Demography and Storage Systems During the Southern Levantine Neolithic Demographic Transition

Ian Kuijt

Abstract Despite its importance in understanding the forager–farmer transition, remarkably little recent research has explored the role of food storage and changes in food production as a foundation for the NDT. Drawing on data from the southern Levantine Neolithic, in this chapter I make two arguments. First, while significant, the NDT in the southern Levant was gradual, and it appears that the major period of growth occurred ca. 1,200 years after the appearance of domesticated plants. Second, rather than focusing on plant domestication as the defining catalyst of the NDT, these data highlight the importance of food storage based on wild foods that facilitated greater sedentism. In the southern Levant, there is clear evidence that the subsistence and nutritional foundation for the NDT appeared several thousand years before the appearance of domesticated plants.

Keywords Food Storage · Pottery Neolithic Periods · Natufian

> *. . .whenever resources are highly seasonal, sedentarism and large-scale storage imply each other: storage brings forth sedentarism, and sedentarism presupposes storage* (Testart 1982: 524).

The Near Eastern Neolithic Demographic Transition: Exploring Changes in Demography and Food Storage

The transition in food production from collecting wild resource to reliance on farming of domesticated plans and animals represents the major social and economic transition in human prehistory. While it has long been noted that population increases were linked to the Neolithic revolution it is only relatively recently that direct explicit research has focused on demography. Focused on north and central Europe, Bocquet-Appel (2002) argues that European Mesolithic and Neolithic cemeteries illustrates a two-phase demographic transition in what is now known

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as the Neolithic Demographic Transition (NDT for short). In the initial phase of the Mesolithic (or Epipaleolithic, and more specifically Early and Late Natufian, if one is focusing on the Levant) to Neolithic transition we see a shift from a quasi-homeostatic equilibrium in birth rates to a much higher birth rate. Bocquet-Appel hypothesizes that this was linked to improved dietary conditions with the introduction of grains, and eventually, the adoption of dairy products (Bocquet-Appel 2002:647). It is hypothesized that after 500–1,100 years an increase in mortality would cause a return to quasi-stationary equilibrium. It is important to note that the highest birth rate (from his samples this represents at rate of 1.24%) occurs between 300 and 800 years after the appearance of domesticates.

Other demographic studies have sought to expand our understanding into new geographical areas and different topics, directing new attention to the demographic links to settlement systems (Bandy 2004), and changes in agricultural labor and subsistence (Eshed et al. 2004). Other studies of settlement and mortuary changes in a mixture of primary and secondary domestication contexts in the Americas (see Bandy 2006; Bocquet-Appel and Naji 2006), and European case studies (e.g., Bocquet-Appel 2002) based on secondary diffused Neolithic economic and technological packages, have yet to resolve if the magnitude and overall timing of the NDT is the same in case studies characterized by the diffusion of farming into new regions compared to regions of primary agricultural origins such as the Near East.

As noted at the start of this chapter, Testart (1982) has forcefully argued that food storage, population growth, sedentism and social inequality are often interlinked. As outlined elsewhere (Bellwood 2005, Bar-Yosef and Meadow 1995; Read and Le Blanc 2003), with greater sedentism, increased birth rates and increased quality and quantity of domesticated foods we see the foundation for dramatic social and cultural developments.

Additional research (Stopp 2002; Ingold 1982) has shed new light on the use of storage among hunter-gatherers: storage is both compatible with nomadic movement, and in some contexts, actually furthers highly mobile settlement systems. While Testart (1982) is largely correct in identifying the potential social and economic byproducts of the use of storage systems, other researchers (Hayden 1982; Ingold 1982:531) convincingly argued that in some situations permanent settlement with agriculturalists, tied to intensive storage, still requires women to move from residential to field areas. From this perspective food storage does not always result in reduced physical stress during the seasons where active fieldwork and harvesting are required, although clearly it does result in an overall decrease. While there is disagreement as to the links between food storage and population growth among researchers (e.g., Hayden 1981; Ingold 1983; Testart 1982), there is general agreement that while food storage may not directly result in population growth, significant population growth is largely predicated on intensive agriculture and food storage.

This chapter is focused on the unexplored intersection of Neolithic food storage and demography, and is grounded on the assumption that the development of storage technologies is critical aspect of population growth, such as witnessed with the NDT. Focusing on the southern Levant with the gradual transition from collector-foragers to foraging-farming economies, I examine current modeling of the NDT

from two archaeological perspectives: population growth, as seen in through the lens of settlement size, and shifts in subsistence strategies, as reflected in changes in storage practices. In the first section I explore some of the interrelationships between settlement practices and demographic increases. This analysis suggests that while there was a concomitant increase in the size and nature of settlements with the initial appearance of domesticated plants and animals, there was also a much greater increase in settlement size some 1,500 years after the first appearance of domesticates. These results highlight that the NDT does not appear to be as pronounced in the primary domestication context of the Near East compared to contexts where population migration and diffusion of agriculture occurred. In the second half of the chapter I present available data for changing storage practices before and during the NDT, and discuss some of the possible links between economic intensification, sedentism and food storage. Drawing upon these data, I develop the argument that Epipaleolithic–Neolithic storage practices and settlement data illustrate a higher degree of pre-agricultural sedentism than seen in the European Mesolithic–Neolithic transition. Collectively, I argue that to understand the southern Levantine NDT it is necessary for us to understand how food storage created the conditions for reduced residential mobility, increased access and control over plant foods throughout the year and ultimately led to reduced stress for females and increased birth rates.

Neolithic Settlement Size, Population Levels and Storage: Methodological Considerations

Before proceeding further it is necessary to briefly address some methodological complexities of reconstructing settlement systems, demographic patterns and storage practices. Recent research (Eshed et al. 2004; Hershkovitz and Gopher 1990; Henry 2002; Kuijt 2000) has explored a number of thematic and methodological questions related to Neolithic demographic change. Archaeologists often follow one of two methodological pathways when looking at demography: study of mortuary data, and population estimates based on settlement size and architectural density. Both approaches have strengths and weaknesses. As noted by Berner and Schultz (2004), demographic reconstruction based on skeletal material and death rates requires a series of assumptions. Similarly, site-level demographic reconstruction based on architectural data requires estimates of the size of settlements, the amount of time the settlement was occupied, and if the architectural remains at a settlement reflect a single contemporaneous occupation or multiple occupations in different points within a single phase (see Banning and Byrd 1987, 1989; Bienert et al. 2004:168–169).

