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Prehistoric Demography in a Time of Globalization

Jean-Pierre Bocquet-Appel and Ofer Bar-Yosef

Abstract The signal of a relatively abrupt increase, in the immature proportion of skeleton is observed in cemeteries during the foraging-farming transition. This signal is interpreted as the signature of a major demographic shift in human history, now known as the Neolithic Demographic Transition (NDT). How can population growth be explained?' Was population increase gradual or abrupt? Was it related to the stability in food provisioning due to building and maintaining storage facilities? Or was it just annual cultivation and harvesting under favorable climatic conditions that allowed the number of humans to increase? The volume presented here is divided into four parts. Part 1 concerns the demographic and economic aspects of the NDT. Part 2 focuses on settlement and village practices. The relatively rapid growth of human populations during the NDT radically transformed settlement behaviour. In this part, we consider the varied implications of the NDT for settlement and village practices at both regional and local or intra-village scales. Part 3 is concerned with community size and social organization. The growth of larger communities gave rise to unprecedented stresses within these expanding villages, which in turn stimulated the appearance of novel social practices and institutions. This part is concerned with the transformations of human social life that resulted from the NDT. Part 4 focuses on population growth and health. Can the signal of a return to homeostatic demographic equilibrium be detected, and what would have been its tempo during the NDT? Was the signal the same in the different geographical centres of agricultural innovation and expansion? Did the NDT produce a decline or an improvement in the living conditions of early farmers? The time has come to reflect upon the multiple consequences of that qualitative leap in human demographic history.

Keywords Neolithic Revolution · Neolithic Demographic Transition · sedentism · foragers · farmers · maternal energetics · fertility explosion · Natufian

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J.-P. Bocquet-Appel, O. Bar-Yosef (eds.), *The Neolithic Demographic Transition and its Consequences*,

Human history began some 2.6 million years ago with the first stone tool makers, who were hunters, gatherers, and sometimes scavengers. The foragers' way of life evolved during most of this time, when major changes in the colonization of the world were taking place. Both fossil and genetic evidence record a series of "out of Africa" movements, with the main ones occurring first some 200,000–150,000 years ago and the second, namely the dispersal of modern humans, some 50,000–45,000 years ago. By that time Australia had been colonized. The Americas were the last to become inhabited around 14,000 years ago or perhaps earlier. Through all this long period, human societies based their economy on hunting and gathering and were organized, as we believe on the basis of ethnographic and historical examples, as bands of foragers, keeping a mating system that allowed biological survival within the so-called "dialectical tribe". The archaeology of the Palaeolithic period, and especially of the Upper Palaeolithic, tends to support this general view. The major social and economic changes occurred in several regions, when groups of foragers became farmers.

This revolutionary shift in human history is known as the Neolithic Revolution. Communities of foragers started cultivating several species of wild plants (barley, wheat, millet, rice, etc.), eventually also becoming herders in several regions where wild animals could be domesticated. The importance of the agricultural economy was the crucial first step towards greater social complexity, population growth, and the ensuing emergence of states. The process and the timing were not the same in every region. It started some 11,500 years ago in the Levant (Near East), in northern China (millet), and later with rice cultivation in southern China (Fuller et al. 2007). New Guinea was another locus and so were Ethiopia, south-east North America, Central Meso-America, and South America (Bellwood 2005; Weiss et al. 2006; Fuller et al. 2007). While the number of original plant domestication loci is still being debated, mostly due to lack of sufficient archaeo-botanical research in several regions, the evidence for the dispersal of the agro-pastoral economies in the Old World is relatively well dated.

One of the main questions raised by the outcome of the Neolithic Revolution is 'how can population growth be explained?' More specifically, 'was population increase gradual or abrupt?' 'Was it related to the stability in food provisioning due to building and maintaining storage facilities? Or was it just annual cultivation and harvesting under favourable climatic conditions that allowed the number of humans to increase?'

At first, the answer had to come from the ethno-archaeological evidence. Based on ethnographic evidence, the often small sites of Late Pleistocene foragers could be interpreted as the remains of an average band of some 25–30 humans. However, one site only gives a partial picture. It is obvious to most scholars that biological survival depends on having a reasonably large mating system with a minimal number of 400 people (Wobst 1974). The more commonly observed size of a "dialectical tribe" as defined by Birdsell (1968, 1985), based on a sample of 256 American native societies, was in the range of 113–7142 people, with an average of 897 (Newell and Constandse-Westermann 1986: 256). Such units are currently referred to as ethno-linguistic groups (e.g. Marlowe 2005).

The archaeological record is marked by the transition to sedentary communities since the Late Pleistocene and during the Holocene. Sedentism or semi-sedentism is taken to indicate that for at least half or most of the year, the social group stays in one location. Sedentism could be afforded when food resources were stable, predictable, and accessible, as in the case of the Northwest Coast Indians. In other regions, an economy based on plant cultivation with continuous gathering and hunting allowed the population of early villages to be estimated according to the overall site size. Here too, ethnographic records play a major role in the proposed interpretations (Kramer 1982, 1983; Kramer and Boone 2002). Thus, the mean number of people per hectare is 150, and an early Neolithic village site such as Jericho, with a size of about 2.5 hectares, accommodated some 300–4000 people. Therefore, the estimate of population growth based on sites required archaeologists to obtain information on site size, average depth, and radiometric dates in order to calculate the duration of the occupation and the potential changes in the number of community members. In addition, when a larger region is considered, comparisons between archaeologically observed social entities and changes through time should be taken into account. While the overall picture for a limited area such as the southern Levant is feasible, in many other regions the records are too fragmentary.

The causal link between demography and cultural change has been a recurrent topic of discussion in archaeology. But the problems involved in gathering archaeological data have resulted in contradictory population estimates. The current investigation of this critical issue, namely, understanding the process of population growth during the Holocene in various regions of the world, is changing thanks to the simultaneous use of two methodological innovations in palaeodemography. Palaeoanthropological data from archaeologically exposed cemeteries, in spite of the limitations imposed by past mortuary practices as expressions of cultural concepts as well as taphonomic processes (Guy et al. 1997; Gordon and Buikstra 1981), are still the best candidates for detecting demographic change. In seeking to obtain palaeoanthropological information from archaeological cemeteries, a methodological innovation was employed: the large-scale use of a non-conventional demographic indicator that pinpoints the proportion of young individuals in the age pyramid of a given population. This indicator expresses the input parameters in the living population (birth, growth, and fertility rates) and not, counter-intuitively, mortality (McCaa 2002; Johansson and Horowitz 1986; Sattenspiel and Harpending 1983). As the transition from foragers to farmers occurred at different times in different places, the space–time distribution of the palaeodemographic indicators obscures the uniqueness of this phenomenon. While absolute chronology is essential for the historical record of every region in the world, it temporally masks distant statistical regularities that need to be compared in attempting to detect the signature of a global population process. Therefore, the second methodological innovation presents the data in relative rather than absolute (historical) chronology, by concentrating on the shift from foragers to farmers regardless of the precise timing. Hence, we can detect the common denominators behind the demographic patterns within the archaeological data. By removing the absolute chronology for methodological reasons, we can trace the demographic process across different cemeteries in various regions of the world (Bocquet-Appel

2002; Bocquet-Appel y Paz de Miguel Ibanez 2002). This signal is characterized by a relatively abrupt increase – over two to three millennia in the epicentre, few centuries elsewhere – in the immature proportion in cemeteries during the transition, which expresses a corresponding increase in the parameter values for entry into the age pyramid of the population (birth, growth, and fertility rate). This signal is interpreted as the signature of a major demographic shift in human history, now known as the Neolithic Demographic Transition (NDT). From archaeological data, a two-stage process has been identified in the NDT (Bandy 2005) with a first stage when the density of remains increases, followed by a second stage with a declining density. It is interpreted as the signature of a density-dependent demographic process. The signal of the NDT has been detected in cemetery data in Europe and North Africa, in several regions of North America (Bandy et al. 2007; Kohler and Glaude, this volume; Warrick 2006; Bocquet-Appel and Naji 2006) and the Levant (Guerrero et al., this volume; Hershkovitz and Gopher, this volume), and in archaeological data from Meso-America and South America as well (Bandy 2005). The two-stage NDT now appears to be a global process that is characteristic of most – if not all – early agricultural sequences worldwide. This NDT initiated the demographic regime of the preindustrial populations, with their high birth and mortality rates. Once such a large-scale process was identified, questions began to emerge as to its causes and consequences.

Putative Causes of the Neolithic Demographic Transition

The NDT was caused by two factors that occurred in tandem but need to be distinguished in order to elucidate the biological and cultural nature of the transition. These are (i) a shift in the mobility regime of foragers towards sedentism, and its impact on female fertility, and (ii) an increase in regional carrying capacities thanks to the invention (at the sources) or the introduction (elsewhere) of the agro-pastoral economy. In the empirical data sets acquired by archaeologists, demographic growth is observed with the sedentism of hunter-gatherer populations (in the Levant: Guerrero et al., this volume; Bar-Yosef and Belfer-Cohen 1991; Belfer-Cohen and Bar-Yosef 2000; in Meso-America: MacNeish 1972; in eastern North America: Bandy et al. 2007; Hassan 1973; Sussman 1972). The primary factor of this demographic growth, i.e. biological reproduction and, beyond this, a fertility explosion, is therefore not to be sought in the emergence of the new farming economy. The potential for an increase in biological reproduction thus predated the emergence of the farming communities and was realized with sedentism of females. We must therefore conclude that the cause of the fertility explosion, independent of the survival rate of born individuals, is what led to this major demographic shift: sedentism.

Another assumption could be that demographic growth was caused by the slackening (or abandonment) of ancient conscious mechanisms of self-limitation, i.e. relating to density dependence, which are assumed to have existed in hunter-gatherer societies, such as infanticide (Howell 1980). But besides the fact that we do not see the cause of this new abundance in terms of resources and their patterns of regularity which would prompt communities to give up possible self-limitation measures, we believe that the practice of infanticide has been greatly exaggerated, partly as an American anthropological myth (see Caldwell and Caldwell 2003; Caldwell et al. 1986). Mobile foragers (see Lee 1979) or female chimps, with their typically low fertility, cannot afford to routinely kill their few babies as a means of regulation. But then by what mysterious process does mobility affect the reproductive performance of populations everywhere on the planet? What could be the causal link between forager mobility and putative fertility?

Mobility, in fact, can be seen as a proxy variable for maternal energetics. The NDT was caused by a major shift in the maternal energetics of farming communities relative to mobile foragers. The energy budget included (i) on the intake side, an underlying trend towards a reduction in low-calorie food items from hunting and fishing, and a correlative increase in the high-calorie food from agriculture, and (ii) on the expenditure side, a reduction in the physical energy devoted to mobility and the maternal stress of children transportation. Suckling frequency and intensity is a necessary but not sufficient condition for regulating the rate of the reproductive cycle.

We thus have the following causal sequence: (1) carrying capacity decreases, (2) energy expenditure via mobility and energy intake of low-calorie food items increase, (3) fertility decreases, and (4) population density decreases. The process is reversed when the carrying capacity increases. The causal sequence of variables can be deduced from various sources (see for instance in Binford 2007, from graphs 1.1–1.3: 7–8; Bocquet-Appel, this volume; Valeggia and Ellison 2004). Mobility is a difficult variable to measure. It is characterized in various ways in ethnographic data, in terms of seasons, residence, or logistics, but finding the correlates in the archaeological data is hard (e.g. Belfer-Cohen and Bar-Yosef 2000). In fact, the type of mobility that would correlate best with energy expenditure is total mobility, which is seldom known (it is not, for instance in Binford's data 2001).

An Unprecedented Fertility Explosion Was Circumstantially Supported by the Emergence of the Farming System

When foragers become sedentary, which may roughly increase by 1:3 their fertility, we know that if the carrying capacity of a production system remains more or less unchanged, then the population will experience hardship. For the population to survive, which now means to support its increasing numbers, the production system has to be able to feed the additional mouths. This is exemplified by the archaeological sequence from the Natufian to the early Neolithic or the Pre-Pottery Neolithic A in the Levant.

The Early Natufian (14,500–13,000 cal BP) population became semi-sedentary surviving on the consumption of vegetal food (probably cereals, legumes, and nuts) obtained by gathering and hunting gazelles, fallow dear, roe deer, wild boar (in certain areas), as well as fishing and trapping various types of birds (e.g. Bar-Yosef and Belfer-Cohen 1989; Belfer-Cohen and Bar-Yosef 2000; Bar-Yosef 2002). The archaeological evidence includes the small villages (such as Eynan) and hamlets (Wadi Hamme 27, el-Wad terrace, Hayonim terrace, and other sites). Elaborate mortuary practices, collection and use of marine shells for making beads, and several hard rocks for making pendants, as well as bone beads and pendants, reflect the relative richness of this society. Exchange with other regions is exemplified by shells from the Red Sea, basalt mortars and pestles that were brought from distances of 80–100 km. The change took place with what is known as the Late Natufian culture and occurred during the cold and dry periods of the Younger Dryas. The short stress season did not affect well rain-fed areas such as Mount Carmel, but it led to a decrease in the predictability, reliability, and thus accessibility of vegetal foods and possibly certain game animals (e.g. Bar-Yosef and Belfer-Cohen 2002). This crisis caused a shift for increased mobility, reduction in the use of body decoration, the building of more flimsy dwelling structures, and the like. These worsening conditions resulted biologically in lower sexual dimorphism (Belfer-Cohen et al. 1991), conventionally interpreted as a decline in living conditions. Thus, many Late Natufian groups had to increase their mobility in order to feed themselves. However, sedentary groups in areas which were not affected by climatic vagaries, such as along river valleys or on Mount Carmel, became the earliest Pre-Pottery Neolithic A (PPNA) villages where we see the first clear indications of plant cultivation (Bar-Yosef and Belfer-Cohen 2002; Weiss et al. 2006). Moreover, we know from the archaeological data that sedentism or semi-sedentism occasionally existed among forager groups before the Neolithic, as demonstrated in certain Middle Palaeolithic Mousterian sites in Israel (Lieberman and Shea 1994; Lieberman 1993; Hietala and Stevens 1977) or in the Early Natufian (Bar-Yosef 1983; Bar-Yosef and Belfer-Cohen 1989; Belfer-Cohen and Bar-Yosef 2000; Bar-Yosef 2001). If these groups were not able to increase the amount of their food resources, i.e. their carrying capacity, they must have experienced miseries, using the famous word of Malthus himself, as predicted by his model.

In this volume, we will not address the reasons for the emergence of sedentism, as this is a major topic in itself (e.g. Davis 1983; Hesse 1979; Hitchcock 1987; Matson 1985; Sellet et al. 2006; Tangri and Wyncoll 1989; Tchernov 1991, 1993). We will simply say for now that the reason should in all likelihood be sought in the demographic saturation of many areas across the world that were exploited by hunter-gatherers (Cohen 1977), despite their very low demographic densities (Bocquet-Appel et al. 2005; Binford 2001: 142–159).

The time has come to reflect upon the multiple consequences of the NDT, a qualitative leap in human demographic history, which, to give an order of magnitude, saw regional populations multiply perhaps 200-fold in the space of a few hundred to a few thousand years.

This volume is divided into four parts. Part I concerns the demographic and economic aspects of the NDT. Starting with demography, we discuss the causes of the NDT at its onset. We ask whether the combined impacts of sedentarism and an agricultural economy generated an auto-catalytic process that dramatically increased the population growth rate. Agricultural populations managed their relatively rapid demographic growth during the NDT by expanding geographically into ecologically favourable zones, through an overall shift from a broad-spectrum diet to a more narrow agro-pastoral subsistence focus, and by applying new cultivation and storage techniques. This expansion raises two questions: (i) what was the pace of this intensification, as measured directly by dietary reconstruction or indirectly by associated tools and raw materials? (ii) What happened to the "other" foragers who occupied neighbouring regions? Did they join the farmers or were they extinguished by the advance of the farmers? This part features contributions from Peter Bellwood, Jérome Dubouloz, Matt Glaude, Emma Guerrero, Timothy A. Kohler, Richard G. Lesure, Stephan Naji, Marc Oxenham, Mehmet Özdoğan, Jean-Denis Vigne, and Jean-Pierre Bocquet-Appel.

Part II focuses on settlement and village practices. The relatively rapid growth of human populations during the NDT radically transformed settlement behaviour. In this part, we consider the varied implications of the NDT for settlement and village practices at both regional and local or intra-village scales, with contributions from Anna Belfer-Cohen, Adrian Nigel Goring-Morris, Ian Kuijt, and Stephen Shennan.

Part III is concerned with community size and social organization. The growth of larger communities as a consequence of the NDT had radical implications for human social practices and village life. The growth of larger communities gave rise to unprecedented stresses within these expanding villages, which in turn stimulated the appearance of novel social practices and institutions. This part is concerned with the transformations of human social life that resulted from the NDT, with contributions from Matthew Bandy, Robert D. Drennan, Elizabeth Perry, Christian Peterson, Richard H. Wilshusen and Gary O. Rollefson.

Part IV focuses on population growth and health. We ask what were the variations in the growth of children and adolescents, in the frequency of food deficiency pathologies and in the stature of adults and sexual dimorphism during the NDT? Can the signal of a return to homeostatic demographic equilibrium be detected, and what would have been its tempo during the NDT? Was the signal the same in the different geographical centres of agricultural innovation and expansion? What was the degree of relationship between demographic, health, social, and cultural changes? Did the NDT produce a decline or an improvement in the living conditions of early farmers? This part features contributions from Mark Nathan Cohen, Avi Gopher, Israel Hershkovitz, Nicolas Tomo, and Ursula Wittwer-Backofen.

Globalization means the contraction of geographic spaces, so that what was distant becomes close. It forces us to raise the question of the common origin of populations in our global village. Our planet's inhabitants were dispersed due to historical processes, which we can analyse on three levels of chronological definition, i.e. in the short term, meaning the last century; in the medium term – the last 2000–3000 years; and in the long term, which covers the prehistoric periods. Globalization thus brings prehistory, our long evolutionary macro-history, into the focus of current research.

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Part I
Demographic and Economic Dimensions of the NDT

The Expansions of Farming Societies and the Role of the Neolithic Demographic Transition

Peter Bellwood and Marc Oxenham

Abstract The hypothesis of the Neolithic demographic transition (NDT) postulates that sharp increases in birthrates occurred as populations in different parts of the world adopted sedentary lifestyles and food storage, reduced their birth intervals, and came to depend increasingly on food production as opposed to foraging. For a period after these regional transitions to food production occurred, birth rates and absolute population numbers increased dramatically, at least in those areas (Europe, Middle East, North Africa, North America, Southeast Asia) so far subjected to cemetery analysis. This chapter discusses some general issues connected with early farmer expansion and presents archaeological and cemetery data relevant for an evaluation of the NDT hypothesis from East and Southeast Asia.

Keywords Neolithic demographic transition · first farmers · food production · palaeodemography · southeast asian prehistory · human migration

The chapter also raises two general questions for further discussion. First, was a passage through an Neolithic demographic transition (NDT) in a homeland region of agriculture an essential prerequisite for any subsequent and successful trajectory of population dispersal into new environments? Was the resulting high birthrate then carried by those populations into these new environments, so that their population growth continued rapidly from the commencement of the new settlement? As a corollary of this, were NDT signals more abrupt in regions of agricultural spread than in regions of agricultural origin, owing to residual forager behavior in the latter regions acting as a brake on the process (as proposed by Guerrero et al., Kuijt, and Bocquet-Appel, this volume)?

Secondly, does the NDT hypothesis imply a birthrate increase up to and over a "threshold" during the shift to agricultural dependence, self-reinforcing and very difficult to turn off, once started, unless stifled by increasing mortality, environmental downturn, or other negative situations? This assumption would be in line

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with the "competitive ratchet" metaphor of Richerson et al. (2001) for early farming societies, and it raises the question of where, within the histories of agricultural societies, we should locate the phenomenon of "low-level food production" (Smith 2001).

First Farmers and the NDT

> Everywhere on the planet, the use of a harvest grown from planted seeds, whether native or foreign, represents a qualitative leap that clearly separates foragers from horticulturalist-farmers, regardless of the proportion of the harvest used for food (Bocquet-Appel and Naji 2006:389).

During the past few years, prehistorians have become highly interested in the relationships between the development, or adoption, of a farming economy and the likelihood of substantial growth in population size and density. This is because, in many regions of the world, the growth in population numbers amongst early farmers led quite clearly to expansions of human groups, their farming technologies and lifestyles, and their languages. On occasions, some of these expansions ultimately attained continental scales. These observations have led to what Colin Renfrew and Peter Bellwood have termed "the farming/language dispersal hypothesis" (Bellwood and Renfrew 2002). The descendants of those who underwent such expansions, via processes of both demic and cultural diffusion, we know today by their linguistic affiliations – for instance, the speakers of Bantu, Indo-European, Austronesian, and Uto-Aztecan languages, to name a few of the more striking cases.

In fact, languages are the clearest markers in the present world of those communities that share historical descent from Holocene population dispersals, agricultural, or otherwise. We are unable to point in such a direct way to the cultural descendants of archaeological complexes that existed several millennia ago (no one makes Linearbandkeramik pots any more!), and the genetic evidence does not allow recognition of populations with deep historical trajectories that are as clearly bounded as language families. If we wish to make the data of Holocene prehistory relevant to the world we live in now, then language history becomes a very significant matter. It informs us that major expansions of human populations took place in the early centuries of agricultural development, into and through many regions of the world (Bellwood 2005).

First Farmers: The Insistent Traces of Expansion

A number of recurrent multidisciplinary observations point to population dispersal as an essential ingredient of Neolithic/Formative landscapes and raise agriculture-prompted population increase, via the NDT birthrate signal, to the status of a very significant process. First of all, from an archaeological perspective, the first farmers in many regions of externally derived farming spread, rather than agricultural origin, such as Europe, sub-Saharan Africa, Southeast Asia, and Oceania (excluding New Guinea), seem to have belonged to more homogeneous and widespread cultural spheres than their descendants. For instance, we might, through time, compare patterns of homogeneity versus heterogeneity between LBK and Iron Age Europe, between Phillipson's (2005) Chifumbaze pottery style and those of East African late prehistory and between Lapita and ethnographic Melanesian pottery styles. In each case, the older styles are much more widespread than the later ones, a situation that might suggest population dispersal as the distributing factor (Bellwood 2005: Fig. 1.3). In regions of agricultural origin, such as the Middle East, central China, and Mesoamerica, early cultural homogeneity is often visible but not always so convincing, as one might expect in situations of cultural upwelling rather than spread.

In addition, the crop and animal complexes that underpinned these Neolithic cultures also spread over enormous distances. The relatively small number of plant and animal species that dominated food production, mostly coming in sets that shared closely set regions of origin (the "agricultural homelands" – see Diamond 2002 for the Middle East), drives this point home for regions of unargued agricultural spread such as Europe, East Africa, Southeast Asia, and Oceania (excluding New Guinea). Of course, suitable local crops were often domesticated, and local species of animals were sometimes added. But, as Zeder et al. (2006: 148) note

> . . .genetically independent domestication events are not necessarily culturally, or even biologically, independent. Perhaps many of the proposed recognized 'independent' domestication events in animals represent the movement of a few domesticated individuals into an area, with the genetic signatures of the introduced founders subsequently submerged in the recruitment of local wild animals.

From a linguistic perspective, many of the major agriculturalist language families (i.e., those language families for which an agricultural vocabulary can be reconstructed from an early stage) had attained their AD 1500 distributional limits long before history and any conquest empires. Some of the most significant and widespread of these families include Afroasiatic and Indo-European in western Eurasia and northern Africa; Niger-Congo (with Bantu) in sub-Saharan Africa; Austroasiatic, Austronesian, and Sino-Tibetan in eastern Asia; Mayan, Otomanguean, and Uto-Aztecan in Mesoamerica and the southwestern USA; and Arawakan and Tupian in Amazonia (Bellwood 2005: Figs. 1.1 and 1.2). All of these would appear to have spread from homelands either within or very close to the archaeologically defined homelands of agriculture (i.e., Middle East, West Africa, China, Mesoamerica, and Andes/upper Amazonia, respectively), at least in terms of the majority homeland opinions of linguists. There may be argument, for instance, over whether early Indo-European languages spread from Anatolia or the Pontic steppes. But both of these regions are far closer to the Middle Eastern region of agricultural origin than are the Irish Republic, Norway, or Bangladesh.

In addition, not only did the major language families spread long before history, but they also spread mainly with their speakers, rather than by language shift alone. English and Spanish were spread as nation-founding vernaculars mostly by colonial migration. Language shift on a continental scale, equivalent to the distribution of a major language family, through political or social domination has been a very rare event in history, indeed has never really occurred at all. Most ancient and medieval languages that were associated with conquest, but not large-scale population migration and colonization, did not spread far as long-term language-replacing vernaculars beyond their home regions (Ostler 2005). The list includes Sanskrit, Latin, Arabic, Hellenistic Greek, Persian, Mongolian, and even Spanish in many regions of the Americas with dense Native American populations. In addition, we must not forget, in thinking for instance of Indo-European, that this language family had reached from Ireland to Bangladesh prior to the creation of any historical records, in actuality at some point within the regional Neolithic or Bronze Ages, well before the eras of the Hittites or the Rig Veda (which certainly does not record the initial arrival of Indo-Aryan speaking peoples in South Asia). Just how did the ancestral languages that gave rise to these very large families spread, if not predominantly through native speaker movement? Bulk shifting to elite languages is not the answer; they rarely established themselves as the vernaculars of whole populations through shift, except on single-nation scales (e.g., Turkish in Anatolia, Hungarian).

Human biology, with its geographical races and their genetic underpinnings in terms of mtDNA and NRY lineages, offers far too complex a record for detailed discussion here. Suffice it to say that the Old World genetics and morphological literature for populations in Africa, Europe, Asia, and Oceania tend to support a migratory profile for early farming populations, to the extent that one could ever expect it to be supported and allowing for clinal intermixture via demic diffusion (Cavalli-Sforza 2002; Renfrew 2002).[1]

We conclude from the above observations that a hypothesis which gives considerable expansionistic ability to those populations who adopted farming relatively early, within a world still populated mainly by hunter-gatherers, will have a good chance of success. The NDT clearly gave rise to some major redistributions of human populations.

Different Trajectories of Agricultural Dispersal

The archaeological record of agricultural origins is focused on several major regions – the Middle East, central China, West Africa, New Guinea highlands, Mesoamerica, central Andes, and Eastern Woodlands of the USA (Fig. 1) – and illustrates the growth of agricultural dependence over time. The transition from hunting and gathering to farming was not always rapid in millennial terms, but the two-way feedback between food production and population density in these regions eventually snowballed into considerable population growth and a need for some members of each population, perhaps the younger ones, to seek new farm land outside their home range.

Are there are any cross-cultural generalizations that can be made about how and why the various agricultural "unfoldings" differed in spatial and temporal expression? Can early farming spreads be classified in terms of observable and sometimes

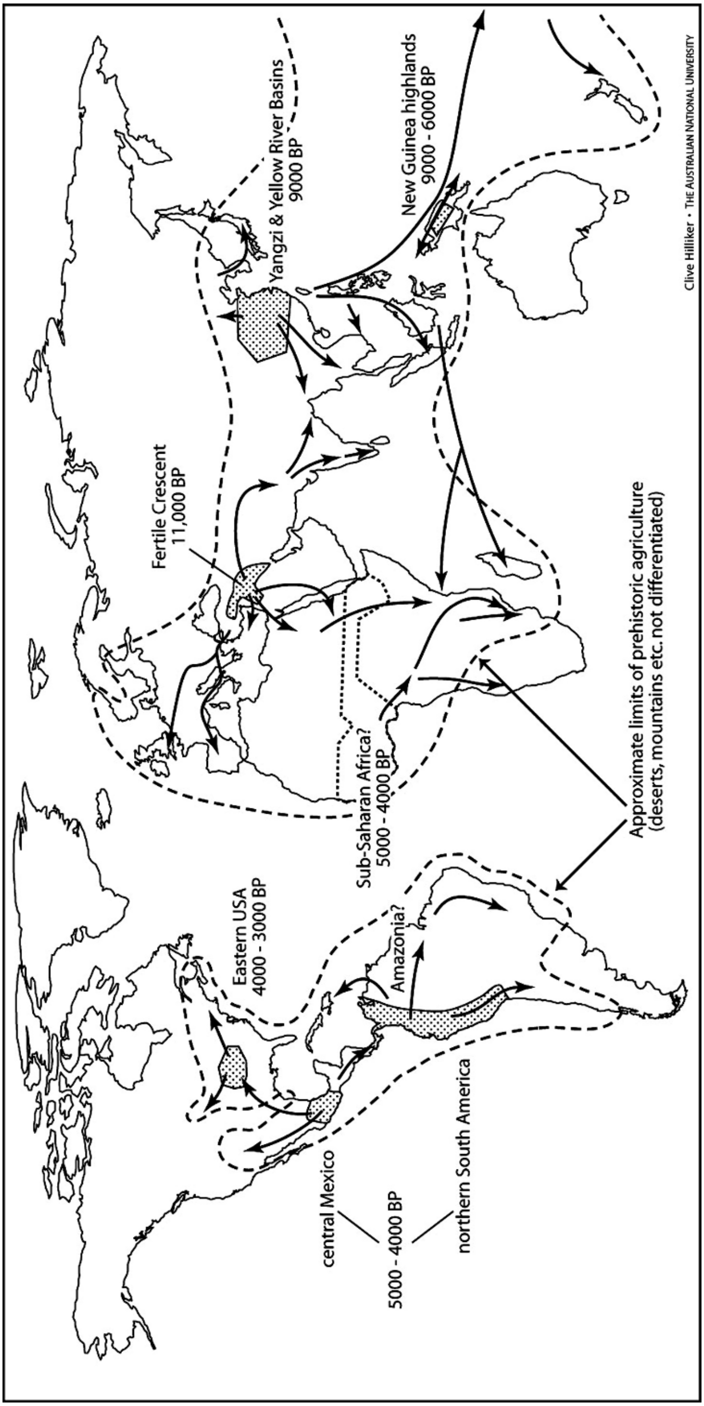

Fig. 1 Regions of agricultural origin, according to the archaeological record

quantifiable variables, such as rate of frontier movement, overall chronology of dispersal, and degree of isomorphism in linguistic, cultural, and biological expansion patterns? Issues of productivity affect the success of agricultural spreads, with examples such as the Middle East and China clearly being far more expansive in terms of populations and languages than, for instance, New Guinea (Harris 2002). Such differences reflect clear-cut differences in the numbers of high-yielding cereal and domesticated animal species present, or absent as the case may be. Issues of climate and latitude are also important, affecting the rate of movement from winter into summer rainfall regimes and vice versa, or across latitudes (Diamond 1994). Issues of hunter–farmer interaction are also crucial, relating to relative demographic profiles and relative suitability of terrain for the two lifestyles.

It may be useful to visualize four different zonal concepts as being involved in processes of agricultural origin and spread (Bellwood 2001; 2005:274–5). First, *homeland or starburst zones* have high suitability for agriculture and reveal upwelling patterns with radial spread, associated with considerable hunter-to-farmer continuity across the agricultural transitions. Examples include the major regions of agricultural and language family origin.

Secondly, *spread zones* (following earlier usage of this term, with a slightly different meaning, by linguist Johanna Nichols (1992:13)) involve spreading populations of early farmers with widespread high levels of cultural homogeneity and strong indications of temporal and cultural discontinuity from preceding Mesolithic/Archaic complexes. Rates of spread tend to be high, until environmental or demographic limitations come to dominate in peripheral locations.

Thirdly, *friction zones* are characterized by genetic admixture and cultural reticulation between hunters and farmers. Some friction zones lie at the end of the road for agriculture, for instance in northern and western Europe, where climatic factors or high hunter-gatherer densities backed by coastlines imposed barriers to further spread. In these cases, rates of farming spread slowed down markedly. But in other cases, for instance lowland New Guinea with respect to Austronesian spread, the friction zone was not at the end of the line, but rather a salient in its middle caused by the existence of New Guinea as an independent and culturally separate focus of early agriculture. In the case of the Lapita (Austronesian) settlement of western Oceania, the rate of spread became extremely rapid again beyond western Melanesia, in previously uninhabited Oceanic islands. On the other hand, Austronesian dispersal was very slow to affect New Guinea itself, and for the most part never penetrated the interior.

Finally, *overshoot zones* occur where farmers found themselves, for varying reasons, in adverse environments and so modified their economies accordingly, often converting to hunting and gathering. The southern Maoris, the Punan of Borneo, and the Numic speakers of the Great Basin would appear to be excellent examples of this. Some of the examples of low-level food production discussed by Smith (2001) fall into this historical category, to which we return below.

Some examples of rates of agricultural spread, averaged as km per year over very wide extents, are given in Table 1 with respect to identified spread zone and friction zone conditions. It will be noted how maritime (Austronesian) and Iron Age (Bantu)

Table 1 Some average rates of spread of farming as determined from the archaeological record (Bellwood 2005a: Table 12.1)

Situation of Neolithic/Formative spread	Time required for spread (approx.)	Distance in km (approx.)	Rate (km per year)	Latitudinal difference between origin and endpoint	Degree of environmental change
SPREAD ZONES					
Italy to Portugal (Cardial Neolithic)	200 years	c.2000, if moving coastally	10 (maritime)	Nil	Very little
Hungary to France (LBK)	400 years	1000	2.5	< 5 degrees	Very little
Zagros to Baluchistan PPN (Mehrgarh)	500 years	1600	3.2	5 degrees	Very little
Philippines to Samoa (Red-slip/Lapita)	1000 years	8500	8.5 (maritime)	Nil in terms of degrees from equator	Very little
Central Mexico to Arizona	500 years	1850	3.7	12 degrees	Little, but desert barriers
Lake Victoria to Natal (Chifumbaze)	700 years	3000	4.3 (Iron Age)	30 degrees	Major in terms of winter temperature, but no change in rainfall seasonality

Table 1 (continued)

Situation of Neolithic/Formative spread	Time required for spread (approx.)	Distance in km (approx.)	Rate (km per year)	Latitudinal difference between origin and endpoint	Degree of environmental change
FRICTION ZONES					
Neolithic, from LBK to Britain	1300 years	500	0.4	Nil	Very little (hunter-gatherer resistance?)
Neolithic, Yangzi to Hong Kong	2500 years	1000	0.4	8 degrees	Very little (hunter-gatherer resistance?)
Chalcolithic, Baluchistan to Haryana and eastern Rajasthan	3000 years	1000	0.33	Nil	Major: Mediterranean to summer monsoonal
New Britain (Lapita) to southern Papua	1300 years	1000	0.8 (maritime)	5 degrees	Very little

spreads were very fast indeed. The rate of spread of farming increased *very rapidly* as the degree of environmental difficulty declined and as technological capacity increased. These are situations in which the concept of a NDT would have been very significant.

The NDT – Research So Far

The NDT concept, based on cemetery data, first came to our attention with the 2002 *Current Anthropology* paper of Jean-Pierre Bocquet-Appel. In it, he analyzed European and North African Mesolithic and Neolithic cemetery data with respect to the proportion of young people aged between 5 and 19 years at death, compared to the total population, minus neonates to under five (the ${}_{15}P_5$ ratio; see below). The results indicated a stable, perhaps even declining population during the terminal Mesolithic (but based on a very small sample size), followed by a period of 500 years or so of rapidly increasing European Neolithic fertility, equated with a reduction of the birth interval under increasingly sedentary circumstances. After this 500-year increase there is some uncertainty owing to a gap in the sample distribution, but the birth rate possibly declined slightly (due perhaps to zoonotic diseases, or over-intensification in some fragile environments?). Nevertheless, during the first 500 years of Neolithic life in Europe, it is suggested that the mortality rate did not rise and so the overall population could have grown at up to 1.3% per annum (doubling every 55 years or so). In this volume, the chapters by Shennan, and Dubouloz and Genouvès, provide strong support for rapid early farmer population growth for the Linearbandkeramik of central Europe, as does that of Özdoğan for Anatolia and the Balkans.

More recently, Bocquet-Appel and Naji (2006) have applied a similar NDT analysis to cemetery data from the US Southwest and the Eastern Woodlands. As with the European data, the archaic (non-agricultural) cemeteries reflect a stable or even declining birth rate, whereas those positioned after agricultural initiation (admittedly a difficult concept in both of these regions) reveal a marked increase in birth rate for the first 700 years or so. Indeed, the authors use terms such as "birthrate explosion. . .possibly unprecedented on this scale" (2006:350). In the case of the US Southwest we are certainly dealing with agricultural introduction from Mesoamerica,[2] whereas in the eastern Woodlands we have a situation of indigenous agricultural development.

Whether this difference influences the relative strengths of the two NDT signals is not clear from the analysis as presented, but we would certainly expect the transition to be more marked and rapid (step-like) in the Southwest, where maize agriculture was introduced into an area of archaic foraging, than in the Eastern Woodlands, where pre-maize agriculture developed indigenously. Indeed, the Eastern Woodland pre-maize sequence is classified as low-level food production by Smith (2001). Unfortunately, the absence of large cemeteries during the Early Agricultural period in southern Arizona (San Pedro and Cienega phases) renders direct observation of an NDT signal here difficult, and both Diehl and Waters (2006) and Kohler and Glaude (this volume) downplay the role of maize farming prior to AD 200. However, we regard the Uto-Aztecan linguistic evidence (Hill 2001, 2002) and archaeological evidence from second millennium BC maize-bearing sites such as Cerro Juañaquena and Las Capas (Bellwood 2005: 172), the latter with irrigation and pit storage, as highly suggestive of a preceramic maize farmer movement at around 1500 BC, perhaps fuelled by an earlier NDT in Mesoamerica.

As far as estimated population growth rates through an NDT are concerned, those presented by Bocquet-Appel (2002:645) for Europe and North Africa, both mainly spread zones, are a maximum of 1.3%. Bocquet-Appel and Naji (2006:350) offer an aggregated crude birth rate for North America and Europe together of 1.26% per annum, but in this case for a mixture of homeland and spread zones. In the case of the Levant, an undoubted homeland of agriculture, Eshed et al. (2004) use age at death distributions over a 3000-year period in Natufian to Neolithic cemeteries to suggest population growth rates between 0.5 and 1% per annum, in a situation of increasing fertility combined with decreasing mortality (except for increasing female mortality during childbirth).

In support of the hypothesis of slower NDT signatures in homeland zones, Kuijt, Gopher, and Guerrero et al., in this volume, all delay the onset of the NDT by over 1000 years after the beginning of food production in the Levant, placing it well into the later part of the Pre-Pottery Neolithic, by which time both animal domestication and increased dependence on domesticated plants are firmly attested. All seem to agree that such a time lag, when compared to the more rapid onset of the NDT in Europe, reflects that status of the Levant as an agricultural homeland and the slowing factor of residual forager behavior.

Bocquet-Appel and Naji also offer the important observation that sedentism rather than dietary change per se might have been the main factor behind the lessening birth interval. Perhaps this was so, but would it not be better to regard both, in a mutually reinforcing combination, as of equal significance? Pre-agricultural sedentism was not common anywhere in the world (Binford 2001:437; Fuller 2006:59; Bellwood 2005:23), certainly not in Australia where well-recorded and universal mobile hunting and gathering survived until recently (Keen 2006). There is scope here for much deeper research by archaeologists – just how widespread was true (i.e., 100%, not 50 or 75%) sedentism immediately prior to regional developments of farming? Did it really exist at all?

Settlement and Other Proxy Data that Support the Validity of the NDT Hypothesis

Given that the NDT hypothesis is essentially about changing birth rates, and since birth rates undoubtedly reflect cultural inputs, the hypothesis can also be tested against data of a more proxy nature, for instance the archaeological record of settlement numbers and sizes. Prior to the publication of Bocquet-Appel and Naji, Bandy (2005) examined data supporting what he termed a “two stage Neolithic demographic transition” (initial growth followed by leveling off) for the Valleys of

Mexico and Oaxaca, plus the Titicaca Basin. His data were purely archaeological, incorporating population estimates from site areas and surface artifact densities. Interestingly, the results paralleled those of Bocquet-Appel (2002) quite closely, with birth rates up to a possible 0.74% p.a. for the first 800 years or so following the Formative transition, followed then by birth rate declines.

The circumstantial archaeological evidence that populations underwent considerable growth after transitions to agriculture, particularly in regions with cereal agriculture and domesticated animals, is often not hard to miss, regardless of whether they were origin or spread zones. For instance, Kuijt (2000:85, and this volume) documents an increase by a factor of about 60 in the mean estimated populations of settlements in the south-central Levant (a presumed agricultural origin zone) between Late Natufian and PPNC (ca. 9500 to 6500 BC). Although it is not possible to estimate the extent to which these increased site/population sizes reflect absolute population growth, as opposed to aggregation into a small number of large settlements, the figures undoubtedly reflect the power of a developing agropastoral economy to concentrate humans in one place, presumably on a sedentary basis for much of time.

For Neolithic central China, another undoubted agricultural homeland, Liu (2004) records for Shandong an increase in site numbers from 16 in the Beixin early Neolithic (6000 BC) to 893 in the Longshan late Neolithic (2500 BC). Longshan sites are up to 246 ha in size, but early Neolithic sites are much smaller. What rate of population growth we are witnessing is uncertain, but over the 3500-year period involved we could have a 100-times (or more) multiplication of population in the survey regions concerned.[3] Similarly, for the Dongtian Lake region of Hunan Province, Zhang and Hung (in press) record an increase in site numbers from 22 in the Pengtoushan Phase (ca. 6000 BC) to 200 in the Qujialing-Shijiahe Phase (ca. 3000 BC).

Within Neolithic Southeast Asia, this time a spread rather than a homeland zone, Hung Hsiao-chun (2005) documents a similar scale of population increase in Neolithic eastern Taiwan. Here, there are five recorded Dabenkeng sites dating from ca. 3500 to 2500 BC, but 43 “fine corded ware” sites dating between 2500 and 1500 BC – clearly a situation of considerable population growth. Likewise, Tsang Cheng-hwa (1992:60–2) records for the sandy and windswept Penghu Islands in the Taiwan Strait, between 3000 and 1500 BC, a total of 4 Dabenkeng sites (oldest), 32 fine corded ware sites (middle), and 4 plain red ware sites (youngest). Remarkably, the Penghu Islands appear to lack subsequent occupation until the Chinese historical period within the past 1000 years. There is an interesting possibility here that colonization by a Neolithic rice-growing population led to such high levels of population growth and environmental over-exploitation in the fine corded ware phase that these islands were actually abandoned for upward of 2000 years. It is most interesting that the movement of Neolithic populations from Taiwan into the northern Philippines can now be dated with considerable confidence to about 2000 BC (Bellwood and Dizon 2005), thus at a time when the Taiwan and Penghu local sequences reveal maximum site numbers. High population densities, regardless of precise causality, clearly had some role to play in stimulating this movement.

Of course, data on high birth rates in ethnographic situations (e.g., rural Papua New Guinea, 2% per annum, or doubling every 35 years – Bourke 2002), and small island "laboratory" situations, make it fairly obvious just how fast subsistence farmers can/could increase their numbers in suitable circumstances (see also Bandy, this volume). As examples of the latter, we have prehistoric population trajectories for the Hawaiian Islands, Pitcairn Island, and New Zealand (Bellwood 2005:14–19). Doubling every generation is not hard to imagine in such circumstances, as recorded for early colonial South Africa, Australia, and the USA amongst the immigrant populations (but not, of course, amongst the native populations in the two latter cases). Interestingly, recent mtDNA research suggests that between 170 and 230 Maori women reached New Zealand in canoes during prehistory (Whyte et al. 2005), but even here the rate of internal population increase must have been quite rapid, given that the Maori population at AD 1770, only perhaps 500–600 years after settlement, was around 100,000 people. This is roughly equivalent to the increase of 1.3% per annum, or a doubling every 55 years, calculated for the European Neolithic by Bocquet-Appel (2002 – see above). For the Hawaiian Islands, Kirch (2005) estimates a European-contact population of 400,000, after a settlement duration within the islands of under 1000 years.

Cemetery Evidence from Southeast Asia

While palaeodemographic descriptions have been developed for prehistoric Southeast Asian cemetery assemblages (e.g., Pietrusewsky and Douglas 2002; Domett and Tayles 2006), specific discussion of these data in terms of a global or regional NDT has not been addressed. We present here a number of measures of fertility for five Southeast Asian skeletal assemblages (data compiled by Marc Oxenham – for site locations see Fig. 3). Of the three measures used, the JA ratio[4] and MCM[5] both increase with increasing fertility. For the third, the D20+/D5 ratio,[6] a decrease indicates increasing fertility (see Jackes 1992; Chamberlain 2006). While the JA and D20+/D5 ratios allow for estimates of fertility in samples with poor sub-5-year-old preservation, a common feature in many archaeological samples, Bocquet-Appel (2002; see also Bocquet-Appel and Naji 2006) have removed this age category from their ${}_{15}P_5$ calculations, for which values of 0.16–0.18 indicate zero growth rates.

Figure 3 shows the age-specific mortality profiles for the five analyzed Southeast Asian skeletal series, and Table 2 summarizes their fertility measures. These sites are all large Neolithic to Iron Age cemeteries in Vietnam and northeastern Thailand, with agricultural economies that included rice growing (this is contextually likely but still undemonstrated Man Bac), and with sample sizes large enough for statistical inference. Unfortunately, no pre-farming sites in Southeast Asia have skeletal assemblages sufficiently well recorded to be analyzed in this way. While there is variability, the majority of fertility measures for three of the four earliest assemblages point to elevated levels of fertility, particularly so for the Man Bac series from Vietnam. The ${}_{15}P_5$ scores (×100) for these same three samples range between a high of 47.6% for Man Bac and a low of 25% for Khok Phanom Di, values higher

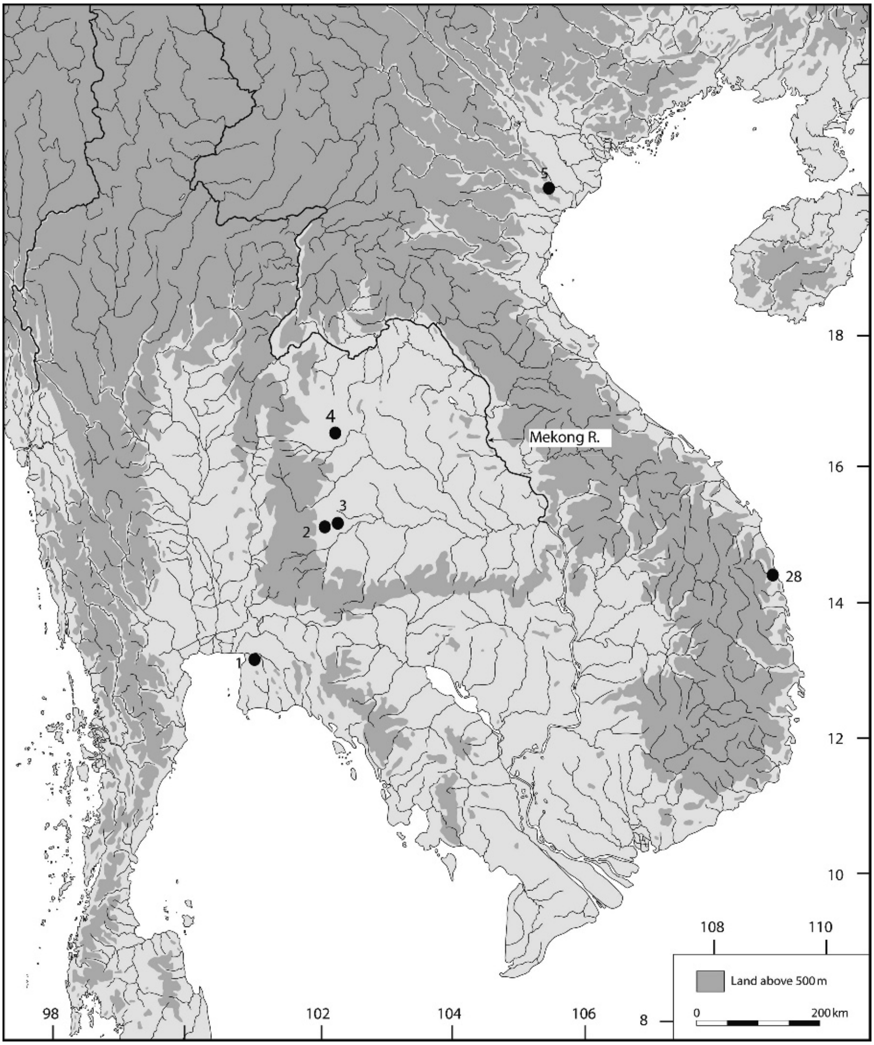

Fig. 2 Sites in Thailand and Vietnam discussed in the text. Background map courtesy of Charles Higham and Leslie O'Neill, Department of Anthropology, University of Otago. 1, Khok Phanom Di; 2, Noen U-Loke; 3, Ban Lum Khao; 4, Non Nok Tha; 5, Man Bac

than the majority of forager populations from North America and Europe sampled by Bocquet-Appel and Naji (2002: Figure 3, p. 346), and all indicative of elevated growth rates.

Non Nok Tha, dated to between 1500 and 1000 BC, appears somewhat anomalous in displaying low levels of fertility (its JA ratio is the lowest and D20 + /D5 the highest for all sites sampled). Its ${}_{15}P_5$ (×100) score of 11.0% indicates growth stagnation or decline. While these fertility measures (except for MCM) are robust

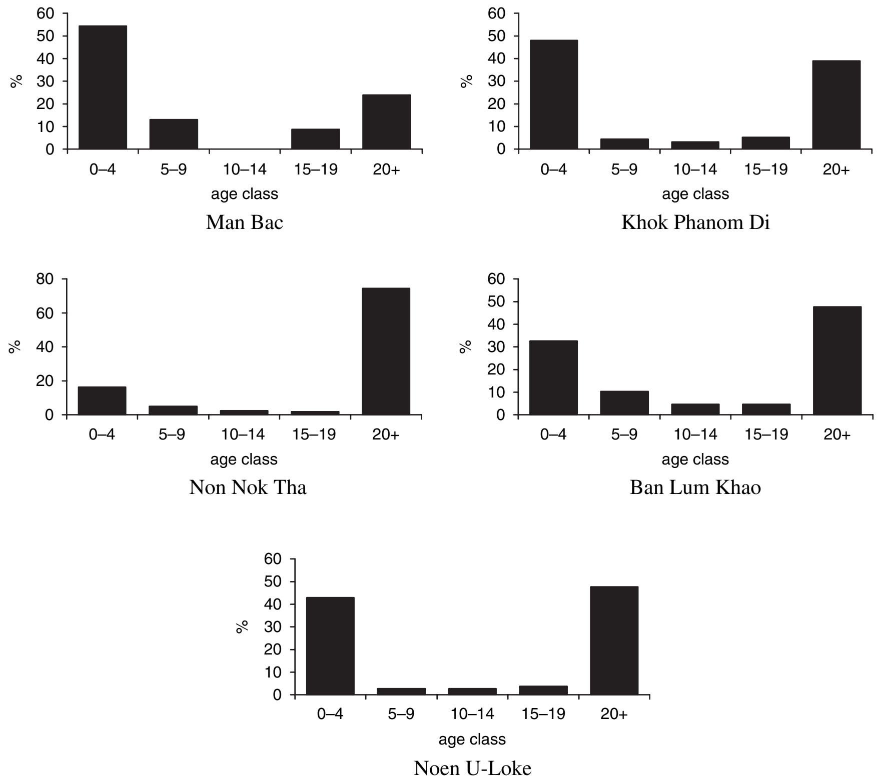

Fig. 3 Age-specific mortality profiles for the five analyzed Southeast Asian skeletal series

in the face of poor preservation of sub-5-year-olds, an examination of Fig. 3 shows a low proportion of juveniles in the Non Nok Tha series, potentially reflective of poor preservation and a biased sample. However, a certain degree of variability in fertility across all sites is to be expected, even in populations having passed dt = 0 (the economic shift front), as can be seen in Figures 2 and 3 of Bocquet-Appel and Naji (2006: 346).

The timing of the economic shift into agriculture in Mainland Southeast Asia is likely to fall somewhere between 2500 and 2000 BC, a little prior to the earlier

Table 2 Demographic characteristics of the Southeast Asian samples discussed in the text

Sample	Data Reference	Date BC	JA Ratio	MCM	D20 + /D5+ Ratio	$_{15}P_5$ Ratio
Man Bac	1	2000–1500	0.778	0.417	0.500	0.476
Khok Phanom Di	2	2000–1500	0.200	0.091	0.750	0.250
Non Nok Tha	3	1500–1000	0.125	0.045	0.727	0.110
Ban Lum Khao	4	1200–600	0.314	0.108	0.708	0.292
Noen U-Loke	4	300–AD 300	0.118	0.058	0.836	0.164

1 Oxenham et al. 2006; 2 Tayles 1999; 3 Douglas 1996; 4 Tayles and Domett 2006

assemblages of Man Bac and Khok Phanom Di examined here. As already noted, high rates of growth at, or soon after, the economic shift front are predicted for populations peripheral to the origin regions of agriculture (Bocquet-Appel and Naji 2006:350); in this case Southeast Asia was on the expanding periphery of earlier developments in China.

The NDT as a Stimulus for Population Spread, and the Significance of Low-Level Food Production

Following the discussion by David Harris (2002), who reviews the power to promote population dispersal in the various packages of cereals, legumes, tree crops, tubers, and domestic animals that characterized the different regions of agricultural origin, the following rating of agricultural homelands in terms of their dispersal energy can be proposed, commencing with the most expansive:

1. Southwest Asia, source of a large combination of cereals and domesticated animals, spreading ultimately as far as northern India, central Asia, and western Europe.
2. China, source of a slightly more restricted suite of cereals and animals than Southwest Asia, but nevertheless an expansive one that ultimately spread through Southeast Asia and in part into Oceania.
3. Sub-Saharan Africa, with cereals and domesticated animals, eventual source of the Bantu expansion, but fuelled in this case by an Iron Age technology.
4. The American homelands (Mesoamerica, the Eastern Woodlands of the USA, the central Andes, and Amazonia), relatively rich in seed crops, tubers, and legumes but lacking in domesticated meat sources, thus less expansive than the three Old World systems.
5. Other regions such as the New Guinea Highlands, where tubers and fruits without cereals or domesticated animals (pigs being a post-3000 BP introduction into New Guinea) only allowed more limited geographical expansion.

Agricultural transitions thus occurred in many situations, and the resulting growths in population size fuelled the ensuing episodes of dispersal that we can read so clearly in the archaeological and linguistic records. NDT signatures from early food producer cemeteries are recorded for North America, the Middle East, Europe, and Mainland Southeast Asia (this chapter), and likely for Mesoamerica, central China,[7] and North Africa. Whether or not they occurred in sub-Saharan Africa, New Guinea, or Amazonia we do not know, but the proxy evidence for agriculturalist dispersal through or out of these regions is quite suggestive. As suggested, the NDT signatures seem to have taken longer to "take hold" in regions of agricultural origin than in regions into which farmers moved through immigration.

This being the case, the question arises of the role in agricultural history of the adaptation described by Smith (2001) as "low-level food production", identified as a 30–50% dependence on domesticated plants and animals, the remaining food being derived from hunting and gathering. Smith regards this as a stable evolutionary end point for many populations, both ethnographic and prehistoric (see also Winterhalder and Kennett 2006: 4). He clearly does not regard it as a necessary stage on the route to more intensive forms of food production, and with this viewpoint we entirely agree. However, if the "competitive ratchet" of inter-group competition favored by Richerson, Boyd, and Bettinger really existed amongst early farming societies, then such low dependence on food production should only have survived in regions beyond the reach of more productive economies:

> Thus, subsistence improvement generates a competitive ratchet as successively more land-efficient subsistence systems lead to population growth and labor intensification. Locally, hunter-gatherers may win some battles . . . but in the long run the more intensive strategies will win wherever environments are suitable for their deployment. (Richerson et al. 2001:395)

Of course, in the development of agriculture, there has to be a phase during which food from domesticated plants and animals is replacing hunted or gathered food in the diet. As discussed above, this phase in the Levant, from late Natufian to Middle PPNB, could have exceeded 1000 years in length.[8] The NDT hypothesis underscores this by showing that agricultural dependence, at least in homeland zones, developed through a period of finite time rather than instantaneously. Late Natufian wild grain harvesters therefore probably were equivalent in productive capacity to some ethnographic low-level food producers. But their descendants did not remain at this level for all time.

We are not questioning the existence of low-level food production per se, since it is an obvious entity in the economic record of humanity. But we are asking in what historical circumstances it might have developed, and if it could have survived for long in agriculturally productive environments. If Richerson, Boyd, and Bettinger are correct, and if NDT experiences propelled Neolithic populations into population growth and increasing food production, then low-level food production must occupy a relatively residual position in history and geography.

Bellwood (2005:26–7) has approached this problem by compiling data from the *Ethnographic Atlas* of G.P. Murdock (1967; see also Hunn and Williams 1982, who carried out a similar analysis), suggesting that few societies occupied an intermediate position in which food production provided under 50% of their food intake, owing mainly to scheduling differences between mobile forager and sedentary agriculturalist lifestyles. In other words, populations over the long term (regardless of the existence of short-lived intermediate stages) will tend to be pulled toward either hunting and gathering or toward farming, giving a slightly U-shaped distribution to the relative proportions of produced versus gathered/hunted food in the diet. Smith (2001: 33) suggests that many of the world's former intermediate societies had already been replaced by or retooled into agriculturalists before ethnographic records were compiled. But if low-level food production really were such a "successful long-term socioeconomic solution" (Smith 2001: 34), we would have to ask why this occurred.

In our view, low-level food production was generally a product of specific circumstances, some involving people actively moving out of agriculture rather than in, others involving situations of environmental stress in which food production was becoming marginalized. Three types of situation come to mind here.

The first is one in which former food producers were obliged to revert to hunting and gathering owing to adverse human impact or environmental changes. An excellent example of this would be the demise of maize agriculture in the Fremont culture of Utah and the subsequent expansion of Numic (Uto-Aztecan) speaking peoples with residual food-producing technology across the Great Basin (Hill 2002; Bellwood 2005: 281; Smith 2001 refers to the Owens Valley Paiute of eastern California, who belong to this group).

The second type of situation occurs when food producers, in migration mode, simply moved beyond the range of agriculture altogether. The southern Maoris and possibly the Takic-speaking peoples of eastern Califormia fall into such groups. The latter, as Uto-Aztecan speakers, like the Numic speakers of the Great Basin, traced linguistic ancestry from a Mesoamerican maize-growing population that entered the Southwest about 2000 BC (Hill 2001, 2002; Bellwood 2005: 242–3). But in this case there was no Fremont-like intermediate phase of in situ food production within California itself.

The third type of situation occurs where food production developed in marginal areas, given the crops available, or in areas in which a particular wild (especially arboreal) resource was sufficiently plentiful to continue in production without domestication. Palm sago harvesters in the Sepik Basin of New Guinea (Roscoe 2002) come to mind here, likewise the sago-harvesting Punan in some regions of interior Borneo. Smith (2001) also refers to the Nuaulu, Austronesian-speaking farmers and foragers with a related economy in Seram, eastern Indonesia. All of these groups inhabit densely forested and relatively non-seasonal equatorial environments which, even today, are not conducive to the establishment of open field agriculture without considerable infrastructure. Archaeologically, the Jomon cultures of Japan (also discussed by Smith) practiced related forms of arboriculture of highly productive but non-domesticated species, such as chestnuts and acorns (Matsui and Kanehara 2006). Like the Nuaulu, Jomon people practiced some cultivation, which is possibly why estimated population sizes in eastern Japan rose so high during the Middle Jomon (Habu 2004:46–50). Under these circumstances, it is perhaps necessary to be cautious about using the concept of low-level food production to apply to the whole of the Jomon trajectory.

In other words, low-level food production was probably only a stable and successful long-term socioeconomic solution when environmental limitations offered little chance of intensification. It is unlikely that it played a major role in the rise of food production, except as a stage to be passed through in regions of agricultural origin such as the Levant. It has come into its own, on a long-term basis, mainly in situations of agricultural reduction or demise, or in other marginal circumstances, particularly when former agriculturalists entered difficult peripheral terrain. In those environments in which agriculture was initially developed or early to spread, especially those which were highly productive, the NDT hypothesis suggests that intensification of production was fairly inexorable, albeit with plenty of opportunity for subsequent problems to occur (as in the demise of the Linearbandkeramik – see Shennan, and Dubouloz and Genouvès, this volume). The archaeological and linguistic records, together with the NDT research published so far, generally suggest a similar conclusion, even for regions of uncertainty such as the US Southwest and Eastern Woodlands.

Conclusions

This chapter presents data to support the existence of NDTs amongst early agricultural populations, including data for East and Southeast Asia. We suggest that the NDT signal would have been stronger in population-size terms when farming spread, by whatever means, into new and "pristine" territories, particularly uninhabited ones, than in regions where former hunter-gatherers were gradually developing their farming economy themselves. Regions of primary agricultural origin undoubtedly witnessed population growth, but it occurred most intensively in the later rather than the initial Neolithic/Formative time span, as increasingly sedentary settlement patterns and increasing dependence on domesticated plants and animals fuelled the process. Population growth was generally most explosive in the migratory situations characterized by agricultural spread.

We also see the NDT research as indicating that, once populations began the shift to agriculture, many would have found it difficult, or unnecessary, to slow the process, at least not until environmental limitations were reached or mortality rates increased. Many ethnographic cases of low-level food production involved previous farming populations who crossed environmental limits into agriculturally marginal zones, or people who depended heavily on arboriculture. Their low-level food production was thus environmentally contingent, not representative of a significant and stable way of life relevant for the early millennia of food production. Ethnographic evidence suggests that mixtures of, for instance, 25% cereal farming and 75% hunting/gathering were not stable lifestyles, even if rare examples can be found in the ethnographic literature. Agricultural dependence with sedentism was a very important grade in prehistory, one which modern linguistic, genetic, and archaeological studies show to have played a major role in the creation of the genetic and linguistic landscapes which still unite and divide the world today.

Notes

1. For instance, bioanthropological papers published since 2004 that support a migration profile for early farmers, at least for the Old World and with population admixture in many cases, include Richards et al. (2004) (Bantu Africa); Luis et al. (2004), Arredi et al. (2004) (North Africa and Levant); Semino et al. (2004), Dupanloup et al. (2004), Brace et al. (2006) (Europe and Levant); Quintana-Murci et al. (2004), Cordeaux et al. (2004a) (but cf. Sahoo et al. 2006 who disagree) (West and South Asia); Cordeaux et al. (2004b) (South and East Asia); Trejaut

et al. (2005), Cox (2005), Karafet et al. (2005), Matsumura and Hudson (2005), Matsumura (2006), Hill et al. (2006) (East and SE Asia); Cann and Lum (2004), Cox and Lahr (2006), Kayser et al. (2006), Pierson et al. (2006) (SE Asia and Oceania).
2. Doolittle and Mabry (2006) suggest that an independent domestication of amaranths and chenopods occurred before maize introduction in the Southwest, but present no archaeological or botanical evidence in support.
3. Bocquet-Appel, Naji and Bandy (this volume) state that farmer population densities can be up to 1000 times higher than those for foragers.
4. Ratio of juveniles aged 5–15 years to adults 20+ years old.
5. Mean childhood mortality: calculated as an average of the probability of death [qx] for 5q5, 5q10, and 5q15.
6. The proportion of those living beyond 20 years to all those who lived to at least 5 years.
7. Drennan and Peterson (this volume) claim only very low birthrates from settlement numbers in Neolithic northeastern China, but the settlement data, discussed above, from further south in the Yellow and Yangzi basins suggest they may be factors of site survival that adversely affect the results in the northeastern sites.
8. Longer time lags for the Eastern Woodlands and parts of Mesoamerica are proposed by Kennett et al. (2006), Smith (2006), and Bettinger (2006), but in these cases the chronologies for the economic shift front are more poorly understood than those for the Middle East.

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Explaining the Neolithic Demographic Transition

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Abstract Three main questions are raised in this chapter.

1. The part of the signal of the NDT which is demographically identifiable, based on the proportion of the immature skeletons in cemeteries, shows that a baby-boom occurred and, beyond that, with the onset of the change in the economic system, a fertility transition towards high values also occurred. What was the biodemographic cause of this fertility explosion, beyond the proxy variable represented by sedentarism? The cause is a major shift in the maternal energetics of farming communities relative to mobile foragers. In the energy balance there was (i) on the intake side, an underlying trend towards a reduction in low-calorie food from hunting and fishing, and a correlative increase in high-calorie food from agriculture, (ii) on the expenditure side, a reduction in the physical energy devoted to mobility and the maternal stress of child transportation.
2. The NDT is detectable from a signal representing a fertility transition, but the transition relating to mortality is missing and must be inferred. If, during the fertility transition, mortality had remained the same as in the preceding forager period, then the population would have grown infinitely. The assumption of unchanged mortality during the entire fertility transition is therefore not realistic. Mortality, in its turn, must have begun to rise well before the end of the fertility transition. But when? Why? One of the answers consists of a model where, except at the start of the process, birth and mortality rates rise more or less simultaneously, bringing about a typical rate of increase for pre-industrial populations of slightly above zero.
3. According to the level and speed of the population growth, what should we expect in terms of population structure? What are the expected effects of this growth, not only on the population in numbers but also on age distribution, the distribution and structure of families, the distribution of households and on family systems?

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Keywords Neolithic demographic transition · fertility explosion · maternal energetics · farming · mobile foragers · western North American Indian Sample

Introduction

The signal of a major demographic shift during the transition from forager-horticulturists to farmers in Europe, North Africa and North America was detected in palaeoanthropological data from more than 120 cemeteries. This signal, which is characterised by a relatively abrupt increase in the proportion of immature skeletons, has been named the Neolithic demographic transition (NDT) (Bocquet-Appel and Naji 2006, Bocquet-Appel 2002, Bocquet-Appel and Paz de Miguel Ibanez 2002). The demographically identifiable part of the signal indicates a sharp increase in the birth rate, and beyond, a transition towards higher fertility values than those characterising the preceding forager period. This NDT raises a number of questions, starting with the cause of the increase in fertility. Because of its overall impact on the fertility of populations that turned to farming, wherever they were located on the planet, we would expect one or more identical causes having a determining effect on the variability of fertility, which should contribute to their identification.

Assumption number one, which was formulated a long time ago, is the impact of sedentism on fertility in nomadic forager populations (Lee 1972b, 1979, Binford and Chasko 1976, Sussman 1972, Binford 1968, Carr-Saunders 1922, Malthus 1798). Although this is a broad assumption, it tends to be borne out by the few data we have on nomadic populations in the process of sedentism (Binford and Chasko 1976, Romaniuk 1981, Roth 1981, Roth and Ray 1985), which are outlined below. The same applies to archaeological data representing the cemeteries of forager and farming populations, whose putative gradient of mobility from nomadic to sedentary (see below) closely coincides with the expected birth rate estimates. However, this broad assumption is a proxy variable for other underlying biodemographic variables that come into play. Which are these? In this chapter, the model of the relative metabolic hypothesis (for a summary see Valeggia and Ellison 2004), which is used in order to integrate the physical constraints of mobility, breastfeeding and maternal nutrition, is set forth to explain the variation in fertility during the NDT.

The second question raised by the NDT concerns its scenario. The NDT is detectable from a signal representing a shift towards higher fertility values, but the mortality part of the signal is missing and must be inferred. It is as if, in the contemporary demographic transition (CDT), only the profile representing the drop in birth rate was known, so that the drop in mortality would have to be estimated from this. The contemporary transition has multiplied the world's population by six in 150 years. So what should be done? In order to build up the scenario of the NDT, we need a model. The universal density-dependent (or homeostatic) demographic model is used. From an updated sample of Old and New World cemeteries in the northern

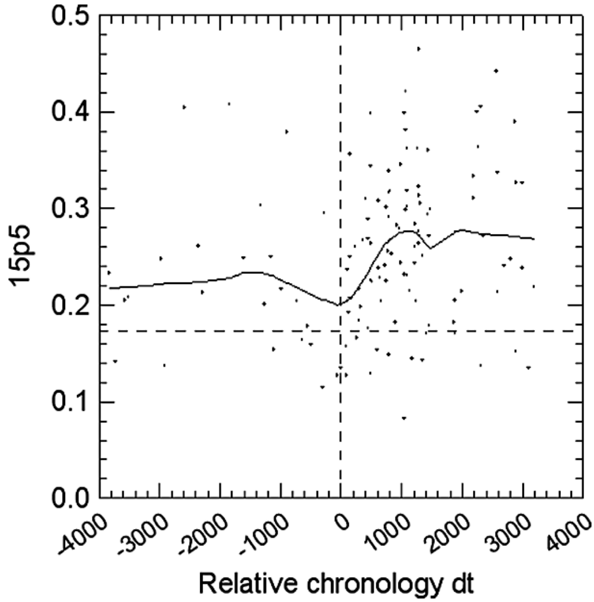

Fig. 1 Observed profile of the $_{15}p_5$ indicator in the northern hemisphere (133 sites, $N \geq 50$)

hemisphere (133 cemeteries; see Fig. 1), a birth rate estimate is obtained ranging from 40.3 to 53.1 per 1000, over 1000 years during the Neolithic fertility transition (see below). If, during the fertility transition, mortality had remained the same as in the preceding forager period ($\leq$ 40.29 per 1000), then the population would have reached an unrealistic number. The assumption of unchanged mortality throughout the fertility transition is therefore unrealistic. Mortality must have increased in turn well before the end of the fertility transition. But when and why did this happen? What timing for birth and mortality rates should we put in the NDT scenario? How should this scenario be tested, and with what data?

The third question, which follows on from the model of the NDT, concerns the impact of population growth on the population itself and its cultural expression. What were the effects of this growth, not only on population numbers but also on the various aspects of its evolving structure such as age distribution, the distribution and composition of families, the distribution of households, family systems (extended or nuclear) and the institutions developed to regulate tensions between groups/individuals in a steadily growing population?

In the first part on "experimental demographics", the model of the relative metabolic load is tested with an ethnographic sample of 172 populations of western North American Indians (Jorgensen 1979, 1999). In the second part, we explore a model of the NDT where birth rate and mortality evolve in tandem, producing a growth rate slightly above zero. In the third part, the effects of this demographic growth on the population structure are briefly reviewed.

Putative Cause of the Neolithic Fertility Transition

Direction of Fertility Change During the Transition to Sedentarism

Thirty years ago, the archaeologists and anthropological demographers Binford and Chasko (1976) detected what they called the "first major demographic transition" and which, in this volume, is called the NDT. They correctly identify its major cause – fertility and not mortality – along with its starting point at the end of Pleistocene. The fascinating aspect of this discovery, which did not receive the coverage it deserved, is that the demographic data on which it rests are very far removed, historically and ecologically, from Neolithic data, since they relate to the Nunamiut Eskimos of Central North Alaska. More interesting still is that, in the space of a single generation, from 1950 to 1965, the Nunamiut – who became sedentary at the same time as other geographically close Indian populations (Athapascan: Roth 1981, James Bay Cree: Romaniuk 1981) – successively experienced the explosive fertility of the NDT, followed by a collapse with the advent of the contraceptive practices of the CDT. The same is true of neighbouring populations. Binford and Chasko explore several avenues in attempting to account for this fertility explosion, from variations in coital frequency with the mobility of hunters to a dietary shift. They detect an influence of cereal consumption on fertility (Fig. 2) and conclude that this first demographic transition would have been a by-product of sedentarism and its impact on diet and the division of labour.

To these ethnographic data can be added palaeoanthropological data from cemeteries, which, although cannot be used to test the biodemographic assumption, do make it possible to test the proxy assumption of sedentism. Table 1 gives the values of the non-conventional demographic indicator ${}_{15}p_5$ for a set of nearly 20,000 skeletons from 138 cemeteries worldwide (Guerrero et al. this volume, Bocquet-Appel and Naji 2006, Bocquet-Appel 2002), which are divided into three mobility groups as indicated by archaeologists: nomadic (foragers), semi-sedentary (shell-midden foragers) and sedentary (farmers). A further breakdown of mobility is not

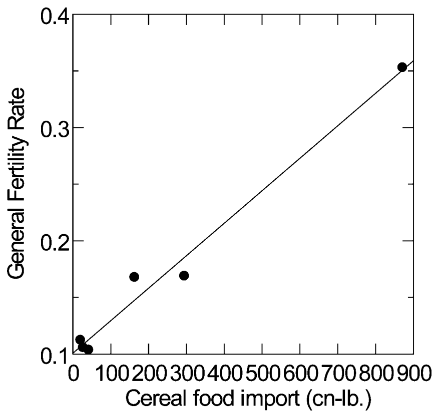

Fig. 2 Correlation between quantities of imported cereals and the general fertility rate among Nunamiut Eskimos (1949–1970). Note: From Binford and Chasko (1976, Table 10: 72 and Table 41: 129)

Table 1 Values of the paleodemographic indicator $_{15}p_5$ in three groups of cemeteries according to the degree of putative mobility

	Mobility		
	Nomadic (hunter-gatherers)	Semi-sedentary (shell-midden foragers)	Sedentary (farmers)
N sites	25	8	105
d(5–19)	715.92	147.30	4075.73
d(5+)	3213.02	642.50	16066.14
15p5	0.22282	0.22926	0.25368

(Sources: Bocquet-appel y Paz de Miguel Ibanez 2002, Bocquet-Appel 2002, Bocquet-Appel and Naji 2006, Guerrero, et al. this volume)

necessary for this exercise. We know that $_{15}p_5$ is highly correlated with the birth rate (r^2 adj. $= 0.963$: Bocquet-Appel 2002). We would therefore expect low $_{15}p_5$ values for nomads, intermediate values for semi-sedentary groups and high values for sedentary groups. The values of the demographic indicator $_{15}p_5$ are distributed in the expected direction (Table 1), ranging from $_{15}p_5 = 0.2228$ in nomads (foragers) to 0.2536 in sedentary groups (farmers). Table 2 gives the result of the validation test for the null hypothesis positing no difference in the $_{15}p_5$ proportion between paired groups. The difference is significant between the two most different mobility groups, i.e. hunter-gatherers (mobile) *vs*. farmers (sedentary) ($P = 0.0001$), with a lower indicator of expected birth rate in hunter-gatherers than in farmers, but it is not significant between the intermediate group of foragers (semi-sedentary) and each of the two other preceding groups. This test underlines, first, that not only the expected gradient of birth rate with mobility has been well observed in the archaeological data, but also the ambiguity of the demographic response of the intermediate semi-sedentary group attributed to the shell-midden foragers of the literature. This ambiguity is definitely accounted for by the test of relative metabolic load with the ethnographic data given below (see Table 3). Fertility remains uniformly low with a low-calorie diet of aquatic animals (fish and some shellfish), but rises when the energy constraint of mobility decreases.

Table 2 Probability of acceptance for the null hypothesis of equal $_{15}p_5$ proportions between paired groups. The corresponding data are in Table 1

	Nomads (hunter-gatherers)	Semi-sedentary (shell-midden foragers)
Semi-sedentary (shell-midden foragers)	0.367	–
Sedentary (farmers)	0.0001	0.151

Table 3 Fitting models (OLS) of demographic density (proxy for fertility) by the impact of diet b_1 (energy intake) and mobility b_2 (energy expenditure). In rows: diet category. Figure 4 provides 2D and 3D graphical representations of the data and the corresponding adjusted planes

	Constant (b_0)	t-value	Diet (b_1)	t-value	Mobility (b_2)	t-value
Hunting	**−8.879**	**−2.737*****	4.573	0.605	**4.675**	**8.558******
Fishing	**−5.667**	**−2.931****	**−7.628**	**−2.691****	**4.756**	**9.698******
Farming	−3.327	−1.816	**29.553**	**5.942******	**2.671**	**4.879******

$P > |t|$: $^{*} \leq 0.05$, $^{**} \leq 0.01$, $^{***} \leq 0.001$, $^{****} \leq 0.0001$

The Relative Metabolic Load Model

Taking a different angle, anthropological demographers and reproduction biologists are trying to understand the determinants of natural female fertility. Let us recall that for a fixed reproductive duration of roughly 35 years, the fertility level can be expressed by the duration of the birth interval. During the fertile life of a mother, when the duration of the birth interval increases, the number of children born decreases. The duration of the birth interval is inversely proportional to fertility. But the inter-population variation of the birth interval is large (Wood 1994). In the context of the shift to agriculture, three main assumptions can account for this variation in the birth interval. The first is maternal stress from transporting children, caused by the forager mother's inability to care for more than one dependent offspring at a time (Blurton Jones 1986, Blurton Jones and Sibly 1978, Binford 1968, Sussman 1972, Lee 1972a, b; Bleek 1928). The duration of the birth interval is a function of the distance covered by a mother and of the growing weight of a child. This assumption has produced contradictory results (Roth 1981, 1985; Vitzthum 1994).

The second assumption postulates (i) that the duration of the birth interval is an (inverse) function of the intensity and frequency of suckling (Konner and Worthman 1980, Wood et al. 1985, Diaz 1989, Lewis et al. 1991, Peng et al. 1998) and (ii) that suckling during the transportation of children by their mothers decreases during the transition on the mobility gradient from nomadic foragers to sedentary farmers (Bocquet-Appel and Naji 2006, Lee 1979, Sussman 1972). But several studies have shown no correlation between the intensity of suckling and the return of the reproductive cycle (Fink et al. 1992, Worthman et al. 1993, Tay et al. 1996). The third assumption is the relative metabolic hypothesis for maternal nutrition (Huffman et al. 1987, Lunn et al. 1984, Ellison et al. 1993, Ellison 1994, Valeggia and Ellison 2004). The duration of the birth interval is an (inverse) function of the energy balance (energy status and energy balance). The energy balance is determined by energy expenditure (on necessary milk production and physical activity) and postpartum energy intake (mother's diet).

Curiously, interpretations of the field data have been possible sometimes thanks to one of the assumptions, and sometimes to the other. But a recent study has produced a major advance in favour of the relative metabolic load model. In breast-feeding women with natural fertility, the date of resumption of the cycle is determined by a positive return of the relative energy balance after childbirth and its stability for a period of about 3–4 months (Valeggia and Ellison 2004), the whole determining the duration of postpartum amenorrhea. In the remainder of this chapter, the variable representing the positive return of the relative energy balance *(EB)* is written as $\Delta_t EB + e$, with the index t indicating the positive return at time t after childbirth and e the stable duration of *EB* positive, ending with the return of the menses. Without additional studies, the stable duration of *EB* positive cannot be regarded as invariant between populations. The duration of postpartum amenorrhea is equal to $t + e$. The suckling frequency is a necessary but not sufficient signal determining the duration of postpartum amenorrhea. To this duration, in an anthropological context, we need to add the postpartum sex taboo, c, determined for cultural reasons. The whole gives the birth interval $t+e+c$. In ethnographic populations, the average duration of the postpartum taboo is shorter among mobile foragers than among sedentary farmers (see Table 4, Saucier 1972).

Valeggia and Ellison's data and their interpretation by their relative metabolic load model make it possible to take into account the intensity of suckling frequency and the maternal energetics required to ensure reproduction, in a given economic and ecological context. This in turn makes it possible to understand the reasons for the diversity of interpretations of the survey data, which sometimes control one variable and sometimes another. In the context of the shift from a forager to a farming economy, if the cursor for suckling frequency (high), energy status (regular in the context) and the postpartum sex taboo is kept fixed, we would expect input and output in the energy balance to be affected by

- a reduction on the input side in the proportion of low-calorie food items (tissues from hunted animals and fish) relative to high-calorie food items (wheat, lentils, peas, maize);
- a reduction on the output side in energy expenditure among foragers, via reduced physical activity involved in mobility and the maternal stress of child transportation.

Table 4 Mobility patterns (in columns) versus duration of post-partum abstinence (in rows). Sample of 201 populations of mobile foragers and sedentary farmers, from the 1267 populations in George P. Murdock's Ethnographic Atlas (Gray 1998; Murdock GP and White DR 1969) (see text for comment). Mobile foragers have a post-partum abstinence significantly shorter than sedentary farmers (χ^2 of homogeneity $= 11.18597$, with 5 df. $P = 0.047$)

Time duration	Mobile foragers	Sedentary farmers	Total
None	0	7	7
$\leq$ 1 month	9	22	31
1–6 months	17	40	57
6–12 months	4	19	23
12–24 months	7	36	43
$\geq$ 24 months	3	37	40
Total	40	161	201

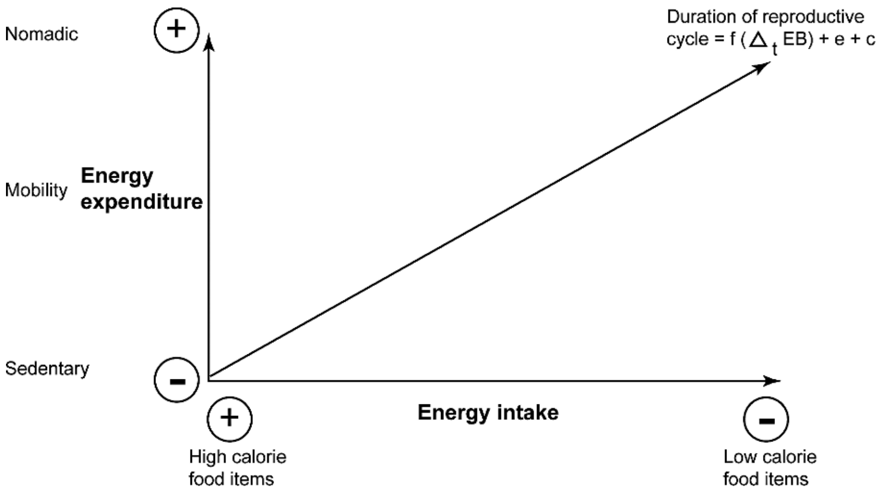

Fig. 3 Model of reproductive cycle duration. The diagonal line represents the lengthening of the reproductive cycle, expressed by the birth interval. The birth interval is determined by the time taken to reach a positive return of the relative energy balance *(EB)* after childbirth ($\Delta_t EB$), by the stable population-dependent duration of *EB* positive *(e)* and by the postpartum sex taboo *(c)*. The energy balance is determined by (i) energy intake (*horizontal axis*), ranging from low-calorie food items (*on the right*, −: hunted animals, fishes) to high-calorie food (*on the left*, +: wheat, lentils, maize and peas); (ii) energy expenditure (*vertical axis*) represented by the physical activity corresponding to mobility and to the maternal stress of child transportation

This double effect on the energy balance results in a shorter duration of postpartum amenorrhea ($t + e$), and thus to increased fertility. The fertility model determined by the relative metabolic load is represented in Fig. 3. We notice that its demographic effect is similar for sedentary populations using high-calorie food items, whether these are farmers or foragers such as the Natufians in the Levant (Fig. 3: position "+" on the horizontal axis of the energy intake and "−" on the vertical axis of the energy expenditure).

The predictions of this fertility model are tested with the data for the 172 ethnographic populations of Jorgensen's western North American Indian sample on their first European contact (1979, 1999). These data provide information on the density of consumed calorific energy, via the percentages of diet items (hunting, aquatic animals, agricultural produce) and physical activity, via a graduation of mobility (from nomadic, coded "0", to sedentary coded "7"). Information is thus given on demographic density (per mile^2), but none on fertility or the postpartum sex taboo. To test the fertility model with these data, two assumptions must be made. The first relates to the use of demographic density as a proxy variable for fertility. If the demographic regime of populations (determined by their inputs and outputs: birth rate, mortality and migration in and out) has not been disturbed in the recent past, their demographic densities will therefore mainly reflect their fertility. There are two main causes of disturbance: (i) a variation in demographic density due to migratory movements (in or out), as in the contemporary examples of rural migration and concentration in megalopolises across the entire planet, and (ii) an abrupt negative or positive variation in the fertility of a population, but where the current demographic density is a reflection of its former fertility: an example is the Chinese population today, with its high demographic density and very low fertility. The assumption of an absence of major disturbance in the demographic regimes of the ethnographic sample prior to the first European contact seems acceptable. The second assumption relates to the postpartum taboo, whose duration is not indicated in the ethnographic data and which we might be tempted to regard as a random variable, independent of the demographic density. As seen above, it is not. Average postpartum duration *(c)* is longer in the relatively high-density populations of sedentary farmers than in mobile foragers. Paradoxically, when demographic density rises in these data, we should expect an undervaluation of fertility energetics. This will be looked into below.

The impact of mobility and diet on demographic density, used as a proxy variable for fertility, is tested by means of simple linear adjustments (OLS), $z = b_0 + b_1 x + b_2 y + h$, with *x, y, b* and h, respectively, representing, for energy intake, the proportion of a specific food (from hunting, aquatic animals and agricultural produce), for energy expenditure mobility, regression coefficients and an uncontrolled residue. The 2D and 3D representations of the models are given in Fig. 4.

A successive examination of the three diet categories (Table 3) shows the following:

- with energy intake from hunting (Table 3, line 1, Fig. 4a), i.e. from low-calorie food items, only energy expenditure (mobility) has a significant influence on fertility, which rises when energy expenditure decreases;
- with energy intake from aquatic animals (mainly fish and some shellfish, Table 3, line 2, Fig. 4b), there are two significant influences: a relatively weak negative influence of low-calorie food items and a strong influence of energy expenditure (mobility). Fertility rises when the low-calorie food items and the energy expenditure both decrease.
- with energy intake from farming produce (mainly maize, Table 3, line 3, Fig. 4c), the influences of energy expenditure and energy intake from high-calorie food items are both significant. Fertility increases more when, simultaneously, energy intake from high-calorie food items increases and energy expenditure decreases, with energy intake exerting a more perceptible influence than energy expenditure.

