strategy throughout the Natufian period at Hayonim Cave. Ungulates were the main source of meat, but small game played a consistent and major supplementary role. Inflated proportions of juvenile gazelles were also constant across the Natufian phases, well above their frequencies in all earlier Paleolithic occupations at Hayonim Cave (M. Stiner, personal communication 2001). In Chapter 8, I argued that Natufian hunting of gazelle populations caused region-wide age depression, causing increased proportions of young animals to be available to hunters, at the expense of adult gazelles. Bone fragmentation, body part representation, and the frequency of human-caused damage on the assemblages are also similar throughout the occupation, indicating that the Natufians followed long-term traditions of hunting, prey transport, butchery, and carcass preparation. Fragmentation indices, bone damage, and gazelle skeletal representation indicate that carcasses were butchered for meat, bone grease, and marrow at similarly high intensities during the Early and Late Natufian phases (see Chapters 4 and 5). Overall the relative contribution, intensity of use, and pressure exerted by humans on large prey was remarkably consistent throughout the duration of the Natufian occupation at Hayonim Cave, and appears to be similar during the Late Natufian occupation of Hayonim Terrace.

It therefore is very significant that the proportion of tortoises rises dramatically in comparison to quick-moving small prey, including hares and partridges, in Late Natufian assemblages. Earlier I argued that this shift reflects a reduction in site occupation intensity. An alternative hypothesis might posit that the increased frequency of tortoise remains shows that these animals played a special role related to human burial practices. After all tortoise carapaces have been found in association with human graves in an Early Natufian context at el-Wad (Garrod and Bate 1937) and in a Late Natufian grave at Hayonim Terrace (Tchernov and Valla 1997), and numerous modified tortoise shells serving unknown purposes have been recovered from Hayonim Cave (see chapter 5), though they are rare to nonexistent at other Natufian sites. However, the taphonomy and distribution of the Hayonim Cave tortoises, however, do not change over the course of the Natufian. In fact, the percentage and density of modified tortoise shells decrease significantly in the Late Natufian (by at least three times), the opposite of what is expected if tortoise hunting was increased simply to fulfill some kind of ritual role. Neither unmodified nor worked tortoise bone segments show an affinity with graves or domestic areas. Rather, they are scattered through fills of all kinds in Early and Late Natufian contexts. What is interesting here, is the virtual absence of modified tortoise segments at the adjacent Late Natufian occupation on Hayonim Terrace. Though every tortoise carapace fragment was examined, only 7 of the 3483 fragments showed evidence for striated use-wear, and no fragments were modified in any other way.

The continued use of the burial ground at Hayonim Cave has invited arguments that the function of the site changed in the Late Natufian to a place where Natufian groups returned specifically to bury their dead (Bar-Yosef and Belfer-Cohen n.d.; Belfer-Cohen 1991b; Belfer-Cohen et al. 1991). Changes in Natufian burial practices do attest to a special link between a group of Natufians and Hayonim Cave. The intentional transport of the dead for burial, especially after decomposition has advanced shows that the cave was perceived as a cemetery. It also suggests that the burial of an individual at this site held special importance to the inhabitants of the region, and probably also the maintenance of a long-term traditions directly traceable to the Early Natufian. But cemeteries are not particularly unusual for large Natufian sites in the Mediterranean zone. Most other Late Natufian Mediterranean sites of the same size also contain cemeteries, as does Hayonim Cave itself during the Early Natufian. It is likely, that as the occupation of Hayonim Cave declined with time, the inhabitants used the site for more specific purposes including human burial as well as for more mundane activities such as the seasonal extraction of plant resources. It appears, then, that Hayonim Cave remained a central hub despite apparent depopulation in the Late Natufian.

The changes in material culture, and the use of animal and plant resources from Hayonim Cave point to regional depopulation more than a categorical shift in site function. Indeed, the evidence suggests that the range of activities undertaken at the cave changed very little from the Early to the Late Natufian. It is clear that Hayonim Cave retained its role as a cemetery despite increases in human mobility, and that it continued to serve as a resource extraction site and hosted a broad range of activities, even if these activities were largely taking place on the Terrace. The site likely continued to be the burial site for the descendants of the same, though more mobile group of foragers.

CHAPTER 10: THE EARLY TO LATE NATUFIAN TRANSITION AND THE ORIGINS OF AGRICULTURE IN THE MEDITERRANEAN ZONE

INTRODUCTION

This chapter considers synchronic and diachronic variability in Natufian material culture and subsistence and settlement strategies in the Mediterranean Hills and surrounding areas. The objective is to establish the context of the faunal trends revealed in Chapters 7 and 8 to provide some independent assessments of the zooarchaeological interpretations. Though traditionally the Natufian culture is largely treated as a single unit, views are becoming increasingly dynamic as research expands and diachronic change is identified within the period in the Mediterranean zone and beyond (see Bar-Yosef and Valla 1979; Belfer-Cohen 1991b; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris 1987; Moore and Hillman 1992; Valla 1987).

Outlining cultural change within the Natufian period is also important for interpretations of agriculture origins. Because the Natufian period lasted for roughly 2500 years, refinements in our knowledge of both the Early and Late Natufian phases are required if the data are to comment on the origins of agriculture. The Natufian culture appears to have been directly involved in early cereal domestication, for example. The major period of cultural fluorescence in the Natufian seems to have taken place in the Early phase, though the Late Natufian phase is less well known and likely to reveal conditions relevant to the origins of agriculture in the area of the fertile crescent. Understanding human adaptations in the Late Natufian phase is thus central to constructing and evaluating current models of agricultural origins.

This chapter seeks to provide an integrated regional picture of Early and Late Natufian strategies with special reference to diachronic change in settlement, subsistence, demography, technological change, and their implications for models of the transition to agriculture. Data from sites outside the Mediterranean zone, specifically from the arid parts of southern Negev and Jordan, are included to comment on the relationship between the Mediterranean zone and neighboring areas.

THE EARLY TO LATE NATUFIAN TRANSITION IN THE MEDITERRANEAN ZONE

Because Natufian sites were sampled by different researchers using a variety of excavation strategies, it is not possible to accurately compare quantitative data for material classes among sites. At a few sites large exposures were excavated and sediment was meticulously screened, at others excavation was limited to small units or test trenches, and some sites were only surface collected. This resulted in the removal of vastly different volumes of sediment, and thus varying artifact sample sizes. Presence and absence data is thus introduced as a more reliable technique to compare material data classes among sites. Though presence/absence data is subject to some of the same flaws as quantitative data, if used cautiously it can potentially reveal trends in material culture.

Diachronic Variation in Natufian Material Culture

Recent research has exposed variation in aspects of settlement, subsistence and material culture in the Mediterranean zone and surrounding areas during the Natufian period (Bar-Yosef and Belfer-Cohen 1989, 1991; Bar-Yosef and Valla 1979; Belfer-Cohen 1988, 1991b; Belfer-Cohen and Bar-Yosef 2000; Byrd 1987; Garrod 1957; Goring-Morris 1995a; Valla 1987).

Lithics

Garrod's original definition of the Natufian culture was based on the presence of high proportions of lunate microliths (Garrod and Bate 1937). She further subdivided the Natufian into Upper and Lower phases according to the frequency of lunates with Helwan retouch. Since Garrod's time the Lower and Upper phases have been renamed the Early and Late Natufian, but her original criteria for phase definition remains unchanged. The frequency of Helwan retouch has proven extremely reliable for assigning relative ages within the Natufian period. In addition to changes in the frequency of Helwan retouch, a gradual decline in the average length of lunates over the course of the Natufian period has been proposed (Bar-Yosef and Valla 1979). In general, lunates from Early Natufian assemblages average more than 21 mm in length, while those from the Late Natufian average less than 20 mm. The decline in average length corresponds to the shift from Helwan to abrupt retouch.

