Small game, the younger dryas, and the transition to agriculture in the southern levant

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ABSTRACT: *The Younger Dryas, an intense cooling and drying event of global proportions, has been attributed a major causal role in the adoption of agricultural economies in the southern Levant. Here, the impact of the Younger Dryas on human adaptations is evaluated using a small game index that measures the efficiency of human foraging as a proxy for site occupation intensity. The study examines faunal assemblages spanning the agricultural transition and dating to the Early and Late Natufian and Pre-Pottery Neolithic periods (ca. 14,500 to 11,000 Cal. BP). The small game index and other supporting evidence document major fluctuations in human site occupation intensity across this critical phase. Site occupation reached an unprecedented high during the Early Natufian, but quickly reverted to pre-Natufian levels with the onset of the Younger Dryas in the Late Natufian phase. By decreasing site occupation intensity and increasing mobility, the Late Natufians implemented effective demographic strategies to cope with changing resource distributions. In contrast, there is no evidence for intensified resource use or food stress in the Late Natufian, at least in comparison to the Early Natufian phase. Although, it is tempting to assign the Younger Dryas a causal role in the adoption of agricultural economies, support for this hypothesis (in the form of food stress and resource intensification) does not currently exist.*

Zusammenfassung: *Der jüngeren Dryas, einer Zeit merklicher Abkühlung und ausgeprägter Trockenheit von weltweitem Ausmaß, wurde eine kausale Bedeutung für den Übergang zur produzierenden Wirtschaftsweise in der südlichen Levante beigemessen. In diesem Beitrag wird das Verhältnis zwischen der jüngeren Dryas und der Mobilität bzw. Sesshaftigkeit von Menschen unter Berücksichtigung der derzeitigen Modelle über die Ursprünge der Landwirtschaft erörtert. Der Einfluss der jüngeren Dryas auf menschliche Anpassungen wird durch Analysen der Besiedlungsdichte im Verhältnis zu Zeit und Raum untersucht, wobei ein so genannter „Kleinwildindex" angewandt wird, der etwas über die Nahrungsbeschaffungseffizienz und den Einfluss der menschlichen Jagd auf die lokalen Kleinwildbestände aussagt. Der Kleinwildindex – berechnet als „langsames Kleinwild" ÷ „langsames Kleinwild" + „schnelles Kleinwild" - beschreibt die relative Häufigkeit von sich langsam fortbewegenden Arten (Schildkröten) im Verhältnis zu sich schnell fortbewegenden Arten (Kaninchen, Rebhühner und Wasservögel).*

Die Studie untersucht die Zusammensetzung von Kleinwildknocheninventaren aus der Zeit des Übergangs zur produzierenden Wirtschaftsweise in der südlichen Levante, der ins frühe bis späte Natufien und ins präkeramische Neolithikum (14.500 bis 11.000 v. Chr.) datiert.

Der Kleinwildindex und weitere Beobachtungen sprechen für erhebliche Schwankungen in der menschlichen Besiedlungsintensität während des Übergangs zur produzierenden Wirtschaftsweise. Ein hoher Anteil an sich schnell fortbewegenden und daher schwer zu jagenden Tieren in frühnatufienzeitlichen Inventaren spricht für einen Rückgang der Nahrungsbeschaffungseffizienz im Vergleich zu früheren Zeitabschnitten und dafür, dass die Menschen ihre Basislager viel intensiver als jemals zuvor nutzten. Eine aufwendigere Bebauung und verhältnismäßig viele Primärbestattungen auf frühnatufienzeitlichen Fundplätzen ergänzen diese Beobachtung.

Überraschenderweise stellt die intensive Besiedlung einzelner Wohnplätze im Frühnatufien keinen Punkt dar, von dem es auf dem Weg des Übergangs zur produzierenden Wirtschaftsweise kein Zurück mehr gab. Statt dessen wurde der kulturelle Wandel in Richtung zunehmend sesshafter Gesellschaften im Spätnatufien unterbrochen. Dieser Zeitraum von 1500 Jahren ist von zunehmender Mobilität und abnehmender Siedlungskontinuität gekennzeichnet und entspricht der jüngeren Dryas. Der Wandel wird auch durch einen Rückgang des Kleinwildindexes auf vornatufienzeitliches Niveau markiert, was auf ein Wiederaufleben der Jagd sich langsamer fortbewegender und einfacher zu erlegender Tierarten am Beginn des Spätnatufiens zurückgeht. Außerdem wird dieser Trend durch eine vergleichsweise leichtere Bebauung der Lagerplätze bestätigt. Erst das Aufkommen von ackerbautreibenden Gemeinschaften vor ca. 11.500 Jahren stellt eine Wiederaufnahme des Weges in Richtung dauerhafter Sesshaftigkeit dar. Während des vorkeramischen Neolithikums fiel der Kleinwildindex auf seinen niedrigsten Stand, als die Menschen

wieder schnelles Kleinwild jagten. Auch die Fundplätze des präkeramischen Neolithikums A sprechen z.B. durch zahlreichere Bebauungsspuren als in den frühnatufienzeitlichen Siedlungen für eine intensivere Besetzung. Insgesamt handelt es sich um bedeutende Schwankungen in der Besiedlungsintensität, nicht nur weil sie den als sehr eben angenommenen Weg zur Landwirtschaft eher als „Holperstraße" erscheinen lassen (Belfer-Cohen & Bar-Yosef 2000), sondern vor allem wegen ihrer Bedeutung für übergreifende Tendenzen menschlicher Demographie, Besiedlung und Mobilität. Es wurde angenommen, dass die Menschen des späten Natufiens effektive demographische Strategien verfolgten, die Mobilität, Auswanderungen und den Rückgang des Bevölkerungswachstums umfassten, um die Veränderungen der jüngeren Dryas zu überstehen und mit den sich verändernden Ressourcen umzugehen. Im Gegensatz dazu legen die Tierknochen jedoch nahe, dass die Menschen des Spätnatufiens – zumindest im Vergleich zu ihren frühnatufienzeitlichen Vorfahren - ihre Ressourcen nicht intensiver nutzten oder unter Nahrungsmangel litten, wie es für eine Bevölkerung am Übergang zur eigenen Nahrungsproduktion zu erwarten wäre. Obwohl man der jüngeren Dryas gern eine Schlüsselrolle bei der Übernahme der neolithischen Wirtschaftsweise beimessen würde, gibt es derzeit keine eindeutigen Bestätigungen für diese Hypothese, wie z.B. Nahrungsmangel oder eine intensivere Nutzung von Ressourcen.
Die jüngere Dryas könnte den Menschen des Natufiens zu ihrem Wissen um die Kultivierung von Pflanzen verholfen haben, sie scheint aber nicht den letzten Anstoß zu ihrer Durchsetzung gegeben zu haben.