Allowing for a probable undervaluation of the fertility energetics in the ethnographic data when the demographic density rises due to the impact of the postpartum taboo as discussed above, the slopes of the adjusted planes in the graphs (Fig. 4) should be tilted a little more towards demographic density. To summarise, the relationships observed in the ethnographic data between the variables representing the relative metabolic load and demographic density, used as a proxy for fertility, all take the directions predicted by the fertility model. This is the message contained

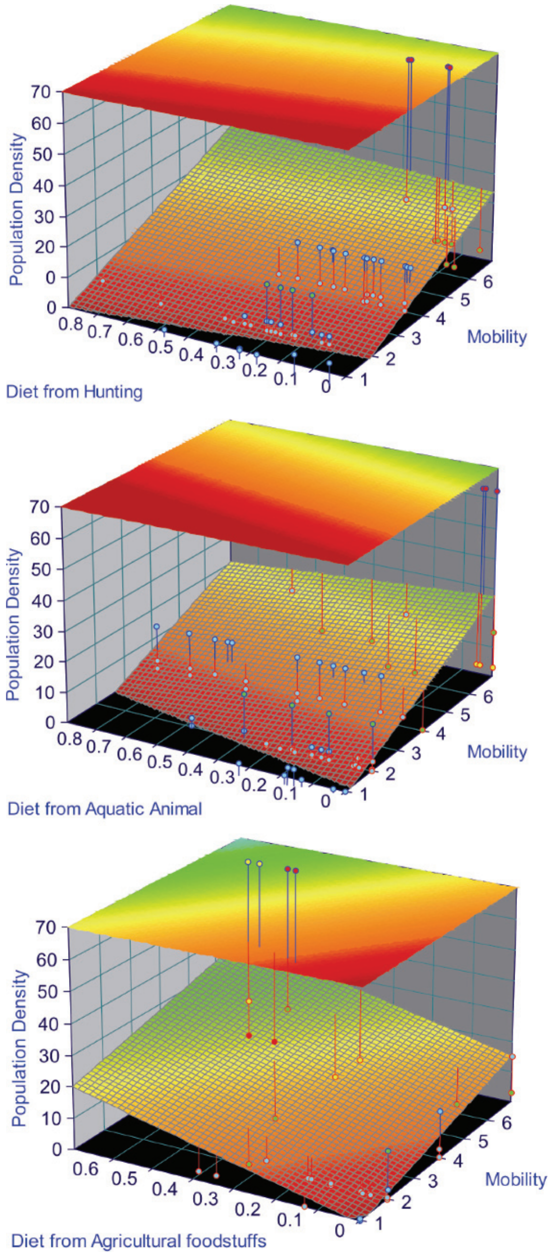

Fig. 4 3D representation of demographic density (proxy for fertility), accounted for by energy expenditure (mobility, from 0 = nomadic to 7 = sedentary) and energy intake (diet from (**a**) hunting, (**b**) aquatic animals, (**c**) agricultural produce) with the relative metabolic load model applied to Jorgensen's sample (1979, 1999) of western North American Indians on first European contact. A 2D representation of demographic density is given at the top of each graph. The statistical tests are given in Table 4

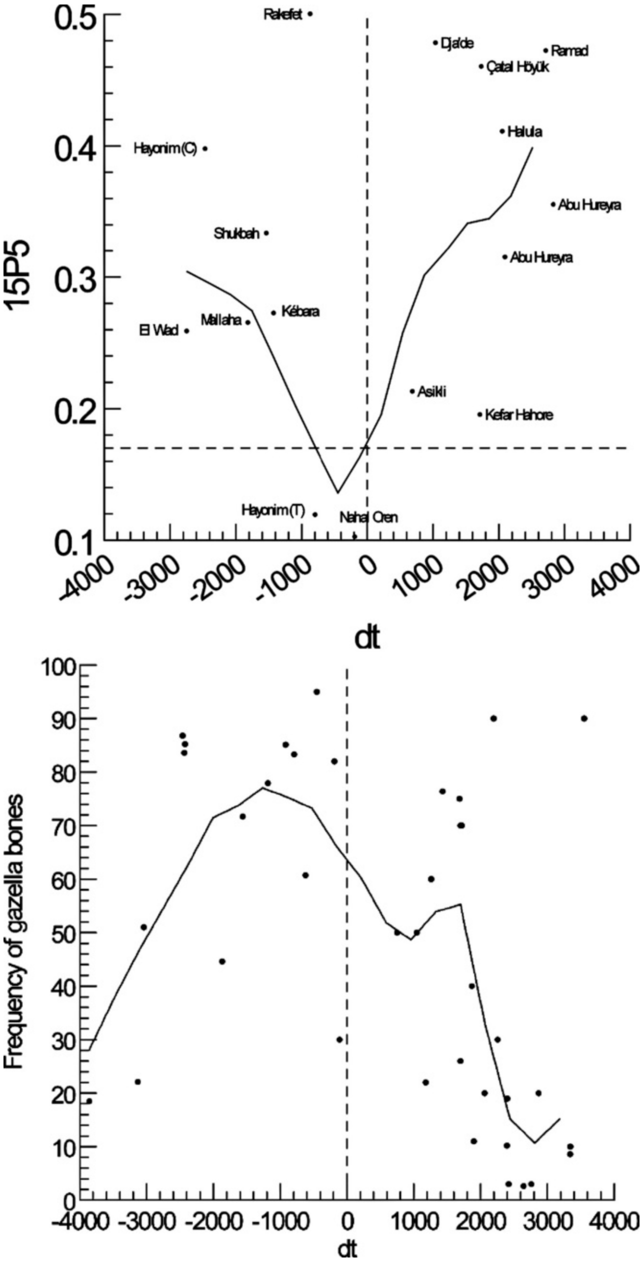

Fig. 5 Profile of variation in the Levant, in the relative chronology *d*t, in (*top*) the demographic indicator ${}_{15}p_5$ and (*bottom*) the proportion of gazelles in animal remains (two smoothers, DWLS, the smoothest, and Loess, the least smooth; same parameters alpha = 0.5; from Guerrero et al., this volume)

in the ethnographic data, which should help us to gain a better understanding of the cause of the NDT.

The interpretation of the ${}_{15}p_5$ profile of the NDT at the source of agricultural invention in the Levant can thus be taken further. Along with the increase in fertility, the signal of the NDT expresses a steady reduction in the duration of the reproductive cycle and, beyond this, of the positive return of the relative metabolic load. This reduction must have been determined relatively to the forager society, simultaneously by an energy intake comprising a decreasing proportion of low-calorie food items (hunting) and an increasing proportion of high-calorie food items (cultigens), as well as a reduction in energy expenditure accompanying sedentarisation. Figure 5 represents the profiles for the fertility transition in relative chronology (dt) and for hunting (Guerrero et al. this volume). These profiles show a negative correlation: when the share of hunting in the diet increases, fertility decreases, and vice versa. This is rather remarkable since the phenomenon covers two periods of increasing fertility/decreasing hunting (at $-4000\,d$t and $2000\,d$t). The coincidence of hunting profiles and demographic profiles in the Levant, over a relatively long duration, has already been noted (Guerrero et al. this volume). The fertility model can provide at least three explanations for the parallel direction of these profiles, one in terms of a reduction in energy expenditure, via reduced mobility, another in terms of a reduction in the proportion of low-calorie food items (represented by gazelles) with a probable correlative increase in high-calorie food items (represented by wheat, lentils and peas) or a combination of both. This last explanation seems the most likely. With regard to the reduction in energy expenditure, this certainly relates to the transportation of children. But with the growth of the population, the number of families, of individuals within families and of extended families also increases. This increase in average family size and in the number of extended families points to a probable supply of surrogate carers for the mothers, i.e. to more collective responsibility for taking on the physical constraints of motherhood and domestic activities during the nursing period, which causes a further increase in fertility.

Explorations of a New NDT Model

Long-Term Growth and Homeostatic Equilibrium: A Brief Reminder

As for other animals, demographic growth in human populations is regulated by density-dependent mechanisms (Reher and Ortega Osona 2000, Lee 1987, Blum, Bonneuil and Blanchet 1992; for a discussion, see Wilson and Airey 1999; for mammalians, see Sibly, Hone and Clutton-Brock 2003). Any significant variation, due to a disturbance, from the long-term average value of the birth rate *(b)* or mortality rate *(d)* will quickly return to near this average value. The difference between the birth and mortality rates corresponds to a population where demographic growth *(r)* is close to zero ($b-d = r \cong 0$). It is said of such a population that it is in homeostatic equilibrium or that it fits the density-dependent model. If density-dependent regulation were absent, then any reduction in the population's growth rate could end in extinction, while any increase could lead to an infinitely expanding population (Sibly, Hone and Clutton-Brock 2003). This density-dependent pattern has been detected in the archaeological data representing the increase in site density in Peru (Bandy 2005). The near-zero value of the long-term growth rate of prehistoric populations is generally agreed upon (Hayden 1986, Hassan 1981, Dumond 1975; Boone 2002 countered) and is verified in the archaeological data (Bocquet-Appel, Demars, Noiret and Dobrowsky 2005).

A remarkable and well-documented fact in human demographic history is the response of the metapopulation to the major disturbance represented by the CDT. Across the planet as a whole, this transition has raised life expectancy at birth from 25 to 70 years and lowered the average number of children per woman (TFR) from 8 to 2 or less in just three centuries. Against the backdrop of the density-dependent model, the CDT has to be seen as a very large-scale disturbance with intrinsic causes (see below), whose return time to homeostatic equilibrium towards a zero growth rate in the endogenous geographical zones of invention was proportional to the scale of the disturbance. This transition lasted nearly 250 years in the UK and 150 years in Denmark. It must be remembered that the scenario of the CDT was a transition towards lower mortality, followed by a transition towards lower fertility (Fig. 6). The pattern of this global transition is therefore, in fact, of two superimposed transitions that vary together, with a greater or lesser time-lag. The CDT is the only known historical reference pattern of a major demographic shift (other than induced by a catastrophe) representing a demographic transition. It is therefore legitimate to compare these two transitions, the NDT and the CDT, which, in terms of the scale of their impact on human evolution, are of the same order.

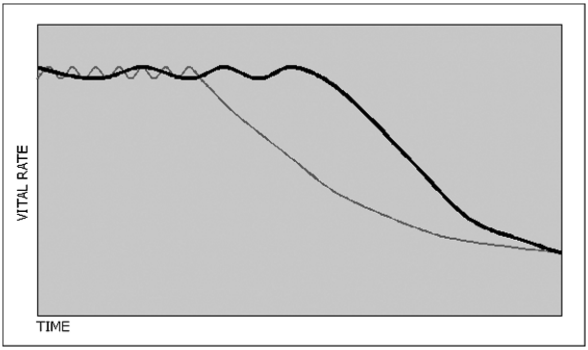

Fig. 6 Model of contemporaneous demographic transition. From a value of about 40 per 1000 before the transition, we see a drop in the death rate (*in grey*), followed by a drop in the birth rate (*black*), down to approximately the same value as the death rate, after a variable duration of about 250–150 years

Lessons from the NDT and CDT Comparison

First of all, as indicated above, compared to the CDT, only the fertility transition profile for the NDT is observed from cemeteries data, but the mortality transition is missing. We then see that the direction of the fertility transition is reversed, tending towards higher values for the NDT and lower values for the CDT. This reversal has led me to formulate the assumption of an NDT pattern that is a mirror image of the contemporary transition, both in the order of the demographic variables (*b* followed by *d* in the NDT, and not *d* followed by *b* as in the CDT) and in their directions (transitions towards increasing and not decreasing values). Therefore, the scenario begins as follows: for reasons due to the demographic densification of the foragers' world (Cohen 1977), which determined ecological pockets of sedentism in Eurasia at the end of Pleistocene and in Mesoamerica around 4500 BP, the transition towards an increase in fertility would have begun, followed by a mortality transition towards these same high values, for the reasons of homeostatic equilibrium indicated above. The important question is the tempo of this return to equilibrium, during which there would have been an appreciable growth in the population.

Figure 1 represents the profiles of the fertility transition in the NDT observed in 133 sites in the northern hemisphere (no Levantine sites). From the relationship between ${}_{15}p_5$ and the birth rate given by the estimators of the pre-industrial model (Bocquet-Appel 2002), life expectancy at birth, average number of children (TFR) and females surviving to mean childbearing age can be estimated using the assumption of a stationary population, for example with Coale's chart (1974: 45). This chart uses the different relationships between TFR, NRR and a growth rate set at zero (Hinde 1998: 187, Pressat 1972: 350–352). Table 5 gives the values of these different demographic variables on the average profiles (${}_{15}p_5$) of the fertility transition in the northern hemisphere (Fig. 1), at $d\mathrm{t} = 0$, marking the onset of the NDT, and at $d\mathrm{t} = 1000$, the first plateau of the ${}_{15}p_5$ profile marking the end of the transition. The estimated birth rate is 40.3 per 1000 at $d\mathrm{t} = 0$ and 53.1 per 1000 at $d\mathrm{t} = 1000$. The large differential of the two values indicates that the return to the equilibrium could not occur at the end of the fertility transition, otherwise the number of humans would have become unrealistically enormous. To reconcile a birth rate (fertility) that rises slowly but continuously for 1000 years with a realistic growth rate slightly above zero (about 0.2%), which is typical of pre-industrial populations, mortality must

Table 5 Estimated values for different demographic parameters using Coale's relationship (1974: 45), starting from the birth rate estimate given as input data using the paleodemographic estimators (${}_{15}p_5$) for the pre-industrial model (Bocquet-Appel 2002)

dt	${}_{15}p_5$	Birth rate (1)	TFR (2)	e_0 (3)	Surviving females % (4)	Growth rate
0	0.200	40.3	5.2	24.8	39.4	0.
1000	0.300	56.2	7.2	18.3	28.5	0.

(1) Birth rate per 1000. (2) Total fertility rate (births per female). (3) Life expectancy at birth. (4) Females surviving to mean childbearing age (%).

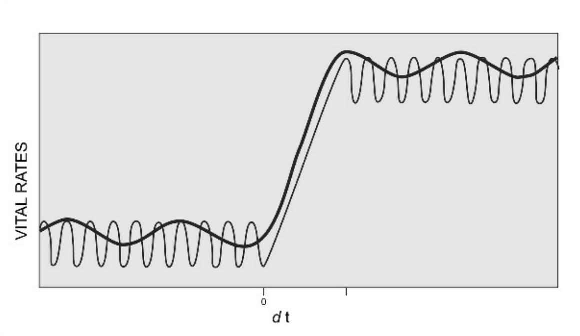

Fig. 7 Model of the Neolithic demographic transition. In this model, a fertility transition towards higher values (*in black*), driven by sedentism, appears at the onset of the new economic system, at dt = 0. But a mortality transition soon follows, also towards higher values (*grey*), driven by the density of village life and contamination (drinking water, latrines) associated with zoonoses, as well as by a change in nursing patterns. In a similar model published by Coale (1974), the two transitions are reversed compared to the model presented here

rise at approximately the same rate. This model is shown in Fig. 7. At this rate of increase, the population doubles in 350 years.

In this model (Fig. 7), the birth rate (and fertility) rises continuously, determined by the age pyramid and age-specific fertility rates, which (with the TFR) increase as a result of a shift in maternal energetics. With the growth of the population, the number of surrogate carers also increases (grandparents, older children), which may have helped to increase fertility. The maximum stable birth rate (53 per 1000) may have been reached when, in the farming system, maternal energy expenditure on physical activities fell to a minimum as it became integrated into the overall workings of the social system, while energy intake rose to a maximum through the incorporation, thanks to regular and stable supplies, of the high-calorie food items now being selected.

Causes of the Increase in Mortality

With sedentary village life and the corresponding growth in local population density, mortality rates inherited from the foragers eventually rise, particularly in children under 5 years of age. Causes of increased infant mortality would include lack of drinking water supplies, contamination by faeces and the absence of latrines, as well as reduced breastfeeding. The susceptibility of humans to new infectious diseases results from complex factors such as modified exposure to animals, microbial adaptation, nutritional status and density of the host population. The high proportion of children in Neolithic burial sites could have resulted from the emergence of highly virulent zoonoses that were newly acquired. Interestingly, however, it can be seen that the variation in the proportion of skeletons aged 0–4 years in cemeteries, set within the frame of the relative chronology dt, mimics the proportion of 5- to

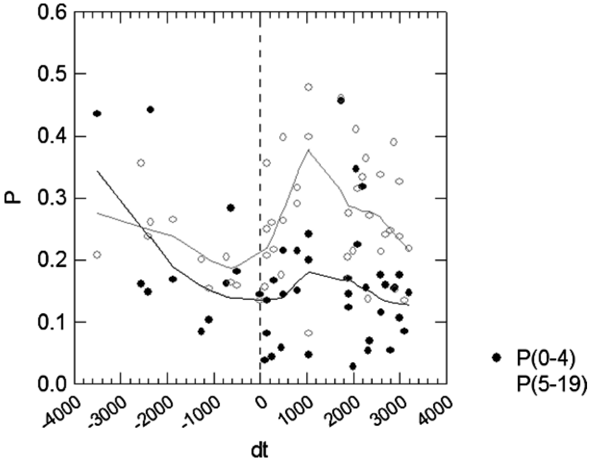

Fig. 8 Variation in the profile of the proportion of 0 to 4 year-old immature individuals, P(0–4), and 5 to 19 year-olds, P(5–19), obtained with the Loess fitting procedure. Both profiles show the same signature of the NDT pattern

19-year-olds, in spite of the taphonomic impact (see Fig. 8). This role of infectious diseases in the homeostasis of population growth is still mainly hypothetical. Molecular analyses of the divergence between related animal germs are only an indirect way of assessing their period of acquisition by humans. Candidate germs by "epidemiological inference" from current pre-industrialised areas and those with poor health facilities should include germs associated with animal domestication, such as *Paramyxovirus* (measles), *Poxvirus* (smallpox), *Rotavirus* and *Coronavirus* (diarrhoea, one of the main killers of children under 5 years of age), *Streptococcus* (including *Streptococcus agalactiae*, linked to cattle milking) or *Staphylococcus*. Some germs believed to co-evolve with humans should also be studied, such as *Plasmodium* (*P. falciparum*, and *P. vivax*, which is believed to have emerged more recently) or *Herpesvirus*. But only diseases involving a haematogenic process will be easily detected. Research in molecular anthropology should provide information in this promising area (Mira, Pusker and Rodriguez-Valera 2006). During the NDT, the population may have lost several years of life expectancy. Finally, mortality stops rising once the regional density and concentration of the population have stabilised.

A model of a Neolithic transition, graphically resembling of the one in Fig. 7, has been published by Coale (1974) but, contrary to the model put forward here, "the death rate increased as a result of greater susceptibility to disease in village life, and perhaps also because agriculture is vulnerable to climatic crises. If the death rate did increase, then it is certain that the birth rate also rose, and by a slightly greater margin" (Coale: 48). In Coale's model, the increase in the birth rate does not have any explicit cause other than homeostasis. This question as to which variable, the birth rate or the mortality rate, initiated the NDT is not a chicken-and-egg problem. The idea that demographic growth in the Neolithic, which was without historical precedent, could have been triggered by an increase in mortality is bizarre. To sustain a village life, the population had to reach a certain number and this number could only be achieved through an increase in fertility. Rising mortality, as the population density increased, could only come after, and not before, the initial population growth. Seeing an increase in mortality as triggering demographic growth is like starting off a race by making the runner shoot herself in the foot: she will not run far. But Coale has correctly thought out the constraint weighing on the increase in these rates: they must follow each other closely for the growth rate to remain viable.

Some Expected Demographic Consequences of the NDT

During the NDT, with the tempo at $d\mathrm{t} = 1000$ years (Fig. 1), although fertility increased considerably (the estimated TFR increased from 5.2 to 6.8 children per woman), average family size increased only moderately, from 4.3 to 4.7 people, because of the increase in mortality; the size of households including one of the two surviving grand-parents more than 60 years of age rose from 5 to 5.2 people. At the onset of the NDT, life expectancy at birth could have been about 24 years for males and 25 years for females, but rises to 33.6 years and 34.1 years, respectively, at the age of 20. By the end of the NDT, due to the transition to higher mortality values, life expectancy at birth is about 18 years in both sexes, but 28 years for males and 29.5 years for females at the age of 20; 55% of the population is under 20 years old and the median age is 17. These figures must be taken rather as orders of magnitude in order to try to indicate the trend during the NDT, rather than precise statistical data.

What consequences should we expect from a very young population, with a birth rate and a median age identical to that of Niger today (57 per 1000 in 1977: Direction de la statistique 2003)? One of the effects of an increase in the growth rate caused by a combination of high birth and mortality rates is that families, on average, have more surviving children but families do not last as long. In societies with low life expectancy at birth, extended families, first to collaterals, are taken as the standard relative to nuclear families, with “their patriarchal or matriarchal and nepotistic tendencies that stifle individual initiative” (Kuznets 1965: cited by McNicoll 1984: 214). To individuals, mainly children, they provide a form of life (or survival) insurance when mortality causes families to fall apart. In many traditional village societies, the inhabitants make a distinction between the descendants of the original founders of the village and other inhabitants who do not have this ancestral link (McNicoll 1984).

Villages have historically expanded by fission in most peasant societies, with the establishment of “daughter villages” as population grows. The resulting pattern of clustered hamlets, each village typically having a few hundred homes at most, is largely found in Asia and the Middle-East. In the context of open borders, the inhabitants can create new villages in distant settlement areas.

Concluding Remarks

The cause of the Neolithic fertility transition put forward in this article, beyond the proxy variable represented by sedentism, is the impact of an unprecedented shift in the energetics of female mobile foragers over 3000 years in the Levant. However, this unprecedented increase in fertility did not result in demographic saturation of the planet as might be expected but, probably only in a growth rate typical of pre-industrial populations of about 0.1–0.2%. The hypothesis is therefore that, with the appearance of village life and the corresponding increase in local population density, higher mortality soon followed the increase in fertility. This would have produced the net effect of an appreciable increase in the population during the NDT and, at the same time, a reduction in life expectancy at birth. The difficulty, however, lies in detecting the signal of the mortality transition in the (bio)archaeological data available. This is the first new challenge.

A new question relates to the insights provided by the NDT scenario that help us to understand the archaeological data, and vice versa. At which point in the timing of the fertility transition did archaeological artefacts appear, or disappear, that are interpretable in terms of indicators of economic, social and ideological reorganisation or adjustment? What changes in the archaeological data can be linked to the tempo or the scenario of the NDT? (for a review see Kuijt 2000a, Kuijt and Goring-Morris 2002). The second challenge is the integration of the archaeological data (Kuijt and Goring-Morris 2002, Belfer-Cohen and Bar-Yosef 2000, Kuijt 2000a, 2000b) into the model of the NDT and the reverse, in order to understand the multidimensional aspects of the first human experiment in unprecedented population concentrations and the birth of a New world.

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The Signal of the Neolithic Demographic Transition in the Levant

Emma Guerrero, Stephan Naji and Jean-Pierre Bocquet-Appel

Abstract In this chapter, we test the prediction of a Neolithic demographic transition in the Levant, with palaeoanthropological data from 31 cemeteries. The demographic profile obtained is the same as the profile obtained for Europe and North Africa and for North America, with a significant increase of the ${}_{15}P_5$ values when the new farming economy emerges ($d\mathrm{t} = 0$), over a time span of more than 2000 years. However, the tempo of this transition in the epicentre of the transition to farming differs from the tempo in the peripheral areas: in the Levantine cemeteries the increase in immature skeletons is as high as in the rest of Europe but the time span in which it occurs is three times as long. The question of the tempo of the NDT in the Levant is discussed in terms of the impact on change in the fertility of residual forager mobility in the new farming system.

Keywords Neolithic · Near East · Levant · demographic profile · site size and population mobility

Introduction

The signal of an abrupt demographic change during the transition from forager to producer economies has been detected in palaeoanthropological data from 38 Mesolithic–Neolithic cemeteries in Europe and North Africa (Bocquet-Appel 2002). This abrupt change has been called the Neolithic demographic transition (NDT) (Bocquet-Appel 2002). The detection of the signal made it possible to predict that if this NDT occurred in Europe and in North Africa, it must also have occurred in all centres of agriculture invention across the world. This prediction has been confirmed for North America, with the detection of a similar signal in data from 62 cemeteries (Bocquet-Appel and Naji 2006). In this chapter, we report on continuing tests for

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this prediction, this time in the Levant, a strategic region of farming invention, with data from 31 cemeteries.

In these geographical regions located around the periphery of major epicentres of farming invention, the observed tempo is relatively rapid over time corresponding to the rate of impact of a farming “tool-kit” that was already technically, ideologically and socio-economically established. But in the epicentre of farming invention in the Levant, should we not expect, on the contrary, a slower rate of demographic change than in the peripheral areas, corresponding to the length of time required for a complete switch from foraging to farming thanks to the invention of the new tool-kit? How long, in the Levant, did the NDT last? If, as expected, the transition was slower in the Levant, can a parallel be drawn with other economic indicators in the archaeological data for the PPNB, particularly the rate of disappearance of hunting as a proxy measure of the self-sufficiency of the farming system? This item of information opens the way to hypotheses about the mobility of sections of PPNB populations, which has a direct influence on fertility. These hypotheses may account for a slower tempo of demographic change in the Levant epicentre than around the periphery.

The palaeodemographic data are presented below, after a brief summary of the archaeological context.

A Brief Summary of the Origin of Farming Communities in the Levant

The transition to the Neolithic in the Levant area of the Near East is relatively well known. The process of neolithisation of this area is characterised by a number of economic and social transformations that produced a transition from a way of life based on hunting and gathering to a new way of life based on food production, as a result of the adoption of agriculture and animal husbandry (Aurenche & Kozlowski 2003; Balkan-Atli 1994; Bar-Yosef 1998a, 1998b; Bar-Yosef and Belfer-Cohen 1992; Cauvin 1997; Kuijt and Goring-Morris 2002; Özdoğan 1998; Özdoğan and Başgelen 1999). In contrast to other geographical contexts, as in Europe for example, these transformations appeared gradually over 6 millennia, from 14400 to 8250 cal BP, during different historical and chronological phases (Table 1). The first evidence of sedentism and the emergence of the first real settlements, formed by little circular clusters of huts, are documented during the Natufian. In the Levant, there are a number of archaeological and biological categories of evidence that archaeologists have equated with the appearance of sedentism during the Natufian. The main categories are stone architecture, large artefacts such as heavy stone mortars, features such as storage pits and cemeteries, the presence of commensal fauna (specifically the house mouse, house sparrow and rats) and the thickness of archaeological deposits (Bar-Yosef and Belfer-Cohen 1989; Belfer-Cohen and Bar-Yosef 2000; Boyd 2006; Valla 1998). Nevertheless, two different settlement patterns are accepted for the Natufian: first, the existence of sedentary base camps and second,

Table 1 Chronology of the Levant used in this study (dates are in Calibrated dates Before Present, cal BP)

	From cal BP	To cal BP
Natufian - Early	14400	12950
Natufian - Late	12950	11950
Late Nat/PPNA	11950	11450
PPNA	11450	10750
PPNB - Early	10750	10150
PPNB - Middle	10150	9450
PPNB - Late	9450	9050
PPNC-a / PN	9050	8550
PPNC-b / PN	8550	8250

the existence of secondary seasonal and specialised camps (such as hunting camps) (Bar-Yosef 2001; Bar-Yosef y Meadow 1995).

The first evidence of plant cultivation appears during the next historical and chronological phase, the PPNA (Pre-Pottery Neolithic A), at some archaeological sites such as Jericó (Palestine), Netiv Hagdud (Israel), Mureybet, Jerf el-Ahmar (Syria), Qermez Dere and M'lefaat (Iraq). Because of the wild morphology of the seeds recovered from these sites, Jacques Cauvin has called this early evidence of plant cultivation "a kind of predomestic" agriculture (Cauvin 1997; Hillman 1996; Miller 1992; Willcox 2000). Other innovations documented for the PPNA are the gradual introduction of a rectangular plan for the construction of buildings, the equally gradual extinction of cave settlements and, at a symbolic level, the humanisation of art. Concerning the burial practices documented for the PPNA, the frequent recovery of headless skeletons and depositions of human skulls (as skull caches), a practice already observed during the Late Natufian and involving the separation of the skull from some buried individuals, strongly suggests that ancestor worship had taken a firm hold in society (Bar-Yosef 1998a; Cauvin 1978, 1985, 1997; Kuijt 1995, 2000a; Le Mort 1992; Stordeur 1999, 2000; Stordeur and Abbès 2002; Verhoeven 2004).

In spite of these evidences of plant cultivation, it will not be until the next phase, the PPNB (Pre-Pottery Neolithic B), that full-scale agriculture in the whole Levant is documented. At the same time, the first evidences of animal husbandry appear, first, on the northern Levant and, later, in the southern Levant (Horwitz et al. 1999; Peters et al. 1999). There is also an important shift concerning the size and the spatial organisation of sites, with record, for the first time in the Levant, of large sites such as Ain Ghazal, Abu Hureyra or Tell Halula, with a surface of 10 or 12 hectares (Cauvin 1985, 1997; Kuijt 2000b). On the other hand, it is important to note the continuity of burial practices such as the removal and reburial of skulls, of which some of them are plastered and painted, in the southern Levant or the appearance of real "houses of dead" in the northern Levant (Cauvin 1997; Coqueugniot 1998; Ferembach 1970; Ferembach and Lechevallier 1973; Goring-Morris 2000; Özdoğan 2003; Rollefson et al. 1999; Stordeur 2003). These practices have been interpreted as ritual practices associated to the "cult of ancestors" held by the whole community.

Furthermore it has been interpreted as a form of social cohesion among the inhabitants of large PPNB settlements. These settlements are hypothesised to result from population growth associated with full-scale agriculture and animal husbandry in the Levant and the emergence of the first evidence of social inequality (Kuijt 1995, 1996, 2000a).

Finally, the last phase of the neolithisation process in the Near East, known as the Late Neolithic, PPNC (Pre-Pottery Neolithic C) or Pottery Neolithic (PN), is characterised by the prevalence of animal husbandry in the southern Levant and by the appearance in the northern Levant of the first pottery at sites such as Tell Halula, Abu Hureyra, Sabi Abyad, Akarçay Tepe, Çatal Höyük and Çayönü. It is therefore only during this phase that the main economic and social categories that defined the Neolithic (sedentism, agriculture, animal husbandry, pottery and social inequality) are documented throughout the Levantine area of the Near East (Akkermans 1993; Campbell 1992; Le Mière and Picón 1999). It is important to emphasize the continuity of occupation in the Levantine area of the Near East throughout all the historical and chronological phases that characterise the process of neolithisation of this region. This continuity allows us to understand the relationship between population growth and the adoption of agriculture and animal husbandry.

Palaeoanthropological Data and Techniques

Unlike Europe and America, the Levant has only yielded a few cemeteries for hunter-gatherers (Natufian) and farmers (Neolithic, pre-pottery and pottery), and even fewer cemeteries with a sample size of $N \geq 50$. A thorough search in the literature yielded 31 cemeteries altogether (see Table 2 and Fig. 1). The auditing criteria for these 31 sites were the same as previously used (Bocquet-Appel and Naji 2006), plus one new criterion and minus one inapplicable criterion. The earlier criteria included the value for the total estimated excavated size (> 50% of the estimated site), which is too drastic for the Levant. The extra auditing criterion was a significant departure of the demographic indicator $_{15}P_5$ from Hutterite fertility considered as the maximum in controlled human experiments (Bocquet-Appel and Naji 2006: 356). On the whole, 16 points were obtained, with 8 Natufian points and 8 Neolithic points (see Table 3).

Sampling of Natufian sites was another issue to be resolved. In the southern Levant, for example, Natufian sites are primarily in caves, with or without an adjacent occupational terrace. Caves are rarely excavated in their entirety and their terraces even less so. Excavated artefacts are thus almost always merely samples. In order to address these characteristic issues in Levantine sites, the following hypothesis was made for skeleton distributions: because archaeologists have sampled their excavations randomly in relation to the total surface of the site, we can consider excavated skeletons as random distribution samples. Provided there was no mortuary selection among the dead, skeleton samples can be considered as random samples of dead individuals from the relevant meta-population. This is the usual hypothesis and is

Table 2 Identified cemeteries in the Levant

Site	Country	Region	Culture	DateCal BP	N	Sources
El Wad	Israel	Southern Levant	Natufian	13945.0	67.00	Bocquentin (2003)
Erq-el-Ahmar	Israel	Southern Levant	Natufian	13700.0	7.00	Bocquentin (2003)
Et Tin	Israel	Southern Levant	Natufian		5.00	Eshed et alii (2004)
Hayonim (C)	Israel	Southern Levant	Natufian	13980.0	58.00	Bocquentin (2003)
Hayonim (T)	Israel	Southern Levant	Natufian	12310.0	9.00	Bocquentin (2003)
Kébara	Israel	Southern Levant	Natufian	14560.0	47.00	Bocquentin (2003)
Mallaha	Israel	Southern Levant	Natufian	13387.0	108.00	Bocquentin (2003)
Nahal-Oren	Israel	Southern Levant	Natufian	11720.0	44.00	Bocquentin (2003)
Rakefet	Israel	Southern Levant	Natufian	12715.0	5.00	Bocquentin (2003)
Shukbah	Israel	Southern Levant	Natufian	12450.0	6.00	Bocquentin (2003)
Abu Maadi	Egypt	Southern Levant	PPNA	11390.0	1.00	Eshed et alii (2004)
Gilgal I	Israel	Southern Levant	PPNA	11335.0	3.00	Eshed et alii (2004)
Hatoula	Israel	Southern Levant	PPNA	11630.0	10.00	Eshed et alii (2004)
Netiv Hagdud	Israel	Southern Levant	PPNA	11330.0	17.00	Eshed et alii (2004)
Abu Gosh	Israel	Southern Levant	PPNB	9600.0	30.00	Eshed et alii (2004)
Abu Hureyra	Syria	Northern Levant	PPNB	9350.0	168.00	Guerrero 2006; Molleson (2000 a,b,c) Guerrero 2006; Özbek (1998, unpublisdhed data and personal communication)

Table 2 (continued)

Site	Country	Region	Culture	DateCal BP	N	Sources
Asikli	Turkey	Northern Levant	PPNB	9795.0	64.00	
Beisamoun	Israel	Southern Levant	PPNB	9600.0	19.00	Eshed et alii (2004)
Dja'de	Syria	Northern Levant	PPNB	10405.0	69.00	Guerrero (2006); Desmeulles (2001)
Halula	Syria	Northern Levant	PPNB	9390.0	108.00	Guerrero (2006); Anfruns et alii (in press)
Horvat Galil	Israel	Southern Levant	PPNB	10265.0	4.00	Eshed et alii (2004)
Kefar Hahore	Israel	Southern Levant	PPNB	9800.0	49.00	Eshed et alii (2004)
Nahal Hemar	Israel	Southern Levant	PPNB	9465.0	15.00	Eshed et alii (2004)
Nahal Oren	Israel	Southern Levant	PPNB	10100.0	10.00	Eshed et alii (2004)
Wadi Tbeik	Egypt	Southern Levant			2.00	Eshed et alii (2004)
Ujrat El Mehed	Egypt	Southern Levant			17.00	Eshed et alii (2004)
Ramad	Syria	Northern Levant	PPNB	8775.0	56.00	Guerrero 2006; Anfruns and Oms (2006)
Atlit-Yam	Israel	Southern Levant	PPNC	8760.0	50.00	Eshed et alii (2004)
Khirokitia	Cyprus	Northern Levant	PPN	1950.0	248.00	Guerrero 2006; LeMort (1994, 1995, 2000, 2003)
Abu Hureyra	Syria	Northern Levant	PN	8615.0	21.00	Guerrero 2006; Molleson (2000 a,b,c)
Çatal Höyük	Turkey	Northern Levant	PN	8750.0	92.00	Guerrero 2006; Molleson and Andrews (1996, 1997); Molleson et alii (1998, 1999, 2005)

Fig. 1 Geographical distribution of the cemetery samples

Table 3 Selected forager and horticulturist-farmer cemeteries

Site	Sources	Date cal BP			Number of Skeletons				
		Site	Front	*d*t	0–4 yr	5–19 yr	20+ yr	Total	5–19/5+
Abu Hureyra	Guerrero 2006; Molleson (2000 a,b,c)	9350	11450	2100	37.8	41.0	89.8	168.0	0.31490
Abu Hureyra	Guerrero 2006; Molleson (2000 a,b,c)	8615	11450	2835	6.92	5	9	21	0.355114
Asikli	Guerrero 2006; Özbek (1998 & unpublished data, personal communication)	9795	10490	695	17.0	10.0	37.0	64.0	0.21277
Çatal Höyük	Guerrero 2006; Molleson and Andrews (1996, 1997); Molleson et alii (1998, 1999, 2005)	8750	10490	1740	42.0	23.0	30.0	92.0	0.46000
Dja'de	Guerrero 2006; Desmeulles (2001)	10405	11450	1045	16.7	25.0	28.0	69.0	0.47801
El Wad	Bocquentin (2003)	14260	11520	−2740	9.0	15.0	43.0	67.0	0.25862
Hayonim C	Bocquentin (2003)	13980	11520	−2460	10.2	19.0	28.0	58.0	0.39749
Hayonim T	Bocquentin (2003)	12310	11520	−790	0.6	1.0	7.0	9.0	0.11905
Kébara	Bocquentin (2003)	14560	11520	−3040	6.6	11.0	30.0	47.0	0.27228

Table 3 (continued)

Site	Sources	Date cal BP			Number of Skeletons				
		Site	Front	*dt*	0–4 yr	5–19 yr	20+ yr	Total	5–19/5+
Kefar Hahore	Eshed et alii (2004)	9800	11520	1720	11.0	8.0	30.0	52.0	0.19512
Mallaha	Bocquentin (2003)	13387	11520	−1867	18.2	23.8	66.0	108.0	0.26503
Nahal Oren	Bocquentin (2003)	11700	11520	−180	8.5	4.5	31.0	44	0.10227
Rakefet	Bocquentin (2003)	12385	11520	−865	1.0	2.0	2.0	5.0	0.50000
Ramad	Guerrero (2006); Anfruns and Oms (2006)	8775	11520	2745	9.4	22.0	26.0	56.0	0.47210
Shukbah	Bocquentin (2003)	13100	11570	−1530	0.0	2.0	4.0	6.0	0.33333
Tell Halula	Guerrero (2006); Anfruns et alii (in press)	9390	11450	2060	37.4	29.0	42.0	108.0	0.41076

reinforced by the detection of the global signal of the NDT. This hypothesis allowed us to aggregate small skeleton samples from these excavations.

In a sample of size N, random fluctuations decrease proportionally to $\sqrt{N}$. Consequently, in small samples, we have to expect wide variations in the age distribution even if the underlying distribution of the mother population is demographic. We believe that interpreting these variations as ethnographic biases, to the detriment or in favour of selecting such and such age distributions, is theoretically incorrect. For example, at the Hatoula site, only 10 individuals were uncovered, including only one sub-adult (> 20 years of age). Were sub-adults selected through specific funerary practices and placed elsewhere or is this a sample of a pre-industrial population that is random but dependent on size? Assuming a theoretical demographic population of immature individuals aged 5–19 years, relative to the 5+ -year-old stationary pre-industrial population, represented by 45 life tables (Bocquet-Appel 2002), the null hypothesis of the difference between the observed proportion ${}_{15}P_5$ in the cemetery (1/10) and the theoretical demographic proportion (0.173) is accepted ($P = 0.7053$; exact test of equal frequencies). The simplest interpretation of this distribution is therefore not a selection of immature individuals for specific funerals, but the impact of random sampling fluctuations.

The data are represented by the demographic indicator ${}_{15}P_5$, which is the proportion of immature skeletons aged 5–19 years (d(5–19)), relative to the total population of the cemetery, minus children under 5 years of age, d(5+), that is ${}_{15}P_5 = d(5\text{–}19)/d(5+)$ (Bocquet-Appel 2002). The average date for each site is calibrated BP for the northern part of the Levant (which includes Turkey and northern Syria), ^{14}C calibrated dates were gathered from the published CANEW database web page (Central Anatolian Neolithic e-Workshop, Thissen 2006). For the southern Levant (southern Syria and Israel), the ^{14}C dates used here were compiled from the "Near Eastern radiocarbon context database" from Köln University (Germany) (Bischof 2006; Böhner and Schyle 2006; Thissen 2006). The data were set in the framework of a relative chronology (dt) so that we could make worldwide comparisons which are simply impossible with absolute chronology. But in the context of the Levant, the chronological framework could have been the traditional absolute (historical) chronology considering the relatively low space–time dispersion of the data (for a detailed explanation on relative chronology, see Bocquet-Appel 2002; Bocquet-Appel and Naji 2006). The date for the Neolithic front was the local one when available and the regional date otherwise. At the regional level, for the entire south-eastern Levant, we used three different dates for the Neolithic front for the lowest strata of the sites analysed: the first date is for the central Anatolian region (10490 cal BP), where the oldest evidence of the first farming society was found on the archaeological site of Pinarbaşi A; the second date is for northern Syria, more specifically the region of the middle Euphrates valley, where the estimate for the Neolithic front was calculated from the average date of the Mureybet and Jerf el-Ahmar sites (11450 cal BP). The third date is for the southern Levant region, which was treated as a single group and was estimated at 11520 cal BP from the average dates of the Jericó, Gilgal, Netiv Hagdud, Hatoula and Dhra' sites (Aurenche & Kozlowski 2003; Bar-Yosef 1998b, 2001; Bischof 2006; Böhner and Schyle 2006;

Cauvin 1997; Özdoğan and Başgelen 1999; Thissen 2006). Finally, for south-eastern Turkey, evidence of the oldest traces of an early farming society is documented at the archaeological sites of Çayönü (11670 cal BP) (Aurenche & Kozlowski 2003; Bischof 2006; Cauvin 1997; Özdoğan and Başgelen 1999).

Detecting the Signal of the NDT

The profile of ${}_{15}P_5$ variation over dt was obtained using the Loess fitting procedure (Bocquet-Appel 2002) (Fig. 2), but weighting the data points by the inverse of the binomial variance of ${}_{15}P_5$ (see Kohler and Glaude, this volume). This weighting is proportional to the quantity of information provided by a point in the fit. This makes it possible to keep the cemeteries such as they are numerically, without the need for regrouping. At $d\mathrm{t} = -800$, the curve passes under the level ${}_{15}P_5$ ($\times 100$) of a stationary population to reach a low point of a frankly decreasing population ${}_{15}P_5$ ($\times 100$) $= 13\%$ at $d\mathrm{t} = -500$. At the onset of the new farming economy ($d\mathrm{t} = 0$), the curve again goes above the level ${}_{15}P_5$ ($\times 100$) corresponding to a stationary growth rate, then increases continuously until reaching 40% (a 135% increase) over 2300 years.

The profile of ${}_{15}P_5$ indicates that during the final phase of the Natufian, the population was subject to demographic stress. We can hypothesise that the cause of this stress should be sought in the demographic saturation of the Natufian system in a context of scarcer local resources. This period of stress is confirmed by the decrease in sexual dimorphism (Belfer-Cohen et al. 1991). In order to reduce the pressure on resources, which would worsen with the deteriorating climate linked with the Younger Dryas, Natufians increased their mobility and became more widely spread, causing a decrease in population density in the same region (Belfer-Cohen and Bar-Yosef 2000; Munro 2004). This coincides with a decrease in the birth rate (Fig. 2). With the change in the economic system, farming practices and animal husbandry gradually replaced hunting as a subsistence strategy. The consequence is a gradual decrease in overall mobility, especially logistic mobility for local hunting. This underlying decrease in mobility is probably the cause of the steady increase in the birth rate. From the palaeodemographic estimators, estimates of birth rate, growth rate and the average number of children per woman can be obtained. However, we must remember that these estimates represent the same information as ${}_{15}P_5$ up to a constant. The different values obtained for a specific dt cannot be manipulated among themselves. These estimates (Table 4) have been computed for the Natufian group with a birth rate $b = 40.0$‰ (PI 95% = 27.4–52.5) and a growth rate $r = 0.41\%$ (PI 95% = −0.1 to 2.0) and a TFR = 5.4 (PI 95% = 4.5–6.3); for the Neolithic group $b = 66.3$‰ (PI 95% = 53.6–79), $r = 2.4\%$ (PI 95% = 0.9–3.9) and TFR = 9.7 (PI 95% = 8.4–10.9). The intervals are large because they include ${}_{15}P_5$ binomial variability as well as the standard error of the estimator. The values for these parameters are very high, which is typical of a very young population, but not exceptional compared to the contemporary values. For the Natufian, the estimation

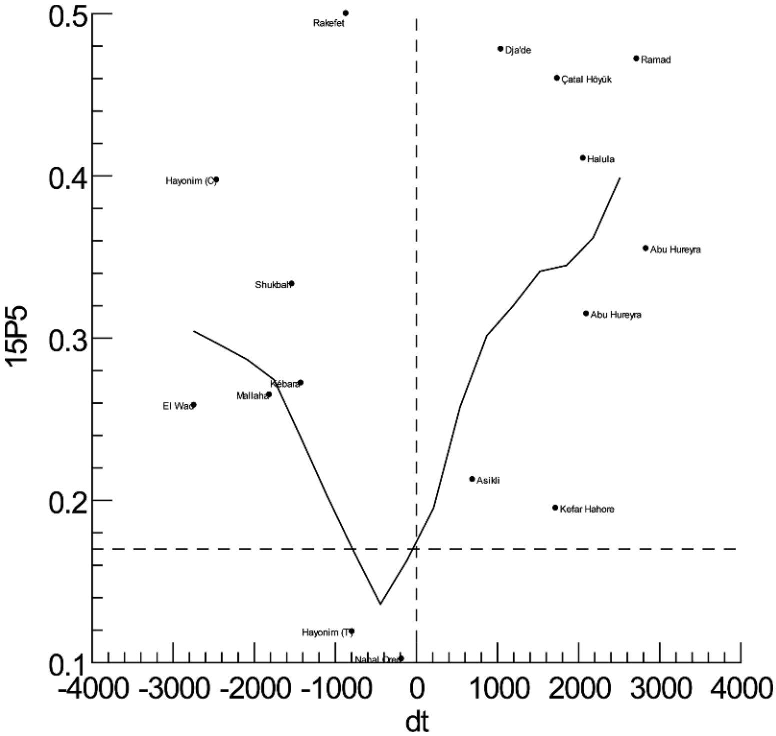

Fig. 2 Observed profile of ${}_{15}P_5$ in 16 Levantine cemeteries (*vertical axis*) with chronological distance from the economic shift front from foraging to horticulture farming (*horizontal axis*) obtained with the Loess fitting procedure (*continuous line*; $\alpha = 0.5$). The horizontal *dotted line* ($y = 0.173$) represents the expectation for ${}_{15}P_5$ with the zero growth-rate hypothesis given by the estimators: inverse regression of $r = f({}_{15}P_5)$

for r includes the stationary hypothesis, whereas for the Neolithic, this hypothesis is rejected and the estimator indicates a growing meta-population. Particular attention is given to the fact that the average number of children per woman is 5.4 for the Natufian group but almost double, at 9.7, for the Neolithic group. Overall, these estimates are very high even if we take the lower values of the 2σ prediction intervals. The values for birth rate or fertility given by the estimators are possible. The picture given by the 16 cemetery samples is of sharply pointed age pyramids, which are typical of young, rapidly growing populations. The values for growth rates are problematic, however, since they are impossible for the corresponding Mesolithic-Neolithic time spans.

Several explanations can be put forward to account for these systematically high growth-rate values. (i) The pre-industrial model for the estimator is inadequate. The transitional demographic regimes of the Natufian population and the subsequent Neolithic population do not correspond exactly to the pre-industrial population model, as formalised in the palaeodemographic estimators. (ii) Episodic

Table 4 Birth rate (b), growth rate (r) and TFR estimates for weighted average of "Natufian" and "Neolithic" groups with 2σ prediction confidence limit

	Natufian	Neolithic
dt	−2032	1862
N5–19	78.30	176
N5+	394.90	481.70
${}_{15}P_5$	0.19828	0.36537
−2σ	0.15815	0.32149
+2σ	0.23841	0.40925
b	40.04‰	66.29‰
−2σ	27.43	53.57
+2σ	52.49	78.96
r	0.41%	2.37%
−2σ	−0.12	0.86
+2σ	1.99	3.86
TFR	5.36	9.66
−2σ	4.46	8.43
+2σ	6.32	10.95

demographic collapse periodically did occur, but the corresponding cemeteries, if any, do not show up.

Covariation of Archaeological Data with the Demographic Profile

How do other archaeological profiles vary relative to the profile observed for the demographic change represented by ${}_{15}P_5$? The profile for the total area estimated for each site (Table 5 and Fig. 3), and the profile for the frequency of gazelle remains relative to the total number of fauna remains, set in the relative chronology (Table 6 and Fig. 4), show the same trend. Regarding the area covered by sites, assuming an approximately linear relationship between demographic density and archaeological density (Bocquet-Appel et Dubouloz 2004), the increase in site size, and therefore in demographic density, coincides exactly with the transition (dt = 0) and the continuous intensification, over 3000 years, of the new farm production system. Regarding the profile for the frequency of gazelle meat in the hunted meat diet, why does this vary in parallel with the increase in birth rate? The link between these two indicators is to be sought in population mobility. It indicates the residual impact of forager mobility in the developing farmer system. On the one hand, foragers depending mainly on gazelle for meat had important logistic mobility whose effect is to limit fertility. On the other hand, farmers with a reduced logistic mobility, which is assumed to raise fertility (Bocquet-Appel 2007, this volume), would only hunt gazelle as a dietary supplement. We should therefore expect a negative correlation between a high birth rate and a low rate of gazelle hunting, and vice versa.

Even though Natufian populations are described as sedentary, their subsistence strategy was nonetheless based on hunting (mainly gazelle) and foraging, which

Table 5 Estimated archaeological site sizes in hectares

Site	Area	Chronology	Front	*dt*	Period	Sources
Beidha	0.3	14652	11520	−3132	Natufian	Aurenche & Kozlowski (2003)
Kébara	0.05	14560	11520	−3040	Natufian	Bocquentin (2003)
Hayonim (C)	0.03	13980	11520	−2460	Natufian	Bocquentin (2003)
El Wad	0.08	13945	11520	−2425	Natufian	Bocquentin (2003)
Erq-el-Ahmar	0.02	13700	11520	−2180	Natufian	Bocquentin (2003)
Mallaha	0.2	13387	11520	−1867	Natufian	Bocquentin (2003); Kuijt (2000)
Shukbah	0.2	12450	11532	−918	Natufian	Bocquentin (2003); Kuijt (2000)
Hayonim (T)	0.08	12310	11520	−790	Natufian	Bocquentin (2003)
Nahal-Oren	0.2	11720	11532	−188	Natufian	Bocquentin (2003); Kuijt (2000)
Dhra'	0.45	11670	11520	−150	PPNA	Kuijt (2000)
Hatoula	0.25	11630	11520	−110	PPNA	Lechevallier et al. (1989)
Gesher	0.1	11630	11520	−110	PPNA	Kuijt (1994)
Iraq ed-Dubb	0.02	11540	11520	−20	PPNA	Kuijt (1994)
Abu Maadi	0.01	11440	11520	80	PPNA	Kuijt (1994)
Gilgal I	1	11335	11520	185	PPNA	Kuijt (2000)
Netiv Hagdud	1.5	11330	11520	190	PPNA	Kuijt (2000)
Jericó	2.5	11140	11520	380	PPNA	Kuijt (2000)
Nevali Çori	4	10409	11670	1261	EPPNB	Aurenche & Kozlowski (2003)
Dja'de	2	10405	11450	1045	PPNB	Coqueugniot (1998)
Tell Aswad	4	10340	11520	1180	PPNB	Kuijt (2000)
Nahal Oren	0.2	10100	11532	1432	PPNB	Bocquentin (2003); Kuijt (2000)
Yiftahel	1.5	9836	11520	1684	PPNB	Kuijt (2000)
Nevali Çori	4	9801	11670	1869	MPPNB	Aurenche & Kozlowski (2003)

Table 5 (continued)

Site	Area	Chronology	Front	*dt*	Period	Sources
Kefar Hahoresh	0.5	9800	11485	1685	PPNB	Kuijt (2000)
Asikli	3.7	9795	10490	695	PPNB	Esin & Harmankaya (1999)
Abu Hureyra	16	9750	11450	1700	MPPNB	Moore et al. (2000)
Ain Ghazal	4.5	9620	11520	1900	PPNB	Aurenche & Kozlowski (2003); Kuijt (2000)
Abu Gosh	0.2	9600	11520	1920	PPNB	Aurenche & Kozlowski (2003)
Beisamoun	10	9600	11520	1920	PPNB	Kuijt (2000)
Nahal Hemar	0.003	9465	11520	2055	PPNB	Aurenche & Kozlowski (2003)
Halula	8	9390	11450	2060	PPNB	Molist (1996)
Basta	14	9124	11520	2396	PPNB	Aurenche & Kozlowski (2003); Kuijt (2000)
Abu Hureyra	16	9050	11450	2400	LPPNB	Moore et al. (2000)
Ramad	2.7	8875	11520	2645	PPNB	Aurenche & Kozlowski (2003); Kuijt (2000)
Atlit-Yam	6	8760	11520	2760	PPNC	Galili et al. (1993)
Çatal Höyük	14	8750	10490	1740	PN	Hodder (2005)
Abu Hureyra	7	8615	11450	2835	PN	Moore et al. (2000)
Ain Ghazal	12	8178	11520	3342	PPNC	Kuijt (2000)

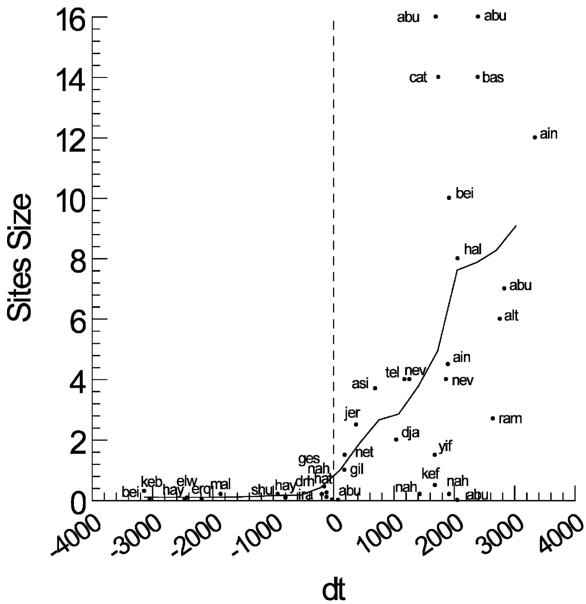

Fig. 3 Profile of archaeological site areas (in hectares) with the chronological distance from the front of the economic shift from foraging to horticulture farming (*horizontal axis*) obtained with the Loess fitting procedure (*continuous line*; $\alpha = 0.4$)

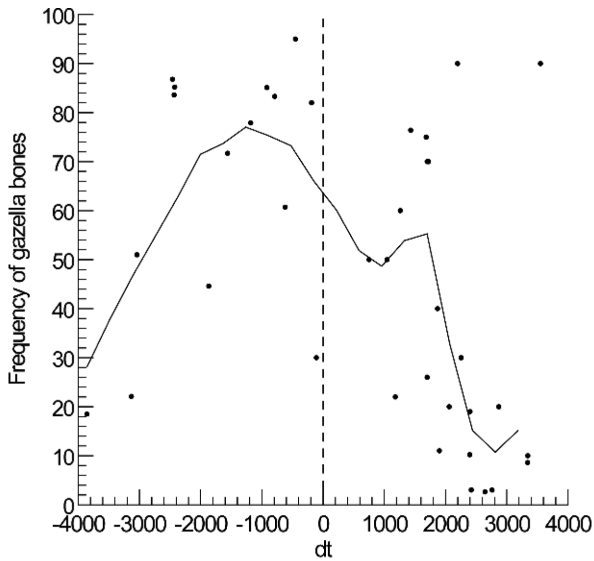

Fig. 4 Frequency of gazelle bones relative to the total number of animal bones in archaeological sites, with the chronological distance from the front of the economic shift from foraging to horticulture farming (*horizontal axis*) obtained with the Loess fitting procedure (*continuous line*; $\alpha = 0.4$)

Table 6 Frequencies of gazelle bones relative to the total number of animal bones in a site

SITE	% Gazelle	Chronology	Front	*dt*	Period	Sources
Wadi Judayid	18.5	15377	11520	−3857	Natufian	Byrd (1989)
Beidha	22.1	14652	11520	−3132	Natufian	Byrd (1989)
Kébara	50.7	14560	11520	−3040	Natufian	Byrd (1989)
Hayonim (C)	86.8	13980	11520	−2460	Natufian	Byrd (1989)
Wadi Hammeh 27	83.6	13954	11520	−2434	Natufian	Byrd (1989)
El Wad	85.2	13945	11520	−2425	Natufian	Byrd (1989)
Mallaha	44.6	13387	11520	−1867	Natufian	Byrd (1989)
Abu Hureyra	71.7	13010	11450	−1560	Natufian	Byrd (1989)
Rakefet	77.9	12715	11532	−1183	Natufian	Byrd (1989)
Shukbah	85.1	12450	11532	−918	Natufian	Byrd (1989)
Hayonim (T)	83.3	12310	11520	−790	Natufian	Byrd (1989)
Rosh Horesha	60.7	12140	11520	−620	Natufian	Byrd (1989)
Nahal Ein Geiv	95	11972	11520	−452	Late Natufian/PPNA	Davis (2005)
Nahal-Oren	82	11720	11532	−188	Natufian	Byrd (1989)
Hatoula	26.8	11630	11520	−110	PPNA	Davis (2005)
Göbekli Tepe	50	10919	11670	751	PPNA	Peters et al. (1999)
Nevali Çori	60	10409	11670	1261	EPPNB	Peters et al. (1999)
Dja’de	50	10405	11450	1045	PPNB	Coqueugniot (1998)
Tell Aswad	22	10340	11520	1180	PPNB	Ducos (1993)
Nahal Oren	76.4	10100	11532	1432	PPNB	Horwitz et al. (1999)
Yiftahel	75	9836	11520	1684	PPNB	Horwitz et al. (1999)
Ghoraifé I	26	9820	11520	1700	PPNB	Ducos (1993)

Table 6 (continued)

SITE	% Gazelle	Chronology	Front	*dt*	Period	Sources
Nevali Çori	40	9801	11670	1869	MPPNB	Peters et al. (1999)
Kefar Hahoresh	75	9800	11485	1685	PPNB	Horwitz et al. (1999)
Wadi Jilat	70	9800	11520	1720	MPPNB	Martin (1999)
Abu Hureyra	70	9750	11450	1700	MPPNB	Peters et al. (1999)
Ain Ghazal	11	9620	11520	1900	PPNB	Khöller-Rollefson et al. (1993)
Halula	20	9390	11450	2060	PPNB	Saña (1999)
Dhuweila	90	9323	11520	2197	LPPNB	Martin (1999)
Azraq 31	30	9266	11520	2254	PPNC	Martin (1999)
Gürcütepe	3	9250	11670	2420	PPNB	Saña (pers. communication)
Basta	10.2	9124	11520	2396	PPNB	Becker (1991)
Abu Hureyra	19	9050	11450	2400	LPPNB	Peters et al. (1999)
Ramad	2.63	8875	11520	2645	PPNB	Ducos (1993)
Atlit-Yam	3	8760	11520	2760	PPNC	Galili et al. (1993)
Wadi Jilat	20	8650	11520	2870	PPNC	Martin (1999)
Ain Ghazal	8.6	8178	11520	3342	PPNC	Khöller-Rollefson et al. (1993)
Burqu' 27	10	8176	11520	3344	LN	Martin (1999)
Dhuweila	90	7969	11520	3551	LN	Martin (1999)

would involve a certain degree of logistic mobility. It has been suggested from excavations conducted on the Salibiya I site (Crabtree and Campana 1990; Crabtree et al. 1991), as well as from ethnographic examples (Anell 1969; Campana and Crabtree 1990; Driver 1990; Holliday 1998; Lupo and Schmitt 2002; Satterthwait 1987), that the gazelle was probably hunted communally, using techniques such as fire, traps and nets. These techniques required collaboration between large groups and even the whole community. This communal hunting method may have even required the participation of women, children and elders to help round up or channel gazelle herds (Campana and Crabtree 1990; Lee 1979; Lupo and Schmitt 2002; Noss and Hewlett 2001). Looking at percentages of hunted gazelle, three phases appear to substantiate this hypothesis: in the first, from $d\text{t} = -4000$ to $d\text{t} = -1200$, there is a steady increase in gazelle remains, from 30% to almost 80%. At this point, the frequency decreases until $d\text{t} = 1000$, when the percentage stabilises at around 50% over a period of roughly 600 years. Finally, at $d\text{t} = 1600$, the curve drops sharply until $d\text{t} = 2800$, when the percentage reaches its lowest point at around 10%. However, this hypothesis is disputed, since it has also been suggested that communal hunting occurred on a small scale at best. Another accepted model for Natufian populations is cooperative hunting involving small groups of hunters and small numbers of animals. Some Natufian hunting thus occurred through small-scale cooperative efforts in a single community, with no real evidence being found for large-scale mass kills in the southern Levant (Munro 2004).

Concluding Remarks

The data from the Levant reinforces the prediction that if a NDT occurred in Europe and North Africa and in North America, it should also have occurred in all the centres of farming invention across the world. The same is true for the hypothesis of a slower tempo of change in the epicentres than in the secondary transition zones. Levantine cemeteries reveal an increase in immature skeletons as high as in the rest of Europe but over a period of more than 2000 years, which is three times as long as the 600–800 years found in Europe. This much slower tempo of the NDT is confirmed by archaeological data that show a large and gradual increase in the size of sites as well as a gradual decrease in gazelle remains over a similar length of time. However, the late Neolithic sites (PPNC and PN) still need to be integrated to complete the whole picture of the NDT and its tempo in the Levant.

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The Nature and Timing of the Neolithic Demographic Transition in the North American Southwest

Timothy A. Kohler and Matt Glaude

Abstract Maize agriculture was practiced in the US Southwest slightly before 2000 BC, but had a negligible impact on population growth rates until it was coupled with other innovations in subsistence and social practice. These include the development or introduction of more productive landraces; the ability to successfully cultivate maize under a greater variety of conditions, with dry farming especially important; the addition of beans, squash, and eventually turkey to the diet; and what we infer to be the remapping of exchange networks and the development of efficient exchange strategies in first-millennium-AD villages. Our tabulations of the P(5–19) proportion emphasize the heartlands of the Chaco and Mesa Verde Anasazi (prehispanic Pueblo) populations. We find that this measure is somewhat affected by warfare in our region. Nevertheless, there is a strong identifiable Neolithic Demographic Transition signal in the US Southwest in the mid-first-millennium AD in most subregions, visible a few hundred years after the introduction of well-fired ceramic containers, and more or less contemporaneous with the first appearance of villages.

Keywords Maize · North American Southwest · ceramic containers · demography

Background Considerations: Early Maize in the US Southwest

Following its domestication in southern Mexico more than 6300 years ago, maize arrived in the southern portions of the US Southwest slightly before 2000 BC[1] (Diehl and Waters 2006; Huber 2005; Huckell 2006). The earliest presently known maize sites in the American Southwest (Fig. 1) do not form a strong south-to-north chronological gradient (Blake 2006; Huber 2005: Fig. 36.11; Smiley 1994), since maize appears to have reached northeastern Arizona by 1940 BC (Smiley 1994), which is almost as early as the southern Arizona dates. More lag can be seen in its subsequent east–west spread—for example, it reached the Northern Rio Grande in

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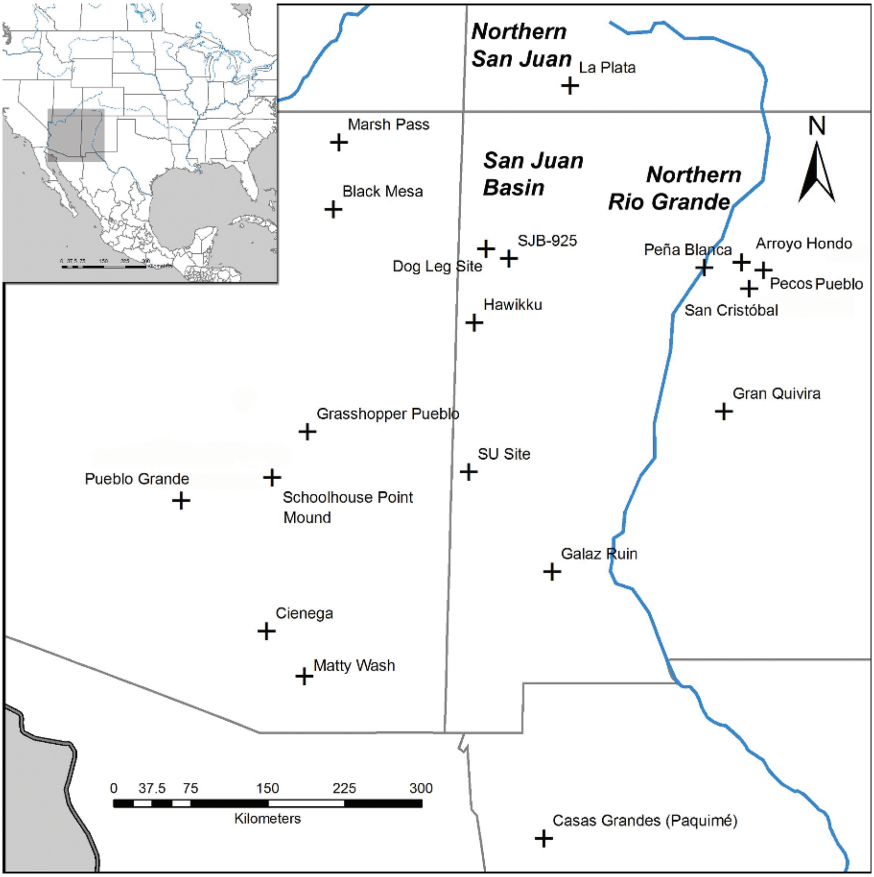

Fig. 1 Location of study area and some of the key sites used in the analysis

New Mexico by about 1200 BC (Vierra and Ford 2006:505)—and in its later spread into the northern reaches of the Colorado Plateau in Utah, around AD 600 (Barlow 2006) (Fig. 2). While the core cultigens of the Mesoamerican agricultural adaptation also included beans and squash, their entrance into the Southwest was later and less distinct. Macrobotanical evidence for these plants is much less abundant than is the evidence for maize throughout southwestern prehistory, and the first occurrences of each are generally in the first millennium BC (Smith 2001).

So familiar is the concept of the Neolithic wave-of-advance defined for Europe by Ammerman and Cavalli-Sforza (1973) that archaeologists tend to assume that the model will work elsewhere. But in Europe, a highly productive package of domesticates, including animals, and ceramic vessels for cooking and storage, was “assembled” early and was then able to spread very rapidly from east to west through zones of relatively similar climate and biota. From its probable homeland in the tropical deciduous forests or thorn forests of the Balsas depression to the US Southwest,

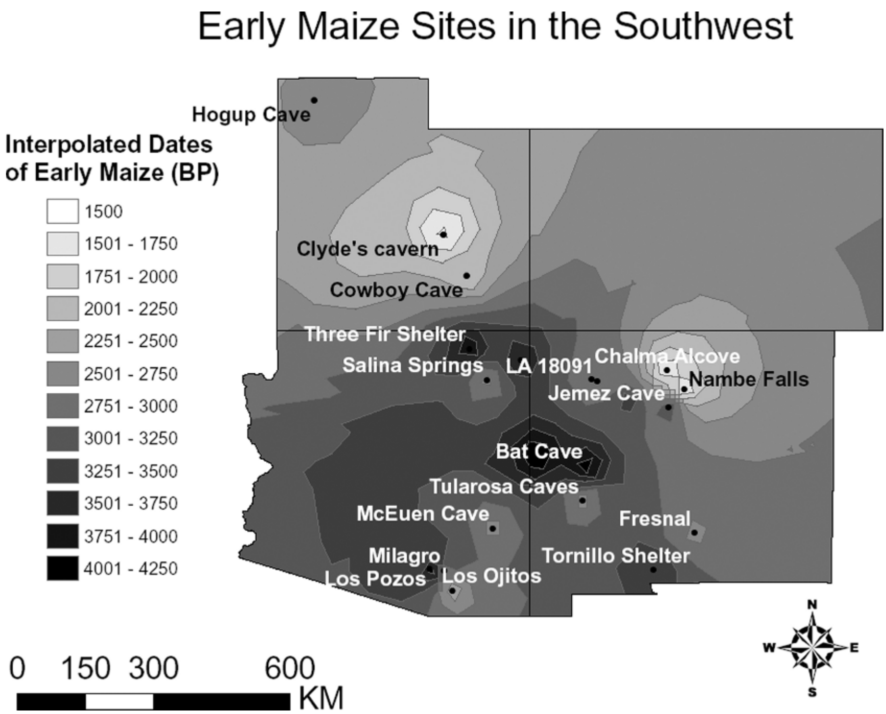

Fig. 2 Interpolated dates for earliest maize in the US Southwest

by contrast, the spread of maize was largely south to north, demanding selection for domesticates capable of thriving under novel combinations of heat units, day lengths, and precipitation regimes (Adams et al. 2006).

The spread of maize was accompanied and to some extent made possible by the development of novel cultivation strategies. Early maize husbandry apparently emphasized water-table farming and overbank flood farming. The Southwest is famous for its aridity, and in many areas, irrigation is either helpful or essential to maize production, yet the earliest irrigation in the Southwest follows the first appearance of maize by some 500–1,000 years (Doolittle and Mabry 2006). Dry farming—essential to opening up large and highly productive mesa tops in the northern Southwest—was added last of all, ca. AD 300 (Doolittle and Mabry 2006; Kohler 1993).

Except in the northern-most portions of the Southwest a considerable lag exists between the first appearance of maize and the development of well-fired ceramic vessels, which regionally varies between about AD 1 and 500. Moreover, South-western domesticated animals (dog and turkey) never rivaled in dietary contribution the ovicaprids, cattle, and pigs that yielded so much protein to European Neolithic diets. Turkey, which has greater dietary importance, is relatively uncommon before the AD 1100s in many portions of the Southwest.

Finally, recent research has helped to trace changes in the nutritional value of maize, which has important implications for its role in prehistoric diets (Benz 2006; Iltis 2006). Although it is not currently possible to accurately assess the yield of Early Agricultural period (roughly, the last two millennia BC) maize, it does not seem to have been particularly productive. Morphological observations underscore its very small size, with cupule size increasing very slowly through the 2000-year Early Agricultural period and then more rapidly in the first millennium AD (Diehl 2005). Adams (1994: Table 16.9; Huckell 2006) recounts the prehistory of maize landraces in the Southwest as it is currently understood, demonstrating important additions to the maize repertoire at ca. 100 BC, AD 500, and AD 1000. In short, the inhabitants of the ancient US Southwest spent some 3000 years assembling their Neolithic package; it was not given to them at the outset. Considering this history, it is highly uncertain whether a specific threshold that resembles the Neolithic Demographic Transition (NDT) identified in Europe by Bocquet-Appel (2002) can be identified in the human remains of the Southwest.

Indeed, the relative dietary and social importance of maize cultivation during the Early Agricultural period has been debated for some time. A series of recent discoveries at sites in the Tucson Basin such as Milagro (Huckell et al. 1995; ca. 1100–800 BC), Santa Cruz Bend (Mabry 1998; ca. 800–100 BC), and Las Capas (Mabry 1999; ca. 800–400 BC) showed use of irrigation canals at Las Capas and an extensive distribution of 730 features covering a total over 1.2 hectares of excavations at Santa Cruz Bend, which is thought to represent only 15 percent of the total site (Bellwood 2005:172). These Early Agricultural period sites are near streams and contain pit structures, probable storage pits, and large quantities of maize. The presence of multiseasonal residences is suggested, as is a reliance on storage for winter months.

Nevertheless, the extent to which the use of maize affected other aspects of those societies adapting it during the Early Agricultural period remains an open question. In part, this reflects a lack of consensus within the literature as to how productive early maize was, as well as how dependent early populations were on agriculture. Some researchers (e.g., Huckell 1995:127–133) argue that such usage was relatively intensive and precipitated significant increases in sedentism. A program of fluoride dating on one of the latest of these sites, Los Pozos, however, suggests that what looks like a large settlement with many contemporaneous households, from the perspective of the chronological resolution available from ^{14}C dating, is more likely a series of small settlements occupying a favored locale over several centuries (Schurr and Gregory 2002). Based on decreases in diet breadth from ca. 1200 BC to the local onset of the Early Ceramic period ca. AD 150 in southern Arizona, Diehl and Waters (2006) have argued that floodplain agriculture markedly intensified early in the first millennium AD with the appearance of high-quality ceramic containers that may have significantly reduced maize seed storage losses.

Further north, on the Rainbow Plateau in northeastern Arizona and in Grand Gulch, Utah, the earliest evidence of intensive agriculture dates from approximately 300 BC (Geib and Spurr 2002), though the use of domesticates is considered common by ca. 600 BC on neighboring Black Mesa, Arizona (Gumerman and Dean

1989:111). Both of these dates lag first appearance of maize in northeastern Arizona by well over a 1000 years. In these Pueblo areas of the Southwest, as well as adjacent portions of the Mogollon region to the south, large pithouse villages appeared only around the middle of the first millennium AD (Kohler 1993; Wills 1991, 1995), although fairly intensive use of maize seems to be indicated by stable isotope analyses of (preceramic) Basketmaker II human remains and analysis of pollen and macrofossil concentrations in rockshelter middens and coprolites in SE Utah by ca. AD 1 (Matson and Chisholm 1991), now pushed back to ca. 400 BC for adjacent portions of NE Arizona by a comprehensive program of radio- and stable-isotope analysis of Basketmaker II human remains (Coltrain et al. 2007).

In overview, although we know much more now than we did 20 years ago about the time of arrival of maize in most areas of the Southwest, much about the importance and impact of preceramic maize cultivation in the US Southwest remains contested. In this chapter, we hope to further understand the processes by which farming becomes central to lifeways in the US Southwest by answering the following questions:

- Was there an NDT in this region that can be recognized with existing data?
- If so, does it coincide with the earliest appearance of Mesoamerican domesticates, or was it triggered only by later, presumably more intensive use—and if so, when?
- If a regional NDT exists, does it differ from that suggested for Europe by Bocquet-Appel (2002)? In what ways, and why?

Investigating the NDT in the US Southwest

NDT theory predicts a relatively abrupt increase in the proportions of immature (aged 5–19) individuals for some 500–700 years following the local onset of the Neolithic. The increase is thought to reflect an increase in crude birth rate, perhaps because of decreased birth spacing accompanying sedentism (Bocquet-Appel and Naji 2006:349). This is eventually offset by an increase in mortality due, Bocquet-Appel and Naji (2006:349) suggest, to the emergence of new pathogens, especially zoonoses, with aggregation.

Data Collection and Methods

To determine whether an NDT exists in the US Southwest, we have compiled data for as many relatively large, well-dated assemblages of human remains as we could find. We began from compilations by Kramer (2002) and Bocquet-Appel and Naji (2006:349).[2] To these we added the other assemblages in Tables 1 and 2. Our sample is not comprehensive, though it is more complete for the eastern Pueblo areas (central and northern New Mexico and Southwest Colorado) than for the remainder of the Southwest. We follow Bocquet-Appel's (2002; see especially online

Table 1 Sites used in analysis of Southwestern demographic data

Area/Site	Subregion	Calibrated Dates AD					Demographic Data		Sources
		Site date	Early Maize	Effective use of Maize	dt Early Maize	dt Effective Maize	n(5+)	P(5–19)	
Hohokam Area									
Cienega[a]	Tucson Basin	−125	−2000	150	1875	−275	55	0.236	Mabry 1998: Table 16.2
Matty Wash[a]	Tucson Basin	−443	−2000	150	1557	−593	15	0.133	Huckell 1995: Table 3.5
Pueblo Grande – Early Classic	Phoenix Basin	1212.5	−2000	150	3212.5	1062.5	88.67	0.222	Sheridan, in Mitchell and Brunson-Hadley 2001
Pueblo Grande – Late Classic	Phoenix Basin	1362.5	−2000	150	3362.5	1212.5	61.33	0.217	Sheridan, in Mitchell and Brunson-Hadley 2001
Mogollon Area									
Casas Grandes	Chihuahua	1300	−2000	1	3300	1299	550.8	0.4	Bocquet-Appel & Naji 2006:243
Galaz Ruin – Late Pithouse[a]	Mimbres	775	−2000	1	2775	774	64.75	0.377	Anyon & Leblanc 1984
Galaz Ruin – Classic Mimbres[a]	Mimbres	1075	−2000	1	3075	1074	540.75	0.299	Anyon & Leblanc 1984
Grasshopper Pueblo	Cibecue	1337.5	−2000	1	3337.5	1336.5	279	0.323	Bocquet-Appel & Naji 2006:243
SU	Cibola	500	−2000	1	2500	499	27	0.111	Buron & Grauer 2002: Table 1
Pueblo Area									
Arroyo Hondo*	Northern Rio Grande	1362.5	−1250	300	2612.5	1062.5	59	0.305	Bocquet-Appel & Naji 2006:243

Black Mesa – Early Pueblo[a]	Kayenta	925	–1900	600	2825	325	35.43	0.294	Martin et al. 1991: Table 2-11
Black Mesa – Late Pueblo[a]	Kayenta	1100	–1900	600	3000	500	79	0.291	Martin et al. 1991: Table 2-11
Gran Quivira – Early Phase	Northern Rio Grande	1375.5	–1250	300	2625.5	1075.5	22	0.136	Hayes 1981
Gran Quivira – Middle Phase	Northern Rio Grande	1475	–1250	300	2725	1175	49.7	0.264	Hayes 1981
Gran Quivira – Late Phase	Northern Rio Grande	1611	–1250	300	2861	1311	62	0.166	Hayes 1981
Hawikku LA37	Zuni	1562.5	–2000	300	3562.5	1262.5	147	0.299	Bocquet-Appel & Naji 2006:243, Stodder 1994
La Plata[a]	La Plata	1100	–400	500	1500	600	41	0.268	Martin and Akins 2001
Marsh Pass[a]	Kayenta	–233	–1900	600	1667	–833	21.00	0.125	Coltrain et al. 2007: Table 1
NRG – 1150[a]	Northern Rio Grande	1150	–1250	300	2400	850	17.96	0.122	Kramer 2002: Appendix D
NRG – 1250[a]	Northern Rio Grande	1250	–1250	300	2500	950	17.02	0.142	Kramer 2002: Appendix D
NSJ – 850[a]	Northern San Juan	850	–400	300	1250	550	86.14	0.241	Kramer 2002: Appendix D

Table 1 (continued)

Area/Site	Subregion	Calibrated Dates AD					Demographic Data		Sources
		Site date	Early Maize	Effective use of Maize	dt Early Maize	dt Effective Maize	n(5+)	P(5–19)[b]	
NSJ – 950[a]	Northern San Juan	950	−400	300	1350	650	20.4	0.167	Kramer 2002: Appendix D
NSJ – 1050[a]	Northern San Juan	1050	−400	300	1450	750	31.78	0.024	Kramer 2002: Appendix D
NSJ – 1150[a]	Northern San Juan	1150	−400	300	1550	850	65.77	0.380	Kramer 2002: Appendix D
NSJ – 1250[a]	Northern San Juan	1250	−400	300	1650	950	82.3	0.313	Kramer 2002: Appendix D
Pecos Pueblo – Forked Lightning	Northern Rio Grande	1225	−1250	300	2475	925	99.33	0.195	Mobley 1980
Pecos Pueblo – Glaze B&W	Northern Rio Grande	1337.5	−1250	300	2587.5	1037.5	39.57	0.242	Mobley 1980
Pecos Pueblo – Glaze I	Northern Rio Grande	1400	−1250	300	2650	1100	118.71	0.174	Mobley 1980
Pecos Pueblo – Glaze II	Northern Rio Grande	1450	−1250	300	2700	1150	69.86	0.127	Mobley 1980
Pecos Pueblo – Glaze III	Northern Rio Grande	1512.5	−1250	300	2762.5	1212.5	122.71	0.161	Mobley 1980

San Cristóbal	Northern Rio Grande	1502.5	−1250	300	2752.5	1202.5	203	0.271	Bocquet-Appel & Naji 2006:243
SJB – 700[a]	San Juan Basin	700	−980	300	1680	400	43.94	0.217	Kramer 2002: Appendix D
SJB – 850[a]	San Juan Basin	850	−980	300	1830	550	42.76	0.222	Kramer 2002: Appendix D
SJB – 900[a]	San Juan Basin	900	−980	300	1880	600	9	0.111	Herrmann et al. 1993
SJB – 925[a]	San Juan Basin	925	−980	300	1905	625	15	0.364	Herrmann et al. 1993
SJB – 950[a]	San Juan Basin	950	−980	300	1930	650	89.85	0.409	Kramer 2002: Appendix D
SJB – 1050[a]	San Juan Basin	1050	−980	300	2030	750	139.74	0.277	Kramer 2002: Appendix D
SJB – 1150[a]	San Juan Basin	1150	−980	300	2130	850	222.63	0.411	Kramer 2002: Appendix D
SJB – 1250[a]	San Juan Basin	1250	−980	300	2230	950	26.76	0.450	Kramer 2002: Appendix D

[a] Composite samples (more than one site). See Table 2 for additional information.

Table 2 Details on composite burial assemblages

Area/Site	Number of sites	n(5+)	Sites	Largest contributing site	Comment	Sources
Hohokam						
Matty Wash	2	15	Donaldson Site, Los Ojitos	Los Ojitos (n = 10)	(none)	Huckell 1995: Table 3.5
Cienega		55	Coffee Camp (AZ AA:6:19), Wetlands (AZ AA:12:90), S. Cruz Bend (AZ AA:12:746),Stone Pipe (AZ AA:12:745), Los Pozos (AZ AA:12:91), Clearwater (AZ BB:13:6), Pantano (AZ EE:2:5)	AZ AA:12:90 (Wetlands), n = 21	Compendium of sites from South-Central Arizona	Mabry 1998: Table 16.2
Pueblo						
Black Mesa – Early Pueblo	13	35.43	7:98, 7:134, 7:135, 7:262, 7:234, 7:707, 7:2103, 11:2023, 11:2025, 11:2030, 11:2040, 11:2062, 11:2068	7:234 (n = 8)	Compendium of Black Mesa sites dating to A.D. 800 – A.D. 1050.	Martin et al. 1991: Table 2-11
Black Mesa – Late Pueblo	39	79	7:11, 7:12, 7:23, 7:27, 7:102, 7:109, 7:216, 7:716, 7:719, 7:220, 7:725, 7:2001, 7:2017, 11:3, 11:12, 11:14, 11:97, 11:260, 11:265, 11:275, 11:289, 11:290, 11:300, 11:335, 11:348, 11:352, 11:409, 11:425, 11:426, 11:500, 11:569, 11:666, 11:686, 11:687, 11:2013, 11:2048, 11:2068, 11:2108, 11:2155	11:500 (n = 7), 11:300 (n = 7)	Compendium of Black Mesa sites dating to A.D. 1050 – A.D. 1150.	Martin et al. 1991: Table 2-11

Marsh Pass	4	21.00	Sayodneechee Cave, Kinboko Cyn Cave 1, White Dog Cave, Tsegi Canyon Cave 3	Sayodneechee Cave, n = 9	Compendium of regional sites dating to Kayenta.	Coltrain et al. 2007: Table 1
NRG – 1150	4	17.96	LA000649, LA006865, LA011633, LA000654	LA000649 (Nogales Cliffhouse), n = 11	Compendium of regional sites dating to A.D. 1100 – A.D. 1199.	Kramer 2002: Appendix D
NRG – 1250	9	17.02	LA011843, LA022866, LA022867, LA022868, LA022895, LA022902, LA023043, LA011850, LA011841	Even distribution of burials	Compendium of regional sites dating to A.D. 1200 – A.D. 1300.	Kramer 2002: Appendix D
NSJ – 850	16	86.14	5MT02192, 5MT02848, 5MT02853, 5MT05107, 5MT02182, 5MT00023, 5MT04671, 5MT04725, 5MT02320, 5MT04475, 5MT05108, 5MT04480, 5MT01604, 5MT08899, 5MT08937, 5MT03868	5MT05107 (Pueblo de las Golondrinas), n = 19	Compendium of regional sites dating to A.D. 800 – A.D. 899.	Kramer 2002: Appendix D
NSJ – 950	5	20.4	5MT04477, 5MT02525, 5MT08934, 5MV01452, 5MV00875	5MV01452 (Badger House), n = 11	Compendium of regional sites dating to A.D. 900 – A.D. 999.	Kramer 2002: Appendix D
NSJ – 1050	7	31.78	5MT05501, 5MT05106, 5MT08827, 5MT02433, 5MV01452, 5MV00866, 5MV01229	5MV01452 (Badger House), n = 12	Compendium of regional sites dating to A.D. 1000 – A.D. 1099.	Kramer 2002: Appendix D

Table 2 (continued)

Area/Site	Number of sites	n(5+)	Sites	Largest Contributing Site	Comment	Sources
NSJ – 1150	10	65.77	5MT05498, 5MT02149, 5MT02235, 5MT00948, 5MT02148, 5MT02544, 5MV01595, 5MV00499, 5MT07723, 5MT10207,	5MV01595, n = 20	Compendium of regional sites dating to A.D. 1100 – A.D. 1199.	Kramer 2002: Appendix D
NSJ – 1250	7	82.3	5MT09735, 5MV00034, 5MV01452, 5MV01200, 5MV01228, 5MV01229, 5MT10206	5MV01200 Long House (n = 28)	Compendium of regional sites dating to A.D. 1200 – A.D. 1300.	Kramer 2002: Appendix D
SJB – 700	10	43.94	LA045689, LA002507, LA008939, LA016029, LA004195, LA008662, LA080407, LA083505, LA083506, LA083507	LA004195 (Sambrito Village), n = 16	Compendium of regional sites dating to A.D. 600 – A.D. 799.	Kramer 2002: Appendix D
SJB – 850	12	42.76	LA003562, LA004487, LA003646, LA004363, LA004384, LA004151, LA004131, LA004148, LA004242, LA004198, LA080934, LA083507	LA004487, n = 15	Compendium of regional sites dating to A.D. 800 – A.D. 899.	Kramer 2002: Appendix D
SJB – 925	2	15	423–129, 423-130	423-130, n = 8	Upper Puerco River burial sites	Herrmann et al. 1993

SJB – 950	16	89.85	LA050337, LA004169, LA004298, LA004380, LA004131, LA004053, LA004086, LA004088, LA002585, LA000226, LA040299, LA040626, LA040627, LA040935, LA041629, LA083506	LA004086 (Sanchez Site), n = 27	Compendium of regional sites dating to A.D. 900 – A.D. 999.	Kramer 2002: Appendix D
SJB – 1050	35	139.74	LA016660, LA 104984, LA008846, LA080440, LA059497, LA002675, LA002699, LA002701, LA002937, LA005062, LA006383, LA006387, LA016254, LA008779, LA002585, LA002592, LA080377, LA040395, LA000226, LA000838, LA000841, LA002470, LA040394, LA040396, LA040399, LA040597, LA040626, LA042385, LA083498, LA100627, LA100628, LA100629, LA083500	LA040399 (Tom Mathew's Dig), n = 19	Compendium of regional sites dating to A.D. 1000 – A.D. 1099.	Kramer 2002: Appendix D
SJB – 1150	17	222.63	LA000045, LA008846, LA005057, LA000226, LA002985, LA002987, LA002988, LA002470, LA040394, LA040396, LA002464, LA008978, LA040395, LA040397, LA040721, LA002592, LA040399	LA000226 (Pueblo Bonito), n = 62	Compendium of regional sites dating to A.D. 1100 – A.D. 1199.	Kramer 2002: Appendix D
SJB – 1250	17	26.76	LA003292, LA000045, LA008846, LA085235, LA005596, LA002714, LA004485, LA006372, LA006380, LA006400, LA035867, LA041947, LA002508, LA004050, LA040399, LA040589, LA040633	LA00004 (Aztec Ruin), n = 88	Compendium of regional sites dating to A.D. 1200 – A.D. AD1300.	Kramer 2002: Appendix D

supplemental materials) methods for quantifying the proportions of individuals aged 5–19 in these assemblages. For example, these proportions are calculated against a total that excludes individuals below the age of 5. We excluded assemblages obviously affected by massacres or extreme perimortem processing possibly indicating cannibalism. We did not enrich the reported counts for the 20 + group by 10 percent (accordingly decrementing counts for the 5–19 interval) following Bocquet-Appel's rule 5. In cases where counts of individuals had to be reapportioned from age categories that crosscut those used here, we used rules from Bocquet-Appel (2002: online supplemental materials) or followed advice from Stephan Naji (personal communication 2006).