Drawing on ethnographies attuned to the use of space, archaeologists (e.g., Cessford 2005; Henry 2002; Kuijt 2000) have employed architectural data sets to better understand Neolithic demographic change. This approach is complicated by several operational assumptions: (1) that the type and density of structures in excavated areas are a representative sample; (2) that the horizontal extent of cultural

materials for each site represents the maximum extent of the site while occupied; (3) that the occupation density is constant in all areas of the site; and, (4) the social and economic systems for sites from different periods are similar enough to 20th century ethnographic or mortuary studies to permit reasonable comparisons. Population reconstruction based on settlement data generally requires acceptance of these assumptions, but such analysis is complicated by the fact that not all parts of settlement were always occupied at the same time (see Akkermans et al. 2006; Kuijt 2004).

As argued elsewhere (Akkermans et al. 2006: Bienert et al. 2004:168–9: Rollefson and Köhler-Rollefson 1989:79), most structures/areas of settlements were probably occupied at different temporal points (perhaps separated by tens or hundreds of years) within a single phase. While arguably these are contemporary in archaeological time, in reality the occupants would not have known each other and the human processes that produced materials residues were largely unconnected. Researchers also debate how site area and architectural density might have been linked to population density (see Cessford 2005; Garfinkel and Miller 2002: 258; Kuijt 2004 for a range of estimates). Such debate is understandable as there is considerable variation in the ethnographic estimates provided by the researchers (e.g., Kramer 1982: van Beek 1982; Watson 1979) used to model prehistoric population levels. Based on the ethnographic and ethnoarchaeological research of van Beek (1982), Kramer (1982) and Watson (1979), researchers have developed a range of estimates on the basis of the amount of floor space/person, or the number of people living in a 1 ha settlement. For example, working backward from how many people lived around 1 ha of land, the resulting estimates vary between 97 and 83 people per ha (Kramer 1982 and Watson 1979) to 294 people per ha (van Beek 1982). Choosing the larger of these estimates, many researchers (including Kuijt 2000, Table 2) employ van Beek's (1982) estimates to generate population estimates. In the absence of any clear consensus, it is probably best to employ Kramer's (1982) and Watson's (1979) more conservative, lower estimates, for developing population estimates. It is, moreover, probably better to employ such data as comparative estimates, rather than as straightforward reference for past populations (see Akkermans et al. 2006; Hassan 1981; Hershkovitz and Gopher 1990 for further discussion).

Along similar lines it must be recognized that there are numerous complexities in identifying the material manifestations of different types of storage in the past (see Ingold 1983; Stopp 2002; Testart 1982). The reconstruction of past storage through archaeological data is both highly complex, and given that it deals with materials that do not always preserve well in the archeological record, our archaeological understanding at some level will always remain incomplete. Our confidence in interpreting select features as being used for storage, as well as the scale of storage, is tempered by several constraints. First, due to differential preservation not all food storage can be identified in the archaeological record. While not random, direct preservation of foods through burning or other agents of conservation, is inconsistent and unlikely to be representative of the entire range of foods used and stored in a prehistoric economy. Second, ethnographic accounts of hunter-gatherers and farmers provide evidence for a wide range of storage practices, many of which have

no or few material manifestations, and occur off site (Stopp 2002). It is important to acknowledge that at times storage is largely untraceable even with the most sensitive and sophisticated archaeological research. Third, while we can use ethnography to help us understand the past use of architectural features, it is possible that Neolithic storage practices differed from the comparative case. Much of our archaeological understanding of past storage practices is based on preserved features and structures that are empty, rather than direct evidence such as the recovery of burned paleobotantical remains from inside of features. Researchers are often left with no alternative but to develop circumstantial arguments that specific features were used for food storage rather than on general storage of goods.

While recognizing the methodological complications in reconstructing storage practices, this does not negate the importance of addressing this issue. If one accepts, as I do, that subsistence intensification, population growth and the emergence of new forms of property are interrelated, then it is critical that we seek to understand changes in Neolithic storage systems. In cases where we have preserved remains, it is possible to generalize to the use of wider storage technologies and practices.[1] Let us now turn the archaeological evidence for settlement change and food storage before, during and after the NDT.

The Levantine NDT: What Does the Settlement Data Tell Us?

How does southern Levantine Neolithic settlement data help us understand demographic change with the forager–farmer transition in general, and the NDT model in specific (Bocquet-Appel 2002)? To what extent do we find a corresponding increase in the size of settlements and density of architecture in the period directly after the appearance of domesticated plants and animals? Working on the assumption that the largest settlements provide a relative idea of changing demographic patterns through time, several researchers note that the overall Neolithic settlement pattern illustrates considerable expansion in communities from the period of 11,500 to ca. 8,400/8,000 cal BP and a drastic reduction in the size of settlements after this point.[2] As one would expect, there is a significant increase in the size of settlements

[1] My aim here is to examine available evidence for storage with the understanding that while much of it is related to food storage, there is the distinct possibility that some of these features and structures were used for other forms of storage. Just as importantly, this recognizes that archaeologists have only a limited understanding of the possible role of the range and importance of storage types with mobile foragers and early agriculturalists.

[2] The major phases of the Pre-Pottery Neolithic period, include the first semi-sedentary collector-agricultural villages in the Pre-Pottery Neolithic A (PPNA) appearing between ca. 11,500 and 10,500 cal. BP., the formation of established agricultural villages of the Middle Pre-Pottery Neolithic B (MPPNB) between ca. 10,500 and 9,500 cal. BP., and the emergence of large aggregate villages of the Late Pre-Pottery Neolithic B period (LPPNB) dating to between ca. 9,500 and 8,700 cal. BP. The Pre-Pottery Neolithic C period (PPNC) is viewed as a transitional phase between the LPPNB and Pottery Neolithic period at select sites. It remains unresolved, however, if PPNC was a regional or local phenomenon, or if it is significantly different, both materially

directly after the domestication of plants. For example, as seen in Fig. 1, the five largest known Late Natufian settlements are each approximately .2 ha. In contrast, the largest PPNA period settlements averaged over 1 ha. With the appearance of domesticated plants and some animals, we find that the largest known MPPNB period settlements increased in area to nearly 4.5–5 ha. Interestingly, a second and much more significant increase is seen in LPPNB settlements such as Basta, 'Ain Ghazal, which were between 10 and 14 ha in size (Fig. 1). Most of these villages appear to have lasted for only 3–400 years, or drawing on the research of Eshed et al. (2004), probably between 10 and 14 generations. Our understanding of the period in which these villages were abandoned, termed the PPNC period, remains poor. Excavations at PPNC components of sites, including Atlit-Yam (Galili et al. 1993), 'Ain Ghazal (Rollefson and Köhler-Rollefson 1989) and possibly Es-Sifiya (Mahasneh and Bienert 2000; Mahasneh and Gebel 1999), suggest that while some settlements may have become smaller in size and population, other settlements (such as Es-Sifiya) may have stayed at approximately the same size as LPPNB settlements, and were characterized by a high density of residential architecture (Figs. 1 and 2).