INTRODUCTION

Over the past few years advances in climatic research and the recalibration of the carbon curve have improved the resolution of climatic and environmental reconstructions across the transition to agriculture in the southern Levant. This process has illuminated the significance of the Younger Dryas—a major cooling and drying climatic event with global impact—for human settlement, subsistence and social behavior at the origins of agriculture. Climatic explanations for agricultural origins stem back to Childe's (1951) oasis propinquity theory which proposed that a dessication trend forced humans into close contact with plants and animals surrounding permanent water sources. Childe's theory was later disproved by Braidwood (1960), but climatic explanations for agricultural origins resurfaced as environmental and climatic records were refined and the Younger Dryas was identified (Binford 1968; Broecker et al. 1988, 1989; Kudrass et al. 1991; McCorriston and Hole 1991; Moore 1982; Moore and Hillman 1992). Bar-Yosef and Belfer-Cohen (Bar-Yosef 1996, 2001, 2002; Bar-Yosef and Belfer-Cohen 1989, 1991, 2002; Belfer-Cohen and Bar-Yosef 2000) have refined their argument for a link between the Younger Dryas and agricultural origins over the past decade and a half. They argue that climatic instability introduced by the Younger Dryas reduced the distribution of cereal crops, lowered carrying capacity, and thus uprooted the sedentary way of life that began ca. 14.5-13/12.8 thousand calibrated years ago (kya) in the Early Natufian cultural phase. Human foragers were prompted to return to a more mobile settlement strategy to optimize their use of increasingly dispersed resources. Further stress induced by the Younger Dryas eventually encouraged the Natufians to begin cultivating wild cereals and set humans on the path to agriculture.

Several recent studies confirm that the Late Natufian (ca. 12.8-11.5 kya) phase which immediately precedes agriculture and coincides directly with the Younger Dryas, was a time of heightened mobility more on par with the preceding Kebaran and Geometric Kebaran periods than the sedentary Early Natufian phase (Bar-Yosef 2001, 2002; Bar-Yosef and Belfer-Cohen 2002; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris and Belfer-Cohen 1998; Grosman 2003; Grosman and Belfer-Cohen 2002; Valla 1998). A previous study of the faunal record from Early and Late Natufian sites in the Levant also corroborates these trends, and shows unprecedented intensity of site occupation in the

Early Natufian followed by a significant drop-off in site occupation intensity and greater mobility in the Late Natufian (Munro 2001; Stiner and Munro 2002).

The influence of the Younger Dryas on the adoption of agriculture immediately after the Natufian period, however, is more complex. Belfer-Cohen and Bar-Yosef (2000) argue that the Late Natufians were pushed to adopt agriculture to overcome resource stress initiated by the Younger Dryas. It is this issue—the influence of the Younger Dryas on the transition to agriculture—that is explored here. This study extends previous research on site occupation intensity in the Natufian period across the transition to agriculture into the earliest Neolithic periods (Pre-Pottery Neolithic) in the southern Levant using faunal measures. The correspondence between human patterns of sedentism and mobility, climatic shifts, and the initiation of early agriculture are addressed with reference to current models of agricultural origins. All dates given below are in calibrated years BP (Stuiver et al. 1998) to provide more accurate linkages between the climatic and archaeological records.

Human patterns of sedentism and mobility are measured here by monitoring the intensity of site occupation across time and space. Site occupation intensity is gauged using a small game index that measures human foraging efficiency and its impact on local small animal populations that inhabited the area directly surrounding an archaeological site (Stiner and Munro 2002).

LATE PLEISTOCENE AND EARLY HOLOCENE CLIMATES IN THE SOUTHERN LEVANT

Several significant climatic changes coincided with the transition to agriculture in the Levant and undoubtedly influenced cultural developments during this period. Paleoclimatic and paleoenvironmental reconstructions 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 the reconstruction of Late Pleistocene and Early Holocene climates in the southern Levant and has called upon multiple data sets including oxygen isotope ratios from dated ice cores, deep sea cores, cave spelothems (Bar-Matthews et al. 1997, 1999; Frumkin et al. 1999), and pollen cores (e.g., Baruch 1994; Baruch and Bottema 1991; Grosman 2003; Leroi-Ghouran and Darmon 1991; Niklewski and van Zeist 1970; van Zeist and Bottema 1982, 1991). Faunal series and geomorphological observations also provide climatic evidence but on a grosser scale (Begin et al. 1980; Macumber and Head 1991; Goldberg 1986, 1994). Conflicting interpretations exist for much of the pollen data (see Rossignol-Strick 1995, 1997 for details), thus only those climatic trends for which there are multiple lines of support and general agreement are presented here. These trends correlate well with globally established climatic events (e.g., Kudrass et al. 1991). Bar-Yosef (1996, 2002) has been the forerunner in the synthesis of climatic data relevant to the transition to agriculture. The following summary draws heavily from his work.

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 1: *Summary of climatic evidence used to reconstruct climatic events (Bölling-Allerød, Younger Dryas, and Early Holocene) relevant to the transition to agriculture in the southern Levant. Dates are in calibrated years BP.*

Three major climatic trends are relevant to the transition to agriculture in the Levant—the Bölling-Allerød interstadial, a postglacial warm and wet phase, the Younger Dryas, a brief, yet harsh, cold and dry event, and the Early Holocene which was characterized by warm and wet conditions (See Table 1 for summary of supporting evidence). This story begins shortly after the termination of the extremely cold and dry Würm glaciation (oxygen isotope stage 3) with the onset of the Bölling-Allerød interglacial (ca. 19 kya) which was characterized by climatic amelioration and a rise in annual precipitation and mean temperature. This warming trend accelerated with the onset of the Natufian period (ca. 14.5 kya) and peaked ca. 13.5 kya in the heart of the Early Natufian phase. In the southern Levant, the beginning of the Bölling-Allerød is evidenced by a gradual increase in the $\delta^{18}O$ values of cave speleothems recovered near modern day Jerusalem (Bar-Matthews et al. 1999; Frumkin et al. 1999). Pollen spectra from Hula Lake cores

(Baruch and Bottema 1991) and the excavations at the Jordanian sites of Wadi Hammeh 27 (Colledge 1991) and Wadi Juyadid (Henry and Turnbull 1985; Sellars 1998) contain abundant arboreal pollen from ca. 17 kya until well into the Natufian period, and indicate an expansion of the Mediterranean forest (Baruch and Bottema 1991). Geomorphological data from the Wadi Hammeh area in Jordan reveal a long sequence of deposition in the wake of steadily rising waters in Lake Lisan from the end of the Late Glacial Maximum to ca. 13 kya (Yechieli et al. 1993; Macumber and Head 1991). Finally, the formation of paleosols along the northern fringe of the Negev desert prior to 13 kya indicates a period of high moisture beginning ca. 18 kya (Margaritz and Goodfriend 1987).

Ca. 13 kya the Younger Dryas interrupted the warming trend of the Bölling-Allerød and returned the Levant to near glacial dry and cold conditions (Overpeck et al. 1989). The Younger Dryas has been identified by spikes in oxygen isotope ratios from deep sea cores from across the globe (Kudrass et al 1991), and locally in the southern Levant in speleothems from caves in central Israel (Bar-Matthews et al. 1999; Frumkin et al. 1999). Pollen spectra also record a reduction in arboreal pollen associated with the Younger Dryas event on both global (Engstrom et al. 1990) and local scales (Baruch and Bottema 1991). Furthermore, increased aridity is documented ca. 13 kya in Wadi Hammeh, Jordan where a cessation of sedimentation and the initiation of downcutting attest to the rapid drying of Lake Lisan (Macumber and Head 1991; Yechieli et al. 1993). The Younger Dryas terminated at the Pleistocene/Holocene boundary ca. 11.5 kya with a return to pluvial conditions just as the Natufian period came to a close and agriculture began.