We did depart from Bocquet-Appel's analysis routine in one important way. Because the assemblages we used ranged greatly in size, from 7 to 540 individuals, we weighted assemblages according to their sample sizes in the loess algorithm used to fit the relationship between time and the proportion of subadults. This limits the effects of the sampling errors that are unavoidable in small assemblages on the fits obtained. Practically speaking, this makes it less essential for us to aggregate small samples that are close in space and time. In producing the loess graph discussed below, we allowed our fitting routine[3] to determine the size of the window used (Bocquet-Appel's α), within a permissible range of 0.3–0.6, so as to minimize the AIC_c value (Hurvich et al. 1998). The smoothing parameter chosen by the optimization algorithm in each of the two cases reported below was ≈ 0.3, the value typically used by Bocquet-Appel.

Results

To examine the relation of this proportion to the first arrival of maize, we use the estimates for the first use of maize in each site's region or subregion, as reported in Table 1. Figure 3 graphs, on its x-axis, the difference between the midpoint date for each assemblage and the date for the introduction of maize to that subregion, against the proportion of individuals from each site aged 5–19 on the y-axis. The horizontal dashed line represents an estimate for the location of a growth rate (r) of zero, based on simulations on 45 reference life tables as explained by Bocquet-Appel (2002:639–640).

It is immediately apparent that we have no sites with enough human remains to graph that are within 1000 years of the first local introduction of maize. This seems to imply, given the density of excavation in the US Southwest, that for a millennium or more following first local appearance of maize, populations remained low and perhaps relatively mobile (see, e.g., Coltrain et al. 2007; Diehl and Waters 2006; Simmons 1986). Figure 3 suggests that population growth rates began to increase some 1200 years after the first appearance of maize, and that growth rates peaked some two millennia after the local introduction of maize, declined over the next 500 years, and then increased once more, though more slowly. Both the first increase and the decline are interpretable in terms of NDT theory, though this first increase comes

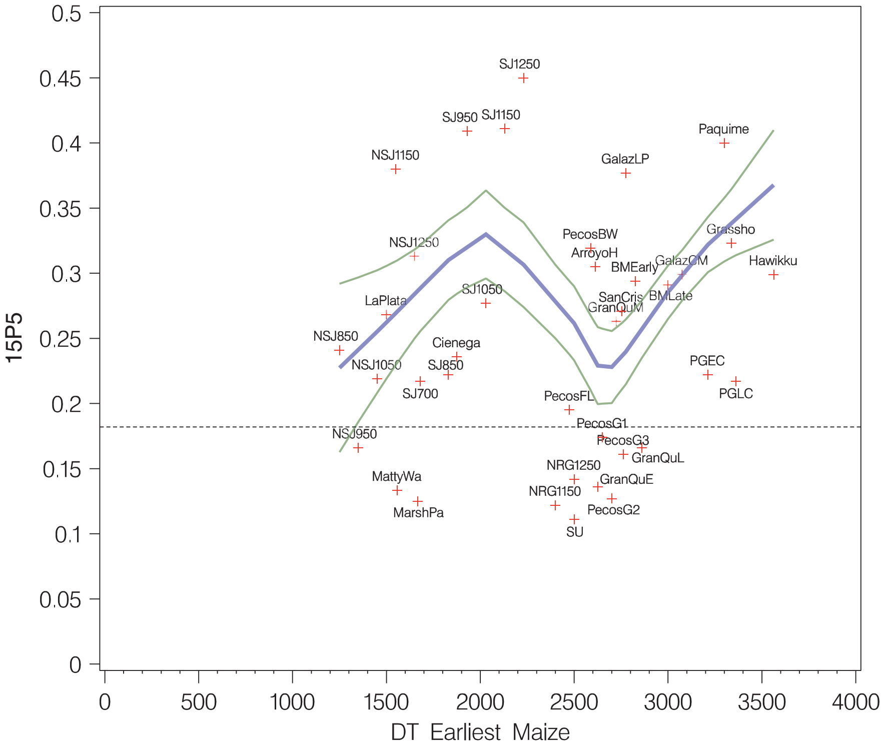

Fig. 3 Proportions of immature individuals in sites and composite samples plotted against the difference between earliest maize use in that site's subregion, and midpoint date of site occupation. Relationship fitted using loess, a nonparametric method for estimating local regression surfaces

some 1200 years later than expected. The second increase is somewhat unexpected, and we return to it below.

Perhaps we would see a better fit between the Southwestern data presented here and the NDT graphs of Bocquet-Appel (2002) for Europe and Bocquet-Appel and Naji (2006) for North America (where they include a few sites from the Southwest) if we examined the relationship between the proportion of 5- to 19-year-olds and an estimate for the earliest *intensive* use of maize. Bocquet-Appel and Naji (2006, Table 1) use AD 200 as the date for the introduction of maize throughout the Southwest except for Casas Grandes (Paquimé) where they use a date of AD 700. They do not explain the derivation of these dates, but they are much more in line with the local appearance of ceramics than they are with the first appearance of maize (Table 1). Crown and Wills (1995) and Diehl and Waters (2006) give local reasons, and theoretical arguments, to suspect that earliest well-fired ceramic containers coincide with the increasingly intensive use of cultivated plants and markedly increased sedentism, although Coltrain et al. (2007) provide much new evidence based on stable carbon isotopes that maize was a staple for Basketmaker II populations in the Four Corners area by 400 BC, some 700 years before the first local appearance of ceramic containers (see also Chisholm and Matson 1994; Matson and Chisholm 1991). Given that we do not presently have enough samples of stable-carbon isotopic data throughout the Southwest to draw exclusively on that line of very direct evidence, we will try using the local first appearance of well-fired ceramic vessels as a surrogate for the first local intensive use of maize, and see what happens.

Figure 4 shows the relationship between P(5–19) and the earliest local intensive use of maize as proxied from the appearance of ceramic containers. This graph indeed resembles that produced by Bocquet-Appel for Europe (2002:Fig. 4) more than did our Fig. 3. Six data points, all with relatively small assemblages, predate the intensive use of maize estimated in this way, and all have low P(5–19) values relatively near the estimate for $r = 0$. Unlike the European case, however, the proportions (and presumably the underlying growth rates r) appear to begin to increase markedly not around dt 0, but rather some 300–400 years after the first local use of ceramic containers. Of course, the dearth of data between about dt −200 and almost 400 weakens this suggestion. If this *is* correct, though, it would suggest that intensive maize use (as proxied by first ceramic containers) perhaps slightly

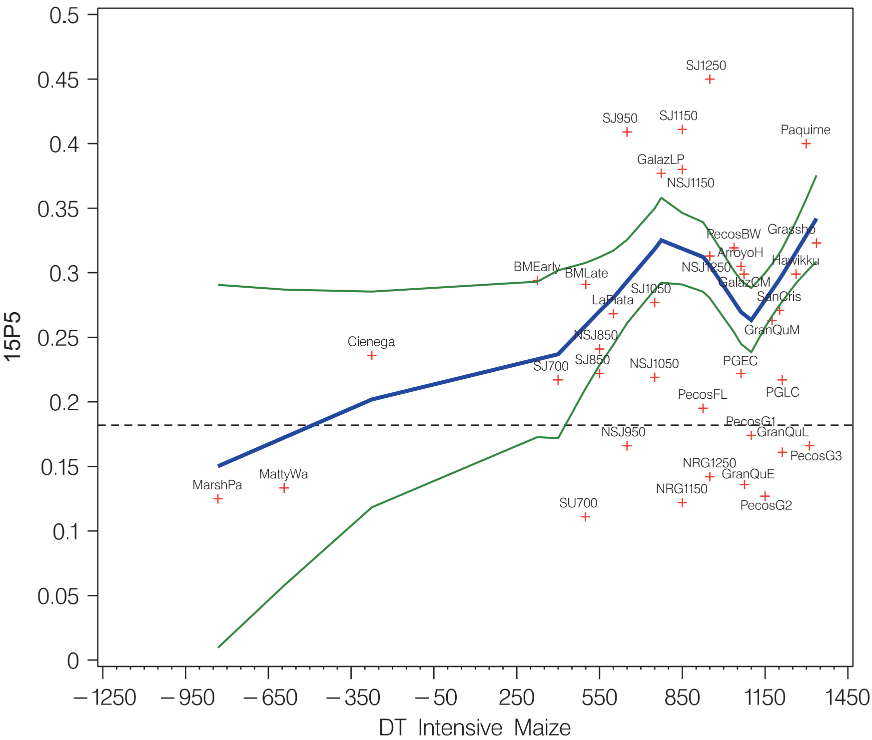

Fig. 4 Proportions of immature individuals in sites and composite samples plotted against the difference between earliest intensive maize use in that site's subregion, as proxied from appearance of ceramic containers, and midpoint date of site occupation. Relationship fitted using loess, a nonparametric method for estimating local regression surfaces

increases population growth rates, but that some other factor, generally occurring later, is even more important. The first marked increase in the P(5–19) values, beginning around dt 400, corresponds in a general way to the first pulse of aggregation in the Southwest, where it is most striking in the Northern San Juan Pueblo I villages discussed elsewhere in this volume by Wilshusen and Perry (2006), perhaps suggesting that early aggregation increased economic efficiency. This rapid increase also generally corresponds to the first appearances of Maís Blando and Harinosa de Ocho (Maís de Ocho) ca. AD 500–700 (Adams 1994), and follows shortly on the opening of a vast new agricultural niche with the development of successful dry-farming strategies. The growth rates toward the top of the peak may also be influenced by the increased use of turkey for protein ca. AD 1100 (Cowan et al. 2006).

The decline in the proportions beginning about dt 900 until about dt 1200 seems to be associated with the period of the retrenchment of population from the Northern San Juan and the San Juan Basin into the Northern Rio Grande at sites like Pecos, Gran Quivira, and into some portions of the Mogollon area, for example Point of Pines. There appears to have been great variability in P(5–19) values in sites in these destination areas, though, and some large, late assemblages with high P(5–19) values—especially San Cristobal, Hawikku, and Grasshopper—raise the fitted curve unexpectedly, on the eve of the Spanish entrance to the Southwest in 1540.

Discussion

Possible Problems with the P(5–19) Proportion

Of course, we expect the P(5–19) measure to be noisy for a variety of reasons relating to the archaeological and analytical contexts, including but not limited to possible variability through time and space in mortuary practices and preservation for children and adolescents vs. adults; differences in analytic standards for (and expertise in) determining ages for human remains; changes through time in how these decisions are made by bioarchaeologists; sampling error; and so forth. To the extent that these are random errors they will weaken but not bias the fitted relationship between the P(5–19) value and time relative to agricultural innovation.

There are as well processes in the systemic context that may tend to bias the signal, and these are of somewhat greater importance. The first of these is worthy of mention but possibly not of great concern in itself, since while it may lead to local anomalies in P(5–19), these should be balanced out in the regional data sets compiled in Table 1. This is the recent discovery by Kramer (2002) that Chacoan centers, in at least the eleventh and thirteenth centuries, seem to be importing women from outlying regions, possibly through raiding activities.

Although this effect per se might not bias our results when these are averaged over large enough spaces, the warfare that probably underlies these patterns might cause biases. Warfare differentially affects young adults and could therefore, in principle at least, raise the P(5–19) values in some of the assemblages considered here.

Kramer (2002) constructed life tables for many of the composite samples reported in Table 1 and compared the tables she constructed for each century in each region, with a composite table constructed from all the samples in that region, aggregated through time. Specifically, she compared the cumulative proportions of the numbers of individuals in each category, after smoothing as outlined by Weiss (1973), between each temporally specific subsample and the entire population from that region, including that subsample, using a Kolmogorov–Smirnov test. This approach is obviously conservative because the sample from each century also contributes to the regional distribution with which it is being compared and also, to a smaller extent, because of the smoothing before the test.

In the San Juan Basin region, only one century, the 1200s, is anomalous on this measure, with significantly more individuals in the 6- to 25-year-old age groups than in the regional sample pooled by period, and as a result, fewer individuals in the 36- to 55-year-old age categories (Kramer 2002:67). Indeed, we can see in Figs. 3 and 4 that this sample (SJ1250) has the highest P(5–19) value in our entire Southwest data set, although, since the sample size is relatively small, its effect on the fitted line is not large.

A similar, though slightly weaker, effect is seen in the contemporaneous assemblages from the Northern San Juan region to the north. In the 1200s, all age categories between 3 and 25 years are over-represented relative to the assemblage representing all *other* periods from that region (Kramer 2002:91). This effect is no longer statistically significant, though, if the assemblages from the 1200s are included in the composite assemblage with which the 1200s are being compared. It is not surprising then to see that the data point for this century (NSJ1250) is slightly above the fitted line in both Figs. 3 and 4, though it is not among the highest proportions in the data set.

Taken together, we can conclude that the P(5–19) proportions are at least somewhat affected by warfare-related processes in the Southwest, conflating as they do the high values for these proportions due to depressed denominators reflecting high mortality in young adults due to warfare, with the high values due to high numerators for the proportions that the index is designed to measure.

Other Patterns of Interest

Despite these problems—and beyond the NDT signal itself—there appear to be signals in Figs. 3 and 4 of interest to regional specialists. We note, for example, that the P(5–19) value tends to decline through time at Pecos (at the far eastern edge of the Pueblo world); and that the Gallina subregion of the Northern Rio Grande, which lies at the northeastern edge of the Pueblo world, tends to also have low growth rates. Indeed, some of the highest growth rates, as proxied by P(5–19) values, tend to be in regions that lie toward the center of the Southwest, perhaps suggesting that the reason they were at the center is that they were able to export population in various directions. Peripheral areas supported lower growth rates, contributing to their peripherality.

The second increase in the fitted line, in both Figs. 3 and 4, is not anticipated by the NDT model itself, though it has a possible analog in the second bump seen in Fig. 4 of Bocquet-Appel (2002:645) that appears to correspond, in general, to Chalcolithic sites with a megalithic aspect that are often considered to reflect a more hierarchical form of sociopolitical organization than the earlier Neolithic sites. In our sample, following the logic of the NDT model, the highly aggregated nature of late sites such as Hawikku, San Cristobal, Grasshopper, and Paquimé would lead us to anticipate low values for the P(5–19) measure, but in fact their values are high, and in conjunction with their large samples, cause the second increase in our fitted lines. We are not certain what economic or social organizational factors may contribute to the apparently high growth rates in such sites,[4] but this model throws them into relief as worthy of explanation.

Independent Corroboration for a Late Southwestern NDT

Brian Kemp (2006) recently analyzed mitochondrial DNA (mtDNA) variation in 897 individuals from 13 populations in Mesoamerica and the American Southwest—a much larger sample than those previously available for these regions. These individuals represented all the mtDNA haplogroups (A, B, C, D, and X) known for Native American populations. Kemp sampled individuals from groups speaking languages in the Uto-Aztecan family preferentially but not exclusively.

His results for haplogroup B are relevant to this chapter. This haplogroup, which was exhibited by 315 individuals, is particularly common in the US Southwest, occurring in highest frequencies in populations with a Pueblo affiliation ("Anasazi" [Carlyle et al. 2000], $n = 25$, 60 percent B; Jemez, $n = 71$, 86 percent B; Zuni, $n = 50$, 76 percent B; but by contrast, e.g., Akimel O'odham, $n = 146$, 47 percent B; Aztecs, $n = 37$, 16 percent B).

One major clade within this haplogroup exhibits a particular transition that was seen only in the Southwestern populations, and never in the Mesoamerican populations, so long as the Cora and Huichol, who exhibit this transition, are included in the "Greater Southwest" (Beals 1974). In fact, this clade was represented in every Southwestern population sampled. Kemp calculates that the expansion of this clade dates to 2,105 BP (99.5% CI $\pm$ 1, 273–3, 773 BP). This confidence interval encompasses the mid-first-millennium-AD date reported here for marked increase in growth rates accompanying the NDT in the Southwest.

Dean, Doelle, and Orcutt (1994:73–76) attempted to make pan-Southwestern population estimates by abstracting estimates from the available archaeological literature. These measures ultimately depend on site counts and sizes by phases, not by human remains, as used here. Their tabulation begins at AD 100 and ends at AD 1600. They reconstruct a rapid population increase beginning around AD 550, with population peaking around AD 1000, remaining high until AD 1200, and then declining irregularly until the end of the period they plot. The sharp mid-first millennium increase, as they point out, is not entirely credible, since it is influenced by the first availability of Hohokam-region population estimates at AD 600. If it were possible to control for that effect, they suggest, the increase would be more gradual, ramping up more slowly in the first half of the first millennium AD, but with, likely, a significant increase at that time.

Potential Issues

While this discussion focuses on changing demographic patterns subsequent to a point *dt*, these changes are understood to reflect a departure from long-term hunter-gatherer growth rates occurring prior to this transition. It should be noted, however, that this implicit contrast between population trends on both sides of the *dt* axis is based on the reconstruction of a synthetic population using individual points ordered through a relative chronology and not by linear time. Long-term hunter-gatherer population trends are unlikely to be meaningfully ordered in relation to an unknown future event, especially when the hypothesized demographic transition occurs at different times across this region. An ordered demographic process among hunter-gatherers is more likely to be affected by regional or pan-regional climactic trends occurring in linear time. This issue is unlikely to seriously affect such analyses, given the paucity of large pre-agricultural cemeteries, as well as the predominant focus on events post-dating the transition. It should serve as a cautionary note, however, especially when comparing features of the curve predating the event by which the chronology is ordered.

Conclusions

An NDT is visible in the US Southwest, but it appears much later than the earliest appearance of maize in the region (at ca. 2000 BC), providing another piece of evidence that earliest maize merely supplements a hunter-gatherer lifestyle without fundamentally altering it. Somewhat more surprisingly, the NDT also lags the earliest intensive use of maize, measured here by the appearance of ceramic containers in this region at ca. AD 300, though by a much shorter period.

The NDT, when it finally arrives, is built on the shoulders of earlier accomplishments, including the development of ceramic containers, coupled with newly arrived (or newly developed) races of maize that help make it possible to dry-farm many new areas, including some very productive mesa tops in portions of the Northern San Juan region. But before this niche can be fully developed, given the higher risk of dry farming relative to earlier forms of water-managed maize production, a way of efficiently storing and exchanging agricultural surpluses must be found. The explosive growth in places like the central Mesa Verde portions of the Northern San Juan region (Varien et al. 2007) and its accompanying Pueblo I villages (Wilshusen and Perry 2006) is the most obvious result, though less obvious population growth in other portions of the Southwest benefiting from dry farming is also probable. That these early villages appear when and where they do is logical if, as Kohler and Van West (1996) argue, such villages make possible, for the first time, durable patterns of efficient exchange among non-kin of relatively bulky goods such as maize.

Prior to the development of these villages, habitation sites, usually referred to as hamlets, appear to have been composed of a single kin group which probably practiced internally a form of generalized reciprocal exchange. Villages, on the other hand, contain several hamlet-scale roomblock units. We infer that exchange among households across roomblocks was important in the success of these villages, and that such exchanges would have been structured through balanced reciprocal exchange. This would have greatly increased the role of such exchanges in these societies, ultimately allowing much more efficient allocation of production among all households in the village. Agent-based modeling exercises on virtual landscapes resembling those used by these early villages (Kobti et al. 2006; Kohler et al. 2007) are investigating the affects of various exchange practices on population size, aggregation, and degree of settlement permanence.

Although the measure of the NDT proposed by Bocquet-Appel for Europe is not without its problems, we conclude that it gives us a new and powerful way of looking directly at the degree of reproductive success of the new Neolithic (or Formative) way of life in the US Southwest. This way of life developed slowly over 3000 years, rather than spreading dramatically at the expense of foragers or their lifestyles at its earliest appearance. Nevertheless, by midway through the first millennium AD, a threshold was reached allowing much more rapid growth. For the next 600 years or so, southwestern societies explored new sociopolitical arrangements allowing them to cope with the larger group sizes resulting from this growth. A feature of these periods, known in the Pueblo area as the Pueblo I and Pueblo II periods, is that their innovations focused more on competitive success in this new sociopolitical environment, than on innovations in food-getting. It was one of those rare periods in human history where populations found themselves, for a time at least, well below the carrying capacities of their natural environments.

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Notes

1. All dates in this chapter are either general dates, tree-ring-based dates, or calibrated ^{14}C ages.
2. We made chronological subdivisions within aggregated assemblages reported by Bocquet-Appel and Naji (2006:349) for Black Mesa and Pecos Pueblo, and we did not use their data for Mesa Verde and Pueblo Bonito, since these were included in more chronologically precise fashion in the data assembled by Kramer.

3. SAS v. 9.1.3, PROC LOESS. 80% confidence intervals are displayed around the fitted line.
4. Though we have some suspicions; Kohler et al. (2004) have pointed to the proto-market forces visible in Classic period (late fourteenth century through early sixteenth century) towns in the Northern Rio Grande and suggested that this vibrant new economic organization, which is accompanied by novel forms of ceremonial organization, contributes significantly to the success of these large aggregates.

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The Neolithic Demographic Transition in Mesoamerica? Larger Implications of the Strategy of Relative Chronology

Richard G. Lesure

Abstract The Neolithic Demographic Transition (NDT) has been generalized from its origin in Near Eastern/European prehistory for application to early agricultural settings across the world, and it should apply in Mesoamerica as well. This chapter explores the articulation of the NDT as a generalized culture-historical scenario with the more "homegrown" accounts of Mesoamericanists. Most of my effort is devoted to working through, at multiple scales, these larger resonances of the NDT in Mesoamerica. I confront that task by turning as much as possible to selected categories of primary data, thus moving toward grand culture-history from the bottom up. That work lays the basis for a return, at the end of the chapter, to the more concrete problem of setting dt = 0 in Mesoamerica.

Keywords Mesoamerica · demic-diffusion · agriculture · culture-history · scale

Relative chronology plays a strategic role in formulations of the Neolithic Demographic Transition (NDT) – it makes demographic patterns detectable. Cases are aligned according to the local moment of transition to the Neolithic (dt = 0), as determined from culture-historical synthesis of regional or even continental scope. Postulating that the transition in Europe was a "single demographic process," Bocquet-Appel (2002:639) originally measured dt as "the chronological distance of a cemetery from the Neolithic diffusion front." The relative chronology was therefore founded on a synthesis of prehistory involving a wave of agricultural diffusion moving from one end of Europe to the other.

The Neolithic transition in other areas of the globe is wave-like to varying degrees, and the NDT has been adapted accordingly. For North America, Bocquet-Appel et al. (2006:345) trace an "economic shift front" by drawing on syntheses of various sorts, including the Archaic/Woodland framework. The strategy of relative chronology probably makes recourse to big-picture culture-history unavoidable. But

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I would push the point further. The NDT is most compatible with a particular class of syntheses, those in which demic expansion by agricultural populations plays a significant role (see Bellwood 2001, 2005; Bellwood and Renfrew 2003; Cavalli-Sforza 1997; Renfrew 1987, 1992, 2003). The NDT and demic-expansion hypotheses both emphasize increased fertility at the transition to agriculture. Indeed, it seems likely that a demographic transition of the magnitude identified by Bocquet-Appel would generate radial movements of population from agricultural heartlands. Dispersals of early farmers would thus be causally related to the NDT.

Like the NDT, the scenario of early farming dispersal has been generalized from its origin in Near Eastern/European prehistory for application to agricultural heartlands across the world. Of course, different agricultural systems would have had different capacities for expansion (Harris 2003). Bellwood (2005:274–277) adds nuance to the general model by distinguishing between homeland, spread, friction, and overshoot zones, with varying tempos of agricultural spread and differing relations between hunter-gatherers and farmers.

The model provides a "universalized" culture-history, since it makes predictions concerning the form that particular histories will take – at least at a grand scale. That ambitious scale has been a point of challenge. Wylie (2002:219), reviewing Renfrew's work on demic expansion and early agriculture through the mid-1990s, notes charges that his model "is not properly grounded in, or congruent with, lower-level, local reconstructions of the transitional processes responsible for the Neolithic revolution." She thus questions whether processes observed to have been operating at smaller scales are consistent with the continental processes claimed in the model.

Faced with applying the NDT concept to Mesoamerica, I am brought up short by these larger resonances. Fixing the relative chronology requires a synthetic culture-historical framework potentially of continental proportions. A very compatible framework derived from the European record has recently been generalized for application worldwide, but at the same time criticized for its purported lack of attention to local-level reconstructions. Mesoamerica is an agricultural heartland implicated in that framework (Bellwood 2005:237–244; Diamond and Bellwood 2003:600), but the scenario of demic expansion has had, overall, a minor impact on regional specialists' accounts of the transition to agriculture. How well does it make sense of more localized culture-history? At the same time, debates over big-picture issues in the culture-history of early Mesoamerica seem increasingly stale (Lesure 2004). Could the NDT and/or early farming dispersals reinvigorate the field?

My goal is to explore the articulation of the universalizing scenario with the more "homegrown" accounts of Mesoamericanists. I am not seeking either/or answers but rather something more complex involving an interplay of multiple scales. Most of my effort is devoted to working through these larger resonances of the NDT in Mesoamerica, a task that I confront by turning as much as possible to selected categories of primary data, moving toward grand culture-history from the bottom up. That work lays the basis for a return, at the end of the chapter, to the problem of setting $dt = 0$ in Mesoamerica.

The Transition to Agriculture in Mesoamerica

Mesoamerica is a land of contrasts, from the tropical forests of the Gulf Lowlands to the rugged, semi-arid highlands of interior Mexico. Domestication of crop plants – most importantly, maize, beans, and squash – predated sedentary life by millennia. Sedentism instead arose in the Formative period in association with pottery and economies centered on agriculture, though how precisely all these coincided is subject to debate. Knowledge of the Archaic – the era preceding the Formative – has not developed at the pace that characterizes later periods, and results of 1960s fieldwork in the southern highland valleys of Tehuacán and Oaxaca remain primary data sets. It was long thought that maize, the staple crop of later eras, was domesticated in these semi-arid highlands settings (e.g., MacNeish 1975), but botanists have in recent decades clarified its ancestry. Genetic evidence now points to domestication along the Balsas River, west of Tehuacán/Oaxaca and at lower elevations (Piperno and Pearsall 1998:158–163). Archaeological study of the Archaic and Formative along the Balsas is in its infancy.

It is nevertheless clear that Mesoamerican crop plants had spread as far as South America before the emergence of Formative village life back in the center of domestication. Concepts like "the onset of the Neolithic" thus need to be applied with caution. Arguably, we could choose between three epochs to establish dt = 0: (1) a point in the Archaic during the development of crop plants, (2) the transition from Archaic to Formative, or (3) a point several hundred years into the Formative when, according to recent suggestions (e.g., Blake et al. 1992; Smalley and Blake 2003), maize became more important as a staple. It is worth keeping all these possibilities in play, but I am strongly inclined toward (2). Traditional understandings of that transition make it seem the most likely point at which to expect an NDT in Mesoamerica, and I will note as I proceed how evidence considered here appears consistent with that received wisdom. The transition to the Formative will thus be the principal focus of my attention.

Demic Expansion and Mesoamerican Controversies

While Mesoamericanists routinely place the earliest Formative at around 1800/1700 cal B.C. at least some areas were later, and in other cases there is ongoing debate about the relative timing of agricultural or Formative developments. Those controversies over priority in one area versus another have potentially profound implications for any grand synthesis of the early culture-history of Mesoamerica and therefore also for efforts to unveil a local NDT or trace expansions by early agriculturalists. I will consider two such controversies.

The first is between the role of highland versus lowland areas in the transition to agriculture. Highland regions have until recently been viewed as centers of domestication. The expansion of lowland data sets in the last 25 years has led to the emergence of lowland partisans who view the highlands as lagging behind in the development of "effective" Archaic agriculture (Piperno and Pearsall 1998:313–314) or in the emergence of the Formative itself (Clark and Gosser 1995).

A second homegrown controversy concerns claims for preeminence of one particular area, the Southern Gulf Lowlands, in Early Formative social developments. Opponents of such claims instead see essentially simultaneous developments in multiple areas. Vociferous debates center on the widespread Olmec art style and the degree to which it can be ascribed to an "Olmec people" of the Gulf Coast. An early formulation saw "Olmec" as a *cultura madre* or "mother culture" of Mesoamerica, while subsequent reactions insist that Formative developments were the product of interaction among multiple groups (e.g., Hammond 1989). For my purposes here, the issue raised is whether stunning early developments on the Gulf Coast might indicate a precocious demographic curve for the region. For example, the site of San Lorenzo is estimated at 500 ha during the San Lorenzo phase of ca. 1450–1000/900 cal B.C., only 350–800 yr dt if we set the zero point of a relative chronology at the beginning of the earliest local ceramic phase (Symonds et al. 2002).[1] If Gulf Coast developments were precocious, demic expansion, applied to Mesoamerica, might start to look like a mother culture model. In other words, we could be led to take sides in an increasingly sterile local debate – always a disadvantage when bringing in theory from outside.

Bellwood's (2005) strategy for avoiding that trap is thus of considerable interest to any pursuit of the NDT in Mesoamerica. The basic argument is that the effects of "Neolithic" population expansions can still be perceived in patterns of language diversity 1000 years later (Renfrew 1987). Expanding populations brought with them the language of the agricultural heartland, creating zones of linguistic homogeneity. Diversification of languages in those areas has developed since that time. Based on this principle, the distribution of indigenous Mesoamerican languages millennia after the origins of agriculture can provide expectations concerning basic patterns of farming dispersal.

At the time of contact by European colonists, Mesoamerica was characterized by a significant linguistic diversity (Kaufman 1974). Four of the larger language families, Mayan, Mixe-Zoquean, Otomanguean, and Uto-Aztecan, are of particular interest (Fig. 1). Hill (2001), inspired by the demic-expansion model, has recently expounded a linguistic argument that would turn received wisdom concerning the spread of Uto-Aztecan on its head, positing an origin point in a plausible agricultural heartland of Western and Central Mexico. Bellwood (2005:237–244) generalizes that argument, seeing a similar expansion of Mayan languages through the Yucatán Peninsula. Expansion by speakers of early Otomanguean and Mixe-Zoquean languages may have occurred, but on a smaller scale, since early agricultural populations in the central part of Mesoamerica were hemmed in by other groups undergoing similar transformations.

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[1] B.C. dates in this chapter are in calendar years. Symonds et al. (2002), like others cited, use uncalibrated radiocarbon years for their phase boundaries. I have estimated calibrated ranges in each case. I occasionally refer to the following divisions of the Formative: Early (ca. 1800/1600–1000 B.C.), Middle (1000–400 B.C.), and Late (400 B.C.–200 A.D.).

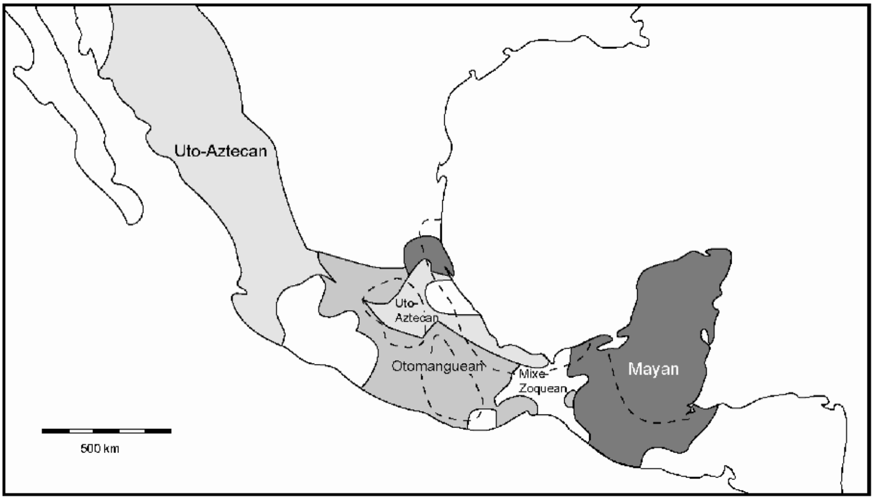

Fig. 1 Distribution of four major Mesoamerican language families (Uto-Aztecan, Otomanguean, Mixe-Zoquean, and Mayan) approximately 3000 years after the transition to agriculture (redrawn from Kaufman 1974). The *dotted lines* show the archaeological "macroregions" discussed in the text

How well this generalized view of language/early farming links will stand up to detailed empirical scrutiny is not yet clear. Hill (2003) is enthusiastic, Wichmann (2003) "agnostic," and Campbell (2003:52–53) pessimistic. Language distributions do, however, provide a means for moving from the universal model of demic expansion to a plausible set of expectations tailored to Mesoamerica.

An Analytical Agenda

My goal is to explore the relationship between homegrown and universalized culture-historical schemes for early Mesoamerica. The specific course of my analysis is determined by three subsidiary goals: recourse to primary data, examination of multiple scales, and a bottom-up approach to grand culture-history.

Data

Although the task I was assigned for this volume was to work up something "synoptic" concerning the NDT in Mesoamerica, I have deliberately avoided a literature summary. Instead, I try to return as far as possible to raw data. In a short paper, this means being very selective. It proves possible, though, to make headway by focusing on *paleoecological evidence* of early agricultural disturbance and *evidence of settlement history*. For paleoecological data I rely primarily on lake core sequences dated by C14. Particularly important is the appearance of maize pollen, the decline of arboreal pollen, and a rise in disturbance taxa (grasses and/or Cheno-Ams [Chenopodiacea/*Amaranthus*]); these yield insights into the timing and nature of impacts on the environment by agriculturalists.

Data on settlement history are of two sorts. Pedestrian survey is well developed in Mesoamerica, though coverage varies. Lowland forests and pastures are less conducive to survey than arid highland areas. There is also the problem of temporal correlations between settlement surveys in different areas, particularly at larger scales. Although new survey data continue to appear, much of what I consider has been available for decades without leading to resolution of the larger controversies. Some complementary approach is needed.

That most favored by Mesoamericanists would be comparative ceramic analysis, but I have chosen something different here: the summing of radiocarbon probability distributions. The basic idea, inspired by Rick's (1987) notion of "dates as data," is that histograms of C14 dates could provide a kind of proxy for population history, since more people would produce more charcoal. The approach has been developed in Paleolithic research (e.g., Housley et al. 1997) and calibration programs now provide this option. I have used the 2-D Dispersion Calibration Program Calpal Version May 2006 (University of Cologne Radiocarbon Calibration Program Package). I have spent considerable effort locating as many published Early–Middle Formative dates as I could; however, my efforts should not be considered exhaustive.

Multiple dates of the same "event" pose a problem. In the case of dates that appear stratigraphically equivalent I have calculated pooled means using the program Calib (Stuiver and Reimer 1993). Some reported dates were rejected by the original investigators. In such cases I have assessed whether rejection was based on discordant evidence or on presuppositions concerning chronology. Only in the former case have I left the date out of the analysis.

A concern here is that results may be more sensitive to contemporary research history than to ancient population history. The long-term curve for the Tehuacán Valley, shown in Fig. 2, may raise confidence in these procedures, as well as in my decision to concentrate on the Archaic/Formative transition. Recent redating of materials from older excavations has emphasized the stratigraphic mixing of dry cave deposits, complicating any effort to date stratigraphic "events." The curve in Fig. 2 (unlike my others) includes all dates reported, irrespective of stratigraphy (from Johnson and MacNeish 1972; Long et al. 1989; Smith 2005). By including all dates I maximize the danger that the summed dates will suggest spuriously high "population" in the Archaic, the era of most interest to the investigators. That seems not to be the case. While the Archaic dating programs are registered in Fig. 2, the curve begins to rise sharply around the Archaic/Formative transition and peaks at around 800 B.C. The decline after that point is probably the most serious effect of research history registered in the curve.

The biggest advantage of the summed radiocarbon curves is that dates from different regions can be directly compared; they provide a means of confronting big-picture culture-history with evidence. Still, the tangle of assumptions linking

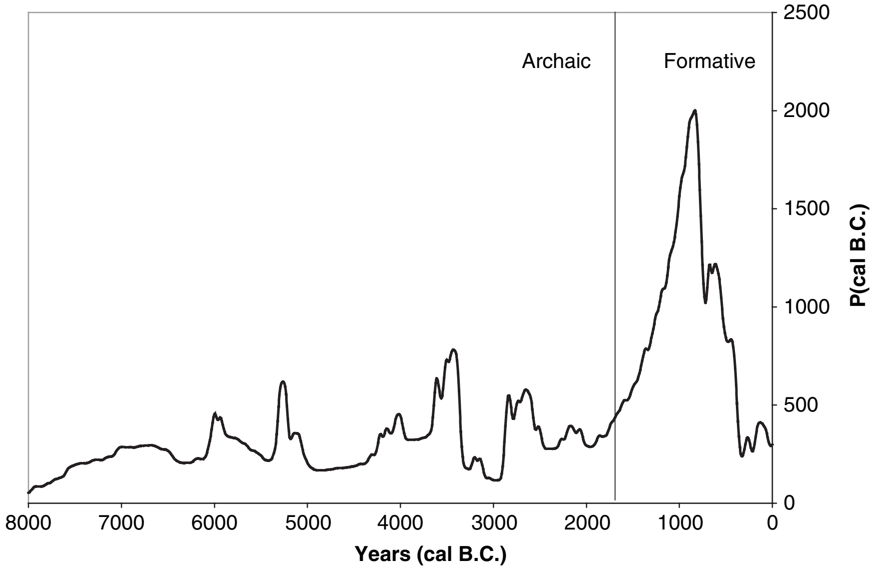

Fig. 2 Summed radiocarbon probabilities in the interval 8000 B.C.–A.D. 1 for 133 dates reported by Johnson and MacNeish (1972), Long et al. (1989), and Smith (2005)

radiocarbon curves to population history remains a concern and my plan is to build toward the big picture from smaller scales of analysis.

Multiple Scales

Since the ability of demic expansion to make sense of local culture-history is at issue, it is important to consider multiple scales. The scale on which I organize my review of evidence is the *macroregion*, a large area with geographic as well as cultural integrity. Each macroregion comprises multiple *regions*, areas of suitable size for individual survey projects.

I consider parts of four macroregions, two "highland" and two "lowland" (Fig. 3): *Central Mexico* (the Basin of Mexico and surrounding valleys, including Toluca, Morelos, and Puebla-Tlaxcala), the *Southern Highlands* (primarily modern Oaxaca, but also including the Tehuacán Valley), the *Gulf Lowlands* (modern Tabasco and Veracruz), and the *Maya Lowlands* (northern Guatemala, Belize, and the Yucatán Peninsula). The macroregions are of an appropriate scale for assessing the relevance of the demic expansion model to Mesoamerica.

My analytical strategy is to compare radiocarbon and survey evidence at regional scales, then synthesize those results, along with paleoecological evidence, at a macroregional scale. I will then compare those macroregional syntheses. However, I also sum up radiocarbon curves by macroregion for a "direct" comparison at that scale.

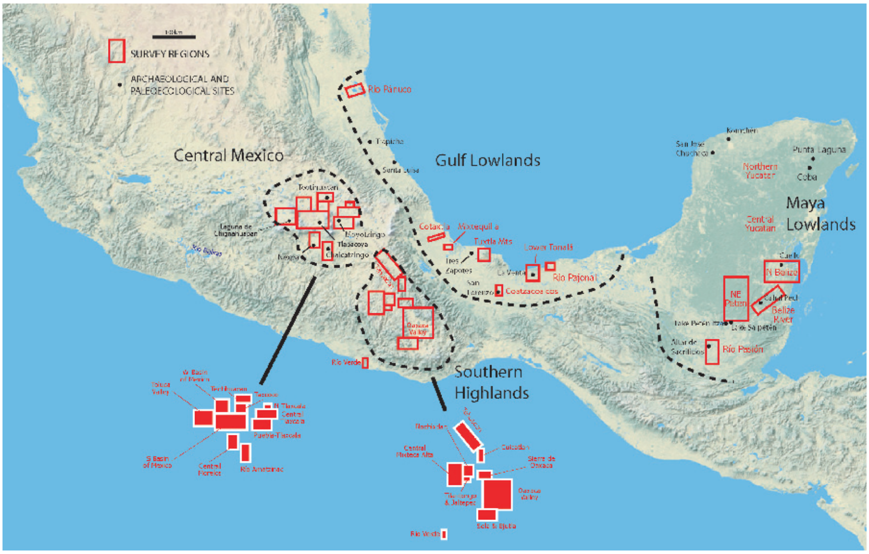

Fig. 3 Map of Mesoamerica showing Central Mexico, the Southern Highlands, the Gulf Lowlands, the Maya Lowlands, as well as locations of survey regions considered. Some of archaeological sites and paleoecological study locations are also indicated

Bottom-Up Approach to Grand Culture-History

I am suggesting that competing culture-historical schemes might interrelate in some sort of complex way if multiple scales are considered and proposing to build toward the larger picture from the bottom up. Some kind of intermediary framework is nevertheless necessary. As an aid in building up culture-historical insight, I propose a set of *generalized scenarios*. These can be applied at a variety of scales and make no specific claims concerning the Archaic/Formative transition. Though not devoid of processual implication, they are more focused on pattern than process and are not necessarily mutually exclusive. They can, though, be linked in a relatively straightforward way to evidence. I consider four such scenarios:

1. *Wave of advance*. In this scenario – obviously inspired by the demic-expansion model – populations expanded in one area and then colonized adjacent regions. Of most interest are cases in which adjacent areas were populated by hunter-gatherers and the people moving in Formative farmers. Settlement evidence is critical. We would expect an area of primacy in the transition to the Formative (a "homeland"), and radiating from there, a wave-like pattern in which areas further from the homeland underwent the transition at later times. However, rates of expansion reported by Bellwood (2005: Table 12.1) – 2.5–4.3 km/yr for spread zones not involving water transport – are fast enough that, on small scales with coarse chronological resolution, a wave of advance could look like simultaneity. Rates of that magnitude, though, are only expected in sparsely inhabited territory; if pre-existing populations are larger, a slower advance in a friction

zone is more likely. The wave-of-advance scenario makes no definitive predictions about paleoecological evidence, though an ecological impact accompanying the wave of advance would not be surprising. Significant human impact on the landscape *prior* to the Formative transition might signal the presence of sufficient Archaic populations to create friction rather than spread zones.

2. *Two-step transition*. In this scenario, slash-and-burn agriculture was sufficiently developed to have had an identifiable impact on the landscape well before the transition to the Formative. I am drawing here on recent work in lowland areas (Piperno and Pearsall 1998; Pohl et al. 1996) but have disarticulated the two-step pattern from specific claims about lowland/highland relations. With forest clearance and slash-and-burn agriculture widespread by the later Archaic, we might expect Formative friction rather than spread zones or localized Formative transitions without colonization. Paleoecological data should reveal human impact on the landscape hundreds, if not thousands, of years before the transition to the Formative.
3. *Local-processual*. This scenario plays down the importance of population movement. I am inspired here by the models of MacNeish (1975) and Flannery (1986a, b), in which transitions from Archaic to Formative lifeways occurred among locally stable populations. Flannery (1986a:26–27) suggests that the rise in productivity of maize above that of wild mesquite triggered removal of mesquite trees and initiation of farming on choice lands. Migration becomes irrelevant. Important instead are, on the one hand, general processes that would have affected all Mesoamerica (such as the emerging potential of maize) and, on the other hand, local ecological variation. I have again disarticulated the scenario from claims of highland preeminence (e.g., MacNeish et al. 2000). The prime empirical correlate of the local-processual scenario is that transitions to the Formative should be more or less simultaneous, with variation depending on local ecological conditions. In specific formulations of this model (Flannery 1986a:10–13, 1986b:26–27), demographic processes are not central to the adoption of agriculture. Populations are seen to have been low across the Archaic–Formative divide and for centuries thereafter. Rapid demographic expansion occurred instead in the Middle to Late Formative in the context of similarly rapid elaboration of sociopolitical complexity (Kowalewski et al. 1989:509–510). Because of low Early Formative populations, identifiable human impacts on the landscape are likely to post-date the Archaic/Formative transition.
4. *Political dynamics*. While the transition to agriculture occurred "late" in Mesoamerica in comparison to Old World cases, the subsequent trajectory of increasing complexity was rapid. There are hints that political dynamics of the Formative period in certain cases had such marked effects on the distribution of people across the landscape that they could complicate our ability to observe demographic patterns associated with the transition to the Formative. Scholars working in the Gulf Lowlands have suggested that centers of rapid social and political development became magnets that drew people from surrounding regions; such centers could also collapse dramatically, leading to the dispersal of people to neighboring areas (Pool 2005; von Nagy 1997:267). I consider whether that pattern may be a general one.

Review of the Evidence at the Macroregional Scale

Central Mexico

Central Mexico is an upland area consisting of a series of broad valleys separated by rugged mountains. The Basin of Mexico and the northern portion of the Puebla-Tlaxcala Valley are above 2000 m in elevation, while much of Toluca to the west and central-to-northern Tlaxcala to the northeast ascend above 2500 m. Beyond the volcanic range that forms the southern boundary of Toluca and the Basin of Mexico, elevations fall to below 1500 m in Morelos and Southern Puebla. These last areas, plus much of Puebla-Tlaxcala, drain to the south into the Balsas River, while Toluca drains further to the west into the Lerma River. The Basin of Mexico had no natural drainage but contained a series of interconnected lakes.

Survey data are available for a variety of regions, though the manner of presentation of evidence and detail of publication vary. In Fig. 4, each row is a region, and the scale at the bottom is in calendar years B.C. The curves are the summed radiocarbon probability distributions (Formative dates only) produced by the Calpal program. The thin tick marks at the bottom are the calibrated mid-points for the individual dates. Superimposed on the radiocarbon curves is settlement evidence for the corresponding area, varying in its manner of presentation according to the form of the evidence available. The thick-lined steps show population densities by phase as estimated in original reports or from information provided therein (for methods, see Sanders et al. 1979:34–52). The vertical scale for population density ranges from 0 to 10 people/km^2, with arrows indicating when density rises off the scale. Where population estimates are not available, the number of sites per phase or else some sort of qualitative assessment of settlement, again by phase, is provided. I have re-dated the phase boundaries associated with the settlement evidence for central and northern Tlaxcala according to our own recent suggestions (Lesure et al. 2006). The original reports would set the earliest settlement in northern Tlaxcala in the 1200–800 B.C. interval and in central Tlaxcala between 1600 and 1200 B.C.

Correspondence between summed radiocarbon probabilities and survey evidence seems tolerable for early time ranges. The C14 curves are sensitive to the history of research in individual regions. They are also affected by the fact that my collection of dates cut off at 1 A.D. in all regions and tailed off by 400 B.C. in areas with significant second millennium B.C. settlement. In most cases the declines on the right-hand portions of the radiocarbon curves are thus an artifact of my methods; it is the left-hand portion of each curve that is of interest.

The paleoecological evidence, such as it is, is not consistent with the two-step scenario described above: significant agricultural impacts on the landscape occurred only after the initiation of the Formative. At Tlapacoya in the Southern Basin, traces of maize pollen appear at 6000–5300 B.C., but maize becomes common only after 1500 B.C. (Niederberger 1987: Fig. 170). Around 1200 B.C., deforestation is indicated by a rise in grass pollen and diminishment of pine and oak. In the Toluca Valley (Metcalfe et al. 1991), Lake Chignahuapan Pit 1 yielded evidence of increased erosion after about 1350 B.C. At Santa Cruz Atizapan, a peak in non-arboreal pollen

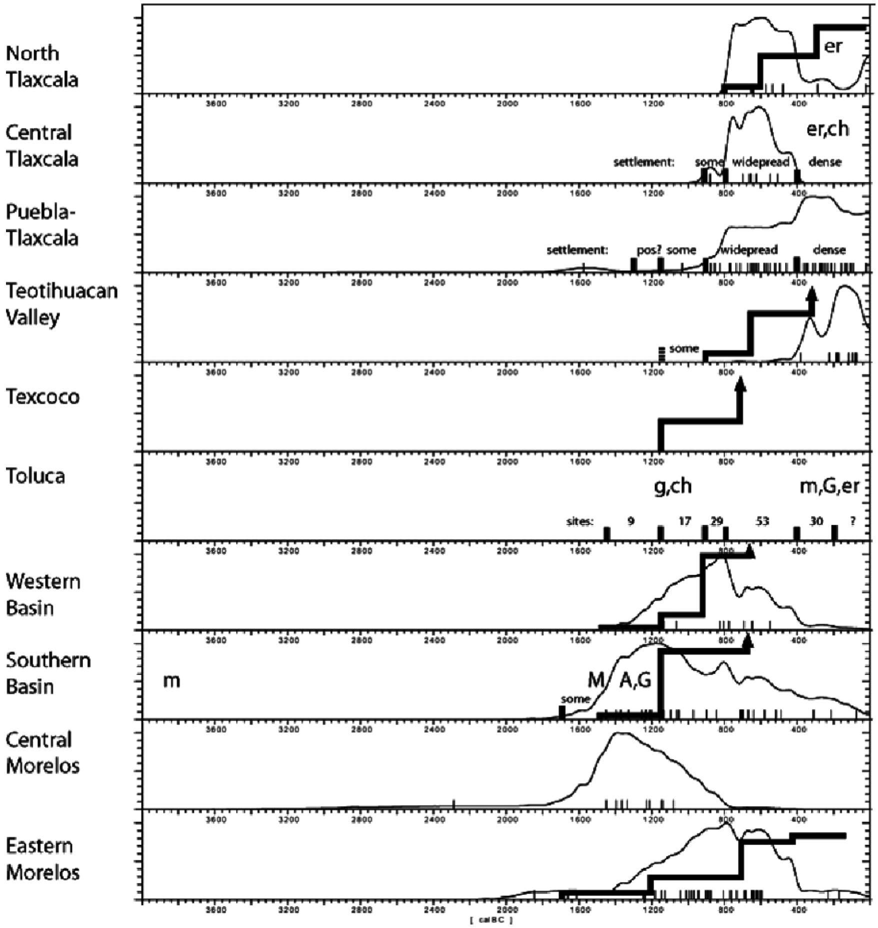

Fig. 4 Paleoecological and settlement data from 10 regions of Central Mexico. Scale at the bottom in calendar years B.C. Survey evidence in heavy lines superimposed on summed radiocarbon probabilities (see text). Paleoecological evidence summarized by region using the following letter codes: *a/A* some decline/dramatic decline in arboreal pollen; *g/G* some rise/dramatic rise in disturbance taxa pollen; *m/M* trace/significant presence of maize pollen; *ch* increased input of charcoal particles. Settlement data are from: Garcia Cook and Merino Carrión (1997a), García Cook (1981), González de la Vara (1999), Hirth (1987), Merino Carrión (1989), and Sanders et al. (1979)

and an increase in the input of charcoal particles are recorded at about the same time and interpreted as evidence of initial deforestation (Caballero et al. 2002; Lozano García et al. 2005). An increase of erosion, a peak in Cheno-Ams, and the first identified maize pollen appear later, around 50 B.C. In central and northern Tlaxcala, farmers had no appreciable sedimentary impact on the landscape until after 400 B.C. (Borejsza 2006). These patterns are consistent with a synthesis of evidence from highland lakes all along the Neovolcanic axis of central Mexico, including areas to the east and particularly west of our macroregion (O'Hara et al. 1994:971).

Initial anthropogenic erosion occurred between 1650 and 1150 B.C., often with the first appearance of maize. More severe erosion occurred sometime between 550 B.C. and A.D. 750.

Turning to the settlement evidence, the data suggest a Formative wave of advance playing out over 600–800 years. The pattern has been clear in its outlines since the Basin of Mexico survey (Sanders et al. 1979:183, 216–219). The earliest Formative settlement in Central Mexico was in Morelos and the Southern Basin (also Southern Puebla, not considered here). Settlement in the Toluca and Puebla-Tlaxcala Valleys as well as the Western Basin followed, by 100–300 years. Movement into the rest of the Basin of Mexico and into central and northern Tlaxcala followed in the next few centuries. While the advance seems clear, the pace was slow (Tlapacoya to Teotihuacan 0.14 km/yr, Nexpa to Teotihuacan 0.37 km/yr, Chalcatzingo to Moyotzingo no more than 0.33 km/yr). These values are consistent with Bellwood's (2005: Table 12.1) friction zones (0.33–0.8 km/yr) rather than his spread zones (2.5–10 km/yr).

Friction zones are characterized by interaction between farmers and hunter-gatherers, the latter expected to be present in significant numbers. Substantial late Archaic populations have *not*, however, been documented in the later-settled regions of Central Mexico. Mesoamericanists have instead tended to explain the slow advance of agriculturalists across this area in terms of altitude, rainfall, and the emergence of strains of maize adapted to high elevations (Sanders et al. 1979:369–370).

If the early farmers were at first "circumscribed" and then released by the development of strains of maize adapted to higher elevations, then one might expect to see significant early build-up of population in areas of initial settlement. The Southern Basin of Mexico arguably fits such a scenario while Morelos does not. The wider pattern seems to be relatively small populations between 1600 and 1200/1000 B.C., soaring rapidly – in both newly settled areas and regions of long-standing settlement – after 1000/800 B.C. Both Formative demography and agricultural impacts on the landscape are consistent with the local-processual scenario, as is the hint of coordination in the observation of low Early Formative and soaring Middle Formative populations almost irrespective of settlement history.

The later Early Formative population of the Southern Basin soared, as noted above. I am not inclined to see this as a demographic build-up of people waiting to be released into northern areas with improved strands of maize, however. The Manantial phase (1200–900 B.C.) witnessed the emergence of Tlapacoya as a political center (Niederberger 2000). I suspect that the high population density at that time is attributable to political dynamics, particularly "magnetic" effects of the regional center at Tlapacoya. I will note such patterns repeatedly as I turn to other macroregions.

Southern Highlands

The Southern Highlands is a rugged region with smaller valleys than those of Central Mexico. The largest expanse of farmland is in the Valley of Oaxaca

(1500–1700 m elevation), drained by the Atoyac River, which empties into the Pacific as the Río Verde. Two regions to the south are more marginal for agriculture because of lower rainfall (Ejutla) or limited availability of agricultural land (Sola). The Tehuacán Valley varies from 1700 m in the north to 600 m elevation in the south. It and the narrow Cañada de Cuicatlán just to the south are drained by rivers flowing into the Gulf of Mexico. The multiple small valleys of the Mixteca Alta rise above 2000 m, with drainages either into the Atoyac-Verde or Balsas River systems.

Survey data are available for numerous regions. In Fig. 5, I provide them as hectares occupied, numbers of sites, and/or estimated population densities. In a

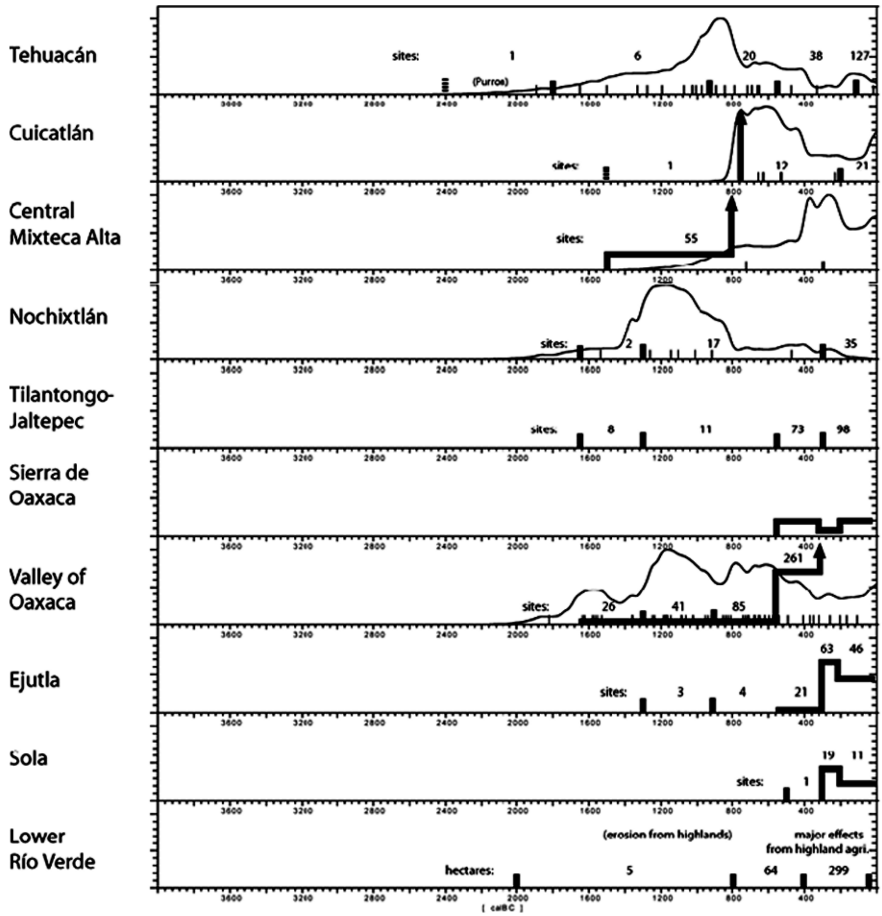

Fig. 5 Settlement data from nine regions of the Southern Highlands plus the Lower Río Verde Valley. Survey evidence in heavy lines superimposed on summed radiocarbon probabilities. Survey data are from: Balkansky (2002), Balkansky et al. (2000), Byland and Pohl (1994), Drennan (1989), Feinman and Nicholas (1990), Johnson and MacNeish (1972), Joyce (1991), Kowalewski et al. (1989), MacNeish et al. (1975), Redmond (1983); Spencer and Redmond (1997), and Spores (1972, 1983a, b)

couple of cases, population density values are not provided in the reports, but I have calculated them in a manner similar to procedures of Kowalewski et al. (1989) from population estimates (Cuicatlán) or hectares of occupation (Central Mixteca Alta). In both the cases the densities seem high in comparison to those of the Valley of Oaxaca. The numbers of sites by phase are an alternative means of comparison. Significant numbers of Formative radiocarbon dates are available only for the Tehuacán Valley, the Cañada de Cuicatlán, and the Valley of Oaxaca, but in those cases the dates accord well with the survey evidence. Again, it is the left-hand portion of the summed radiocarbon probability distributions that is of interest.

The Southern Highlands include two regions in which influential models based on what I am here calling "local-processual" scenarios were developed (Tehuacán, Valley of Oaxaca), and, indeed, the data seem to conform to such a scenario. Early Formative settlement emerged simultaneously – given current chronological resolution – between 1800 and 1600 B.C. in three areas: Tehuacán, the Valley of Oaxaca, and the Mixteca Alta. These areas of initial Formative settlement include the largest, best-watered valleys, though elevations range considerably (600–2100 m). Population densities were low in these "homelands" for centuries following the transition to the Formative. Surrounding areas tended to be drier or more mountainous, with restricted farmland, and in some cases they seem to have been settled later in the Formative: Ejutla 400 years after the initial transition, Sola and Sierra de Oaxaca more than 600 years after that. Significant settlement in Cuicatlán began 800–900 years after the Formative transition, but there was actually Early Formative (Tierras Largas equivalent) occupation in the canyon at Rancho Dolores Ortíz (Redmond 1983:63). Traces of very early occupation also appear in the coastal area of the lower Río Verde (Goman et al. 2005).

Previous investigators have suggested that Formative settlements outside the three "homeland" areas were established by immigrant farmers (e.g., Christensen 1998; Feinman and Nicholas 1990:223). It seems possible to contemplate "waves of advance," most particularly from the Valley of Oaxaca north into the Sierra de Oaxaca and perhaps Cuicatlán as well as south to Ejutla, Sola, and perhaps the lower Río Verde. However, the "wave" that most clearly emerges in the survey data is related to the formation of the Monte Alban state (beginning 500 B.C.) rather than any movement of "early" agriculturalists (Balkansky 2002; Redmond 1983; Feinman and Nicholas 1990). The far-flung traces of very early ceramic occupation are, however, worth remembering; I will return to that issue below.

Paleoecological data are limited, but seem more consistent with a local-processual framework than a two-step transition. In Fig. 5, I have noted only the work of Joyce and colleagues on the distant ecological effects of highland agriculture along the lower Río Verde drainage (Goman et al. 2005; Joyce and Mueller 1997). In the Oaxaca Valley, Schoenwetter and Smith (1986) report no evidence of deforestation due to agricultural activities up through about 2000 B.C., when their pollen records from excavations at Archaic sites tail off. In Tehuacán, McAuliffe et al. (2001) report significant anthropogenic erosion beginning during the Formative.

While a local-processual scenario seems promising, political dynamics were also at play, beginning quite early. In the Valley of Oaxaca, settlement was persistently clumped in the Etla arm of the valley for centuries after the transition to the Formative. While the Etla region was a comparatively favorable place for agriculture (Nicholas 1989:460), it seems likely that the large settlement of San José Mogote had a magnetic effect on Early–Middle Formative population distributions within the valley, delaying movement of people to adjacent areas (see Marcus and Flannery 1996:106–110).

Gulf Lowlands

I concentrate on the Southern Gulf Coast of southern Veracruz and westernmost Tabasco (the "Olmec heartland") and Central Veracruz, though I make brief reference to northern Veracruz and southernmost Tamaulipas. Formative settlement evidence is summarized in Fig. 6 either qualitatively or as densities (people/km^2). The study of early settlement is particularly difficult here because sites are buried by river sediments. The Pajonal and lower Tonalá surveys concentrated on exposed river or canal banks. There is a good correspondence between summed radiocarbon probabilities and survey evidence in three of the regions for which C14 dates are available. In the Tuxtlas, an early spike in the radiocarbon distribution can be ascribed to Arnold's (2003, 2005) dating program at La Joya, where a Middle Formative component is lacking. The early importance of the Middle Coatzacoalcos – setting for the colossal site of San Lorenzo – is evident in Fig. 6. Also noteworthy

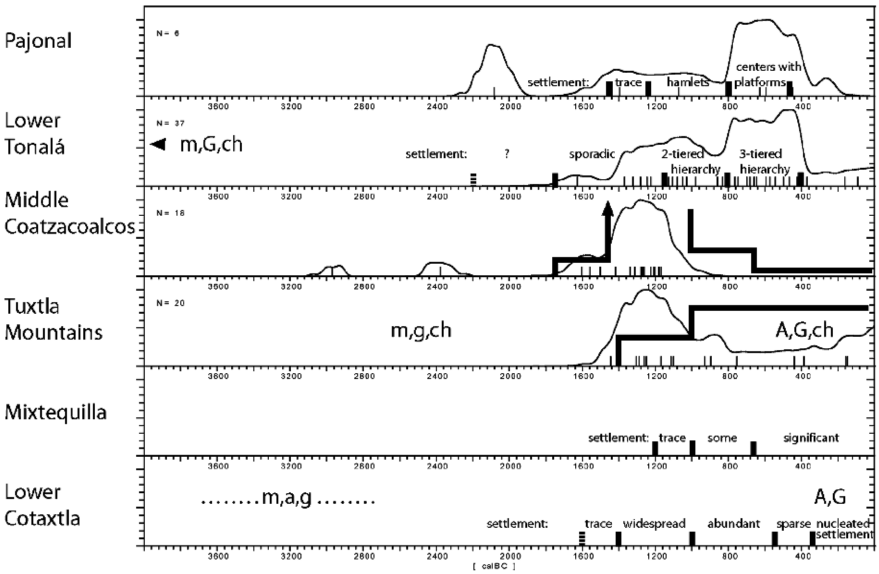

Fig. 6 Settlement data from six regions of the Gulf Lowlands. Survey evidence in heavy lines superimposed on summed radiocarbon probabilities. Paleoecological evidence summarized by region using letter codes (see caption for Fig. 4). Survey data from: Daneels (1997), Santley and Arnold (1996), Santley et al. (1997), Stark (1991), Symonds et al. (2002), and von Nagy (1997)

is that in this macroregion the right-hand portion of the radiocarbon curves seems in several cases to be “real” – not an artifact of my method of collecting the dates. Sharp rises in population are, at the regional level, often followed several centuries later by equally sharp declines. As Pool (2005) points out, the peaks in different regions do not coincide: the population crash along the middle Coatzacoalcos is prelude to the sharp increase along the lower Tonalá and the Pajonal. Those areas in their turn go into decline as Tres Zapotes expands in the later Formative. Daneels (1997:213–216) suggests that two population peaks along the lower Cotaxtla are separated by a period of “sparse” settlement in the later Middle Formative.

In contrast to the two highland cases reviewed above, paleoecological data are consistent with the two-step scenario for the transition to agriculture. Data derive from a lake near the lower Cotaxtla survey area (Sluyter and Dominguez 2006), Laguna Pompal in the Tuxtla Mountains (Goman and Bryne 1998), and the archaeological site of San Andrés within the lower Tonalá area (Pope et al. 2001). In each case there is an impact on the landscape by human food producers well before the advent of the Formative. Near Cotaxtla, the appearance of maize pollen corresponds with a decrease in arboreal pollen and an increase in grasses at either 3800 or 2700 B.C. On the lower Tonalá, maize pollen appears and spikes in grass pollen and inputs of charcoal indicate extensive forest clearance by 4800 B.C. In the Tuxtlas, maize pollen appears around 2880 B.C., accompanied by a rise in grasses and a single thin layer rich in charcoal; continued inputs of arboreal pollen, however, indicate that the forest was not significantly impacted. In both the Tuxtlas and Central Veracruz, much more serious effects of agriculture are registered in the later Formative, after 600 B.C. (Goman and Bryne 1998:86; Sluyter and Dominguez 2006:1149).

The settlement histories in Fig. 6 have something of the character expected of a wave of advance emanating from a “homeland” along the Coatzacoalcos River, but the balance of evidence does not favor such an interpretation. Traces of Early Formative settlement are noted along the lower Cotaxtla, further from the “homeland” than Mixtequilla. In northern Veracruz, Early Formative settlement has also been documented at Trapiche/Chalahuite (García Payón 1966) and on the lower Pánuco (Merino Carrión and García Cook 2002). The transition to the Formative itself left no impact on the paleoecological record. Finally, the dramatic rises and declines of population at the regional level suggest that the effects of political dynamics on settlement patterns are stronger here than in the other macroregions under consideration. I see the apparent preeminence of the Middle Coatzacoalcos as an indication that San Lorenzo attracted population from a wide swath of the surrounding landscape.

For the transition to the Formative in this area, a combination of the two-step, localized-transition, and political dynamics scenarios seems indicated. Wilkerson (1981) some time ago identified Santa Luisa in northern Veracruz as a sedentary, preceramic settlement. Archaic components have now been documented in the Cotaxtla, Tonalá, and Pajonal areas (Daneels 1997; Pope et al. 2001; Pohl et al. 2004; von Nagy 1997). It is also now clear that Archaic populations cleared forests and grew maize hundreds or even thousands of years before the Formative, consistent with the two-step scenario. Subsequent transitions to the Formative appear localized, particularly once the likely effects of political dynamics are taken into consideration.

Maya Lowlands

The final macroregion is particularly large, and the settlement data are not strictly comparable to the other cases (see Santley 1990:330–336). I have targeted a few regions and relied on prior syntheses rather than raw data. The generally flat and tropical Maya Lowlands extend from Central Guatemala through the Yucatán Peninsula, with the north much drier than the south. Rain drains into limestone bedrock and there are significant rivers only toward the south. Ground surface visibility is nothing like it is in the semi-arid highlands, but, alternatively, deep burial of sites is not an issue in most areas. Surveys have focused on surface mounds and architecture. The data produced emphasize later time periods. In Fig. 7, I simply mark the beginning of the earliest ceramic phase.

Radiocarbon dating in the area has a checkered history. The dating of Cuello in northern Belize was particularly problematic; I include only post-1976 dates (Andrews and Hammond 1990). Aside from a few remaining anomalously early

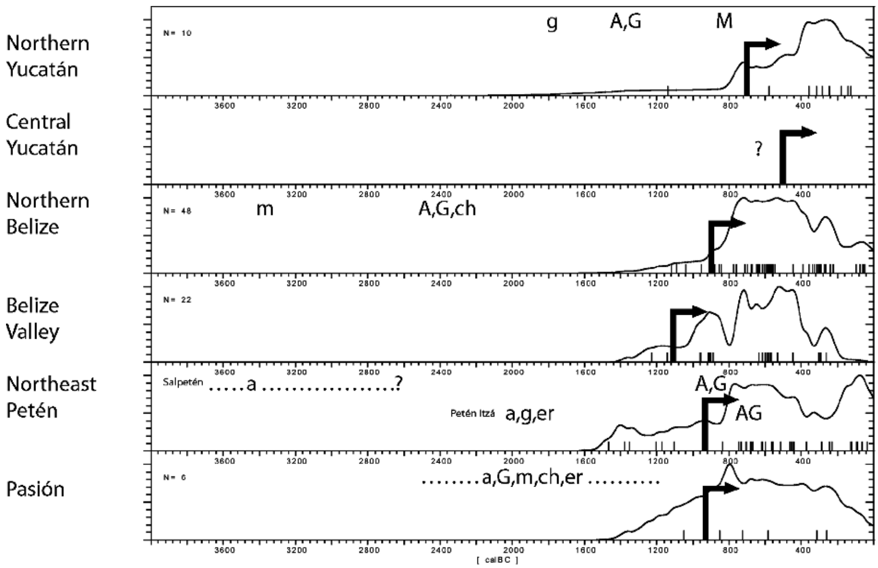

Fig. 7 Abbreviated settlement data from six regions of the Maya Lowlands. Heavy arrows superimposed on summed radiocarbon probabilities indicate the earliest ceramic occupation (based on syntheses in Adams ed. 1977; Andrews 1990; Clark and Cheetham 2002; Clark et al. 2000). Paleoecological evidence summarized by region using letter codes (see caption for Fig. 4)

dates, the radiocarbon distributions accord reasonably well with investigators' syntheses of the chronology of early settlement. Those syntheses rest fundamentally on detailed ceramic analysis.

Earliest ceramics are later than in other cases and models of the transition to the Formative here have emphasized population movements (Andrews 1990:2–5). Recently, a sizable preceramic Archaic occupation has come to light in Belize. Iceland (2005) argues against population replacement between the late preceramic and early ceramic occupations in northern Belize. Clark and Cheetham (2002) and Cheetham (2005) suggest population continuity across the Archaic/Formative divide also in the Belize Valley, northeastern Petén, and the Pasión area. Thus, after decades in which agricultural colonists from the south or west were thought to have brought Formative lifeways to the Maya Lowlands, the situation is now less clear in four of the six regions considered here. In the others – northern and central Yucatán – the seemingly rapid spread of ceramics with links to the Mamom sphere still seems amenable to interpretation as the movement of agriculturalists colonizing vacant terrain (Ball 1977:106–109). Ceramic crossties lead Andrews (1990:14–15) to postulate two episodes of expansion. The first, at around 700–650 B.C., began near the Pasión region and took a route from the Usumacinta up the western side of the peninsula. The second expansion, from northern Belize and northeastern Petén into central Yucatán, would have occurred several hundred years later.

Claims for continuity rather than Formative colonization are best worked out in northern Belize. Only in that region is there evidence for significant preceramic populations in the second millennium B.C. Paleoecological data are important, since they point toward a "two-step" scenario in which deforestation and agriculture preceded pottery by more than a millennium (Jones 1994; Piperno and Pearsall 1998:299–308). For instance, pollen from the Cob3 core registers a dramatic fall in high forest trees and a rise in Cheno-Ams, associated with a rise in the concentration of charcoal particles, at around 2500 B.C. (Pohl et al. 1996:361–363).

How believable are the other claims for population continuity from Archaic to Formative? Given chronic problems with locating Archaic occupations across Mesoamerica, the abundant paleoecological evidence from this area is an attractive resource. Extrapolating from the case of northern Belize, we might expect Archaic–Formative population continuity to have involved human ecological impacts prior to the Formative. Where agriculturalists moved into a vacant landscape, on the other hand, we would expect evidence for human disturbance to correspond with or post-date the earliest local Formative.

Unfortunately, the paleoecological data do not allow resolution of the issue. First, dating of the cores is complicated by "hard water lake error" in which redeposited, C14-free carbon from limestone makes dates on bulk sediment samples problematic (Leyden et al. 1998:116–117; Vaughan et al. 1985:74). (I have not considered studies that use archaeological preconceptions about the settlement sequence to date zones within the cores.) Second, there are hints in several studies that climatic variability might be a factor in the period of interest (Leyden 2002:95–98; Brenner et al. 2002:148–151).

I have nevertheless summarized relevant data in Fig. 7. Limited evidence from Laguna Tamarindito in the Pasión area (Dunning et al. 1998) appears to indicate agricultural impacts hundreds of years (if not a millennium) before the appearance of pottery. Evidence for deforestation in the lakes district of northeastern Petén also precedes the earliest ceramics, but "debate continues over whether this initial reduction of forest represents climatic or cultural effects on the vegetation" (Leyden 2002:94). Noted in Fig. 7 are studies by Rosenmeier et al. (2002) of Lake Salpetén and Curtis et al. (1998) of Lake Petén Itzá. There is in each case a gradual reduction of the forest in the centuries before the earliest local Formative. Dramatic deforestation, though, seems associated with Formative rather than Archaic occupations. If the earlier reductions were climate driven, then the paleoecological evidence here could fit a model involving early agricultural colonists.

The timing of agricultural impacts in northern Yucatán is of particular importance, but appears uncertain. Cores from Cenote San José Chulchaca in far northwestern Yucatán – an area with little prehispanic human activity – show plausible evidence of a drying trend after perhaps 1800 B.C. (Leyden 2002:95–96). A core in Lake Cobá in eastern Yucatán (at the center of a large archaeological site of the same name) revealed evidence of increased grasses and a rapid decline in trees/shrub pollen at around 1650 B.C. (based on interpolation between 850 B.C. and 4690 B.C.). However, maize pollen appears only later (ca. 850 B.C.) and the whole dating scheme involved elaborate adjustments for hard water lake error relying on parameters extrapolated from a study at Lake Punta Laguna, 20 km away (Leyden et al. 1998:116–117). Given uncertainties in the dating as well as the possibility of climatic drying in the period of most interest, the issue of agricultural impacts in northern Yucatán predating documented Formative occupation must remain unresolved.

If we accept, provisionally and hypothetically, a combination of the models offered by Andrews (1990) and Clark and Cheetham (2002), several insights relevant to the demic expansion model follow. Let us postulate that localized transitions to the Formative occurred between 1100 and 900 B.C. in Belize, northeastern Petén, and the Pasión area, whereas the northern Yucatán was colonized after 700 B.C., by agriculturalists moving from the Usumacinta region up the western part of the peninsula. A rate of expansion in the latter case across the 510 km from Altar de Sacrificios (c. 900 B.C.) to Komchén (c. 700 B.C.) would be about 2.6 km/yr. This is an order of magnitude greater than rates calculated above for the Basin of Mexico and is well within the range Bellwood (2005: Table 12.1) would expect from a spread zone involving movement into vacant or sparsely populated areas – just the situation postulated by Andrews (1990) and Ball (1977) in early first millennium B.C. Yucatán.

Still, the successful match between the demic-expansion model and local reconstructions would also appear to depend on historical contingencies. If we brought agriculturalists from Cahal Pech on the Belize River, the rate would fall to 1.1 km/yr, below Bellwood's range for spread zones. Even worse, if we were to choose instead migration from the closest edge of the Gulf Lowlands, agriculturalists expanding at

2 km/yr should have gotten to Komchén before 1200 B.C. Could this be yet another case in which political dynamics – the attraction of all that was going on at San Lorenzo – hindered demic expansion?

Direct Comparison of Macroregions

The radiocarbon evidence has been of interest because dates from one area can be compared directly to those of another. If one accepts the idea that summed radiocarbon probabilities might approximate population histories, then this source of evidence becomes valuable in assessing big-picture claims about Mesoamerican culture-history. Pooling dates within each macroregion allow me to return to a question with which I began: by importing demic expansion to Mesoamerica, do we risk getting caught up in local debates?

If we were to uncover evidence that population expansion was early in the Gulf Lowlands, demic expansion might find itself dancing with the *cultura madre*. Alternatively, highland or lowland priority would involve us in another ongoing debate. What sort of timing between macroregions would be most friendly to a model of demic expansion? The appeal to language distributions (Fig. 1) helps fix expectations. The Southern Highlands and the Maya Lowlands correspond to the areas in which Bellwood expects demic expansions of proto-Otomanguean and Mayan speakers, respectively. The history of language distributions in the Gulf Lowlands is complicated, but it might have been part of any expansion of proto-Mixe-Zoquean speakers. Finally, Central Mexico could have been something of a friction zone on the interface of Uto-Aztecan and Otomanguean expansions (Bellwood 2005:239). If we take observed language distributions to indicate that expanding populations in each of these locations did not overrun the others, then the expansions would have had to unfold concurrently. The timing of population increase should be similar between macroregions.

Methodological Issues

The right-hand portions of the individual curves in Figs. 4–7 were problematic because my radiocarbon database cuts off sometime between 400 B.C. and A.D. 1. To compare macroregions, I experimented with ways of eliminating those later dates and eventually decided to consider some set number of the earliest dates in each area. If we assume that more dates mean more people, then dates bunched together mean many people living in a short span, while dates spread out over a longer time indicate fewer people. Figure 8 incorporates the earliest 70 dates from each macroregion. The form of the curves and ranges of the dates with high probabilities vary. Much of that variability, though, seems related to bunching or dispersal of dates after 1000 B.C. – the effects of Formative political dynamics. The 40-date version in Fig. 9 avoids political and demographic vicissitudes after 1000 B.C. and the ranges

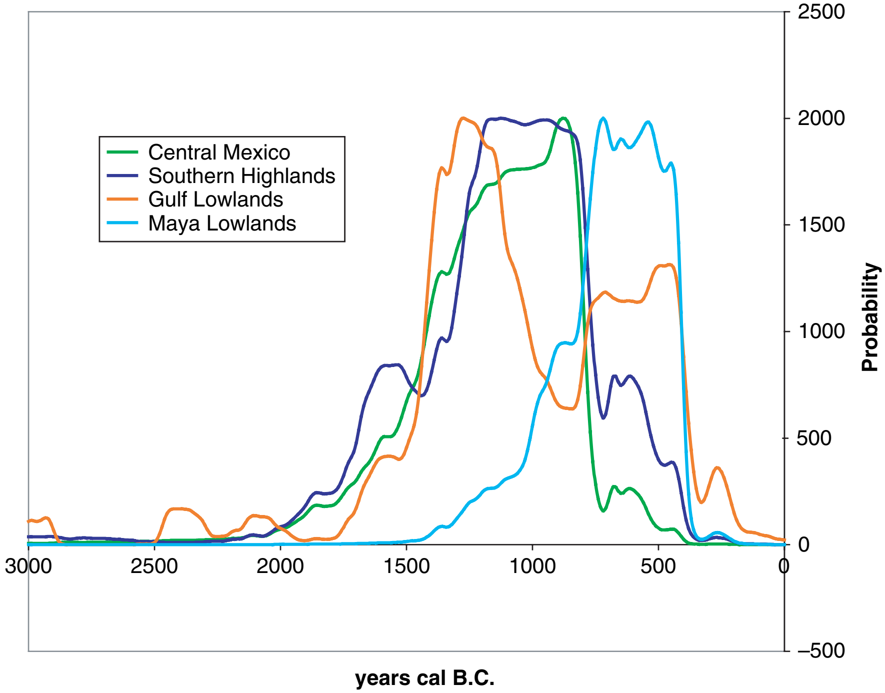

Fig. 8 Summed probabilities of the earliest 70 radiocarbon dates in each macroregion

of dates turn out to be very similar for the three areas with early settlement. My discussion focuses on the Fig. 9 curves.

The Cultura Madre *Debate*

I expected that radiocarbon dates would indicate an early population rise in the Gulf Coast. That proves not to be the case. The summed radiocarbon distributions for the Southern Highlands, the Gulf Lowlands, and Central Mexico are very similar. Taking the curves as rough proxies of population, there is a modest early population spike at 1600/1500 B.C. in the Southern Highlands. The prominence of this preliminary spike may be in part a function of the intensity of work at San José Mogote in the Valley of Oaxaca. At any rate, a more modest preliminary plateau is identifiable in the same range in the Gulf Coast and Central Mexico. If these preliminary plateaus reflect an era of established farming communities, its emergence was virtually simultaneous in the three macroregions. After this initial plateau, the curves all soar rapidly and essentially simultaneously, providing support for the currently popular view that Archaic populations in at least some parts of these macroregions underwent transitions to the Formative around the same time (1700 ± 100 cal B.C.), without significant movements of people on scales larger than the macroregion.

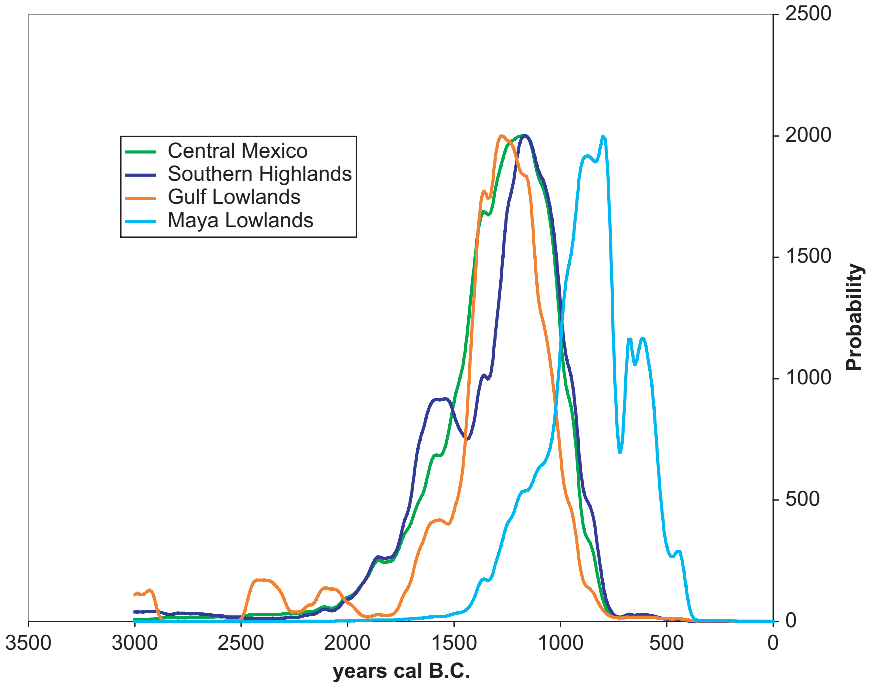

Fig. 9 Summed probabilities of the earliest 40 radiocarbon dates in each macroregion

Highlands Versus Lowlands

A second topic of debate among Mesoamericanists has been whether processes leading to the establishment of agriculture and village life were different in lowland tropical forests as opposed to the semiarid highlands – or even whether one of those zones held priority over the other. Paleoecological evidence seems to indicate that in both Gulf and Maya Lowlands, deforestation by food producers preceded the transition to the Formative (though the possibility of climatic drying has been raised in the latter case). Data from the Southern Highlands, Central Mexico, and elsewhere along the Neovolcanic axis point instead toward human impacts on the landscape only *after* the transition to the Formative. There does seem to be a lowland/highland divide in the success of the two-step scenario.

In the Maya Lowlands section, I suggested that deforestation before the Formative might signal significant Archaic populations. Can that sort of argument be extrapolated to other areas, and might it point toward a differential distribution of Archaic populations between lowland forests and semiarid highlands? Piperno and Pearsall (1998:313–314) seem to suggest something along those lines when they emphasize the relative marginality of Tehuacán, Oaxaca, and Highland Central Mexico in the development of "effective" food production. Figure 9, however, suggests very similar demographic trajectories in three macroregions. If there had been a significantly larger Late Archaic demographic base in the Gulf Coast, we would surely have expected more rapid expansion of Formative populations in that area. Obviously, also, early deforestation in the Maya Lowlands is actually associated with a tardy transition to the Formative. My database, however, does not yet include Archaic dates from Belize. When those are ready, it will be interesting to see if they are bunched toward the very end of the local Archaic to suggest a "pre-pottery Formative."

While there is support for a two-step scenario in the lowland but not the highland regions considered (as pointed out previously by Piperno and Pearsall (1998)), the processes behind the lowland/highland divide are not clear. The divergent patterns may relate to a different mix of subsistence strategies that did not translate into different demographic trajectories. In that case, lowland/highland differences would not constitute any particular threat to the demic expansion model.

Results

The radiocarbon curves suggest that it is possible to import the universalized culture-history of early farming dispersal to Mesoamerica without getting tangled in big-picture local debates. It is noteworthy that three of the cases considered fit the expectation of rough simultaneity, while, one case, the Maya Lowlands, does not. That observation nudges us back to the issue raised by Wylie (2002): can a demic expansion model conform with local culture-history?

The Macroregional Syntheses Compared

The macroregional syntheses provide a basis for assessing Wylie's concerns. My conclusions pull two ways. On the one hand, there is evidence of the sort of processes championed by the model of early farming dispersal at scales predicted by the model. On the other hand, that model *alone* cannot make sense of culture-historical patterns at the macroregional scale.

In terms of my four generalized scenarios, waves of advance suggest demic expansion, while the two-step, local-processual, and political dynamics scenarios complicate matters in a variety of ways. The two-step scenario may be appropriate in the Gulf Coast and the Maya Lowlands, but I have just argued that early slash-and-burn agriculture does not seem to have given lowland areas a demographic leg-up. Focusing, therefore, on the Formative transition, we see no good evidence for a wave of advance in the Gulf Coast, where a combination of a local-processual scenario and political dynamics involving cyclical clumping and dispersal of populations seems most promising. While there is little role here for the model of demic expansion, the expected territory of any expansion by proto-Mixe-Zoque-speaking farmers is muddled by the complicated linguistic history of this area. The transition to the Formative in the Maya Lowlands has long been interpreted in a manner more clearly amenable to demic expansion, but that framework has recently been challenged for Belize and parts of the Petén. If we accept these new interpretations, then the applicability of local-processual scenarios is expanded in those areas. In northern and central Yucatán, colonization by early farmers is still likely, with a rate of expansion appropriate for a spread zone if we accept the "homeland" identified by local ceramic specialists. This good news is tempered, though, by the puzzling realization that proto-Mixe-Zoque-speaking farmers, expanding at that same rate from the Gulf Lowlands, should have been able to colonize northern Yucatán 300 years before the Maya.