Settlement Pattern and Site Occupation Intensity

With the onset of the Early Natufian, large residential sites were established at several locations in the Mediterranean hills of the southern Levant. These sites differ significantly from those of preceding periods in their large size, thick midden deposits, cemeteries, and diverse material culture. The sites have thus been referred to as "base camps" (Bar-Yosef 1970) and are one hallmark of the Early Natufian adaptation. The Natufian settlement strategy was more complex, however. Belfer-Cohen and Bar-Yosef (2000) argue for a dichotomy between large base camps in the Mediterranean area and smaller seasonal sites in the surrounding deserts and steppes during the Early Natufian. Site use changes abruptly with the onset of the Late Natufian. Occupation of many of the large base camps continued (i.e., Ain Mallaha, el-Wad and Hayonim Cave and Terrace), but the sites seem to have diminished in size and occupational intensity (Belfer-Cohen and Bar-Yosef 2000; Garrod and Bate 1937; Valla 1991). Numerous medium-sized seasonal camps spring up along the margins of the Mediterranean environment where it meets the Irano-Turanian steppes in the Jordan Valley (e.g., Salabiya I, Fazael IV), the Negev (e.g., Rosh Zin and Rosh Horesha) and south and east Jordan (e.g., Khallat 'Anaza, Ain el-Saratan, Taine Ain Rahub and others)(Bar-Yosef and Meadow 1995; Belfer-Cohen and Bar-Yosef 2000; Belfer-Cohen and Grosman 1997; Betts 1991; Byrd 1989a; Gebel and Muheisen 1985; Goring-Morris 1987; Grosman et al. 1999; Henry 1989, 1995). The difference between base camps and smaller seasonal sites is much less pronounced during the Late Natufian phase.

The base/seasonal camp division apparent for the Early Natufian may result partly from a research bias that has long favored research in the Mediterranean zone (see Byrd

1991; Byrd and Colledge 1991; Garrard 1991). Recent work in southern Jordan and the Negev has shown that many so-called marginal sites share more material characteristics with Mediterranean base camps than originally thought (i.e., architectural features, rich bone tool and groundstone assemblages). Many of these sites represent seasonal or possibly multi-seasonal occupations, yet none come close to the scale of occupation at the largest Early Natufian base camps in the Mediterranean zone (Byrd 1991; Byrd and Colledge 1991; Garrard 1991).

Architecture: Energy Investment into On-site Features and Facilities

The major episode of Natufian building in the Mediterranean zone occurred during the Early phase. Many medium to large circular structures were constructed at Ain Mallaha, Hayonim Cave, and Wadi Hammeh 27, as were the major pavements and retaining walls at el-Wad. Built hearths and stone slab pavements are common at most of the major base camps in the Early Natufian (see Table 10.1), although their distribution is restricted beyond these sites. Some structures and other features were constructed in the Mediterranean zone in the Late Natufian (e.g., at Ain Mallaha, Hayonim Terrace, Hilazon Tachtit and Nahal Oren), but with the possible exception of Ain Mallaha these are less substantial and required less energy investment than those of the Early phase (Bar-Yosef and Belfer-Cohen 1991; n.d., Grosman n.d.; Stekelis and Yizraely 1963; Valla 1991; Valla et al. 1998). Outside of the Mediterranean zone, however, building was actually more intensive during the Late Natufian phase and is associated with the appearance of larger, more significant sites than the Early Natufian phase in the same region. Round

SITE	Structures /Walls	Built Hearths	Slab Floors	Slab Graves	Reference
Early Natufian					
Hayonim Cave	++	++	++	+	Belfer-Cohen 1988
Hayonim Terrace	+	-	-	-	Henry et al. 1981
Ain Mallaha	++	++	++	-	Perrot 1966
el-Wad	+	+	+	-	Garrod and Bate 1937
Kebara	-	-	-	-	Turville-Petre 1932
Wadi Hammeh 27	+	-	-	-	Edwards 1991
Upper Besor VI	+	-	-	-	Horwitz and Goring-Morris 2000
Azariq XV	-	-	-	-	Goring-Morris 1987
Beidha	-	-	-	-	Byrd 1989a
Wadi Juyadid	-	-	-	-	Henry 1995
Tabaqa	-	-	-	-	Byrd and Colledge 1991
14/7 Black Desert	-	-	-	-	Betts 1982
Late Natufian					
Hayonim Cave	-	-	-	+	Belfer-Cohen 1988
Hayonim Terrace	+	+	-	-	Valla et al. 1991
Ain Mallaha	+	+	+	+	Perrot 1966; Valla et al. 1998
el-Wad	-	-	-	-	Garrod and Bate 1937
Nahal Oren	+	+	-	?	Noy et al. 1973
Hatoula	-	-	-	-	Ronen and Lechevallier 1991
Hilazon Tachtit	+	-	-	-	Grosman n.d.
Fazael IV	-	-	-	-	Grosman et al. 1999
Salibiya I	-	-	-	-	Belfer-Cohen and Grosman 1997
Upper Besor VI		-	-	-	Horwitz and Goring-Morris 2000
Rosh Zin	++	-	-	-	Henry 1976
Nahal Sekher	-	-	-	-	Goring-Morris and Bar-Yosef 1987
Rosh Horesha		-	-	-	Marks and Larson 1977
Wadi Humeima	-	-	-	-	Henry 1995
Jebel es-subhi	?	-	-	-	Betts 1991
Khallat 'Anaza	+	-	+	-	Betts 1987, 1991
Mugharet el-Jawa	-	-	-	-	Betts 1991
Ain el-Saratan	-	-	-	-	Garrard 1991
Taine Ain Rahub	+	?	?	-	Gebel and Muheisen 1985

Table 10.1: Built architectural features at Early and Late Natufian sites from the southern Levant. Please note: + is used to designate presence of a feature which could not be quantified; and ? is used when no information was available. Sites in the sample were excavated with different intensities and thus the lack of features in some sites may be due to small sample size. If a feature could not be assigned to either the Early or Late Natufian it was excluded from analysis.

subterranean structures were constructed at Rosh Horesha, Upper Besor VI, and Rosh Zin in the Negev during the Late Natufian (Henry 1976; Horwitz and Goring-Morris 2000; Marks and Larson 1977). Walls are also identified for the first time at seasonal camps in the Jordanian deserts during the Late Natufian (Betts 1987, 1991; Gebel and Muheisen 1985). Regardless of location, however, architecture from Late Natufian sites is still more ephemeral than the Early Natufian structures from the Mediterranean zone.

Graves

Over 250 published human burials from three major cemeteries at Hayonim Cave, el-Wad and Ain Mallaha provide a large data set for diachronic and synchronic comparisons (Belfer-Cohen 1988, 1995; Garrod and Bate 1937; Perrot and Ladiray 1988). Recent analyses of the burial data have identified four shifts in burial customs with the onset of the Late Natufian phase (see Belfer-Cohen 1988, 1991b; 1995; Belfer-Cohen et al. 1991; Byrd and Monahan 1995). Most of these are changes in the relative frequency of their occurrence and because of small sample sizes none is statistically significant in treatments of the data undertaken thus far.

First, decorated burials, though rare, are restricted to Early Natufian graves. Second, there is an increase in the proportion of individual burials versus group burials during the Late Natufian, though group burials are more common than single burials in both phases. Third, the ratio of secondary to primary burials increases during the Late Natufian. Most Early Natufian graves contain groups of individuals in primary context, but by the Late Natufian more graves are composed partially if not entirely of secondary burials. Finally, the practice of skull removal, which became widespread during the Early Neolithic originates in the Late Natufian. At Hayonim Cave all of the 13 primary burials from the Early Natufian include the cranium, but in the Late Natufian, 3 out of 5 primary burials were recovered without the cranium. Headless burials are restricted to the later Natufian phase at other sites as well, with examples from the latest phase of occupation at Ain Mallaha (Perrot and Ladiray 1988) and the Late Natufian deposits from Nahal Oren (Stekelis and Yizraely 1963) and Hayonim Terrace (Valla et al. 1986).