The Early Holocene was marked by warmer and wetter conditions than today, but never reached those characteristic of the Early Natufian phase (Bar-Yosef 1996). Significant decreases in oxygen isotope ratios obtained from Mediterranean Sea cores and dated 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 in response to increased temperatures and precipitation (Luz 1982). The Hula pollen spectrum is marked by increased arboreal pollen counts in the Early Holocene and points to a re-expansion of the Mediterranean forest. Even so deciduous trees that prefer warmer climates never reached the extent of the Early Natufian 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 birds, rodent, and aquatic plant species, indicating proximity to a substantial body of fresh water (Leroi-Gourhan and Darmon 1991; Tchernov 1994).

The beginnings of the Natufian culture emerged against a background of mild climatic conditions. During the Early Natufian phase 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 associated with the Younger Dryas correspond to the beginning of the Late Natufian phase (ca. 12.8 kya). Populations living in the core Natufian areas were faced with shrinking habitats, and undoubtedly associated declines in resource productivity per unit land area. The end of the Younger Dryas ca. 11.5 kya roughly correlates with the disappearance of the Natufian adaptation and the initiation of the PPNA. 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.

SITE OCCUPATION INTENSITY, HUMAN MOBILITY, AND SMALL GAME

Site occupation intensity refers to the number of human hours a site is inhabited per unit time, and is determined by the combined effect of human population size, length of stay, and frequency of visits. Human foraging efficiency—the total energy gained from hunting after capture costs are accounted for (Broughton 1994; Stephens and Krebs 1986)—is expected to vary directly with site occupation intensity since humans must extract more energy from the surrounding environment as the number of human hours of site occupation increases.

A small game index monitors human foraging efficiency in the vicinity of human habitation sites and thus provides a simple measure of site occupation intensity (*Stiner* and Munro 2002). In the Mediterranean zone of the southern Levant, the most common small prey species include the Mediterranean spur-thighed tortoise (*Testudo graeca*), the cape hare (*Lepus capensis*), the chukar partridge (*Alectoris chukar*), and a range of waterfowl species (i.e., *Fulica atra, Crex crex*, and others; see Appendix A). The slow-moving tortoise is easily captured, does not require investment in special technology, and is thus highly ranked. On the contrary, hares, partridges, and waterfowl are fast-moving and require increased effort and/or more elaborate technologies such as nets, bows and arrows or traps for their capture (Stiner et al. 1999, 2000). Although these technologies decrease the cost-benefit ratio associated with the hunting of fast small game animals, they still require significant energetic investment for their manufacture and maintenance in comparison to the capture of prey by hand. The small game index pits the high-ranked tortoise against low-ranked hares, partridges, and waterfowl (small game index = slow small game/slow small game + fast small game). An assemblage comprised primarily of tortoises will produce a high small game index indicative of an efficient foraging strategy. As more low-ranked animals enter the archaeological record, the index will drop, signaling a reduction in foraging efficiency as humans invest more in the capture of game but earn the same returns.

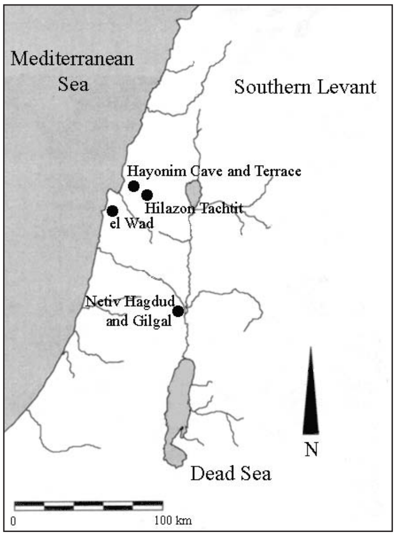

Figure 1: *Map of the southern Levant depicting sites included in the small game analysis*

Intensified hunting may also exert sufficient pressure to depress prey populations, particularly those with low population turnover (Stiner et al. 1999, 2000). The fact that those animals that are the highest-ranked are also the easiest to capture compounds the sensitivity of the small game index. Tortoises recover slowly from predation pressure and thus if site occupation intensity increases to the point that tortoise populations are depressed the need to compensate using low-ranked animals will be accelerated.

SITE	CULTURAL PERIOD	TIME PERIOD (CAL. BP)	SMALL GAME SAMPLE SIZE	REFERENCE
el-Wad Cave	Early Natufian	14,500-13,000	1092	Munro 2001
Hayonim Cave	Early Natufian	14,000-13,000	4728	Munro 2001
Hayonim Cave	Late Natufian	13,000-11,500	3279	Munro 2001
Hayonim Terrace	Late Natufian	13,000-11,500	4226	Munro 2001
Hilazon Tachtit	Late Natufian	13,000-11,500	975	Munro 2001
Netiv Hagdud	PPNA	11,500-10,000	742	Tchernov 1994
Gilgal	PPNA	11,500-10,000	47	Noy et al. 1980

Table 2: *Cultural periods, time periods, and references for assemblages from the Levantine series. Time ranges are provided for the general cultural period and are not given individually for each site. All dates are in calibrated years BP.*

The small game index is a particularly effective measure of site occupation intensity at the transition to agriculture when the proportion of small game in human diets reached an all time high. All faunal assemblages considered here are comprised of 40% (NISP) small game at minimum (Munro 2001; Noy et al. 1980; Stiner and Munro 2002; Tchernov 1994). The most common species consumed by humans (tortoises, hares, and partridges) had generalist subsistence strategies, broad geographic distributions, and could tolerate a wide range of temperatures and annual precipitation (Lambert 1982; Nowak 1991). Thus the relative distribution and abundance of these species should not be influenced by the climatic and environmental changes characteristic of the Late Pleistocene.

THE SMALL GAME ASSEMBLAGES

The small game index is examined at a series of sites spanning the transition to agriculture from the southern Levant (see Figure 1; Table 2). The study is restricted to the Mediterranean hills and the western edge of the Jordan Valley to ensure environmental continuity across time and space. Only assemblages for which the small game animals were meticulously collected, studied, and published are evaluated. Small game are defined as non-carnivorous animals weighing less than five kilograms that were hunted and consumed by humans. Human use is identified through the analysis of taphonomic indicators such as cutmarks, burning, fragmentation, and body-part representation. Taphonomic analyses were performed for most but not all of the sites and are presented in detail elsewhere (Munro 2001: 120-131; Tchernov 1994). Animals designated as small game include the Mediterranean spur-thighed tortoise, the chukar partridge, several species of waterfowl, most notably ducks, geese and bustards, the cape hare and a small sample of unidentified fish (see Appendix A for species list and NISP counts). Several other small game species including songbirds, amphibians, lizards, snakes, birds of prey, rodents, and hedgehogs were identified but are not included in the following analysis—they were either naturally deposited at the sites or collected by humans and not consumed (i.e., birds of prey). None of the removed taxa with the exception of the birds of prey (i.e., hawks, eagles, vultures, owls) from Hayonim Cave (NISP = 431) and the crows (*Corvus sp.*) from Netiv Hagdud (NISP = 285) are well represented in the assemblages, and their removal has an insignificant impact on the results. If these species were included the patterns depicted below would be stronger, but less reliable.