When we contrast the NDT model of Bocquet-Appel (2002) and the settlement data from the southern Levant we see some interesting, if not unexpected, patterns (Fig. 3).

Looking at the timing of these events several observations and queries can be made:

1. In contrast to the European examples, the pre-agricultural context of the Natufian and PPNA reflect a much higher degree of sedentism, and much larger settlements. Does this data support that such developments were only possible in a high-resource density region, where people could live well in small villages and rely on wild plants and animals in a relatively local catchment area?
2. There is a clear increase in the size of settlements, density of structures and the number of burials in the MPPNB immediately after the appearance of domesticated plants and animals. This would appear to be a physical by-product of increased sedentism, increased birth rate and subsistence intensification.
3. While MPPNB sites were considerably larger than PPNA sites, they were much smaller than those of the LPPNB. LPPNB villages were 3–4 times larger, with much greater architectural density. What were the social and economic factors that contributed toward the remarkable growth of LPPNB settlements?
4. The emergence of the large LPPNB villages occurs 1,000–1,500 years after the first appearances of domesticated plants and animals in the Levant. If the emergence of LPPNB villages was related to the NDT, then how do we explain the time lag between domestication of plants and animals and emerging villages?

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and culturally, from other contemporary settlements. The length of this period remains unclear. The Pottery Neolithic is subdivided into two major sub-phases (with local adaptations) generally known as the Pottery Neolithic A and Pottery Neolithic B periods. Readers are directed to Gopher and Gophna (1993) for detailed discussion of the Pottery Neolithic period.

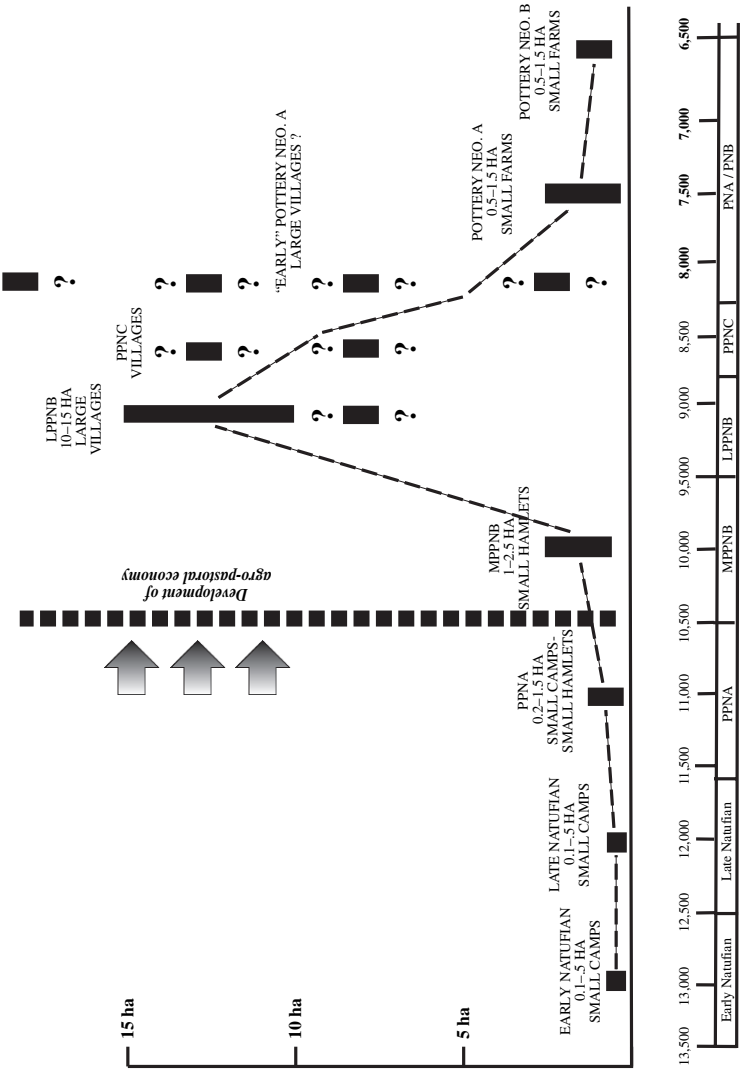

Fig. 1 Estimated changes in the horizontal extent of open air Late Natufian through Pottery Neolithic settlements located in the Mediterranean vegetative zone of the southern Levant. These data are based on the mean size of the largest sites by period (Kuijt 2001). Despite considerable field research over the last 10 years, variation in the size of Late Pre-Pottery and Pottery Neolithic villages remains unclear

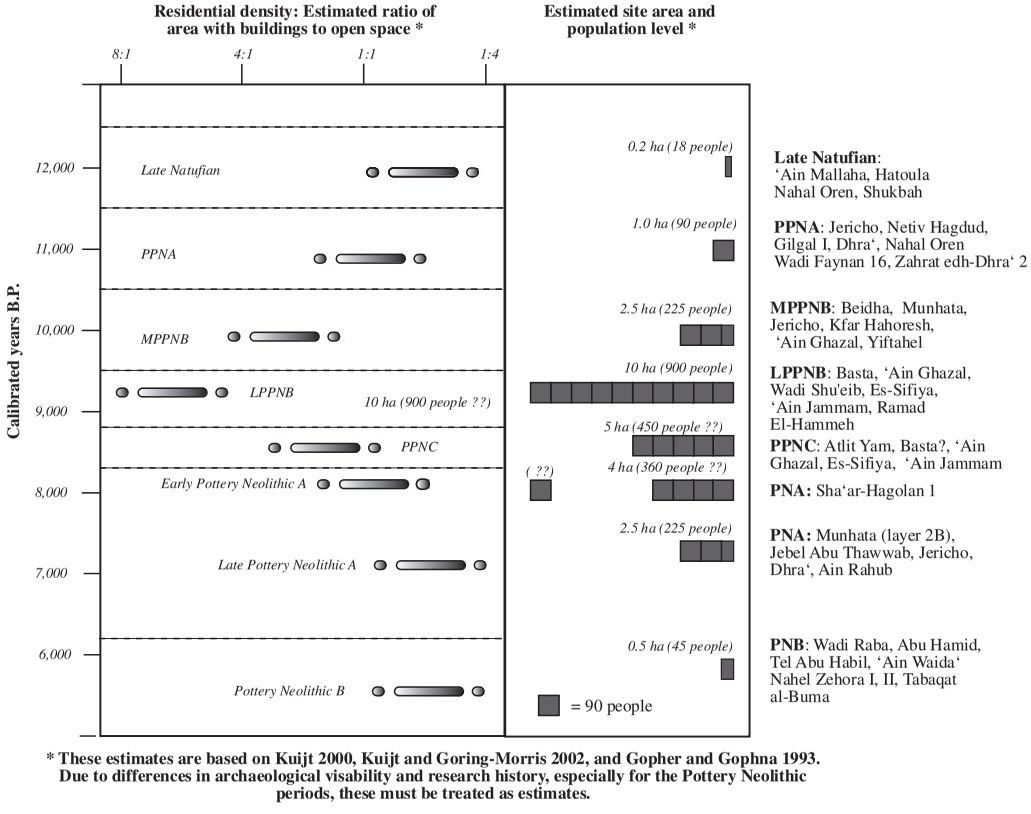

Fig. 2 Estimated changes in community housing in open air Late Natufian through Pottery Neolithic settlements located in the Mediterranean vegetative zone of the south-central Levant. The population estimates are based on rates developed from Kramer (1982:162) and Watson (1979:35–47)