Plant Processing Equipment: Groundstone and Sickle Blades

Plant remains are extremely rarely preserved in Natufian sites. The relative abundance of plant processing equipment, including groundstone implements (mortars, pestles and hand stones) and sickle blades may provide indirect measures of human plant processing activities (Tables 10.2). Few direct associations between mortars and pestles and plant processing activities exist, but an acceleration in human dental attrition caused by more grit in human diets accompanies increasing frequencies of archaeological groundstone in sites from the Kebaran to the Neolithic periods (Smith 1972, 1991).

Ethnographic associations between groundstone and plant processing on a global scale provide a basis for this assumption (Wright 1991, 1994). Mortars and pestles likely served other functions as well, as indicated by the presence of ochre-stained fragments at Hayonim Cave and other Natufian sites. Experimental research has also revealed a strong association between sickle blades and plant processing during the Natufian. Repeated contact between the blade edge and silicates found in grass stems has been shown to leave a glossy sheen on the cutting edge of sickle blades (Anderson 1980; Anderson-Gerfaud 1983; Unger-Hamilton 1989, 1991).

SITE	Ground Stone	Sickle Blades	Reference
Early Natufian			
Hayonim Cave	+++	++	Belfer-Cohen 1988
Hayonim Terrace	+++	+	Henry et al. 1981
Ain Mallaha	+++	++	Perrot 1966
el-Wad	+++	++	Garrod and Bate 1937
Wadi Hammeh 27	+++	-	Edwards 1991
Upper Besor VI	+	n/a	Horwitz and Goring-Morris 2000
Beidha	+	+	Byrd 1989a
Wadi Juyadid	+	-	Henry 1995
Tabaqa	+	-	Byrd and Colledge 1991
14/7 Black Desert	-	+	Betts 1982
Late Natufian			
Hayonim Cave	+++	++	Belfer-Cohen 1988
Hayonim Terrace	+++	++	Valla et al. 1991
Ain Mallaha	+++	n/a	Perrot 1966; Valla et al. 1998
el-Wad	+++	++	Garrod and Bate 1937
Nahal Oren	+++	+	Noy et al. 1973; Stekelis and Yizraely 1963
Shuqba	n/a	++	Garrod and Bate 1928
Hatoula	-	+	Ronen and Lechevallier 1991
Hilazon Tachtit	++	+	Grosman n.d.
Fazael IV	++	++	Grosman et al. 1999
Salibiya I	++	+	Belfer-Cohen and Grosman 1997
Upper Besor VI	+	n/a	Horwitz and Goring-Morris 2000
Rosh Zin	++	+	Henry 1976
Nahal Sekher	+	n/a	Goring-Morris and Bar-Yosef 1987
Rosh Horesha	++	+	Marks and Larson 1977
Wadi Humeima	+	-	Henry 1995
Jebel es-subhi	-	-	Betts 1991
Khallat 'Anaza	+	+	Betts 1987, 1991
Mugharet el-Jawa	+	+	Betts 1991

Table 10.2: Distribution of groundstone artifacts and sickle blades at Early and Late Natufian sites. Pluses indicate presence of artifacts, minuses indicate absence of artifacts, and n/a (not applicable) indicates that no data was available. The number of pluses refers to the abundance and richness of the assemblages. Please note that the abundance and richness of the assemblages also correlates roughly with the volume of sediment excavated at each site. Those sites which were more intensively excavated tend to have larger assemblages. Groundstone is recorded up to three pluses, while sickle blades were recorded up to two pluses.

Groundstone and sickle blades are distributed similarly across Natufian sites (Table 10.2). The abundance of both tool types, though groundstone in particular, correlate strongly with site environment (Byrd 1989b; Wright 1994). Groundstone and sickle blades are most common in the Mediterranean area, the Jordan Valley, and in highland sites of the Negev. The only exception to this pattern is the site of Hatoula, where no groundstone was recovered from the Natufian layers. Many cup-holes were found in bedrock near the site, but these are believed to associate with the later PPNA levels (Ronen and Lechevallier 1991). All of the regions where groundstone and sickle blades are common were home to seasonal patches of cereal grasses in the Natufian period. The distribution of cereal grasses is restricted to areas that receive at least 200 millimeters of rainfall *per annum* (Hillman et al 1989). Although groundstone is also present at sites in the steppes and deserts of Jordan and the Negev lowlands, they are less common, as was the estimated natural abundance of cereals and nuts during much of the Natufian period. Grasses also grew in localized patches near springs, perennial water sources, or standing water in regions receiving less than 200 mm of annual precipitation. High aridity in steppe and desert regions of Jordan most likely resulted in very patchy distribution of grasses, unlike the neighboring Mediterranean zone where water and cereal grasses were widespread and abundant. It is certainly true that the Natufians may have transported some of their cereals with them and thus the distribution of groundstone is likely to extend beyond the distribution of cereals, however the frequency of groundstones in these situations are expected to be lower.

In general, sickle blades are common in Early and Late Natufian occupations from the Mediterranean zone and the Jordan Valley. Although the distribution of sickle blades at Natufian sites is similar to that of groundstone, a few anomalies exist. For example, some Natufian basecamps in the Mediterranean zone, such as the Early Natufian occupation at Hayonim Cave and the Late Natufian encampments at Hayonim Terrace and Hatoula, yielded only small quantities of sickle blades, as did sites from the Negev highlands. Byrd (1989b) notes similar patterns in the distribution of non-geometeric microliths, which are most common at his "cluster 1" sites located primarily in the Mediterranean zone and Jordan Valley. Non-geometric microliths have been found embedded in the grooves of sickle handles from the Natufian layers at Kebara Cave and Wadi Hammeh 27 (Edwards 1991; Turville-Petre 1932).

Though sample sizes vary, overall the distribution of both groundstone and sickle blades is strongly associated with availability of wild cereal grains during the Pleistocene (see also Wright 1994), and not at all with temporal divisions within the Natufian period. Abundant groundstone and sickle blades in both Early and Late Natufian sites in the Mediterranean hills attests to the importance of plant processing activities in the region throughout the Natufian period.

Beads, Decorated Artifacts, and Mobiliary Art

Table 10.3 records the presence and absence of Natufian art and ornament types at sites from the Mediterranean zone and surrounding regions. Data are insufficient to quantify each category, but the presence and absence data reveals a few obvious patterns. First, ornaments are present at nearly every Natufian site. The few sites that lack ornaments are those that were only surface collected or tested, thus their absence is probably attributable to excavation biases and small sample sizes. Ornamental mollusk shells, including *Dentalium* and other Mediterranean and Red Sea shells, are ubiquitous in all regions, even at the smallest campsites in arid environments. The distribution of other bead types is more variable. Stone beads occur frequently in the deserts and steppes, and a variety of bone bead types are found throughout the Mediterranean zone. This dichotomous pattern may be a partial product of poor bone survival in the arid environments of the Negev and Jordan in general.