The assemblages originate from Early and Late Natufian and PPNA sites (see Table 2). The Natufian data have been presented elsewhere (Munro 2001; Stiner and Munro 2002), and the PPNA data derive from published analyses by Eitan Tchernov (Noy et al. 1980; Tchernov 1994)—the combination of these datasets to address site occupation intensity is new.

The Early Natufian assemblages include a small sample from Chamber III in el-Wad Cave, Mount Carmel located on the fringe of the Mediterranean coastal plain (Weinstein-Evron 1998). The large game fauna from el-Wad Cave was reported by Rivka Rabinovich

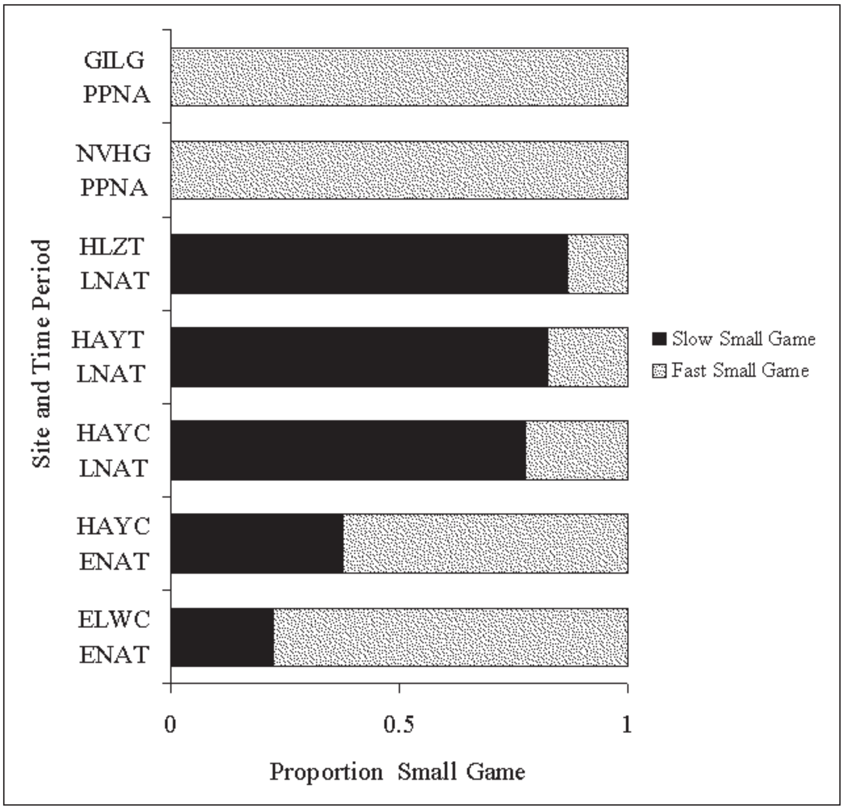

Figure 2: *Relative proportion of slow small game (tortoises) and fast small game (hares, partridges, and waterfowl) at Natufian and early Neolithic sites in the southern Levant. Site name abbreviations are as follows ELWC – el-Wad Cave, HAYC – Hayonim Cave, HAYT – Hayonim Terrace, HLZT – Hilazon Tachtit, NVHG – Netiv Hagdud, GILG – Gilgal. Time period abbreviations are ENAT – Early Natufian, LNAT – Late Natufian, PPNA – Pre-Pottery Neolithic A. See Table 2 for small game sample sizes.*

(1998), and the small game assemblage (NISP = 1092) was analyzed by myself. Small game from Early and Late Natufian sites also derive from the large habitation at the multi-component site, Hayonim Cave (Munro 2001; Stiner and Munro 2002). The Early and Late Natufian occupations at the site were separated according to essential contextual information provided by Ofer Bar-Yosef and Anna Belfer-Cohen (n.d.; Bar-Yosef 1991; Belfer-Cohen 1988) who defined the boundaries between occupational phases, and between mixed and clean archaeological deposits. Small game samples from the

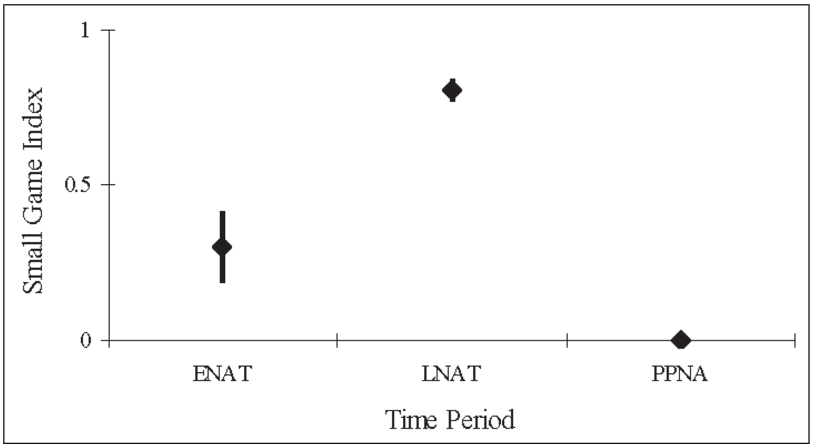

Figure 3: *Diamonds represent the average small game index for the time period and the upper and lower bars represent standard deviation. Sample sizes are small ENAT = 2 assemblages, LNAT = 3 assemblages, PPNA = 2 assemblages. Time periods include ENAT – Early Natufian, LNAT – Late Natufian, and PPNA – Pre-Pottery Neolithic A.*

Early and Late Natufian components total 4728 and 3279 respectively. Additional Late Natufian assemblages originate from François Valla's (Valla et al. 1986) excavations at Hayonim Terrace which is situated directly outside of the mouth of Hayonim Cave, and from Hilazon Tachtit (Munro 2001), a small campsite located less than 10 kilometers to the southwest of Hayonim Cave and excavated by Leore Grosman (2003). The small game component from Hayonim Terrace totals 4226 while that from Hilazon Tachtit contains 975 identifiable specimens. Finally, PPNA assemblages are represented from Netiv Hagdud and Gilgal (Noy et al. 1980; Tchernov 1994), two early agricultural campsites from the Jordan Valley. Small game samples from Netiv Hagdud and Gilgal total 742 and 47 respectively. Sites are not examined from ensuing agricultural periods since small game frequencies drop off as domestic animals begin to dominate the meat component of human diets from the mid- Pre-Pottery Neolithic B period onward.

RESULTS: THE SMALL GAME INDEX

The small game index does not depict a straightforward trend in site occupation intensity, but flip-flops back and forth across the three thousand years of human occupation investigated here (Figure 2). Three major shifts are detected. First, in the Early Natufian assemblages from el-Wad and Hayonim Cave, the small game index is low. Fast-moving small game animals are common and outnumber slow-moving tortoises in relative abundance. The significance of this result springs into focus when compared to previous Paleolithic and Epipaleolithic occupations in the region where tortoises greatly and consistently outnumber fast small game in relative abundance (Bar-Oz n.d.; Stiner 2001, n.d.; Stiner et al. 1999, 2000; Speth and Tchernov 2002). In the Late Natufian tortoise frequencies skyrocket reverting back to pre-Natufian proportions (see Stiner et al. 1999, 2000 for comparative data). Fast small game continues to be consumed attesting to its continued presence in the region, but despite good evidence that the Natufians knew how to exploit these animals, they exerted significantly less energy into their capture than in the Early Natufian phase.