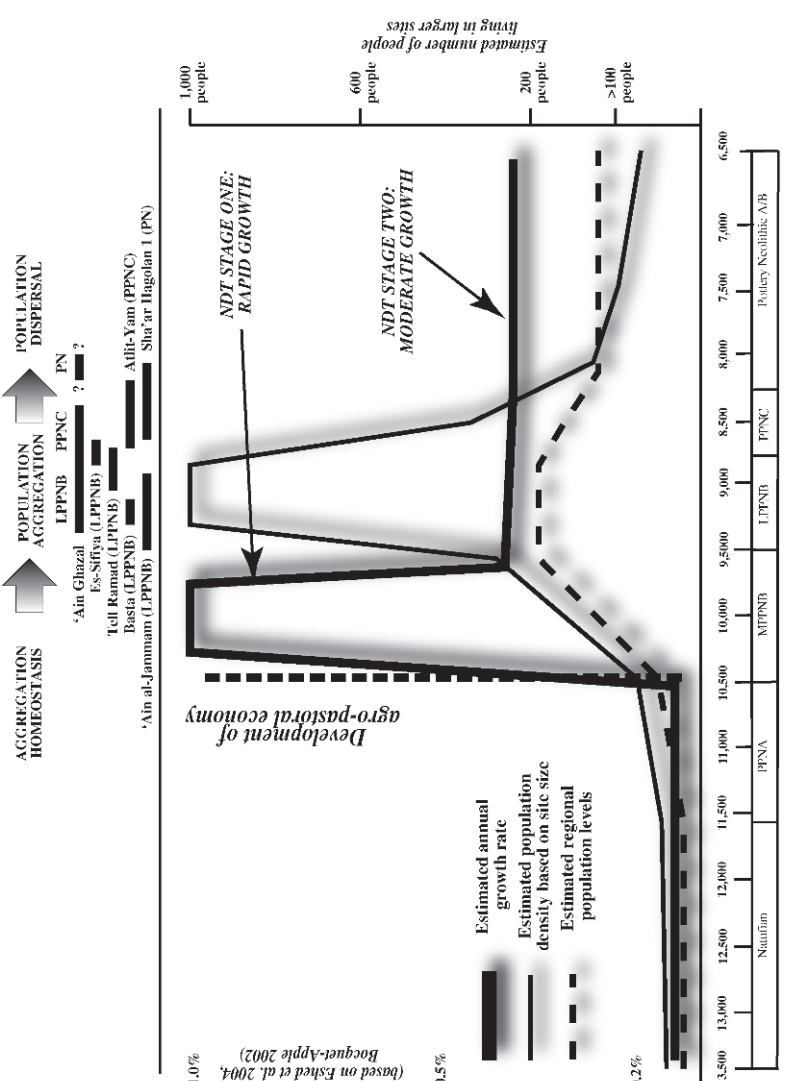

Fig. 3 Comparison of the estimated demographic growth pattern with the onset of agriculture and number of people living in large settlements (based on Fig. 2). Based on Eshed et al. (2004) and Bocquet-Appel (2002)

5. The dramatic increase in the density and size of LPPNB sites occurs just when Bocquet-Appel's (2002) model predicts a return to quasi-stationary equilibrium of birth rates. It is not clear that these are related events. If not, how are we to explain the patterning?
6. The large village systems of the LPPNB/PN were abandoned approximately 2,000 years after the development of domesticated plants and animals, and just before the 8.2 ky climatic shift. To what extent is this transition related to environmental, social and economic shifts?

Given space limitations I want to focus on the emergence of large LPPNB villages some 1,200–1,500 years after domestication occurred, and make two arguments: first, their appearance was at least partially linked to population aggregation rather than increased growth rates, and second, that unlike the European context, the southern Levantine transition was less marked or abrupt. Clearly any trajectory of regional Neolithic demographics potentially conflates two interrelated processes: (1) gradual and steady regional population growth through the Neolithic period(s), and (2) population aggregation in large and important settlements for ritual, political and economic reasons (Rollefson 1987). Disentangling these is, needless to say, challenging and complex, and of considerable importance to understand the social and demographic contexts of Neolithic lifeways. For methodological reasons, we need to understand this relationship to accurately estimate population levels. Since population pressure and growth are potential mechanisms of long-term change, this awareness is critical for us to understand the social and evolutionary processes that brought people together in the LPPNB.

While it is tempting to view the growth of LPPNB villages as reflecting some direct by-product of the NDT, I think there are strong reasons to suspect that the phenomenon is linked to population aggregation, economic shifts and the development of new systems of property and ownership. Over the last 15 years archaeologists working in the southern Levant have demonstrated that people living in the LPPNB built a series of large settlements, with densely packed one and two-story residential housing, and occupied by hundreds if not thousands of people (Fig. 4) (Banning 1998; Bar-Yosef and Meadow 1995; Gebel 2004; Rollefson 1989; 1998; Simmons 2000). Despite the broad horizontal extent of these villages, as well as the densely packed architecture, archaeologists have noted a puzzling pattern: the apparent under representation of human burials in LPPNB villages (Bienert et al. 2004). In one of most direct explorations of this topic Bienert et al. (2004) provide a range of possible explanations for this pattern. Reflecting further on the question of where are the dead, it strikes me that there is no corresponding increase in the number of burials and site size in the LPPNB, and that the number of burials per standard area in the MPPNB and LPPNB are relatively similar. If correct, this supports the argument that annual population growth rates in MPPNB and LPPNB communities were relatively similar. From this perspective, the increase density of architecture and large horizontal extent of LPPNB settlements were related to shifts in how labor was organized, how food and other resources were stored and how buildings were constructed. I will return to this point in the second half of this chapter.