EARLY NATUFIAN	**Dent.**	**Marine Shells**	**Bone/ Stone Bead**	**Engr. Slabs**	**Figurine**	**REFERENCE**
Hayonim Cave	+	+	+	+	-	Belfer-Cohen 1988
Hayonim Terrace	+	+	+	-	-	Henry et al. 1981
Ain Mallaha	+	+	+	+	+	Cauvin 1977, Reese 1991
el-Wad	+	+	+	+	+	Garrod and Bate 1937
Kebara	+	+	+	-	+	Tuville-Petre 1932, Reese 1991
Wadi Hammeh 27	+	+	+	+	+	Edwards 1991
Upper Besor VI	+	+	-	-	-	Goring-Morris and Bar-Yosef 1987
Azariq XV	+	+	-	-	-	Goring-Morris 1987
Beidha	+	+	-	-	-	Byrd 1989a
Wadi Juyadid	+	+	-	-	-	Henry 1995
Tabaqa	+	+	+	-	-	Byrd and Colledge 1991
14/7 Black Desert	-	-	-	-	-	Betts 1982
LATE NATUFIAN						
Hayonim Cave	+	+	+	+	-	Belfer-Cohen 1988
Hayonim Terrace	+	+	+	-	-	Valla et al. 1991
Ain Mallaha	+	+	+	+	+	Perrot 1966; Reese 1991
el-Wad	+	+	+	-	?	Garrod and Bate 1937
Nahal Oren	+	+	+	+	+	Noy 1991; Stekelis and Yizraely 1963
Hatoula	+	+	+	-	-	Ronen and Lechevallier 1991
Hilazon Tachtit	+	+	+	-	-	Grosman n.d.
Fazael IV	+	+	?	?	?	Grosman et al. 1999
Salibiya I	+	+	+	+	-	Belfer-Cohen and Grosman 1997
Upper Besor VI	+	+	-	+	-	Goring-Morris and Bar-Yosef 1987
Rosh Zin	+	+	+	+	-	Henry 1976
Nahal Sekher	+	+	-	-	-	Horwitz and Goring-Morris 2000
Rosh Horesha	+	+	+	-	-	Marks and Larson 1977
Wadi Humeima	+	+	-	-	-	Henry 1995
Khallat 'Anaza	+	+	+	-	-	Betts 1991
Ain el-Saratan	+	+	-	-	-	Garrard 1991

Table 10.3: Presence and absence of art and ornaments at Early and Late Natufian sites in the southern Levant. Dent. = *Dentalium*, Engr slabs = Engraved slabs.

During the Early Natufian in the Mediterranean region, a range of bone ornaments are common in and outside of graves, though styles vary dramatically in frequency from one site to the next (Belfer-Cohen 1988; Belfer-Cohen and Bar-Yosef 2000; Edwards 1991; Garrod and Bate 1937; Perrot 1966). For example, partridge tibiotarsus beads are common at Hayonim Cave but are either nonexistent or rare at most other sites (Belfer-Cohen 1991a). Paired oval bone beads recovered at el-Wad have rarely been found elsewhere (Garrod and Bate 1937), and only at Ain Mallaha are ornaments carved from distal gazelle phalanges the most common type (Perrot 1966), although they occur in very low frequencies at other Natufian base camps such as Hayonim Cave, el-Wad and Wadi Hammeh 27 (Belfer-Cohen 1988; Edwards et al. 1988; Garrod and Bate 1937). The frequency of non-shell ornaments drops off somewhat during the Late Natufian, but mostly because of the absence of ornaments in Late Natufian burial contexts. It is clear, however, that ornaments occur at virtually all Natufian sites, though the richest assemblages are found in the Mediterranean zone regardless of time period because these include the biggest sites of all.

A second trend in Natufian artwork is the restriction of engraved limestone slabs and carved figurines to the Mediterranean zone and its border with the semi-arid steppic zone. The figurines originate primarily from the Mount Carmel sites (Nahal Oren, Shuqba, el-Wad, and Kebara), but examples have been recovered from sites in the Judean Hills and at Ain Mallaha (Garrod and Bate 1928, 1937; Neuville 1951; Noy 1991; Noy et al. 1973; Perrot 1966). Trends in the distribution of mobiliary art adhere primarily to geographic rather than temporal differences. Artistic expression continues well into the Late Natufian, as evidenced by finely sculpted figurines from Nahal Oren and engraved limestone slabs from the Negev (Horwitz and Goring-Morris 2000; Marks and Larson 1977; Noy 1991).

Summary of Cultural Change in the Natufian Period

Variation in material culture during the Natufian period corresponds primarily to geography (Byrd 1989b) rather than temporal change. It is of particular interest that the expression of Natufian culture remained largely unchanged across the duration of the period, despite decreased population density and increased mobility during the Late Natufian phase (see conclusions). A few cultural changes, namely those associated with aspects of settlement strategy -- population mobility and site use intensity -- however, correspond to the Early/Late Natufian division. For example, though sample sizes are small, changes in burial practices have been interpreted by Natufian researchers as signals of decreased site permanence and increased mobility during the Late Natufian phase (Belfer-Cohen 1988, 1991b; Belfer-Cohen and Bar-Yosef 2000; Perrot 1966; Perrot and Ladiray 1988; Valla 1998). High numbers of secondary burials appear to have been created by the addition of disarticulated humans to pre-existing graves. At Hayonim Cave many of the secondary graves include both primary and secondary interments, with the primary interments located at the bottom of the grave. If secondary burials were created only by later disturbance by other humans searching for a place to bury their dead, the most recent additions, or those interred near the top of the grave are more likely to be in primary position. Available evidence suggests that the individuals interred during the Late Natufian were already disarticulated at the time of burial. Scholars have thus argued that most individuals who were secondarily interred did not die at the site, but rather died earlier and were transported there from elsewhere (Belfer-Cohen and Bar-Yosef 2000; Belfer-Cohen 1988; Byrd and Monahan 1995; Perrot and Ladiray 1988). This interpretation may also account for the lack of decorated burials in the Late Natufian because ornaments are more likely to be buried with primary interments, when individuals are fleshed and can be buried with clothing, headdresses or other attire (Belfer-Cohen and Bar-Yosef 2000). The changes in Natufian burial customs suggest that populations were occupying base camps for shorter intervals during the Late Natufian. Though a few Late Natufian individuals were buried in primary context, attesting to the continued occupation of these sites, individuals generally appear to have been less likely to die and receive primary burial on site (Belfer-Cohen 1988, 1991b; Belfer-Cohen et al. 1991).

The fluorescence of artistic expression during the Early Natufian in comparison to preceding periods in the southern Levant has been interpreted as a reaction to social stress brought on by more intensive human interactions in the context of increased sedentism (Bar-Yosef and Belfer-Cohen 1991b; Belfer-Cohen and Bar-Yosef 2000). Artistic expression may have developed in response to the need to demonstrate group affiliation, increased territoriality linked to rich cereal habitats, and associated increases in competition between communities. The need to express group cohesion is suggested by distinct stylistic variation in ornaments, mobiliary art, and decorated utilitarian artifacts (i.e., basalt mortars and sickle handles) among Natufian sites in the core area (Belfer-Cohen 1991b). The artistic repertoire may have declined slightly during the Late Natufian, but art and ornaments continued to play an important role in Natufian social identity. Stylistic differentiation between sites remained constant over great spans of time suggesting that groups maintained their territorial ties across the Early to Late Natufian transition despite changes in mobility. This point is of particular importance since it suggests that the Natufians may have faced similar degrees of territorial circumscription in the Early and the Late Natufian phase.

Faunal Indicators of Regional Resource Use in the Mediterranean Zone

The following section compiles multiple lines of faunal data relevant to regional patterns of settlement, subsistence and demography during the Early and Late Natufian phases. In particular, three kinds of faunal evidence are expected to inform us about the intensity of prey exploitation (see Chapter 1, 7 and 8). These are the proportion of large to small game animals in human diets, the age profiles of hunted gazelles, and the average body size of tortoise exploited populations.

Relative Proportion of Large to Small Prey

Without question the gazelle is the single most important ungulate species of the Natufian period. Gazelle dominate the majority of faunal assemblages in sheer quantity of meat throughout the Natufian period, particularly in the Mediterranean region (see Table 10.4) where the Natufian dependence on gazelle is ubiquitous and does not change from the Early to the Late phase. The proportion of ungulate species captured by Natufian hunters was partially determined by local availability and thus influenced by environmental conditions. The only site in which gazelles had reduced importance is Ain Mallaha, located in a riparian habitat that likely supported different animal communities than the surrounding Mediterranean forest. Other ungulate species, in particular wild goat (*Capra aegegrus*), played more important roles in human diets in arid regions of the Jordanian and Negev deserts (Table 10.4).