The complications of the two-step scenario do not arise in the highland macroregions. Mesoamericanists have long identified a wave-of-advance in Central Mexico, with farmers filtering to the north over the course of 600–800 years. The problem is the pace of that expansion. Although the rate of spread is on the low end for friction zones, there is no evidence of significant hunting and gathering populations in the areas into which agricultural settlers were moving. Mesoamericanists explain timing of the spread by reference to environmental factors rather than resistance by hunter-gatherers. As in the Gulf Lowlands, political dynamics also seem to have been a factor from very early, leading in this case to a concentration of people in the Southern Basin.

The Archaic-Formative transition in the Southern Highlands has been interpreted with local-processual and political dynamics scenarios. Recurring themes in homegrown accounts are that the transition to the Formative took place in various locations around the same time, that these local populations were small for hundreds of years after the transition to the Formative, that population growth accelerated dramatically later in the Formative in the context of state formation, and that a colonizing wave of advance at that time entered areas that were in some cases vacant but which in other cases had supported tiny Formative populations for centuries. There appears to be empirical foundation for all these themes, and it is not clear how an early farming dispersal scenario could be injected. One option would be the observed Middle–Late Formative wave, but a classification of the colonists involved as "early farmers" would seem dubious and there is the issue of the tiny ceramic-using populations in far-flung places centuries before the arrival of the "wave." The other option, of course, would be to see that sparse, widespread Early Formative occupation as resulting from a truly early wave of agricultural colonizers. One would then be faced with explaining why the demographic character and consequences of this wave of farmers differed so much from those of the spread into Northern Yucatán: in the former case, populations were tiny and persisted with low visibility for centuries, whereas in the latter case colonizers were highly visible and apparently multiplied rapidly. No doubt we could produce hypotheses that would account for this difference – different expansionary potential of crops or technologies – but one can see why Mesoamericanists have opted for a different approach, explaining tiny, disbursed Early Formative occupations across the Southern Highlands as a result of multiple, localized transitions to Formative lifeways.

What, then, do we find when we bring the model of demic expansion into confrontation with culture-history at macroregional scales? There does not appear to be any serious disjunction of scales. The predicted pattern – a wave of advance – is identifiable in Central Mexico, the Maya Lowlands, and arguably the Southern Highlands at the scale predicted when the model is applied to Mesoamerica by appeal to later language distributions. The problem is that each wave or possible wave is distinct. They involve different rates of expansion, different densities of people, different sociopolitical conditions, and different demographic consequences. Further, each of our other generalized scenarios is relevant in more than one macroregion. Of particular note is the repeated success of themes associated with local-processual and political dynamics scenarios. Populations everywhere seem to have been very low for hundreds of years after the Formative transition. In the Southern Highlands and Central Mexico, populations began to soar rapidly in most areas by the mid-first millennium B.C. (a "UDT"? see next section). In those areas and the Gulf Lowlands, certain centers seem to have attracted people – delaying the infilling of a still pretty open landscape – from as early as 1500 B.C. The challenge for the model of demic expansion at the macroregional scale and below is not that other factors seem to have been at play – any generalizing scheme expects as much – but that these other factors seem to have been so important.

Searching for the NDT in Mesoamerica

The strategy of relative chronology enlisted to reveal the NDT, relies on culture-historical synthesis. It thus acquires a variety of larger resonances, and it is those I have been concerned with here. At a general level, my results are good news for the pursuit of the NDT in Mesoamerica. It seems reasonable to focus on the very visible transition to the Formative as dt = 0 and possible as well to avoid local culture-historical controversies. There is a reasonable correspondence between the scale of observed "economic shift fronts" and expectations based on the demic expansion model. The shift to agriculture was essentially simultaneous (1700 ± 100 cal B.C.) in the "heartlands" of three of the four areas considered.

At another level, however, my results highlight significant challenges associated with the strategy of relative chronology, especially when it is applied to settlement evidence (e.g., Bandy 2005). On what spatial scale should we trace the "economic shift front"? Do we set dt = 0 as 1700 B.C. for the entire macroregion of, say, Central Mexico or does the Formative wave of advance across the area over the span of 800 years count as the "front" of an economic shift?

That unresolved question leads to my final point: that relative chronology should only be applied with sober attention to possible confounding effects of spatial scale and history. Figure 10 illustrates the problems. I have analyzed cases from the Southern Highlands using an approach introduced by Bandy (2005 and this volume) to reveal a "two-stage" NDT in survey data from Mesoamerica and South America. In the top chart, the entire Valley of Oaxaca – a case considered by Bandy – is shown in bold, against its constituent subregions. Results are calculated by phase, making the curves a series of horizontal plateaus. Because the formula for calculating population growth involves dividing the estimated population of each phase

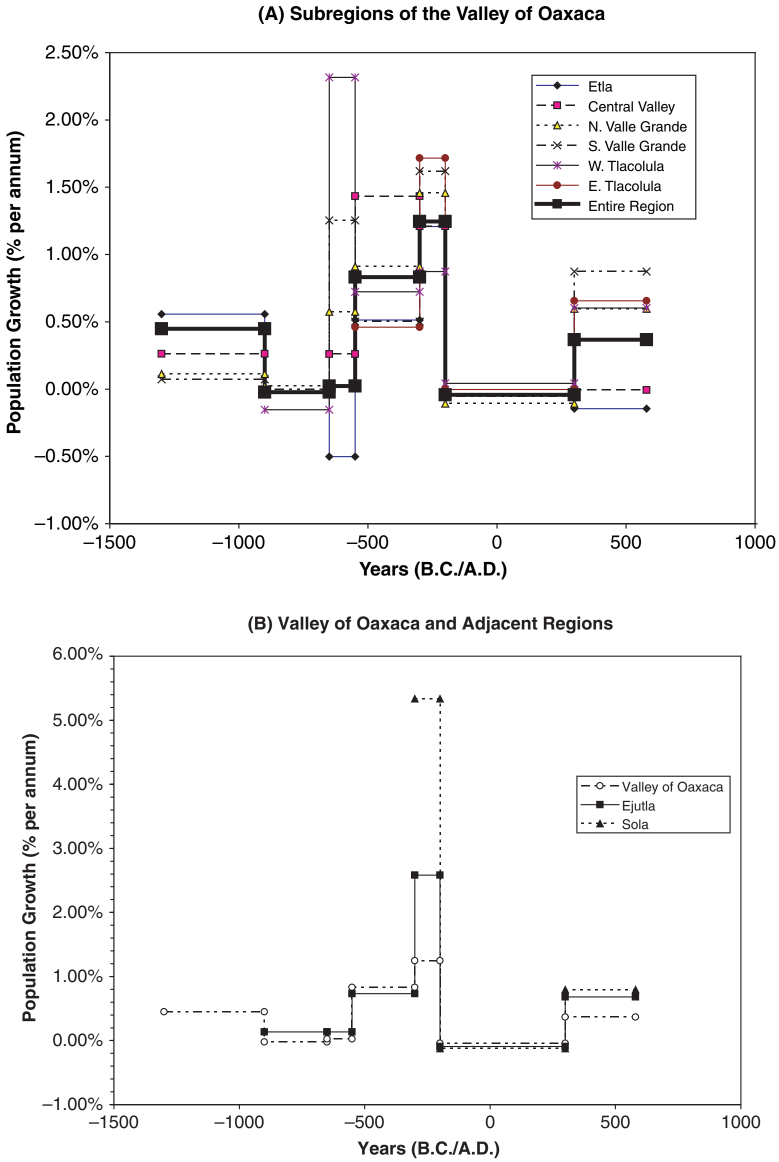

Fig. 10 Scale, history, and the NDT. (**A**) Population growth in the Valley of Oaxaca (*in bold*) compared to its constituent subregions, across absolute time. (**B**) The Neolithic Demographic Transition dwarfed by the "Urban Demographic Transition"? Population growth in the Valley of Oaxaca compared to the neighboring Ejutla and Sola areas, also in absolute time. Calculated from data in Feinman and Nicholas (1990: Table 1) and Balkansky (2002: Table 2.6) using the method described by Bandy (2005)

by the population of the previous phase, each curve begins with the *second* local Formative phase. A high initial Formative population growth rate with subsequent slowing appears, just as noted by Bandy (2005). Still, running the clock further and using an absolute chronology reveals a greater subsequent surge, a point I return to in a moment. My main point with the first plot is to emphasize the importance of spatial scale in any search for demographic patterns among survey data. During all three episodes of elevated population growth in the region as a whole, there is great variability in the rates of growth between subregions. Political dynamics appear to have been affecting the distribution of people across the landscape. If people tended to migrate to centers of sociopolitical florescence (as I have repeatedly suggested for early Mesoamerica), then we need to choose our analytical scale with care if we are interested in treating population growth rates inferred from settlement data as proof of a demographic transition. The initial bump in population growth in Oaxaca (the NDT) is a case in point. There is a hint of a two-staged NDT in all subregions, but the magnitude varies considerably. Much of what is observed, valley-wide, as a robust NDT is driven by the high population growth in one subregion (Etla) and, within that area, one site (San José Mogote).

I have noted repeatedly how the focus of regional specialists investigating Formative demographics in the Southern Highlands has been the era of urbanization beginning around 500 B.C. rather than the earlier transition to the Formative. There seems a sound basis for that focus even when we shift from the population densities of Fig. 5 to growth rates in Fig. 10. The NDT appears, but it seems rather more modest than the UDT ("Urban Demographic Transition") that began 1100–1200 years after the transition to agriculture. Although this UDT is surely of interest in and of itself, its presence in the local sequence helps to emphasize the importance of caution in any shift from historical to relative temporal scale. The bottom chart of Fig. 10 is a comparison of the Valley of Oaxaca to the two neighboring regions in absolute time. The two-stage demographic blip of the NDT in Oaxaca is identifiable at left, but it pales beside the UDT. Both the Ejutla and Sola curves reveal a two-stage demographic transition in the centuries after the local initiation of Formative occupation – but use of an *historical* scale reveals that what is observed in those two cases is the UDT, not the NDT. Use of a relative chronology to align the earliest Formative in the three areas would obscure important historical relations among them.

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An Alternative Approach in Tracing Changes in Demographic Composition

The Westward Expansion of the Neolithic Way of Life

Mehmet Özdoğan

Abstract The dispersal of the Neolithic way of life from the place of its origin to other regions and the way this was achieved is one of the most debated, but at the same time challenging, problems of Neolithic archaeology. To resolve this problem, numerous contradictory models, ranging from local developments to demic movements have been suggested. No matter how contradictory these models are, their verification would, in each case, depend on proving whether or not there has been a demographic shift from one region to the other. Thus, understanding the demographic structure of both the primary and the secondary zone of neolithisation becomes essential in answering the question. This, evidently is also intermingled with the problem why there was a decline in the population at the core area by the end of the Pre-Pottery Neolithic Period.

Keywords Neolithic package · migration · cultural interaction · core · periphery · Turkey

The Neolithic way of life began and evolved in certain parts of the Near East for several millennia without having a notable influence on neighbouring regions. It is only by the first half of the seventh millennium BC that the Neolithic way of life made a sudden appearance in the western parts of the Anatolian plateau and soon after in the Aegean and in the Balkans. A number of different and mostly contradictory theories have been developed regarding whether the dispersal of Neolithic way of life was due to the migration of Neolithic communities or to the transfer of ideas and commodities. To resolve this debate, we have been trying to analyse the available information using various parameters, such as changing patterns in site locations, changes in settlement sizes, comparative analysis of utilitarian and non-utilitarian artefacts to understand the difference between the core area and the newly settled regions. In an overall assessment, the evidence implies that, in the initial stage there was a rather sporadic infiltration, which in time increased its pace to what can be termed as a massive migration. However, still along with the demic movement, a

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number of different happenings were taking place simultaneously that further away from the primary zone become more evident.

The Problem: Neolithic Dispersal

The main concern of this chapter is to test whether or not the appearance of Neolithic way of life in Europe was due to a demographic shift from the East, mainly from Anatolia to South-Eastern Europe. Evidently there are a number of different ways of testing changes in demography, the most conventional ones being the analysis of burials and settlement densities. Regretfully, the area to test this hypothesis, i.e. the western parts of the Anatolian peninsula and the neighbouring regions of the Balkans, constituting the contact zone between the core area of primary neolithisation and the areas where the Neolithic cultures occurred later in time is at the same time archaeologically the least explored region. Our knowledge on the Neolithic cultures of this critical zone is still in its incipiency, the number of known burials is too few and there is almost no data on the sizes of the settlements; accordingly, here we shall be trying means other than the conventional ones in answering the problem.

The beginnings of the Neolithic way of life in Europe is one of the most debated topics of European prehistory; discussions on this issue has been going on for more than 60 years, and yet no consensus has been reached either on the mode or on its pace.[1] It is evident that no easy solutions to this problem are to be expected; the difficulties encountered are not only due to the complex nature of the problem, but also more due to the tendency of implying envisaged solutions to an immensely large geography, covering almost the entire extent of Europe. Evidently, this problem is a multi-dimensional one with an immense geographical scope, incorporating diverse issues, none with easy solutions. Nevertheless, almost all of the suggested explanations, in spite of the extreme diversity of approaches, consider some sort of a demic movement from the core area in the East to the target areas in the West. Presenting even a conspectus of different views on the emergence of Neolithic way of life in Europe is beyond the concern of this chapter[2]; however, we shall just restrict ourselves in noting that, while in the early years of research the only suggested model was colonisation of Europe by immigrant farmers from the East, later, especially from 1970 to 1990, under the impact of anti-diffusionist trends, other explanations were brought up, ranging from autochthonous developments to transfer of commodities and/or technologies. Since then, there has again been a turn to the diffusionist models, though no more implying a colonial model, but hypothesising on other forms of demic movements;

[1] With the recent achievements in the field of biogenetics, the discussion has taken a new trajectory, however still with considerable controversy; see especially Bandelt (2002), Bentley et al. (2002), (2003), Gronenborn (1999) and Renfrew (2002).

[2] For a survey of different ideas and models on the neolithisation process in Europe, with extensive bibliography, see Budja (2001), Özdoğan (1996), Özdoğan (1997a), Price (2000), Sherratt (1997) and Zvelebil (2005).

however still, in spite of the active interest on this line, there is a considerable discrepancy in the meaning conveyed by various definitions, not to say in defining the models. The newly developed models (Zvelebil and Lillie 2000), including "wave of advance", "moving frontiers", "pioneer colonisation", "acculturation", "assimilation", "matrimonial dispersal", etc., have their assumptions based either on genetic, linguistic or artifactual evidence. Likewise, there is no shortage on theories in explaining why such a diffusion ever took place; possible explanations as to why such a diffusion took place range from climatic deterioration to demographic pressure, to social turbulence or pressure. Causal use of terms, usually without proper specifications, such as core, periphery, exterior or coine is yet another entity blurring the view of the overall picture. What is evident is the fact that the westward expansion of Neolithic culture coincides in time with the collapse of the Pre-Pottery culture in the east, where decline in population is also to be seen.

Needless to say, before defining the model in explaining the how Neolithic way of life began, it is necessary to reach a consensus on the implications of available concrete data. As we have already noted, there is no shortage of theories on the neolithisation process in Europe; moreover, each proposed model has its own set of evidence which are as convincing as the others, implying that the process was more complex than envisaged and that a new way of looking at the problem is needed. Even a brief survey of the relevant literature is enough to indicate that in approaching the problem there are some methodological biases; one of them, probably the most important one, is drawing cultural boundaries without understanding the underlying limits of the cultural geography. This is reflected either as overlooking the contact zones that buffered between major cultural territories or as merging distinct entities together. In this respect, considering Anatolian peninsula as a single uniform geographical unit is a rather commonly met falsification of cultural geography. Anatolia consists of diverse habitats, each covering extensive territories that are separated from each other by ranges of mountains; it is for this reason that the peninsula has occasionally been referred to as a "small continent". The impact of cultural geography is evident both at the time of Neolithic formation and during its expansion period, when the eastern, central and western parts of the peninsula were developing as totally diverse cultural entities. Likewise, considering the Aegean, the modern boundary between Turkey and Greece, also to stand for the past is another example of how cultural geography is misconceived. The actual line separating the "East" from the "West", for example during the Pre-Pottery Neolithic Period was in the Central Anatolian plateau, while during the later stages of the Pottery Neolithic, it shifted eastwards to the Taurus ranges.

Likewise, it is quite often that in discussions on the spread of Neolithic cultures, the "time depth" is distorted, overlooking the fact that the time difference between the appearance of Neolithic way of life on the west and on the east is more than 5000 years, and that the chronological denominators such as "Early Neolithic" has totally different connotations in either region. The discrepancy due to misuse of time is easier to detect than the one concerning geographic setup, except when the discussions are interweaved with complex local chronological frameworks.

In dealing with a macro-scale problem, such as the beginning and the dispersal of Neolithic way of life, there is always the danger of being lost in our own details. The trajectory of our thinking must be re-adjusted from the level of details to the level of generalisations. This of course, does not imply underestimating the significance of having detailed concrete data, but in an overall view, considering the large geographic scope of the problem, extending from the Near East to the western fringes of Europe, the bias of our own field of competence might in most cases can be a deceptive trap blurring the picture. Generalisations should have solid bases, though still accepting that when applied to the level of details, there always will be contradicting evidence. Likewise, "time" and "geography" are among the agencies, which in the case of our present subject, must be considered with due perceptiveness.

In looking at the emergence of Neolithic way of life in Europe, numerous sets of questions can be formulated depending on our regional concern; however, regardless of which part of Europe we are looking at, all answers eventually have, in some way or other, to refer to the principal question: defining role that the Near East played in this process. In dealing with this problem, it has almost been conventional to consider the problem in two distinct geographical zones, the primary zone that is the Near East and the target area, covering almost all of Europe and the Mediterranean. The bias in this approach is overlooking the impact of the interim zone, which not only provides the contact between the core and other parts, but also more significantly it is where the Neolithic package has undergone significant changes before being transferred. It then seems logical that, for a proper assessment, the immense geographic coverage that is related to the problem, extending from the Levant to Western Europe must be considered as three distinct entities, the primary zone, the interim zone and the area of later neolithisation.

The Primary Zone of Neolithisation or the "Core" Area

The primary zone of neolithisation comprises the regions where the components of the Neolithic way of life emerged and evolved without any detectable exterior interference for several millennia. Even though its boundaries, at the present stage of our knowledge, cannot be drawn with precision, nevertheless, it extends to cover all of Levant, northern Syria, Iraq, South-eastern Turkey, Central Anatolia and Cyprus. Problems related to the discussion on how Neolithic way of life ever emerged in this area, that is whether it was a local development from the preceding Epi-Paleolithic stage or not, are evidently beyond the concern of this chapter. Relevant to the subject of this chapter's discussion, the following issues should be noted:

- The components of the Neolithic way of life have appeared in this region as early as the 11th millennium BC, almost 4000 years before detectable components of Neolithic package appeared in any of the neighbouring regions, including Western Anatolia, the Balkans and the Aegean.
- The appearance of Neolithic elements in regions outside of the core area coincides more or less to a time when significant changes are occurring within the

core area, mainly the transition from Pre-Pottery to Pottery Neolithic. As extensively noted by many colleagues, this is not only a simple change in technology, but also marks, in certain areas, the introduction of herds of domestic species and a social turmoil, also known as the "Neolithic Collapse". Even though there is a lot of discussion on the details of what had happened in the core area, it is evident that, at least in some regions, there are clear signals of depopulating.

- Even if there are a number of local variants, in an overview looking from the exterior, there is a notable homogeneity within the core area; this is evidenced not only in the employment of new technologies and in the appearance of new commodities, but also more significantly in the way of life and in shared symbolic values.
- Main components of the "Neolithic package" that will be transferred to other regions in time are present in this region, either as prototypes or as already fully developed.
- Most of the colleagues specialised on the core area are not concerned with the other regions; this inevitably results in a lacuna in the discussions on the expansion of this model.

The Area of Secondary Neolithisation or the Interim Zone

The interim zone must be considered as regions where the components of the Neolithic package were not present before the seventh millennium, but appeared rather suddenly in a fully developed stage with no local antecedents, implying that the "Neolithic Package" or the "Neolithic Way of Life" has been introduced from the neighbouring core area.

Geographic limits of the interim or the contact zone are less definable than the core area; due to lack of research, at present, it is not possible to define either the northern or the western boundary of the core area. However, it is more or less clear that the principle zone of primary neolithisation must have stopped before reaching the western parts of the Anatolian peninsula. Likewise, there is no evidence from the northern parts of the peninsula; however, the presence of Late Mesolithic assemblages from the littoral areas of the Black Sea clearly indicates that the boundary of the primary zone must have been somewhere further to the south. There is no definite line demarcating the western extend of the interim zone, as it merges with area of the non-Neolithic communities in the western and northern fringes of South-eastern Europe.

Accordingly, the region that can be defined as the interim zone covers all western parts of Anatolia, the Aegean, the Marmara region and most of the Balkans. Within this region, prior to the seventh millennium BC, sites are extremely rare, and when they exist, they reflect typical Mesolithic or Epi-Paleolithic assemblages with no detectable components that can be related to the Neolithic of the core area.[3]

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[3] Evidently, from 1960s to late 1980s, with the impact of "anti-diffusionist" considerations denying any migration from Anatolia, much had been written to prove that Neolithic package of the Balkans had local origins; even though this trend is mostly gone, there still are some colleagues who see a continuum between the two stages (Kyparissi-Apostolika 2006).

- Within the area of secondary neolithisation, detecting new, intrusive elements is much easier than in the areas of later neolithisation, as there is an almost total break between traditions of the pre-Neolithic and Neolithic assemblages.
- In most of the interim zone, the sub-stratum of Final Palaeolithic or Mesolithic Era is either missing or insignificant.
- Within the interim zone, it is possible to demarcate a more specific contact zone along the western parts of Anatolia. It seems logical to surmise that the boundary of the primary zone of neolithisation fluctuated in time, thus the recovery of sporadic sites in the Aegean littoral areas of Anatolia that reveal Pre-Pottery Neolithic assemblages should not be regarded as surprising.[4] This also would further point to the significance of the interim zone in the dispersal of Neolithic elements.
- It should not be overlooked that the process of neolithisation in the core area lasted for about 4000 years before effectively expanding to other regions. This implies that, all detectable components of the Neolithic package had already fully developed before appearing in the interim zone.

The Area of Subsequent or the Late Neolithisation

Taking the term literally, it is a vast area; here within the perspective of this chapter, we connote only Central and Western Europe where the Neolithic way of life appeared, relatively earlier than many other places such as Northern or Eastern Europe. Even though there are contradictory dates from different parts of Central and Western Europe for the beginning of Neolithic period,[5] the very end of the sixth millennium would suffice the common view. The scale of Neolithic research conducted in Central and Western Europe is, incomparably greater than the other two regions. Accordingly, here there is an overflow of data which provides the means to scrutinise local cultures, an asset that is not possible in other parts. On the other hand,

- In most of Europe, from the northern parts of the Balkans to the further west, also including the coastal zones of the Mediterranean, there is a very strong Mesolithic component underlying the Neolithic horizon; numerous sites of the Mesolithic era are known with well-developed assemblages and it is also evident that Mesolithic substratum sustained up to the appearance ofNeolithic elements,

[4] The presence of an Aceramic layer in Western Anatolia and in the Aegean has been a disputed topic since Milojicic's time, on recent re-assessment of this problem, see especially Perlès (2001):64ff., Runnels (2003). Nevertheless, there is also some, but rather sporadic recent claims on the presence of pre-pottery assemblages that are notably different from those of the Mesolithic (see discussions on Özdoğan and Gatsov 1998)

[5] For an overview, see especially Gkiasta et al. (2003), Pinhasi (2003) and Price (2000).

and even possibly co-existing with it for some time (Perrin 2003). Accordingly, in the discussions related to the emergence of Neolithic way of life, it is inevitable not to have this cultural sub-stratum considered.

– There is a remarkable difference between the Neolithic packages of zone 2 and 3; firstly, all over Central and Western Europe, not considering exceptional cases, its content is reduced to minimal, only comprising basic elements, almost all non-utilitarian and/or prestige objects being absent and the symbolic ones are only very rarely present. This, considering the vast number of excavated Neolithic sites throughout Europe, in our view, is highly significant. In this respect, the differences between the primary zone and the interim zone is not that apparent; though not as abundant and as sophisticated in the primary zone, still a number of status objects are present in the assemblages of the interim zone, indicating that the specialised craftsman had also moved in and that it was not only due to the transfer of commodities.
– Even the basic components of the Neolithic package, such as the food-processing tools or lithic implements, by the time they appear in the western parts of Europe, have lost some of their authentic characteristics, thus becoming more difficult to diagnose between what is of local origin and what is introduced. This inevitably blurs the picture.
– The significance of extensive documentation, such as in Central and Western Europe in testing various hypotheses is evident; however, it is also a fact that the clarity of the picture is overshadowed by conscientious descriptions due to the presence of over-documentation. This is more evident especially in differentiating local and introduced technologies.
– Most of the colleagues working in Central and Western Europe are not well acquainted with the assemblages in the east; drawing an over-simplistic picture usually overlooks the critical evidence from the contact zone. A brief survey of literature dealing with the neolithisation process of Europe clearly indicates that the new evidence that became available during the last 25 years from the interim zone is almost totally overlooked or ignored.[6]

This all leads to the fact that, if we are to develop an understanding on the role that the primary neolithisation zone might have played in initiating the Neolithic way of life in Europe, and especially to see whether or not this was the result of a movement of people and if so to what degree, the interim zone stands as the most dependable area to test.

[6] In most of the works on the emergence and development of Neolithic in Europe, there is almost no mention of either the recent finds from Eastern Thrace, Marmara region or from the western parts of Anatolia, still referring to what had been published in 1960s, one of the most recent examples being Colledge et al. (2005). In this respect, late A. Sherratt stood as one of the exceptional scholars, who kept updated with all three regions (Sherratt 2004).

The Evidence

With this chapter, we shall only be considering the evidence from the interim zone; our approach will be looking more specifically to the evidence of the immediate periphery of the core area, which is what we consider as the principle contact zone. This, as noted above, comprises the western parts of the Anatolian plateau, the Aegean and the southern parts of the Balkan peninsula. The following points are to be noted:

(a) Scarcity of Mesolithic/Epi-Paleolithic sub-stratum

Contrary to the extensive presence of Mesolithic/Epi-paleolithic sub-stratum in Central and Western Europe, this period is either absent or very poorly represented, both in the western sections of the Anatolian plateau as well in the southern parts of the Balkan peninsula. Even if this can be considered as the result of research strategies, paucity of material of that horizon is apparent even in the most extensively surveyed areas, thus implying that whatever population was present, it was not as intensive as in the other parts of Europe. Moreover, in spite of the paucity of datable material of this early horizon, those that are known are so different from that of the Neolithic ones that defining local and introduced elements is less problematic. This, in our view, provides a much better opportunity to detect new elements.

In spite of the intensified research during the last decades, with the exception of coastal zones, there is almost no material that can safely be allocated to the Mesolithic/Epi-paleolithic horizon either in Western Anatolia, the Aegean or in Greece. More or less, the same situation is also applicable to Bulgaria south of the Balkan Mountains. As noted above, the lack of sites between final Palaeolithic up to the beginning of Neolithic, cannot be explained by lack of research, as either in the regions where intensive surface surveys has been conducted or in the caves that have been explored, these horizons are conspicuously missing. In this respect, for example, we had the possibility to see either by archaeological work or through the deep trenches of treasure hunters almost all existing caves in Eastern Thrace; we have not seen any material that can even be suggestive of the time period between the very early stages of the Upper Palaeolithic and the Neolithic. On the other hand, along the coastal areas, both along the Mediterranean (including the Aegean) and the Black Sea, there are well-defined cultural assemblages that can safely be dated to the later stages of the Upper Palaeolithic, such as the Öküzini, or to the Mesolithic stages, such as the Ağaçlı group. This of course does not exclude that in future some inland sites of that period might appear; even so, at least the lithic assemblages of the known coastal sites are so distinctive and different from the succeeding Neolithic cultures that, there is no risk, like in the case in other parts of Europe, in deciding whether a certain tool type of a technology is of local origin or introduced. Accordingly, discontinuity between the pre-Neolithic and the actual Neolithic sequences is apparent (Runnels 2002).

It is a fact that the western parts of Turkey has not been extensively surveyed and that yet there is a considerable lacuna in our knowledge considering the early prehistory of the region. However still, there are certain regions where a number of surface surveys, mainly oriented to the early prehistory, have been conducted. In this respect, besides general surveys[7] by J. Mellaart (Mellaart 1961), D. French and R. Meriç, the following should be considered among the regions that have been as more or less intensively surveyed[8]:

a) The Lake District, mainly the basins covering the catchments areas of the Burdur, Isparta, Eğridir and Beyşehir lakes (Özsait 1991)
b) The high plateau and basins along the Eskişehir-Kütahya region (Efe 2005)
c) The region around the gulf of İzmir (Peschlow and Gerber 2004)
d) The Troas Region
d) The Gelibolu Peninsula
f) Eastern Thrace
g) South-eastern parts of the Sea of Marmara, mainly the İznik, Yenişehir, Bursa and Bandırma basins
h) The valley of the Büyük Menderes River and its tributaries (Günel 2005; Erkanal 1999)

In an overall assessment of these surveys, sites that can be safely attained to the Final Palaeolithic and Epi-Paleolithic period with the exception of the very controversial site of Baradız (Kansu 1945) by the Burdur basin are all located along the coastal areas of the Mediterranean, the Aegean, the Sea of Marmara and the Black Sea. According to these surveys, there is a notable cluster in and around the Gulf of Antalya and on the coastal dunes on either side of the Bosporus (Gatsov and Özdoğan 1994). However, considering that the coastal strip of the Final Paleolithic/Epi-Paleolithic horizon must be submerged due to the rises in the sea levels (Andel and Shackleton 1982), it is evident that the actual density of coastal sites must have been much higher than as known. The distribution of Final Palaeolithic and Epi-Paleolithic/Mesolithic sites in Greece[9] and in the Aegean islands, presents an almost similar picture to that of Western Anatolia (Runnels 2001). Sites that preceded Neolithic are mainly along the coastal areas, seemingly more common on the littoral areas overlooking the Adriatic Sea. Withholding the fact that there is a general deficiency of surveyed areas, both Greece and Turkey present a similar picture, implying that there was a very low density of Mesolithic population in the region. Needless to say, the reasons beyond the paucity of Mesolithic settlements in this area is beyond the scope of this chapter (Özdoğan 1997b).

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[7] An extensive bibliographic reference to most of the surface survey reports can easily be found in almost any handbook on Anatolian prehistory; here we shall only be noting the references to some recent ones.

[8] An overview and references to detailed assessments of our surveys covering Eastern Thrace, the Gelibolu Peninsula, Southern Marmara and the Troas are to be found in Özdoğan (1999).

[9] See also Perlès (2001), Figs. 2 and 1 as it shows all sites that have been associated to the Mesolithic period in Greece, even including the controversial ones; as indicated in the map, with the exception of Theopetra cave, all of the sites are on the coastal areas.

(b) The initial populating of Western Anatolia and the Aegean[10]

As noted above, whatever occupation there was in the western parts of Anatolia, it must have been extremely scarce to go unnoticed in surveys. On the other hand, by the early stages of the sixth millennium BC, almost all over the area, numerous settlements appear with no detectable predecessors. However still, it is also evident that this was not as instantaneous as previously thought; on the contrary, a brief survey of the evidence clearly indicates that the westward expansion lasted for about a 1000 years, taking place at least in three detectable instalments, each having a different mode and paste from the others. These are:

The Initial Expansion (Figs. 1 and 2):

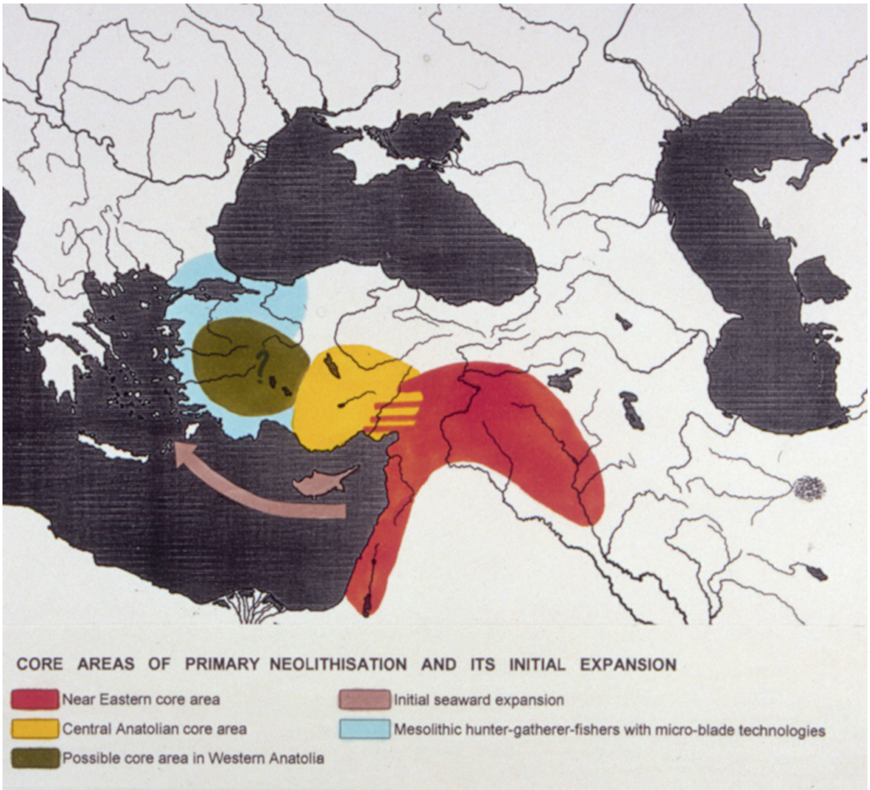

Fig. 1 Core areas and the contact zone

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[10] As the absolute dates, with their calibration have been explicitly published in the CANEW reports that are also kept regularly updated (CANEW 2006) they will not be repeated here with due references.

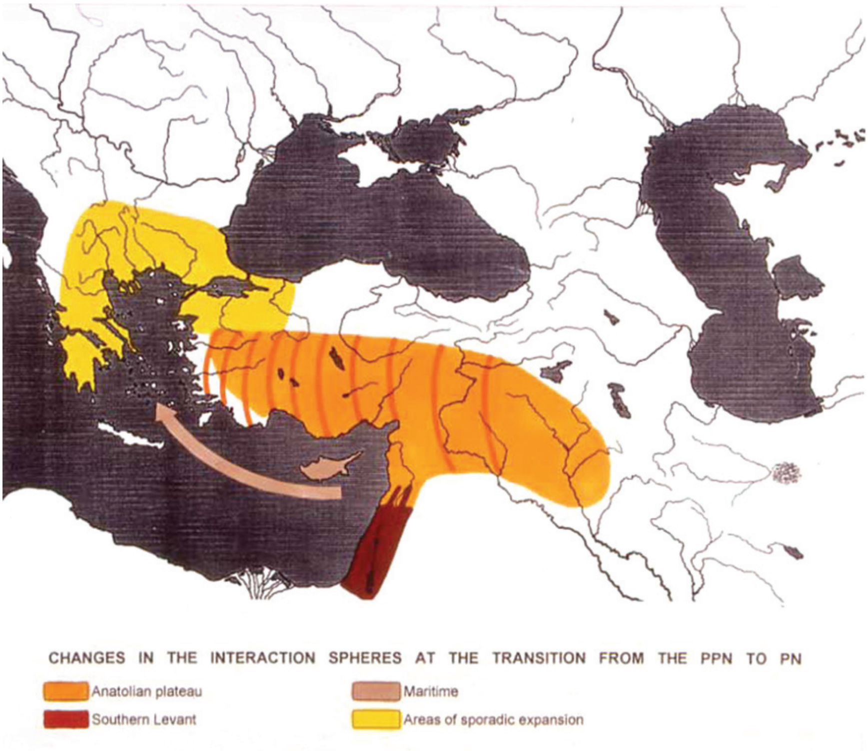

Fig. 2 Cultural regions and the initial expansion of the Neolithic cultures from the core area

The expansion of the Neolithic way of life from its traditional core is, for some reasons, coincides with the beginning of pottery; thus conventionally, the basal date of the Pottery Neolithic also stands for the Neolithic expansion. This, until recently was rather convenient; however, it only became clear during the last decade that defining when the use of pottery vessels began is not as clear as it was assumed. Recent works at sites such a Çatal Höyük, Mersin Yumuktepe or Mezraa Teleilat have indicated that in the transition from the Pre-Pottery to Pottery Neolithic, there was a hitherto overlooked cultural stage, going back as early as 7500 cal. BC, when, while most of the cultural indicators were still within the framework of the Pre-Pottery Neolithic stage, very sporadically there were some pottery vessels in use. Gradual introduction of this new technology is of course reasonable; thinking in retrospect, there were a number of early excavations giving the signals of this transitional stage. Mellaart had claimed in early 1960s that there was an Aceramic horizon at Hacılar; later, Duru, re-excavating the same area, found some sherds, but extremely sporadic (Duru 1989). The discussion whether or not there was an Aceramic horizon at Hacılar, inevitably was equated with the similar dispute on the Milojicic's claim of Aceramic period in Thessaly and thus, the relevance of facts went unnoticed. Now, as indicated by the recent work at the basal levels of Çatal Höyük, pottery is already present as early as 7400 BC, but very rarely. Thus, it is possible to surmise that by around 7500–7400 cal. BC, there was an initial movement from the Central Anatolia to the western parts of the peninsula, by groups either at the very end of the Pre-Pottery stage or at the very beginning of the Pottery Neolithic, and the pace of this movement gradually increased in time. Sites such as basal Hacılar, Keçiçayırı (Efe 2005)[11] and Çalca (Özdoğan and Gatsov 1998) are to be considered among the forerunners of this event.

At present, our knowledge of the incipient era is still too incomplete to draw a detailed picture and it is not possible to say how much of this initial movement went further west of the Anatolian plateau, either into the Aegean or into the Balkans. Considering the presence of pressure-flaked tanged arrow points and of circular-scrapers of Central Anatolian type at Keçiçayır, it is possible to surmise that similar finds in some of the Aegean islands are to be associated with this phase (Özdoğan 2006).

The movement of the Neolithic communities from the core area seems to have been through two distinct routes: one through the Anatolian plateau and the other along the coast. The presence of early sites such a Keçiçayır and Çalça, both located on high plateaus not at all suitable for farming, suggests that the first movement out of the core area might have preferred to follow highlands moving with their herds. The other trajectory is evidently a maritime route, reaching the Aegean bypassing Anatolian plateau (Perlès 2005).

The second wave: the monochrome phase:

A distinct type of an assemblage, best known with its dark surfaced monochrome pottery (Fig. 3), represents the second and relatively more intensive habitation of the region. Until about a few decades ago, the presence of an early dark faced pottery Neolithic horizon in the western parts of the Anatolian plateau was met with considerable scepticism, most of the discussions being focused on the chronological position of the Fikirtepe assemblage (Fig. 3). Actually, ever since its recovery early in the twentieth century, significance of the monochrome pottery of the Fikirtepe culture had been disputed[12]; to most scholars of the time Fikirtepe assemblage could only have been the forerunner of Early Bronze Age Troy I culture, as no earlier habitation was considered to be possible on the Anatolian plateau. In this respect, in spite of the prevailing tendencies of 1960s, J. Mellaart and D. French should be acknowledged for their foresight to assign Fikirtepe culture to the Neolithic period (Mellaart 1955; French 1967). The dispute on the dating of this culture was resolved only after the recovery of Fikirtepe assemblage stratified in the Ilıpınar sequence[13];

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[11] The site previously known only with pressure flaked lithic objects similar to the Aceramic tools of Central Anatolia is currently under excavation by Efe, also yielding some sherds (Personal communication with Dr.T.Efe)

[12] For an extensive bibliography on the Fikirtepe culture, see Özdoğan (1999).

[13] The dates for Fikirtepe culture range between cal. BC 6450 and 5900 (Thissen 2001); depending on the typological comparisons with the Central Anatolian assemblages, it is possible to surmise cal. BC 6600 as the beginning of Fikirtepe culture.

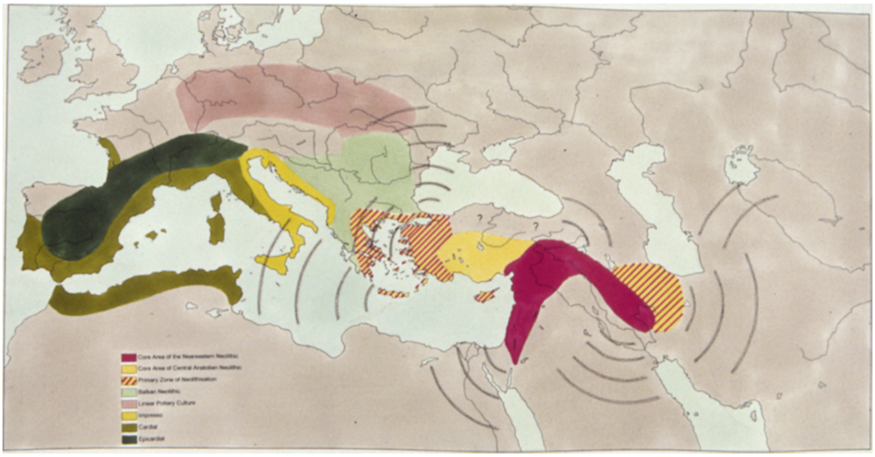


Fig. 3 Major expansion of the Neolithic way of life

nevertheless, in spite of the secure dating of this culture with numerous absolute dates, some of our Balkan colleagues continue to be sceptic of its chronological position (Nikolov 2002).

During the last two decades, our knowledge of this horizon has increased considerably; it is now possible to define the assemblage through the excavations at sites such as Fikirtepe, Pendik, Yarımburgaz, Ilıpınar, Menteşe, Barcın, Aktopraklık and Demircihöyük. Besides the excavations, numerous surveys carried out in the western parts of the plateau have indicated that the cultural phase associated with the Fikirtepe culture was much more wide spread in the western parts of Anatolia than previously envisaged. The characteristic features of this horizon (Özdoğan 1999) such as the dark coloured burnished wares, hole-mouthed jars, large ledge handles, rectangular or ovoid vessels, bone spoons and spatulas, sling missiles, bone hooks, all of which have their ancestral types further to the east and south in Central Anatolia, clearly indicate the roots of the Fikirtepe culture was in the Central Anatolian plateau, probably in the Lakes District. It also seems possible that the introduction of the so-called "bullet cores" to the western parts of the peninsula took place during this stage (Gatsov 2005). How far west into the Balkans this culture moved passing through Thrace is still far from being clear; the presence of monochrome pottery in some sites in Eastern Thrace, as well as the controversial assemblages such as Koprivets and Krainitsi in Bulgaria[14] are highly suggestive that the initial advance of Neolithic communities into the Balkans began during the "monochrome stage", but still more evidence is needed.

[14] The monochrome pottery assemblage of these sites are considered to be earlier than the red slipped and white painted pottery of Karanovo I horizon (Todorova 2003) also bearing certain resemblance to Pre-Karanovo assemblages such as basal Hoca Çeşme (Gatsov 2006); however, there is some arguments that they can be contemporary (Stefanova 1996)

It seems evident that this period represents a much more massive demic movement than the previous one. The distribution of sites of this horizon suggests that the movement from the initial core area has been in the direction of northeast towards the Sea of Marmara, following the high plateaus. What exactly was taking place along the Aegean coast of Anatolia during this time is not clear; considering the early dates in mid-sixth millennium from the recent excavations in this region, including Ulucak, Yeşilova (Abay 2005) and Ege Gübre,[15] it is evident that the appearance of Neolithic cultures in this region must be almost at the same time as the expansion of Fikirtepe culture. On the other hand, initial information on the composition of the cultural assemblage of these sites reveals a different picture, though still related. In this respect, it is of interest to note that the main component in the early levels of sites of the İzmir region is red-slipped monochrome pottery (Fig. 4), occasionally with impressed decoration, showing a notable similarity both with the early pottery Neolithic pottery of the Lakes District and Thessaly.

The Third Wave: Mass Movement (Fig. 5)

The third phase of demic movement is much more easily detectable than the previous ones, as it is known through hundreds of sites in Western Anatolia and in the Balkans. Pottery with painted decoration on brilliantly burnished red surfaces is the most apparent feature of this horizon (Fig. 6); even though there are a number of local variants within the vast geographical area covered by this culture, extending from the Danube to Central Anatolia, in an overview, shared elements that cannot be considered as incidental are apparent. Besides certain elements of pottery such as the use of tubular lugs, profiled bowls, relief animal or human motives, applied bucrania, anthropomorphic and zoomorphic vessels, bone spoons, bone polishers, pintaderras, bone belt hooks, the so-called ear studs, marble bracelets and steathophygic clay figurines are among the easily discernible features. The number of excavated sites of this period is numerous, especially in Bulgaria; even though excavated sites in western Anatolia and in the Marmara region are still too few, nevertheless, the level of our understanding is steadily increasing. In this respect, besides the type-site of Hacılar, others including Kuruçay, Höyücek, Bademağacı, Yenibademli, Ulucak, Hoca Çeşme and Aşağı Pınar have contributed in drawing a new picture of the period. In view of the extensive data on this period, a lot can be noted, but here we shall restrict in noting a few that are relevant to the discussion of our theme:

Cultural Uniformity: As noted above, the sites of this phase have an extensive geographic distribution from Central Anatolia to the Körös region in Hungary. Significant is the uniform composition of assemblages through this vast geography. Most of the characteristic features that had been noted above are present in almost all of the excavated sites of this period; however, what is more significant is the uniform composition of the assemblages, including the featuring of the settlements. Considering the geographic extent of this culture, the uniform composition of their

[15] Personal connection with the excavators. See also Abay (2005), Çilingiroğlu and Abay (2005).

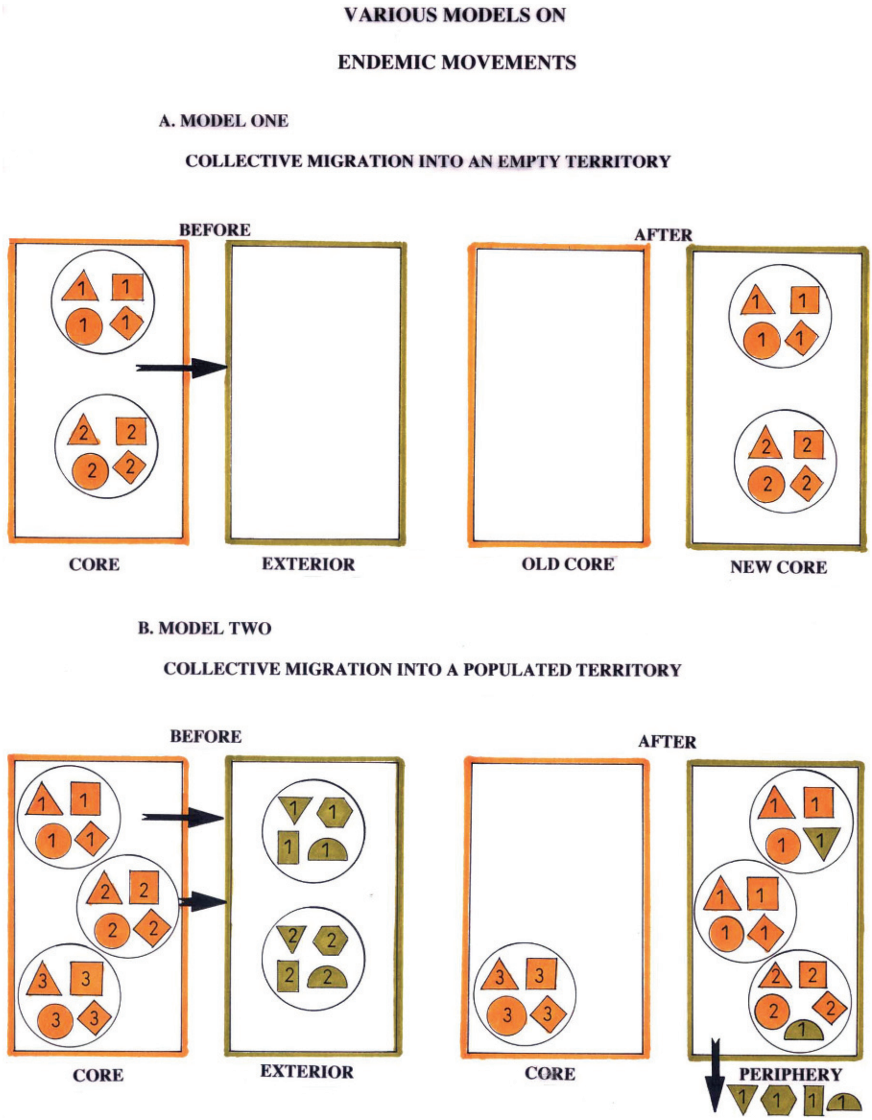


Fig. 4 Some conventional models of endemic movement

assemblages implies that the expansion must have been a very rapid process,[16] which is also indicated by the absolute dates associated to the initial stages of this cultural stage, all clustering within the narrow time span of cal. 6200–6000 BC.

[16] For the sake of clarity, it should be noted that the pace and the mode of Neolithic expansion using the land route or following the river basins in Europe and the maritime dispersal along the Mediterranean differed considerably, the latter being a much slower process (Biagi et al. 2005; Forenbaher and Miracle 2005).

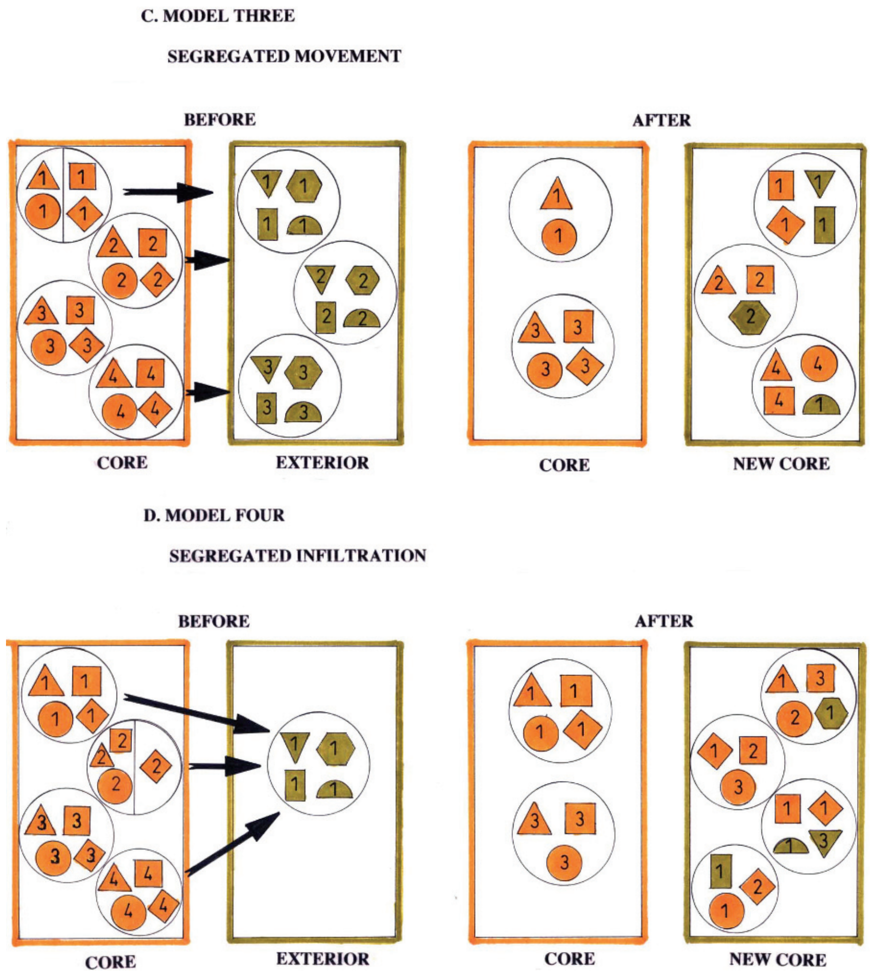


Fig. 5 Modelling segregated endemic movement

Emerging without forerunners: Bulgaria stands as the most extensively studied region of this cultural stage, the number of excavated sites mounting to a hundred, there different names such as Karanovo I-II, Kremikovci or Gradisnitsa have been attributed to this phase, according to regional variants; nevertheless, all settlements of this horizon were founded directly on the virgin soil, with no detectable predecessors. Also considering the multitude numbers of newly founded settlements, the uniformity displayed, it seems justifiable to speak of a rapid demic movement originating from the central plateau of the Anatolian peninsula into the Balkans.

On the other hand, sites of this horizon or sites yielding this type of an assemblage are conspicuously missing in the Eastern Marmara region, suggesting that the mass movement must have taken the route oriented to the west, through the valleys of the Menderes River, reaching the Aegean. It is evident that in the Eastern

(A)

		PRE-POTTERY NEOLITHIC CORE AREA	INITIAL EXPANSION	EARLY MONOCHROME PHASE	AEGEAN AND THE BALKANS	LINEAR BAND KERAMIK	MEDITERRANEAN
Bone Status Objects	Bone spoons/spatula		X	X	X		X
	Bone belt hooks	X	X	X	X		X
	Bone fish hookss	X	X	X	X		
	Festooned bone plaques	X	X	X	X		
Special Bone Tools	Polishing Tools	X	X	X	X		X
	Antler/Horn Sickles	X	X	X	X		
	Long Awls	X	X	X	X		
	Handles	X	X	X	X		
	Needles	X	X	X	X		
Groundstone Tools	Celts, Chisels etc.	X	X	X	X	X	
	Grinding Stones	X	X	X	X	X	
Stone Status Objectz	Fine Stone Bowl	X	X				
	Grooved Stone	X	X	X	X		
	Bracelets, Rings	X	X	X	X		X
	Fine Beads	X	X				
	Ear Stud		X	X			
Special Clay Objects	Sling Missile			X			
	Spindle Whorls, Discs						
	House Models	X					
	pintaderra	X	X	X			X
Special Crafts	Mat, Basketry	X	X	X			X
	textile	X	X	X			X

(B)

		PRE-POTTERY NEOLITHIC CORE AREA	INITIAL EXPANSION	EARLY MONOCHROME PHASE	AEGEAN AND THE BALKANS	LINEAR BAND KERAMIK	MEDITERRANEAN
Lithic Tools and Technology	Projectiles with Pressure Flakeking	X	X				
	Long, straight Blades	X	X	X	X	X	X
	Thin, long Blades	X	X	X	X		X
	Segments	X	X	X	X	X	X
	Cylindrical Blade Cores	X	X	X	X		
	Prismatic and Bullet Cores	X	X	X	X		
	Round Scrapers	X	X	X			
	Chipped discs	X	X	X	X		X
Symbolic Representations	Steatopygous Figurines	X	X	X	X		
	"M" shapad Figures	X	X	X	X		
	Cylindrical Figurines		X	X	X	X	
	Animal Figurines	X	X	X	X	X	X
	Skull Cult, Modelled Skulls	X					
	Phallus Symbols	X	X				
	Bucrania	X	X	X	X		
Imported Raw Materials	Obsidian	X	X	X	X	X	X
	Exotic Shells	X	X	X	X	X	
	Malachite	X	X	X	X		
	Ocr	X	X	X	X	X	
	Native Copper	X					
Settlement and Architecture	Village life	X	X	X	X		
	Rectangular Buildings	X	X	X	X	X	
	Special Cult buildings	X					
	Buttressed Walls	X	X	X	X		
	Painted lime Floors	X	X	X	X		
	Burnt Lime	X					
Subsistence	Domestic Animals	X	X	X	X	X	X
	Cultivated Plants	X	X	X	X	X	X

Fig. 6 a, b: Index of the Neolithic package

Marmara and in particular the region around the Bosporus, Fikirtepe culture of the previous stage sustained its presence, however, evolving locally into what is known as the "developed Fikirtepe" or the Yarımburgaz culture. It still seems plausible to consider that there was some interaction between the two cultural groups, as evidenced by the presence of red-slipped wares at Fikirtepe and Pendik and by the presence of sporadic painted sherds in the sites of this culture.

In this respect, the position of Aşağı Pınar, located in Eastern Thrace is of interest. At present, Aşağı Pınar is the easternmost site in the Balkans yielding a typical assemblage of Karanovo I-II type (Özdoğan 2005). The pottery recovered in Layers 6 and 7 is dominated by white on red-painted pottery also displaying the characteristic types of the Bulgaria. The site covers an area, considerably larger than many in the Balkans, and the assemblage is so prosperous that it will be difficult to consider Aşağı Pınar as a settlement located on the eastern periphery of this culture. On the other hand, the architectural layout of the settlement displays a different pattern than the Bulgarian ones, being almost identical to that of Ilıpınar in Anatolia. Taking into consideration the location of Aşağı Pınar, between Thrace and the Bosporus, at the present stage of our knowledge, it is not possible to say that whether the site is an eastward reflection of the Balkan cultures or represents a stage that has been overlooked in the Eastern Marmara.

Diversity: The uniform composition and the presence of shared elements had been noted above. In spite of this, it is also possible to detect a number of diverse elements that can potentially hint on the mode of this expansion. The diversity is more apparent, for example in the type of figurines, or the presence and/or lack of certain components of the Neolithic package. However still, no matter how seldom these elements occur, the origins of all can be traced to the different parts of the core area of neolithisation. This highly suggests that the expansion or the demic movement was not a uniform event, such a group moving together from a region into another, but more as an infiltration, that is moving from all regions to all regions. Such a movement can only be explained by a social mode that can be termed as "momentum to migrate". Otherwise, no matter what had happened in the core area, whether an environmental deterioration or a social turbulence, or both, all of this population could have stayed and sustained easily in the Aegean or in the Marmara region without moving into Europe. The impetus to move must have been the main motive in this expansion, bringing with them their life style, some of the social framework and the specialised craftsman. However still, further away from the contact zone, it is also evident that other agencies, such as adaptation to local conditions, merging with local communities and, as in the case of Linear Band cultures, breaking down of the social system into small farmsteads are to be considered.

Reflections on Demography: A Few Concluding Remarks

What we had presented above is a conspectus of a much more complicated and multi-facetted story, here categorically narrated; we are conscious of the fact that whatever happened at that time was not as straightforward as we have put, and certainly did not develop on a linear line. Moreover, what we know is much less than what we do not know or what we should have known. Still, with a wider geographical perspective and with an unbiased look, some facts are apparent. With this chapter we have considered the "Neolithic Package" as the basis of our working hypothesis in looking at problems related to demography. In developing this approach, we are conscious of the fact that there are other means, cultural, genetic and paleoanthropological (Bocquet-Appel and Naji 2002:637; Bocquet-Appel and Naji 2006) and that the most efficient one would have been the analysis of human burials. In regions where there is ample evidence, it is evident that the hard core of the discussion must be based on the cemeteries. However, in the regions that we are concerned with, there is not enough skeletal material to reach a consensus; likewise, there are serious problems in using some of the cultural entities as criteria. At the present stand of our knowledge, it is not possible to make a dependable assessment either on settlement densities or on settlement sizes of the Neolithic period. So as to avoid misunderstandings, we consider to present a conspectus on some related entities as necessary, from both the "Core Area" and from the "Interim Zone".

When added up, it may seem that the number of human burials known from the Neolithic Period would be sufficient for a statistical evaluation. Considering that the total number of known burials is much over a 1000, it provides an excellent data pool for understanding the development of burial customs, physical characterisation, etc. However, it should not be overlooked that the time span we are considering is in the scale of 5000 years and the aerial coverage extends over numerous vast geographic territories. Moreover, most of the human burials are not from cemeteries, but from collective burials within structures and we have no idea who were selected to be buried within these special buildings. In this respect, Çayönü stands as the best case in understanding what the problem is; the number of human burials recovered at Çayönü is over 650; however, most of them were found in the so-called "Skull-Building", a building of a limited duration within the 3000-year long extent of the site. Moreover, the age distribution of the burials within that particular building clearly indicates that there was a selection on those to be deposited there, a fact also supported by the presence of other burials scattered around the settlement. A more or less similar statement holds true for Çatal Höyük, where the number of burials is even more than Çayönü, displaying a variety of distinct treatments. Further west, Fikirtepe culture stands as the only Neolithic culture with a significant number of burials, the total number being 70 (Alpaslan-Roodenberg 2007); however, this is the total number of burials from seven sites at the same time representing an extended time period of at least 500 years. On the other hand, the total numbers of Early Neolithic burials from hundreds of excavated sites in the Balkans are less than a hundred (Bacvarov 2000; Lichter 2001). It seems evident that with so much evidence, no inference can be drawn on the demographic set up of regions under concern.

There have been numerous attempts in calculating the dimensions of Early Neolithic settlements in the Near East (Gebel 1984; Hershkovitz and Gopher 1990), providing rather useful data as an insight into the overall picture. However again, the evidence is extremely dispersed both in time and in aerial coverage, at the same time far from being conclusive. It should be considered that the exposed areas in most of the excavated sites are very limited; calculations on site dimensions have been extrapolated from very scant evidence, mostly overlooking the impact of recent alluvial deposition and/or erosion. Likewise, in the case of Çayönü, the most extensively excavated Neolithic site in the Near East, we have no dependable estimation of settlement dimensions for any of the phases; northern parts of the site dips under alluvial plain, the south and west have been cut off by a meandering stream. We cannot even be sure whether the site was expanding or shrinking in time due to surface erosion. Almost every early site in the Near East and Anatolia have more or less similar post-depositional histories.

Calculating the intensity of settlements is even more problematic especially in the Anatolian peninsula; all coastal sites have been submerged due to the rise in global sea levels since Neolithic period, others covered by expanding deltaic plains, in the intermountain plains; occasionally the thickness of post-Neolithic alluvial deposition is over 10 m. Neolithic sites can only be recovered if they were located on rocky outcrops or by deep soundings penetrating below the alluvial fills of the plains. Even a brief look into the distribution map indicates that 90% of the Neolithic sites are in the karstic zones of Anatolia, where there is no alluvial deposition (Özdoğan 1997b). Accordingly, at the present state of our knowledge, calculations based on either intensity of settlements or on their dimensions are misleading and thus, it seems necessary to look for other trajectories that would give an insight into the demographic structure. In this respect there are some cultural traits that are particular to the Neolithic of the Near East that, if not provided an eventual picture, can serve as indicators.

The Neolithic of the Near East is a very particular culture, not only because of the complexity of its structure, but also more of its dynamic nature. It is a highly innovative period where the knowledge and know-how had been shared through vast areas. The pace that the Neolithic of the Near East developed is incomparably higher than any other early culture. Intensity of interaction and especially the vast volume of raw materials such as obsidian being transferred and consumed are all to be accounted as indicators of population density, at least by the very beginning of the Pre-Pottery Neolithic B Period, if not in PPNA. The presence of monumental architecture such as at Göbeklitepe, that requires not only a social drive but a considerable input of labour also indicates that population density was achieved, at least in some areas, already by the early stages of PPNA. In going through the Neolithic of the Near East, it is possible to find other cultural entities that would provide hints on demography. The analysis of cultural activities would help draw a general picture or define the trajectory of developments, but none would provide precise data for a statistic assessment.

What we have described with this chapter as the "Neolithic Package" is actually a conspectus of cultural activities. During the last decade or so, it became possible to define the components of the "Neolithic Package", not only more precisely, but also more exclusively. There is now ample evidence to reach some conclusions through regional analysis of this package, or packages (Figs. 7–10), by taking utmost care to the chronological order by tracing the origin, dispersal and at the same time extinction of certain elements (Fig. 11a–b); it is possible to deduct the following:

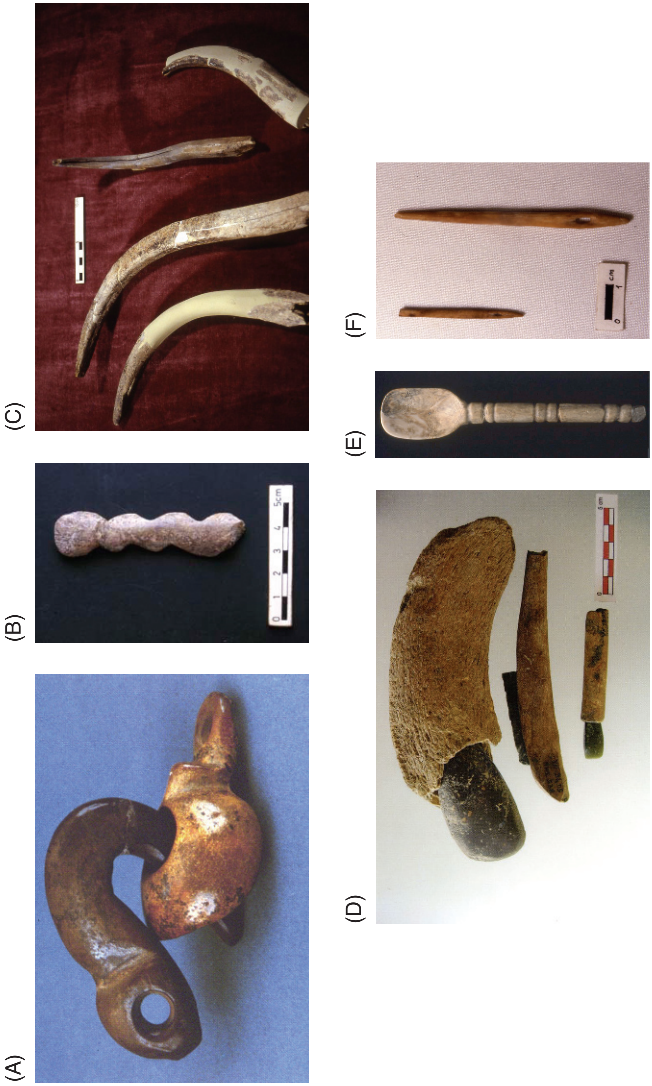


Fig. 7 Basic components of the Neolithic Package

(A)

(B)

Fig. 8 Basic components of the Neolithic Package

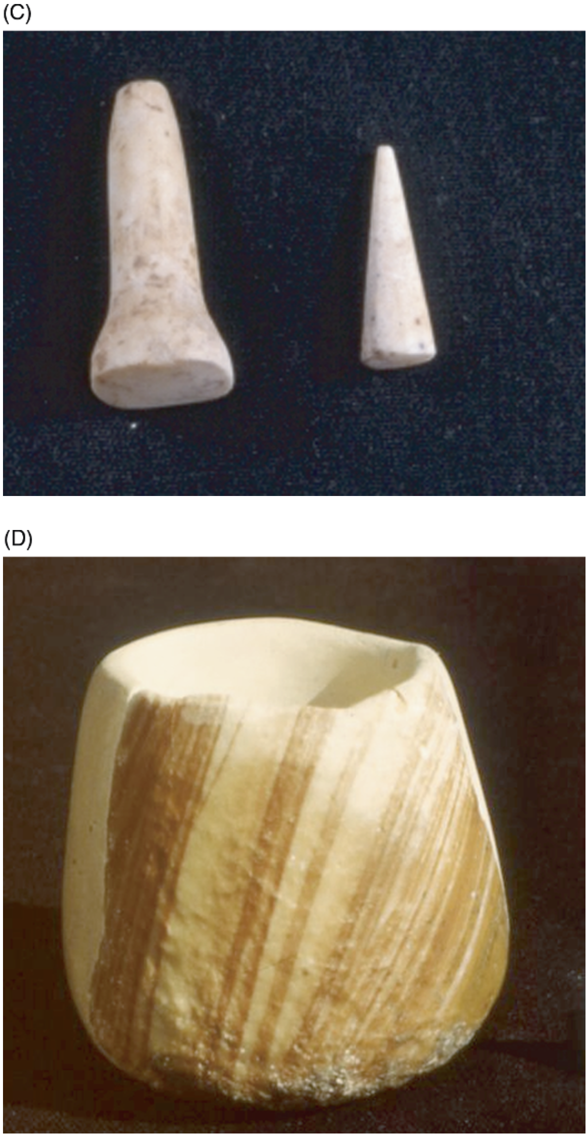


Fig. 8 (continued)

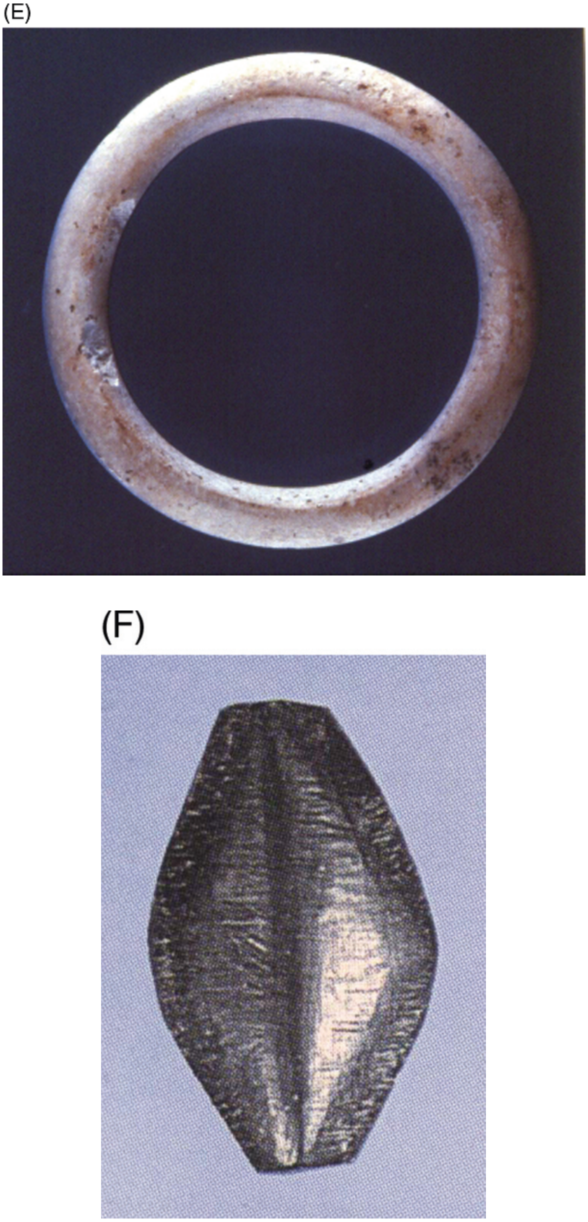
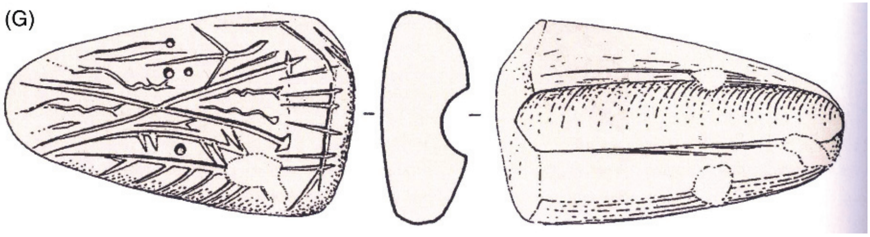


Fig. 8 (continued)

(G)



(H)

(I)

Fig. 8 (continued)

Fig. 9 Basic components of the Neolithic Package

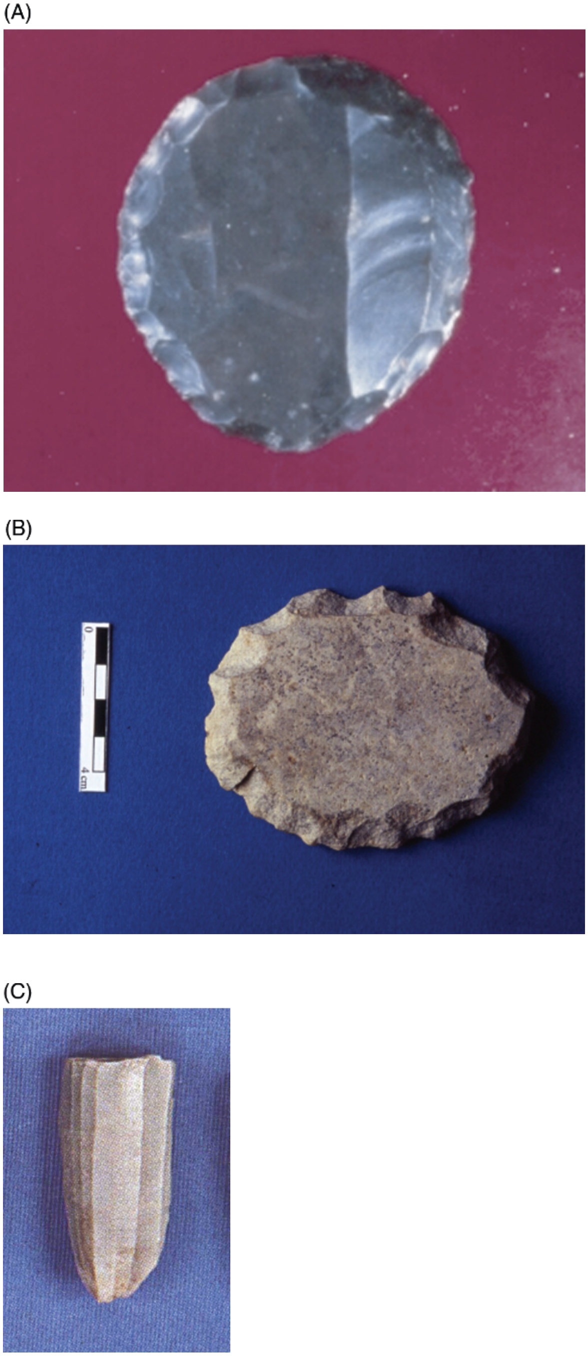
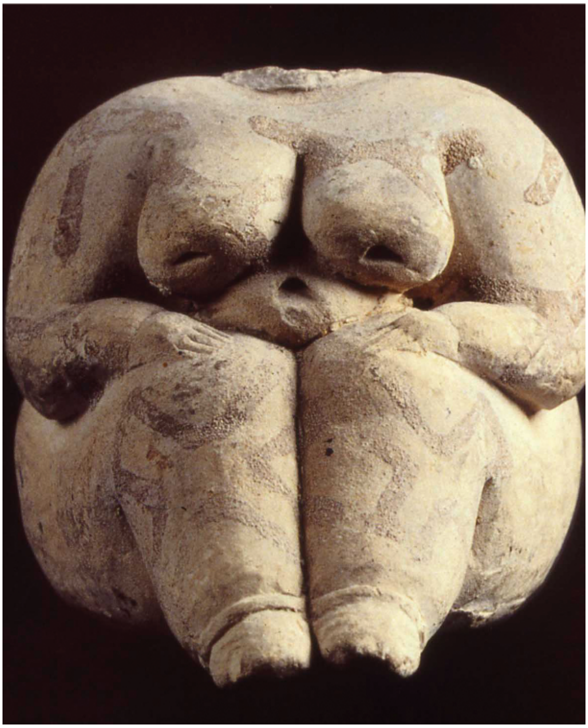


Fig. 9 (continued)

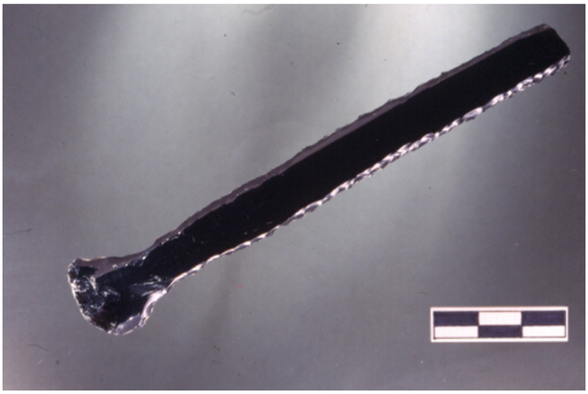
(D)



(E)

Fig. 9 (continued)

(F)



(G)

	CORE AREA	WESTERN ANATOLIA AND AEGEAN	BALKANS	MEDITERRANEAN	LINEAR BAND KERAMIK
Footed Rectangular Cult Tables	X	X	X		
Footed Triangular Cult Tables			X		
Comb Impressed Decoration	X	X	X	X	
Impresso Decoration			X		
Dark Faced Burnished Ware	X	X	X		
Burnished Red Slipped Wares	X	X	X		
Cream,White Slipped Wares	X	X	X		
Tubular lugs	X	X	X	X	
Ledge handles	X	X	X		
Anti-Splash Rims		X	X		
Relief human Representation	X	X	X		
Relief Bucrania Decoration	X	X	X		
Applied Human/Animal heads	X	X	X		
Anthropomorphic Vessels	X	X	X		X
Zoomorphic Vessels	X	X	X		

Fig. 10 Basic components of Early Neolithic Pottery

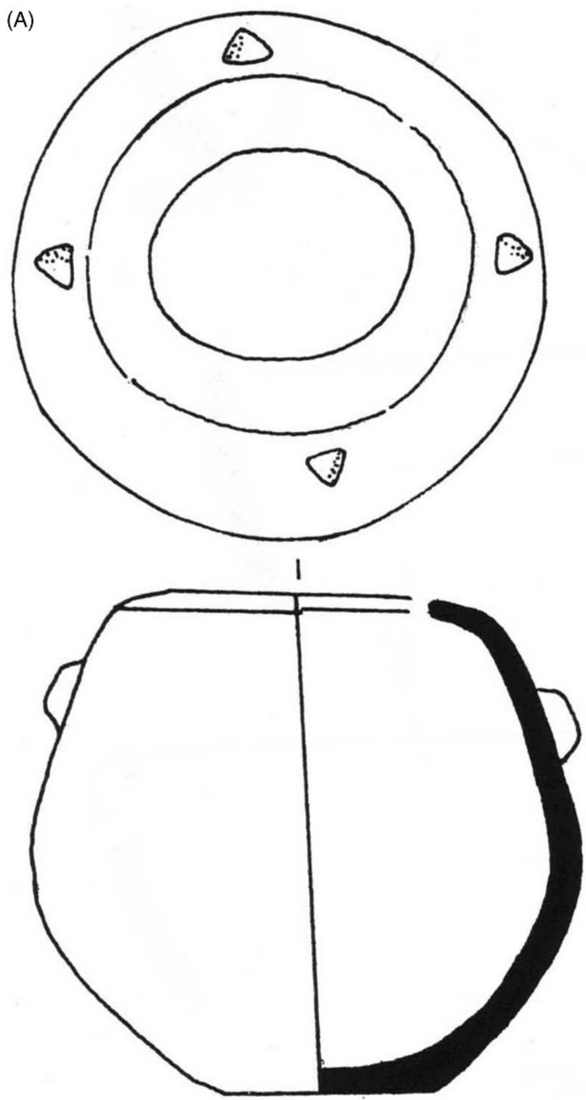


Fig. 11 Selected pottery from the Monochrome Phase; 11 a from, 11 b from Fikirtepe

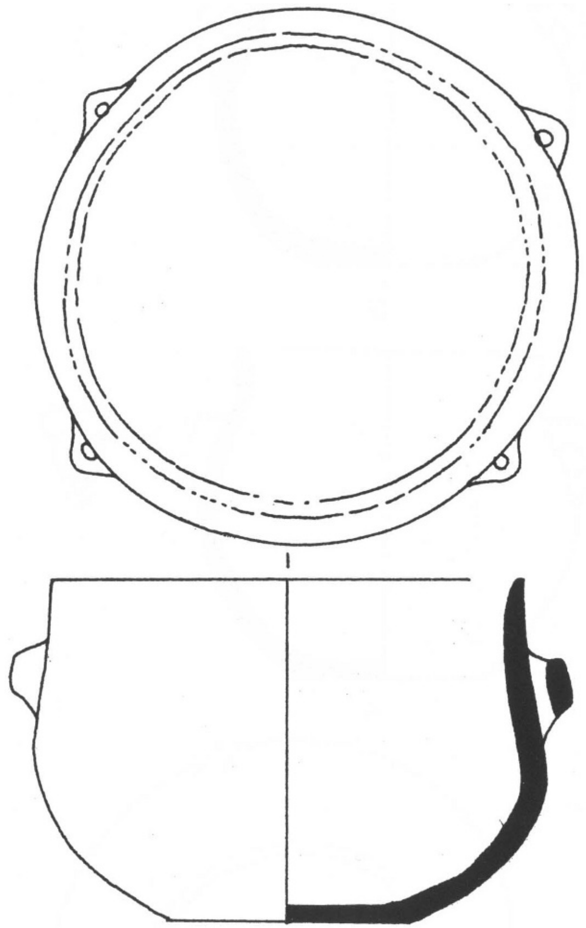
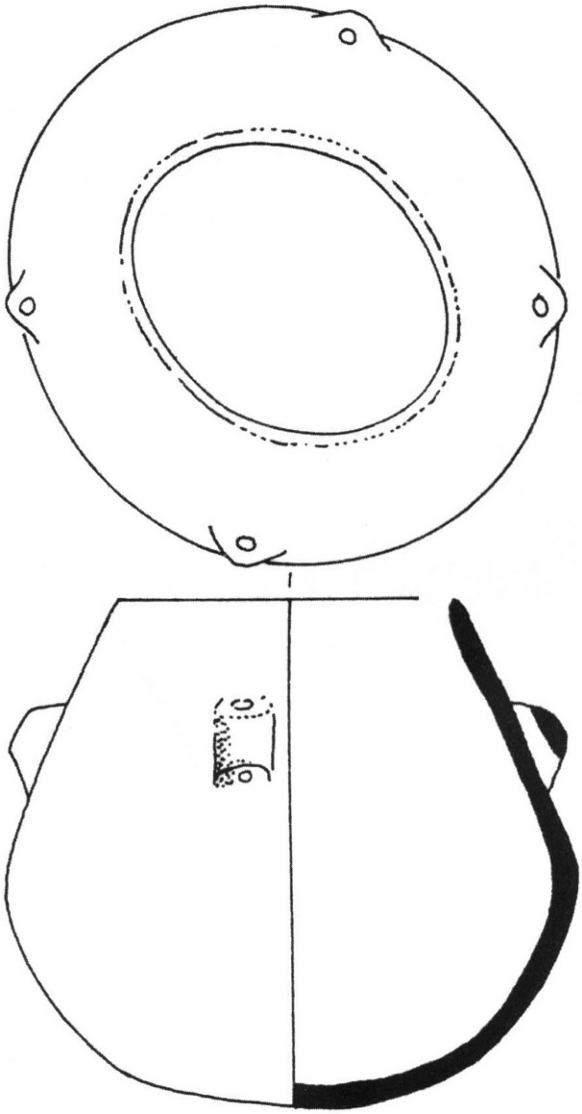


Fig. 11 (continued)



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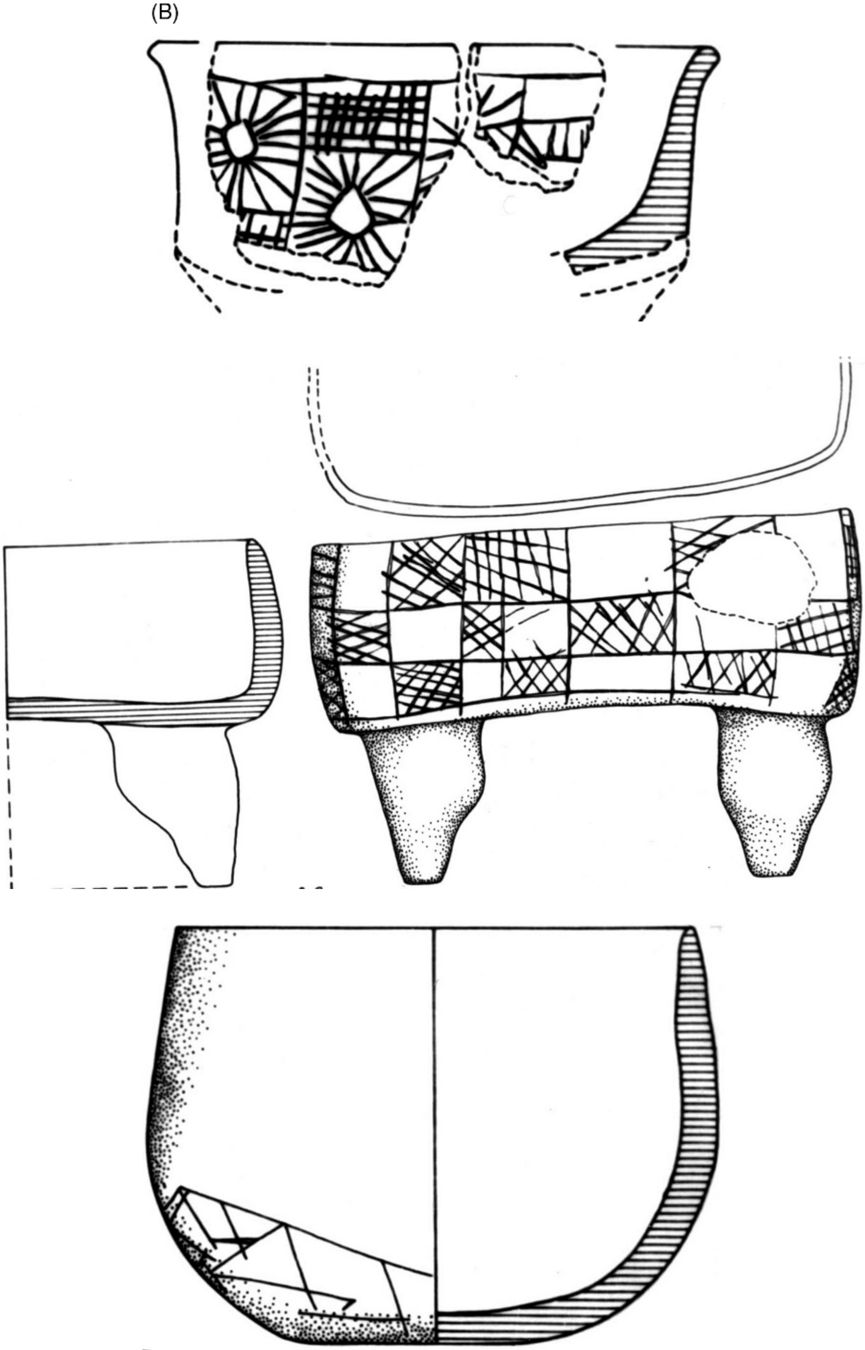


Fig. 11 (continued)

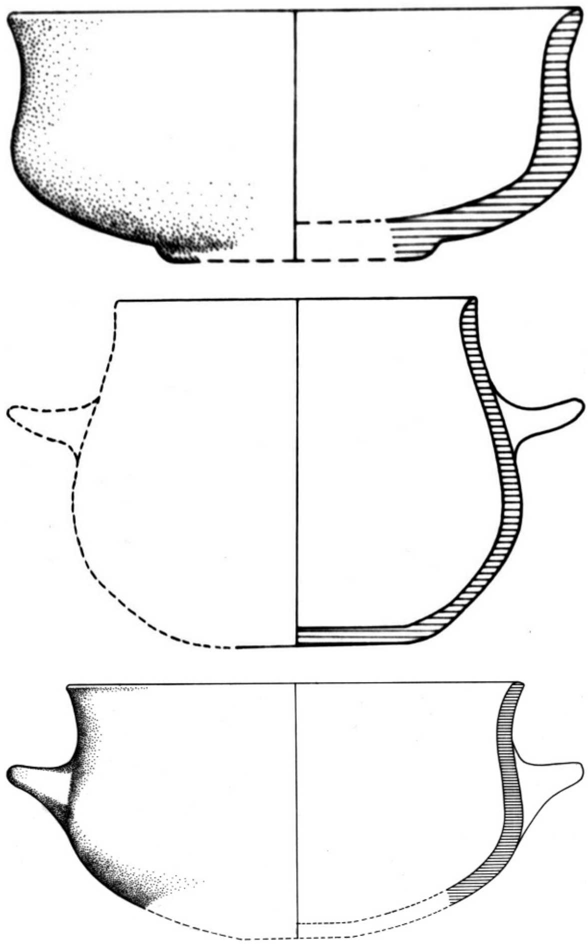


Fig. 11 (continued)

- It is possible to define different sets of Neolithic packages, though the so-called staple crops and domesticates, pottery, polished and ground stone are present in all.
- All what appears as "new", in both areas of late neolithisation, have their antecedents in the primary area of neolithisation.
- Some objects that were present in core area before the time of the Neolithic expansion are found only in the areas of late neolithisation, disappearing in their original area, suggesting that some of the specialised craftsman have also moved away.
- On the other hand, the composition of non-utilitarian objects, mainly the so-called cult and/or status objects varies considerably, suggesting that the social status of the groups that moved and/or formed new clusters were not homogeneous.
- The presence of different core-reduction technologies is also evident, also implying the heterogeneity of the moving groups.