Finally, in the PPNA the small game index swings back again and exceeds even Early Natufian proportions—PPNA assemblages are comprised of hares and waterfowl to the virtual exclusion of slow-moving animals. Furthermore, it is of particular importance that the small game index is similar among sites from the same time period, but varies substantially when compared among sites from different periods (see Figure 3). The consistency of shifts in the small game index across multiple sites and time periods attests to the reality of these patterns, and the magnitude of the changes.

Diachronic analyses have revealed very little change in the relative abundance of ungulate species in Natufian assemblages (Byrd 1989b; Davis 1978, 1981; Munro 2001). However, the preceding analysis reveals that much variation is hidden in the small end of the faunal spectrum. The small game index provides a novel and informative approach to investigate human site occupation intensity by measuring human foraging efficiency and by focusing on the small game animals that occupy the area directly surrounding human habitation sites (Stiner and Munro 2002). Increases in the abundance of fast-moving small game in the Early Natufian suggest that humans inhabited their basecamps with greater intensity than ever before. These people invested significantly more energy into the capture of small game than their predecessors suggesting that the more cost-effective tortoise was not enough. Early Natufian sedentism, however, did not mark a point of no return on the route to agriculture. Instead this cultural transition was interrupted by the Late Natufian, a 1500 year phase characterized by increased mobility and reduced occupation intensity that corresponds directly to the Younger Dryas. The appearance of agricultural communities ca. 11,500 years ago marked a return to the path toward increasingly long-term sedentism. The PPNA boasts evidence for intensive occupation that greatly surpassed even the Early Natufian settlements. These fluctuations in site occupation intensity are significant not only because they recharacterize the path to agriculture as a "bumpy road" (Belfer-Cohen and Bar-Yosef 2000), but because of their large-scale implications for patterns of human demography, settlement, and mobility—topics that will be visited shortly.

SUPPORTING ARCHAEOLOGICAL EVIDENCE

Several non-faunal indicators can also be used to track relative changes in site occupation intensity and population mobility. The most telling of these include human investment in site architecture such as built features and structures, the distribution and size of settlements, and human burial customs.

Settlement Patterns and Site Size

At the onset of the Early Natufian phase, large residential sites were first established in the Mediterranean hills. The size of these sites and the thickness of their archaeological deposits were unprecedented in the region. The sites were also characterized by new cultural features including cemeteries, structures, and diverse and abundant assemblages of ground stone, bone tools, ornaments, and mobiliary art (Bar-Yosef and Belfer-Cohen 1989, 1991). The sites are commonly referred to as "base camps" (following Bar-Yosef 1970), and are considered the hallmark of the Early Natufian adaptation in the Mediterranean zone. Elsewhere in the Levant, Early Natufian sites were smaller and provided seasonal venues for short-term habitation and resource extraction. The dichotomy between permanent base camps in the core Mediterranean zone and smaller seasonal sites in the surrounding steppes and deserts was most pronounced in the Early Natufian (Belfer-Cohen and Bar-Yosef 2000). This pattern changes abruptly with the onset of the Late Natufian. Although, the occupation of many of the large base camps continued (i.e., Ain Mallaha, el-Wad, Hayonim Cave and Hayonim Terrace), there is good evidence that these sites diminished in size and occupational intensity (Belfer-Cohen and Bar-Yosef 2000; Garrod and Bate 1937; Valla 1991). The primary function of some Late Natufian sites in the Mediterranean zone may have shifted from everyday activities to graveyards. Hilazon Tachitit and Hayonim Cave show substantial evidence for ritual and burial activities, and less evidence for formalized domestic activities in the Late Natufian (Grosman 2003). In contrast, numerous medium-sized seasonal camps sprang up at the juncture of the Mediterranean zone and the Irano-Turanian steppes in the Jordan Valley (e.g., Salibiya I, Fazael IV), the Negev (e.g., Rosh Zin, Rosh Horesha) and southern and eastern Jordan (e.g., Khallat 'Anaza, Ain el-Saratan, Taine Ain Rahub; 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; Goring-Morris and Belfer-Cohen 1998; Grosman et al. 1999; Henry 1989, 1995). Although few of these sites have been fully excavated, current evidence suggests that they are significantly larger, more abundant, and equipped with more substantial features (see architecture section below) than the steppic sites dating to the Early Natufian phase. Although many of these sites represent seasonal or perhaps multi-seasonal occupations, 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).

The PPNA witnessed a contraction in regional settlement patterns from a pan-Levantine distribution in the Natufian period to a more restricted distribution centered in the Jordan Valley (Kuijt and Goring-Morris 2002). Site settings shifted from caves and ecotones to open air locations adjacent to alluvial terraces and valleys (Bar-Yosef and Belfer-Cohen 1989). Settlement was particularly active in the Jordan Valley proper, where several large villages (i.e., Dhra, Jericho, Gilgal, and Gesher) emerged on the fringes of arable terraces or freshwater lakes and marshes that were home to a diversity of water-loving species. The PPNA is not the first period of intensive occupation in the Jordan Valley—seasonal resource extraction sites were common in the Late Natufian—but the big PPNA sites are the largest and contain the deepest deposits up until this point (Bar-Yosef and Gopher 1997; Bar-Yosef 2002; Kuijt and Goring-Morris 2002). In the Mediterranean Hills the Natufian sites of Nahal Oren and Hatoula continue to be occupied in the PPNA, but most other Natufian sites in the Mediterranean Hills were poorly suited for agriculture and were abandoned. Settlement activity also dropped off in the arid deserts and steppes previously occupied by Natufian foragers, as people aggregated in the Jordan Valley which could sustain higher populations of farmers. The most impressive difference between Natufian and PPNA settlements is sheer size. Even the largest Natufian sites do not exceed 2000 m^2, while some big PPNA sites reach up to five times larger (10,000 m^2; Bar-Yosef and Meadow 1995; Kuijt and Goring-Morris 2002). It is estimated that the big PPNA sites supported between 300 and 500 people (Bar-Yosef and Belfer-Cohen 2002) which is many times greater than the Natufian basecamps.

Architectural Investment: On-site Features and Facilities

The major episode of Natufian building in the Mediterranean zone occurred in the Early phase. For example, the site of Hayonim Cave housed 9 stone loci, 5 slab-lined pavements, 4 slab-lined graves, and 6 built hearths all of which required a significant investment of labor and energy to plan, acquire materials for, and construct. With the exception of two slab-lined graves built at the very end of the Late Natufian occupation, all of the built features at Hayonim Cave were constructed and maintained exclusively during the Early Natufian phase (with the possible exception of the slab-lined floor in Locus 7; Bar-Yosef and Belfer-Cohen n.d.). Likewise, medium to large circular structures, stone slab pavements, and built hearths at Ain Mallaha and Wadi Hammeh 27, and the pavements and retaining walls at el-Wad Terrace were all manufactured during the Early Natufian phase (Belfer-Cohen 1988; Perrot 1966; Garrod and Bate 1937).