Early Natufian	**G.g.**	**Ov/cp**	**Bp**	**Cc**	**Dm**	**Ce**	**Cerv**	**Ss**	**Eq**	**Ab**	**NISP**	**REFERENCE**
Hayonim Cave	88.0	1.0	1.0	<1	3.0	1.0	2.0	1.0	0.0	0.0	**1677**	This study
Hayonim Terrace	83.3	0.5	0.1	1.1	14.2	0.1	0.0	0.9	0.0	0.0	**4522**	Henry et al. 1981
Ain Mallaha	63.8	5.9	5.2	8.0	6.7	4.2	0.0	6.2	0.0	0.0	**713**	Bouchud 1987
Kebara Cave	48.2	0.0	14.3	1.8	1.9	3.6	10.7	10.7	3.6	10.7	**56**	Saxon 1974
Wadi Hammeh 27	82.7	7.9	0.5	0.9	0.5	0.5	0.0	5.6	0.9	0.0	**215**	Edwards 1991
Fazael VI	76.8	3.7	1.2	0.0	0.0	0.0	12.2	6.1	0.0	0.0	**82**	Horwitz and Tchernov 2000
Upper Besor VI	65.0	26.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	**138**	Horwitz and Goring-Morris 2000
Beidha	21.7	69.8	6.2	0.0	0.0	0.0	0.0	0.0	2.3	0.0	**129**	Hecker 1989
Wadi Juyadid	17.6	66.3	6.2	0.0	0.0	0.0	0.0	0.0	9.8	0.0	**193**	Henry and Turnbull 1985
Wadi Mataha B	27.1	71.9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	**199**	Baadsgaard 2000
LATE NATUF												
Hayonim Cave	87.0	1.0	<1	<1	3.0	1.0	3.0	4.0	<1	0.0	**1010**	This study
Hayonim Terrace	95.0	<1	2.0	<1	1.0	<1	0.0	1.0	0.0	0.0	**4483**	This study
Ain Mallaha	47.4	3.8	5.6	10.3	9.0	9.4	0.0	14.5	0.0	0.0	**941**	Bouchud 1987
Nahal Oren	83.3	0.2	9.2	0.7	2.6	0.1	0.0	3.9	0.0	0.0	**1846**	Noy et al. 1973
Hatoula	97.8	0.3	0.6	0.0	0.0	0.0	0.0	0.6	0.0	0.7	**2340**	Davis 1985
Hilazon Tachtit	92.0	2.0	1.0	0.0	1.0	0.0	2.0	3.0	<1	0.0	**393**	This study
Salibiya I	89.4	1.6	0.9	0.0	2.2	0.0	0.0	5.9	0.0	0.0	**320**	Crabtree et al. 1991
Rosh Horesha	60.7	37.4	0.1	0.0	0.0	0.0	0.0	0.0	1.8	0.0	**977**	Butler et al. 1977
Khallat 'Anaza	25.9	66.7	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0	**27**	Byrd 1989b
Ain al Saratan	24.5	0.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	37.6	**237**	Byrd 1989b
Wadi Mataha C	33.3	60.8	4.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	**273**	Baadsgaard 2000

Table 10.4 Proportion of ungulate species represented in Natufian faunas. Gg = *Gazella gazella*, Ov/cp = Ovids and Caprids, Bp = *Bos primigenius*, Cc = *Capreolus capreolus*, Dm = *Dama mesopotamica*, Ce = *Cervus elaphus*, *Cerv = Cervidae, Eq = Equus sp., Ab = Alcephalus bucephalus*.

Despite their general dominance in the Natufian period, the ratio of gazelles in relation to small prey decrease markedly by the Early Natufian (Munro 1999; Stiner *et al.*

1999, 2000). The routine capture of a diverse array of small reptile, bird and mammal species has long been recognized in Natufian assemblages (cf. Bar-Yosef and Belfer-Cohen 1989; Byrd 1989b; Davis et al. 1994; Tchernov 1993a, 1993b) and is generally consistent with the prediction of Flannery's (1969) Broad Spectrum Revolution (BSR) hypothesis. Recently, several researchers have questioned the value of the BSR hypothesis, arguing that prey diversity changes little from the Middle Paleolithic to the Natufian period (Bar-Oz et al. 1999; Neely and Clark 1993; Edwards 1989). Nonetheless, the high proportions of small game quantified at Hayonim Cave, Hayonim Terrace, el-Wad, and Hilazon Tachtit in this study far exceed proportions in all earlier Paleolithic assemblages (see Figures 7.1 and 7.13), and there is a demonstrable trend toward more even dependence on the three categories of small prey, an indication of expanding dietary breadth. Stiner et al. (1999, 2000) show that small game, particularly slow-moving or sessile types, were important contributors to Paleolithic diets in the Mediterranean region from the Mousterian onward. Birds become important prey during the early Upper Paleolithic, but the proportion of quick small game in human diets --birds and hares -- increased most dramatically in the Natufian period (see Figures 7.1 and 7.2 for the Wadi Meged sequence). The small size of the new prey precluded them from replacing ungulates as the primary meat source, but high relative abundance indicate an increasing human dependence on lower-ranked small resources in habitats directly surrounding Mediterranean Natufian sites (see Figure 7.1). Unfortunately, the abundance of the full suite of small game species is rarely quantified thoroughly in Natufian assemblages (but see Pichon 1984; 1991; Tchernov 1993a), but hopefully more ambitious inter-site comparisons will become possible in the future.

Although diversity measures based on species-based counts have failed to detect it, clearly something was up with small game use towards the end of the Late Pleistocene. Part of the problem appears to be the level of inquiry, that is the tools used to detect change. How we rank prey and define the "broad spectrum economy" strongly affects the patterns we identify in the archaeological record. Recently Stiner (2001; Stiner et al. 1999, 2000) has argued that small prey should be grouped and ranked according to their predator evasion strategies (slow-moving, high-ranked small game types such as tortoises and many shellfish; fast low-ranked birds; and fast low-ranked small mammals), and then measured for evenness among types. When this technique is applied to Paleolithic faunas from the circum-Mediterranean region, it is clear that diets began to expand from the Upper Paleolithic onward, but most of all in the Natufian. Natufian faunas generally stand apart from earlier assemblages in the remarkable evenness in small game types when ranked by cost of capture. Yet this pattern is not true of every Natufian assemblage: it is most apparent in the large sites of the Mediterranean zone of the Early Natufian phase. The balance of small game types declines after the transition to the Late Natufian, returning in scale to that observed for the Epipaleolithic Kebaran.

Gazelle Mortality Profiles

As first argued by Davis (1983), and confirmed in many Natufian assemblages considered in Chapter 8 (see Table 8.2), the mortality profiles of gazelles from

Mediterranean Natufian sites show consistently high proportions of juveniles, particularly in comparison to earlier Paleolithic assemblages. The strong juvenile bias in Natufian assemblages crosscuts many other archaeological variables, including site size and time period. In Chapter 8 it was shown that inflated proportions of juveniles are expected in prey populations subjected to persistent, heavy hunting pressure. The greater the harvesting pressure, the more pronounced the expected juvenile bias. This is not the only way juvenile bias can come about (i.e., Nunamiut skin hunting in spring, Binford 1978, Stiner 1990), but in the Natufian case it occurs everywhere and all of the time, indicating sweeping change in predator-prey relationships for the entire period. This exploitation pattern was not sufficient to drive gazelles to extinction -- they shifted instead to a remarkable variety of other resources -- some with great intensity such as hares and cereals.

Average Body Size of Hunted Tortoise Populations

Like the age profiles of gazelles, the average body size of hunted tortoise provides an indirect indication of human harvesting pressure, since large specimens are both more visible and expected to be preferred when encountered. Because individual tortoises and their populations grow very slowly, increased harvesting pressure is expected to cause a reduction in the average body size of tortoise populations (see Chapter 8). Trends in tortoise body size were investigated earlier using the minimum medio-lateral breadth of the humeral shaft, which preserves well in the archaeological record. Measurements of the average breadth of tortoise humeri are available for only a few Natufian sites, but the sample includes the Early and Late phases from Hayonim Cave and the Late phase at Hilazon Tachtit. Comparative measurements are also available for the entire Paleolithic sequence of occupation at Hayonim Cave, and the Kebaran layers from Meged Rock Shelter (Stiner et al. 1999, 2000). The results show that the average breadth of tortoise humeri from Natufian assemblages are similar regardless of their origin in the Early or Late phase, Natufian tortoises as a group are also somewhat smaller than those from all preceding Paleolithic assemblages (see Figure 8.11). This means that the minimum pressure required to keep them small was continuous throughout the Natufian period.