It seems evident that the initial dispersal of the Neolithic way of life was due to a considerable demic movement initiating from the core area. The assessment of the Neolithic package in the new areas of neolithisation clearly indicates that the antecedents of most objects that have been transferred are in the eastern parts of the core area, in Northern Syria, Levant and South-eastern Turkey and not in Central Anatolia. Accordingly, the initial "push" for migration must have originated from that region. What had happened when this passed through Central Anatolia, where there was already a Pre-Pottery Neolithic sub-stratum, is not yet clear, but again, the Neolithic package that is found in the immediate contact zone in the western parts of Turkey suggests that they somehow merged with each other. The various amalgamations of the Neolithic package implies that the movement to west, at least in its earlier stages, was not as an organised migration such as the population of a certain locality moving and settling together, as in our model in Fig. 12. On the contrary, the mixed or merged composition of the assemblages supports our model 2 in Fig. 13, that we named as "segregated migration" until a better term is

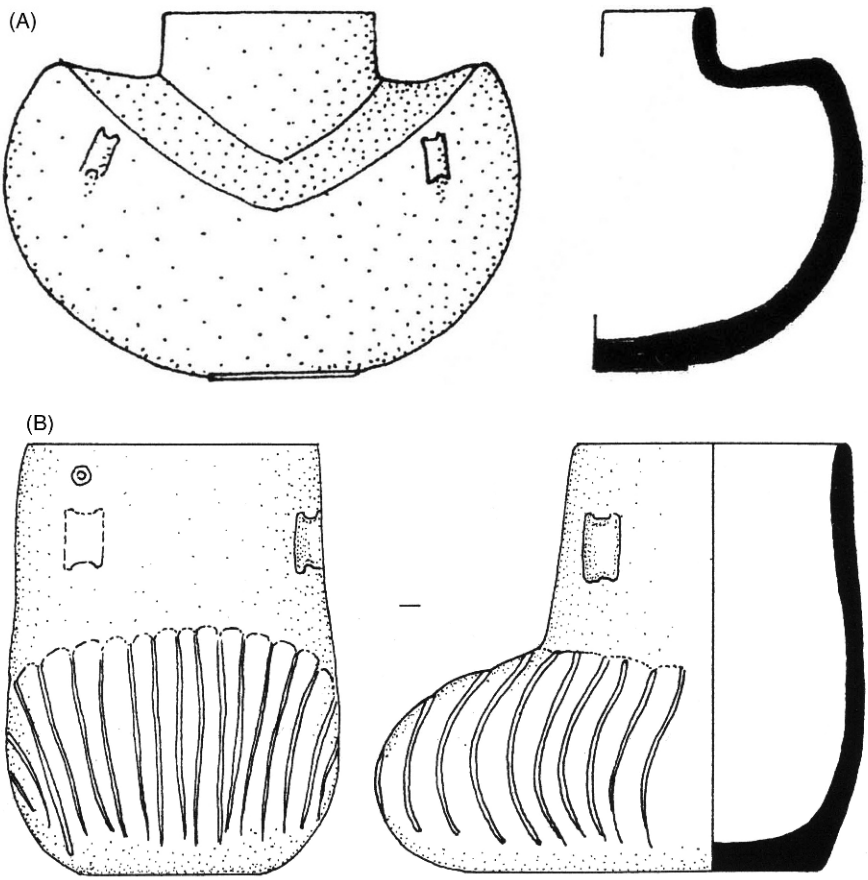


Fig. 12 Selected pottery from the Red Slipped Phase

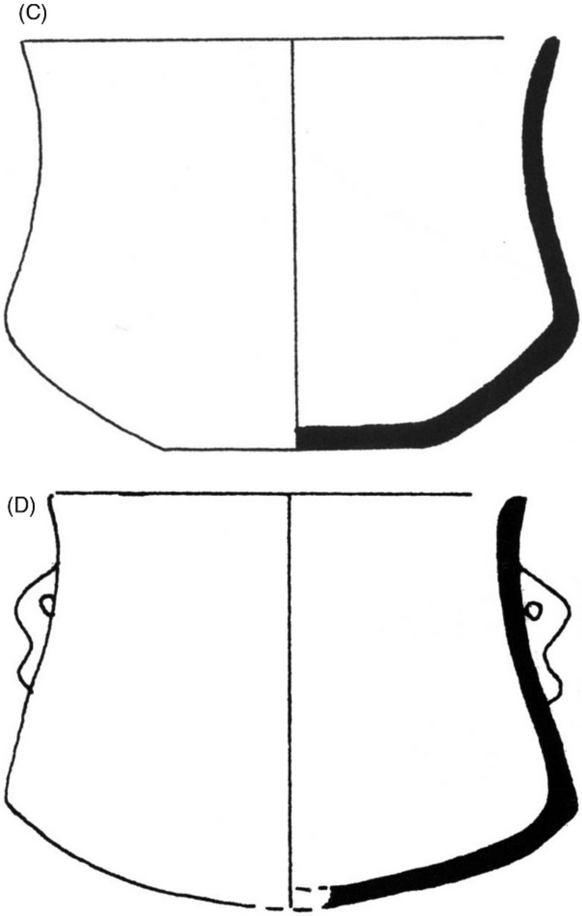


Fig. 12 (continued)

suggested. However still, as we have noted before, at any time segment, different types of happenings were taking place simultaneously. That is to say, while most apparent model was segregated migration type, at the same time, direct migration, acculturation and/or transfer of know how and technologies were also taking place. Evidently, further away from the core area, the latter ones were more effective.

Whatever model we take, they all imply a demographic shift from the core area towards its exterior. This evidently implies that there must have been a substantial human reservoir in the core area, enough to fill in the void in its exterior, at the same time sustaining its presence in its homeland. In this respect, looking back to the core area, the end of the Pre-Pottery Neolithic B marks the peak of population increase in that particular region, as evidenced not only by the increase in the number of sites and the appearance of "mega-sites" but also the marked intensification of cultural interaction. Likewise, the end of that period, whether called PPNC or the Neolithic

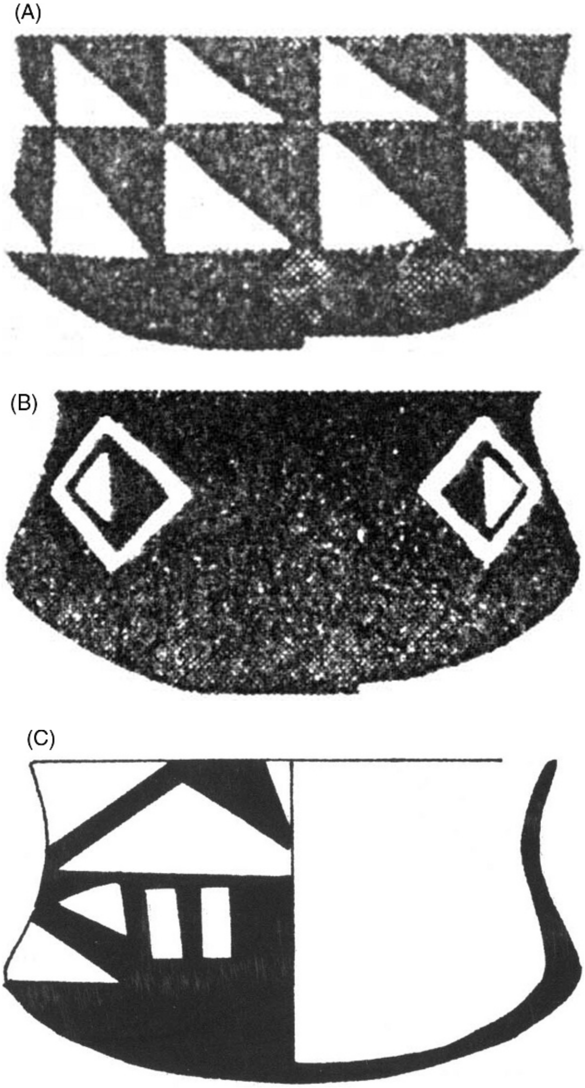
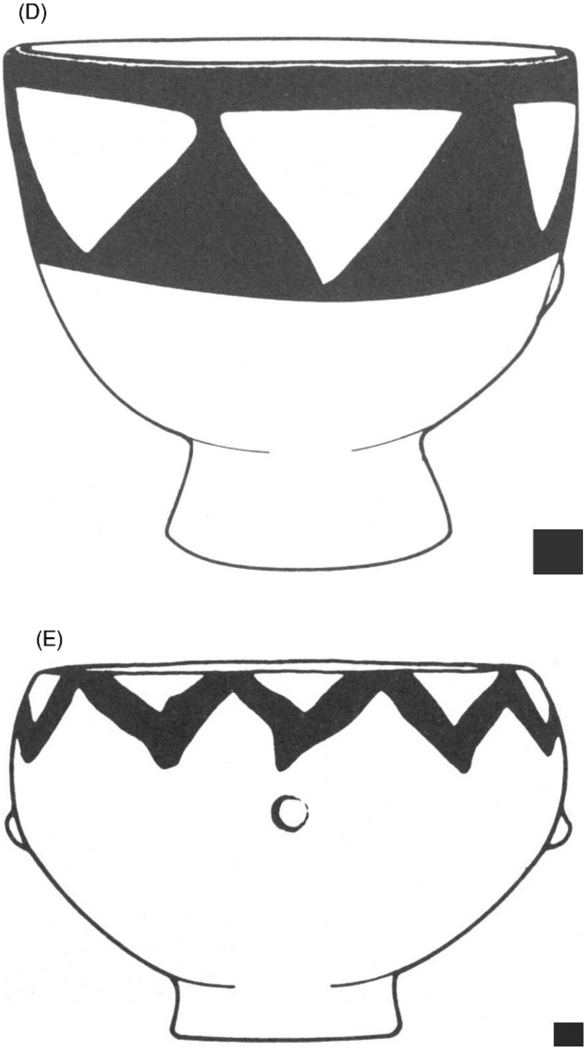


Fig. 13 Selected pottery from the Painted Phase

Collapse, is at the same time when a decline in habitation is evident; however, this also coincides with the rapid increase in the population in the western parts of Anatolia, the Aegean and in the Balkans. A demic movement off the core area, must inevitably had its consequences in that area, not only a decline in demographic composition, but also further provoking the already existing social turbulence, losing some of the craftsmen and the extensive labour needed to maintain the previous system. The settlements of the Pottery Neolithic Period throughout South-eastern Anatolia, Iraq, Syria and in the Levant can be described as "simple" villages devoid of all complexity and monumentality of the preceding PPN culture of the same

Fig. 13 (continued)



geographic zone. This, nevertheless does not imply that there was no interaction within the region or that the obsidian trade had subsided; they still continue but not in the calibre of the earlier times. Prestige buildings, monumental architecture or sculpture will re-appear in this region at a much later date.

To conclude, the end of the Pre-Pottery Period was a period of crisis that among other things led to a decline in population. Rapid increase in the population of previously uninhabited regions implies that these regions received a new population, mainly coming from the core areas.

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Zooarchaeological Aspects of the Neolithic Diet Transition in the Near East and Europe, and Their Putative Relationships with the Neolithic Demographic Transition

Jean-Denis Vigne

Abstract The goal of the first part of this chapter is to summarize the recent results of zooarchaeological research into the beginning of ungulate domestication in the Near East (more precisely southeastern Anatolia, the northern Levant and Cyprus) and Europe. It focuses on the earliest evidence of animal domestication and dispersion, and on its slow and complex tempo. The impact on diet varies in the different regions, especially in Western Europe. The second part of the chapter inventories differing deliberations, as well as both osteological and isotopic results, in order to estimate the technical skills of the last hunters/first farmers in animal management and exploitation. A special section is devoted to the question of early milk exploitation during the early stages of the Neolithic. In the conclusion, based on a new chronology of the different steps in the birth of animal husbandry in the Near East between 8500 and 7000 B.C., the author posits that these developments provoked a substantial qualitative and quantitative improvement of the animal food supply, and discusses these proposals with reference to the Neolithic Demographic Transition (NDT) and the other components of neolithization in these areas.

Keywords Animal domestication · neolithization · archaeozoology · human diet · milk · near east · Europe

Introduction

The transition from foraging to farming made by an important section of human societies beginning in the 10th millennium B.C.[1] is the last, most important prehistoric step in the evolution of humankind. In this respect, it is clearly a revolution,

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[1] In this chapter, all the dates are given as B.C. (calibration according to Stuiver & Reimer, 1993, and using Calib. Rev. 5.0).

J.-P. Bocquet-Appel, O. Bar-Yosef (eds.), *The Neolithic Demographic Transition and its Consequences*,

the “Neolithic Revolution”. However, it is not a true revolution in terms of tempo, since there is now consensus that it was slow and irregular both chronologically and spatially, and that the mechanisms involved were very complex and varied. Demography is obviously one of the most important of those factors if only because of dispersion. Its role has recently been once more highlighted by the proposal of the model of the Neolithic Demographic Transition (NDT; Bocquet-Appel, 2002a, b; Bocquet-Appel & Dubouloz, 2003; Bocquet-Appel & Naji, 2006), which is discussed in this volume.

In the scope of this discussion, it is necessary to revisit the available cultural and bio-archaeological data, in order to investigate possible chronological coincidence between them, and try to investigate their causal relationships. This chapter aims to contribute to this scientific reappraisal within the scope of animal domestication in the framework of the Near East and Europe. The first part of this chapter will examine the numerous new archaeozoological data which have been collected in these areas during the last decades. In the second part, we will take advantage of recent archaeozoological data to get an indirect estimate of the technical skills of the last hunters/early farmers in animal management and exploitation in order to discuss the important question of the qualitative and quantitative interactions of the rise of animal domestication, then animal husbandry, with the NDT and, more generally, with the neolithization process.

The Beginnings of Animal Food Production in the Near East and Europe

Carnivore domestication as precursors is largely beyond the scope of the diet transition.

Dogs and perhaps cats are the earliest known domesticates, but they have little connection to the present topic. The domestication of the dog took place in various locations on the Eurasian continent during the Late Glacial times (ca. 18,000 to 12,000 B.C.; see Vigne, 2005/2006, for a recent review), starting with the wolf (Savolainen et al., 2002). It would not have triggered any deep change in human subsistence, except due to modification of the hunting tactics and techniques in connection with the increase in wooded environments beginning in the late Dryas period and, later on, with the invention of bows and arrows (see, for example, Street et al., 2006). The earliest cat taming is thought to have taken place somewhere in the Near East about the time of the Early PPNB (Davis, 1987; Vigne et al., 2004; Vigne & Guilaine, 2004). It may be due to the appearance of the commensal “house” mouse in the first grain collecting or cultivator villages (Cucchi & Vigne, 2006).

Dog domestication by hunter-gatherers long before the Neolithic at many different places in the Old World suggests that foragers were able to keep an animal alive for a long time. In the Amazons, the Achuar and Matis hunter-gatherers (Erikson, 1988; 2004) keep pets even today, such as young monkeys or peccaries which are milked and raised by women together with the babies. This is to be understood as a symbolic payment to natural supply and a guarantee of good yields in future hunting. Both modern pet-keeping and Late Glacial dog domestication clearly indicate that Neolithic animal domestication did not result from a sudden technological innovation. As a snowball effect, however, carnivore then ungulate domestications imply technological improvements such as more or less deliberate selection of behavioral or morphological characteristics, and tools and techniques for transformation and preservation of new animal products.

Early Ungulate Domestication in the Near East as Part of the Diet Transition?

Contrary to carnivore taming, later domestication of sheep, goat, cattle and pig correlates more or less strictly to deep changes in food supply. Over the last decades, the dates and places for earliest ungulate maintenance have changed several times, from Iran eighth millennium to Israel seventh millennium, then to Syria eighth millennium (see, e.g., Harris, 1996; Vigne et al., 2005). Currently, most archaeologists agree that the earliest domestication of sheep, goat, cattle and probably pig was about the mid-ninth millennium or early PPNB, on the Southern slopes of the eastern Taurus Mountains, in Southeastern Anatolia, Turkey. In this area, in the Early PPNB layers at Nevalı Çori (ca. 8500 cal. B.C.), Peters et al. (2005) observed both a significant size decrease and an increase in the proportion of sub-adult sheep (*Ovis orientalis*) and goat (*Capra aegagrus*), while the size of the gazelles (*Gazella*) remained static during the same time frame (Fig. 1). At approximately the same time, in the North Syrian site Dja'de, Helmer et al. (2005) observed a slight decrease in cattle sexual dimorphism (Fig. 2) which is a good indicator of the beginnings of stock keeping practice. Early husbandry of the pig is a more debated question (Ervynck et al., 2002) but it could not have occurred after the mid-ninth millennium.

There were several other domestication centers, such as the Western Iranian Zagros for goat (Zeder, 2005) or the lower Indus valley for cattle (Meadow, 1989). But all of them seem to be later, i.e., the early eighth millennium and the seventh millennium B.C.

From southeastern Anatolia, domesticates were rapidly transferred out of their original area. Sheep and goat appeared in the Middle Euphrates valley at the very beginning of the eighth millennium (middle PPNB) at sites such as Tell Halula and Tell Abu Hureyra (Peters et al., 1999), where they had no wild ancestors. Together with pig and cattle, they were transferred even earlier (ca. 8300–8200 cal. B.C.) and further to the Damascus region (Tell Aswad; Helmer & Gourichon, in press) or, through seafaring, to Cyprus (Shillourokambos; Vigne et al., 2000; 2003; in prep.). From there, early domesticates and their husbandry spread in numerous directions, so that at the end of the Recent PPNB, ca. 7000 B.C., they were present everywhere from the Mediterranean shores to the Zagros mountains and from the Taurus to the Negev, except in arid zones.

In the Near East, animal domestication seems to have begun late in the Neolithic process (Fig. 3), i.e., ca. 30 centuries after the beginnings of settlement in

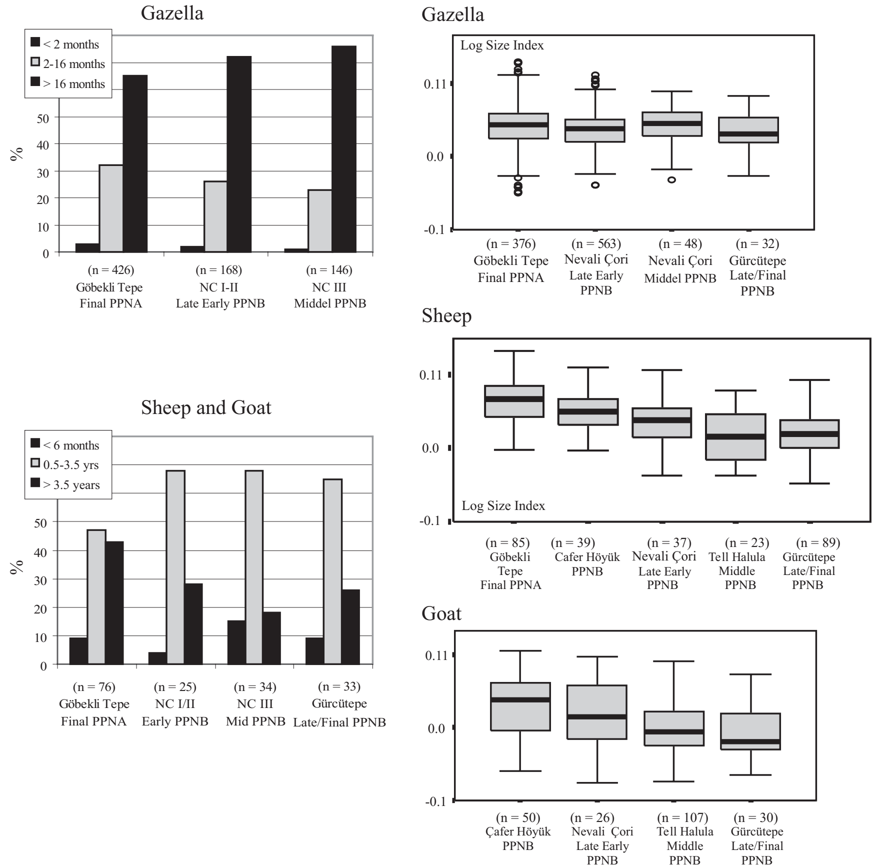

Fig. 1 Early evidence of sheep and goat domestication in southeastern Anatolia, according to Peters et al. (2005). While there is no modification in the kill-off pattern or skeleton size of the wild gazelle (*Gazella subgutturosa*), sheep (*Ovis orientalis*) and goat (*Capra aegagrus*) were conversely subjected both to deep changes in their slaughtering management and to a slow and constant decrease in size beginning in the Early PPNB, ca. 8500 B.C

the Natufian period (12,000 to 11,000 B.C.), and 10–15 centuries after early grain cultivation in the northern Levant (10,000 to 9300 B.C.; Tanno & Willcox, 2005) or in the southern Levant (9400–9200 B.C.; Kislev et al., 2006; Weiss et al. 2006). It represents the last major techno-economic event of neolithization before the invention of pottery, ca. 7000 B.C. As such, it might appear to be a consequence of the demographic transition, which came together with early agriculture (Guerrero et al., this volume). However, according to Guerrero et al. (this volume), the increase in the birth rate and in the size of villages were just beginning at the time when keeping animal stock began, and went on long after the beginning of true animal domestication. Therefore, viewed on that kind of time scale, there is nothing

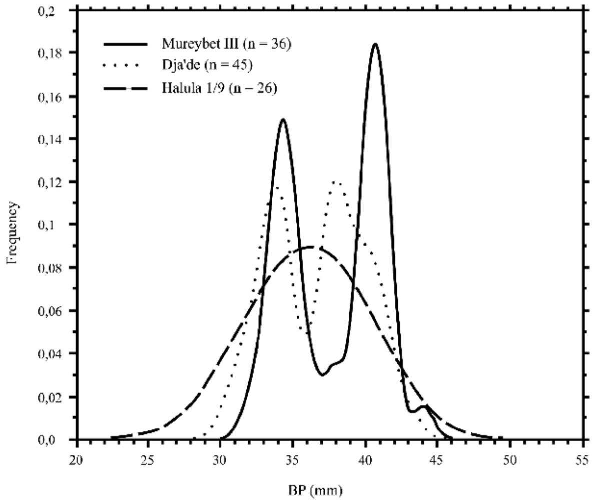

Fig. 2 Mixture analyses of the frequencies of the second anterior phalanxes of cattle (*Bos primigenius*) at three sites in the Middle Euphrates Valley: Mureybet III (PPNA, tenth millennium), Dja’de (Early PPNB, mid-ninth millennium) and Halula (Middle PPNB, first half of the eighth millennium). The two peaks representing the two sexes are clearly distinct at Mureybet III, the distance between them is decreasing at Dja’de, and there remains no statistically significant difference between them at Halula (after Helmer et al., 2005)

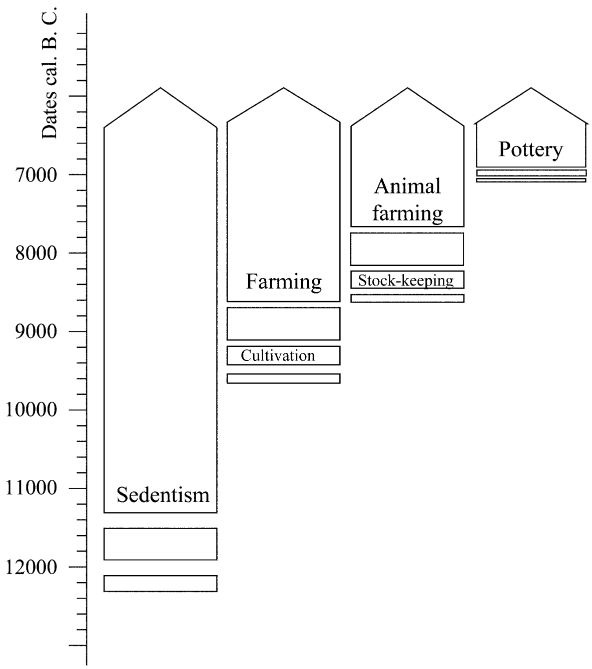

Fig. 3 Summary of the chronology of the different components of neolithization in the Near East. For plant and animal domestication, *dotted parts* of the arrow represent the “pre-domestic” cultivation and livestock breeding, respectively. The *solid arrow* represents true plant and animal farming

to preclude the idea that animal domestication could have played a role in sustaining the demographic increase during the late ninth and all through the eighth millennia, as a kind of snowball effect.

Nonetheless, this discussion must remain ongoing, since the date of the first significant impact of animal management on the human diet might have been significantly earlier or later than suggested by Fig. 3, according to the two following considerations, respectively:

– Legge (1972) and several other archaeozoologists after him pointed out very specialized hunting management of large game in the northern and southern Levant during the Late Natufian or the PPNA. Since this does not correlate with any decrease in the size of the animals, archaeozoologists generally consider this management apart from the influence of domestication. But recent observations in Cyprus (Vigne, 2000) or Iran (Zeder, 2005) show that ungulate domestication did not mean systematic size decrease. In addition, even if it differs from true domestication, Late Natufian incipient animal management could have had an important impact on the diet as early as the eleventh or tenth millennium B.C.
– Since we know that acclimatization of vertebrates to human environments automatically provokes physiological modifications that act on both behavior and ontogeny (Arbuckle, 2005), most of the early modifications (e.g., size decrease) induced by incipient domestication probably did not result from deliberate activities by the last hunters–early farmers. True animal management, with deliberate selection of morphological (and probably behavioral) characteristics is not convincingly proven before the transition to the end of the Middle PPNB (Zohary et al., 1998; Helmer, in prep.). In short, early PPNB livestock keeping ca. 8700–8500 B.C. in the Euphrates valley must be clearly distinguished from true animal farming, which begun during the late Middle PPNB, ca. 7500–7300 B.C., in the Near East, shortly before the first evidence for pastoral nomadism in the arid zones (Stordeur, 2000). As Fig. 3 shows, this situation could be compared with the beginning of grain cultivation, which did not bring significant morphological modifications between 10,000–9300 and 8300 B.C., and only then gave rise to much larger cereal grains (Tanno & Willcox, 2005; Willcox 2007). The first one could have had only very little or no impact on the human diet, the only important time being the second period, which is late with reference to the NDT.

Consequently, if we want to understand the relationship between the beginning of animal domestication and the NDT, we have to investigate not only the first evidence of true animal management, but also the actual impact of animal management on the health and diet of human societies in the early Neolithic era. Information on this topic is very poor. However, if we investigate the relative proportions of wild and domestic animal remains in the food refuse of PPNB sites in the northern Levant, which are a rough estimate of diet, we observe that hunting continued to play a dominant role in the economy until the end of the Middle PPNB or the beginning of the Late PPNB (Fig. 4; Vigne & Helmer, 2007). This suggests that early livestock

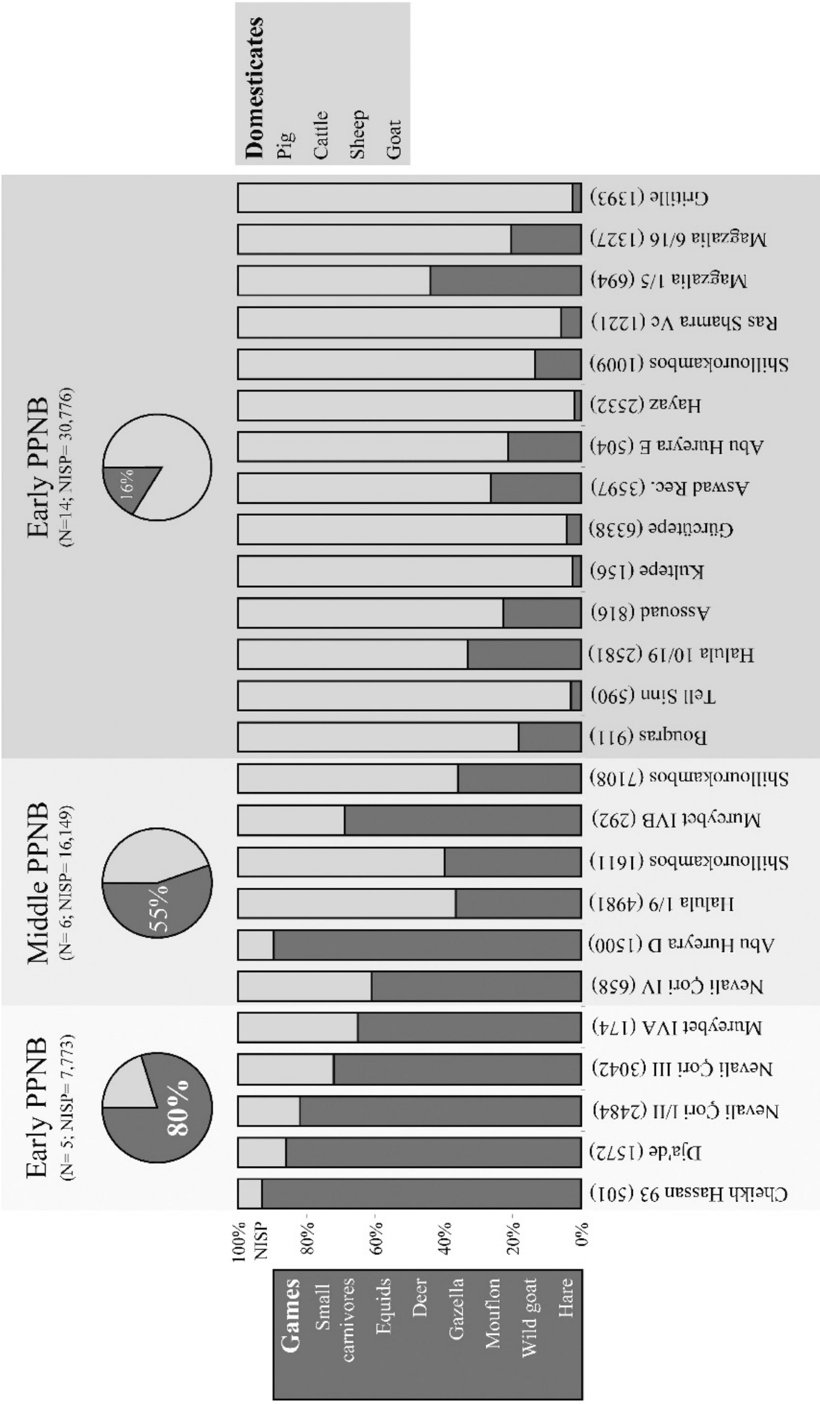

Fig. 4 Evolution of the proportion of the number of identified specimens (NISP) of mammals in 25 chrono-cultural phases of the Early, Middle and Late PPNB in the northern Levant (after Vigne and Helmer, 2007)

keeping did not have any significant impact on the meat supply of human beings before the beginning of what we call true animal farming.

However, this also suggests that the quest for more meat was not the main reason for early PPNB domestications. In order to understand the aim of these early domestications, we must list what wild animals cannot provide and conversely, what can be extracted from tame or domestic animals. As I recently emphasized (Vigne, 2004; 2006; Vigne & Helmer, 2007), milk might have been one of these products. If this is true, we have to consider that early PPNB domestication could have brought significant modifications to the human diet not because of a better meat supply, but because of the introduction of milk and milk products. However, we must also take into consideration the uses of animal dung in agriculture, building and heating, the use of hairs and of load-bearing or draft power capabilities (mainly of cattle), as well as the social or religious advantages of owning an animal. The latter must be seriously considered since these societies were developing social hierarchies as early as the tenth millennium PPNA (Stordeur, in Guilaine, 2001). They also developed very strong animal symbolism (Helmer et al., 2004; Peters and Schmidt, 2004) and probably changed their religions together with their mental representation of the world (Cauvin, 2000). To return to the question of diet, milk exploitation during the early phases of livestock keeping appears to be a central question for future investigations. We will discuss it in more depth later on.

The Beginnings of Livestock Keeping and the Diet Transition in Europe

The spread of animal domestication into Europe began during the first half of the seventh millennium B.C. but lasted for more than 30 centuries. It did not reach the most remote northeastern European areas before the fourth millennium. Although we use the word "neolithization" for these areas, the process and mechanisms are completely different from those of the Near East. Settlement, farming and pottery progressively spread from east to west as a Neolithic package, i.e., as the main characteristics of the developing Neolithic way of life (e.g., Lichardus & Lichardus-Itten, 1985; Whittle, 1996; Guilaine, 2003; Mazurié de Kéroualin, 2003) with very few or no long distance human migration (Haak et al., 2005).

In this long and complex process of the spread of the Neolithic package, the dissemination of livestock keeping must be considered a special issue, at least for sheep and goat. The ancestors of these two species (respectively, the oriental mouflon, *Ovis orientalis*, and the bezoar goat, *Capra aegagrus*) were absent in Europe at that time (Poplin, 1979) and must have been transferred from place to place, together with the technical know-how for their husbandry. Although ethno-archaeological observations suggest that it was the same for cattle and pig (Vigne, 1993), the question is less clear in that case, because they had native European ancestors (respectively, aurochs, *Bos primigenius*, and the wild boar, *Sus s. scrofa*). Recent paleogenetic data, however, suggest that most, if not all, cattle were introduced from the

Near East (Troy et al., 2001; Edwards et al., 2003; 2007; Bollongino et al., 2005), while local domestication of the European wild boar seems possible (Larson et al., 2005; 2007).

So tracked by sheep and goat progression, rhythms for ungulate husbandry dispersal through Europe have been approximately the same as for the entire Neolithic package, although more or less rapidly in some areas (Vigne & Helmer, 1999; Tresset & Vigne, 2001; Guilaine, 2003). These variations are mostly due to complex interactions between the mode of transportation (land or sea), the local environment, the demographic and cultural characteristics of the local Mesolithic populations and the relationships with their immediate Neolithic neighbors (Vigne, 2000; Tresset & Vigne, 2001). The Neolithic package reached most of the large Mediterranean islands at the same time as their respective mainlands (Fig. 5; Vigne, 1999; Vigne & Cucchi, 2005), which is clear evidence of seafaring transportation at that time,

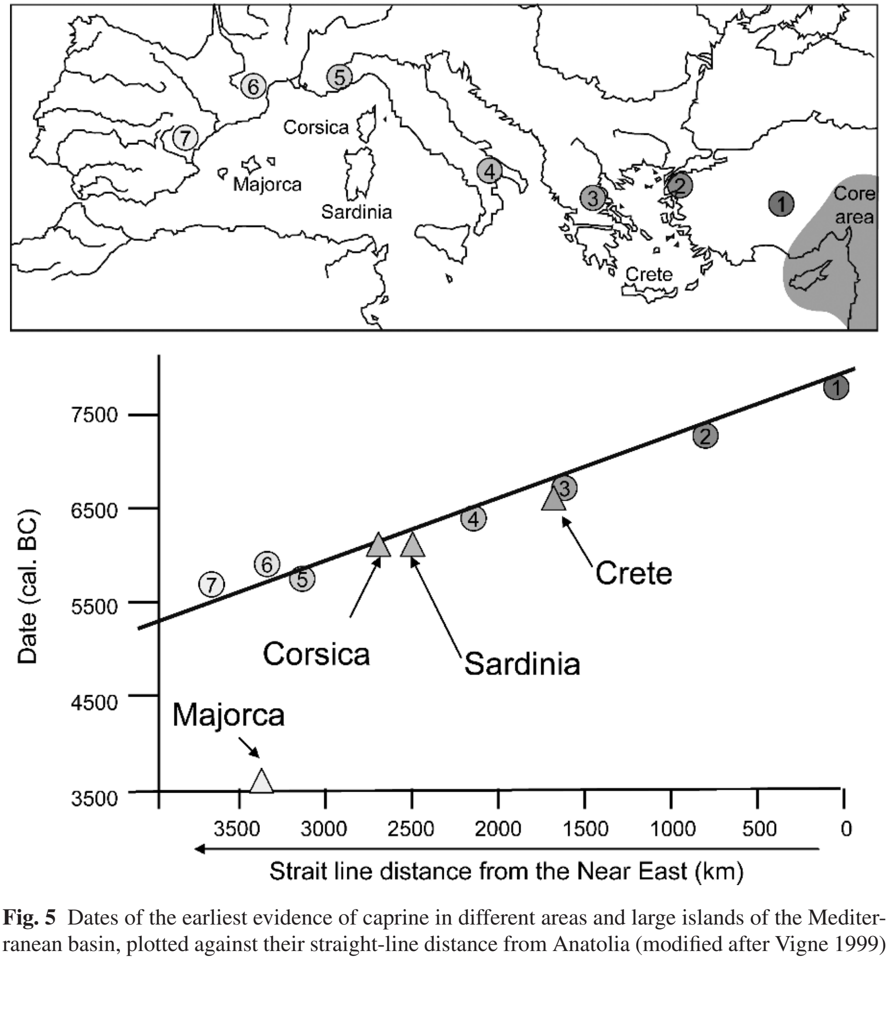

Fig. 5 Dates of the earliest evidence of caprine in different areas and large islands of the Mediterranean basin, plotted against their straight-line distance from Anatolia (modified after Vigne 1999)

albeit limited to short distances. Without doubt, there were short and even medium distance animal exchanges between these communities during neolithization, as also suggested by the early genetic diversity of goats in Southern France (Fernández et al., 2006).

The impact of this transfer on the diet would have been very diverse, depending on the local situation. In some areas, such as Greece or southeastern Italy, subsistence systems specialized in cattle products (meat and milk) before the end of the seventh millennium, with few contributions from hunting, trapping or seafood (Vigne, 2003). By contrast, hunting and small game trapping remained very important for some time in the diet of most of the early Neolithic sites in the Mediterranean hinterland of the French Midi. A recent regional study in the Aude Valley (Tresset & Vigne, 2007; Vigne, 2007) showed that subsistence at the seashore pioneer *Impressa* site, Pont de Roque-Haute at Portiragnes, was overwhelmingly dominated by livestock keeping (ca. 5700–5600 B.C.), while at the Neolithic Cardial medium-altitude sites of Dourgne (5300–5000 B.C.) and Camprafaud (5300 to 4600 B.C.), hunting still dominated in the meat diet (Fig. 6). The penetration there of the new way of subsistence less than 50 km into the hinterland took three centuries for low-altitude sites such as Gazel cave, but eight centuries for medium nearby altitude sites. In some southwestern French sites, characterized by an abundance of pottery, and probably cultivation, beginning in the fifth millennium (e.g., Roucadour; Lesur et al., 2001), livestock keeping only appeared toward the end of the Neolithic (ca. mid-third millennium). Hunting large game (aurochs, deer, wild boar) remained the only source of meat for two millennia (Fig. 7; Tresset & Vigne, 2007). By contrast, in the most remote Atlantic coastal sites in Europe, from Spain and Portugal to Ireland and northern Scotland, where seafood was very important in the Mesolithic diet and where belated neolithization could be expected, the early arrival of the first domestic animals rapidly provoked a drastic shift in the diet toward meat (and milk?), as shown by comparing stable isotopic and ^{14}C analyses (Fig. 8; Schulting et al., 2004; see also Richards et al., 2003 for Britain). Tresset (2002, 2003) showed that the faunal spectra in southern England were very similar to the corresponding ones on the other side of the English Channel, which suggests a very fast transfer of the new diet across the Channel.

Altogether, these data show that the diet transition in Western Europe has been, in a very patchy way, either very fast or very belated. In some regions, such as the well-known Baltic area, the delay is simply due to a true "resistance" to the whole Neolithic package. But in most of the regions where it actually came in, the package was adapted to regional, or even local, environmental and cultural conditions. Thus medium-altitude zones in the Aude Valley adopted the Neolithic Cardial ware but constituted "frictions areas" (sensu Bellwood, 2005; this volume) for livestock keeping; the hinterland sites of southwestern France could be considered "overshoot" areas for livestock breeding, while the Channel and Atlantic seashore regions changed their diet very fast. In order to analyze the interactions between the diet transition and the demographic transition, it is therefore necessary to investigate both the continental scale and regional or local scales.

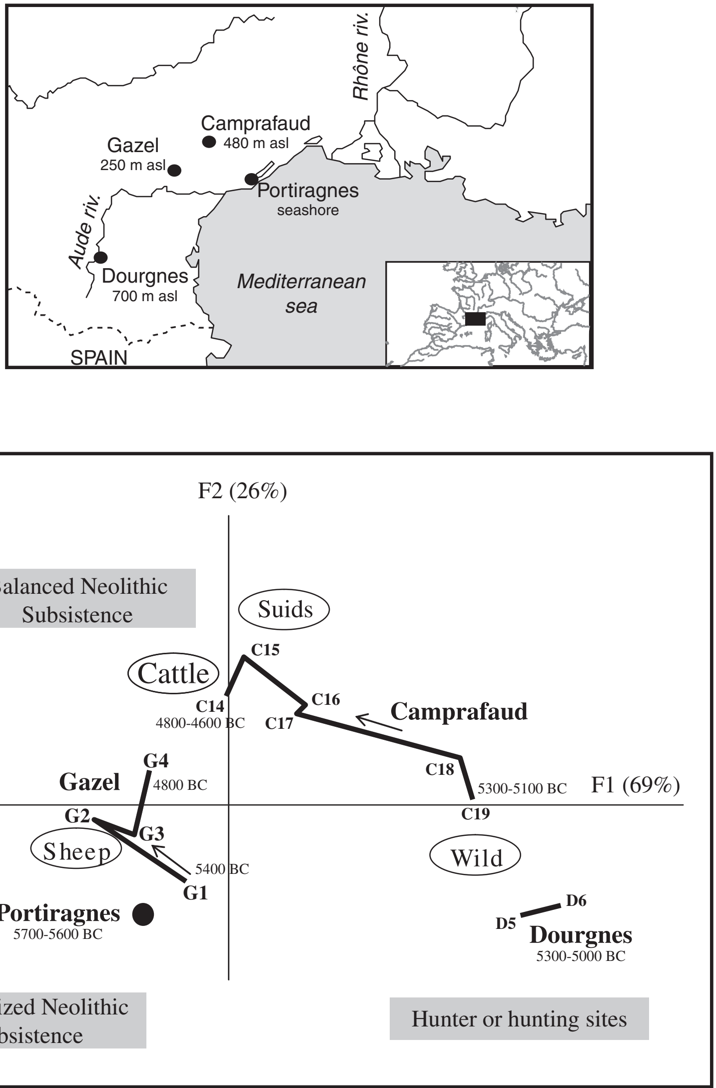

Fig. 6 Comparisons of the contribution of hunting and livestock keeping to the diet in four early Neolithic sites in the Aude Valley, Southern France, by the way of a correspondence analysis of the number of identified specimens of the large mammal species (lower bow): wild, domestic cattle, sheep and suids (Tresset & Vigne, 2007; Vigne, 2007). See interpretations in text

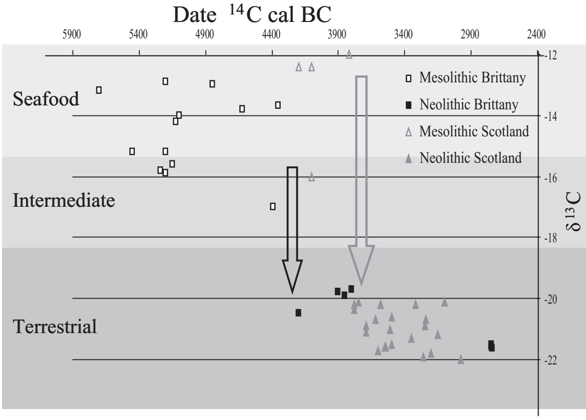

Fig. 7 Scatter diagram of stable isotope and ^{14}C dating for a set of Neolithic sites in Brittany and Scotland, as examples of the drastic Early Neolithic diet change at seashore sites on the European Atlantic coast (after Schulting et al., 2004)

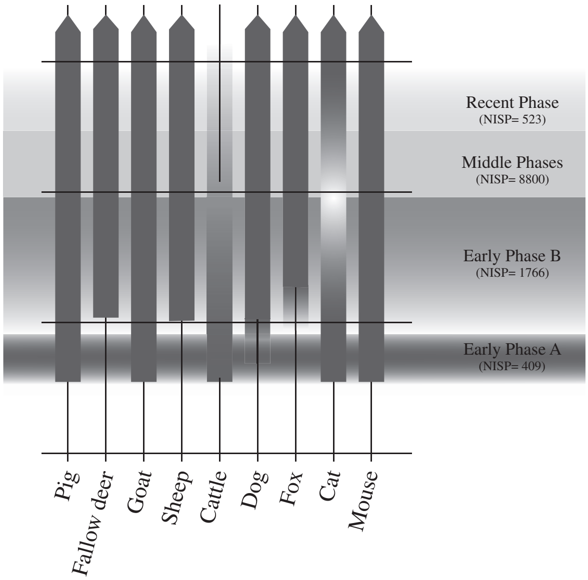

Fig. 8 Occurrence of the different mammal species introduced by PPNB Neolithic people to Cyprus in successive chronological phases at Shillourokambos (Parekklisha, Cyprus; Vigne et al., unpubl.)

Estimating Early Neolithic Livestock Keeping Efficiency

In order to estimate the impact of early livestock keeping on the diet, a more indirect way is to estimate the husbandry skills of the Early Neolithic animal farmers as an indication of their food production efficiency. Until now, this question remained poorly documented by archaeological bone remains, but recent technical improvements provide enough information for a preliminary discussion. First, we will briefly examine the question of animal transfer and acclimatization, then we will focus more deeply on milk production, because this is also a key issue in the Neolithic diet transition.

Early Animal Acclimatization

The long distance transfer of domestic ungulates necessitated the capacity for acclimatization. Before the end of the ninth millennium, sheep and goat were transported 200 km south from their mountainous or hilly southeastern Anatolian environments to the Syrian lowlands, semi-arid plains villages such as Tell Halula or Tell Abu Hureyra (Legge in Harris 1996, Peters et al. 1999) and then another 200 km further south to Aswad near Damascus (Helmer & Gourichon, in press). All these sites are located in zones that currently have less than 300 mm (less than 200 mm for Damascus) annual precipitation. Although they were probably less arid at the time and although the sites were near the abundant waters of the Euphrates or Damascus Lake, the climatic difference was significant enough (Cauvin et al., 1998) that early livestock ranchers would have had to adapt herding practices to local conditions.

But the most striking early transfer is the one which took place no later than 8300 B.C., from the mainland to Cyprus (Vigne et al., 2000; 2003). In addition to acclimatization to a more Mediterranean environment, this transfer is especially amazing because it meant transporting animals with adult weights between 500 and 1000 kg (for cattle) across a 50–60 km wide sea channel, including replicating this feat often enough to settle stable island populations, i.e., with sufficient genetic diversity (Vigne & Cucchi, 2005). This was done for each of the eight species involved. Before 8300 B.C. this included cattle, goats, pigs, dogs and cats. At the very beginning of the eighth millennium, sheep, the Mesopotamian fallow dear (*Dama mesopotamica*) and the fox (*Vulpes vulpes*) (Fig. 8) followed. Nothing is known about the boats which were used. But these introductions and acclimatization suggest, at a minimum, the use of hobbles, corrals and corridors for driving animals, and at most a selection of less aggressive animals. The small curvilinear ditches attributed to the earliest occupation of Shillourokambos (Guilaine et al., 2000), which are much more sophisticated than the nets which were used for mass hunting during the PPNA (see representations at Göbeckli Tepe: Peters & Schmidt 2004), could be the earliest evidence of such devices.

These events were the start of a long series of acclimatization throughout Europe, Asia and Africa. In addition to climatic changes, early farmers had to face vegetation changes and, depending on latitude, differing photophases, which impose hard constraints on the reproductive cycle of the bovid (Balasse & Tresset, 2007). Recent work on the Orkney Islands, northern Scotland, illustrates possible problems and how Neolithic people solved them. In that extreme northern area, with its great photoperiodic and climatic constraints, sheep husbandry would have to include feeding seaweed, at least during the winter season when no grass is available. Seaweed is the only food available all year. Modern sheep on these small islands belong to special lineages that have the rare capacity to live on seaweed all year. However, the earliest evidence of sheep herding on those island dates back to the beginning of the fourth millennium B.C., the same time as the first Neolithic manifestations in the area. Balasse et al. (2005; 2006) reconstructed the seasonal changes in the diet of Orkney Neolithic sheep, based on very high resolution mass spectrometry measurements of $\delta^{13}C$ and $\delta^{18}O$ ratios (IRMS) in very small serial samples of tooth enamel taken along the crowns of the molars, which grows for a long time during the life of the animal (Fig. 9). They concluded that there is no evidence of seaweed feeding at the earliest known Neolithic site in the Orkneys (Knap of Howar, ca. 3600 av. J.-C.), but that ewes at Holm of Papa Westray were fed seaweed during the winter as early as 3000 B.C. Early farmers invented new technical systems in order to adapt husbandry to local resources at the very beginning of the Neolithic (see also on this topic: Ruas & Vigne, 2005).

Early livestock keepers had or rapidly acquired increased technical skills at animal management than they are generally believed to have had. This suggests that they soon benefited greatly from domesticates from the moment they adopted the Neolithic way of life. Were these skills enough to significantly exploit milk and milk products?

Early Milk Exploitation?

The late Andrew Sherratt (1981; 1983) proposed a model of a "Secondary products revolution", which claims that dairy farming, wool and the use of animals for plowing and carting originated as technical innovations in connection with meat production during the fourth millennium in the Near East and the third millennium in Europe. These led to deep economic transformations in these late Neolithic/Chalcolithic societies (see also Greefield; 1998). This theory was based on many archaeological observations that are now being re-examined. But it was also underpinned by an unformulated assumption that technical progress is linear and that last hunters–early farmers had not reached the stage beyond getting meat from animals. Testing the "secondary products revolution" is therefore another good way to estimate the capability of Early Neolithic people to control their subsistence, while at the same time exploring the possibility that milk products could have been one of the diet innovations brought about by early livestock keeping.

A series of recent results sheds new light on the early exploitation of animal milk, fleece and the use of draft animals in the Near East and Europe.

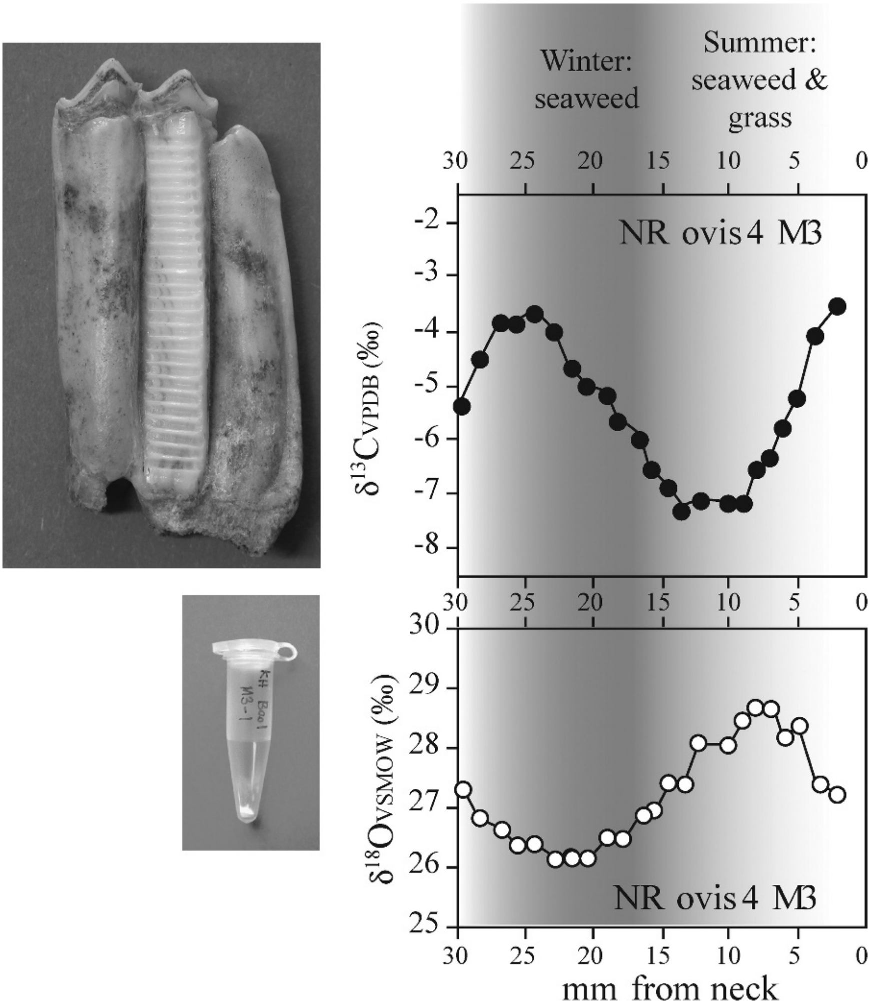

Fig. 9 Serial sampling of the enamel of the crown of Orkney sheep molars for mass spectrometry measurements of carbonate hydroxyapatite $\delta^{13}C$ and $\delta^{18}O$ ratios (IRMS). The diagrams correspond to a modern reference ewe. They show seasonal variations in isotopic ratios, with very high $\delta^{13}C$ values due to seaweed consumption, and poorly negative values of $\delta^{18}O$ during winter due to the ingestion of sea water together with seaweed (after Balasse et al., 2005)

Remnant Fats in Ancient Pottery

Dudd & Evershed (1998) have shown that the extraction of C18:0 fatty acids by gas chromatography-combustion (GC-C) and the measurement of the $\delta^{13}C$ values by isotope ratio mass spectrometry (IRMS) allows us to detect the dairy origin of fat residues in ancient clay vessels. Copley et al. (2003) applied this technique to nearly 1000 pottery shards from 14 British sites, 438 of them dating from the fifth millennium Neolithic. Twenty-five percent of the Neolithic shards carried residues of dairy fat. They conclude that “dairy farming was an established component of agricultural practices that reached Britain in the fifth millennium” together with the Neolithic package. Later on, Craig et al. (2005) applied the same method to a series of 40 pottery shards from two Early Neolithic sites in the Carpathian basin, dated to 5959–5500 B.C. (Starčevo-Criş culture) and to 5800–5700 B.C., respectively (Köros culture). Only 12 shards yielded fatty residues, six of them probably coming from milk products. They also evidenced the presence of mid-chain ketones, which are lipid pyrolysis products and suggest that dairy products were heated in the vessels.

Isotopic Evidence for Dairy Farming of Cattle

None of the papers cited in the previous paragraphs referenced isotopic evidence for Neolithic dairy farming of cattle (Balasse et al., 1997; 2000; Balasse & Tresset, 2002). While dealing with human practices rather than with their direct products, they are clearly complementary.

The origin of this evidence is the strange culling profile at Paris-Bercy mid-Neolithic settlement site (Tresset, 1997), with an uncommonly sharp 6- to 9-month peak. This peak can only be explained by the elimination of some of the cattle at the end of the summer season, either in order to limit the number of animals to be fed during the winter season, or because they were no longer useful for milk. This second hypothesis, called “post-lactation slaughtering” practice, would be evidence of herd management for dairy farming. Studying variations in the collagen $\delta^{15}N$ ratio at different heights in the dentin of molars, Balasse et al. (1997, 2000) found that the strange slaughtering peak at Bercy occurred at weaning time, strengthening the “post-lactation slaughtering” hypothesis, and thus the idea of herd management for dairy farming. In addition, Balasse & Tresset (2005) found that the age at weaning was earlier in Bercy than in present day natural domestic cattle populations (Fig. 10). This can be interpreted either as a consequence of a shorter lactation period in primitive breeds, or as deliberate weaning by the herders

Paleogenetic Data

The persistency of the capability to digest the lactose sugar after the weaning age in the mankind is due to the persistence of the lactase enzyme, which is itself due, in European peoples, to a single mutation, thus transmitted by a very simple Mendelian way with one unique allele located at position 13.910 in the human genome. On the basis of ancient DNA of one Mesolihic and eight Neolithic European human skeletons, Burger et al. (2007) convincingly evidenced that this mutation was not already present before the Neolithic in the European human populations, and that it increased in frequency during the Neolithic period. This suggests that this mutation has been selected by environmental pressures during the Neolithic, i.e., under the selective advantage that was provided by the consumption of unfermented milk,

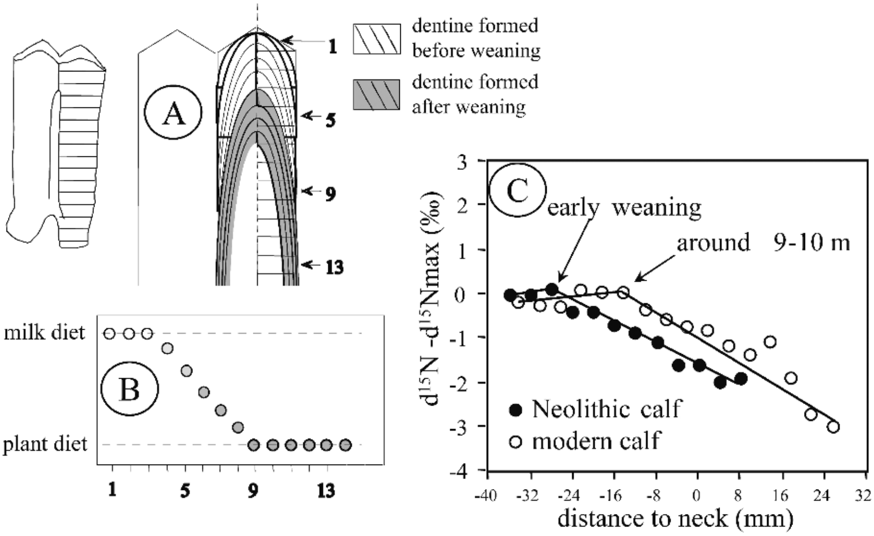

Fig. 10 **A**, Serial sampling of the dentin of sheep molar crowns for mass spectrometry measurement of the collagen $\delta^{15}N$ ratio (IRMS). **B**, weaning provokes a drastic decrease in the isotopic ratio. **C**, weaning appears to have occurred earlier for the Paris-Bercy Middle Neolithic calf than for the modern reference one (Balasse & Tresset, 2005)

long before the so-called 'secondary product' revolution. This suggests that the diet of the European people at least significantly benefited of milk supply as early as the beginning of the Neolithic period.

Paleodemographic Evidence

Biochemical and isotopic approaches have already produced a lot of good evidence that dairy farming and using processed dairy products were common practices in the temperate and northern European Neolithic. But they give little information about the relative role of cattle, sheep and goats in milk production. There is also as yet no evidence of it in the Near East or the Mediterranean region before the sixth millennium, which is nearly 30 centuries after the beginning of animal husbandry. One of the best ways to get this information is to use a frequency distribution of the age at death of the domestic animals, which reveals herding practices, especially milk exploitation or dairy farming.

There have been important technical advances over the last 20 years (Vigne et al. 2005). These allow for standardization and increased accuracy in age determination, increased taxonomic resolution (distinguishing sheep from goat management), improved quantitative processing of data and refined models (Fig. 11; Vigne and Helmer, 2007). These recent advances have also brought results for caprines and cattle.

Caprines. Among 14 well-supported Early Neolithic profiles (seventh and sixth millennium) from the Balkans to Spain, Vigne & Helmer (2007) showed only three

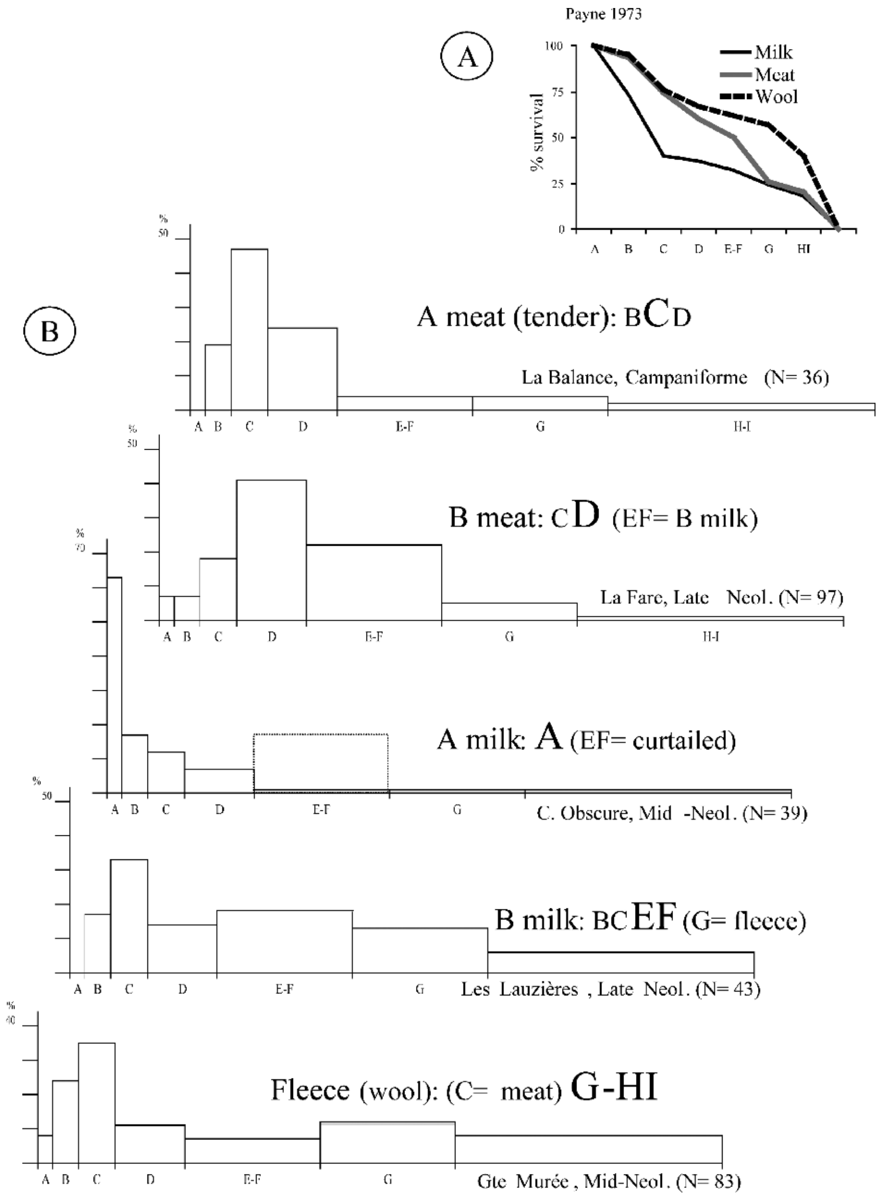

Fig. 11 **A**, The three main types of survival profiles as defined by Payne (1973) for the main types of sheep or goat exploitation; **B**, the five types of mortality profiles as defined by Helmer & Vigne (2004) and Vigne & Helmer (2007)

Table 1 Frequency of the different types (see Fig. 11) of age mortality profiles of sheep and goat during the Early Neolithic in the Mediterranean basin (Vigne & Helmer, 2007)

		Total	Meat	Mixt meat-milk	Milk B	Milk A	Fleece
NW Medit.	6th mill	10	2	4	2	2	0
Balkans	7th mill	4	1	1	1	1	0
Near East	7th mill.	8	0	5	1	0	2
	2nd half 8th mill.	9	0	9	0	0	0
	1st half 8th mill	1	1?	3-4?	1	0	0

typical meat exploitation profiles, five combined milk–meat profiles and six typical milk profiles. Half of the latter were specialized exploitation of goat's milk (Table 1). Twenty-two well-supported profiles were collected for the Near East. Only four are related to the very early stages of animal domestication, i.e., the first half of the eighth millennium (Middle PPNB): three are clearly combined meat-milk profiles, one may be a meat profile and one (Shillourokambos, Cyprus) is a non-specialized milk exploitation profile. For the second half of the eighth millennium, i.e., the Late PPNB and the actual beginning of animal farming, the nine profiles are all combined milk-meat profiles. During the seventh millennium, i.e., pre-Halaf and other early ceramic Neolithic periods, five of the eight profiles are of different kinds of mixed milk–meat profiles, one is a typical unspecialized milk profile (Tell Aswad, Damascus) and the last two show unambiguous signatures of fleece exploitation, although wool did not yet exist (it appeared much later on, during the Bronze Age).

Cattle. It is more difficult to discuss cattle milk exploitation because (i) there are few large samples, (ii) milk exploitation of cattle is complicated by the milk release reflex, which requires the presence of the calf near the cow when milking and precludes early calf slaughtering and (iii) consequently, it is difficult to use well-defined present-day models since humans have bred this reflex out of most modern breeds. However, Vigne & Helmer (2007) found that a post-lactation slaughter peak (5–9 months) similar to the one in Bercy appears not only in four of the five profiles of the French Middle Neolithic, but also in the three available early Neolithic profiles at Baume d'Oulen (Vigne & Helmer, 2007), Trasano (Vigne, 2006) and Blagotin (data modified after Greefield, 2005). In addition, Helmer and Gourichon (in press) observed clear evidence of the use of cattle for transportation of heavy loads in the Middle PPNB layers at Aswad (Damascus).

Conclusion: "Secondary Products"

Biochemical, isotopic and osteo-archaeological data supply convergent evidence that 'secondary products', especially milk, did not appear secondarily in the Early Neolithic process. Even though large-scale dairy farming reportedly began during the second half of the Neolithic age, the exploitation of milk clearly began with the Neolithic, as finally conceded by Sherratt (2006) in one of his last papers. It must be dissociated from the emergence of other “secondary products” (Vigne & Helmer, 2007). This new observation has at least two important implications:

First, taking into account that one of the main differences between hunting and husbandry is that only the second makes milk available, we must ask whether domestication of bovines and caprines (sheep-goat) in the Near East was at least partly motivated by milk exploitation. This would explain the late increase in the importance of domestic animals in meat consumption refuse in the Near East (see Fig. 4). During the first centuries, meat would have come mainly from wild ungulates, as hunter-gatherers had traditionally done for millennia. Domesticates would have supplied either milk and dung (cattle and caprines) or fat (pig; see Vigne, 1998). This would explain how those early Neolithic societies could have had a dairy economy in spite of sparse milk yields, since they compensated with the important animal proteins got by hunting.

Since milk exploitation (and possibly beasts of burden) appeared very early in the Neolithic process and was probably directly involved in the birth of a production economy, D. Helmer and I propose no longer using the misleading expression ‘secondary products’, but rather using something such as “*ante mortem* products” (Vigne & Helmer, 2007). Another more important consequence is that the technical skills of the last hunters–early farmers have to be rehabilitated. Although they had no writing (which is still the main criterion for ‘true civilization’ in the mind of some ethnocentric archaeologists), they were able to adapt their technical practices very quickly to full use of the newly domesticated ungulates. It could even be suggested that the invention of the exploitation of animals for something other than meat should be considered among the main components of neolithization.

Conclusion: Neolithic Diet and Demographic Transitions

More analysis is needed to test this reappraisal of the first Neolithic animal domestication in the Near East and Europe. This is already in progress, as recently demonstrated by several presentations at the tenth ICAZ Conference in Mexico (August 2006; presentations by R. P. Evershed and S. Payne) showing very early milk exploitation. It becomes more and more obvious that early livestock keepers (who were still hunters before becoming true animal farmers) had greater skills in animal management, transfer, acclimatization and exploitation than is currently believed. This does not preclude a slowing effect of local climatic or environmental conditions on the spread of the Neolithic way of life in the Near East and Europe. But it suggests that animal domestication actually implied a Neolithic diet transition that significantly influenced the NDT. This assessment can be specified as follows:

- From an historical point of view, animal domestication does not seem to have been initiated before the middle of the ninth millennium in the Near East. That would be several tens of centuries after some of the human groups in that area had adopted the sedentary life and begun grain and legume cultivation. In other words, animal domestication in the strictest sense could not have had any impact on a population increase before this period, although broad spectrum animal exploitation during the Natufian and the PPNA played a key role in sustainable settlement. The very long transition from early livestock keeping to true animal farming and then pastoral nomadism (more than 1,500 years; Fig. 12) must also be taken into consideration. It argues for a progressive impact of livestock keeping on technical–economic systems, and for a snowball effect in conjunction with the demographic transition.

– From a purely quantitative standpoint, if animal domestication actually brought milk into the diet, it would have been in addition to meat from hunting wild ungulates. This situation can be assumed in the Near East from 8500 to 7700–7500 B.C. prior to reduced meat procurement from hunting. It can also be assumed for the Early Neolithic age in the regions of western Europe (e.g., throughout the sixth millennium in Southern France) where hunting remained dominant or at least significant in archaeozoological records. Pig breeding might have brought an additional source of animal food, especially fat. This would mean that animal domestication must have brought a true increase in food resources, and could have played an important role in sustaining subsistence and in the population increase.
– From the more precise point of view of resource management, the domestic animal also represents a more stable seasonal resource, which must have rapidly became a good alternative to the Mesolithic or Natufian-PPNA system of seasonal exploitation of a broad spectrum of animal resources. This was fully accomplished in the Near East beginning at the end of the eighth millennium,

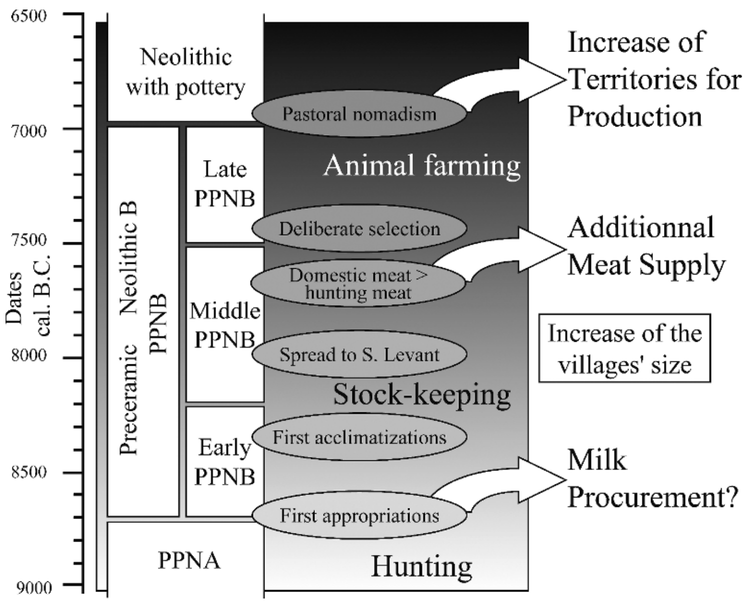

Fig. 12 The different phases in the emergence of animal farming in the Near East, as suggested by current knowledge

with the true farming economy of the Late PPNB and the emergence of nomadic pastoralism. Both of these brought important quantities of meat throughout the year, with hunting decreasing drastically during the same period. But that relative emancipation from seasonal constraints could have been achieved as early as the second half of the ninth millennium, as soon as sheep, goat and cattle were exploited for milk.

– From a more qualitative point of view, consumption of milk (and the fat of pigs) must have increased the quality of the diet, at least reducing amino-acid deficiencies. Milk is indeed four times more efficient as a conversion of grazing to flesh than hunting (Enattah et al. 2002) which could have helped increase the life expectancy of Neolithic people. This is especially true for those of the youngest ones by prolonging the beneficial effects of milk diet (proteins, fats, but also calcium supply) long after the weaning age. According to the discussions at the Harvard conference, however, this apparently did not help to reduce the length of human lactation periods.

Consequently, I posit that rapid improvement in the animal domestication skills of the last hunters/first farmers brought significant qualitative and quantitative improvement in the food supply and partial emancipation from seasonal constraints, which would have sustained the demographic transition. Together with favorable climatic conditions and substantial improvements in agriculture, this snowball effect would have contributed to an increase in the size of villages. The most striking example of this occurred midway through the animal domestication process (Fig. 12). This seems to be true for both the Near East and Europe, although the process and tempo were very different in the two regions.

However, given the infinite complexity of human systems, these generalizations should be re-examined with regard to regional or local situations. Each of these was a distinctive system, with its own local environmental conditions and cultural traditions. This is the everyday task of field archaeologists and laboratory archaeozoologists, the tireless data producers to whom falls the task of taking charge of this complexity.

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Impacts of the Neolithic Demographic Transition on Linear Pottery Culture Settlement

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Abstract This study aims to look for a new signal of the demographic transition linked in time to the installation and development of an agro-pastoral lifestyle. Demographic growth has always been a component of models for the spread, during the second half of the sixth millenium BC, of the Linear Pottery Culture (LBK), and the analysis of the space–time distribution of sites appears to confirm the hypothesis. Now a different signal is used here to examine in terms of quantitative trends the strength and rate of supposed growth: household size, measured by house groundplan surface-area. This criterion is particularly suitable because the data for houses are more accurate and manageable on a large scale than the data for the sites themselves. Thus the research issue can be addressed with a representative and uniform sample.

While the demographic transition is a phenomenon in itself, its coherence can best be gauged by measuring the time passing (dt) after the start of the process in each locality (time zero: $t0$). The intention here is to look for intrinsic trends in the strength and rate of the process.

Using time-spans of 100 or 50 years, changes in the ground surface-areas of 505 houses (433 for the shorter time-span) from the different regions of LBK Europe show a curve with a sharp increase in the first two centuries of a Neolithic economy, with values falling back over the following one or two centuries. A possible rise occurs again up to 450–500 years after the start of the process, but the evidence for this needs completing. So it seems that the average size of the "family" living under the same roof (household) increases considerably for two centuries after $t0$ and then decreases, before rising again at roughly $d\text{t} = 500$.

This growth and decline is visible at a continental scale, as well as at local (Bylany, Merzbachtal) and subregional scale (Aisne, Meuse/lower Rhine), in the same rate and proportions. The trend thus appears universally valid for the LBK.

The local data (Merzbachtal) suggest two correlated phenomena: a population density threshold per village and community fission once this was crossed. Further evidence suggests that the process involved the largest households rather than the

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village itself, although this must remain a working hypothesis for the moment. These phenomena may well explain the rapid and widespread nature of LBK dispersal.

Finally, a broad overview of the historical and environmental context reveals a good match between the "universal" demographic trend proposed here and the main climatic and culture-historical changes affecting the LBK. Rather than evoking simple ecological determinism, quite contradictory to the data assembled in this study, this highlights the ability and adaptability of the first farming communities in central and western Europe.

Keywords Climate · demographic pattern · ground surface-areas · household · linear pottery culture (LbK) · local dating · neolithic · population · settlement

In Search of New Demographic Signals in Archaeological Data: LBK Settlement

The hypothesis of population growth has existed since the beginning of research on the emergence and development of an agro-pastoral economy. As an integral part of the demic diffusion model (Ammerman and Cavalli-Sforza 1971, 1973, 1979; Ammerman 2003), this hypothesis naturally underlies interpretation of the spread of the Linear Pottery Culture (LBK) as a colonization process. Of particular interest to us here, the LBK phenomenon has been the object of a general demographic overview (Lüning 1998), based on an estimation of numbers of sites and houses to reconstruct population density. The suggested population level (1 to 2.5 million people at the height of the LBK) gives a fair indication of the size and scale of the historic phenomenon under consideration. The question of demography has also been addressed in various ongoing regional projects examining settlement (Hesse, Souabe), even though this aspect is not always the main goal of research.

Thus the information we are currently able to use comes basically from the distribution of sites in space. Yet, in the opinion of many researchers, our large-scale knowledge still remains superficial and imprecise, limiting our capacity to construct reliable models of general value.

Recent paleo-demographic work (Bocquet-Appel 2002; Bocquet-Appel and Naji 2006) has produced an original interpretation of the Neolithic transition, broadly applicable to a variety of spatio-temporal situations. Having been marginally involved in this research (Bocquet-Appel and Dubouloz 2003, 2004), I soon realized the interest and usefulness of looking for new demographic signals in archaeological data. The idea pursued here is that once signals of population growth in various categories of archaeological information have been identified, and the reality, strength and rhythm of these signals measured, one can then go on to examine the range of socio-cultural responses.

At first glance, settlement seems one of the areas most concerned by this issue, and in western Europe it is clearly the LBK that offers the best possibilities for this kind of study.

Now, to examine in terms of quantitative trends the strength and rate of the supposed growth, I shall use here a new signal: household size, measured by house groundplan surface-area. This criterion is particularly suitable because the data for houses are more accurate and manageable on a large scale than the data for the sites themselves. Thus the research issue can be addressed with a probably more representative and uniform sample. By initial assumption, house groundplan surface-area is supposed to be linked, at least partially, to the number of people living under the same roof. And, at the same time, these people are supposed to represent a basic and coherent socio-parental segment within the community. At this point, we can believe that the LBK household and its size variation through time are related in some way with broad demographic evolution.

Background on the LBK

The LBK constitutes the first major manifestation of a Neolithic, agro-pastoral way of life in central, west-central and western Europe (Lichardus and Lichardus-Itten 1985; Lüning 1988). It developed through the entire second half of the sixth millennium BC and is characterized by a surprising abundance of remains, with particularly good evidence for settlement organization. A large proportion of the LBK can be considered as a 'demic' phenomenon (Bogucki 2003), even if some acculturation may have taken place, involving particular aspects which will not be developed further here (Whittle 1996; Gronenborn 1999).

– Variability of the LBK house: size and function

The LBK house is known for its standardization (Coudart 1987; 1998). Indeed, one same architectural conception seems to structure the vast majority of houseplans, recovered at least partially by thousands on hundreds of sites. We can recall here the long, rectangular shape of the groundplan, the large numbers of posts set deeply into the ground, the longitudinally arranged beams, the non-load-bearing walls, the presence of external lateral pits and the proportionately stable tripartite division of internal space.

The internal organization of the LBK houses, however standardized it may be, also includes a certain variability. Besides the predominant tripartite groundplans, there are also bipartite and monopartite variants. The front part of a house (identifiable only with the tripartite groundplans), includes the one recognizable entrance and can include posts supporting an extra floor, termed "granary". The front part is generally assumed to be non-residential. The central and back parts of each house, either connected or separate, are considered as areas for receiving visitors or for sleeping. The question of an area reserved for animals has often been debated, but so far there are no decisive arguments in favor of such an area. The arguments against are in fact more convincing: the absence of a specific entrance, the unsuitability of the internal space for large-horned animals and the lack of traces of stalling on the animal bones. On this subject, I share the opinion that these buildings were constructed for people, although it seems likely at this time that certain young, fragile, or small animals may occasionally have been kept indoors in a non-specific part of the house.

The standardization also includes great variability in size: the length of the buildings varies a great deal (from $\approx$ 7 to $\approx$ 40 m), while the width is relatively constant ($\approx$ 4.5 to $\approx$ 8m). This variation, in terms of floor surface-area, is of particular interest to our study.

– Variability of the LBK village: duration and hierarchy

As with the house-plans, the LBK village shows a certain standardization, with variability notably involving village duration and position in the settlement system. Some sites lasted continuously for several centuries and seem to play an important role in the local organization of settlement (Zimmermann 1995), especially with regard to long-distance exchange. Other short-lived and more peripheral sites were only a generation long: they must reflect the economic and demographic respiration of the LBK system. The average number of contemporary houses revolves generally around 5–7, with a few peaks at over 10 and a some minima at 2–3. In almost all cases, we are dealing with a hamlet rather than a village in the strict sense of the word.

When the evidence is complete, the duration of occupation on these sites and the relative and absolute dating of the houses which make up the different phases in development can be precisely estimated. Several case studies are available (Bylany, Langweiler, Cuiry-lès-Chaudardes, for example) where the temporal resolution of the data is about a generation (17–18 to 25 years); in other cases we must content ourselves with a resolution to the century. Unfortunately too often, the evidence only permits a broad dating of all or part of a site; in this case the individual houses belonging to the occupation cannot be placed in chronological order with certitude.

– Variability in the LBK settlement pattern: density and duration

A third level of variability should be rapidly evoked in order to circumscribe the conditions of our study. The LBK population zones, spread out over 700, 000 km^2, show differences of duration and site density between themselves and between the sectors of actual settlement within these zones. The rate and intensity of occupation was thus variable, involving both short-distance and long-distance expansion (Bogucki 2003). These different impacts are interesting in terms of the variability in population density.

Hypothesis

Given the variability of the house, village and settlement pattern, it is not easy to assess the demographic developments suggested only by the study of the geographic distribution of LBK sites during the half-millennium in question (Lüning 1998). Admittedly, the increasingly widespread dispersal of the LBK cultural and economic system, as well as the dense settlement of the most favorable geographic sectors, cannot have taken place without population growth. However, it is not possible to accurately evaluate the strength and rate of this growth. Indeed, we are far from knowing how many houses are hidden beneath each site marked on a map, how many houses are contemporary, how many villages coexisted at different moments in time, or the duration of each house and village. Detailed evidence currently available at various spatial scales (Bylany, Merzbachtal, Aldenhovener Platte, the Aisne valley) is still too sparce and uneven to support a reliable and precise understanding. New micro-regional and regional projects, in Hesse (Ebersbach and Schade 2004; Schade 2004) and on the Danube (Knipper et al. 2005), based on systematic survey around a few extensive excavations, will surely contribute to improving precision and reliability.

Therefore, population growth during the LBK is a reasonable hypothesis, though difficult to elaborate solely from these quantitative data currently available. In order to bypass this difficulty, I propose to use a criterion related to demographic factors which is more easily definable and measurable than the sites themselves: the household size, measured by house groundplan surface-area. It is therefore necessary to establish a sample of houses which is the most representative possible of the spatial, temporal and functional variability of the LBK.

– House surface-area representative of the number of occupants

The initial hypothesis supporting such a selection of samples is, as we noted before, simple and almost trivial: surface-area is proportional to the number of occupants. This equation has already been tested in ethnography by different authors (Narrol 1962; Casselberry 1974; Cook 1972) and the results used in archeological research on the LBK (Soudsky 1969; Milisauskas 1972; Bakels 1978; Coudart 1998). Beyond a few practical formulas, these ethnographic studies underlined the importance of the socio-cultural context in looking for the rules of correlation between surface-area and the number of occupants. Thus, what emerges from this approach is that there are probably no general rules in this matter, but only select rules.

The small exercise summarized in Table 1 perfectly illustrates the illusory character of a precise evaluation of the numbers of occupants in a LBK house: the estimations can vary by a factor of three and their application to parts considered as truly residential sometimes produces unlikely results (2–3, 5–4).

But the exact figures here matter less than the correlation occupant/surface-area itself, and we shall thus consider that a large house corresponded to a larger population than a small house.

– Which surface-area? total vs. back-central

In their hypotheses on the tripartition of the LBK house-plan, specialists of the central European early Neolithic only consider the central and/or back parts of the

Table 1 Estimation of the number of occupants of an 80m^2 LBK house, using three ethnographic formulas

80 m^2 house	Naroll (1964)	Casselberry (1974)	Cook (1972)
Back part	2	3,5	6,5
Central part	4	6,5	9
Back + central parts	6	10	11
Total	8	13	13

houses as having a truly residential function (Soudsky 1969; Coudart 1998). The analysis of the surface-area of these two parts alone would thus seem well adapted to our problem, especially since the uninhabited front part varies to a great extent; it can be absent, include a simple hallway or support a vast raised granary. On the other hand, the total surface-area of the house is easier to estimate, in a larger number of cases, and with a more reliable margin of error: when the groundplan of a house is not completely preserved, the possible error in calculating its total surface-area is proportionally less than for one of its parts.

Detailed research already undertaken on LBK architecture (Brandt 1988; Coudart 1998) shows that it is possible to use the criterion of total surface-area. Indeed the number of distinct internal spaces varies with the length of houses, jointly increasing or decreasing the number of available "rooms"; the number of rooms also varies with the length of each of the 'residential' parts.

Based on a credible sample stemming from the database of the present study (Langweiler 8 and Cuiry-lès-Chaudardes), it can be shown that variations in the total surface-area perfectly match those of the surface of the back part and the central part ($r = 0.92$ and 0.97). Hence, when the total surface-area of the house increases, the surface-area of the parts considered as truly inhabited also increases. The analysis even shows that this increase is broadly proportional, the share of each of the considered parts remaining stable. The statistics allow us to assess the proportions in relation to total surface-area, centering on 25% for the back part and 50% for the central part, with a sound concentration around these values.

Thus, it is through the architectural rules of the LBK house and the cultural standards underlying its conception that we find the best validation for choosing the total surface-area as a relevant criterion for our argument.

The Database

Gathering data on a vast sample of LBK houses for which surface-areas could be estimated seems a relatively easy task: are there not thousands of houses on hundreds of sites? Nevertheless, the hypothesis underlying this study and its examination of the rate and strength of the supposed phenomenon imposes considerable constraints which greatly restrict the number of potential examples that can be used. Thus, in order to be analyzed with this conception and methodology, an LBK house has to meet several requirements in terms of preservation, representativity and datation.

Constraints

– Preservation of houses and contemporary groups

The first constraint lies, as can be expected, in the preservation of the house-plans. To estimate the total surface-area of a given house implies that we have reliable knowledge of its total length and average width. Only a small proportion of the available data completely fulfills this requirement. Fortunately, the well-known and previously evoked unchanging architectural rules allow us to add less well-preserved houses to the initial database. For example, thanks to stability in the proportions of the various parts of the houses, it is possible to complete a poorly preserved back part with acceptable reliability; or, thanks to the extent of the lateral pits, we can often define with good precision the position of a missing front gable and thus reconstruct the dimensions of the house with a low margin of error.