In the Late Natufian some structures and other features were constructed in the Mediterranean zone (e.g., Ain Mallaha, Hayonim Terrace, Hilazon Tachtit and Nahal Oren), but with the possible exception of those at Ain Mallaha, these are less substantial and required less energy investment than those from the Early phase (Bar-Yosef and Belfer-Cohen 1991, n.d.; Grosman 2003.; Stekelis and Yizraely 1963; Valla 1991, Valla et al. 1998). For example, at Hayonim Cave the few features attributed to the Late Natufian include packed living floors and ash concentrations delineated by human use rather than by built walls. Those features that are attributed to the Late Natufian are often associated with human burials (e.g., at Hayonim Cave and Hilazon Tachtit; Bar-Yosef and Belfer-Cohen n.d.; Grosman 2003). Outside the Mediterranean zone, however, building was more intensive during the Late Natufian phase and was associated with the appearance of larger and more significant sites than the Early Natufian phase in the same region. Round, subterranean structures were constructed at Rosh Horesha, Upper Besor VI, and Rosh Zin in the Negev (Henry 1976; Horwitz and Goring-Morris 2000; Marks and Larsen 1977), and walls appear at seasonal camps in the Jordanian deserts for the first time during the Late Natufian (e.g., Khallat ʻAnaza, Taine Ain Rahub, and perhaps Jebel es-subhi; Betts 1987, 1991; Gebel and Muheisen 1985). Regardless of the location however, architecture from Late Natufian contexts is more ephemeral than Early Natufian structures from the Mediterranean zone.

PPNA architectural features were more frequent, elaborate, and required greater energetic investment than those from the Early and Late Natufian phases. The most remarkable example is a stone tower 8 meters wide and at least 8 meters high associated with human burials and a retaining wall at Jericho (Bar-Yosef 1986). The time and labor required to manufacture and maintain this structure was on a scale well above that required to construct the basic residential architecture and graves typical of both Natufian and PPNA sites. Several PPNA sites are home to a series of round structures, containing small built features such as hearths, cobbled floors, storage features, and the occasional internal dividing wall (Bar-Yosef 2002; Bar-Yosef and Gopher 1997; Kenyon 1981; Kuijt and Goring-Morris 2002; Kuijt and Mahasneh 1998). Although PPNA residential architecture is similar to that of the Natufian basecamps, PPNA structures are more elaborated.

The circular structures, built hearths, and slab-lined floors characteristic of the Early Natufian and PPNA in the Mediterranean zone required significant investment in time and energy. Architectural investment can result in certain kinds of long-term gains, but only if one is reasonably certain to occupy or reoccupy the site for sufficient periods to reap the benefits or if the site has sufficient social or ritual significance to encourage people to return (e.g., a cemetery). The permanence of shelter and other features such as hearths and floors should be inversely correlated with the degree of human mobility (Binford 1990; Kelly 1995), although the investment in ritually significant architecture or that associated with human graves may be completely independent of site occupation intensity. For more mobile foragers who make frequent residential moves the labor required for the construction of domestic architecture is better expended on other more immediate demands required by short-term occupations. The termination of major utilitarian construction events during the Late Natufian in the Mediterranean zone suggest a significant decrease in site occupation intensity during the Late Natufian phase while increased investment in the PPNA evidences a return to more permanent occupation on an even greater scale than in the Early Natufian.

Burial Practices

Although sample sizes are small, increases in the frequency of secondary burials in Late Natufian sites have been interpreted as signals of decreased site permanence and increased mobility during the Late Natufian phase (Belfer-Cohen 1988, 1991; Belfer-Cohen and Bar-Yosef 2000; Perrot 1966; Perrot and Ladiray 1988; Valla 1998). Secondary burials are created by adding disarticulated human skeletons to pre-existing graves—the individuals probably did not die at the site, but were transported there following decomposition (Belfer-Cohen and Bar-Yosef 2000; Belfer-Cohen 1988; Byrd and Monahan 1995; Perrot and Ladiray 1988). A few Late Natufian burials were recovered in primary position, and attest to the continued occupation of basecamps, but the overall increase in secondary burials (Belfer-Cohen 1988, 1991; Belfer-Cohen et al. 1991) suggests a decrease in site occupation intensity. An associated decline in the number of decorated burials (i.e., at Hayonim Cave and Nahal Oren) supports interpretations that human remains were skeletonized at the time of burial, as ornaments are most likely to be associated with clothing or fully fleshed bodies (Belfer-Cohen 1991; Belfer-Cohen et al. 1991). In contrast PPNA graves were interred nearly entirely in primary position. PPNA burials are plentiful and have been recovered from several large habitation sites including Jericho, Netiv Hagdud, and Dhra (Bar-Yosef and Gopher 1997; Kenyon 1981; Kuijt and Mahasneh 1998). The primary graves most often housed one and sometimes two inhumations, and skull removal was common (Bar-Yosef and Gopher 1997; Kuijt 1996; Kuijt and Goring-Morris 2002). The proportion of primary burials in the PPNA outweighs that in both Natufian phases, but much more closely resembles an Early than a Late Natufian pattern. The abundance of primary graves suggests that humans were dying while in residence at a site, and must have occupied habitation sites more intensively than both the Early and the Late Natufians.

Summary of Supporting Archaeological Evidence

The excavation of more precisely dated Natufian and PPNA sites in recent years has allowed researchers to differentiate between Early and Late Natufian and PPNA adaptations, and to better understand variability in material culture across the transition to agriculture. Much of this variability relates to the temporal division between the three periods, although some aspects correspond more closely to variation in site habitat and geography (Byrd 1989b). Temporal changes in Natufian material culture (i.e., site size, site complexity, architectural investment, frequency of secondary graves) corroborate trends in site occupation intensity identified using the small game index. Furthermore, these trends correlate directly with large-scale climatic change and rapid environmental deterioration introduced by the Younger Dryas ca. 12.8 kya. In the PPNA settlement permanence rose again, and by all indications was substantially more intensive than even the Early Natufian period.

SMALL GAME, THE YOUNGER DRYAS, AND THE TRANSITION TO AGRICULTURE IN THE SOUTHERN LEVANT

It has recently become clear that sedentism did not mark a point of no return for human foragers en route to small-scale, permanent agricultural societies. Instead the transition to agriculture in the southern Levant was characterized by sizeable fluctuations in human mobility and site occupation intensity (Bar-Yosef 2002; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris and Belfer-Cohen 1998; Grosman 2003; Munro 2001; Stiner et al. 1999, 2000; Valla 1998). The shifts in site occupation intensity outlined above were undoubtedly influenced by changing social and economic needs, some of which were linked to climatic and environmental change. The permanence of human communities is intimately linked to settlement patterns, subsistence strategies, social organization, and ritual practice. Furthermore, the correlation between shifts in the small game index, the transition to agriculture, and significant climatic change is unlikely to be a coincidence and must have been closely connected with aspects of subsistence evolution that culminated in the intentional cultivation of cereals by humans.