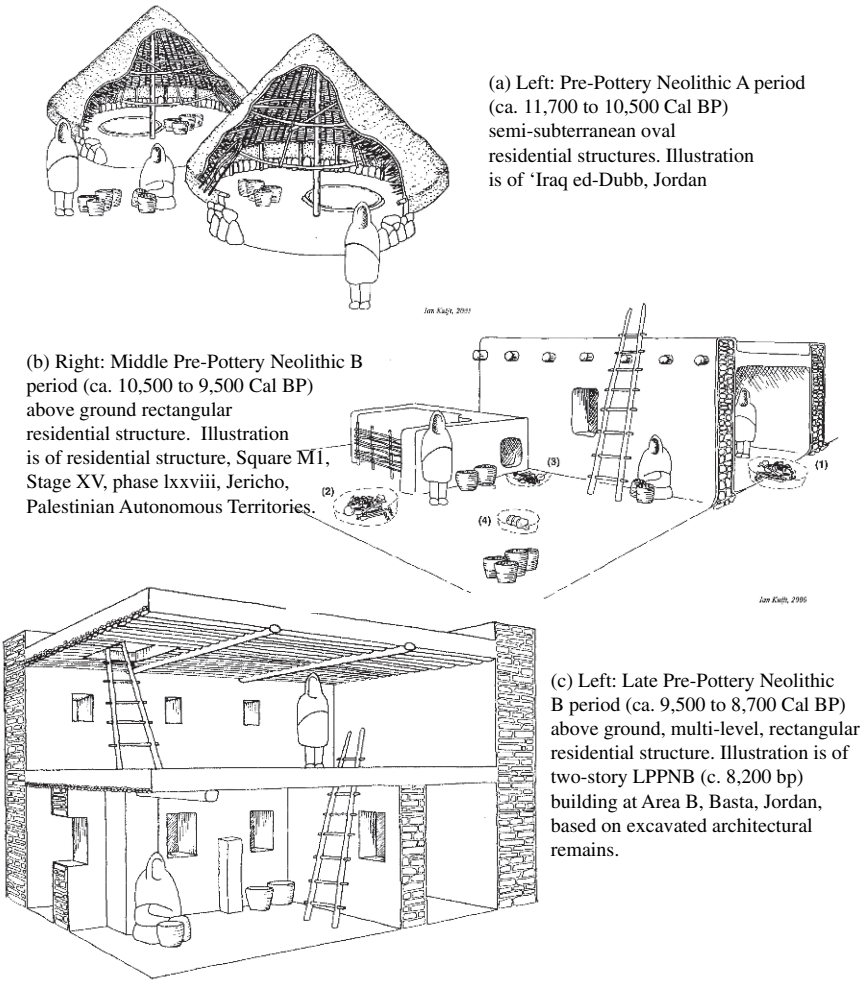

Fig. 4 Changing architectural systems in the Southern Levantine Pre-Pottery Neolithic A and Pre-Pottery Neolithic B periods (illustrations by I. Kuijt)

The Abandonment of LPPNB Villages

With the end of the LPPNB we find evidence for the break-up of large villages into much smaller villages and hamlets of the Pottery Neolithic, presumably with changes in social, economic and political organization. While the settlement data presented here appear to support the continued existence of large settlements into the early PN, these are very different from the settlements of the LPPNB. The large settlements from the LPPNB, PPNC and early Pottery Neolithic periods (such as at sites of Basta, 'Ain Ghazal, Sha'ar Hagolan 1 and Atlit Yam), illustrate a very

different material and architectural form. In the early Pottery Neolithic period (local expressions of which are termed Yarmoukian and Jericho IX), some settlements (such as Sha'ar Hagolan 1 and 'Ain Ghazal) were still quite large.[3] Despite changes in lithic technology, economy, mortuary practices, and the development of ceramic technology, it appears that some groups still lived in large villages in the early PN. These villages, however, were significantly different. Early PN villages had a much lower density of residential architecture; only single-story buildings widely spaced throughout the site, and resulted in fewer cultural deposits. As argued by Banning et al. (1994), and Banning (2004) the transition to the later phases of the Pottery Neolithic represents a shift in settlement systems, one where we see the establishment of new smaller settlements. Research in Syria by Akkermans et al. (2006) argues that this pattern reflects small groups frequently building hamlets in the same general area. They (2006:154) comment: "Whereas people at the start of the Pottery Neolithic primarily continued the life of their ancestors in the same place, those at the end of the epoch began to exploit an even more extensive area in a flexible and varied way." The combination of these overlapping of spatially discrete occupations created the appearance of a much larger settlement. By the end of the general PN period, and more specifically, the PN B period (Readers are directed to Gopher and Gophna 1993 for further discussion of the PN) the average size of settlements was often less than 1 or 2 ha. This broader transition, then, can be characterized as the move from a high-density residential housing to dispersed hamlets reflecting smaller economic and social units.

If the appearance of such large settlements a 1,000–1,500 years after the appearance of the first domesticated plants and animals in the Near East is not related to regional population growth, then how do we explain it? Assuming that the extensive horizontal extent of LPPNB architecture reflects population increase rather than new systems of building, we can identify several explanations for the emergence of LPPNB villages and population growth:

1. Increased interpersonal conflict. The developments of new forms of food production resulted in heightened levels of interpersonal conflict and competition for resources. From this perspective regional population growth would have been relatively stable, but competition over diminishing resources and water may have created the context for people to aggregate into limited number of larger competing villages.
2. Economic intensification and labor. Economic intensification and the emergence of the relatively new agro-pastoral economy would have changed labor needs, and potentially contributed to the context for population aggregation. The potential needs for seasonal labor, and perhaps the improved access and quantities of dairy products, would have encouraged people to live in larger communities and improved the nutritional context of life.
3. More elaborate ritual and social practices. In light of increasingly fissive social forces, such as scalar stress, people may have developed new social and ritual

[3] For the purposes of this chapter I am using the term 'large' to identify any site that is larger than 6 ha in surface area.

practices to hold communities together. While producing a similar archaeological signature to the first point, this clustering of people would have been linked to control and access to ritual, rather than protection.

Clearly, much more work is necessary to understand the social, economic and demographic contexts of LPPNB village abandonment. In the remaining part of this chapter I want to shift focus to the possible role of economic intensification, and more specifically, the possible connection between changes in food storage, the increased subsistence buffer resulting from such storage and how this might have been connected to demographic change.

Food Storage and the NDT

Despite its importance in the forager–farmer transition, remarkably little research has explored the role of developing food storage and changes in food production as a foundation for the NDT. The structure of subsistence resources influences different cultural trajectories, and storage practices alter the balance between human reproductive success and the density and richness of resources. If the NDT was fundamentally based on increased birth rates due to improved quantity and quality of domesticated plants, then this should be reflected in the archaeological evidence for storage practices. Is there archaeological evidence for an increase in the number, quantity or location of Neolithic storage systems with the appearance of domesticates? The quick answer is yes, but the real answer is more complicated. To understand some of these complexities it is necessary to look at the evidence for food storage.