The second constraint constitutes the second important filter for our sample. Excavations of a certain scale and certain spatial coherence are necessary, but not sufficient, so that the variability in dimensions of contemporary houses can be identified: in fact, each building belonged to a variably sized group of contemporary houses, and this size variation is particularly relevant for our study. Single houses with insufficient evidence for their surroundings risk being unrepresentative of the occupation to which they belong. For this reason they are generally excluded from the sample.

– Temporal representativeness of the houses

As it involves measuring the chronological development of a criterion, the question of dating constitutes the third major constraint. In order to be integrated into the analysis, houses must be dated in relationship to one another. This rules out a number of sites for which the evidence is incomplete. The level of precision in dating varies from house to house and from site to site, depending on the quantity and the quality of finds. Thus there are series of houses dated to within a generation, and others dated more approximately to within a century. It is this last level of precision that has been retained as a filter of selection.

The Houses Sample

Five hundred and fifty house groundplans, from 44 different sites, went through this long and harsh sampling procedure. Among them, from 39 different sites, 478 houses belong to the true LBK and 27 to its immediate successor in the Paris basin (VSG: Villeneuve-Saint-Germain group). The latter increase the spatial and chronological range of observation in this peripheral region, without affecting the overall coherence of the study (Table 2). The LBK I houses of Schwanfeld, Bruchenbrücken and Mohelnice were retained in spite of their imprecise dating within this initial period of at least two centuries, and in spite of the incomplete evidence from these sites. They are included in the sample because they provide information on the earliest LBK. Other houses are also approximately dated: Hienheim, Orconte and Ecriennes in particular. The first doubtless belongs to the end of LBK IV; the others are broadly attributed to the main periods of occupation found on each site (LBK III or IV). Together with additional houses which will be mentioned later, these imprecisely dated buildings have not been used in a second level of more finer analyses.

Forty-five other post-LBK houses from the main area of the western LBK (from Slovakia to Dutch Limburg), and which only partially meet our requirements in the selection of the LBK sample, have been added to this main sample: they are not very numerous and concentrated in a single region, the German Lower Rhine (Table 3). In these two respects, their representativeness for the purposes of our study does not offer the same level of confidence as the LBK houses. While post-LBK architecture and hamlets recall the LBK, probable changes in the arrangement of domestic space,

Table 2 Distribution in time and space of the LBK houses analyzed

Areas	Sites	N sites	N houses	Periods
Slovakia	Sturovo *(Pavuk 1994)*	1	17	LBK III à IV
Bohemia	Mohelnice *(Tichy 1962)*, Bylany *(Pavlu et al. 1986)*	2	83	LBK I à IV
Little Poland	Olszanica *(Milisauskas 1976)*	1	12	LBK II à III/IV
Lower-Bavaria	Alteglofsheim-Köfering, Straubing Lerchenhaid, Landshut-Salmannsberg *(Brink-Kloke 1992)*, Hienheim *(Modderman 1986)*	4	37	LBK II/III à IV
Hessen-Main	Schwanfeld *(Lüning 1986)*, Bruchenbrücken *(Stäuble 1989)*	2	10	LBK I
Neckar	Gerlingen *(Neth 1999)*	1	24	LBK I à IV
Souabe	Ulm Eggingen *(Kind 1989)*	1	25	LBK III à IV
Lower-Rhine	Merzbachtal-LW2, 8, 9, 16, LB7, NM4- *(Boelicke et al. 1994; Brandt 1988; Farruggia et al. 1973; Kuper et al. 1977)*	6	79	LBK II à IV
Meuse	Elsioo, Stein *(Modderman 1970)*, Geleen JKV *(Louwe-Kooijmans 2003)*	3	87	LBK II à V
Alsace	Sierentz *(Lefranc 2001)*	1	9	LBK IV à V
Champagne	Orconte *(Tappret et al. 1988, 1991)*, Ecriennes *(Bonnabel et al. 2003)*	2	23	LBK III à IV
Seine	Aisne *(Allard 2005; Allard et al. 1997; Constantin et al. 2003; llett and Hachem 2001; llett and Plateaux 1995)*, Oise *(Bostyn et al. 2003)*, Seine *(Mordant 1991; Prestreau 1992)*, Yonne *(Delor 1991)*	15	99	LBK IV à V

Table 3 Distribution in time and space of the post-LBK houses analyzed

Areas	Sites	N sites	N houses	Periods
Lower-Rhine	Hambach 260 et 471 *(Dohrn-lhmig 1983), Inden 1 (Kuper et al. 1966; 1975), Aldenhoven 1 (Jürgens 1979)*	4	45	Grossgartach, Rössen

in the duration of use and in overall settlement pattern possibly limit the relevance of these houses for the present study (Kuper and Piepers 1966; Kuper and Lüning 1975). We shall thus use them as simple heuristic tools, potentially offering a wider scope to the hypothesis constructed for the LBK period.

Data Processing

Methodology

– Local dating: *d*t

Following the hypothesis that the demographic phenomenon is a process in itself, independent of geography and absolute chronology, I used the method of local dating initiated by J.-P. Boquet-Appel to highlight what he called the 'Neolithic Demographic Transition' (Boquet-Appel 2002; Boquet-Appel and Naji 2006). Because, at first, the actual time in which the phenomenon took place matters little, each element is thus dated by its temporal distance (*d*t) to the local starting date of the beginning of an agricultural way of life ($t = 0$). In this manner we can build a profile common to all the data directly connected to the temporal depth at every location and track down an 'absolute' signal of the effect of the new way of life on demography. This approach was also applied by the present author in a previous study on enclosed sites in the central-western European Neolithic (Boquet-Appel and Dubouloz 2003; 2004). Here, an LBK I house of Bohemia or Slovakia is dated in the same way as a house of the beginning of the Flomborn (LBK II) on the Rhine, and in the same way as a house at the beginning of the RRBP (LBK IV) in the Aisne valley.

– Simple statistics

In analyzing the duration of moderate values, the field of calculation is vast and sophisticated. We nevertheless contented ourselves with simple statistics: scatter plots, fitting curves, distribution histograms and correlation coefficients.

Scatter plots were used to distribute the values of surface-areas on the distance *d*t, first to within a century, then to that of a half-century for the houses best dated. These scatter plots were subjected to an adaptation by calculation through the Lowess smoothing procedure (similar to a moving average) and which allows us to define an average profile-trajectory of the data in time. This trajectory, which can be adjusted by the size of the windows allowing calculation of the successive averages (α), defines the general trends of point dispersal in the plot analyzed. Some frequency histograms served to describe certain distributions of relevant values and, from the initial stages of the analysis, the calculation of the correlation coefficient allowed to ensure on one point in particular the validity of a criterion in the selection.

First Level of Analysis: The 'Continental' Profile

LBK Houses on dt, Dated to Within a Century

The first researched profile was supposed to establish a comprehensive reference of our sample from the point of view of the surface-area variation of the houses in the local chronology; it was thus necessary to take into account the maximum amount of data in space and time. The dispersal of the values of the 505 LBK houses was analyzed according to the time-span of a century in order to take into account the

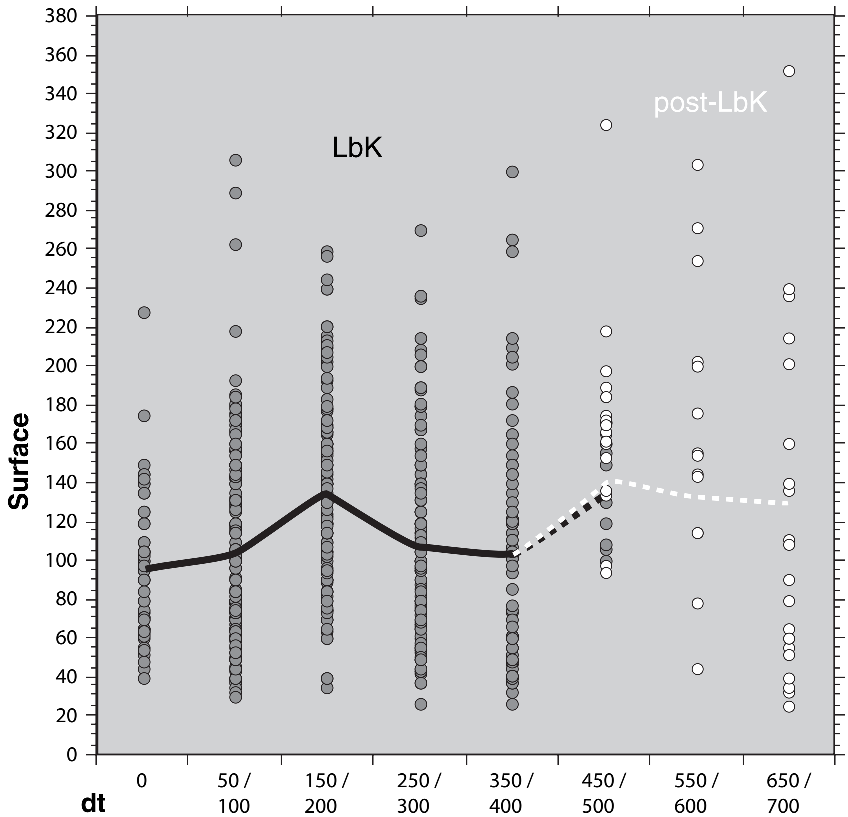

Fig. 1 Surface-area of 505 LBK houses by dt to the century with a Lowess smoothing of 25%

variable precision of the dating of each house (Fig. 1); the scatter plot was summarized by Lowess smoothing ($\alpha = .25$).

This profile, which I will call 'continental', shows a peak around dt = 200, followed by a decline before a possible increase around dt = 450–500. The first peak indicates, at each point of the area studied, a growth of more that 40% in the average surface-area of the houses for the first two centuries of the agro-pastoral economy. The decrease which follows seems statistically viable, though the final increase is only based on a restricted amount of data.

For general heuristic purposes, it is tempting to include data which allow us to follow the curve beyond 500 years (Fig. 1). There, we reach the post-LBK period, for which there are fewer and more diverse documents, probably less viable for the methodology of this project.

The projection of the surface-areas of these houses onto dt and the calculation of the Lowess curve seem to confirm an expected increase on the LBK houses themselves; it defines a new peak at dt = 450–500 years, before a period of possible stability lasting two centuries. With this latter observation, conjectural because based on sparce and poorly distributed data, we can establish a tentative 'continental' profile of about seven centuries; it shows a bi-modal evolution of the average surface-area of the houses and, by extension, of their number of occupants. Over two centuries, there was a 40–50% increase, followed by a decrease over the next two centuries; a century of new rapid growth then occurred reaching a stable level during two centuries.

LBK Houses on dt, Dated to Within the Half-Century

The wealth and the quality of the work on LBK data by several generations of European researchers enable us to employ a much finer chronology than the century-long units used above. Sometimes, local and regional analyses propose a dating to within ±20 years. For example, 14 successive settlement phases over about two and a half centuries (5300–5050 BC) for the LBK occupation of Merzbach valley – Lower-Rhine, Germany – (Stehli 1989); 25 settlement phases over about 450 years (5550–5100 BC) for the LBK occupation of Bylany – Bohemia, Czech Republic – (Pavlu et al. 1986); 5 settlement phases over about 100 years (5050–4950 BC) for the LBK occupation of Cuiry-lès-Chaudardes – Aisne, France – (Ilett and Hachem 2001). In other cases, the houses were only attributed to particular moments in cultural chronology: for example, the end of Flomborn, middle of LBK III, beginning of LBK IV, etc. and it is possible to transcribe this dating to within 50 years. This half-century dating span (2–3 settlement phases) was chosen to establish the most precise 'continental' profile in our selection (Fig. 2). The respective surface-areas of 433 LBK houses[1] are thus included here and summarized by Lowess smoothing ($\alpha = 0.27$).

[1] Houses dated at best to within a century are eliminated from this calculation: the others are from the Seine Basin, the Dutch Limbourg, the German lower Rhine, Bavaria (except Hienheim), Bohemia and Slovakia.

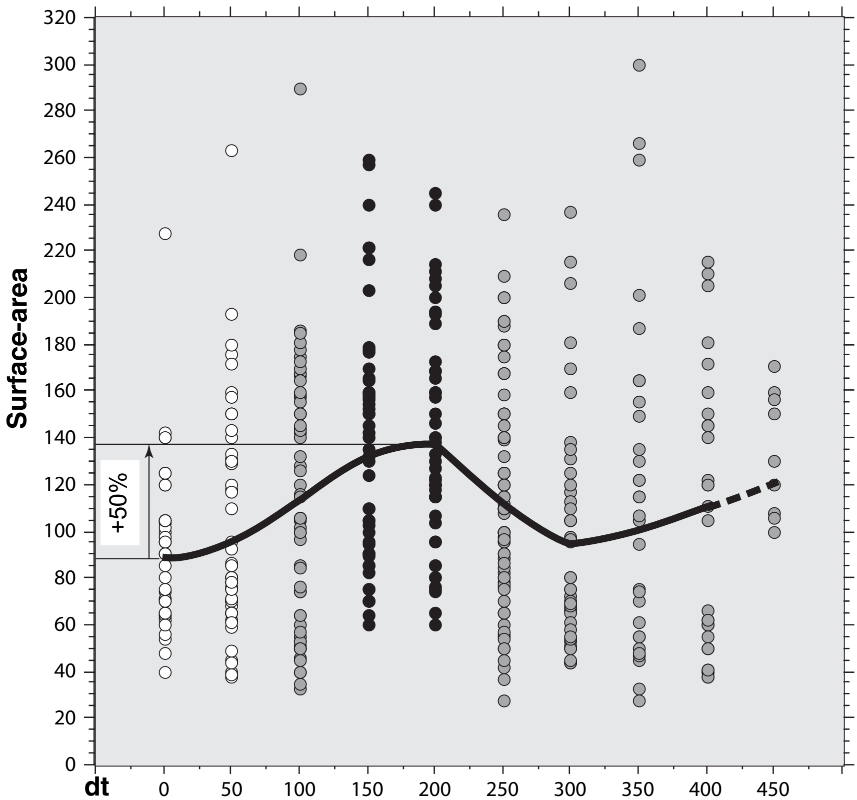

Fig. 2 Surface-area of 433 LBK houses on dt, to within a half-century, with a Lowess smoothing of 27%

A peak appears at *d*t = 200, illustrating a 50% increase in the average surface-area area, followed by a decrease up to *d*t = 300, then a probable rise by at least *d*t = 450. The comparison through histograms of these surface-areas at *d*t = 0–50 (86 houses) and *d*t = 150–200 (91 houses) shows a very clear redistribution of values between comparable extremes (Fig. 3): the maximum peak of 55% of the houses between 50 and 100 m^2 at the beginning of the curve is followed by a maximum peak of 35% of the houses between 100 and 150 m^2 at the apex of the curve. One notes that the classes of larger surface-areas (150–200 m^2 and 200–250 m^2) are also reinforced according to the situation at the beginning of the curve – *40% (for larger surfaces) as opposed to a previous 12%* – confirming that there was an overall increase in the number of middle and large-sized houses over the first two centuries. This suggests that the domestic units and the families composing them had themselves increased in size. At *d*t = 300–350, surface-area value distribution returns to what it was at the beginning of the process studied here, with a peak of about 50% of the surface-areas included between 50 and 100 m^2.

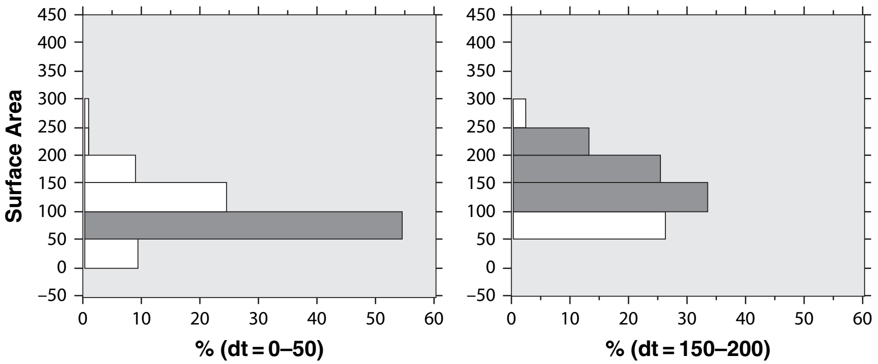

Fig. 3 Surfacce-area distribution at dt = 0-50 (86 houses, 14 sites) and dt = 150-200 (91 houses, 12 sites)

General Validation: Particular Profiles at Local, Micro-regional and Regional Level

As an evaluation of the validity and precision of the conclusions taken from a general profile of the data, one can now tie in the particular profiles from the three main spatio-temporal subsets in our sample (Fig. 4): the local subset of Bylany in

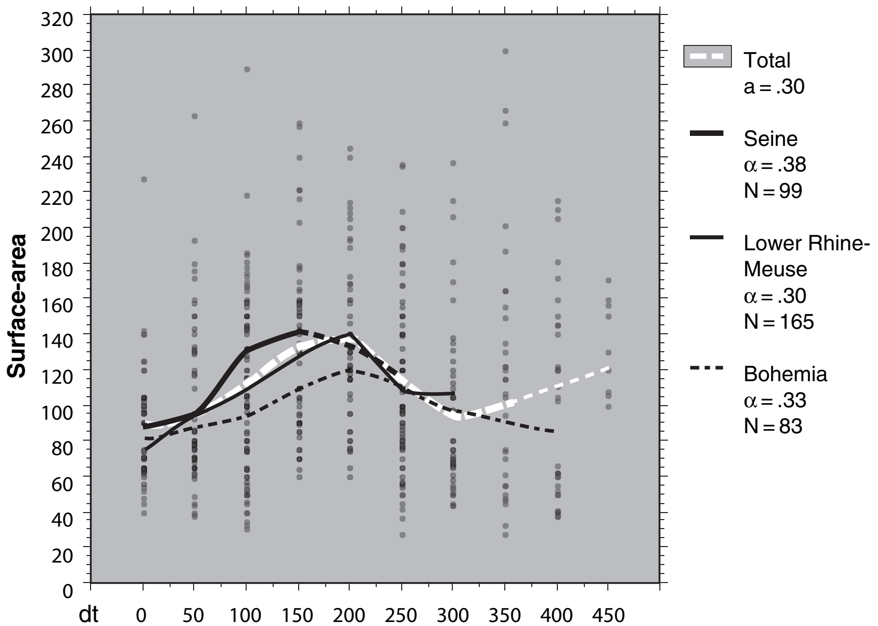

Fig. 4 Surface-area of 433 LBK houses on dt with Lowess smoothing for three principal selections

Bohemia (83 houses); the micro-regional subset of the Maastricht-Aachen region (165 houses) and the regional subset of the Seine Basin (99 houses).

As with the 'continental' profile, these three profiles, established respectively at $\alpha = .33$, .30 and .38, diverge little between each other; one peak takes shape at $dt = 150$–200 followed by a pronounced decrease in each case. One notes that the growth at the local level of Bylany is a little weaker than that of the sub-regional, regional and continental averages; and that growth occurs at a more rapid pace in the Seine basin, at the western edge of LBK dispersal. Beyond these differences which can be accounted for by several factors of variability – *quality of documentation, observable duration of occupation, size of the social integration area involved, dynamic of cultural dispersal* – the group shows an interesting coherence which validates the general curve as representative of the same observable phenomenon at different scales.

Regional Validation: Analyses of Local Examples (Aisne Valley, Merzbach Valley)

We shall now try to show how this broad and sound pattern appears at lower scales and how it matches with other characteristics of settlement data. As we will emphasize later, the amount of information available for the Merzbach valley is to date still exceptional. But extensive research initiated by B. Soudsky in the Aisne valley (Soudsky et al. 1982) and then undertaken for more than 30 years (Dubouloz et al. 2005), offers detailed evidence at a level spatially above that of the Merzbach: the micro-region.

Analysis of a Sub-regional Example: The Aisne Valley

– Surface-areas – Number of houses – Number of sites

The scope of research in this area is sufficient to affirm that the occupation and population density were lower than that of the classic settlement zones of the more eastern regions. Of course, the extent of our knowledge here is probably still partial and concerns a short duration – the last century of the LBK phenomenon (RRBP). However, the space concerned allows us to envisage the demographic question at the scale of a network of several micro-areas. Here, the archeological remains are still better preserved – more than 75% of the located houses can be studied with our criteria – and their dating is easier thanks to the less dense occupation (Ilett and Hachem 2001; Ilett and Plateaux 1995).

This information, very homogeneous in constitution – same team, same protocol – was analyzed within a supra-local perspective, the only spatio-temporal dimension really accessible.

The evolution of the physical and sociological sizes of the domestic units reveals itself well in the chronological phasing of this region (Fig. 5). Lowess fitting curve of the surface-areas of the houses (72 in number) shows an explosive growth in

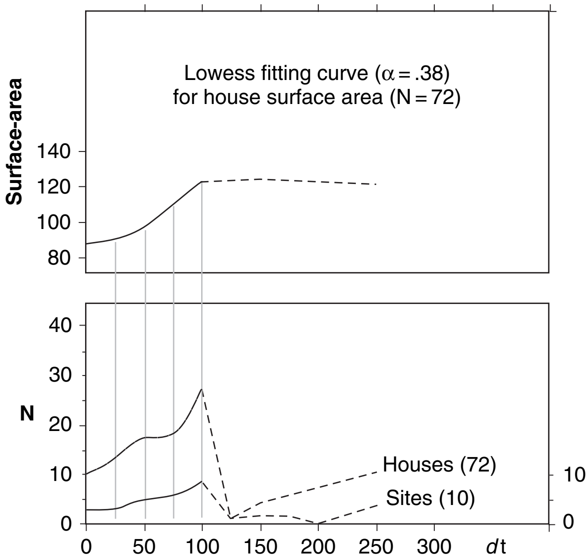

Fig. 5 Demographic signs at a regional level: synchronicity of the variations of three criteria in the Aisne Valley during the LBK

one century; the following of which is too poorly understood to be commented on. Curves of the number of sites and houses show an unequivocal synchronism with this figure: a rapid growth culminated around $d\text{t} = 100$. This would suggest that the local development of the Neolithic lifestyle brought first a rapid population growth, identifiable at the scale of the domestic unit, and a spatial expansion and densification of the LBK occupation (>40% increase in the size of the domestic unit, 300% increase in the number of houses, 300% increase in the number of sites, in one century). Thus, the data at this spatial scale reinforce the hypothesis of a general phenomenon connecting population growth and development of an agro-pastoral lifestyle.

Analyses of a Local Example: The Merzbach Valley

By their extent and precision of results, excavations and research on the Merzbach valley (Lüning and Stehli 1994) have remained a model study at the local level, in an area a hundred times smaller than the previous example. It remains today an essential reference for the economic and cultural phenomenon of the LBK. The hypothesis defended in the preceding analyses must therefore be challenged here, within a heuristic approach, by the best local data available.

– Surface-areas – Number of houses – Number of sites

The proportion of houses possible to study in the different sites of Langweiler, Niedermerz and Laurenzberg only reaches 50% of the total recorded number and certain phases are better allotted than others. To even out this quantitative weakness and neutralize the heterogeneity of the data, a re-elaboration of the chronological data was undertaken by regrouping phases into half-century units. The same procedure was used for the number of contemporary sites and the number of houses in order to construct again three comparable curves on the same timescale.

The evolution of the physical and sociological sizes of the domestic units can be seen rather well in the chronological sequence of this micro-area (Fig. 6). Lowess fitting curve of the surface-areas of the houses and the curves of the number of sites and houses show again an unequivocal synchronism: after a steady growth culminating around $d\text{t} = 200$, the three curves collapse rapidly until an abandonment of the micro-area as a settlement zone. The situation appears to begin in a similar way to the Aisne valley: with the local development of Neolithic lifestyle, the population growth seen at the level of domestic unit first led to spatial expansion and densification of the LBK occupation, and therefore an increase in the number of sites and houses (>20% increase in the size of the domestic unit, 250% increase in the number of houses and a 500% increase in the number of sites, over two centuries). But secondly, the curves suggest a continuously rapid abandonment (an important decrease in the number of sites and houses) under the impact of a sort of local demographic crisis (an important decrease in the average size of the domestic units).

– Demographic evolution

An attempt will now be made to obtain additional information, by transcribing this evolution in terms of population numbers. For this, we need to balance

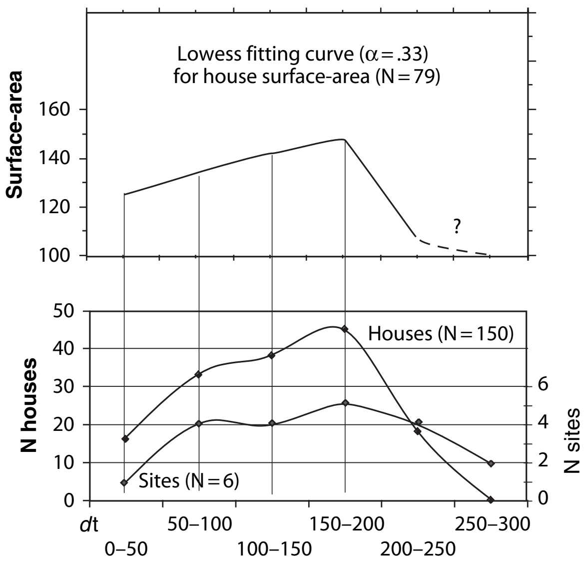

Fig. 6 Demographic signs at a local level: synchronicity of the variations of three criteria in the Merzbach Valley during the LBK

an average population base per household (p) with the evolution coefficient of the average surface-area (ΔS). The result is then applied to the houses 'contemporary' within a half-century time-span. The hypothetical population of each stage (P) is then calculated according to the simple formula: $P = N(p^* \Delta S)$.

A doubt remains, however, in the precision of the Lowess profile for the Merzbach, which we have attempted to reduce. This curve for the single values of the Merzbach differs a little from that of the Lower-Rhine-Meuse region as a whole (Fig. 5 and 4). This difference doubtless reflects, at least partially, a quantitative problem: the number of Merzbach houses used in our approach is twice as less than the actual number of houses recorded in this micro-area, which possibly makes the results of the analysis less reliable at this local scale. However, the great geographic (30–40 km) and chrono-cultural proximity of the houses studied in Dutch Limburg (Elsloo, Stein, Geleen 'JKV') allows us to consider the group 'Lower-Rhine-Meuse' as a relevant analytical unit. As such, and to reduce the quantitative problem which has just been underlined, the fitting curve of this main area will be used as a valid model for the Merzbach itself.

The number of houses by settlement phase (N) being known (Stehli 1989), the surface-area averages (S) and its evolution (ΔS) being given by the Lowess curve for the Lower-Rhine-Meuse, the basic average number of people per house now remains to be determined. As we saw previously, this is a difficult question to answer. But as it is, one must first evaluate a trend, and the exact number matters little. I chose the option of at least six individuals per house, a number often upheld by specialists of this period (Lüning 1988; Ebersbach and Schade 2004). One can note that this value, even if it seems too low, is not incompatible with the results of the three estimations (Narrol; Casselberry and Cook) noted earlier.

We can now construct the evolution curve of the population (P) of the Merzbach as a whole and that of its main site, Langweiler 8, the founding and only permanent village of the micro-area (Fig. 7).

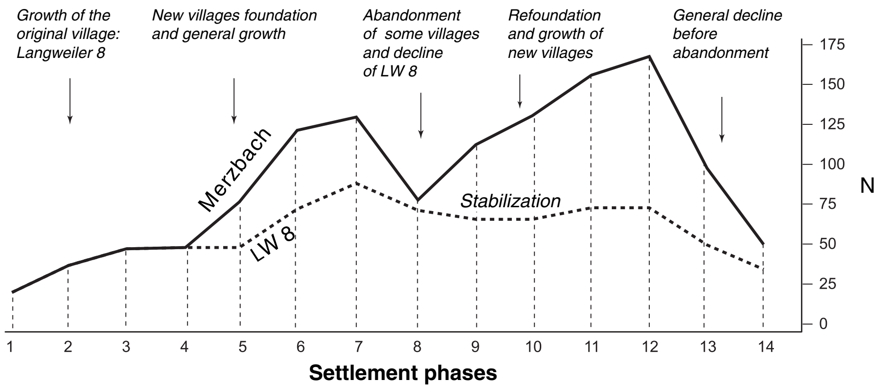

Fig. 7 Estimation of the population of the Merzbach Valley and of Langweiler 8 during the LBK

Here, we observe a continuous growth of the entire occupation over 12 phases of settlement (approximately 200–250 years), supported (tenfold increase of the local population) and marked by a temporary fall-back at the end of 125–150 years. After the culminating point, the abandonment of the micro-area within a half-century is particularly clear. The specific curve of the main site, Langweiler 8, shows two phases of disjunction with this general curve:

– The first disjunction takes place from the fourth settlement phase (approximately 70 years after the beginning of the occupation of the Merzbach valley) and corresponds to the creation of 2–3 new hamlets, whereas Langweiler 8 seems to stagnate for one generation. This short stagnation before a new rapid growth, while the population of the Merzbach as a whole grows continuously, can be interpreted as the result of a 'fissioning event' of the main village, to the advantage of new settlements in close proximity. Even if we envisage the arrival of new settlers from the outside (Zimmermann 1995), it is likely that part of the growth of the new hamlets is connected to the momentary congestion of Langweiler 8; as if part of the surplus population in this main village left to form new local settlements.
– The second disjunction, more pronounced and probably complex, occurs after the recession phase 8 which could represent either a very localized demographic accident (sanitary, ecological or political?), or a voluntary departure by one part of the population for a non-local destination. The strong and rapid return in population growth, of the peripheral hamlets only, evokes the arrival of new extra-local people, while the long stagnation of the main village suggests a voluntary control in its demography, as if a population threshold in this settlement had been reached. Indeed, from this point and during roughly one century, the population growth of the Merzbach valley involves exclusively the creation and development of new hamlets. This difference in the management of local population density may refer again, at least partially, to a repeated fissioning process at the main village level toward the neighboring hamlets.

This hypothesis of a population threshold and of fissioning events as a means of population dispersal is such a general idea that it has rarely been used for the analysis and interpretation of variations in population density and spatial expansion. It was recently the subject of new research (Bandy 2004) where the author recalls the particular documentary conditions that must be brought together in order to recognize such a process. It appears that the LBK data allow us to develop this issue with a certain precision and to detail the implied process from such an analysis (Fig. 8).

Here, in the Merzbach Valley, one notes that between occupation phases 3 and 6, or, in other words, before and after the first supposed fissioning event, the number of contemporary houses of the main village remained more or less stable (7–9), but the number of large and middle-sized houses steadily increased (from 1 to 4 in each phase), with a set-back at phase 5 (a return to one single unit). This rhythm is corroborated by the curve of the surface-areas of the largest houses, whose slight

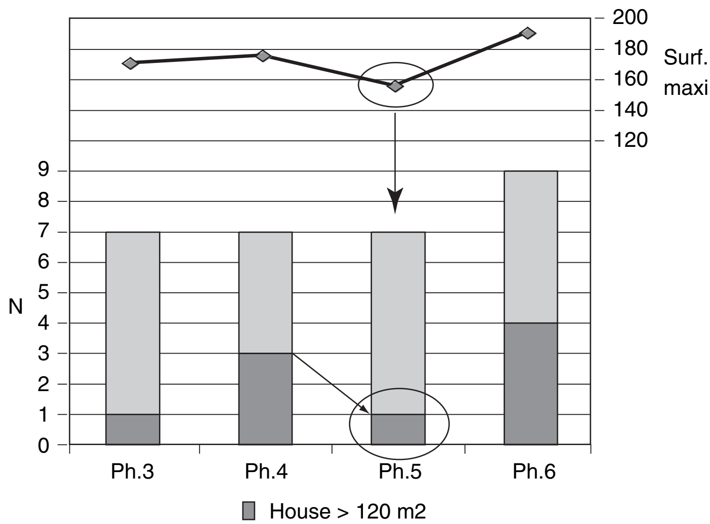

Fig. 8 Average-sized and large houses of Langweiler 8 during the supposed fissioning event of the village

but regular increase (from 170 to 190 m^2) also deviates in phase 5 (a fall to 155 m^2 maximum). One deduces from this episode that the fissioning event phase (4–5) of Langweiler 8, to the benefit of new neighboring hamlets, seen in the provisional lowering in size and number of the biggest houses, involved the largest domestic units rather than the village itself. A big house, sheltering a larger population than the others, may therefore split once it reaches a certain local population threshold, whose significance remains undefined. As well as an explanation of overpopulation, with its negative economic, sociologic and sanitary consequences, one can envisage another reading of the data, stressing the attainment of a population level which allowed a successful expansion. Such a dimension of interpretation was not explored in this study.

Therefore, one can only formulate the following hypothesis: a fissioning event is a process more at a domestic level than at a village level, set in motion once the population density of a domestic unit is sufficiently strong to enable the foundation of a new unit, in a new residential location and all the while preserving the viability of the pre-existing mother-unit.

Conclusions and Perspectives

Conclusions of the Study

Up to this point, the analysis has shown that a general, underlying pattern indeed exists in the data brought together in this representative sample of LBK settlements.

Following the hypothesis of a direct relationship between the surface-area of the houses and the number of occupants, the analysis leads to coherent results:

1. First, a cycle can be found in the variation of the physical and sociological size of the LBK domestic units;
   - the first two centuries following the local establishment of the LBK farming system show a pronounced growth in the size of the domestic unit, followed by a rapid contraction, possibly corresponding to a relocation of the populations toward other less densely settled zones or toward new land;
   - a rapid secondary growth, culminating at about $d\mathrm{t} = 500$, remains more a suggestion than a real hypothesis.
2. Secondly, this trend covaries with the local and supra-local density of occupation;
   - at the local and micro-regional levels, this trend in the physical and sociological size of the domestic units goes hand in hand with the overall numbers of houses and villages. It thus appears that with the local development of a neolithic lifestyle, population growth recordable at the scale of the domestic unit brings with it spatial expansion of the occupation and, therefore, a growth in the number of sites and houses;
   - perceived breaks at about $d\mathrm{t} = 100$ (Aisne) and 200 (Merzbach) would illustrate two different historical situations relating to threshhold in socio-cultural viability: the first corresponds to a more explosive population growth than the second. The reasons for such a difference have not been explored further in this study. Whatever the answers may be, the broad phenomenon identified in the data provides a strong argument to link population growth, at least temporally, with the establishment of a neolithic way of life in this part of Europe.
3. Thirdly, in the absence of specialized political institutions, low threshold of population density and fissionning process at the largest household units level may have played a major role in managing population density;
   - detailed study of the particularly favorable situation offered by LBK settlement of the Merzbach valley suggests that, under certain conditions of occupation density and duration, the fissioning of large domestic units reaching a certain threshold of inhabitants played a major role in territorial expansion;
   - this process, relating to household rather than village decision level (Bogucki 2000), could only be identified locally. It is possible that such a process of fission was also a fundamental driving force in the overall territorial expansion of the LBK.

Thus the Neolithic demographic transition is reflected in the settlement system of west-central Europe by archaeological evidence for quite explosive population growth, and specific 'sociological' adaptations to it. Growth seems to have been managed by the first farmers, so that population density could be maintained at a level compatible with the sociological values on which these communities were founded. This may be the main reason why, along with the wide availability of unoccupied, favorable landscape, the maximum population density seems to have remained low. But this may not be the reason why the first phase of population growth seems to have been short, two centuries, with regard to the general NDT model (Bocquet-Appel and Naji 2006).

Perspectives: A Return to Prehistory

The demographic pattern observed in settlement data is specific to the development of the LBK way of life and is independent of time and space. Yet the phenomenon actually happened in various times and places. Let us recall that five to six centuries separate the beginning of the LBK in Hungary and Slovakia from the appearance of the LBK in the central Seine basin, and that quite varied territories scattered over more than 700, 000 km^2 served as receptacles for the diffusion of this agro-pastoral culture. The variations of the natural environment and its evolution certainly had an influence on the choices and cultural adaptations of the first farmers. It is therefore interesting to set the demographic phenomenon identified in this study into a broad geo-environmental context.

Current interest in climatology, with its series of quite frightening forecasts, follows on much previous work by historians and prehistorians. In France, P. Pétrequin was the first Neolithic specialist to have elaborated an environmental database, enabling him to analyze and interpret the development of lake-side settlement in the peri-Alpine regions (Pétrequin and Pétrequin 1988). As with other authors (Strien and Gronenborn 2005), I too have been tempted, in my study on the demography of the first farmers of central-western Europe, to investigate the possible role of ecological factors.

The work of numerous specialists, notably in France M. Magny (1995; 2004) and more recently J.-F. Berger (2005) has convincingly shown that environmental proxy-data constitute very effective aids for constructing a general framework of analysis and interpretation. For example, the curve of residual ^{14}C in the atmosphere can be considered in an empirical manner as a reflection of the history of late glacial and Holocene climate (Magny 1995). The data that have recently become available ($\Delta^{14}C$, $\Delta^{18}O$) thus offer the possibility of establishing a broad picture of the sixth millennium BC in terms of humidity ($\Delta^{14}C$) and temperature ($\Delta^{18}O$).

The LBK: A Cultural Adaptation to Cold-Humid Conditions

The decadal curve of residual atmospheric ^{14}C (1998 residual $\Delta^{14}C$ data set, QIL Washington) reveals a long period of climatic deterioration between roughly 5600 and 5100 BC (Fig. 9), principally characterized (Magny 1995) by the abundance and rate of precipitation (cold, wet summers and long winters). This period of

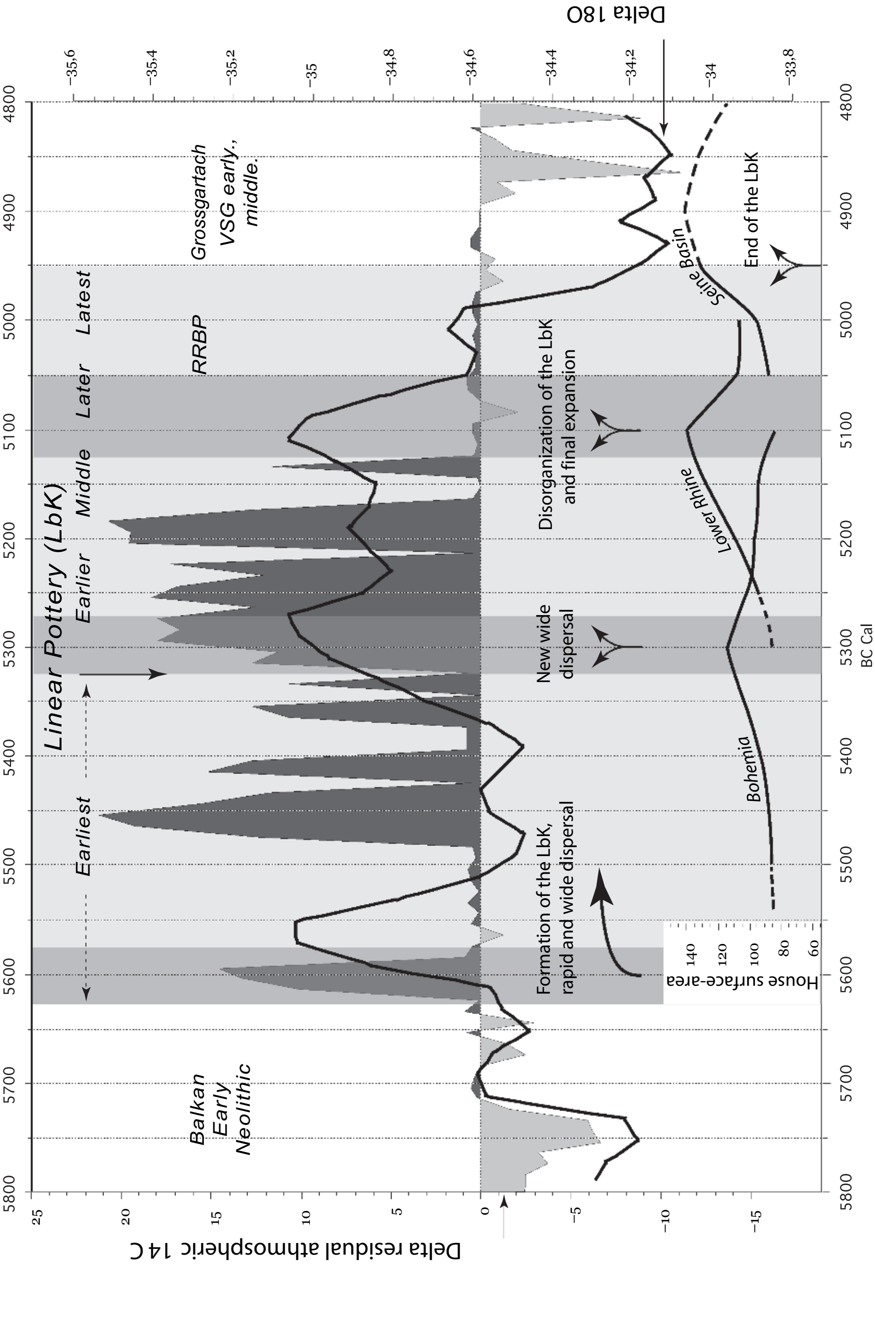

Fig. 9 Climatic, cultural and demographic trends during the LBK

harsh climatic conditions corresponds well to the duration of the LBK. It follows a much milder phase, after c.6000 BC, during which the cultures of the Balkan early Neolithic flourished. A new phase of climatic improvement starts at the end of the sixth millennium BC. The formation of the LBK therefore broadly corresponds to a time of deteriorating climate, and the disappearance of the LBK broadly coincides with the onset of warmer and drier conditions.

Well characterized in the circum-Alpine region, where it is known as the Cerin phase (Magny 1995), the period from 5600 to 5100 BC can be considered as a Little Ice Age, probably comparable to the better known one which lasted from the end of the Middle Ages to the 19th century (Leroy-Ladurie 1967; Lamb 1977; Groove 1988; Magny 1995; Berger 2005). The shortening of the growing season is one of its main characteristics.

Together with the bidecadal curve of the ratio $^{18}O/^{16}O$ (GISP2 bidecadal Oxygen isotope data set, QIL Washington), which focuses on the broad evolution of temperatures during the period (Fig. 9), we can recognize five interesting climatic variations: (1) first cold and humid around 5600 BC, (2) the climate improves rather clearly until just after 5500 BC; (3) it becomes more humid but remains mild until just after 5400 BC; (4) then it turns humid and cold until c.5150 BC, before (5) becoming clearly warmer and less humid or dry from 5100 BC until shortly after 4500 BC.

Thus, humid conditions characterize the start of the LBK and the three centuries between 5475 and 5175 BC; cold conditions also predominate the initial stage, as well as the period 5350–5075 BC. The cold-humid combination, the most unfavorable for an agro-pastoral system due to shorter germination times, thus concerns not only the beginning of the LBK but also the second half of its duration. One has to ask how the LBK system succeeded in developing so well under these conditions, to the point of spreading throughout west-central Europe.

A number of signs of adaptation to these difficult climatic conditions can doubtless be found. In relation to the present study, one can note the massive, robust nature of the buildings (Brandt 1988; Coudart 1998), the frequent location of villages on secondary or tertiary drainage networks, well away from the large rivers and their flood-plains (Kneipp 1995), the importance of cattle-herding (Hachem 1995; 2000; Tresset and Vigne 2001), a marked reduction of the Balkan early Neolithic range of cultivated plants (Kreuz et al. 2005) and the practice of autumn sowing in intensively cultivated plots, according to a recent study (Bogaard 2004). With the help of these adjustments, some of which must have been adopted during the climatic shift at around 5600 BC, the LBK farmers came through the bad times of the second half of the sixth millennium with no apparent difficulty.

A Climatic-Cultural Rhythm?

On closer examination, however, one is under the impression that cultural developments broadly correspond to climatic changes. The important stages in LBK expansion indeed coincide quite well with the main thresholds of climatic change, following a cycle of 150–200 years (Fig. 9):

1. the initial climatic deterioration corresponds to the formation of the LBK at around 5600 BC;
2. the relative improvement of climatic conditions which followed, at around 5450 BC, coincides with the rapid, widespread dispersal of the earliest LBK, probably up to the banks of the middle Rhine;
3. a serious decline sets in to reach a maximum at around 5300 BC, at the moment where one clearly sees considerable LBK expansion both east and west, the westward movement, for example, crossing the Rhine into Alsace and Dutch Limburg. This corresponds to the early LBK (LBK II), which then initiates a long cycle of three continuous centuries of LBK history in the same sectors of occupation;
4. at about 5100 BC, when a new climatic cycle begins, characterized by steady temperature increase and drier conditions, the LBK starts to be rapidly affected by a cultural break-down, notably involving the disappearance of vast circulation networks of raw materials which had characterized the preceding periods (Burnez-Lanotte 2003). With the end of the bad weather, the bell thus tolled for a system specifically adapted to such weather, and this would have triggered the adaptations necessary for ultimate expansion to territories ecologically and culturally very different, as far as the Normandy coast, reached at the beginning of the fifth millennium.

A Demography in Cycles, in Phase with Climatic-Cultural Change?

The various episodes of rapid and fairly massive cultural expansion mentioned above evoke of course a demographic issue, and the possible existence of a two-century cycle brings these two analytical dimensions closer together. Following the same heuristic approach which has guided this study from the onset, and also as a means of opening up research perspectives, the specific LBK demographic pattern revealed by settlement data can be matched against the time in which the phenomena which interest us actually happened (Fig. 9). Only the curves of Bohemia, the Lower-Rhine-Meuse and the Seine basin, representative of the initial hypothesis of a demographic trend, are consistent enough to face the yardstick of a historical chronometer; their reinsertion in absolute chronology shows a good fit with the climatic-cultural trends evoked earlier:

- The curve of the average surface-area of the houses in Bohemia first increases throughout the period of temporary climatic improvement which characterizes this moment of fast, widespread distribution of the earliest LBK. The trend continues up to 5300 BC, the time of the second great territorial expansion in the LBK, and highest point of the climatic deterioration, and then changes in the opposite direction up to around 5100 BC.
- The curve for the Lower-Rhine-Meuse, corresponding to the beginning of the early LBK in the newly occupied territories, starts around 5300 BC and rises sharply until about 5100 BC, during what seems to be the worst period of this Little Ice Age. The reversal of the demographic trend at 5100 BC coincides with

the climatic reversal, which sees the onset of the LBK cultural break-down and its ultimate expansions, notably toward the west.
– It is thus during this period of probable major upheavals that the Seine basin 'demographic' curve begins. This shows a very subtle increase, chronologically linked to the climatic improvement which brings a close to the LBK cycle.

One can note several observations of interest both to the general issue of demography and to the specific historical and cultural question of the LBK. If a two-century growth cycle constitutes the overall demographic and 'universal' pattern of this prehistoric culture, this also matches quite well the cycle of its main socio-cultural adaptations and phases of geographical expansion. One can even imagine, given the analyzed data, that this demographic cycle accelerates and is amplified in time and space; this remains a hypothesis to develop. We may be dealing here with a signal of the steady improvement of the adequacy of the LBK system to its natural environment, as if the time-depth of agro-pastoral experience enabled a greater ability to react to necessities. The demographic success shown by the curve of the Lower Rhine-Meuse, with the harsh climatic period in full swing and hardly favorable to farming way of life, could thus be explained by perfecting the Neolithic socio-economic 'software', after several centuries of experiment. The dismantling of this system during the climatic shift at the end of the sixth millennium would have certainly led to adaptations necessitated by the new environmental order, adaptations which could in turn have contributed to the success of the final expansion into new territories further west.

This brief return to absolute chronology, and the interpretative doors that it opens, underlines the overall interest of the approach followed in this study. Without initial reference to a local chronology, independent of historic time and geography, it is not easy to detect the intrinsic trends of the Neolithic demographic process, as far as its strength and rate are concerned: without this local chronology, the 'universal' demographic pattern would in fact have remained undetected. Ultimately, this pattern enlightens the investigation of the historic and environmental circumstances which certainly interacted and contributed to its form. This repositioning of the demographic question in the center of research on the Neolithic transition was in fact the basic ambition of the study presented here.

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Part II
Settlement and Village Practices

A Roof Over One's Head: Developments in Near Eastern Residential Architecture Across the Epipalaeolithic–Neolithic Transition

A. Nigel Goring-Morris and Anna Belfer-Cohen

Abstract Field research throughout the Near East has provided a large corpus of architectural remains from the terminal Pleistocene and early Holocene periods. These differ dramatically from the architectural remains of preceding cultures and, rather than simply reflecting the growth of technological know-how, indicate profound changes in the more general needs of human groups. The advent of sedentism had major impacts concerning the internal and external mindsets of the communities involved. Moreover, examination of the archaeological record of the Levant reveals that sedentism had an immediate impact as evidenced by increased community sizes and social networks. Concomitantly it brought about more subtle, incremental changes that terminated in the 'Neolithic Revolution,' as reflected in the architecture of the PPNB *koine*. The latter can be considered as the sum of the transformation processes that occurred vis-à-vis the role of architecture in the various domains of the transforming communities – as dwelling and storage structures, public buildings for communal activities and ritual institutions, amongst others.

Keywords Levant · social complexity · sedentism · economy · paleoenvironment

Introduction

Architectural remains have always functioned as a 'backbone' of archaeological research, providing 'hard' evidence that can be easily described by clear and precise vocabulary, numbers and drawings. Yet interpretations of architectural remains and the ideological background concerning human social behaviours remain troublesome. While architecture pertains to the material remains we need to remember that ultimately they reflect the social mores and ideologies of the communities involved. Without doubt the individual household unit changes through the sequence, at one

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time or another incorporating nuclear and extended families, bands, wards, moieties, lodges, clans, etc.

We present a brief overview of the architectural remains in Near Eastern Epipalaeolithic through Neolithic cultures, focusing on the southern Levant while referring also to the northern Levant for purposes of comparison. Our principle intention is to target the accompanying paradigms employed in the study of the architecture of those periods (see Aurenche 1981; Banning 2002; Banning and Byrd 1987, 1989; Byrd 2000; Byrd and Banning 1988; Goring-Morris and Belfer-Cohen 2003; Kent 1990; Lechevallier 1977).

We can identify four basic architectural concepts during the periods through to the end of the Neolithic: (a) mobile Palaeolithic hunter-gatherer band occupations; (b) initial sedentary communities as personified in the Near East by the complex foragers of the Natufian (and to a large extent the PPNA); (c) large PPNB villages ('megasites'); and (d) dispersed hamlets of the Late Neolithic. It is important to note that the tempo of increasing diachronic site densities throughout the Levant is not always synchronous between regions, with differential fluctuations in relative densities and levels of mobility/sedentism (Goring-Morris et al. in press; and see Fig. 1[1]). Other aspects deriving from and at the same time influencing architectural configurations are issues such as scalar stress and social adaptations to increasing community sizes, sedentism and novel modes of economic subsistence. These factors all complicate the comparability of foraging bands, settled communities and transhumant societies.

The building blocks pertaining to site architecture incorporate: perishable structures (see Goring-Morris and Belfer-Cohen 2003), leaving few if any obvious architectural remains, reconstructions of such features being based primarily on the spatial distributions of other finds (e.g. Binford 1983; Leroi-Gourhan and Brézillon 1966). In addition, one notes the appearance of simple stone footings, e.g. Uçagizli (Kuhn et al. 2003), terrace/retaining walls, and even post-holes, e.g. Jiita (Melki 2004); and, during the Late Epipalaeolithic, structures with stone-coursed walls, probably roofed with perishable superstructures, e.g. Eynan (Valla 1988). Building materials progressed from perishables to field stone, to worked stone and wattle and daub, and mudbrick. The shape of structures and, accordingly, construction techniques changed from oval to quadrilateral, culminating in the appearance of multi-storied construction during the Neolithic (Byrd 2000). In addition, there are developments in accompanying site furniture, such as fire-pits, hearths of various kinds, ovens, storage features, platforms, etc. Initially they appear in isolation, but with time both numbers and complexity (on various levels) increase exponentially (e.g. Aurenche 1981; Byrd 2000).

[1] Obviously such data do not take into account individual site sizes and longevity or the degree of packing within them; as such they are problematic in terms of representing demographic trends. Still, we believe they do provide a rough proxy of general developments from one region to the next.

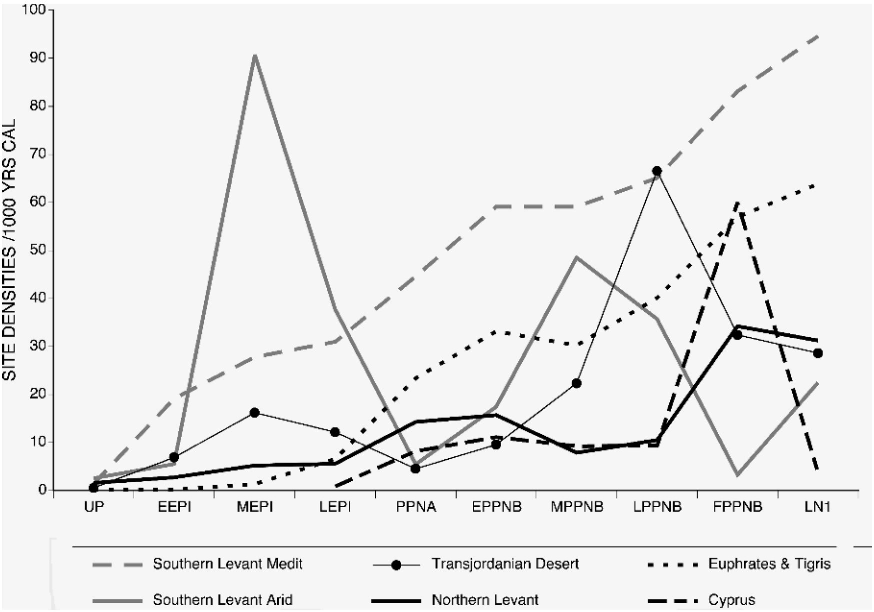

Fig. 1 Site distribution densities in various areas of the Near East through time. Note that differing lengths of each period are taken into account by presenting the **number of sites/1000 years calibrated for each period**. Key to periods: UP – Upper Palaeolithic; EEPI – Early Epipalaeolithic; MEPI – Middle Epipalaeolithic; LEPI – Late Epipalaeolithic; PPNA; EPPNB – Early PPNB; MPPNB – Middle PPNB; LEPI – Late Epipalaeolithic; FPPNB – Final PPNB (PPNC); LN1 – Early Late (Pottery Neolithic)

It is, of course, assumed that the architectural remains reflect more than simple technological developments in manipulating the environment. But how do the material remains actually portray the socio-economic and ideological structures of such communities (e.g. Byrd 1994, 2000)? Archaeologists have dealt with the architectural phenomena mostly in a comparative manner, i.e. ethnographic data, while at the same time comparing notes with previous but most especially subsequent developments. Ethnographic analogies are indeed pertinent to comprehend the observed complexity and variety; but one should remember that direct analogies are dangerous to play with since modern, recent ethnography merely provides a general interpretive framework. Ethnography does not reflect human groups 'frozen in time', as once believed (Sahlins 1972); nor do they reflect incipient, embryonic developments. Yet it is still tempting to use ethnographic similes and thus the literature abounds with comparisons between the Epipalaeolithic/Neolithic Near East and pre-colonization North America (e.g. Gebel and Hermansen 2004; Stordeur et al. 2001). Undoubtedly some comparisons are valid, while others are totally out of place and it is often quite difficult to decide which is which (and see for example Banning and Byrd 1987; Byrd 2000).

But we are biased not only by the ethnographic data. Examples abound in archaeological reports of architectural remains. One can observe the association between the appearance of architectural remains and the idea of its residential function. Yet not every structure necessarily represents a 'residential' unit. Moreover, others have addressed the issue of the difference between 'house' and 'home' (see Watkins 1990, 2004). Similar biases are pertinent when estimating *community* or *band* sizes (Flannery 2002; Hole 2000; Kramer 1982; Kuijt 2000; Leblanc 1971; Naroll 1962). Obviously a major theoretical complication derives from the fact that we are dealing *sequentially*, first with mobile foragers, as opposed to later settled communities; the means of estimating population size must accordingly remain flexible (and see discussion in Byrd 2000).

Following a diachronic review of the pertinent data relating to architecture, we shall discuss the above issues in greater depth with reference to the social and organizational correlates associated with shifts in subsistence and mobility modes.

Early and Middle Epipalaeolithic

During the Early (ca. 21,000–15,500 calBC) and Middle (ca. 15,500–13,000 calBC) Epipalaeolithic well-documented huts and related architectural features are found in quite a number of open-air sites (Figs. 2, 3).[2] The site of Ohalo II, dating to the very beginning of the period, is exceptional in its preservation of perishable construction materials; it thus provides a means to identify comparable structures in other sites where preservation is poor.

The flimsy, kidney-shaped or sub-oval structures are ca. 3–5 m in diameter, with internal floor spaces not exceeding 12 m^2. They are generally semi-subterranean (ca. 20–40 cm deep), bowl-shaped in profile, and are constructed from the branches of locally available trees and bushes in a wigwam or arched configuration, not unlike Kalahari San huts (Lee 1979; Yellen 1977). However, it is interesting to note that post-holes appear already at Jiita rockshelter (Melki 2004) (Fig. 2). While formal internal hearths are rare, waste debris is liberally littered both within and outside structures. Internal features include bedding and workslabs. Stone installations are usually located outside the structures. These include cobble platforms or small paved areas, which at Ohalo has been interpreted as a baking oven (Nadel 2006). The rare burials found in sites of this period are single, in simple, shallow pits without stone construction, e.g. Ein Gev I (Arensburg and Bar-Yosef 1973).

The status of the huge aggregation sites (up to 20,000 m^2) in eastern Transjordan dating to the Early and Middle Epipalaeolithic remains uncertain, probably due to the very limited exposures, although most seem to be primarily seasonal winter/spring occupations (Martin 1994).

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[2] Such sites include Ohalo II, Ein Gev I, III and IV, Haon II, Nahal Hadera V, and Azariq XIII, as well as the rockshelter of Jiita (Bar-Yosef 1970; Gopher pers. comm.; Goring-Morris and Belfer-Cohen 2003; Martin 1978; Melki 2004; Nadel 1996, 2003, 2006; Nadel and Werker 1999; Nadel et al. 2004; Saxon et al. 1978; Shimelmitz 2002; Stekelis and Bar-Yosef 1965).

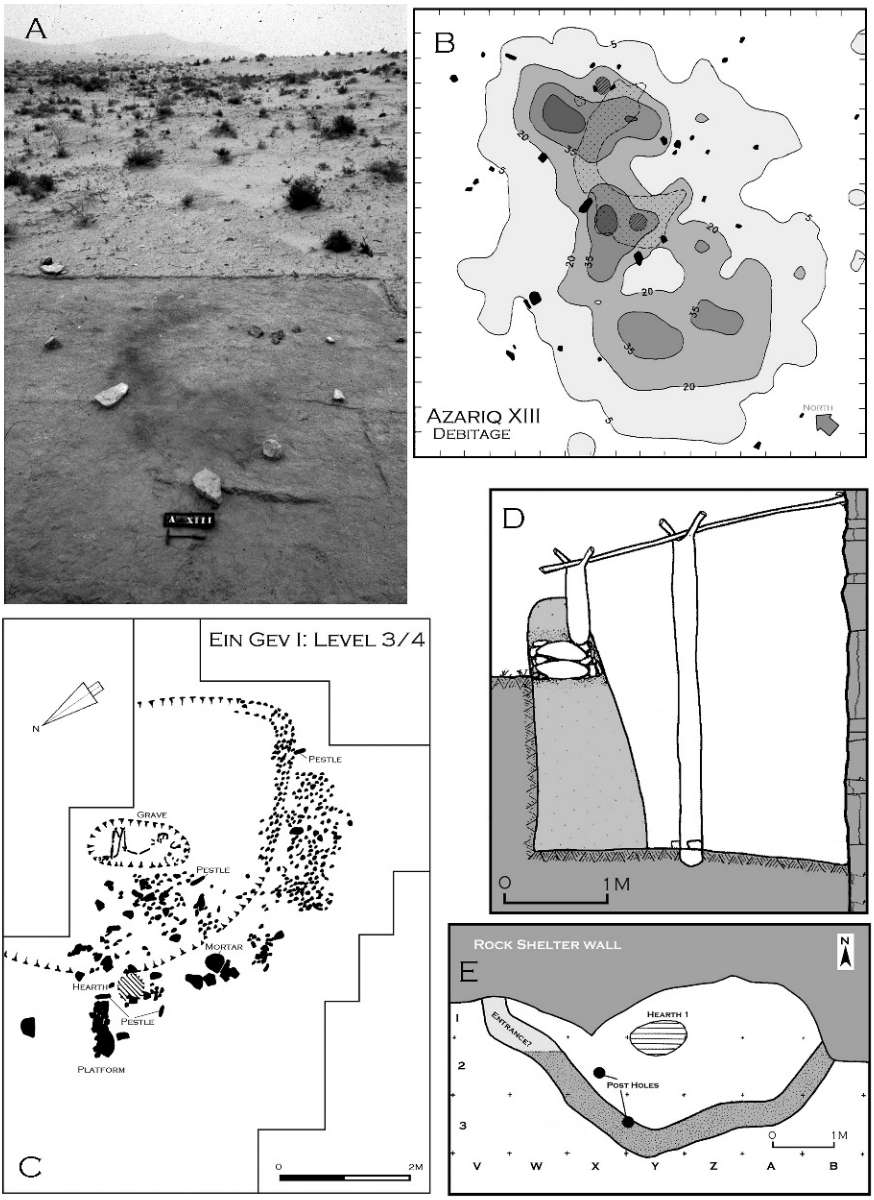

Fig. 2 Early Epipalaeolithic: A,B, probable *fond de cabane* at Masraqan Azariq XIII in the western Negev; C, plan of *fond de cabane* at Kebaran Ein Gev I (modified after Bar-Yosef 1970); D,E, reconstruction and plan of shelter at Kebaran Jiita (modified after Melki 2004)

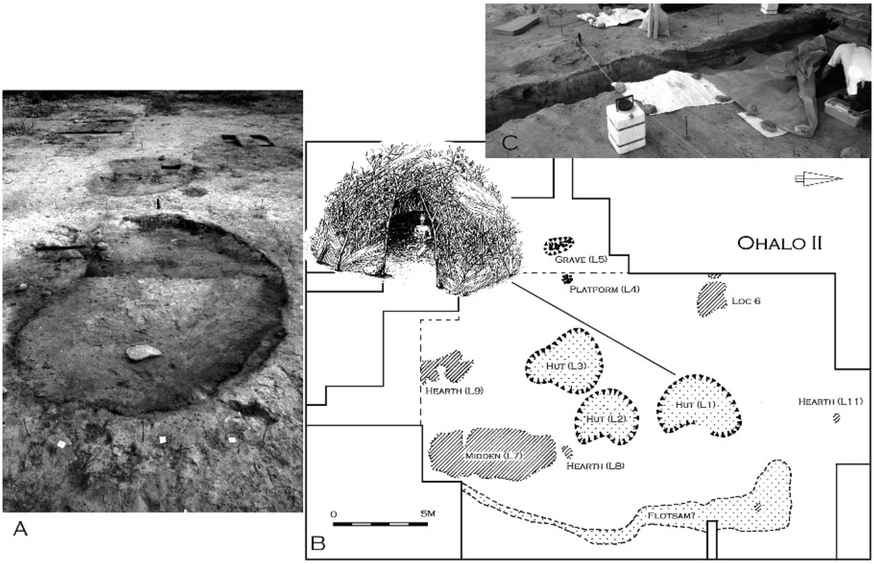

Fig. 3 Early Epipalaeolithic: views, plan and reconstruction of *fonds de cabane* and other features at Ohalo II. Note successive floors in section shown in C (after Nadel 2002)

The sum of the evidence thus indicates the use of individual huts by nuclear families.

Late Epipalaeolithic

With the relatively sudden emergence of the more sedentary Late Epipalaeolithic Natufian Complex (ca. 13,000–9,600 calBC), evidence for solidly built structures becomes abundant, most especially in the Mediterranean zone. Natufian basecamp site sizes are variable, reaching up to no more than 0.2 hectares (Bar-Yosef 2002; Byrd 2000; Goring-Morris and Belfer-Cohen 2003). The major changes in the size, scope and time depth of architectural features *during* the course of the Natufian clearly demonstrate that these developments encompassed not only profane aspects, but were also imbued with intense symbolic correlates.

Early Natufian (ca. 13,000–11,000 calBC) architecture in the Mediterranean zone is characterized by large, ca. 7–15 m diameter circular and D-shaped durable structures, which are spatially segregated (Figs. 4–8).[3] Circular internal arrangements of post-holes supported relatively sophisticated roofing – sometimes with a

[3] For example, Wadi Hammeh 27, Eynan [Mallaha] and, perhaps, el-Wad (Edwards 1991, 1993; Goring-Morris 1996; Perrot 1966; Perrot and Ladiray 1988; Valla 1990).

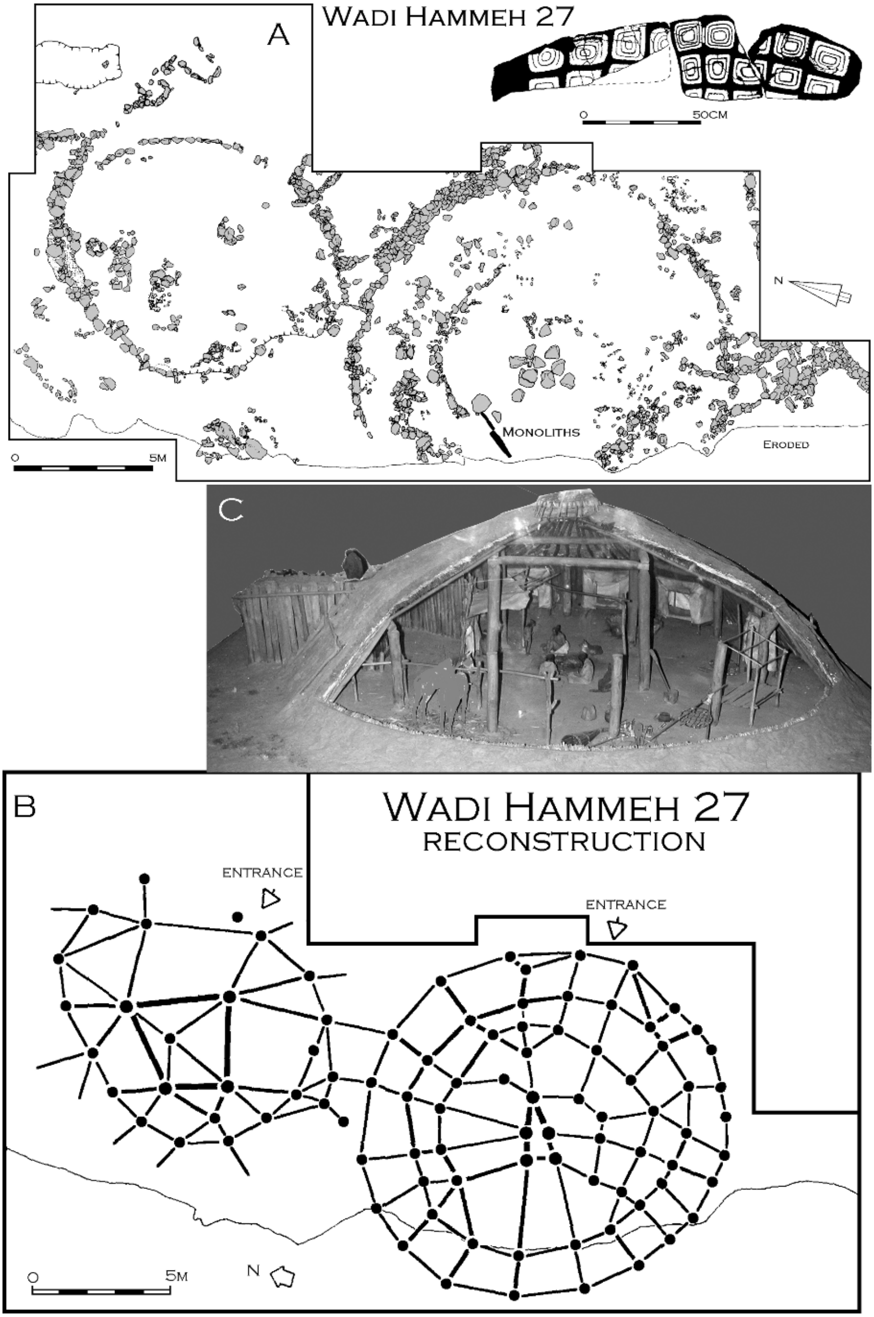

Fig. 4 Early Natufian Wadi Hammeh 27: A,B, plan and reconstruction of location of walls and post-holes for large structures (modified after Edwards 1991). Note location of incised monoliths within one structure. C, model of a Plains Indian lodge in the Museum of Natural History, New York, which may approximate the structures at Wadi Hammeh 27

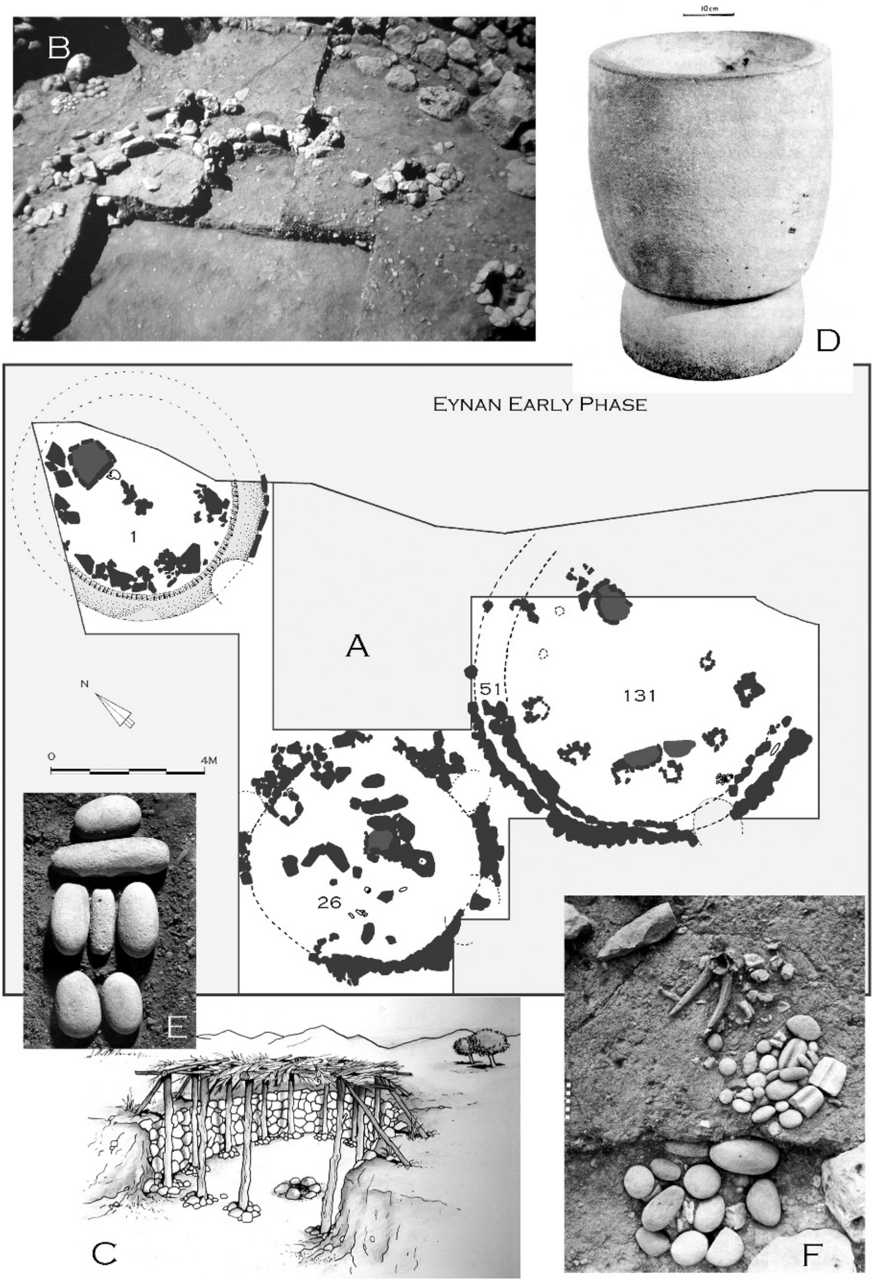

Fig. 5 Early Natufian Eynan: A,C, plan, photo and reconstruction of structures (Structure 1 is probably not a dwelling); Massive communal (?) mortar; D,E, intentional arrangements of coloured pebbles on floors of Structures 26 and 131 (after Perrot 1966; Valla 1991)

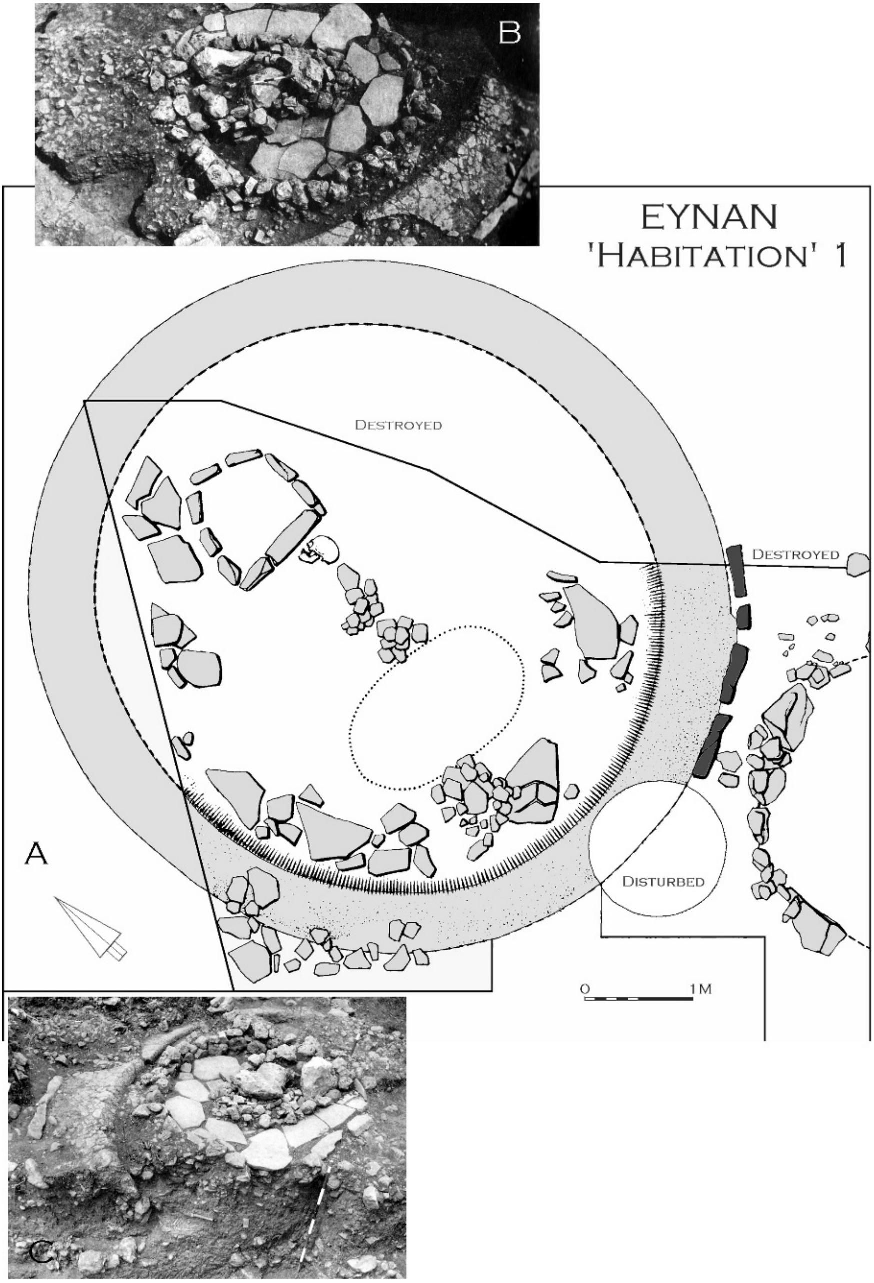

Fig. 6 Early Natufian Eynan: plan and photos of a probable non-domestic (mortuary?) structure; note plastered bench, monoliths, hearth, etc. (modified after Perrot 1966; Perrot and Ladiray 1988)

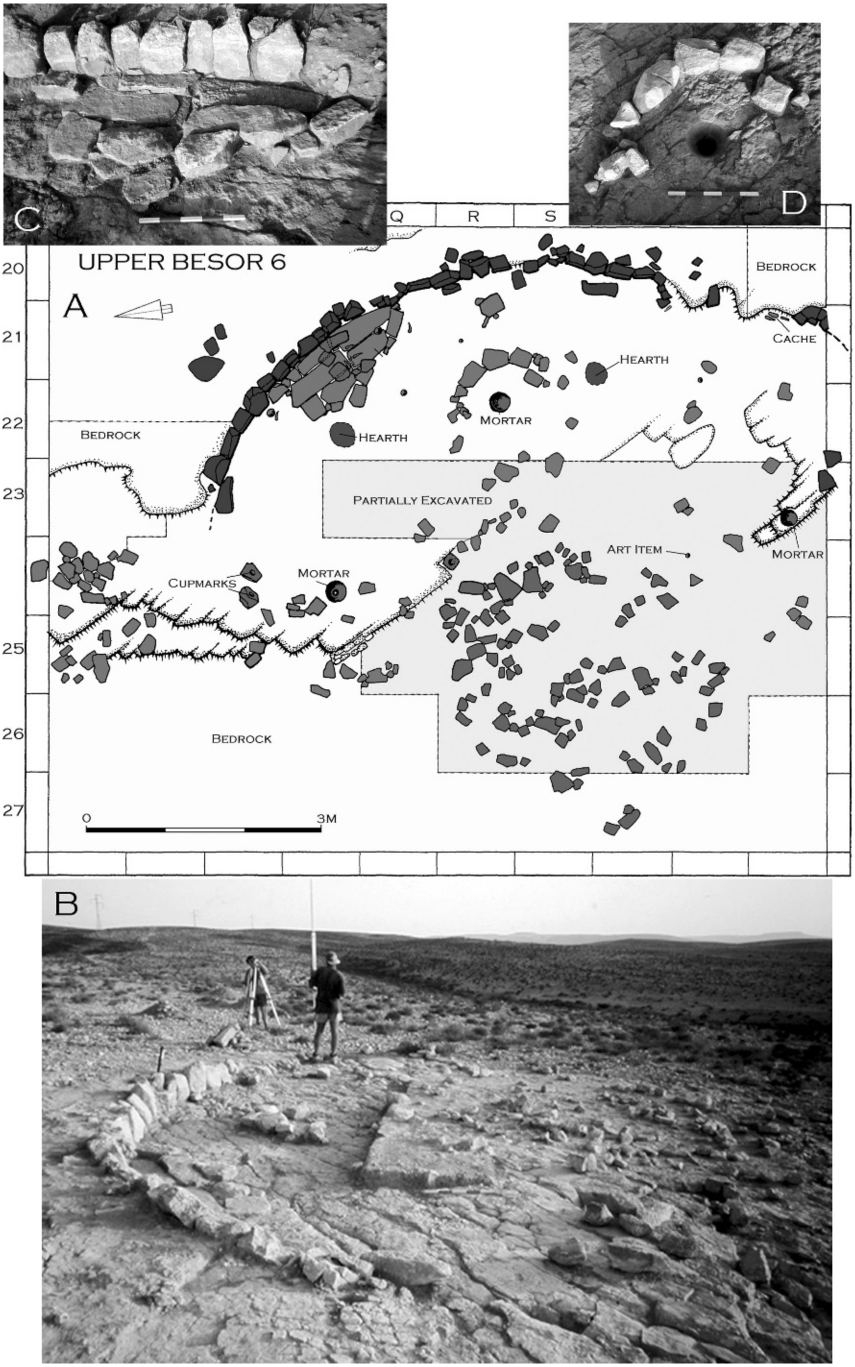

Fig. 7 Early Natufian Upper Besor 6 in the Negev: A,B, plan (dark grey) and picture of large U-shaped structure; C, worksurface; and D, bedrock mortar within structure

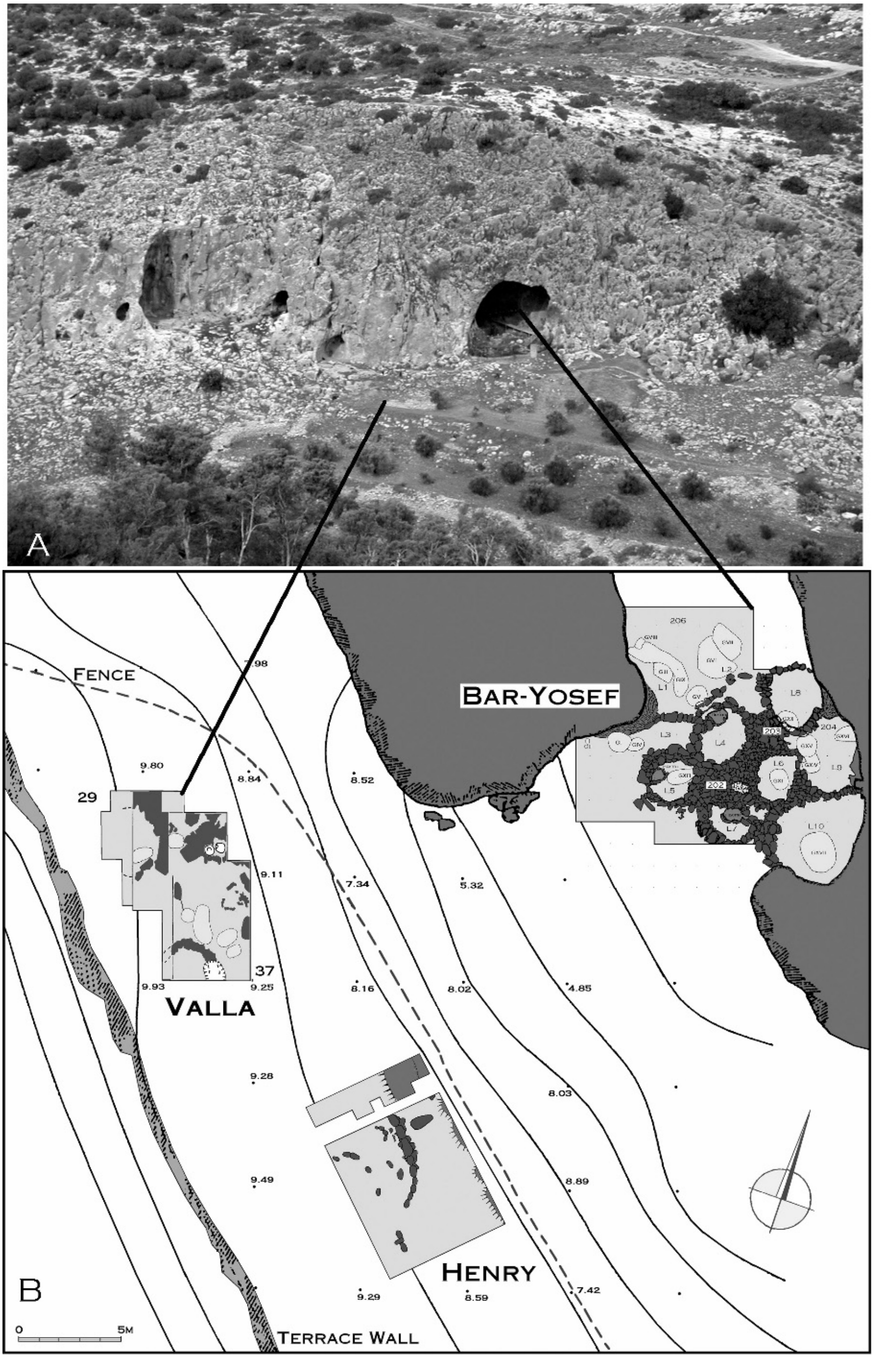

Fig. 8 Natufian at Hayonim: photo and plan of occupation. Residential structures were located on the terrace, while special (non-domestic) structures and activities were centred in the cave

single ring or even double rings of supports, e.g. Wadi Hammeh 27 (Edwards 1991, 1993). The floor spaces of such large structures are on the order of ca. 100–130 m^2. It should be noted that at Wadi Hammeh 27 at least two (and more probably three) adjacent structures were exposed, indicating this to be normative residential patterning. Similar evidence is also forthcoming in the more arid zone, as at Upper Besor 6 (Goring-Morris 1998).

Other examples of early Natufian architecture incorporate much smaller structures, 1.5–2.5 m in diameter, which most probably served for special functions rather than actual habitations, e.g. Hayonim cave (see Bar-Yosef 1991a; Belfer-Cohen 1988a).

Graves occur under the floors of some structures, although it seems likely they commonly either pre- or postdate the daily use of these features. Indeed many graves in Early Natufian sites are spatially segregated (Bar-Yosef 1991a; Belfer-Cohen 1988b). Occasionally, besides the graves themselves, there is also some distinctive funerary architecture, e.g. 'Habitation 1' at Eynan with a plastered bench (Perrot 1966) (Fig. 6).

The *Late* Natufian (ca. 11,000–9,600 calBC) in the Mediterranean core area furnishes evidence for smaller oval or D-shaped domestic residential structures that rarely enclose more than 10 m^2 of internal floor space, as at Eynan (Perrot 1966; Samuelian et al. 2006; and see Fig. 9). Sometimes one or two post-holes support the roof, and a hearth is arranged along the axis of the structure. Subsidiary installations include graves and the enigmatic 'basins' – slightly depressed surfaces consisting of numerous small stones, externally adjacent to structure walls. The structures and 'basins' are spatially interchangeable through time. The overall impression is of a more opportunistic approach to architectural planning and execution, not unlike that in the earlier Epipalaeolithic, although certain elements do continue from the early Natufian, indicating an inherent similarity, as both phases pertain to but one, though changing, entity.

In the peripheral region of the Negev the huge expanse of the highland Rosh Horesha-Saflulim site complex (ca. 4, 000–5, 000 m^2 in size – Goring-Morris et al. 1999) likely represents a regional aggregation site, somewhat akin to those of the Early and Middle Epipalaeolithic in eastern Transjordan. Here durable architectural remains are few, with the exception of a large, 8 m diameter kidney-shaped structure constructed of massive slabs that is unlikely to have served as a domestic dwelling (Marks and Larson 1977; and see Fig. 10).

In smaller seasonal camps at lower elevations 'beehive' type arrangements of clustered, small structures are found. For example at Rosh Zin several stone-built structures, ca. 3–5 m in diameter, were uncovered (Henry 1976; and see Fig. 10). The scale of these is fully congruent with residential structures intended for nuclear families. However, one unusual, paved structure includes a unique interior monolithic pillar, which was interpreted by the excavator as having a symbolic function.