The story begins with a rise in site permanence in the Early Natufian, a period that was originally interpreted as the setting of the first sedentary communities by Garrod (1932, 1957), and has since been confirmed by many subsequent studies (i.e., Bar-Yosef and Belfer-Cohen 1989, 2002; Bar-Yosef and Meadow 1995; Henry 1989; Tchernov 1984, 1991, 1993; Valla 1998). Intensive site occupation is accompanied by thorough exploitation of cereals, nuts, gazelle, and small game, especially in comparison to earlier periods (Munro 2001, Wright 1994; Unger-Hamilton 1989, 1991). Subsistence intensification allowed humans to reap more energy from a given area and to inhabit longer term settlements with more occupants. In the Early Natufian human carrying capacity was effectively raised both through the use of new subsistence and processing strategies and by the presence of prime climatic conditions for cereal growth. Warm and wet conditions favored the growth of C_3 grasses such as cereals (Bar-Yosef and Meadow 1995; Bar-Yosef and Belfer-Cohen 2002), which when harvested and processed with the appropriate techniques, had the potential to produce substantial yields in comparison to other traditional resources.

The return to a more mobile settlement strategy in the Late Natufian corresponds tightly to major climatic change instigated by the Younger Dryas. A significant drop in mean temperature of up to 6°C (Grosman and Belfer-Cohen 2002), and an aridification trend significantly reduced the distribution of cereal grasses in the Mediterranean zone (Baruch and Bottema 1991; Bar-Yosef and Belfer-Cohen 2002; Bar-Yosef and Meadow 1995) and had direct repercussions for human carrying capacity. Resources habitually used in the Early Natufian were no longer sufficiently abundant to support long-term human populations in a single location. Despite emerging territoriality (Bar-Yosef and Belfer-Cohen 2002; Belfer-Cohen and Bar-Yosef 2000), population densities were still small in post-agricultural terms, and thus mobility likely remained a viable solution to combat resource stress instigated by environmental change. Although, mobility remained an option, it could not have been effective unless associated with an overall reduction in human population density. Patterns of mobility likely varied over time in response to short-term fluctuations in climate (Grosman and Belfer-Cohen 2002), seasonality and the configuration of human social territories. Recent evidence suggests that mobility was also intimately linked to ritual activities associated with human death and burial (Grosman 2003). Natufian cemeteries are nearly exclusively located in the Mediterranean zone, despite the expansion of Natufian settlement into surrounding semi-arid zones. Unfortunately, the resolution of the Late Natufian record is insufficient to reconstruct specific details; suffice it to say that increased mobility was likely expressed by shorter term occupations, more frequent moves, and smaller group size—changes that are visible in Late Natufian settlement patterns. Numerous small seasonal camps and resource extraction sites appear in the Late Natufian, particularly in the Jordan Valley (Belfer-Cohen and Grosman 1997; Crabtree et al. 1991; Grosman et al. 1999), and the use of some Early Natufian basecamps in the Mediterranean zone continued perhaps primarily as cemetaries.

Not surprisingly, there is a leap in site occupation intensity between the Late Natufian and the PPNA. It is logical that the demands of a new horticultural lifestyle forced humans to stay closer to home for longer consecutive periods. The small game index confirms that site occupation intensity increased dramatically during the PPNA and surpassed even the Early Natufian phase. Estimates of up to ten times the number of inhabitants at Natufian campsites have been proposed for early horticultural villages including Netiv Hagdud and Jericho (Bar-Yosef and Belfer-Cohen 2002) and attest to an enormous rise in the scale of occupation intensity over even the Early Natufian period. This increase must be attributable to the stability and reliability of small-scale cultivation in comparison to the intensive use of wild cereals that formed the mainstay of Natufian diets. Small-scale cultivation in the PPNA markedly increased the caloric yields of agricultural lands, and thus raised the number of people who could be sustained per unit area. Notwithstanding the possibility that the Natufians experimented with horticulture, the vast scale of difference between Early Natufian and Early Neolithic villages makes it difficult to believe that humans engaged in true cultivation—the intentional, planting, tending, and harvesting of plant foods—prior to the Neolithic period.

How does this reconstruction fit with current explanations for the origins of agriculture in the southern Levant? Recent interpretations of the Late Natufian view the mobile human adaptation as unstable and unsuccessful, and the Younger Dryas as the cause of evolutionary significant food stress that played a causal role in the initiation of agriculture (Bar-Yosef 2001, 2002; Bar-Yosef and Belfer-Cohen 2002; Belfer-Cohen and Bar-Yosef 2000). This is an influential and reasonable interpretation that depends on two important premises. First, that cultivation began prior to the end of the Younger Dryas and second, that humans invoked intensification strategies (i.e., cultivation) to cope with food shortfalls created by climatic change.

We know that cultivation was the dominant mode of subsistence in the PPNA, but did its origin coincide with the Younger Dryas or did it begin later? To answer this question we must determine whether cultivation initially appeared in the Late Natufian or in the earliest PPNA, and whether the Younger Dryas terminated at the junction between the Late Natufian and the PPNA or early in the PPNA. As climatic evidence accumulates and ^{14}C chronologies are refined Bar-Yosef and Belfer-Cohen have gradually revised their view on the timing of the earliest agriculture (Bar Yosef 1996; Bar-Yosef and Belfer-Cohen 1989, 1991, 2002). Most recently they have suggested that early cultivation appears in the southern Levant in the very last stage of the Younger Dryas, although a precise correlation between the archaeological and climatic records is difficult given the differences in the resolution of the two records and the geographic distance between the data sources (Bar-Yosef and Belfer-Cohen 2002). Climatic evidence for the Younger Dryas is rarely available at the archaeological sites themselves, and usually originates from distant locales such as sea and lake bottoms and limestone caves. Thus, although the identification of a secure time range for the Younger Dryas and the occupation of archaeological sites is possible, precise correlations between the two are not. Further complications are raised by the paucity of early agricultural sites in the region, the lack of precise ^{14}C dates for those that do exist, the size of the error margins associated with the radiocarbon dates, the sometimes poor quality of paleoenvironmental data, and the difficulty of determining precisely when the local impact of the Younger Dryas ended (Bar-Yosef and Belfer-Cohen 2002). Clearly, the Younger Dryas and the origins of agriculture are temporally associated, but how closely cannot be resolved with current chronological data. Evidence must instead be sought in the admittedly sparse Late Natufian and PPNA archaeological records. If the Younger Dryas was indeed a primary cause of resource stress sufficient to prompt cultivation, it should coincide with evidence for food stress and subsistence intensification.

Studies of large collections of Natufian skeletons reveal no good evidence for dietary stress or any significant differences between Early and Late Natufian populations (Belfer-Cohen et al. 1991; Smith 1991). Evidence for subsistence intensification is equally elusive in the Late Natufian at the time of the Younger Dryas. Intensification strategies that can be detected in the zooarchaeological record include intensified processing of animal bones to extract grease and marrow, dietary diversification (the capture of less cost-effective animals such as fast, small-bodied game, or juvenile animals), and the acquisition of resources at greater distances from the consumption site (Colson 1979; Miracle 1995; Minnis 1985). An earlier study of Early versus Late Natufian faunal resource use shows that relative species abundance, age profiles, body-part representation, and fragmentation are virtually identical for all major animal taxa, with the exception of the shifts in the relative abundance of small game taxa reported earlier (Munro 2001, Munro n.d.). If anything, human foraging intensity decreased during the Late Natufian when hunters virtually ignored reliable, albeit costly sources of animal protein (hares and birds), despite their popularity in the Early Natufian period.