Implications of Resource Pressure During the Natufian Period

The three lines of faunal evidence reviewed above point to two major conclusions. First, Natufian hunters in the Mediterranean zone exerted sufficient pressure on high-ranked prey (tortoises and gazelle) to affect, though not destroy, their populations on a regional scale. Second, human hunting pressure on high-ranked prey populations was stable throughout the Natufian period. It was not reduced in response to increases in population mobility during the Late Natufian phase. Evidence for greater mobility among small game types in the Late Natufian instead comes from a rising emphasis on tortoise, among small game types, in contrast to the situation in the Early Natufian, but much like that of the Kebaran.

The depression of gazelle populations -- a decrease in the average age of hunted gazelles in the Mediterranean area in comparison to preceding Paleolithic periods -- co-occurs with a decrease in their relative abundance in comparison to prey species in

Natufian archaeofaunas. Increased proportions of small game indicate that the Natufians were meeting more of their meat requirements with animals available in the local environments immediately surrounding their habitation sites. This suggests that during the Natufian the cost/benefit ratio of acquiring ungulate species increased in relation to that of capturing small local prey. Search costs for gazelles rose owing to decreased availability and/or constraints imposed by territorial restrictions created by human social or ecological pressures. The high percentages of juvenile gazelles at many core Natufian sites indicate depression of gazelle populations on a regional scale. The proportions of juveniles indicate that gazelle populations were pushed into a state of continuous growth, an extreme condition, suggesting that average annual mortality was higher than in preceding Paleolithic periods. Other possible explanations were discounted in Chapter 8.

Finally, the depression of tortoise populations is also indicated by a small decrease in the average body size of Natufian tortoises from Hayonim Cave and nearby sites in comparison to earlier Paleolithic periods (see Figure 8.11). The stability in average tortoise body size across the climatic extremes of the Younger Dryas indicates that climatic change is not responsible for sustained diminution. The reduction in body size is instead interpreted as a signal of sustained predator pressure on tortoise populations throughout the Natufian period. The implications for tortoise size reduction are more geographically localized than the age data for gazelles, however, since tortoises live out their lives in smaller areas. People continued to take tortoises whenever possible. Of great interest in the Natufian case is the point at which foragers had to switch to other small game. The proportion of tortoises to quick small game increases in the Late Natufian sites, meaning less intensive site occupation and associated increases in human population mobility. Ultimately, it is a shift in the relative frequencies of tortoises among small game that provides the key to understanding major population shifts in the Late Natufian.

No evidence for the absolute intensity of plant exploitation is available. Increases in the proportion and diversity of groundstone, the introduction of sickle blades, and a marked increase in the attrition of human teeth, at least in comparison to Mousterian populations (Smith 1991), indicate that the Natufians increased their dependence on small, labor-intensive plant resources such as cereals and nuts. Though the intensive use of local plant resources ultimately allows increased energy yields per unit area, a significant decrease in foraging efficiency should be experienced (Wright 1994), since more energy must be invested for each unit of energy returned. Similarities between Early and Late Natufian groundstone and sickle blade assemblages suggest that the intensity of plant exploitation was roughly the same in the Early and Late phases. The difference between the Early and Late Natufian is principally one of declining human population density.

It has been suggested that fairly intensive occupation continued in the Mediterranean zone during the Late Natufian (Bar-Yosef and Belfer-Cohen 1989, 1991b; Henry 1989, but compare Belfer-Cohen 1991b; Belfer-Cohen and Bar-Yosef 2000; Byrd and Monahan 1995). Though Mediterranean camps most likely continued to be more intensively occupied than those in surrounding areas, the results presented here suggest a clear reduction in the intensity of site use during the Late Natufian at least at in the Mediterranean zone. There are no examples of Late Natufian sites in the core area or elsewhere in the southern Levant that match the intensity of Early Natufian occupations at Mediterranean base camps (e.g., Ain Mallaha, Hayonim Cave, el-Wad).

INTERPRETATIONS OF THE NATUFIAN ADAPTATION AND THE ORIGINS OF AGRICULTURE

This research has generated a series of hypotheses on human demography, site use intensity, hunting pressure, and settlement and subsistence strategies during the Natufian period. Most importantly, it provides an empirical test based foremost on the relative proportions of small game animals that can distinguish variation in human site occupation intensity, diachronic and synchronic shifts in human demography within the Natufian period, and its implications for many other facets of cultural change.

The preceding archaeological evidence and published interpretations encourage a synthesis of current hypotheses on cultural change within the Natufian period. Together, the evidence presented above demonstrates three general trends. First, there is a decrease in site use intensity from the Early to the Late Natufian phase, particularly within the core Mediterranean area. This interpretation is supported by the return to a nearly exclusive focus on high-ranked game (tortoises and gazelles), changes in internal site organization, and a reduced investment in architecture and other built features at the Late Natufian base camps. A second, related implication is the shift toward increased mobility during the Late Natufian phase in the Mediterranean area. This interpretation is based primarily on changes in settlement pattern, including the founding of new settlements along the border of the Mediterranean zone (Bar-Yosef and Meadow 1995; Goring-Morris 1987), and on evidence for reduced site use intensity. These two conclusions have also recently been proposed by researchers studying other Natufian data classes such as graves, and settlement patterns (Bar-Yosef and Belfer-Cohen n.d.; Belfer-Cohen 1988, 1995; Belfer-Cohen et al. 1991; Byrd and Monahan 1995; Valla 1998). Third, the data on resource extraction indicates that the Natufians intensively harvested wild plants and animals. Pressure was exerted to the point of causing resource depression in high-ranked, prey species (gazelles and tortoises). Although little direct evidence for plant exploitation exists, secondary evidence provided by plant harvesting equipment suggests that the Natufians invested significant amounts of energy to collect and prepare small, energy rich foods such as grains and nuts for consumption. Of particular interest in the case of both floral and faunal resources is the tenacity of the Natufian subsistence system in the face of strong climatic fluctuations and settlement change from beginning to end. These observations have important implications for understanding the nature of the Natufian adaptation and the transition to agriculture.

Was there Population Growth in the Early Natufian?

In the Early Natufian, the Mediterranean forest was at its maximum extent, and the potential productivity (i.e., in consumable calories per unit area) of the southern

Levant reached unprecedented levels for the Late Paleolithic. Moreover, Early Natufian groups invested more in specialized resource extraction than ever before with the aid of plant processing equipment (e.g., groundstone and sickles) and perhaps new hunting technologies. Together the evidence indicates a remarkable increase in the procurement of consumable energy by unit area in the Mediterranean zone and in the southern Levant in general. This must reflect increased energetic demands from what could only be large, dense human populations who could not meet their needs simply by moving to new areas. In fact, in the Early Natufian phase, the southern Levant likely supported the densest and -- because of greatly expanded Mediterranean habitats -- probably the highest gross population sizes the region had seen to this point. Human populations must have undergone a growth spurt in the Epipaleolithic, most likely beginning in the Geometric Kebaran that accelerated with the onset of the Early Natufian phase.

Why did human population density increase during the Late Epipaleolithic? First, the expansion of the Mediterranean belt beginning ca. 14,500 BP in response to a warm, wet climatic regime greatly improved the region's productivity. This, however, was not the first time in prehistory that the Mediterranean forest expanded, and pulses of population growth do not coincide with each favorable period (Stiner et al. 1999, 2000). Instead, it was the combined effect of broadening habitats and the availability of technologies that facilitated the extraction of spatially concentrated, yet previously untapped resources, that greatly increased the carrying capacity of the region. In general, as carrying capacity increases for any reason, the density-dependent sources of mortality that act on stable populations relax, allowing for population growth. Populations may thus experience new potential for largely unrestrained growth until they again approach the heightened carrying capacity ceiling, when density-dependent population controls take effect (Caughley 1977). One must ask why carrying capacity of environments were raised via technology. This is not the subject of this dissertation, but is necessary if we for determining why the Early Natufians intensified resource use, particularly under favorable climatic conditions.