Subsequent Harifian base camps in the Negev highlands feature standardized architecture of spatially segregated units of larger, single, semi-subterranean

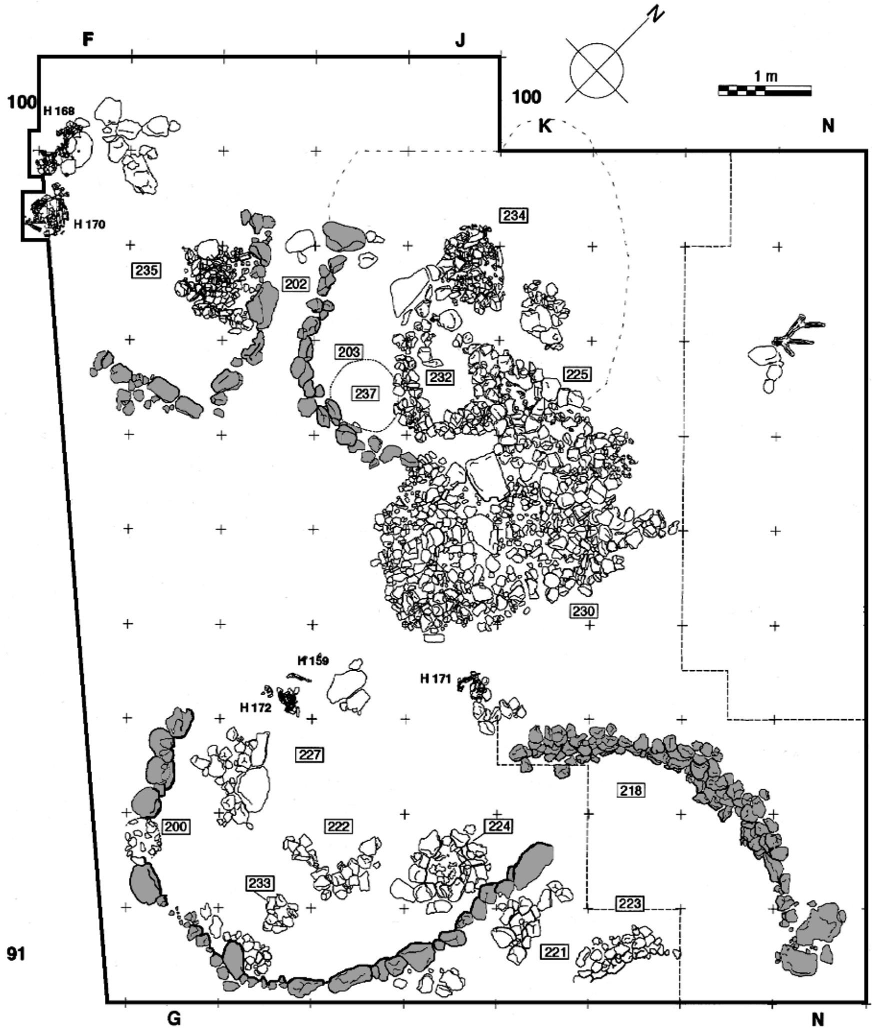

Fig. 9 Final Natufian Eynan: small U-shaped domestic structures (modified after Samuelian et al. 2006)

dwellings, 3–4 m in diameter (Fig. 11).[4] These commonly feature bedrock mortars and large grinding slabs as interior furniture. Smaller, 1–2 m diameter (storage?) structures, are also found, either as appendages or as independent units (Goring-Morris 1991).

[4] For example, Abu Salem, Ramat Harif, Shluhat Harif and Ma'aleh Ramon East and West (Goring-Morris 1991).

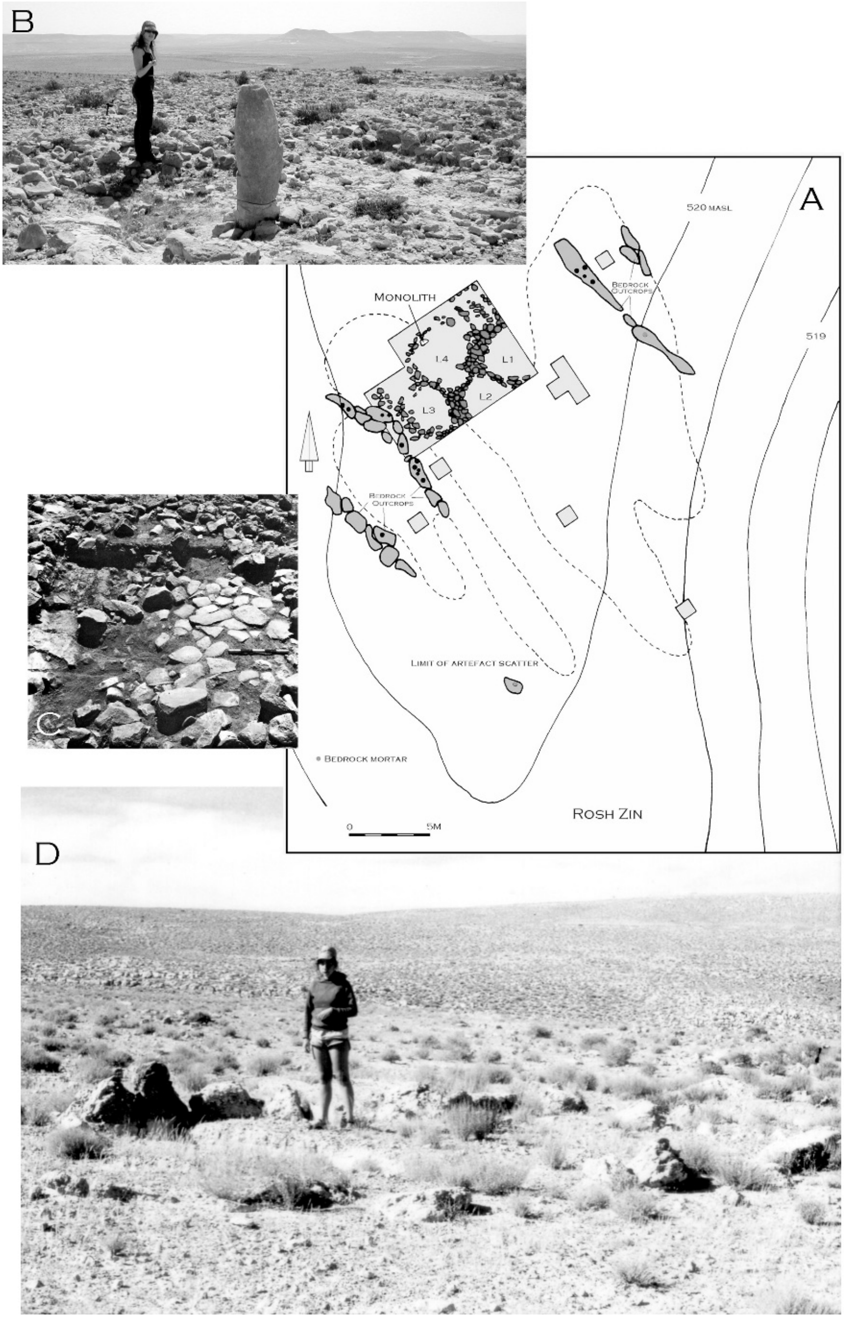

Fig. 10 Late Natufian in the Negev: A, plan of beehive arrangement of seasonally occupied structures at Rosh Zin (after Henry 1976); B,C, photo of non-domestic slab-lined structure with large monolith in Locus 4; D, large, kidney-shaped non-domestic structure constructed of massive slabs at aggregation site of Rosh Horesha

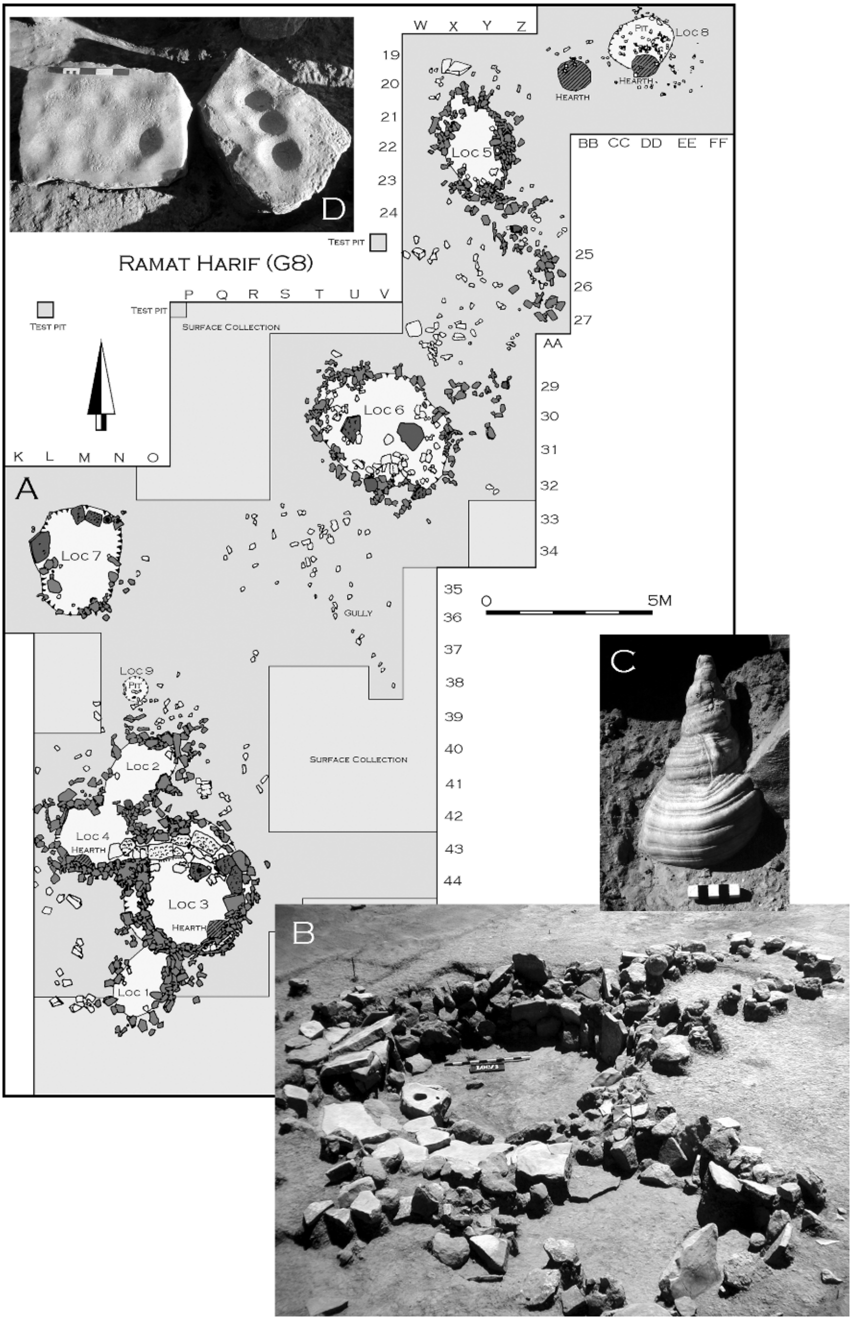

Fig. 11 Harifian Ramat Harif (G-VIII); A, plan of site with discrete, semi-subterranean residential and subsidiary structures; B, the Locus 3 complex (note cupmarked worktable and adjacent mortar); C, large trumpet shell placed at entrance to Locus 4; D, cupmarked grinding slabs in Locus 7

It is important to note that throughout the Epipalaeolithic there is clear evidence for intentional redundant spatial patterning of activities as reflected by the smaller artefacts. However, there is little evidence for the systematic cleaning of residential garbage (see Hardy-Smith and Edwards 2004; Bar-Yosef 1983).

The Archaic Neolithic (Pre-Pottery Neolithic A and 'Round House Horizon')

The PPNA (ca. 9,600–8,500 calBC) is characterized by a hierarchy of small-scale 'villages' up to 2.5 hectares, e.g. Jericho, Gilgal and Netiv Hagdud (Bar-Yosef and Gopher 1997; Bar-Yosef et al. in press; Kenyon and Holland 1983), smaller hamlets, e.g. Wadi Faynan 16, Dhra, 'Ain Darat, Hatoula and Nahal Oren (Finlayson and Mithen 2007; Finlayson et al. 2003; Gopher 1995; Lechevallier and Ronen 1994; Stekelis and Yisraely 1963), as well as more ephemeral, seemingly seasonal campsites, e.g. Iraq ed-Dubb (Kuijt et al. 1991; Kuijt and Goodale 2006; and see Figs. 12–16). Sites appear to be spaced at intervals of 15–20 km along both sides of the southern rift valley.

Residential PPNA architecture in the southern Levant displays much continuity from the Natufian, being based on discrete semi-subterranean, oval structures of various sizes (up to 7–9 m). Depending upon the local availability of raw materials, they are constructed of fieldstone foundations, puddled mud including wattle and daub, and, a notable innovation, mudbricks. Post-holes to support the light organic superstructures also occur. Cobbled bases were often overlain by *terre pisé* or beaten earth. Interesting internal features include raised platforms (for aeration?) on notched slabs, e.g. at Dhra' (Finlayson et al. 2003). Other internal installations include occasional dividing walls and hearths, as well as external silos. The size and scale of residential structures indicate that domicile was likely based upon the nuclear family. Trash disposal of the extensive midden deposits usually occurred in immediately adjacent external areas or abandoned structures.

A major innovation is the occasional appearance of substantial communal architectural endeavours; the most notable being the wall, ditch and tower of Jericho (Kenyon and Holland 1983; Fig. 13). Interpretations have ranged from a defensive function, through protection against flooding, to the demarcation of a 'sacred precinct' (Bar-Yosef 1986; Naveh 2003; Ronen and Adler 2001). While some burials do occur in and around (sometimes abandoned) houses in sites, the overall number of graves in most sites is relatively small. Still, the especially large numbers of the Jericho burials, which cluster around the tower and 'sacred precinct' (Kuijt 1996), may indicate the possibility of separate cemetery sites elsewhere, explaining the paucity of burials mentioned above.

During the later stages of the northern Levantine PPNA, adjacent to the Euphrates and Tigris, other and different traditions occur, seemingly 'out-of-the-blue', as there is currently little, if any, background to the PPNA in the north, Abu Hureyra being a notable exception (Moore et al. 2000). Sites are spaced at intervals of some

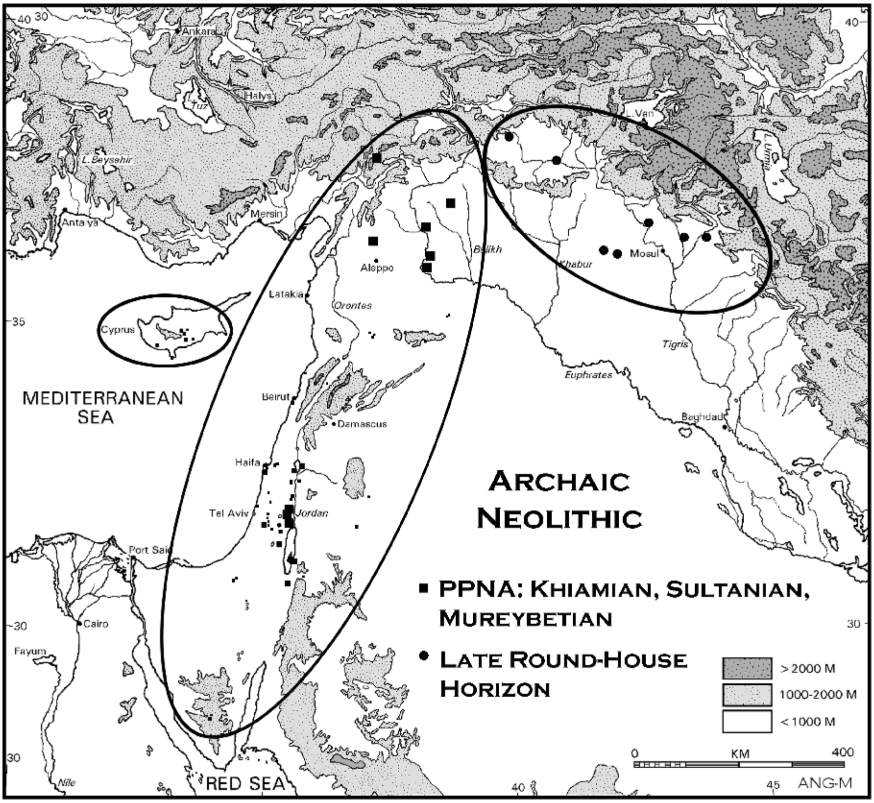

Fig. 12 Distribution map of Archaic Neolithic (PPNA and 'Round House Horizon') sites in the Near East

20–25 km along the Euphrates. In contrast to the south, these sites demonstrate a smooth transition from the PPNA to the PPNB, illustrated (amongst other material culture attributes) by the shift from freestanding circular and D-shaped structures, through to quadrilateral domestic ones (Cauvin 2000; Stordeur and Abbes 2002; Yartah 2004). Some of these have formal subdivisions according to activity, e.g. kitchens. Construction includes the systematic use of dressed masonry in some sites, modified by herminettes (Cauvin and Stordeur 1978) and mudbrick superstructures.

Notable in some sites, and interspersed amongst the houses, there are deep subterranean communal structures, with formal internal divisions for storage or benches, and unusual contents, e.g. Jerf el-Ahmar, Mureybet, and Tel Abr' 3.[5] These clearly functioned within the socio-ritual sphere, whether for extended families or larger

[5] These are akin to the kivas of the American Southwest – and see discussion.

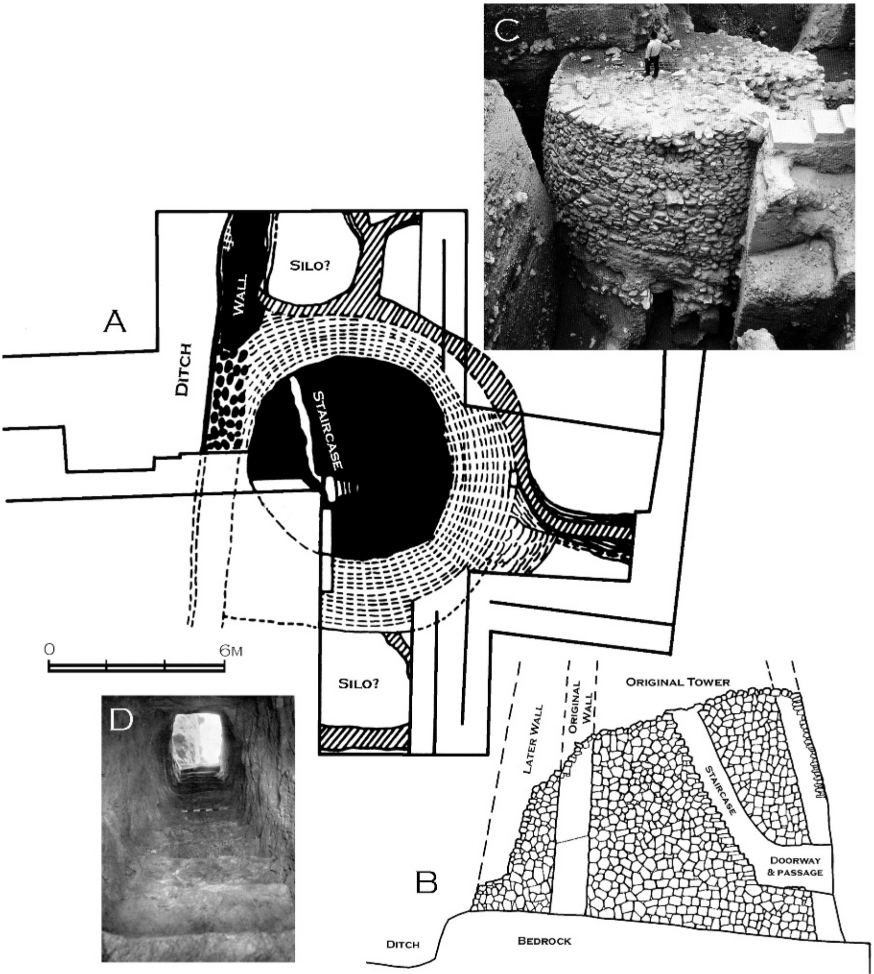

Fig. 13 PPNA Jericho sacred precinct: A,C, plan, section and photo of tower and wall; D, view up the staircase. Note subsidiary installations (silo?) adjacent to tower (modified after Kenyon and Holland 1983)

parts of the community.[6] It is of interest to note that these architectural features portend intra-site social subdivisions.

The large hilltop site of Göbekli Tepe, at the headwaters of the Balikh in Anatolia, is clearly a non-domestic site (Peters and Schmidt 2004). It is especially interesting that several, seemingly similar sites have been identified within a 70 km radius of Göbekli Tepe (Çelik 2000, 2004). The scale of construction of these ritual structures must have involved a large input of manpower from neighbouring communities.

[6] Mureybet, Jerf el-Ahmar, Tell Abr’ 3, Nemrik, Qermez Dere and Hallan Çemi (Kozlowski 2002; Rosenberg and Redding 2000; Stordeur et al. 2001; Watkins et al. 1995; Yartah 2005).

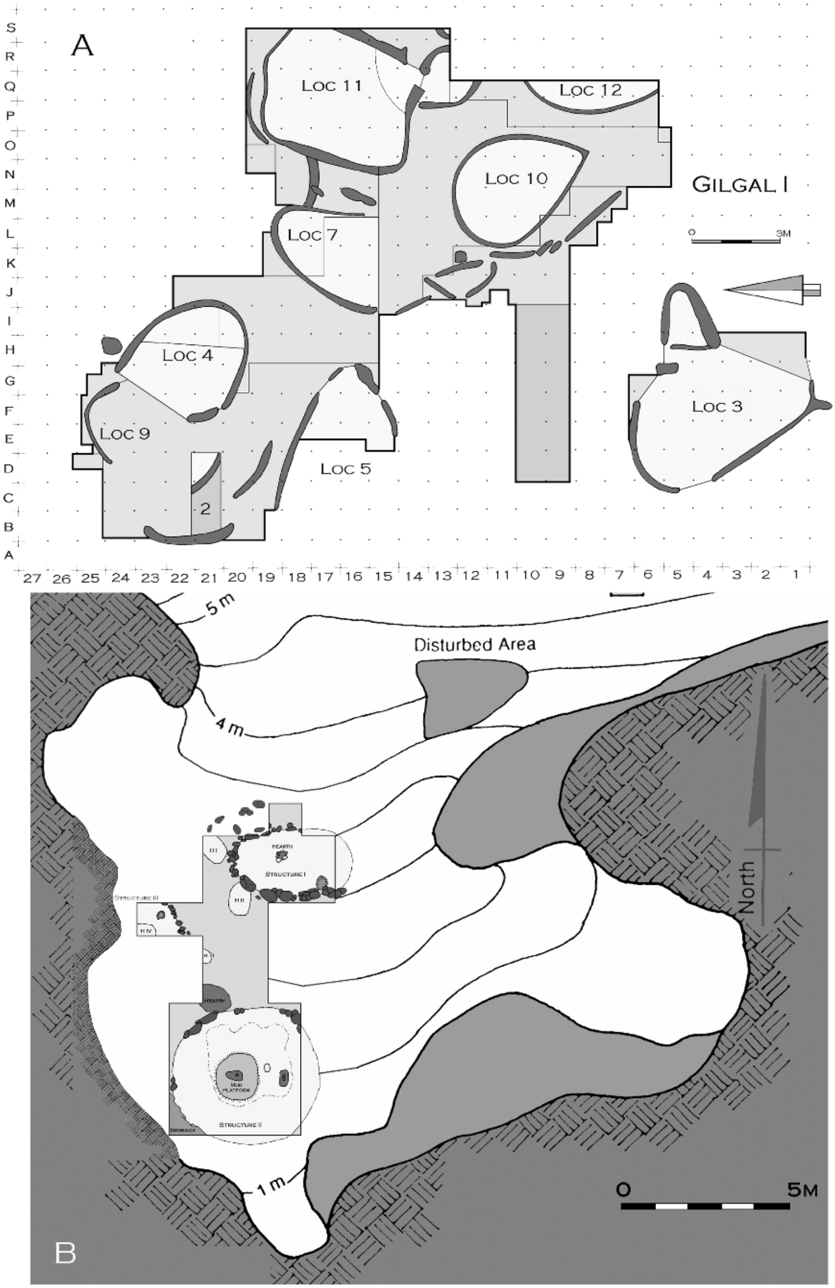

Fig. 14 PPNA: A, plan of semi-subterranean structures of large settlement at Gilgal I (wattle and daub on stone foundations); B, plan of structures within small site of Iraq e-Dubb (after Kuijt and Goodale 2006)

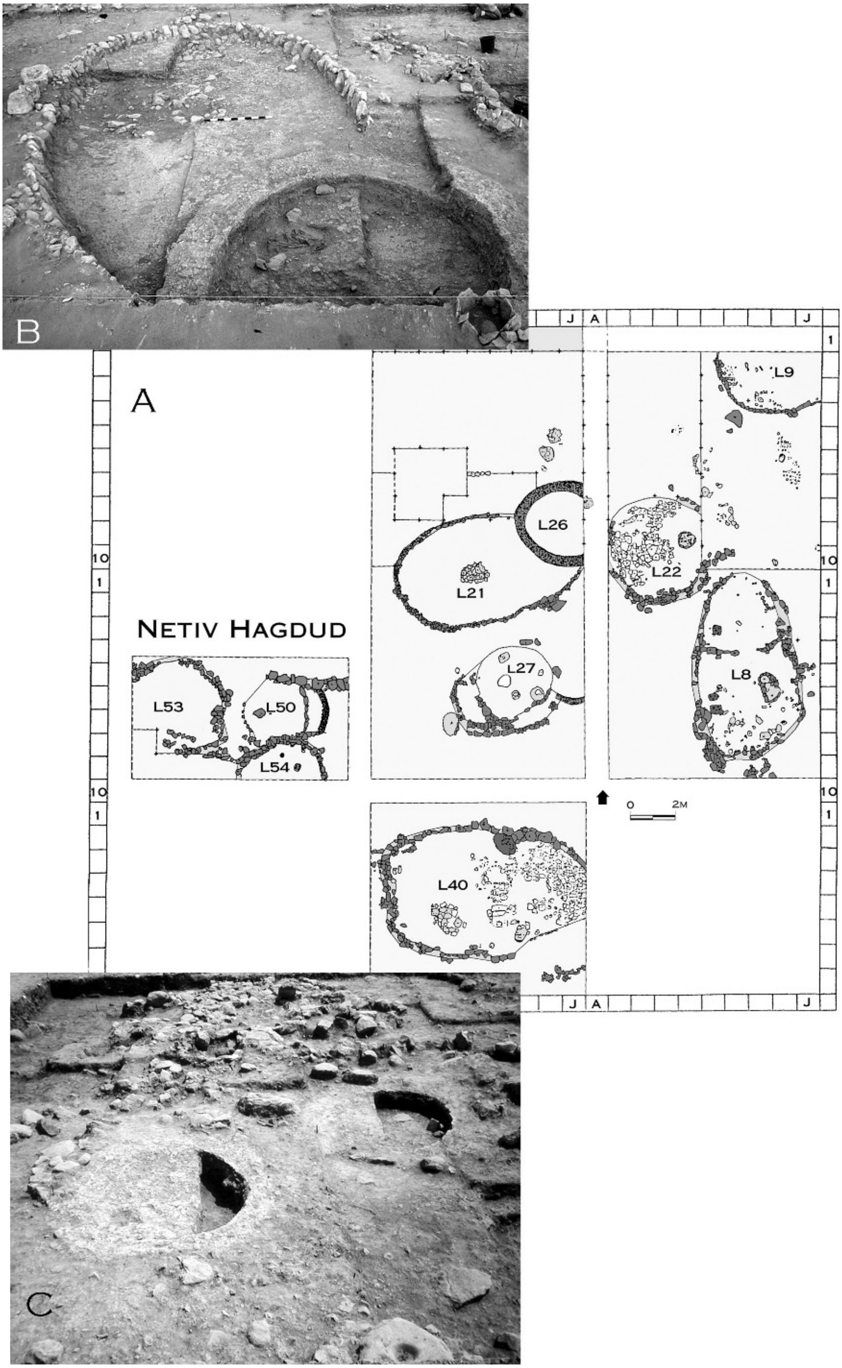

Fig. 15 PPNA village at Netiv Hagdud: A,B, plan and photo of semi-subterranean domestic structures; C, partially excavated silos (after Bar-Yosef and Gopher 1997)

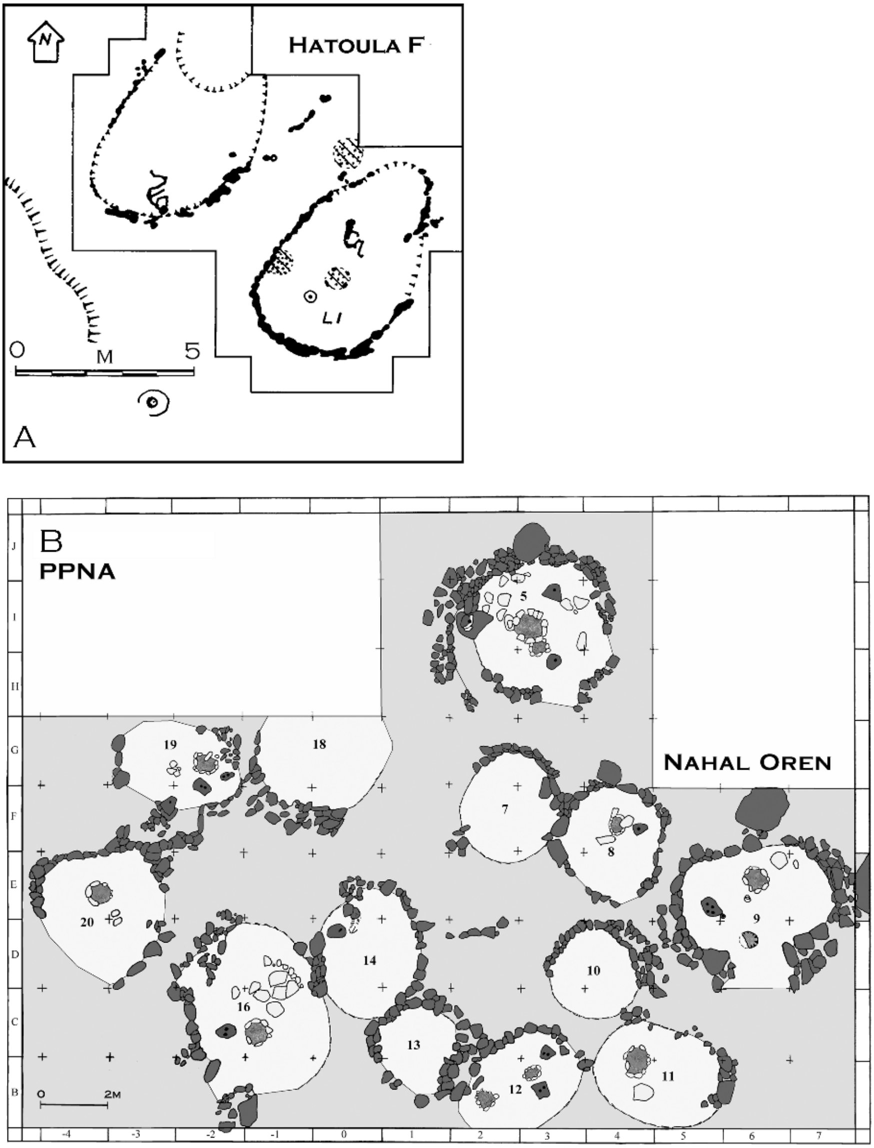

Fig. 16 PPNA settlements: plans of A, Hatoula (after Lechevallier and Ronen 1994); B, Nahal Oren

The Pre-Pottery Neolithic B (ca. 8,500–6,400 calBC)

In the Mediterranean zone of the southern Levant, substantial disruption occurred at the end of the PPNA and the transition to the Early PPNB (Goring-Morris and Belfer-Cohen 1997; Khalaily et al. 2007; Kuijt and Goring-Morris 2002). Indeed, a wide-ranging interaction sphere or *koine* encompassing the entire Levant can be recognized, albeit with sub-regional traditions (Bar-Yosef and Belfer-Cohen 1989; and see Fig. 17). There is a substantial shift in settlement patterns in the southern Levant, and the Middle–Late PPNB (as well as the so-called PPNC [FPPNB], and early Pottery Neolithic, i.e. the Yarmukian[7]) are characterized by the founding and subsequent stabilization of large-scale villages reaching up to 12 hectares (e.g. Gebel 2004; Kuijt 2000; Rollefson 1997, 2001, and references therein).[8] The

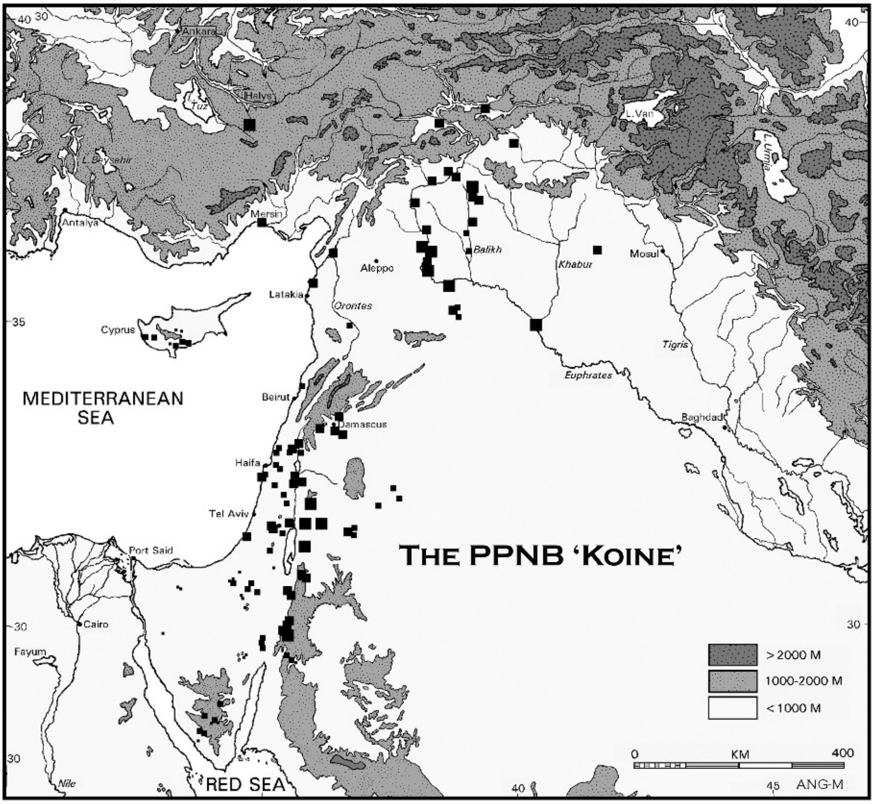

Fig. 17 Distribution map of PPNB *koine* settlements in the Near East

[7] We consider the Yarmukian as representing the culminating phase of early Neolithic village society and the final stages of the PPNB *koine*.

[8] It should be noted, however, that there appears to have been a tendency to overestimate site sizes and densities, leading to exaggerated population estimates (Dana Campbell pers. comm. April 2007).

introduction of domesticated herd animals in various areas and at various times during the course of the PPNB would likely have had a profound impact in terms of corralling the animals within communities; we thus have little, if any, idea as to the density of packing, i.e. population density, within these large settlements. Furthermore, it is important to note that, notwithstanding superficial similarities, and contrary to commonly held tenets, this phenomenon by no means represents the prototype of the familiar Near Eastern village of later and sub-recent times.

The shift from circular to quadrilateral architecture at MPPNB Beidha probably reflects its relatively peripheral location (Fig. 18), as is also the case at nearby MPPNB Shaqaret Msiad (Byrd 2005; Rehhoff-Kaliszan et al. 2002). While some view this shift from a diachronic, developmental perspective, other explanations seem more pertinent, such as the presence of different coeval architectural styles reflecting group identities, e.g. as in the American Southwest (Wilshusen and Potter in press).

Still, the basic architectural concept of PPNB agricultural villages is based on quadrilateral units, often with multiple cells. Three or four basic PPNB residential plans can be recognized:

1. One involves the two-storey, long-axis 'corridor' house, pier-house or 'megaron'; here, domestic activities focused on the upper storey with one or two larger rooms, while the semi-subterranean basement with multiple cells was used for storage and workshops, e.g. Beidha and Ain Ghazal (Banning and Byrd 1987; Byrd 2005; Rollefson 2001; and see Fig. 19).
2. A different residential unit involves the enclosed 'courtyard' house where, again, small cells appear on the ground floor entered through raised 'windows', forming the base for an upper floor allotted to domestic activities, e.g. Basta and es-Sifiya (Gebel et al. 2006; Mahasneh 1997; and see Fig. 20).
3. Another possible pattern seems to involve a loose 'pueblo-style' agglutinative array of structures on steep slopes, up to two or three stories high, e.g. Ba'ja, Ain Jammam and perhaps Wadi Ghuwair (Gebel and Hermansen 2004; Simmons and Najjar 2003; Waheeb and Fino 1997; and see Fig. 21).
4. By the Pottery Neolithic (Late Neolithic) Yarmukian one notes the presence of enclosed single storey courtyard residential units, e.g. Sha'ar Hagolan (Garfinkel and Ben-Shlomo 2002; and see Fig. 22).

Construction in most areas was mainly of mudbrick on stone foundations, while dressed stone masonry was more exclusively used in southern Jordan (see references above). Stone-built channels under some structures seemingly served to prevent rising damp and provided drainage, e.g. es-Sifiya and Basta.[9] The massive use of lime-plaster for floors and walls is a hallmark of the PPNB in the southern Levant (Garfinkel 1988). Expansive stony surfaces may have been laid down to stabilize open areas for corralled herds. Trash seems to have been disposed of within abandoned structures or open areas (often the so-called 'courtyards') between house complexes to form middens (e.g. Byrd 2005).

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[9] These may parallel the raised platforms at PPNA Dhra.

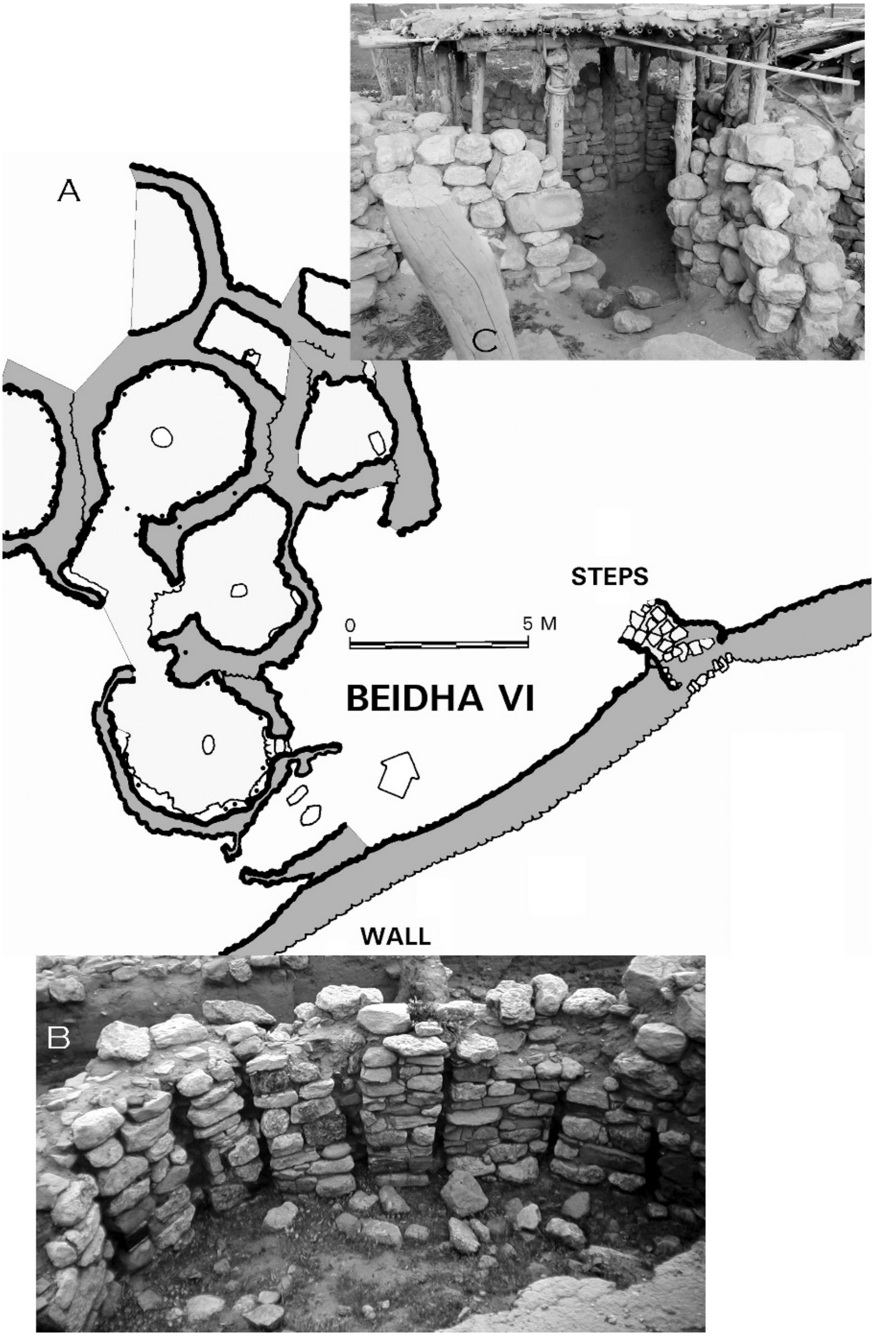

Fig. 18 Earlier MPPNB settlement at Beidha; A,B, plan (after Kirkbride 1966) and photo of circular semi-subterranean structures with timbered supports around circumference; C, reconstruction

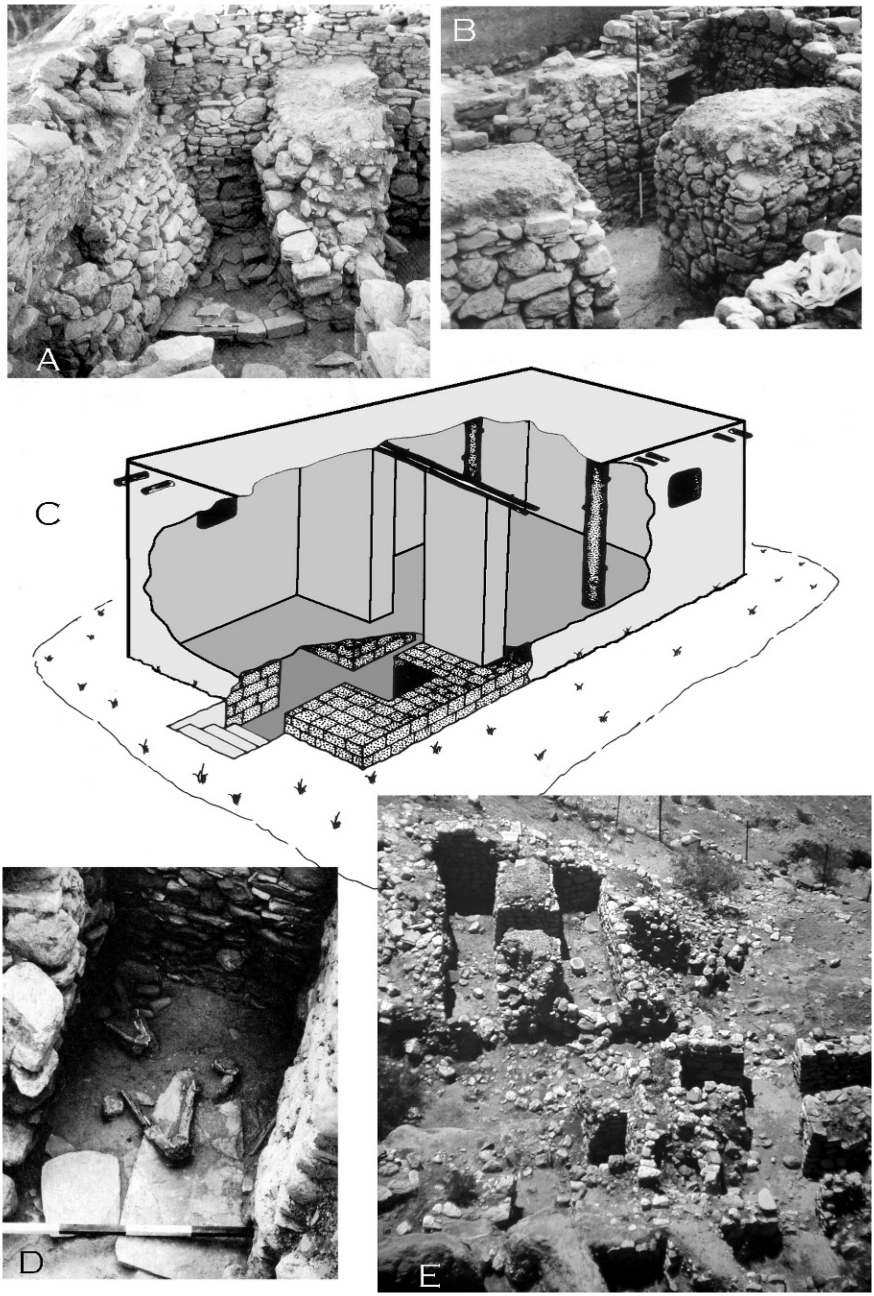

Fig. 19 Later MPPNB settlement at Beidha: photos of two storey pier (corridor) houses with storage/workshop facilities in basement; C, reconstruction (after Byrd 2005)

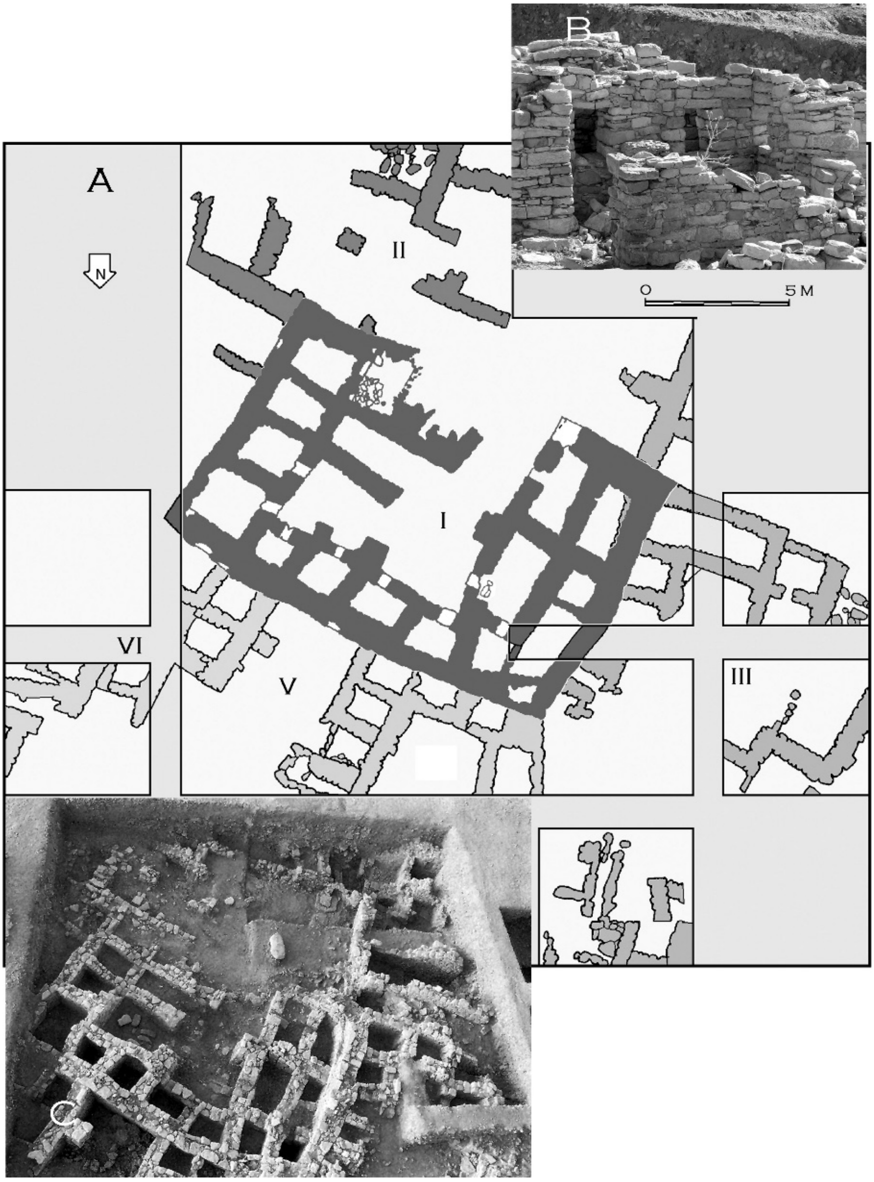

Fig. 20 Late PPNB Basta: plan and photos of two-storied domestic complexes (after Gebel et al. 2006)

Residential units appear to have been based around the extended family. Notably, some family activities seem to have involved the segregation and hiding away of activities from the community at large (see Byrd and Banning 1988). This interpretation may be bolstered by the appearance of a few long walls separating different areas of the site, e.g. Abu Gosh, Atlit Yam (see Galili et al. 1994;

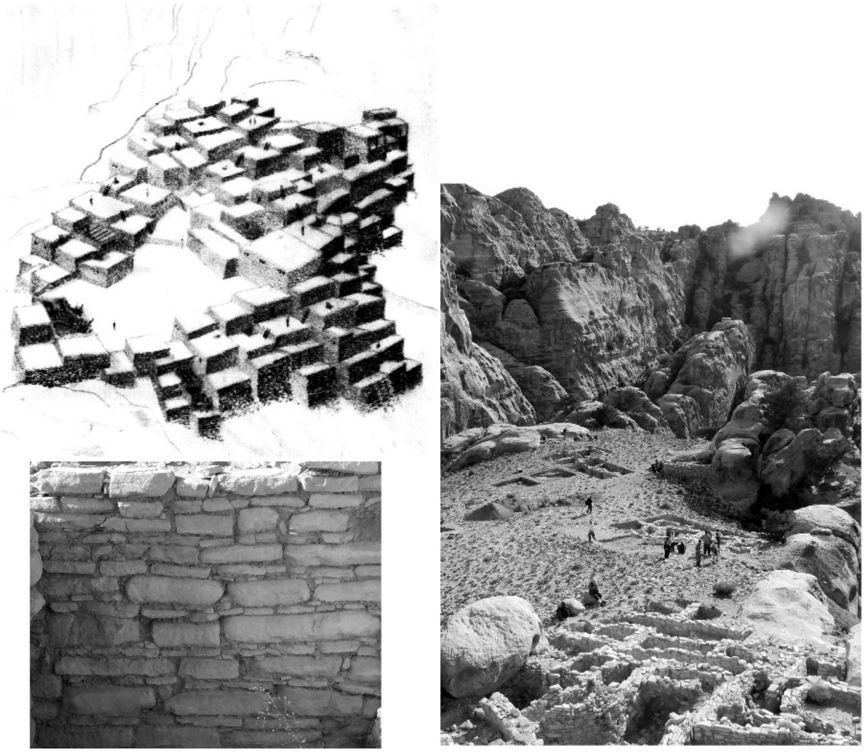

Fig. 21 Late PPNB Ba'ja; view over site, detail of dry-stone walling and reconstruction of architecture (after Gebel and Hermansen 2004)

Khalaily and Marder 2003; and see Fig. 23). There are also a few examples of larger buildings that have been interpreted as representing (secular) communal structures, e.g. Beidha (Byrd 1994).

Sacred precincts are also present on one side of some sites, having distinctive architecture, e.g. Beidha, Ain Ghazal, Atlit Yam and Jericho. At Atlit Yam and Jericho cemetery areas are found in close proximity.[10]

Although burials are found on-site in settlements, sometimes under house floors, as foundations deposits, after abandonment (Kuijt 2001 and references therein), there is the phenomenon of cemetery sites, e.g. Kfar HaHoresh (Goring-Morris 2005). This site is located in a secluded setting, at some distance from the lowland village communities using it. It contains both funerary architecture with plastered surfaces and bounding walls (perhaps 'proto'-charnel houses), post-holes and monoliths, numerous burials, as well as midden deposits deriving from feasting and associated ceremonial activities.

[10] Sha'ar Hagolan may also exhibit a similar communal or sacred complex in Structure II, Area E – see Figure 22A (Garfinkel and Ben-Shlomo 2002).

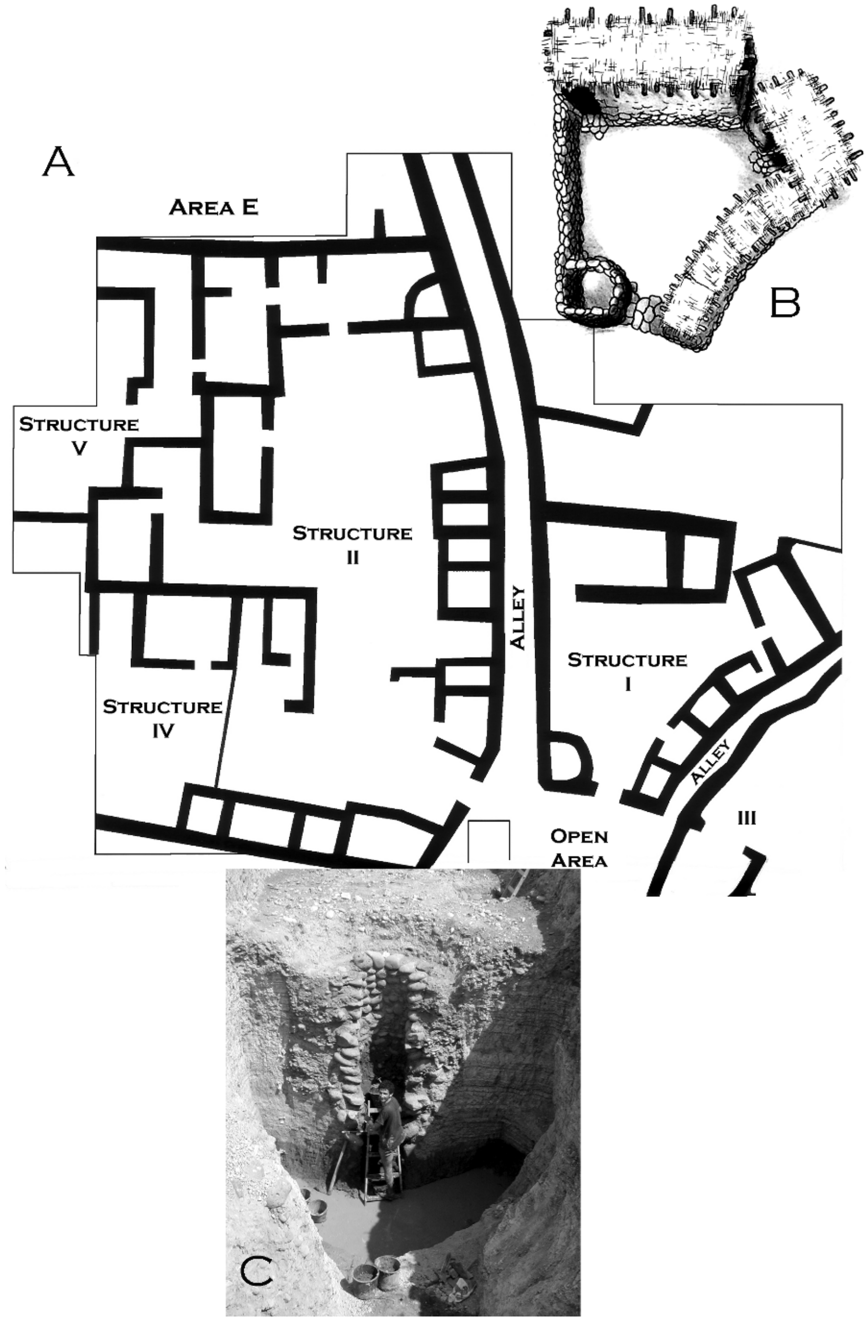

Fig. 22 Yarmukian Sha'ar Hagolan: A,B, plan and reconstruction of walled domestic complex-Structure I.C, well (after Garfinkel and Miller 2002)

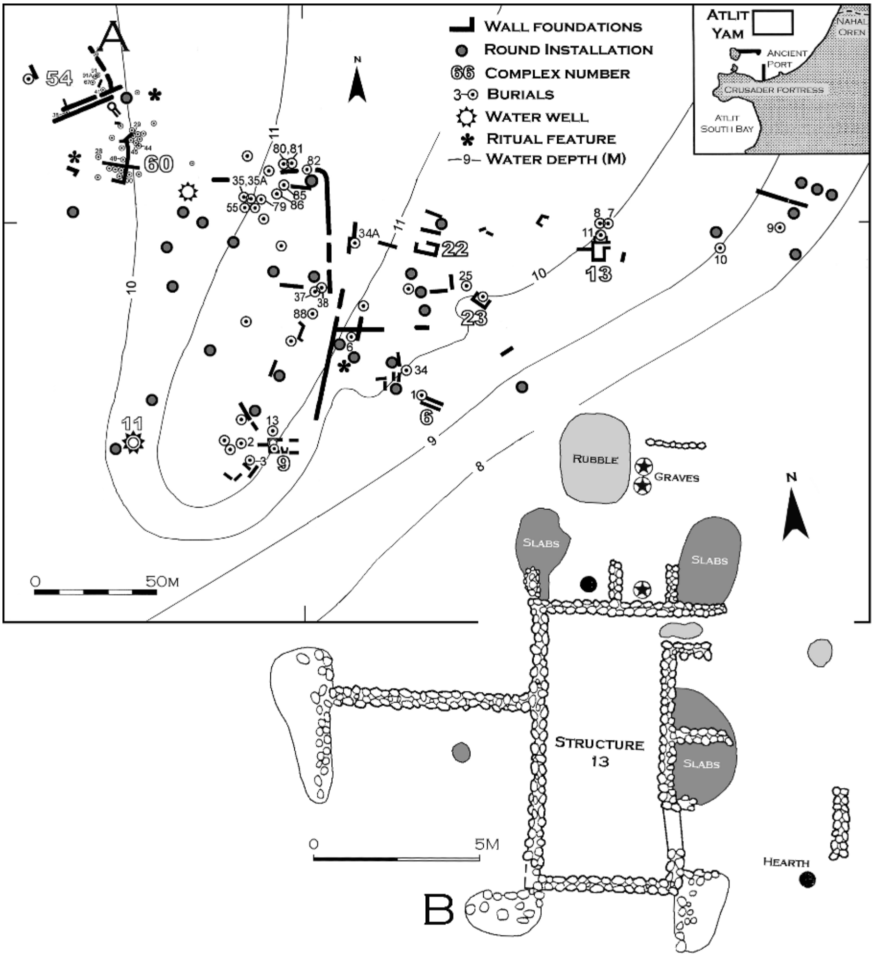

Fig. 23 FPPNB Atlit Yam: A, plan of settlement – note long walls dividing settlement and ritual precinct with numerous burials in NW corner of site; B, plan of the Structure 13 complex (modified after Galili 2004)

In the desert periphery of the southern Levant small, mobile bands of foragers continued the construction of 'beehive' seasonal occupation sites based on waist-height circular stone-built structures with organic superstructures (Bar-Yosef 1981; Betts 1998; Goring-Morris 1993; Henry 2005; and see Fig. 24). The specific location of the sites in the local landscape and the relative thickness of the walls commonly reflect the season of use.

In the north, as mentioned above, there is a smooth transition into the PPNB, as well as expansion into central Anatolia (Bicakci 2001; Cauvin 2000; Esin and Harmankaya 1999; Hauptmann 2002; Özdoğan and Özdoğan 1990). We include here also the initial stages of the Pottery Neolithic (Akkermans et al. 1983).

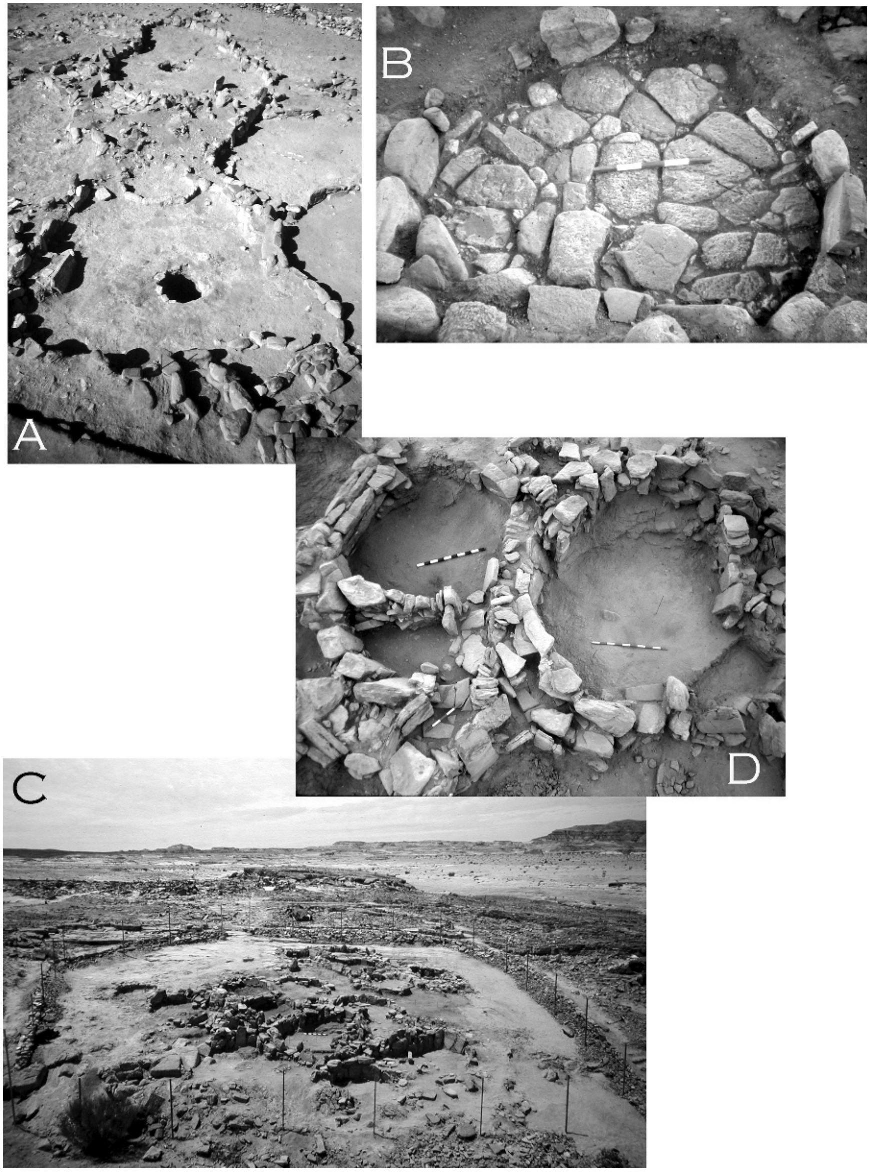

Fig. 24 Seasonally mobile PPNB forager sites in southern Sinai: A,B, summer site of Ujrat el-Mehed with domestic structures and silos; and C,D, spring/autumn site of Wadi Tbeik (photos courtesy of O. Bar-Yosef)

Settlements increase in both number and size, and site planning is obvious, as demonstrated by the systematic orientation of houses.[11] Residential architecture is based on large quadrilateral structures with a range of specific forms including, early in the sequence, 'long houses' on raised 'grill' foundations, e.g. Nevali Çori, Çayönü, etc. (Schmidt 1996 and references above). Interestingly, at least at Çayönü, individual structure sizes decrease through the PPNB sequence (a shift back from extended family domicile to one based on the nuclear family?). Usually most domestic structures are built of mudbrick on stone foundations, with raised floors (perhaps against rising damp) and flat roofs. Gypsum plaster for floors and wall coverings is common in some sites (Kingery et al. 1988). The systematic use of sophisticated wells to provide clean water already appears in the early PPNB of Cyprus at Mylouthkia and Shillourokambos (Guilaine and Briois 2001; Peltenburg et al. 2001); it probably also occurs as early on the mainland, but is only documented there from the FPPB at Atlit Yam on the Carmel coast (Galili and Nir 1993).

In the north, large open areas ('plazas' or sacred precincts) abut residential quarters at some sites, together with communal cult buildings, e.g. Çayönü, Nevali Çori, Asikli Hüyük (see references above). Some of these cult structures functioned as charnel houses for the disposition of the dead, e.g. Çayönü. As in the south, it seems that there are usually too few burials for the areas excavated, perhaps indicating that 'normative' disposal of the dead was conducted off-site. However, exceptions do occur, as with the systematic presence of burial pits, located just inside the entrance of houses at Hallula (Guerrero et al. 2006). Indeed, the possible presence of a necropolis may be indicated at Çatal Hüyük (Hodder 2006; Mellaart 1967), which can be viewed as a precursor of the concept that subsequently flourishes in the Chalcolithic and Early Bronze of the Levant, e.g. Dhra' (Chesson 1999 and references therein). The intentional burial of structures should also be noted (Özdoğan 2006).

Separate PPNB cult sites, at least initially, continued to be used, although they appear to decline in scale and seemingly disappear during the course of the PPNB, e.g. Göbekli Tepe (Schmidt 2005).

With the decline of the PPNB *koine* different domestic arrangements become the norm, with the appearance of small dispersed farmsteads in the Mediterranean zone, and a concurrent shift to pastoral nomadic sites in the peripheries. The architecture changes accordingly (Banning 1995; Goring-Morris and Belfer-Cohen in press).

Discussion

The archaeological literature abounds with examples of architectural manifestations examined assuming a linear, accumulative evolution through time (e.g. Garfinkel and Ben-Shlomo 2002 contra Goring-Morris and Belfer-Cohen 2003). Thus it is a

[11] Probably to maximize exposure of light into the houses, e.g. Bouqras, Çayönü, Tell Abu Hureyra (Akkermans et al. 1983; Moore et al. 2000; Özdoğan 1995).

given that the flimsy structures, which are rarely if ever found in the archaeological record of hunter-gatherers, were replaced through time with structures made of more durable elements. The following stage was a change from rounded to more cost-efficient quadrilateral structures, coinciding with the shift to sedentism and agriculture. With the ensuing rise of social complexity, communal structures become increasingly frequent, while at the same time it has been assumed that any symbolic values imbued in architectural endeavours would appear late in the sequence. Another inherent implication of this approach is that any physical structure is viewed simply as a dwelling, with few if any further connotations (but see Boyd 1995; Valla 1990; Watkins 1996). It is quite obvious that this attitude is simplistic, ignoring the complexities observed in extant primitive societies, as well as those evidenced in the archaeological record through non-architectural remains. Rather than explicating the archaeological material, this approach merely confuses the matter by imposing itself on the data.

One has to bear in mind that architecture ultimately reflects and denotes social organization of any particular society and the manner in which it is imposed upon space; and as such it echoes elements of that society's ideological outlook (e.g. Carsten and Hugh-Jones 1995; Hodder 1994; Preston-Blier 1986; Rapoport 1969; Samson 1990). While we caution in the introduction against the excessive use of ethnographic material, tempting as it is in the face of the meagre archaeological data at hand, we do believe that the ethnographic realities caution us against the simplistic interpretations of linear developments and the one-to-one association between 'simple' societies and 'simple' worldviews.

Amongst many recent hunter-gatherer bands, e.g. the Kalahari San, the physical 'hut', though simply constructed of readily available, perishable materials, nevertheless serves to cordon off and demarcate private space at the level of the individual, nuclear family or the band (Yellen 1977). The vast majority of family and individual activities are actually conducted *outside* the confines of the hut itself, whether around the exterior hearth or elsewhere on-site. "Inasmuch as the hut is actually used, it serves more for storing equipment, and only occasionally is occupied during inclement weather. Even in the most ephemeral San occupations, 'symbolic' huts/shelters are nevertheless constructed to demarcate the private domain of the residential unit, whether or not the hut itself is actually occupied or even used" (Yellen 1977:87).

We believe another important issue to confront is the tendency to considerably overestimate site sizes throughout the sequence; for this has a direct knock-on effect in terms of population estimates. Site sizes did increase and do reflect real demographic processes. And, clearly, differences in basic subsistence patterns require different means of estimating population and community sizes. But one should take into consideration not only the given space area per person but also the ratio of crowding, the existence of both physical and mental stress, as well as considerations of hygiene, social segregation, social stratification, the introduction of herded animals, etc. (e.g. Wattenmaker 1998 and references therein).

These are but examples of the more common assumptions inherent in archaeological thinking that frequently bias our mind-set. All of these caveats to traditional archaeological thinking should be considered when dealing with the vestiges of human architecture, even from its very beginnings.

At various times some have claimed the presence of Epipalaeolithic/Neolithic chiefdoms, whether during the Natufian (e.g. Flannery 1999; Mellaart 1975) or PPNB (Bar-Yosef and Bar-Yosef Mayer 2002). But what, actually, is the hard evidence for such a phenomenon? And what are the archaeological criteria for defining 'chiefdoms'? Should this be based on local or regional population sizes, among others? How are chiefdoms reflected in the material culture remains (Kozlowski and Aurenche 2005)? Few have addressed such issues in an explicit manner (though see discussion in Henry 1989 of possible Natufian social structure). One wonders about the nature of political-cum-ritual control at a time of major population increase and the budding-off of segments of the population, whether to found nearby settlements or farther afield, as with the sustained colonization of Cyprus.

With respect to the specific data as outlined above most Levantine architectural remains prior to the Natufian are scanty and sporadic and it is only with the appearance of the Natufian that we can begin to try and evaluate the available data along lines that differ from the interpretations that prevailed in the recent past. We still have little idea as to the degree that the core area Natufian represents mobile foragers as opposed to incipient settled cultivators. Indeed we need to take into consideration synchronic differences between the desert and the sown, as this dichotomy influenced mobility and subsistence patterns, directly reflected in the architectural remains (e.g. Byrd 2000).

We have chosen to concentrate in the following on but one aspect of the implications of the architectural data discussed herewith, namely the change in the internal spatial organization of sites on the eve and the initial stages of the Neolithization process.

Internal spatial organization

Currently there seems to be little evidence amongst *southern* Levantine foraging societies for the 'ring-shaped' site organization described for the Kalahari San (Yellen 1977). By contrast, in the north, the 'Roundhouse horizon' settlements along the Tigris, such as Hallan Çemi and Mlefa'at, may accord to such a model (see Kozlowski 1999). There, as at Nemrik, the spacing of individual households seems quite pronounced (see Aurenche and Kozlowski 1999).

Of course, one has to consider the issue of site size at any one time during the course of its existence (and see above). This caveat affects 'real' site size estimates and hence community sizes. This same caution is valid for both the Epipalaeolithic sites – how many of the huts at Early Epipalaeolithic Ohalo II are really contemporary? – And how dense were the built-up areas within the Neolithic 'megasites'? With few exceptions, such as Bouqras, we really have little idea as to the density of architectural packing within sites. Another issue concerns the durability of individual structures; raw materials for construction purposes are different in specific geographic settings, i.e. mudbrick, e.g. Jericho, Netiv Hagdud, as opposed to dry stone walling, e.g. Basta, Baja, Beidha. This would obviously affect the lifespan of individual structures.

The sum of the archaeological evidence for pre-Natufian times generally appears to reflect a pattern of residential architecture based on small nuclear family units. The size and intensity of occupations indicate that the majority of Early and Middle Epipalaeolithic sites west of the Rift were only briefly, if repeatedly, occupied – rarely do they exceed 150 m^2. There appear to be few obvious differences in basic architectural design between different ecological zones within the Levant (save the seasonal aggregation localities of the Transjordanian steppe).

The issue of genuine sedentism is especially significant in that the Natufian occupies a unique intermediate position, both chronologically and developmentally, between two quite distinct adaptive modes, namely the socio-economic shifts from mobile hunter-gatherers to sedentary farming communities – a "complex foraging society" (Bar-Yosef 1998; Belfer-Cohen and Bar-Yosef 2000 and references therein). But are these settlements more than hamlets of extended families?

Various lines of evidence at core-area Natufian sites point to year-round use, the scale and intensity of occupation appear most compatible with multiple visits to a focal 'locality' (Edwards 1989; Tchernov 1993; Wyncoll and Tangri 1991). Of interest also is the fact that, superficially at least, the Natufian may be regarded as a sophisticated and successful hunter-gatherer adaptation; yet, ultimately, it was an inherently unstable mode of life in the broader scheme of matters, which displays notable variability.

The larger Early Natufian structures are built on a scale quite different from those encountered previously, and it seems unlikely that they were occupied by nuclear families – perhaps residence was based on extended families, age cohorts, moieties, gender divisions and/or lodges (and see discussion in Goring-Morris 1996). Indeed, the presence of massive mortars at several Mediterranean zone sites provides hints at this time for systematic food processing on a larger scale than that of a nuclear family (Belfer-Cohen and Hovers 2005).

While some Natufian occupations are open-air, others appear on cave terraces as well as inside the caves themselves. In the latter instance it seems that residential structures were located *outside* on the terraces, while the cave interiors were reserved for 'special', basically non-residential activities, e.g. el-Wad, Hayonim (Bar-Yosef and Martin 1981; Belfer-Cohen and Goring-Morris 2007; Goring-Morris 1996; Henry et al. 1981; Valla et al. 1986, 1991; Weinstein-Evron 1998). Where only caves were occupied and no useable terrace exists, activities primarily appear to have been reserved for special purposes such as burials, crafts (bone tool production, shell bead modification, etc.), storage of valued or curated items and/or symbolic tasks, such as lime kilns, e.g. Hilazon, Rakefet (Grosman 2003; Lengyel and Bocquentin 2005).

Given the presence of marked phytgeographic diversity within the Levant, variability in specific Natufian adaptations between more favourable environmental settings and peripheral regions reflects differences in local carrying capacities and hence annual catchment sizes, which in turn affect both seasonality and relative mobility; and, in the final analysis, local, regional and general demographic trends.

Some Early Natufian hamlets display profane and ritual activities, often within the same structures, e.g. the large incised monoliths at Wadi Hammeh 27; or mobile items, e.g. the repetitive intentional arrangements of coloured pebbles at Eynan and Wadi Hammeh 27 (Edwards 1991; Valla 1991). Perhaps these are forerunners of much more spectacular occurrences on the Middle Euphrates in the PPNA at Jerf el-Ahmar, Mureybet and Tell Abr' (Stordeur et al. 2001).[12]

Certain sites during the later stages of the Natufian (i.e. post 11,000 calBC) in the Mediterranean zone likely functioned primarily as cemeteries for more mobile populations focusing on funerary and associated ritual activities, e.g. Nahal Oren and Hilazon Tachtit Cave (Grosman 2003; Noy 1989, 1991).

Accordingly, it seems to us that perhaps it is time to change the basic paradigm, which views the Natufian base-camp as the nascent Neolithic village, and approach the Natufian, its social organization and its material correlates from a different perspective. This was a society in change, adapting to new and different circumstances. We should view this cultural complex in terms of novel, experimental attempts, some more successful than others, to accommodate the stresses and strains of larger community sizes, i.e. 'scalar stress' (Johnson 1982, 1983) together with initial sedentism (staying together for longer spells of time). This was an on-going process, with marked differences observed between its earlier and later stages. We thus disagree with Byrd (2000) who sees a continuity of nuclear households from the Natufian through the PPNB. At the same time it seems to us that Flannery's (1972) assertion that the Natufian base camp represents the dwellings of individuals, as opposed to nuclear family houses during the PPNB, also does not reflect the currently available data, particularly during the early Natufian. Claims for Natufian matrilocal residence patterns should also be treated with extreme caution (see Henry 1989), as direct archaeological data are too scanty, while the ethnographic evidence is equivocal.

Many Natufian structures were either too large or too small for mundane habitation purposes, in contrast to earlier Epipalaeolithic manifestations (and see above). This is particularly evident during the Early Natufian, when the consistent pattern of larger structures can be explained only through the notion of a unique, 'grand' ideological/cosmic concept at the community level. At the same time its scale indicates a high level of co-operation and organization in both planning and execution. The presence of at least three coeval large structures at Wadi Hammeh 27, and comparable phenomena at Eynan and el-Wad, may indicate that domicile was sometimes based on extended families, gender, age, cohorts, moieties, rather than nuclear families.

[12] It is especially interesting to note that, for many years prior to the investigation of the other sites mentioned above, 'House 47' at Mureybet was thought to represent the quintessential PPNA Euphrates region domestic dwelling, but is now clearly a ceremonial structure (Cauvin 1978).

In this context it is worth recalling that even a modest rise in community/group size at the beginning of the Natufian would have created greater complexity on many levels, together with the need to confront and deflect the 'scalar stress' that would have ensued, especially if accompanied by increased sedentism. It should be emphasized that 'scalar stress' is incremental and has little to do with absolute numbers *per se*. Indeed, it has been suggested that 'scalar stress' is relevant to groups with more than seven to nine adult individuals who are responsible for the group's decisions.

Thus, in contrast to earlier mobile forager groups/bands, which seemingly averaged three to four nuclear families, the Early Natufian phenomenon represents a problematic combination of 'scalar stress' resulting from slightly larger community sizes (perhaps 5–10 families?), *plus* the 'fallout' from sedentism, i.e. staying together for longer spells of time in groups that are larger than the average nuclear/extended family. Potential mechanisms for relieving scalar stress include extraneous symbolic behaviours – intensive communal rituals as reflected through the presence of associated material manifestations, e.g. monoliths, artistic items, on-site funerary practices, etc. As later and terminal Natufian communities reverted to more mobile adaptations (leading to a reduction in 'scalar stress') some of these ritual behaviours were modified (Goring-Morris and Belfer-Cohen 1997); the focus may have shifted to burial practices in the Mediterranean core-area, when funerals may have functioned as occasions for aggregation (and feasting?), serving a focal point of rituals intended to strengthen the sense of unity and identity of any specific group (Goring-Morris 2000; Grosman 2003; Kuijt 1996, 2000). This may provide yet another explanation for the differences observed already by Garrod (1957) between the earlier and later Natufian with regard to artistic activities. At the same time, the marked diachronic diminution of Natufian dwellings also reflects major changes in social structure, from larger residential units back to the nuclear family division of the earlier Epipalaeolithic.

Current research indicates that the Natufian should be viewed more in terms of a fluid and flexible mosaic evolution through time and space, with different paces in different places. Though broadly similar, a significant distinction exists as to how matters were handled in the Mediterranean as compared to the semi-arid zones. One of the main (and obvious) reasons lies in the apparently different economic bases of the groups inhabiting those areas. Undoubtedly, variability in mobility patterns needs to be taken into account; all of which most probably influenced and at the same time were reflected in the differences observed in the architectural remains.

The onset of the *Archaic Neolithic (Pre-Pottery Neolithic A)* in the Levant displays considerable regional variability, with a bipartite division between the south/central and northern Levant. In the south many sites are of similar scale to the larger Natufian hamlets, but a few sites in the Rift valley can be defined as real villages in terms of total extent and/or through the presence of communal structures, i.e. Netiv Hagdud or the tower and walls at Jericho (Bar-Yosef 1986; Kenyon and Holland 1983; Naveh 2003; Ronen and Adler 2001). In the former sites one observes the continuity of small nuclear family dwellings much in the Natufian mode, e.g. Nahal Oren II, Iraq ed-Dubb, and Abu Madi I (Bar-Yosef 1991b; Kuijt and Goodale 2006; Stekelis and Yisraely 1963); in the larger sites dwellings are somewhat more spacious, likely representing extended families, e.g. Gilgal, Netiv Hagdud, Jericho, Hatoula and Dhra (Bar-Yosef and Gopher 1997; Bar-Yosef et al. in press; Kenyon and Holland 1983; Kuijt and Finlayson 2001; Kuijt and Mahasneh 1998; Lechevallier and Ronen 1994).

The PPNA in the northern Levantine arc, from the Euphrates across to the Tigris, is also characterized by small villages, deriving from a different, non-Natufian background. Settlements comprise small nuclear family dwellings grouped around semi-subterranean, kiva-like community structures, perhaps serving extended families, e.g. Jerf el-Ahmar, Mureybet, Qermez Dere and Nemrik (Cauvin 2000; Kozlowski 1992; Kozlowski and Kempisty 1990; Peasnall 2000; Stordeur et al. 2001; Watkins 1996). These special structures presage similar structures and precincts of the later PPNB settlements, e.g. Nevali Çori and Çayönü (Hauptmann 1993, 1997, 1999; Özdoğan 1999) or separate ritual sites, e.g. Late PPNA/Early PPNB Göbekli Tepe (Schmidt 1999, 2001). But what is the demographic significance of these structures and precincts? And what scale of settlements did such sites serve? While they must have served as central ritual places, they are not necessarily part of a simple hierarchy of a central site serving satellite settlements. Thus the estimates of population sizes become even more problematic.

While some graves do occur in open areas and abandoned houses, there appears to be a unique clustering of burials around the tower precinct at Jericho, indicating a tie between the burials as such and the sacred precincts. In the north, too, clearly ritually charged burials occur, e.g. Jerf el-Ahmar. Yet the number of burials reported to date from most sites is quite meagre, raising the possibility of either separate burial areas or still undocumented cemetery sites (but see Nemrik – Kozlowski 2002), well known from both, earlier (Natufian) and later (PPNB) cultures. The implications for demographic evaluations are quite obvious and once again preclude a clear estimate of overall population sizes, as well as the demographic break-up by age and gender.

The *Pre-Pottery Neolithic B koine* not only displays a wide-ranging sphere of certain shared material culture traits,[13] but also clear regional variability (Bar-Yosef and Belfer-Cohen 1989; for a different point of view see Asouti 2006). Furthermore, within each area there is a mosaic of specific subsistence modes, resulting in a wide spectrum of settlement patterns, population sizes and degrees of mobility.[14] This pattern was also observed when the reach of the *koine* was expanding during a period of climatic optimum, and when new regions were systematically colonized, i.e. Cyprus and central Anatolia. Still, all the variants of spatial organization were

[13] This involved the innovations of quadrilateral architecture, sometimes two storied, in sedentary sites and bi-directional (naviform) blade technology; additionally, the previous traditions of plaster use and post-mortem skull removal continue in a more pronounced fashion. Ultimately there was clearly a major shift in the intensification of symbols and ideology.

[14] In peripheral areas mobile hunter-gatherers continued with a band type organization, in temporary camps with circular dwellings. Beyond the material culture similarities, the nature of contacts between the settled communities and these mobile foragers and later pastoral nomads remains unclear.

first sighted in the PPNA (at least in the north) and the main difference lies in the regularity and magnitude of the various phenomena (see above for detailed description). Thus Simmons (2007:124) can try and give a population estimate of "... a total population of only 92,500 souls ... adding a few thousand more for non-villagers ..."

By the PPNB issues of land tenure would have required systematic or formalized means of transferral of ownership and rights from one generation to the next. Under such circumstances the very nature of the residential house changed, perhaps with a shift from nuclear to extended families (Byrd 1994; Watkins 1990, 1996), which has some bearing on population packing within sites. Indeed in many sedentary sites we can begin to distinguish the segregation of domestic, craft and storage facilities within the residential complex. This process appears to culminate in the late PPNB at Basta and more formally in the Late Neolithic (Yarmukian) by the appearance of enclosed walled compounds at Sha'ar Hagolan. Still we have no evidence whatsoever of any sort of hierarchical scale of domestic units. The observed differences in PPNB house plans thus not only reflect broad regional customs but also differences *within* those regions – these likely portraying the architectural traditions of specific groups, irrespective of the chronological developments (and see Wilshusen and Potter in press for the American southwest).

The likely division of some larger later PPNB village sites by long-running walls, e.g. Abu Gosh, Atlit Yam and Ain Ghazal, may be indicative of some formal segmentation of the said settlements, whether by moiety or by some other criteria. Open areas within settlements would not always represent plazas or courtyards, but often were likely repositories for waste middens (e.g. Beidha) and/or for penning newly domesticated animals.

The unique nature of PPNB communal structures in the north can be glimpsed also from the location and arrangements of the so-called cult sites, i.e. in the Urfa region (Çelik 2000, 2004), which brings to mind possible similarities to the much later concept of the Greek amphictyonies (Belfer-Cohen and Goring-Morris 2002, 2005). In the south, the secluded site of Kfar HaHoresh in lower Galilee indicates the continuity of earlier Natufian traditions of cemetery and cult sites (Goring-Morris 2005).

Initially the PPNB appears to reflect the successful shift to economies based on farming and herding. But, ultimately, its demise reflects the unforeseeable long-term consequences of large-scale, sedentary communities subsisting on domesticates, e.g. zoonotic diseases, pollution, 'scalar stress', ecological degradation and possible climatic deterioration (Goring-Morris and Belfer-Cohen in press; Molleson 2007; Rollefson and Köhler-Rollefson 1989). These processes took place at different paces in different regions and thus the population sizes changed rapidly and unanticipatedly, making population estimates during the second part of the PPNB rather tenuous. Indeed one wonders what were the real sizes of such 'megasite' communities? Estimates vary from site to site and from one researcher to the next; we may even ask whether Çatal Hüyük really had a population of 3,000–8,000 (Hodder 2006, prologue)? Or whether the L/FPPNB populations of Basta and Tell Abu Hureyra ever really reached 4,000 souls (Kuijt 2000; Moore et al. 2000)?

In summary, it is not surprising that the changes involved in the shift from Epipalaeolithic mobile foragers to sedentary Neolithic farmers and herders, can be traced in the architectural evidence, since those remains reflect the mundane, social and ideological worldviews of their occupants. Yet, the documented shifts, especially in domestic architecture were not always straightforward, linear developments, from the simple to the complex, and from small circular arrangements to large quadrilateral structures. We are facing the transformation from 'shelters' or even 'houses' that simply provided a haven from the elements, to veritable 'homes' with all that they signify from a social perspective (and see Watkins 1990), yet we are just starting to realize the complications involved in these momentous transformations. Undoubtedly, population levels shifted and rose dramatically at this time, globally, regionally and at the level of the individual community (and see Fig. 1). Still, we are just beginning to figure out the relevant approaches for demographic quantification. Understanding the problems and pitfalls inherent in the new archaeological data will be the first step in these attempts, or to paraphrase the saying of Socrates: getting a right answer begins with asking the right questions.

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Demography and Storage Systems During the Southern Levantine Neolithic Demographic Transition

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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

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[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.