Cultivation is another effective intensification strategy that allowed humans to increase resource yield by investing in the production, protection, harvest, and processing of cereal grains in a given unit area. Full-fledged cultivation was undoubtedly preceded by an experimental phase when humans may have intentionally or unintentionally dispersed plants and observed and benefited from the results. Humans may or may not have tended these plants or taken full advantage of their products. The prime difference between experimentation and full-fledged cultivation is in the predictability and yield of plant resources. Knowledge that could be implemented when conditions were ripe was likely the most important benefit of experimentation. Unfortunately it is notoriously difficult to detect evidence for cultivation in the archaeological record, particularly in the Levant where carbonized seeds rarely preserve in pre-agricultural deposits (Bar-Yosef 2002), and early domesticates often resemble their wild progenitors (Kislev 1992). The lack of compelling evidence for cereal cultivation in the Early and the Late Natufian phases is insufficient to refute its existence. Regardless, the first solid evidence for cultivation appears in the early PPNA villages (Zohary 1992; Zohary and Hopf 2000; but see Kislev 1992).

Based on these observations, it is difficult to conclude that cultivation was adopted as a response to resource stress created by the Younger Dryas. There is no question that the Younger Dryas altered climatic conditions and resource abundance and that the Late Natufians had to substantially adjust their strategies to respond to these changes, but resource intensification is only one of many possible solutions (Colson 1979; Minnis 1985; Miracle 1995; Speth and Scott 1989). A more compelling explanation is that the Late Natufians adjusted to fluctuating resource distributions by dynamically adjusting their demographic patterns through increased population mobility, reduced site occupation intensity, emigration, and decreased rates of population growth. This allowed the Natufians to maintain their equilibrium with local resources without substantially altering their subsistence practices. This explanation is supported by the evidence for reduced site occupation intensity and increased population mobility presented earlier. In addition, Late Natufian settlement patterns are characterized by fewer and smaller sites in the Mediterranean zone and an increased number of sites in the neighboring arid zones (see above). The success of the Late Natufian strategy is supported by its lengthy ca. 1300 year duration and the consistency of this adaptation across time and space.

So what was the role of the Younger Dryas in the transition to agriculture? It is tempting to conclude that the Younger Dryas was a driving force in the adoption of agriculturae economies. The archaeological record indicates that the event was of sufficient severity and duration to significantly disrupt the largely sedentary Early Natufian lifestyle that preceded it. The Late Natufians likely experienced episodes of stress of varying degrees over time, but the resolution of the archaeological record is insufficient to capture the details of this variability. Humans may have also experimented with cereal cultivation during this period. The chronological link between the end of the Younger Dryas and the initiation of cereal cultivation, however, is not yet adequately established. Nor is there evidence for telltale signals of intensification in any other aspects of the Late Natufian archaeological record. Finally, we need to ask why humans would successfully implement demographic solutions such as increased mobility to cope with declining carrying capacity during the first thousand years of the Younger Dryas and then suddenly adopt intensification during its last days. It seems more likely that cultivation began with the improvement of climatic conditions in the early PPNA. Clearly, there is an important relationship between the Younger Dryas and the origins of agriculture, but results from this study suggest that although the Younger Dryas may have provided the Natufians with the know-how for cultivation, it did not provide the final ”push” to embrace it.

ACKNOWLEDGEMENTS:

I am grateful to Nick Conard, Hans Peter-Uerpmann, the Tübingen Prize Jury and the Institute of Archaeology at the University of Tübingen for awarding me the 2003 Tübingen Prize in Early Prehistory and Quaternary Ecology, and for hosting my pleasant trip to Tübingen. Thanks also to Laura Niven for being an excellent host. I owe a special debt to Mary Stiner who advised, supported, and inspired all stages of research. The ideas presented this paper were also greatly influenced by discussions with Guy Bar-Oz, Ofer Bar-Yosef, Anna Belfer-Cohen, Leore Grosman, Gideon Hartman, Liora Horwitz, Steve Kuhn, John Speth, Mary Stiner, Eitan Tchernov and Steve Wolverton. Thanks to Ofer Bar-Yosef, Leore Grosman, Eitan Tchernov, François Valla and Mina Weinstein-Evron for generously granting permission to study their collections. This research was supported by grants from the National Science Foundation (Dissertation Improvement Grant SBR-9815083), the University of Arizona Final Project Fund, the Levi Sala Care Foundation, and Doctoral Fellowships from the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Department of Anthropology, University of Arizona (Haury Dissertation Fellowship).

APPENDIX A:

GENERAL CATEGORY	TAXON	ELWC ENAT	HAYC ENAT	HAYC LNAT	HAYT LNAT	HLZT LNAT	NVHG PPNA	GILG PPNA
PICES	Indeterminate	n/a	23	8	10	8	0	0
REPTILIA	*Testudo graeca*	247	1777	2542	3483	848	1	0
AVES	*Anser sp.*	0	1	1	0	0	8	2
Anseriformes	*Anas sp.*	0	1	1	0	1	279	33
	Tadorna sp.	0	0	0	0	0	215	1
Phasinidae	Indeterminate	0	4	2	0	0	0	0
	Alectoris chukar	0	818	231	53	41	3	1
	Francolinus francolinus	0	0	0	0	0	16	0
	Ammoperdix sp	0	0	0	0	0	4	0
	Coturnix coturnix	0	5	7	0	1	120	0
Gruiformes	*Rallus aquaticus*	0	2	1	0	0	0	0
	Fulica atra	0	8	1	0	0	1	0
	Otis tetrax	0	0	1	0	0	0	0
	Otis tarda	0	9	5	0	0	9	0
	Vanellus vanellus	0	1	0	0	0	0	0
	Vanellus spinosus	0	0	0	0	0	0	2
	Crex crex	0	2	2	0	0	0	0
	Grus grus	0	3	0	0	0	0	0
Columbiformes	Indeterminate	0	1	0	0	0	0	0
	Columba livia	0	5	7	0	2	2	6
	Columba palumbus	0	0	1	0	0	0	0
	Streptopelia sp.	0	0	0	0	0	0	1
General Aves	Small Aves	8	14	12	0	0	0	0
	Medium Aves	215	408	1	43	27	0	0
	Large Aves	70	72	30	7	3	0	0
	Huge Aves	16	15	9	0	0	0	0
MAMMALIA	*Lepus capensis*	536	1559	417	630	44	84	1
	TOTAL	1092	4728	3279	4226	975	742	47

Appendix A: *NISP counts for small game taxa included in the analysis. Site name abbreviations: ELWC – el-Wad Cave; HAYC – Hayonim Cave; HAYT – Hayonim Terrace; HLZT – Hilazon Tachtit; NVHG – Netiv Hagdud; GILG – Gilgal. Time period abbreviations: ENAT – Early Natufian; LNAT – Late Natufian; PPNA – Pre-Pottery Neolithic A.*

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