Now that we have explored settlement change during the southern Levantine NDT, let us return to the earlier social and economic foundations from which the NDT developed. In stark contrast to the European Mesolithic, the Epipaleolithic and early Neolithic of the Near East was characterized by a significant seasonal residential sedentism, and the intensive and extensive harvesting of wild plants (Bar-Yosef 1998). There is growing direct and indirect evidence, moreover, for some level of food storage in pre-domesticated contexts *before* the NDT. This suggests, in short, that in the case of the southern Levantine Neolithic, the subsistence and nutritional foundation for the NDT occurred earlier than previously anticipated and was initially based on wild resources. This highlights that in the case of the Levant, it is the move to sedentism, food storage and food production that was important, and not plant domestication.

Early and Late Natufian Period Food Storage

As with earlier peoples, the Natufians were focused on intensive and extensive harvesting of wild cereals (Bar-Yosef 1998). Natufian people utilized a remarkably wide range of wild plants and animals and probably had a detailed knowledge of the seasonality and availability of these resources. Certainly the increased degree

of sedentism in the Natufian period suggests that people were able to reduce seasonal food risks to the point where they could live in the same areas for one or more seasons of the year. There is, however, surprisingly little direct evidence for food storage. As noted by Bar-Yosef (1998), Ain Mallaha is the only site with any evidence for storage features, these being pit features partially coated with plaster. At the same time, there is considerable indirect evidence for food processing and storage, including the presence of sickles, food processing tools, such as mortars, pestles and bowls, all of which are interpreted as evidence for gathering and processing of pulses, cereals, almonds and other plants. One, but by no means the only, way of achieving this relative increase was through the development of new harvesting, processing and storage systems for food. Collectively, this indicates that Natufian people must have engaged in some form of lower level food storage, perhaps oriented toward smaller groups.

Pre-Pottery Neolithic A Period Food Storage

As with the Natufians, people in the PPNA developed a food surplus of wild plants based on the intensive collection and possibly cultivation of plants. Archaeological excavations have revealed that by (11,500 cal) BP in the southern Levant PPNA people employed at least two types of storage systems: small bins and larger storage silos.

Excavations at Netiv Hagdud and Jericho provide evidence for the use of small clay bins, possibly, but not unequivocally, linked to food storage. Two of these were identified at Netiv Hagdud (Bar-Yosef and Gopher 1997) and appear as small areas enclosed by mud walls preserved up to a height of ca. 10 cm. Due to limited preservation conditions it is not clear how high these wall stood, nor for that matter if they were located inside or outside of a structure. The excavators believe that these were used for some form of food storage or preparation features and that they were located inside of the structure. Similarly, Kenyon (1981) reports numerous small stone bin features at Jericho, such as the bins of phase DI.xxix (Kenyon 1981: Plate 37a).

The evidence for storage silos comes from excavations at Dhra‘, Netiv Hagdud and Jericho. Excavations at Dhra‘ have uncovered the remains of large storage silos constructed and used during the PPNA (Finlayson et al. 2003; Kuijt and Finlayson 2001). These storage silos were built on upright stones used to suspend wooden beams. The upright stones, many of which were recycled grinding stones, were notched on one end to allow for the suspension of wooden beams in creating a small (45–35 cm) sub-floor to allow for drainage and ventilation. Excavations at Netiv Hagdud (Bar-Yosef and Gopher 1997) produced a similar feature to that seen at Dhra‘, although this one was not as well preserved. This building, known as Locus 26, was a 3 × 3 meter structure defined by a mud wall. With the exception of the absence of upright stones, which may have been robbed for later buildings for some residential construction, the building is quite similar. Bar-Yosef and Gopher (1997) argue, in fact, that that structure was probably used for food storage, and as with the examples from Jericho, may have served as a dedicated storage building.

There are several important points to note here. First, the presence of these storage silos represents a form and scale of food storage not found in the Natufian period (Bar-Yosef 1998). If representative of regional practices in the PPNA, then this suggests that people not only had a food surplus but that this surplus was also of a significant scale. Second, it is important to note that these silos were developed for the storage of wild plant resources. Finally, these data provide evidence for the nutritional and caloric foundation, largely focused on wild cereals, nearly 1,000 years *before* the NDT. This economic foundation facilitated higher sedentism, established one of the necessary preconditions for increased birth rate seen in the MPPNB and collectively brought about changes in ideas and values attached to food storage.

Middle Pre-Pottery Neolithic B Period Food Storage

It is at around 10,500 years ago calibrated, during the MPPNB period, that we find our first evidence for large-scale storage practices occurring inside and outside of buildings (Tables 1 and 2). First, indisputable evidence for MPPNB food storage comes from the remains of storage bins located inside and outside of structures. In the excavations of Yiftahel, Garfinkel (1987) recovered the well-preserved archaeological remains of a mud storage feature placed in the corner of a room. While only partially preserved, this feature was lined with plaster/clay with an opening that allowed for people to reach into the storage bin. Clearly these installations were dedicated and purposefully designed features for food storage. Similarly, the excavations of Jericho revealed clear evidence for the construction of clay bins of the same design and relative size as the one from Yiftahel. This illustrates a pattern of intentional preservation and storage of food inside buildings for later consumption by multiple people. It is possible, therefore, that access to some of these stored foods may have been restricted and controlled by house or community leaders.

Second, there is evidence for storage in the location of post-holes inside of structures. Excavation results from ‘Ain Ghazal (Rollefson 1989; Rollefson et al. 1992) provide important insights into the organization of space inside and outside of buildings. Their excavations revealed portions of MPPNB buildings with large wooden posts set in upright positions as roof supports. In addition, smaller post-holes define a separate area. Connected together these posthole partitions outline areas in the corner of a room, in one case with an associated flagstone floor, and in other cases, areas at the backs of rooms. Third, we have the remains of small alcoves inside of MPPNB structures created by stone walls. The internal walls of these structures both created 1×2 meter areas and also served as structural supports for the roof. These enclosed areas would have been too small for sleeping. Thus, they probably served as the main internal storage areas for residence. These developments occurred long after the appearance of domesticated plants and animals. It is clear that MPPNB storage features were different from those of the PPNA, but this evolutionary pattern is very different from that of the European Mesolithic/Neolithic transition.

Table 1 General aspects of Levantine Natufian and Pre-Pottery Neolithic storage practices.