Why human populations chose to settle in more permanent villages and adopt intensive foraging regimes during the Early Natufian is a more complex problem. Certainly, site permanence, high population density, and intensive foraging modes are casually linked, but which came first or how they influenced one another in the Natufian case is more difficult to resolve. Settling down to invest in the labor-intensive harvest of small food packages is an expensive enterprise. Foragers are not expected to choose such options unless mobility is already compromised. Resource demands often exceed the availability of high-ranked resources but population decline is the most common result in animal (and human) populations. Exceptional human population packing and territorial circumscription according to all lines of evidence presented here, undoubtedly characterized the cultural context in the Early Natufian Levant. The Early Natufian clearly was a period in which environmental carrying capacity was effectively raised to a new level. Just how and why remain largely in the realm of speculation.

Was There Depopulation in the Late Natufian?

Relative changes in prey abundance in Late Natufian contexts indicate that human groups met their demands for meat almost exclusively with high-ranked game. The poor resilience and depressed state of these prey populations (e.g., tortoises and gazelles) in the Late Natufian means that this strategy could only have been effective if there were also dramatic reductions in site occupation intensity. Forager mobility is closely linked to the productivity of local resources (Kelly 1995). The productivity and geographic extent of the Mediterranean forest contracted with the onset of the Younger Dryas, so Natufian foragers were forced to move more frequently and/or travel in smaller groups than they had in the Early Natufian. The only other viable solution to food stress brought on by deteriorating conditions would have been resource intensification in which these people were already engaged in several resource dimensions. Heavy plant processing equipment remain common at Late Natufian sites, and it is clear that human groups did not abandon the exploitation of seeds and nuts, modes that had sustained their populations in the Early Natufian. By this time, wild resource extraction was already pushed to its limits, and probably could not have been intensified further without agriculture. The Late Natufians, however, did not, as far as we know, turn to agriculture at this point, but instead relied on adjustments in settlement strategy to combat growing pressure added by the climate deterioration of the Younger Dryas. Increased mobility and reduced site occupation intensity could not have been successful under Late Natufian conditions without an associated drop in human population density. This is the partial depopulation of the region ca 11,000 B.P.

Late Natufian depopulation of the Mediterranean zone must have occurred via reduced population growth rates, population emigration, or both. Imperceptible changes in population growth rates most likely occurred from year to year as human populations naturally adjusted to climate-induced declines in environmental carrying capacity. Some population movement may have also occurred as conditions worsened, possibly to surrounding regions, but arid zones could not absolve all of the populations stress. An expansion in the number of small to medium Natufian sites in the deserts of Jordan and the Negev -- habitats which may not have been hit as hard by the Younger Dryas as the Mediterranean zone -- does occur in the Late Natufian. Some of this expansion may have been fed by populations from the Mediterranean zone. Overall, the evidence presented here does not suggest that the Late Natufian adaptation was a failed one at all, but rather represented a flexible solution to worsening environmental conditions at the end of the Pleistocene.

A Role in Agricultural Origins?

Intensive resource use by Natufian foragers suggests that they experienced continuous, low-grade population pressure across the duration of the period, even in the face of major environmental change and population reduction. The constant intensity of this pressure on several resource classes throughout the Natufian has major implications for models of agricultural origins. First, there is no good evidence that the Natufians responded to potential food stress brought on by the Younger Dryas by further intensifying resource use or by adopting agriculture. Indeed, the results of this study suggest that human population size in the Late Natufian shrank, then restabilized at a lower carrying capacity and remained there for at least five to seven hundred years. It is important to distinguish here between changes in carrying capacity associated with technological change (as in the Early Natufian) and that provoked directly by climate change (as in the Late Natufian).

The Natufian culture saw its cultural heyday during the Early phase of the period. By 11,000 B.P. things began to slow down -- most of the traits that epitomize the Natufian culture persist into the Late Natufian, but the intensity of their expression declines. One of the most remarkable developments in the Natufian that no doubt contributed to the evolution of the agricultural adaptation was the manipulation of cereals. To the north, however, the picture in the Late Epipaleolithic is somewhat different. Sites in less explored regions such as the Euphrates valley (e.g., Abu Hureyra and Mureybet) and southeastern Anatolia (e.g., Hallan Çemi) provide evidence for intensification through the remainder of the Epipaleolithic period (Cauvin 1978; Cauvin and Watkins 2000; Moore 1991; Rosenberg et al. 1998).

The conditions of the Younger Dryas did not encourage an immediate agricultural solution to resource stress in the southern Levant. The importance of this period for agricultural origins instead lies in the presence of constant resource pressure which undoubtedly encouraged pre-adaptations to cereal "management" (i.e., the manipulation of resource productivity) in the region. The Natufians may have played a direct role in cereal domestication by initiating the first experiments. When conditions did improve ca. 10,000 B.P. cereal agriculture was adopted immediately. Other facets of the Neolithic, however, may have originated elsewhere, perhaps to the north. These traits eventually merge into a more geographically uniform adaptation (the Neolithic). The general tendency to manipulate the growth conditions of staple animal and plant resources is central to the success of the Neolithic adaptation, and explain much about its origins. The unique properties and biogeography of animals and plants involved in this process had great influence over which species were the most successful domesticates (i.e., wheat, barley and sheep/goat; Garrard 1984), and determined the geographic origin of the primary components of the Neolithic economy.

APPENDIX 1: NISP OF SAMPLED NATUFIAN ASSEMBLAGES

GEN. CATEGORY	TAXON	HAYC	HAYT	HLZT	ELWD
Pices	**Indeterminate**	32	10	8	n/a
Reptilia	***Agama stellio***	212	117	10	n/a
	Ophisaurus apodus	62	74	4	n/a
	Testudo graeca	4793	3483	848	247
Aves	**Aves Assigned to Species**	1688	135	69	0
General Aves	**Small Aves**	28	0	0	8
	Medium Aves	620	43	27	215
	Large Aves	112	7	3	70
	Huge Aves	26	0	0	16
Mammalia	***Erinaceus europaeus***	21	2	3	0
Small Mammals	***Lepus capensis***	2219	630	44	536
	Sciurus anomalous	28	0	0	0
	Procavia sp.	2	0	0	0
Carnivora	**Indeterminate**	152	191	21	0
	Panthera pardus	5	0	0	0
	Felis cf chaus	115	39	12	0
	Ursus arctos	0	0	0	1
	Canis aureus	4	0	0	0
	Canis sp.	6	9	6	15
	Vulpes vulpes	294	153	30	32
	Meles meles	38	16	1	2
	Martes foina	42	11	10	7
	Vormela peregusna	24	3	2	0
	Mustelidae	18	8	4	0
Ungulata	***Capreolus capreolus***	8	1	0	2
	Dama mesopotamica	80	55	2	124
	Cervus elaphus	39	9	0	12
	Cervidae	81	0	7	7
	Gazella gazella	2602	4249	362	654
	Capra aegegrus	26	19	7	7
	Bos primigenius	19	78	2	0
	Sus scrofa	98	51	12	18
	Equus cf. hemionus	0	0	1	0
	Equus cf. caballus	1	0	0	0
General Ungulates	**Small Ungulate**	1716	357	289	519
	Medium Ungulate	151	132	9	90
	Large Ungulate	33	11	4	0
General Mammalia	**Small Mammal**	677	94	76	2
	Medium Mammal	679	75	131	14
	Large Mammal	63	1	6	2
	TOTAL	**16814**	**10063**	**2010**	**2600**

Table A: NISP counts of all identified taxa in assemblages studied from Hayonim Cave (HAYC), Hayonim Terrace (HAYT), Hilazon Tachtit (HLZT) and El Wad (ELWD). Only general avian categories are included in this table, for a species-specific list see Table B below.

APPENDIX 1 - *Continued*

ORDER	TAXON	HAYC	HAYT	HLZT	ELWD
Anseriformes	***Anser sp.***	2	0	0	0
	Anas sp.	2	0	1	0
Falconiformes	***Indeterminate***	215	81	18	0
	Aquila chrysaetos	6	0	0	0
	Accipiter nisus	39	0	0	0
	Buteo buteo	157	0	5	0
	Falco tinnunculus	3	0	0	0
	Falco subbuteo	1	0	0	0
	Gyps fulvus	2	0	0	0
	Aegypius monachus	2	0	0	0
	Neophron percnopterus	1	0	0	0
	Indet. Vulture	5	0	0	0
Phasinidae	**Indeterminate**	6	0	0	0
	Alectoris chukar	1154	53	41	0
	Coturnix coturnix	14	0	1	0
Gruiformes	***Rallus aquaticus***	3	0	0	0
	Fulica atra	9	0	0	0
	Otis tetrax	1	0	0	0
	Otis tarda	18	0	0	0
	Vanellus vanellus	1	0	0	0
	Crex crex	4	0	0	0
	Grus grus	3	0	0	0
	Gallinula chloropus	1	0	0	0
Columbiformes	**Indeterminate**	1	0	0	0
	Columba livia	12	0	2	0
	Columba palumbus	1	0	0	0
Strigiformes	***Indeterminate***	0	1	1	0
	Asio otus	1	0	0	0
	Athene noctua	1	0	0	0
	Tyto alba	3	0	0	0
	Otus scops	1	0	0	0
Passeriformes	**Indeterminate**	5	0	0	0
	Corvus monedula	2	0	0	0
	Corvus carone	1	0	0	0
	Pica pica	2	0	0	0
	Alauda arvensis	6	0	0	0
	Garullus sp.	3	0	0	0
General Aves	**Small Aves**	28	0	0	8
	Medium Aves	620	43	27	215
	Large Aves	112	7	3	70
	Huge Aves	26	0	0	16
	TOTAL AVES	**2474**	**185**	**99**	**309**

Table B: NISP counts of avifauna from Hayonim Cave (HAYC), Hayonim Terrace (HAYT), Hilazon Tachtit (HLZT) and El Wad (ELWD). Note that birds from some sites were assigned to a more specific taxa than others due to time constraints. The absence of a species, does not necessarily mean that it was not present in the assemblage, it may instead have been assigned to a more general body size category.

APPENDIX 2: POTENTIALLY MIXED CONTEXTS AT HAYONIM CAVE

ROW	SQUARE	SUBSQ	SUBSQ B	SUBSQ C	SUBSQD
21	ALL	ALL	ALL	ALL	ALL
22	ALL	ALL	ALL	ALL	ALL
23	F23	ALL	ALL	ALL	ALL
	G23	ALL	ALL	ALL	ALL
	H23	ALL	ALL	ALL	ALL
	I23	ALL	ALL	ALL	ALL
	J23	ALL	ALL	ALL	ALL
	K23	ALL	ALL	ALL	ALL
	L23	ALL	ALL	ALL	ALL
	M23	<170, >215	<170, >215	<170, >215	<170, >215
	N23	<170, >215	<170, >215	<170, >215	<170, >215
	O23	<170, >210	<170, >210	<170, >210	<170, >210
24	I24	ALL	ALL	ALL	ALL
	J24	<168, >265	<168, >265	<168, >265	<168, >265
	K24	<180, >265	<180, >265	<180, >245	<180, >245
	L24	>230	>230	>230	>230
	M24	<170, >215	<170, >215	<170, >215	<170, >215
	N24	<170, >215	<170, >215	<170, >215	<170, >215
	O24	<170, >210	<170, >210	<170, >210	<170, >210
25	G25	<185, >270	<185, >270	<185, >270	<185, >270
	H25	<185, >270	<185, >270	<185, >270	<185, >270
	I25	<185, >270	<185, >270	<185, >270	<185, >270
	J25	<180, >265	<180, >265	<180, >265	<180, >265
	K25	<180, >265	<180, >265	<180, >265	<180, >265
	L25	<180, >265	<180, >265	<180, >265	<180, >265
	M25	<170, >215	<170, >215	<170, >215	<170, >215
	N25	<170, >215	<170, >215	<170, >215	<170, >215
	O25	<170, >210	<170, >210	<170, >210	<170, >210
26	G26	<185, >270	<185, >270	<185, >270	<185, >270
	H26	<185, >270	<185, >270	<185, >270	<185, >270
	I26	<185, >270	<185, >270	<185, >270	<185, >270
	J26	<180, >265	<180, >265	<180, >265	<180, >265
	K26	<180, >265	<180, >265	<180, >265	<180, >265
	L26	<180, >265	<180, >265	<180, >265	<180, >265
	M26	<175	>175	>175	>175
	N26	<140	<140	<140	<140
	O26	<145	<145	<145	<145
	P26	<145	<145	<145	<145
27	G27	<185, >270	<160, >275	<185, >270	<160, >275
	H27	<160, >270	<160, >270	<160, >270	<160, >270
	I27	<160, >270	<160, >270	<160, >270	<160, >270

Appendix 2: Potentially mixed contexts from Hayonim Cave continues on next page.

APPENDIX 2 - *continued*

ROW	SQUARE	SUBSQ	SUBSQ B	SUBSQ C	SUBSQD
	J27	<150, >270	<150, >265	<160, >270	<150, >275
	K27	<175, >265	<175, >265	<175, >265	<175, >265
	L27	<175, >265	<175, >265	<175, >265	<175, >265
	M27	<180, >220	<180, >220	<180, >220	<180, >220
	N27	<180, >225	>150, <220	<180, 225	>150, <220
	O27	<145	<145	<145	<145
	P27	<145	<145	<145	<145
	Q27	<145	<145	<145	<145
28	G28	<160, >225	<160, >220	<160, >225	<160, >220
	H28	<160, >275	<160, >275	<160, >275	<160, >275
	I28	<160, >275	<160, >275	<160, >275	<160, >275
	J28	<150, >270	<150, >270	<150, >270	<150, >270
	K28	<165, >220	<165, >220	<165, >220	<165, >220
	L28	<180, >230	<180, >230	<180, >230	<180, >230
	M28	<180, >220	<180, >220	<180, >220	<180, >220
	N28	<180, >225	<180, >225	<180, >225	<180, >225
	O28	<145	<145	<145	<145
	P28	<145	<145	<145	<145
29	H29	<180, >240	<180, >240	<180, >240	<180, >240
	I29	<180, >240	<180, >240	<180, >240	<140, >240
	J29	<180, >250	<180, >250	<180, >250	<180, >250
	K29	<180, >250	<180, >250	<180, >250	<180, >250
	L29	<180, >250	<180, >250	<180, >250	<180, >250
	M29	<140	<140	<140	<140
	N29	<140	<140	<140	<140
	O29	<140	<140	<140	<140
	P29	<140	<140	<140	<140
	Q29	<140	<140	<140	<140
30	I30	>225	>220	>225	>220
	J30	<180, >250	<180, >250	<180, >250	<180, >250
	K30	<180, >250	<180, >250	<180, >250	<180, >250
	L30	<180, >250	<180, >250	<180, >250	<180, >250
	M30	<155	<155	<155	<155
	N30	<140	<140	<140	<140
	O30	<140	<140	<140	<140
	P30	<140	<140	<140	<140
	Q30	<140	<140	<140	<140
31	N31	<140	<140	<140	<140
	O31	<140	<140	<140	<140
	P31	<140	<140	<140	<140
32	N32	<140	<140	<140	<140
	O32	<140	<140	<140	<140
	P32	<140	<140	<140	<140

Appendix 2: Potentially mixed contexts from the Natufian layer at Hayonim Cave. Bones recovered from these contexts were excluded from relative abundance analysis. Depths are recorded in cm below datum. > = greater than, < = less than.

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