	Extra-mural	Inter-mural	Architecture	Interpretation	Sites
Early Natufian c. 14,500–12,800 BP	• No evidence	• Possible rare storage installations	• Single-story oval architecture • Free-standing semi-subterranean buildings	• Low residential mobility and some storage • Unclear access	'Ain Mallaha, Hayonimn cave, Kebarah, Wadi Hameh 27
Late Natufian c. 12,800–11,700 BP	• No evidence	• No evidence	• Single-story oval architecture • Free-standing semi-subterranean buildings	• Highly mobile groups with limited storage • Unclear access	'Iraq ed-Dubb, Fazael IV, Givat Hayil, Baaz Rockshelter
Pre-Pottery Neolithic A period (PPNA) ca. 11,700–10,500 BP	• Extra-mural storage silos	• Small storage installations in rooms?	• Single-story oval architecture • Free-standing Semi-subterranean buildings	• Low residential mobility and significant storage • Separation of residential and storage areas • Relatively open access	Netiv Hagdud, Jericho, Dhra 'Gilgal I, Zahrat adh-Dhra' 2
Middle Pre-Pottery Neolithic B period (MPPNB) ca. 10,500–9,250 BP	• Clay storage installations in open areas	• Clay storage installations in corner/sides of room • Small compartments	• Single-story rectangular architecture • Free-standing buildings • Sub-basement?	• Low residential mobility and significant storage • Integration of storage facilities and residential areas • Restricted access	'Ain Ghazal, Yiftahel, Jericho, Kfar Hahorish

Table 1 (continued)

	Extra-mural	Inter-mural	Architecture	Interpretation	Sites
Late Pre-Pottery Neolithic B period (LPPNB) ca. 9,250–8,700 BP.	• Unclear (Limited excavations)	• Transition to dedicated storage rooms	• Two-story rectangular architecture • Abutting buildings • Access by ladder/stairs from above?	• Low residential mobility and significant storage • Integration of residential and storage areas • Restricted access	Basta, 'Ain Ghazal, Es-Sifiya, 'Ain Jammam, Ghwair, Ba'ja
Pre-Pottery Neolithic C period (PPNC) ca. 8,700–7,800 bp	• No evidence	• Dedicated storage buildings?	• Abandonment of two-story architecture • Single-story buildings	• Low residential mobility and significant storage • Separation of residential and storage areas? • Unclear access	'Ain Ghazal, Khirbet Sheikh Ali, Atlit Yam

Table 2 Food surplus and practical storage: archaeological manifestations in the Levantine Pre-Pottery Neolithic

	Plant economy	Animal economy	Organization of practical storage (Dedication/Integration)	Scale of practical storage (Residential to Communal)	Access to stored materials (Restricted to open)
Early Natufian c. 14,500–12,800 BP	Intensive collection and variable cultivation of local wild plant resources	Intensive hunting of wild animal resources: no evidence for subsistence husbandry	• Storage inside and outside of residential unit in public context	• Very small volume	• Relatively unrestricted spatial access
Late Natufian c. 12,800–11,700 BP	Intensive collection and variable cultivation of local wild plant resources	Intensive hunting of wild animal resources: no evidence for subsistence husbandry	• Storage inside and outside of residential unit in public context	• Very small volume	• Relatively unrestricted spatial access
Pre-Pottery Neolithic A period (PPNA) ca. 11,700–10,500 BP	Intensive collection and variable cultivation of local wild plant resources: possible early domestication of some plants	Intensive hunting of wild animal resources: no evidence for subsistence husbandry	• Dedicated/storage outside of residential unit in public context	• Small volume	• Relatively unrestricted spatial access • Possible extramural storage facilities between residential structures
Middle Pre-Pottery Neolithic B period (MPPNB) ca. 10,500–9,250 BP	Collecting and cultivation of wild plant resources: variable use of a wide range of domesticates depending upon location	Hunting of wild animal resources: domestication of caprines (goat-sheep) for meat and secondary products	• Dedicated/storage inside of residence	• Medium volume	• Storage installations in corner/sides of room • Clearly identified storage locations

Table 2 (continued)

	Plant economy	Animal economy	Organization of practical storage (Dedication/Integration)	Scale of practical storage (Residential to Communal)	Access to stored materials (Restricted to open)
Late Pre-Pottery Neolithic B period (LPPNB) ca. 9,250–8,700 BP.	Primarily focused on a restricted range of domesticates depending upon location	Hunting of wild animal resources: increased reliance upon narrow spectrum (caprines, pig, cattle)	• Dedicated/separate rooms for storage	• High volume	• Spatially restricted access from second floor to first floor • Dedicated storage rooms in lower floor of building
Pre-Pottery Neolithic C period (PPNC) ca. 8,700–7,800 bp	Primarily focused on a restricted range of domesticates depending upon location	Hunting of wild animal resources: increased reliance upon narrow spectrum (caprines, pig, cattle)	• Dedicated/separate rooms for storage	• Unclear	• Single-story buildings • Dedicated storage rooms in lower floor of building

Late Pre-Pottery Neolithic B Period Food Storage

As in the MPPNB, LPPNB storage space was located in internal areas of buildings (assuming we are not missing important remains). In the LPPNB people developed new, larger enclosed storage areas, where access could be controlled. Archaeological evidence for storage systems is seen in dedicated storage rooms inside of buildings, in some cases with specially designed doorways (see Fig. 4c).

It is in the LPPNB we find our first evidence for two story-buildings, probably with people using space in ground level and upper floors differently. Architectural practices in the LPPNB shifted to the construction of rooms that shared common walls. In some cases rooms were added to buildings and in other cases they were pre-planned and purposefully designed. At Es-Sifyia people constructed multi-story buildings along a relatively steep slope area, with remarkably dense architecture (Mahasneh 1997; Mahasneh and Bienert 2000). Many of these buildings had small (ca. 1.5 × 1.5 meter) rooms, with no windows to exterior areas, and half-door entrances connecting to what was probably a central room. These rooms, as well as at Basta and Es-Sifyia, were accessed from central or adjacent rooms through small half-door entrances that are about 1 meter high (Kuijt 2001; Nissen et al. 1987).

The half-door system, with stone below and some form of wooden door for the upper half, were useful in creating a barrier against rodents and insects (Fig. 4c). This would have created a storage room where sacks or baskets of foods could have been securely stored. Regardless of what was being stored in these areas, it is clear that in the LPPNB people started to actively define space in new ways that limited access to stored resources. Excavations have also provided new information on the spatial connection between LPPNB food storage and food preparation. This includes recovery of domesticated plants from storage areas at ‘Ain Ghazal (Rollefson 1997) and Es-Sifyia. In many of the rooms large grinding stones were left in place, illustrating the spatial connection between food processing and storage (Wright 2000). The food preparation rooms were located relatively evenly across the excavation area.

Pre-Pottery Neolithic C Period Food Storage

Archaeologists have a poor understanding of food storage in the PPNC. (Readers are directed to Rollefson (2001), and Rollefson and Köhler-Rollefson (1989) for the most detailed examination of the PPNC.) As of 2007, no archaeologists have excavated a large horizontal area of a PPNC settlement. As such, researchers know remarkably little about how settlements might have been organized, how large PPNC settlements might have been, the extent to which people living in PPNC villages were mobile or if they were economically focused on the same subsistence resources as in the LPPNB.

Table 3 Comparison of estimated storage area and residential areas by period

	(a) Mean settlement size (ha) (100 × 100 m) (1000 m^2)	(b) Number of compartments (100 m^2)	(c) Number of compartments/site	(d) Ratio of potential storage space to internal area of buildings	(e) Average storage space	(f) Average storage space/Potential storage space (m^2) (= c multiplied by d and e)	(g) Total storage space at 20% occupancy of site
Early Natufian c. 14,500–12,800 BP	0.2	1.0	20	Similar to PPNA Ratio of .11	ca. 2.25 m^2	4.95	0.99
Late Natufian c. 12,800–11,700 BP	0.2	1.0	20	Less than E. Natufian	ca. 2.25 m^2	4.95	0.99
Pre-Pottery Neolithic A period c. 11,500–10,500 BP	1	2.4	240	= 1:7.7–1:10.2 Ratio of .11	ca. 6.25 m^2	165 m^2	33 m^2
Middle Pre-Pottery Neolithic B period c. 10,500–9,250 BP	2.5	6.3	1575	= 1:2.2–1:4.4 Ratio of .33	ca. 2.25 m^2	1,169 m^2	233.8 m^2
Late Pre-Pottery Neolithic B period c. 9,250–8,700 BP	10	14.5	14,500	= 1: 1.3–1: 2.6 Ratio of .5	ca. 2.25 m^2	16,312 m^2	3,262.4 m^2

Pottery Neolithic Period Food Storage

The earliest phases of the Pottery Neolithic illustrate a dramatic shift in how people stored foods, and most probably, the scale and intensity of food storage. In the early PN period settlements such as Sha'ar Hagolan 1 and 'Ain Ghazal, it does not appear that dedicated storage rooms were constructed as integrated parts of residential structures. Instead we see a return to dedicated external storage contexts. Excavations at Sha'ar Hagolan 1 (Garfinkel and Miller 2002), for example, illustrate the PN use of a wide range of features inside and outside of structures that could have been used for small-scale food storage and preparation, including cobblestone installations, raised stone platforms and most importantly the frequent use of pit features outside of structures. While the specific locations of food storage remain unclear in these households, it appears that in comparison to the densely packed LPPNB villages, people in the more dispersed PN villages had less physical space focused on storage. Moreover, food storage was more frequent in areas outside of the main residential building, but inside the compound area defined by stone and mud walls.

In sum, there appears to be a correlation between increased scale of MPPNB and LPPNB settlements size and storage systems, and this pattern changes drastically in the PN, regardless of the size of settlement. There is solid evidence for the appearance of new storage systems in the MPPNB, and storage of significant foods. While suggestive, the archaeological data from the LPPNB are not unequivocal due to methodological questions. The existence of large dedicated rooms is suggestive of an increase in the scale and control of access to storage within buildings. It is not clear, however, how much of this is linked to food storage, fuel or other economic goods.

Discussion

It is widely held that sedentism and improved control of plants resources were major factors in the NDT (e.g., Bocquet-Appel 2002). I agree with this argument. I suspect, however, that further research and this conference will move us beyond this generalization and demonstrate that the timing and pathways of the NDT varied in different case studies. This comparative approach will help us explore new questions.

One outgrowth of this study centers on the importance of food storage. Building on the work of Testart (1982), I argue that the initial stages of the southern Levant NDT were linked to food storage. Pre-domesticated food storage served as an economic and nutritional foundation for the NDT several thousand years before domestication. As noted earlier, people in the PPNA stored pre-domesticated plant surplus, and people in the MPPNB developed a series of new complex systems for storing domesticated plants. The existence of morphologically domesticated plants, as well as specific stone tools for harvesting and processing and now analysis of MPPNB features, highlights the importance of food storage. Looking at similar patterns at Jericho, 'Ain Ghazal and Yiftahel, helps us to recognize the development

of extensive and intensive food storage systems in these villages. Although neither exhaustive nor complete, this study clearly illustrates a significant ratcheting up of storage practices, and probably a new system and ideas about ownership, with the appearance of domesticated plants and the start of the NDT. In light of the likely nutritional improvements, and predictability that effective storage systems would have brought to PPNA communities, it is not clear why we do not see a more significant improvement in health or population growth rates before the MPPNB.

A second outgrowth is an understanding that the southern Levantine NDT was significantly different from that seen in Europe. Some of this is probably linked to the Near East being a primary center of domestication. This examination of southern Levantine settlement data reveals a pattern of gradual growth followed by continued, if not heightened, population aggregation in the LPPNB at least 1,200 years after domestication. Some of this is likely to be related to methodological assumptions (overestimating the number of people per structures is probably a major factor in this) and some of it may be related to shifts in building construction and economic systems. Given that the increase in the horizontal extent of LPPNB settlements occurred some 1,200 years after the appearance of domesticated plants and animals, it is not at all clear that the emergence of these villages was linked to increased birth rate and the NDT phase one. An alternative perspective, and one that is in need of future investigation, is that the emergence of large LPPNB villages was related to the NDT in a different way: the incorporation and impact of secondary products, such as milk, from domesticated animals.

Combined with our understanding of population growth and food storage in the southern Levant, we may be looking at a Neolithic Demographic pattern that was linked to three interrelated, yet very different, processes:

1. The development of Natufian and PPNA intensive and extensive collecting, harvesting and storage of wild plants. This would have served as a foundation for later domestication of plants as well as the biological and technological foundations for the first stage of the NDT.
2. The domestication of plants and animals in the MPPNB. With increased sedentism, new forms of food storage, and greater control over plant resources, population levels would have rapidly increased. Developing new food storage systems, and with a greater surplus of stored plants, birth rates would have increased and resulted in the development of relatively large MPPNB villages.
3. Expanded and new use of animal resources. By increasing the quality and quantity of dairy products, the domestication of animals would have provided new opportunities for population growth in the LPPNB. While in need of further research, I think it is possible that these new dietary conditions countered increased mortality rates hypothesized by Bocquet-Appel (2002). Given the local sequence for the southern Levant, therefore, such a new dietary reality may have created a second, and in some ways delayed, demographic signature.

If one believes that that the underlying proximal factors in increased Neolithic birth rates were linked to increased quality and access to plant foods throughout the year, and reduced stress for females, then it is crucial for researchers to understand

the role of food storage with the NDT. As a minimum the development of food storage technology reflects a critical transition in ideas and values about storage, and just as importantly, heralds a new way of life (Ingold 1983; Testart 1982). As with most research, this exploration of human demography, settlement systems and food storage, has probably raised more questions than it has answered. In doing this, however, I think an improved understanding of southern Levantine Neolithic food storage and demography directs us to new questions, and helps us refine our understanding of the NDT.

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