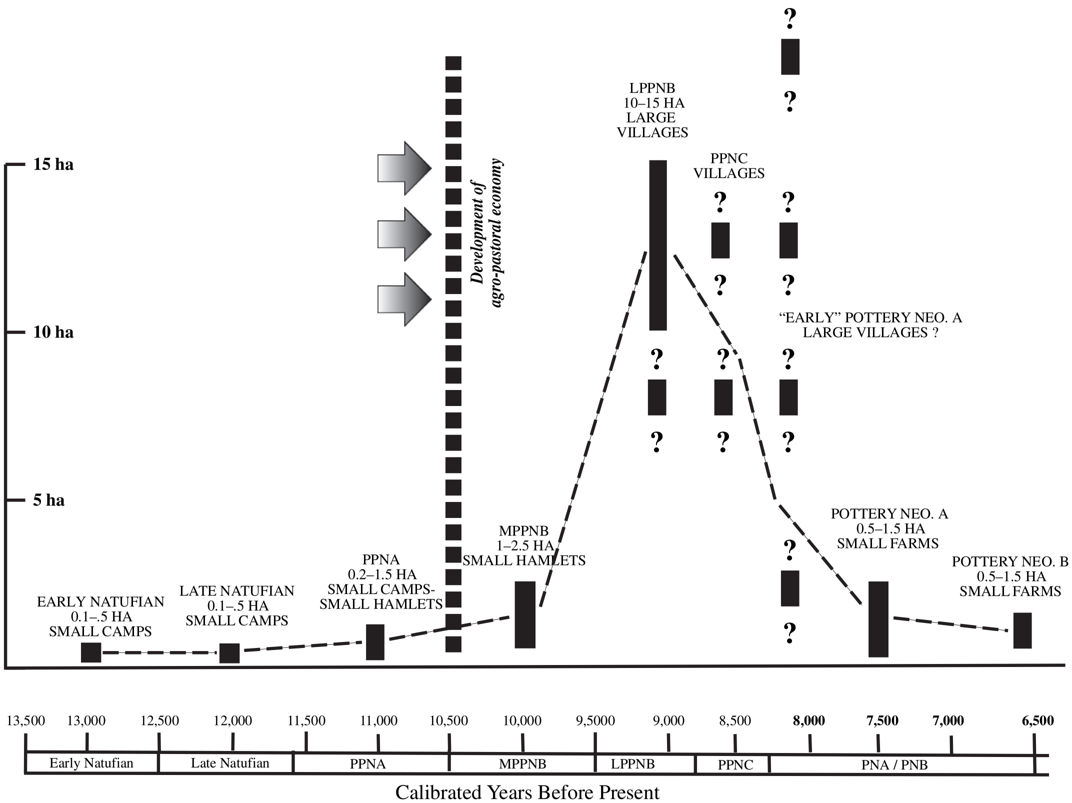
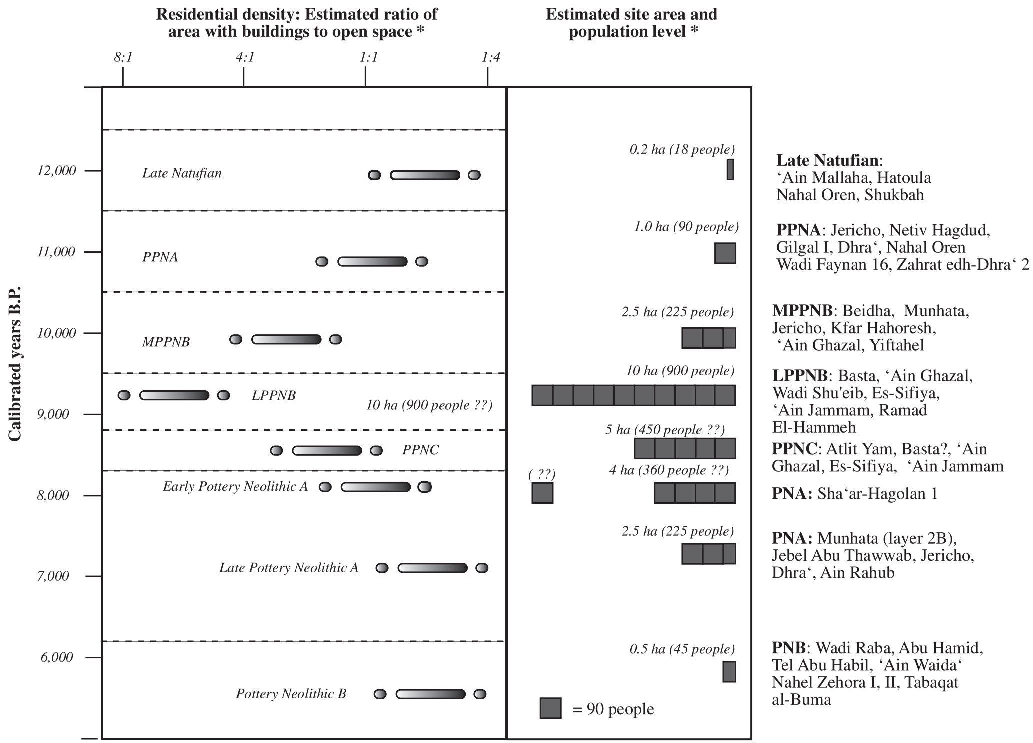


Fig. 1 Estimated changes in the horizontal extent of open air Late Natufian through Pottery Neolithic settlements located in the Mediterranean vegetative zone of the southern Levant. These data are based on the mean size of the largest sites by period (Kuijt 2001). Despite considerable field research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



*** These estimates are based on Kuijt 2000, Kuijt and Goring-Morris 2002, and Gopher and Gophna 1993. Due to differences in archaeological visability and research history, especially for the Pottery Neolithic periods, these must be treated as estimates.**

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)

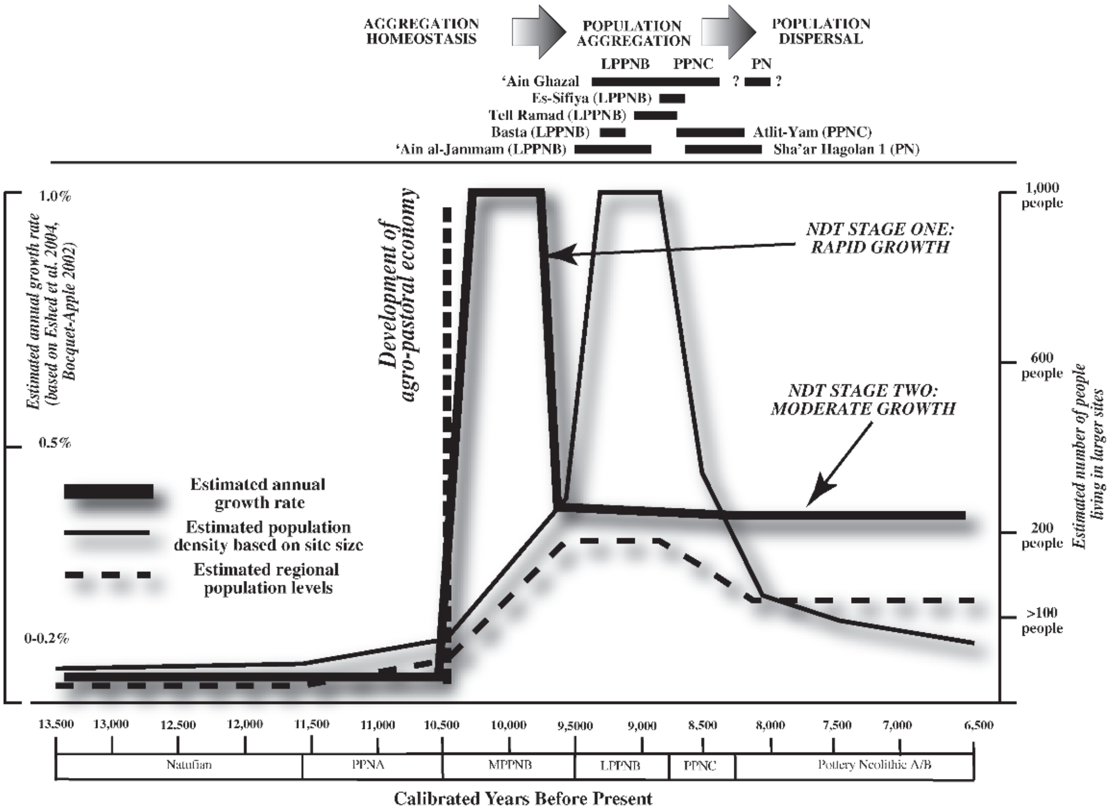


Fig. 3 Comparison of the estimated demographic growth pattern with the onset of agriculture and number of people living in large settlements (based on Fig. 2). Based on Eshed et al. (2004) and Bocquet-Appel (2002)

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.

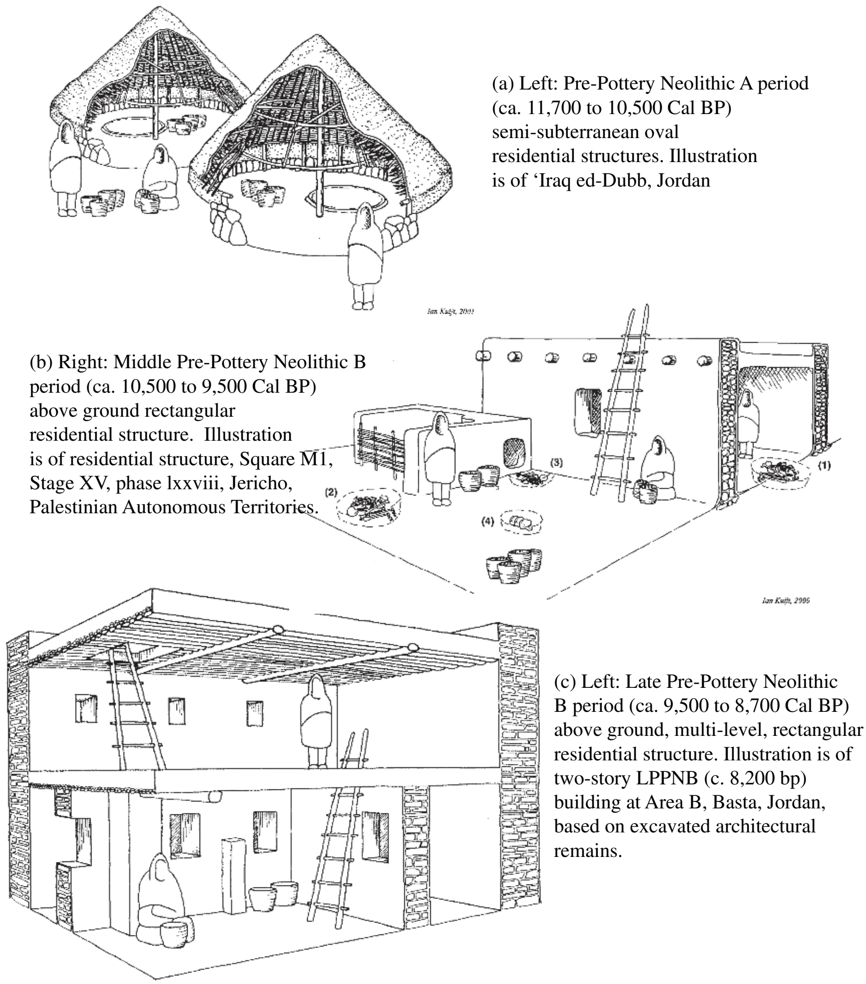


Fig. 4 Changing architectural systems in the Southern Levantine Pre-Pottery Neolithic A and Pre-Pottery Neolithic B periods (illustrations by I. Kuijt)

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 compart-ments/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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Population Processes and Their Consequences in Early Neolithic Central Europe

Stephen Shennan

Abstract On the basis of premises derived from behavioural ecology and life history theory, the chapter proposes a demographically based model for the spread of farming into Central Europe and the social and economic trajectory subsequently followed by the early farming groups of this region. It is entirely predictable that people would take reproductive advantage of the dispersal opportunities provided by the cereals–domestic animals package in a sub-continent with low population densities, while the ideal despotic distribution provides a basis for understanding the subsequent emergence of social inequalities and higher order social entities apparent from the archaeological record. The argument is illustrated with data from the western LBK region. From the archaeological point of view the reconstruction of changing population densities is central to developing explanations of the social, economic and cultural changes associated with the Neolithic Demographic Transition and its consequences, since absolute population levels are as important as growth rates.

Keywords Linear pottery culture · early neolithic · ideal despotic distribution · carrying capacity · population growth · social inequality · reproductive decision making

Introduction

The aim of this chapter is to examine key aspects of the rise and decline of the first farming societies in Central Europe, in the context of the broader phenomenon of the spread into Europe of agriculture based on the Near Eastern founder crops and domestic animals. It will be argued that demographic processes and their consequences are fundamental to understanding the developments that took place. In fact, it is increasingly clear that human populations have fluctuated very considerably in

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all times and places in response to a variety of endogenous and exogenous factors (cf. Shennan 2000), with enormous consequences. It is essential to document those fluctuations and their consequences, and also to explain them.

The foundations for understanding demographic processes lie in Darwinian evolutionary theory and more specifically in life history theory (Charnov 1993; Hawkes and Paine 2006) and human behavioural ecology (Smith and Winterhalder 1992; Winterhalder and Smith 2000). Humans, like other animals, have evolved to maximise their reproductive success. The idea that children are a good in themselves, rather than simply a means to an end, for example to increase the pool of agricultural labour, seems to be held in virtually all human cultures. Decisions to have children or not, and how much to invest in them, are made at the individual or household level in the light of individual interests and the circumstances that affect them. Those circumstances will also affect the outcomes of unconscious 'decisions', such as changing lactation spans arising from changing activity patterns (Bocquet-Appel, this volume; Sellen 2006). Some people have been more successful than others at surviving, finding a mate and bringing up their children and have left more descendants as a result (see e.g. Scriver 2001; Zerjal et al. 2003 for striking examples). The macro-scale population level results of these decisions are unintended outcomes, not goals of regulation (Voland 1998).

There are always trade-offs between the maximum number of children that can be produced and the maximum that can be brought to the stage of being successful parents themselves, because of the costs of parental investment (see e.g. Kaplan 1996). If changed conditions of some kind reduce the severity of those trade-offs, then people will take advantage of them and population will expand to new limits (cf. Wood 1998). Those limits will not in general be set by the starvation carrying capacity but by the point at which external conditions have a density-dependent effect on individual choices relating to fertility, survival and parental investment, such that mean reproductive productivity and mean survival balance one another (Sutherland 1996, 108–113). Those changed conditions may be entirely exogenous, for example climatic variations, or stem from innovations leading to new adaptations. Thus, a regional population increase, unless it is a point on a curve of endogenous cyclical fluctuations, is likely to be an indicator of new conditions promoting increased reproductive success. Population stability is an indication that a local ceiling has been reached, a process that will not take very long given the rapid increases in numbers that even relatively low growth rates produce. Discussions of the demographic consequences of new adaptations such as cereal- and pulse-based agriculture often emphasise the higher population growth rates produced, and, as this chapter will argue, periods of growth are important and have specific socio-economic characteristics. However, on an archaeological time-scale the absolute increases in population density that are sustainable are at least as important, if not more so; no growth phase can last very long before equilibrium population levels are reached and women start modifying their reproductive decisions (cf. Read and LeBlanc 2003). However, new adaptations will be especially successful if dispersal opportunities are available to the human populations practising them (Voland 1998), so that the consequences of the individual reproductive decisions are shifted and when a local population ceiling has been reached expansion can continue elsewhere.

Periods of population growth, as Bocquet-Appel (2002; Bocquet-Appel and Naji 2006) and others (e.g. Sattenspiel and Harpending 1983) have shown, result in an increased representation of younger individuals in the population. If we had the burials associated with the expansion of populations out of the Late Glacial refugia into northern Europe we would find the same pattern. There are, however, three potential features of the expansion of agriculture which may make this different in terms of its demographic properties. First, in many areas the sustainable productivity of agriculture per unit area is so much greater than the possibilities offered by foraging that population growth can continue for longer, leading to higher equilibrium densities, before density-dependent checks take hold. Second, apart from questions of the impact of mobility on fertility, the amount of parental investment per child required to produce successful adults would probably have been higher for foragers than farmers. Kaplan et al. (2000) show that for males in particular, it is not until the age of 20 that they start producing more than they consume. In agricultural societies children become productive earlier and older children actually subsidise the investment in younger ones (Boone 2002; Kramer and Boone 2002). Finally, to the extent that dependence on agriculture led to poorer diets and a greater incidence of infectious disease, and thus decreased life expectancy and increased infant mortality, life history theory predicts a shift in reproductive strategy to producing larger numbers of offspring and investing less in any one of them. In other words, in these circumstances those individuals that switch to this strategy will, on average, have greater reproductive success.

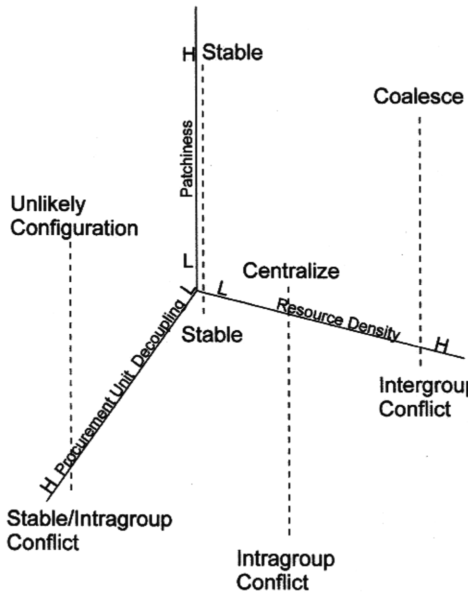

Fig. 1 The three dimensions affecting the outcomes of Read and LeBlanc's decision-making model and the outcomes predicted for the eight configurations defined by extreme values on each dimension. H, high; L, low (From Read and LeBlanc 2003, Fig. 1)

Many of the important implications of this sort of framework for understanding the consequences population processes can have on social behaviour and institutions have recently been developed very clearly by Read and LeBlanc (2003) in their 'self-centered decision model for reproductive decisions.' Their key point is that while an individual/family-centred cost–benefit model is always central to reproductive decision making, the institutional consequences of the aggregated local reproductive decisions vary, depending on three factors: resource density, resource patchiness and the extent to which the reproductive decisions of families are decoupled from the fate of the larger group of which they are a part (see Fig. 1). The specific implications of this model for the social processes associated with the spread of farming into Central Europe will be examined towards the end of this chapter.

The Spread of Farming into Europe

Since the early work of Ammerman and Cavalli-Sforza (e.g. 1973) it has become increasingly clear that the spread of farming into Europe can be regarded as a classic example of a dispersal opportunity. In large parts of Europe, away from coastal and riverine areas with rich aquatic resources, Mesolithic hunter-gatherer population densities were very low. However, the areas with low population densities included zones that were very suitable for growing cereal crops and could thus sustain much higher densities of farmers than hunter-gatherers. Moreover, the combination of annual cereals and domestic animals, in addition to supporting higher population densities, and therefore greater reproductive success before the new higher ceiling was reached, was extremely portable, far more so than many other agricultural systems. The result was a process of demic diffusion, which would have subsumed the small hunter-gatherer populations existing in the areas initially occupied by early farmers (cf. Ammerman and Cavalli-Sforza 1973; Pinhasi et al. 2005).

We are now in a position to put this process in a larger perspective. The recent radiocarbon date-based study by Gamble et al. (2005) showing population fluctuations in the western half of Europe in the late Palaeolithic and Mesolithic, indicated that these populations were not stable, but responded to shifting resource opportunities as the climate changed. What is particularly interesting in the present context is that populations in the later Mesolithic (probably excluding certain coastal and riverine areas) were at historically low levels, presumably because the developing forest cover resulted in decreasing animal population densities. Although he has few Mesolithic data points, Bocquet-Appel's (2002) results corroborate this pattern, showing proportions of 5- to 15-year-olds corresponding to population growth in the earlier Mesolithic but going down to at and below replacement level immediately before the local arrival of agriculture.

One counter-intuitive outcome of Read and LeBlanc's model outlined above is that areas with low resource densities are likely to have more stable populations than those with higher densities. It is in these latter areas that the equilibrium population density and the carrying capacity will be closer to one another, so that populations will be more vulnerable to going beyond the limit, either as a result of the inevitable stochastic fluctuations in available resources, or because individual/family-level density-dependent responses to resource shortages across a large number of individuals are unlikely to produce an aggregate response that stabilises the population at just below the carrying capacity. When the buffer zone is narrow the probability of ending up over the limit rather than under increases. Given the low resource densities away from some rich coasts and rivers, Read and LeBlanc's results suggest that it is far more likely that these populations were in equilibrium with their resources rather than at the limits of desperation implied by Binford (2001, Chapter 6).

Shennan and Edinborough (2007) have taken Gamble et al.'s approach into the Neolithic for three areas where good data are available, and the dramatic demographic consequences of this process in Europe demonstrated by Bocqet-Appel on the basis of the cemetery age profiles are also strikingly apparent in the radiocarbon date distributions for all three areas examined (Fig. 2): the start of the LBK in Germany at ca. 5500 cal. BC, slightly later in Poland; and the beginning of the TRB Neolithic in Denmark at just after 4000 cal. BC. In all cases there is a rapid rise in population to a much higher ceiling than earlier, as the classical demographic models predict. Clearly, on the upswing this implies the unleashing of the high growth potential that human populations always possess, continuing as long as those populations are below the height of the new ceiling that the high productivity of agriculture per unit area can provide. More of a surprise is what happens in the three regions after the early Neolithic, when populations decrease, and I will return to this issue later, but the main purpose of this chapter is to look at the consequences of the spread of farming and the associated population expansion over a specific part of its range, Central Europe, using evolutionary models to understand the processes involved.

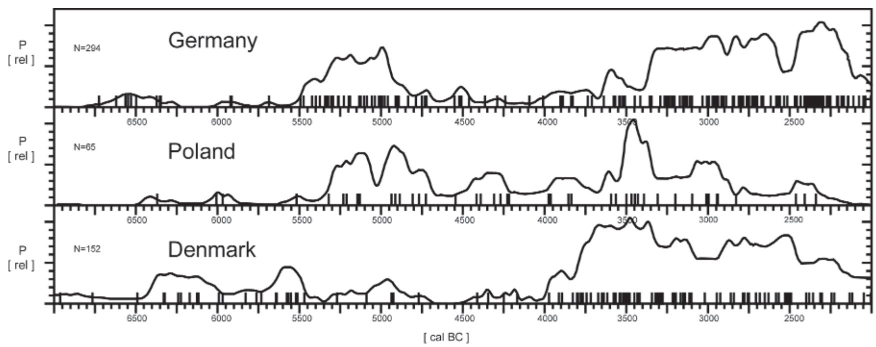

Fig. 2 Summed calibrated probabilities of dated site-phases, using one mean date for each site-phase where multiple dates available. Mean site-phase dates calculated using OxCal's R_Combine function. Summed date model created using CALPAL (From Shennan and Edinborough 2007)

The First Farmers in Central Europe

By the beginning of the sixth millennium cal. BC groups with agricultural economies had spread through southeast Europe into the Carpathian Basin. The so-called Linear Pottery Culture (or LBK after its German name) which characterises the first farming groups of Central Europe appears to have originated in western Hungary/eastern Austria ca. 5600–5500 cal. BC. It spread extremely quickly westwards. The area covered by the earliest LBK seems to have been settled in less than 150 years (Petrasch 2001); subsequently it expanded still further. However, it should be emphasised that the occupation was not spatially continuous but restricted to particular patches with favourable conditions for early farming. In this it was typical of the spatial process by which farming spread across much of Europe (van Andel and Runnels 1995) and this 'leapfrog colonisation' partially explains the rapidity with which the spread occurred. As the radiocarbon date probability distribution and Bocquet-Appel's results imply, the expansion involved rapid population growth. On the basis of studies of the number, size and density of settlements of the Linear Pottery Culture in Central Europe Petrasch (2001, 2005) has calculated population growth rates between 0.9 and 2.7% for these first farming societies. Detailed fieldwork in Germany in the western Rhineland has enabled this growth and expansion process to be traced at a local scale (summarised in Zimmermann 2002; see also Dubouloz, this volume).

The Population Ecology of Demographic Expansion Processes

There has been a tendency to assume, not least on the part of opponents of the idea that demic diffusion was responsible for the spread of the LBK, that demographic growth models of the spread of farming presuppose that spatial expansion would not have been triggered until local populations were coming close to an absolute local carrying capacity. That this cannot have been the case is suggested by the speed of the expansion into Europe and documented by the fact that in certain areas we can see that new places were colonised before others reached any sort of carrying capacity. Therefore, it has been suggested that cultural diffusion through existing forager populations is a more convincing mechanism.

The basis for understanding why further expansion does not necessarily presuppose demographic saturation is provided by principles derived from natural selection thinking, in this case as they relate to decision making concerning spatial behaviour (Sutherland 1996; Winterhalder and Kennett 2006, 16). These principles predict the distribution of individuals in relation to resources on the basis of the 'ideal-free distribution'. When individuals (of any species) seeking to maximise their probability of survival and reproductive success move into a new area they will occupy the resource patch which gives them the best returns. As more individuals occupy the patch the returns to each individual decline, to the point that the returns to an individual from the best patch are no better than those from the next best patch, which at this point has no occupants. Now the returns from both patches are equal and they will be occupied indiscriminately until such time as the population grows to the point at which there is an equal benefit to be gained by occupying a still worse patch, and the process is repeated.

When there is territoriality, however, the situation is different. Here the so-called ‘ideal despotic distribution’ applies (Fig. 3). The first individual occupying an area is able to select the best territory in the best patch. Subsequent individuals settling there do not affect the first arrival, but have to take the next best territory, and so on, until there comes a point where the next settler will do just as well by taking the best territory in the next best patch. Subsequent individuals will then take territories in either patch where the territories are equally suitable. In contrast to the ideal-free distribution, where new settlers decrease the mean return for everybody, including those who arrived first, in the case of the ideal despotic distribution the returns depend on the order of settlement, so that the initial settlers of the best territory in the patch will do best, so long as they can defend the territory against anyone who might seek to take it from them.

It is proposed then that in the case of the spread of farming into Europe, the new households being formed as population expanded would have been evaluating the costs and benefits of staying near their parents’ household or finding somewhere else, following the principles of the ideal despotic distribution. All that would have been required for further spatial expansion is a shift in the balance of costs and benefits between accepting the next best local territory available and taking the risk of finding and settling a new top quality patch some distance away, allowing for the fact that to be the very first occupant of a more distant patch might have some disadvantages, such as limited access to reproductive partners; this is the so-called ‘Allee effect’ (Sutherland 1996, 10–11). It is this that accounts for the rapid expansion of the LBK, coupled with the fact that some of the move distances for newly formed communities were very long ones (cf. Bogucki 2003).

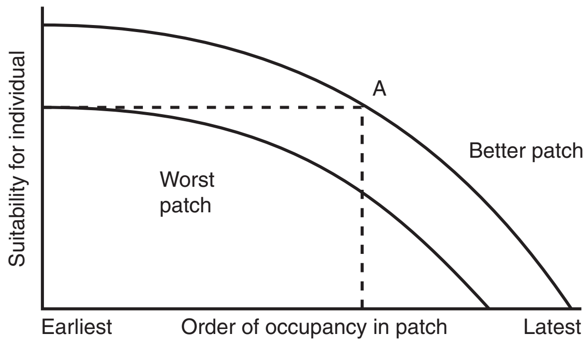

Fig. 3 The ideal despotic distribution. Due to territoriality, the suitability of a patch for each individual decreases with the order of settling. Subsequent individuals do not affect the quality of the territories of those who settled first. Individuals settle in the better patch until point A, at which a new arrival does equally well by taking the best position in the worse patch. Later individuals settle equally in both patches. However, the average return differs between the patches (From Sutherland 1996)

However, if we assume that the principles of the ideal despotic distribution hold, we can make some further predictions not just about the initial process of patch colonisation but also about the subsequent history of patch occupation. First, we expect the founding settlement in a particular area to be the dominant one. This is exactly what we find. LW8 in the Merzbachtal, for example, was occupied throughout the ca. 400 years of the local LBK sequence and was always the largest (Lüning and Stehli 1994; see also Dubouloz, this volume). Apart from its presumptively best location from the farming point of view, it also seems to have had a special position as a redistribution centre for lithic resources obtained from a major source of high-quality raw material some distance away to the west, either as a result of controlling exchange relations with local foragers beyond the agricultural frontier or through direct access to the source (Zimmermann 2002; Jeunesse 1997). Moreover, it was at LW8 that a ditched enclosure of possible ritual significance was constructed in the latest local phases of LBK occupation.

Despite the high population growth rate there would initially have been no competition between different communities because, as new households were formed, they would have been able to move to favourable locations elsewhere. Relatively rapidly though the individual micro-regions began to fill up and reach an equilibrium population size that may well have been close to the carrying capacity limit.

What the limits on carrying capacity were is unclear. Zimmermann (2002) has argued that there would have been more than enough land available for the small-scale intensive garden agriculture that was most probably practised, and which in itself is likely to imply some form of land ownership (Bogaard 2004), but that ensuring the availability of fodder for cattle would have required very large territories. The fact that carrying capacities were reached is indicated by the ceiling in local population size that can be seen in a number of places (Fig. 4). Schmidt et al. (2004) have suggested that the fluctuations in house totals, once an initial ceiling had been reached, were affected by local climatic patterns, with slight rises indicating more favourable conditions and declines pointing to downturns. This sensitivity suggests

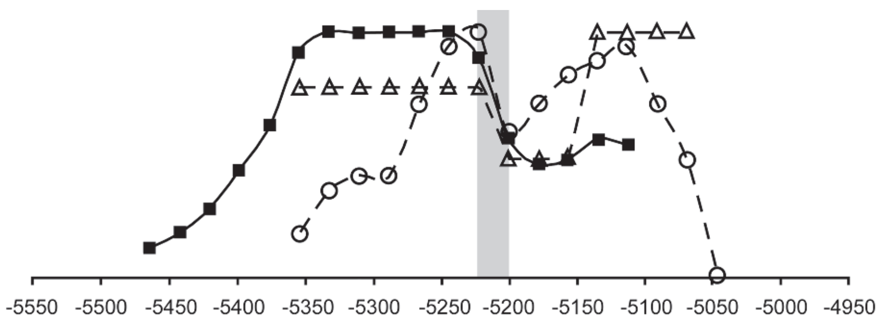

Fig. 4 Numbers of houses existing at different times during the LBK period from three LBK sites in Germany; numbers rescaled so that all sites have the same maximum value (From Strien and Gronenborn 2005). Legend: *circles*, Merzbach; *squares*, Vaihingen; *triangles*, Bischoffsheim. The shaded area marks a suggested climatic downturn

that local populations did indeed near the carrying capacity sustainable by the LBK subsistence system. Although Dubouloz's interpretation (this volume) of what were good and bad climatic conditions for the LBK farming system is almost the opposite of that of Schmidt et al., he too argues for a strong link between settlement and climate.

Again following the predictions of our model, the growth in population should have led to a growth of inequality between territory-holding units as successively poorer settlement locations were occupied. Potentially too it would have increased competition between those units, although those holding the best territories would have retained an advantage in any such competition. Over time these local LBK societies do indeed seem to have become more unequal.

The evidence for this comes from both settlements and cemeteries. For the settlement evidence the case was made by van der Velde (1990), on the basis of sites in the southeastern Netherlands and the Aldenhovener Platte discussed above. LBK houses seem to be made up of three modules with different functions: a northwest, central and southeastern part. Some houses only have the central part, others a central and northwest element, and others still all three parts; the southeastern part, believed to be the front, is generally argued to have included a granary. Van der Velde proposes that the distinctions between houses with larger and smaller numbers of elements relate to the wealth and status of their associated households and cannot be explained by changing household composition arising from family life-cycles or qualitatively different household compositions (van der Velde 1990). At the Dutch sites the houses with all three elements had more room than the others (the individual house elements were larger) and more stone adzes were associated with them. At the site of LW8 cereal processing waste was preferentially associated with the large houses (Bogaard 2004). Elsewhere there is evidence of higher proportions of domestic animal bones being associated with large houses and more remains of hunted animals with smaller ones (Hachem 2000). On the basis of a spatial analysis of the settlements he studied, van der Velde also shows that the units of which the settlements were made up suggest the existence of long-term social patterns: particular households and groups of households seem to have continued through time, with continuing inheritance of status witnessed by the rebuilding of houses of the same type in the same places. Moreover, it seems that over time the proportional frequency of small houses as opposed to large ones increased, suggesting growing inequality. Coudart's (1998) analysis of LBK houses leads her to conclude that major rank or wealth differentiation did not exist but she too points to some indications of status differences. She notes, for example, that granaries were never associated with small houses and that some buildings were more spacious than others. Interestingly, she also suggests that perhaps the largest houses were associated with the groups that had first established the settlement.

As far as burials are concerned, it is clear that there were complex patterns of spatial differentiation involving both burial within settlements and also the existence of separate cemeteries, mainly of individual inhumations, which are very rare in the earliest LBK phases. Jeunesse (1997) concludes that the earliest ones present a picture of relatively egalitarian societies, with indications of achieved status for older men, while the later ones tend to have a small group of graves, including child burials, clearly distinguished from the rest by the presence of markedly richer grave goods and possible symbols of power. This is the case, for example, with the cemetery of Niedermerz 3 that belonged to the settlements of the Merzbachtal on the Aldenhovener Platte and was established in the 52nd century cal. BC. Cemeteries would have come into existence for precisely the reasons proposed in the long-standing Saxe-Goldstein model: to represent an ancestral claim to territory in the face of increasing competition as local carrying capacities began to be reached. Indeed, precisely this argument has been used by van der Velde (1990) and Kneipp (1998) (cited by Zimmermann 2002) to account for the establishment of the Niedermerz cemetery.

Strontium isotope analyses (Bentley et al. 2002) suggest that in the early phases of the LBK there was fairly general mobility but that in the later phases it was mainly women that moved. This would point to the emergence of patrilineal corporate groups. One can therefore postulate that over time the senior line of the lineage in a given micro-area would have maintained control of the prime location and its territory and is represented archaeologically by the larger houses in the settlements. The junior branches, on the other hand, would be in increasingly inferior positions and would have relatively little option to go elsewhere because the same process was going on everywhere around them, hence the increasing number of smaller houses that van der Velde noted.

One can further speculate that as local micro-regions became more fully occupied, contest competition between lineages would have become increasingly important and members of the senior line would increasingly have had to assert their position in order to maintain it. The deposition of rich grave goods as a form of costly signalling (Neiman 1997; Bliege Bird and Smith 2005) would probably have had a role here. In this case, the number of rich burials would not simply be a reflection of the size or power of the senior lineage but of the competitive pressure it was under in particular places and times.

It is not clear whether the processes described above occurred throughout the LBK distribution but they certainly seem to have been prevalent in its western half on the basis of the evidence and sources cited above. The reasons for their prevalence seem to be twofold. First, similar processes of demographic growth and local filling up would have been going on everywhere the LBK settled. Second, all these local societies ultimately had a common origin and thus a very similar starting point in terms of social norms and institutions. This is very apparent in the material dimensions for which we have evidence.

The Decline and Disappearance of the LBK

The emergence of local inequality in terms of hereditary social and economic distinctions based on priority of access during the colonisation process is not the only widespread institutional trend to be observed in the course of the LBK. A pattern of ditched and/or palisaded enclosures in later occupation phases seems to characterise many settlement micro-regions. There has been considerable discussion of the function of these late enclosures. Some certainly have ritual significance, for example evidence of special burial rites (e.g. Herxheim (Orschiedt et al. 2003)), but the idea that defence was often among their roles has been supported in recent years by the finding of two massacre sites dated to local late LBK phases (Wahl and König 1987; Teschler-Nicola et al. 1999).

Kerig (2003) has suggested that the enclosures represent the emergence of a new type of social institution integrating larger numbers of people into a single social unit, which would presumably have been integrated with the patrilineal land-holding lineage system that has been postulated above. The existence of institutions capable of bringing large numbers of men together for warfare, at least on a temporary basis, is suggested by the scale of both the Talheim and Asparn-Schletz massacres (Wahl and König 1987; Teschler-Nicola et al. 1999). In the former case the remains of 34 individuals were recovered, in the latter case at least 67, even though not all the enclosure ditch was fully excavated. These figures imply very large numbers of attackers.

Whether the LBK enclosures were themselves always defensive constructions is not really the point if one accepts that they represent a new kind of social institution involving larger scale integration. In the light of the evidence for massacres it can be suggested that once institutions emerged that integrated larger numbers of people into a cooperating unit that was competitively successful, other groups had little option but to copy them if they wished to avoid potentially disastrous consequences. The general context in which to see this is the reaching of local carrying capacities in many of the areas where LBK farmers had settled, and the apparent vulnerability of the farming system in these circumstances to climatic stresses such as those suggested by Schmidt et al. (2004).

Important further light can be thrown on the whole LBK settlement and social sequence just described by returning to Read and LeBlanc's model (Fig. 1) and the three dimensions or factors – resource density, resource patchiness and the extent to which the reproductive decisions of families are decoupled from the fate of the larger group of which they are a part – affecting the institutional outcome of aggregated local reproductive decisions. The LBK situation was one in which resource density was high and the degree of patchiness low at the level of individual settlement catchments. As population grew intra-group inequality increased, as we have seen. Moreover, since all the local settlement regions were becoming full at the same time, it would increasingly have been the case, in Read and LeBlanc's words (2003, 62), that, 'The demographic dynamics of one group [would] impact the population dynamics of neighbouring groups', thus the fortunes of individual families and their corporate groups would have been increasingly closely bound together. The prediction of the model in these circumstances is inter-group conflict. One role of the social institutions associated with the enclosures may have been precisely to overcome the tensions arising from intra-group inequality and make corporate groups act more effectively as entities, as the dominant social dynamic shifted from a position on the lower left of the space in Fig. 1 to the upper right.

This process many have been one of the factors that led to a population crash in many areas ca. 5000 BC. It is apparent in the aggregate radiocarbon pattern (Fig. 2) and confirmed by evidence from specific local regions. It is seen, for example, in the abandonment of the Aldenhovener Platte region of western Germany (Zimmermann 2002) and of the LBK areas of the Netherlands (Richter 1997; cited in Bakels in press) at the end of the LBK, as well as in pollen and settlement evidence from Hesse (Schweizer 2003; Eisenhauer 1994) showing a marked decrease in occupation intensity at the end of the LBK, continuing for a considerable time. Other factors may well have been climatic (Schmidt et al. 2004; Dubouloz, this volume).

Conclusions

That the appearance of the LBK marked a major population increase in the areas where it is found is well established. What the radiocarbon data make clear is the extremely low levels of Mesolithic population prior to this arrival; the implication being that existing hunter-gatherer populations only made a significant contribution demographically, genetically and culturally to the extent that they were incorporated into the advancing LBK demographic wave. As Bocquet-Appel has shown, this expansion involved high population growth rates before new ceilings were reached. It is also increasingly clear (e.g. Wittwer-Backofen and Tomo, this volume) that, in contrast to earlier population expansions, such as the recolonisation of the northern half of Europe at the end of the last Ice Age, it involved a shift to a new demographic regime in which making less parental investment in more children was more successful in reproductive terms than high levels of investment in a smaller number, in other words, Bocquet-Appel's Neolithic Demographic Transition.

Evolutionary theory provides the basis for explaining these population processes and their consequences, at a variety of scales. From this perspective it is entirely predictable that people would take reproductive advantage of the opportunities for dispersal provided by the culturally (and physically) inherited cereals–pulses–domestic animals package, in a sub-continent with favourable resource patches which had very low existing population densities. At a more local level, the ideal despotic distribution, a specific ecological implication of natural selection, provides a basis not only for understanding settlement and colonisation decisions but also for explaining their subsequent consequences in terms of the gradual emergence of social inequalities based on settlement priority and control of the best territories as population increased. In turn, costly signalling theory in a situation of contest competition for the best territories offers a framework for understanding the growing differentiation in grave goods and its apparently hereditary dimension, indicated by child graves with rich grave goods. Read and LeBlanc's evolutionary model shows not only how higher resource densities can lead to greater population instability but also, more importantly in the present context, the ways in which individually based reproductive decision making has a variety of different consequences, depending on the context, as populations increase towards equilibrium levels, changing the social dynamic and leading, in situations that seem to approximate to the late LBK, to the potential for inter-group conflict.

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Part III
Community Size and Social Organization

Global Patterns of Early Village Development

Matthew Bandy

Abstract The discovery of a two-stage Neolithic Demographic Transition (NDT) has major implications for social evolutionary models of early village development. I explore these implications through a comparative study of 36 early village sequences. A strong relationship is evident between the timing of the formation of systems of autonomous villages and the rapid growth phase of the NDT. This relationship can be explained by a conflict model of village growth and fissioning during the NDT. Further, this kind of early village trajectory has a strong correlation with the process of primary state formation, and is therefore of utmost importance for global models of long-term social evolution.

Keywords Social evolution · scalar stress · village fissioning · village formation · chiefdom formation · state formation

It has been understood for over a century that the transition to agriculture was everywhere associated with a dramatic increase in human population levels. The rate and mechanism of this increase were intensively discussed in the 1970s and 1980s. By the standards of deep prehistory this is a reasonably well-understood problem. However, the recent research interest in the Neolithic Demographic Transition (NDT) has revealed an entirely new and unexpected dimension of the Neolithic demographic increase. This new dimension is the discovery that the NDT was, at least in many parts of the world, a two-stage process. An initial burst of very rapid population growth (stage 1) lasted for something less than a millennium, and was followed by a decline in the growth rate (stage 2) to levels consistent with our knowledge of preindustrial population growth. This two-stage structure was suggested in Bocquet-Appel's (2002) original publication on the subject, and was subsequently demonstrated in a more robust fashion, though with a smaller dataset, by myself (Bandy 2005; Fig. 1) using archaeological settlement data from North and South America. Archaeological settlement data can, in certain circumstances,

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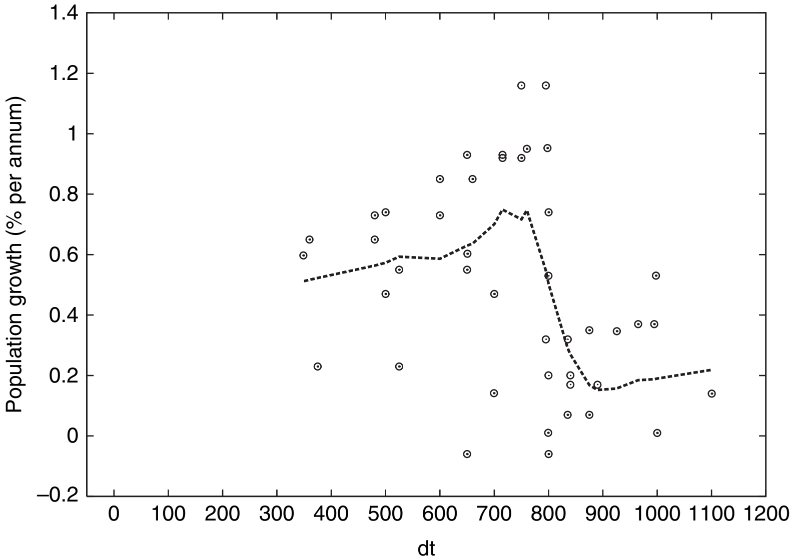

Fig. 1 Estimated population growth rates derived from regional archaeological settlement data relative to the transition to agriculture. Cases are the Valley of Mexico (Bandy 2005), Oaxaca (Bandy 2005), the southern Titicaca Basin (Bandy 2005), southwestern Colorado (Wilshusen 1999a, 1999b; Lipe and Varien 1999), and southern Ontario (Warrick 1990, 2000, 2006). The line was produced by the loess fitting function of the R statistical package

permit a better estimate of the rate of population growth than can cemetery data. The data presented in Fig. 1 indicate that during the NDT the rate of population growth ranged from approximately 0.5 to 1.0% annually, and that after the NDT the growth rate decreased to 0–0.2% annually.

Bocquet-Appel (2002) proposed that this two-stage structure of the NDT could be explained by a succession of demographic events. The initial surge in population growth could be explained by an increase in fertility, while the subsequent decline in the growth rate could be explained by a time-delayed increase in mortality, possibly related to increases in disease and parasite infestation in densely populated sites and regions. There are indeed some preliminary indications (Bocquet-Appel, Naji and Bandy 2008) that bioarchaeological disease indicators do increase with the second stage of the NDT rather than with the initial surge in population growth.

This two-stage structure of the NDT, then, is an entirely novel discovery with important implications for our understanding of the social and cultural transformations undergone by societies of the early agricultural periods of the various world regions. My goal in this chapter will be to present data demonstrating patterning in the global record of early agricultural societies that correlate with the timing of the two-stage NDT.

A Comparative Approach to Early Village Development

To assess the significance of the NDT for the development of early village societies, I undertook a comparative study of 36 archaeological early village sequences. This is an exercise in what Peregrine (2004) calls "archaoethnology," and has as its inspiration comparative studies of chiefdoms by Drennan (1991; Drennan and Peterson 2006) and others. Any study of this kind must choose between the breadth of the sample and the depth of the comparative analysis to be conducted. In this study, I have opted for the largest possible sample size in order to be able to detect patterns that might be related to the timing of the two-stage NDT. Accordingly, I recorded for each case in the sample only three pieces of information. The data are summarized in Table 1. The individual cases are discussed in more detail in an appendix.

1. The date of the transition to agriculture ($dt = 0$). I should emphasize that the beginning of the NDT does not necessarily coincide with the beginning of food production in a region. Many parts of the world, and particularly many regions of the New World, have produced evidence of plant and/or animal domestication that precedes by a considerable interval any NDT-like demographic expansion. The transition to agriculture was therefore defined as the date at which relatively permanent agricultural village life appeared in a region.
2. The date at which large villages appeared in each sequence. Large villages are defined here as having an estimated population of at least 300 people and extending over a minimum of 3 ha. This threshold was suggested by my earlier work on village fissioning as significant in the development of complex forms of social organization (not necessarily hierarchical; see Bandy 2004). This did not occur in all sequences, and where it did it is not always possible to pinpoint the date at which it took place. The dates given in Table 1 represent my best estimates. In most cases I feel confident that the date I have given in within a few hundred years of the correct date.
3. The date at which primary state formation took place in each sequence. Obviously, this only took place in a very few of the cases under consideration. The importance of this date will become clear later in the discussion. Since all cases of primary state formation are relatively well studied, these dates could be ascertained with more confidence and precision than could the dates of the appearance of large villages.

The data on the date of large village formation, when displayed in years dt (the date of large village formation minus the date of the transition to agriculture), display a strongly bimodal distribution (Fig. 2). Zero on the graph represents the date of the agricultural transition in each sequence. The horizontal axis represents the time elapsed since the transition to agriculture (years dt), in 500-year increments. The vertical axis denotes the number of cases for which large village formation took place during the specified interval. The first mode therefore indicates a large number of cases in which large villages emerged within about 1000 years of the appearance of settled village life. The second mode represents a somewhat smaller number of

Table 1 Cross-cultural sample of early village sequences. Estimated dates are given for the agricultural transition (dt), the earliest appearance of large villages, and state formation. All dates are years C.E.

Location	*d*t	Large villages	State Formation	Type Region
Basin of Mexico	−1400	−650	−200	1 Mesoamerica
Central Henan, China	−6300	−5700	−1900	1 Asia
Cochabamba Valley, Bolivia	−1150	−100		1 South America
Henrietta focus, North Texas, USA	1100	1300		1 North America
Ica Valley, Peru	−500	50		1 South America
Indus Valley, Pakistan	−3800	−3500	−2600	1 Asia
Khartoum Neolithic, Sudan	−4900	−4350		1 Africa
Lake Sharpe, South Dakota, USA	1000	1150		1 North America
Mesopotamia	−6000	−5500	−3700	1 Near East
Moche Valley, Peru	−1800	−1550	200	1 South America
Inner Mongolia, China	−6200	−5400		1 Asia
Nile Valley, Egypt	−5200	−4800	−3100	1 Africa
Ontario Iroquois, Canada	600	1300		1 North America
Pajarito Plateau, New Mexico, USA	1150	1375		1 North America
Phoenix Basin, Arizona, USA	1	700		1 North America
Southern Levant	−9750	−8550		1 Near East
Southern Scandinavia	−3100	−2300		1 Europe
Southern Titicaca Basin, Bolivia	−1500	−500	300	1 South America
Southwest Colorado, USA	100	850		1 North America
Tuxtlas Mountains, Veracruz, Mexico	−1400	−700		1 Mesoamerica
Bac Bo, Vietnam	−2000	−250		2 Asia
Central Panama	−2000	500		2 Central America
Cucuteni-Tripolye, Ukraine	−6000	−3900		2 Europe
Cyprus	−8200	−4300		2 Europe

Table 1 (continued)

Location	*d*t	Large villages	State Formation	Type Region
Fúquene Valley, Colombia	−800	1200		2 South America
Negros Island, Phillipines	−1500	850		2 Asia
Northern Luzon, Phillipines	−1500	1000		2 Asia
Valley of Oaxaca, Mexico	−1500	−1000	−100	2 Mesoamerica
Olmec Heartland, Mexico	−1500	−1300		2 Mesoamerica
Southeast Poland	−5380	−3050		2 Europe
Southeast Spain	−5500	−2900		2 Europe
Thessaly, Greece	−7000	−4800		2 Europe
Valdivia Valley, Ecuador	−4400	−1400		2 South America
Highland New Guinea	−6000			4 Melanesia
Mimbres Valley, New Mexico, USA	200			4 North America
Wankarani, Oruro, Bolivia	−2000			4 South America

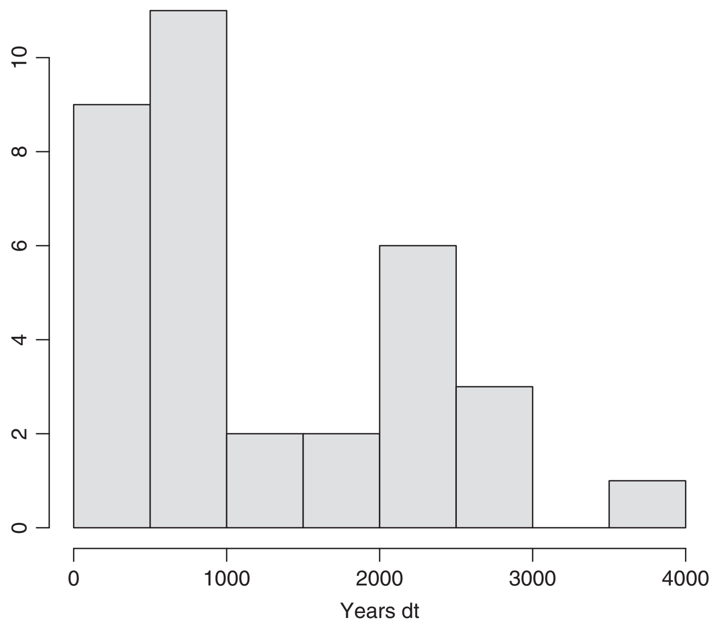

Fig. 2 The distribution of cases of large village formation in time relative to the agricultural transition

cases in which large villages emerged later, between 1500 and 2500 years after the transition to agriculture.

It is not immediately obvious how we are to interpret these modes. The patterning with respect to the date of the agricultural transition is clear, but the underlying processes are not. The situation may be considerably clarified if we classify the cases according to the manner in which the initial formation of large villages took place. I have divided the cases into four types with regard to the manner of large village formation.

1. In some sequences large villages emerge in the context of a system of more or less equivalent and autonomous villages. Large villages in these cases are simply first among equals, and a convex rank-size distribution is expected. In my sample, 20 cases may be classified as Type 1.
2. In some sequences large villages emerge initially as the capitals of small regional polities: as chiefdom centers (Drennan and Peterson 2006). In these cases the large villages are functionally distinct from their smaller contemporaries, serving as seats of political power, and a primate, primo-convex or even log-normal rank-size distribution is expected within the boundaries of the political unit. In my sample, 13 cases may be classified as Type 2.
3. In some cases, the first farmers of a region already live in large villages. This may be expected to occur when agriculture arrives in a region as a result of demic diffusion and the source region for the immigrants is already characterized by the presence of large villages. In this special case, therefore, the date of the agricultural transition and the date of the appearance of large villages are the same, large villages not having developed locally but arrived as part of the cultural package of a migrant group. In the sample under consideration no cases appear to fall into this category.
4. In many cases large villages, as defined here, simply never developed. The small number of Type 4 village sequences in the sample (3) does not reflect the rareness of the type in any representative cross-cultural sample; on the contrary, it reflects a research interest on my part in the process by which large villages develop. Type 4 sequences appear in fact to be extremely common in the world archaeological record, perhaps more common than all of the other types combined.

These four types of early village sequences will henceforth be referred to as Type 1, Type 2, Type 3 and Type 4 sequences. In the discussion to follow, Type 3 and 4 sequences will be largely excluded, effectively reducing the size of the sample to 33 cases.

When we plot Types 1 and 2 separately a clear pattern emerges (Fig. 3). The earlier of the two modes in the distribution is clearly composed primarily of Type 1 sequences, while the later mode is composed entirely of Type 2 sequences. The difference between the two types is even more pronounced when the data are displayed as a barplot (Fig. 4). The bimodal distribution of relative dates of large village formation therefore seems to reflect the existence of two entirely distinct pathways by which large, dense population centers are formed. Further, I shall argue that the

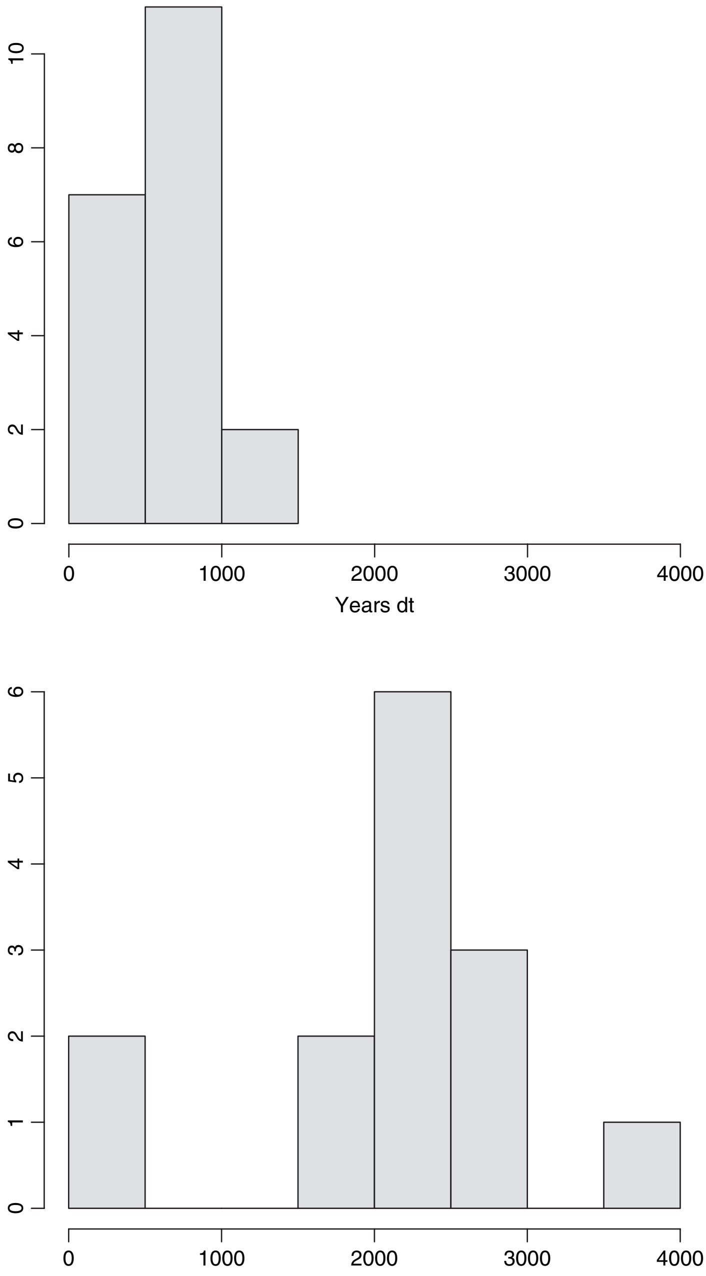

Fig. 3 Histogram showing the distribution of cases of large village formation in time relative to the agricultural transition by type. (**a**) Type 1 sequences, (**b**) Type 2 sequences

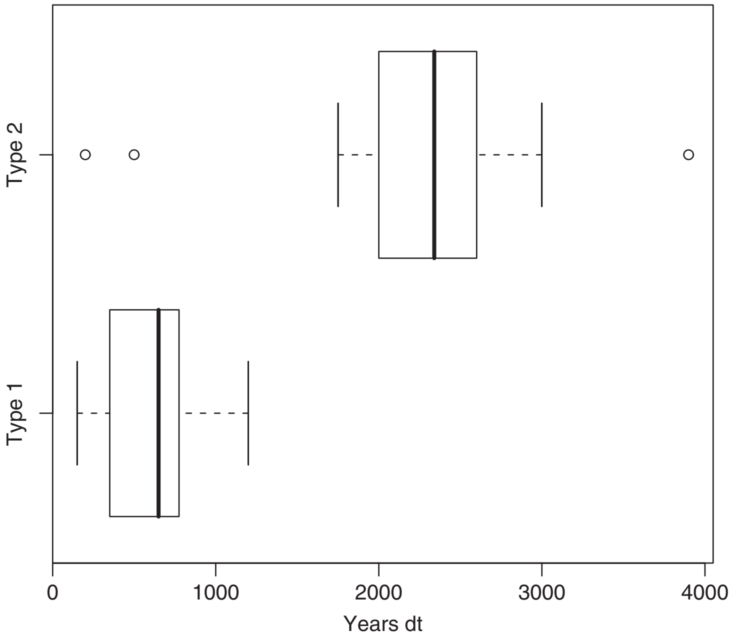

Fig. 4 Bar plot showing the distribution of cases of large village formation in time relative to the agricultural transition by type

differential distribution of the two pathways in relative time (*d*t) reflects a difference in their causal relationship to the rapid population growth of the NDT.

In the sample under consideration, large villages emerge in Type 1 sequences (as a system of autonomous, functionally equivalent villages) only within the first 1200 years following the transition to agriculture (median = 650 *d*t). The great majority of cases (18/20) see large villages appear in the first millennium. Recall that the period of very rapid population growth associated with the NDT has a duration of somewhat less than 1000 years following the beginning of agricultural village life (Bandy 2005). The coincidence between these two figures is remarkable and suggests that Type 1 village sequences are related in some causal way to this initial period of rapid growth.

Type 2 sequences display a complementary distribution in the relative chronology of the NDT. All but two cases (11/13) see large villages emerging (as chiefdom centers) more than 1700 years after the transition to agriculture (median = 2330 *d*t). Three outliers are evident on the boxplot (Fig. 4). On the long side is Cyprus, where apparently almost 4000 years passed between the transition to agriculture and the emergence of large villages. This may be an error, since there may have been an occupational hiatus on the island between the aceramic and ceramic Neolithic periods (see discussion in the appendix). If this was the case, then the transition to agriculture on Cyprus should be 5900 B.C.E., and only 1600 years would have passed before the first large villages appeared, in the Middle Chalcolithic (Steel 2004). This interval, though rather short, is still within the distribution of Type 2 sequences. The other two outliers are the Olmec Heartland and the Valley of Oaxaca. In both cases large villages appear as chiefdom centers very quickly following the transition to agriculture and easily within the expected rapid growth phase of the NDT. They emphasize the extremely precocious development of chiefdom organization in parts of Mesoamerica (see Drennan and Peterson 2006). This issue, however, though fascinating, cannot be addressed here. The important point is that in Type 2 sequences large villages almost always (excepting the Mesoamerican outliers) appear long after the NDT has passed and population growth has slowed. In contrast to the Type 1 sequences, Type 2 village formation is apparently not related to the NDT in any direct way.

A Model for Type 1 Village Formation

The precise manner in which the rapid population growth of the NDT is related to the emergence of autonomous village systems cannot, of course, be stated with certainty. However, I would like to propose the following hypothesis. Rapid population growth during the NDT presented a challenge to early village social organization. Growth in community size produced rapidly increasing levels of internal conflict in these villages. There is reason to believe that this conflict increased at a rate approximately proportional to the square of the village population (Carneiro 1987), and that a critical threshold of social stress was quickly reached. Upon reaching this threshold, village communities were presented with two options: (1) they could fission into two or more daughter communities, each smaller than the critical threshold size, or (2) they could develop some social mechanism that regulated and managed internal conflict in such a way as to make fissioning unnecessary. These conflict management mechanisms were frequently of a religious or ritual character (Adler and Wilshusen 1990; Bandy 2004), but we must imagine that the variety of possible solutions to the problem is as large as the variety of early village cultural diversity and historical experience. However, only the development of novel institutions of social integration at a suprahousehold level could make possible the emergence of villages larger than the critical population threshold, here provisionally defined as approximately 300 persons. I propose that Type 1 village sequences result from just such a process.

If the rate of increase of internal conflict within village communities is directly related to the rate of population growth, then we may conclude that the period of rapid population growth during the NDT was characterized by higher levels of social stress than the period either preceding or following it. Population doubling times during the NDT were on the order of 50–60 years, while after the NDT doubling times increased to something like 500 years. Therefore, after the NDT had passed and population growth rates had declined, there was a dramatic reduction in the kind of internal social conflict and stress that served as a spur to the development of effective mechanisms of social integration and conflict management. The kind of social evolutionary process I have described would be much more likely to have taken place during the NDT than either before or after it.

It is in this way that we can account for the temporal distribution of Type 1 village formation relative to the NDT. All Type 1 sequences in the sample resulted in systems of large, autonomous villages during or slightly after the period of the NDT and its associated rapid population growth. We may tentatively conclude, therefore, that systems of large, autonomous villages will only develop within a well-defined interval (less than 1500 years) following the onset of the NDT. The NDT therefore constitutes what might be called a window of evolutionary opportunity; after the NDT has passed, and the rate of population growth has decreased, Type 1 village formation becomes extremely unlikely.

Models for Type 2 Village Formation?

Type 2 sequences display a temporal distribution complementary to Type 1 sequences. With only two exceptions (both Mesoamerican) the initial emergence of large villages as chiefly centers took place more than 1500 years after the inception of agricultural village life, well beyond the period of rapid growth associated with the NDT. This distribution suggests that Type 2 sequences are unrelated to the NDT itself, and that the process by which chiefly centers emerge is entirely distinct from the model I have just outlined for Type 1 sequences. I will not attempt to formulate a model for this process, but will only suggest that chiefdom emergence may be related to higher overall regional population densities rather than to community size. The kinds of stresses, conflicts and interactions involved would therefore be expressed on a regional or macro-regional spatial scale rather than at the scale of the individual village community. Some Type 1 sequences did of course subsequently result in chiefdom centers, but my analysis suggests that the historical processes involved were of a different type. Though this chapter does not deal with chiefdom formation, it may be productive to delineate a typology of developmental trajectories of chiefdoms relative to the NDT, analogous to the approach taken here to early villages. Efforts in this direction have already been made, most notably by Drennan (1991; Drennan and Peterson 2006).

It is possible to suggest the outlines that such a typology might take. At least three types of chiefdom trajectories may provisionally be identified on the basis of the cases discussed in this chapter.

1. Regional polities that develop out of a system of autonomous villages; in other words, chiefdoms that develop subsequent to a Type 1 early village trajectory. Most of the known examples of primary state formation resulted from this kind of process.
2. Regional polities that develop very rapidly, during the period of the NDT, without being preceded by a system of autonomous villages. The two examples are the outliers of the Type 2 village sequence group: the Valley of Oaxaca and the Olmec Heartland. In both cases, large chiefdom centers developed very

quickly, during the period of the NDT. The processes driving these developments might be entirely different from those that drive the majority of Type 2 sequences.
3. Regional polities that develop according to the tempo of the majority of Type 2 sequences. Some of these developments, like the Philippine chiefdoms, can probably be explained by contact and interaction with expanding states. However, many examples had no contact with expansive states and this type of process can clearly occur autochthonously as well.

This very preliminary typology of chiefdom trajectories suggests that efforts to accommodate widely divergent historical trajectories into a single analytical framework of 'the chiefdom' are flawed. The patterned variability documented for archaeological chiefdom trajectories (Drennan and Peterson 2006) most likely reflects widely divergent evolutionary processes, as I have attempted to suggest in these brief notes. A multilinear approach to chiefdom evolution is called for.

The NDT and Long-Term Social Evolution

The postulation of a causal relationship between the rapid population growth of the NDT and the emergence of systems of large, autonomous villages has important implications that reach well beyond the analysis of early village societies themselves. Eight of the cases in my cross-cultural archaeological sample are primary state formation sequences. If we plot the timing of state formation in these cases relative to the NDT there is again a clear pattern (Fig. 5). In all but one of the cases (the exception is China) state formation took place between 1000 and 2500 years after the local onset of agricultural village life. It would seem therefore that after 2500 years have passed primary state formation becomes quite unlikely.

It is more informative, however, to consider the relative date of the emergence of large villages in cases that resulted in primary state formation (Fig. 6). In no primary state formation sequence did large villages emerge more than 1000 years after the onset of the NDT. This distribution is clearly identical to that of Type 1 village sequences as defined above, and indeed seven of the eight cases of primary state formation are characterized by Type 1 early village sequences (the exception is the Valley of Oaxaca).

This early emergence of large villages in all known primary state formation sequences is a fact of the utmost importance for our understanding of global patterns of social evolution. It suggests that the historical trajectories that result in primary state formation are precisely those in which large villages first appeared in the context of a regional system of autonomous villages; what I have termed Type 1 sequences. Those sequences in which large villages first emerged as chiefly centers (Type 2) are very unlikely to result in primary state formation.

In this chapter I hope to have demonstrated three things. First, that the NDT is one of the fundamental structuring processes of human history, and that consideration

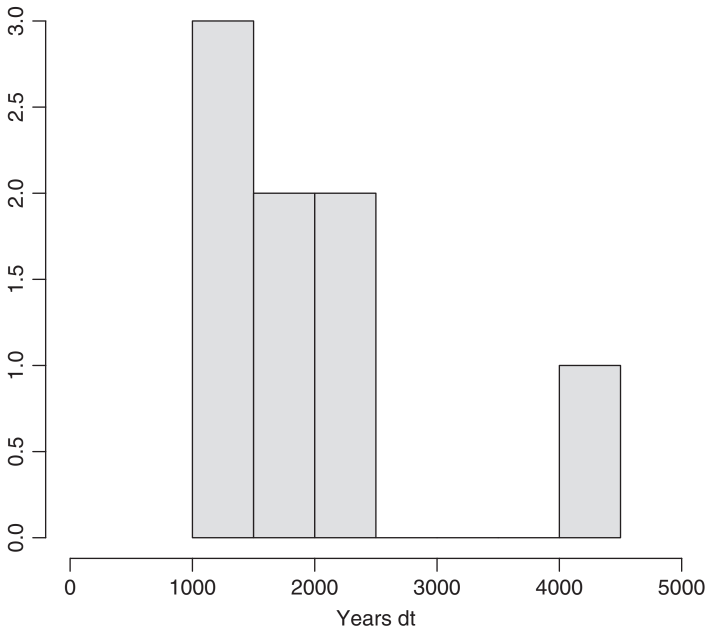

Fig. 5 The distribution of cases of primary state formation in time relative to the agricultural transition

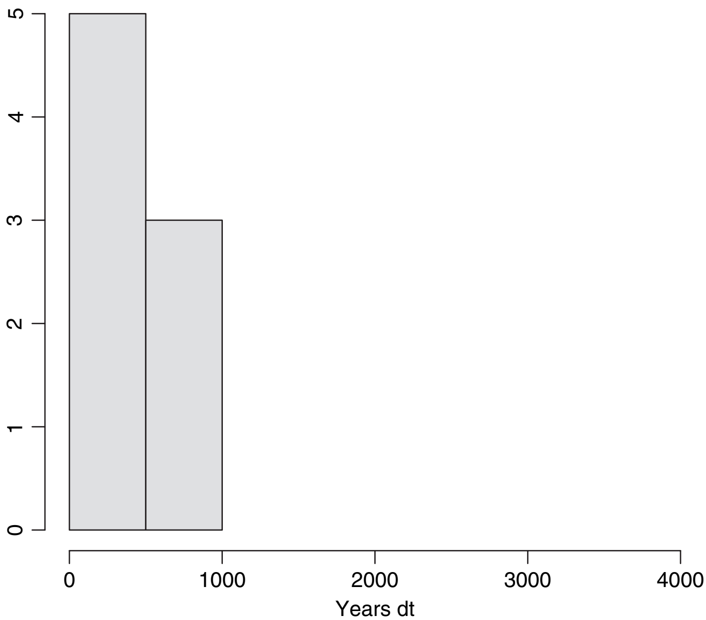

Fig. 6 The distribution of cases of large village formation in time relative to the agricultural transition. Only the eight primary state formation sequences are shown

of the economic, social, and cultural implications of the rapid growth phase of the NDT must be incorporated into any general account of long-term social evolution.

Second, that the two-stage structure of the NDT is of major significance in understanding the effect of the NDT on prehistoric societies and on long-term regional development. The divergent patterns of early village development that I have discussed in this chapter can only be understood by postulating that the evolutionary possibilities of societies experiencing the rapid growth of the NDT are different from those of societies growing at slower rates. Specifically, Type 1 village formation seems to be a possibility during the NDT, but very unlikely afterward.

Third, that the historical developments of the early village period have critical importance for an understanding of the later course of regional trajectories. Drennan has noted, in reference to divergent chiefdom trajectories, that "even the most spectacular differences in sequences of complex society development began to operate much earlier on in those sequences than we are accustomed to think" (1991:286). I make the same claim for early village trajectories. The particulars of early village development have a fundamental structuring significance for the later periods of a region's prehistory. The two-stage NDT as a regularity of early village development is important not only for the analysis of these societies themselves, but is essential for any adequate account of long-term social and cultural evolution at a global scale.

Appendix 1: Detailed Discussion of Cases

Basin of Mexico

Parsons (1974) places the agricultural transition at 1400 B.C.E. Large villages appear sometime during the First Intermediate I period (800–500 B.C.E.). Here I use the phase midpoint, or 650 B.C.E. Primary state formation takes place around 200 B.C.E., with the expansion of Cuicuilco and Teotihiacan.

Central Henan, China

Agriculture begins with the Cishan (Hebei) and Peiligang (Henan) cultures (Pearson and Underhill 1987) at around 6300 B.C.E. Pearson and Underhill (1987:807) state that these early villages are small: 1–2 ha, up to 200 people. For them, then, large villages developed later, in the Yangshao period (after 5100 B.C.E.). More recent sources, however (Liu 1996; Shelach 2000; Shih 1992; Yan 1999), consistently attribute large size to at least some of the earlier Cishan or Peligang villages. Shelach (2000:400), for example, suggests that the village of Cishan extended over 8 ha. Liu (1996:267) suggests that 6 ha might be an upper limit to Peiligang village size. Clearly, then, large villages appeared in pre-Yangshao times. Here I will use the midpoint of the Peiligang phase as given by Pearson and Underhill: 5700 B.C.E.

Primary state formation took place with the appearance of the Erlitou (Early Shang) culture (Pearson and Underhill 1987), at around 1900 B.C.E. (Liu 1996).

Cochabamba Valley, Bolivia

According to Higueras (1995:30) the Formative period in this valley on the Eastern slopes of the Andes dates from 1150 B.C.E to 200 C.E. The date of the agricultural transition would therefore be 1150 B.C.E. On the basis of his settlement survey, Higueras (1995:123) reports two large villages (5 and 7 ha) in the Mizque sub-valley during the Formative period. Large villages are therefore present late in the Formative period. The precise date is unknown. Here I will use 100 B.C.E. Primary state formation never took place in the Cochabamba Valley.

Henrietta focus, North Texas, USA

Most Early Plains Village sequences of the Southern Plains would be classified as Type 4 sequences; they never saw the development of large villages, at least not in the pre-contact period (Drass 1998). They are not included in Table 1 because a proliferation of Type 4 village sequences would have accomplished little in terms of the main interpretive conclusions of this study. The Henrietta Focus of the Upper Red River and Brazos River valleys of north Texas is, however, an exception (Drass 1998:434–438). The Henrietta Focus is poorly known, but village size appears to range from approximately 1 to 10 ha (Drass 1998:434). Assuming house densities are similar to those in the better-documented central Oklahoma phases (Paoli/Washita River), the sites on the large end of this range certainly would exceed 300 inhabitants.

The Henrietta complex seems to date from approximately 1100 to 1450 C.E., though it may be a bit earlier (See Drass 1998 for a discussion). I will here employ the midpoint of this time period, 1300 C.E., for the date of the appearance of large villages. The beginning of the Henrietta Focus (1100 C.E.) is used as the date of the agricultural transition. Primary state formation, of course, never took place in Texas.

Ica Valley, Peru

The transition to agriculture in the Ica Valley took place during the Early Horizon, at around 500 B.C.E. (Massey 1986). Villages on the threshold of my large village category (300 inhabitants) appear as early as the Early Horizon 2 (350–200 B.C.E.; Massey 1986:168, 173), but villages definitely in the large size range appear only in the Early Intermediate 1 (1–100 C.E.; Massey 1986:177). I use the midpoint date of the Early Intermediate 1, or 50 C.E. A chiefdom center (Cerro Tortolita) definitely appears during Early Intermediate 3–4 (200–300 C.E.; Massey 1986:188). This is therefore a Type 1 sequence with large villages by 50 C.E. and chiefdom formation taking place some centuries later. Primary state formation did not take place in the Ica Valley

Indus Valley, Pakistan

According to McIntosh (2002:45) farmers arrived in the Indus Valley proper in "later 4th millennium" B.C.E. from Baluchistan. Possehl (2002) gives a somewhat earlier date for the transition to agriculture, in his Phase II or Hakra Wares phase, dating to 3800–3200 B.C.E. Villages during this phase were already large, averaging greater than 6 ha in extent (Possehl 2002:34), and state formation (or urbanism at least; he prefers not to say that these are "states") took place around 2600 BC.

There are, then, two possibilities. In the first, the earliest farmers of the Indus Valley were immigrants from Baluchistan who already, at the time of colonization, lived in large villages; in other words, that this is a Type 3 sequence. The other is that this is a Type 1 sequence and that large villages developed rapidly sometime during the Hakra Wares phase, around 3500 B.C.E. In this chapter, I have assumed the latter scenario to be valid.

Khartoum Neolithic, Sudan

The Khartoum Neolithic dates from 6000 to 5000 BP, uncalibrated, and by the end of this period large sites were present along the Nile, up to approximately 4 ha and 2 m or more in depth (Mohammed-Ali 1987:128). These would appear to qualify as large villages according to my criteria, though they are not well understood. Large villages therefore appeared sometime during the date range provided by Mohammed-Ali: in the mid-fifth millennium. It certainly took less than 1000 years for these large sites to develop, and perhaps considerably less. I cannot evaluate this question here. I will use 6000 BP as the date of the agricultural transition, and 5500 BP as the date of the development of large villages. These calibrate to approximately 4900 and 4350 B.C.E., respectively.

Lake Sharpe, South Dakota, USA

Agricultural villages appear in the Initial variant of the Coalescent Tradition, around 1000 C.E. (Toom 1992:133). Village sizes are 3.22 ± 2.41 ha, with maximum size of 11 ha (with an estimated 100 houses) and numerous villages in the 7 ha range. These large sites appear during the Initial Middle Missouri Variant, or 1000–1300 C.E. (Toom 1992:144–145). The 11 ha site (the early occupation of the Summors site) is estimated to have had 1000 inhabitants (Toom 1992:148). This clearly qualifies as a large village. There is no evidence of stratified social structure or regional political integration. The date of large village formation will be taken as the phase midpoint, or 1150 C.E.

Mesopotamia

State formation takes place at around 3700 B.C.E., at the beginning of Uruk period (Wright 1977:386). Agriculture arrived in Akkad (northern Mesopotamia) at around 6000 B.C.E., and large villages emerged in the Halafian, beginning around 5500 B.C.E. Villages of the earlier Hassuna culture remained small, between 100 and 200 inhabitants (Knapp 1988:24).

Moche Valley, Peru

Agriculture begins in the Moche Valley in the Early Guanape phase, around 1800 B.C.E. (Billman 1996). In Early Guanape there is already temple architecture, and a large village (Gramalote, 2 ha, around 100–200 habitations, possibly as many as 500–1000 people; Billman 1996:137). So large villages appear at the midpoint of the Early Guanape phase, around 1550

B.C.E. State formation took place early in the Moche phase (ca. 200 C.E.) when the Cerro Oreja polity forced highland colonists out of the coca lands in the Middle Valley (Billman 1996:290).

Inner Mongolia

Agriculture appears at the beginning of the Xinglongwa phase, around 6200 B.C.E. (Shelach 2000). Large villages begin in the Zhaobaugou period (5400–4500 B.C.E.). The beginning date of the Zhaobaugou period, 5400 B.C.E., is used here for the date of the appearance of large villages.

Nile Valley, Egypt

According to Knapp (1988), the agricultural transition in Egypt took place around 5000 B.C.E., large villages appeared sometime during the Amratian, probably around 4500 B.C.E., and state formation took place at 3100 B.C.E., or perhaps slightly earlier. Phillipson (2005:187) gives slightly different though broadly congruent dates: an abrupt agricultural transition in the lower Nile Valley around 5200 B.C.E., and a large village (Merimde, in the Nile delta, covered about 18 ha) by 4800 B.C.E. Here I employ the dates from Phillipson.

Ontario Iroquois, Canada

Maize agriculture began in Ontario with the Princess Point complex, approximately 600–900 C.E. (Warrick 2006). Princess Point sites contain maize and material culture considered to be "directly ancestral to Early Iroquoian sites in Ontario" (Warrick 2000:427). Average Princess Point village population was about 75 people, with a maximum size of about 200 inhabitants, and villages were occupied for 40–50 years (Warrick 2000:430–431). Villages remained small through the Early Iroquoian period (Warrick 2000:438), with large villages, of 400–500 inhabitants, first appearing in the Uren phase (1300–1330 C.E.; Warrick 2000:440).

Pajarito Plateau, New Mexico, USA

The first farmers in this area appeared very late, around 1150 C.E., and were probably immigrants from the San Juan Basin (Kohler and Root 2004a). These early sites were quite small, with less than 20 rooms per site (Kohler and Root 2004a:123 and Table 4.1). Sites were larger in the Late Coalition and Earliest Classic, but remained below the 300 inhabitant threshold used in this study (Kohler and Root 2004b:216). By the Middle Classic (1400s C.E.) there were seven major towns, spaced about 5 km apart (Kohler et al. 2004:216). At least one village, Tyuonyi, had an estimated 400 rooms and certainly was home to more than 300 inhabitants (Kohler et al. 2004:236). The date for the appearance of large villages used here will be 1375 C.E.

Phoenix Basin, Arizona, USA

Agricultural villages appeared in the Phoenix Basin at the end of the Red Mountain phase; around 1 C.E. (Ciolek-Torello 1998). Wallace (2003a:22) sees the agricultural transition as taking place slightly later in Phoenix, around 150 C.E. Ciolek-Torello's date is employed here. Villages of more than 300 inhabitants appear in the Phoenix Basin by 700 C.E., the Snaketown phase (Craig 2000). Incidentally, large villages seem to have appeared much later if at all in the nearby Tucson Basin (Wallace 2003b; Wallace and Lindeman 2003), though agriculture appears much earlier (Ciolek-Torello 1998). Tucson may be a Type 4 sequence.

Southern Levant

The transition to agriculture took place at the beginning of the Pre-Pottery Neolithic A (PPNA) period, which Kuijt and Goring-Morris (2002) place at 9750 B.C.E. According to Hole (2000:194) villages remain small in the PPNA, ranging from 0.1 to 2.5 ha, with perhaps a few hundred inhabitants. Much larger villages appear in the PPNB, including Abu Hureyra (11.5 ha; Hole 2000:198) and 'Ain Ghazal (12–13 ha; Hole 2000:202–203). These very large villages are rather late, however. The largest sites in the Middle PPNB are in the 4.5–5.0 ha range (Kuijt 2000:80), certainly large villages according to the criteria employed here. Data on the Early PPNB are rather vague, but it would appear that large villages first appeared during the period. Kuijt and Goring-Morris (2002) place the beginning of the Early PPNB at around 8550 B.C.E. This date will be used for the appearance of large villages. Primary state formation never took place in the Levant.

Southern Scandinavia

Herding appears at the beginning of the TRB, about 3100 B.C.E. However, sites that might be called 'villages' appear later, around 2600 B.C.E., and hunting appears to decline in importance (Price and Gebauer 1992). The earlier date will be used for the agricultural transition in this study; however, an argument could be made that the later date would be more appropriate. Large villages of 7–30 ha, at least some of which are certainly large villages by the criteria employed here, appear sometime in the Late Funnel Beaker period (2450–2200 B.C.E.; Price and Gebauer 1992:101). The midpoint of this range (2300 B.C.E.) will be used here for the date of the appearance of large villages.

Southern Titicaca Basin, Bolivia

The agricultural transition took place at the beginning of the Early Chiripa phase (1500–1000 B.C.E.), at 1500 B.C.E. (Bandy 2001, 2006). Villages remained small through the Early and Middle Chiripa (1000–800 B.C.E.) phases, only achieving more than 300 estimated inhabitants after 800 B.C.E. during the Late Chiripa phase. The date employed here will be the midpoint date for the Late Chiripa phase, about 500 B.C.E.

Southwest Colorado, USA

The agricultural transition in southwestern Colorado begins around 100 C.E. during the Basketmaker II period (Bandy and Wilshusen in prep). Large villages appear in the Pueblo I period (750–900 C.E.), by no later than 850 C.E. (Wilshusen and Ortman 1999).

Tuxtlas Mountains, Veracruz, Mexico

Occupation begins in the Early Formative at 1400 B.C.E. with two clusters of small villages (Santley and Arnold 1996:228). Large villages appear in the Middle Formative (1000–400 B.C.E.; Santley and Arnold 1996:228). The date used here will be the midpoint of that range: 700 B.C.E. Santley and Arnold (1996:231) maintain that no regional polity yet existed at this time (this appeared later, in the Late Formative) and that these villages were basically egalitarian. This is therefore a Type 1 sequence.

Bac Bo, Vietnam

This is the lower course of the Red River in northern Vietnam. The general region is called Bac Bo by Higham (2002, 2004). The Neolithic begins around 2000 B.C.E. with the Phung Nguyen culture, though it could begin earlier. Villages are in the range of 1–3 ha (Higham 2004:88). The site of Dong Dau is a 3-ha mound (Higham 2004:151) first occupied in the Phung Nguyen phase, and occupied into the Bronze Age. In the Bronze Age (beginning around 1500 B.C.E.) there are two phases: Dong Dau and Go Mun. Go Mun dates to 1000–500 B.C.E. (Higham 2004:175). Go Mun sites apparently remain in the 1–3 ha range. It is not until the Iron Age Dong Son culture, beginning around 500 B.C.E., that large settlements appear (Higham 2004:170–179). Higham singles out Co Loa for mention, a massive walled site covering as much as 600 ha (Higham 2004:172). The urban occupation of Co Loa began in the "third century BC" (Higham 2004:172). I will therefore use the date 250 B.C.E. for the first appearance of large villages in Bac Bo, though I recognize that this could be off by as much as 300 years.

Bellwood (1997) and Nguyen et al. (2004) date the beginning of the northern Vietnamese Neolithic to much earlier, as early as 5000 B.C.E. This would, however, simply expand the time elapsed between the transition to agriculture and the appearance of large villages. The interval I have given here – 1750 years, using Higham's dates – is therefore an absolute minimum.

Central Panama

Drennan (1991:273) suggests that agricultural villages, such as La Mula-Sarigua, existed by 2000 B.C.E. However, in all early periods these settlements seem to have been characterized by very low residential density. Linares and Sheets suggest a rule of thumb (for Volán Barú) of one household/ha. If this is so, then Sitio Sierra, covering 45 ha at about 200 B.C.E. (Drennan 1991:274) probably had less than 300 inhabitants and does not qualify as a large village. After 500 C.E., larger settlements are in evidence (Drennan 1991:274) associated with the Coclé art style, most famously at Sitio Conte (500–900 C.E.). I will therefore use 500 C.E. for the first appearance of large villages.

Cucuteni-Tripolye, Ukraine

Agriculture appears around 6000 B.C.E. at the beginning of the Early Neolithic Bug-Dnestr culture (Milisauskas 2002:153). The Cucuteni-Tripolye culture begins at 5000 B.C.E. in the Middle Neolithic (Milisauskas and Kruk 2002:194). Large villages appear "after 4000 BC" (Milisauskas and Kruk 2002:217–221), in the middle and late phases of the Cucuteni-Tripolye culture. I will here use the date 3800 B.C.E. Some of these later villages are enormous, with sizes in excess of 200 ha and possibly 10,000 inhabitants or more.

Cyprus

Cyprus was initially colonized in the early aceramic Neolithic, ca 9000 BP (Mylouthkia and Shillourokambos; Steel 2004:34–35). The late aceramic Neolithic continues through 7000 BP and has no large villages, though sites are densely occupied. There is an apparent gap of 500–1000 years in the existing radiocarbon dates for the island between the end of the aceramic and the beginning of the ceramic Neolithic periods (Steel 2004:63). Steel believes that this represents an occupational hiatus. The ceramic Neolithic appears around 6000 BP, and is characterized by small villages (0.5–1.5 ha; Steel 2004:67). Large villages appear in Middle Chalcolithic (5500–4500 BP; Steel 2004:86). The largest, Mosphilia, extends over 10 ha; nearby villages cover 3 and 6 ha. This is a hierarchical organization, and therefore a Type 2 sequence. Calibration of Steel's BP dates produces 8200 B.C.E. for the transition to agriculture and 4300 B.C.E. for the appearance of large villages.

The possibility of abandonment and recolonization of the island is a critical issue, since it makes the difference between a long (3900 year) and a much shorter (1600 + years) gap between the agricultural transition and the appearance of large villages. I here assume that occupation was continuous, though I recognize this to be problematic.

Fúquene Valley, Colombia

Agriculture begins here at the beginning of the Herrerra Period (800 B.C.E.–800 C.E.; Langebaek Rueda 1995). Sites are small, with no evidence of nucleated habitation (Langebaek Rueda 1993:138). In the Early Muisca Period (800–1200 C.E.) there is some aggregation into villages as opposed to dispersed farmsteads, but maximum village size still remains quite low. The largest is only 3.15 ha (Langebaek Rueda 1993:162). No large villages are present, and the system has a convex rank-size distribution (Langebaek Rueda 1993:166). In the Late Muisca Period (1200–1600 C.E.) chiefly centers are clearly present. The largest site (VF320) is larger than 20 ha, and probably had more than 300 inhabitants. The beginning date of the Late Muisca Period (1200 C.E.) is used here for the first appearance of large villages.

Negros Island, Phillipines

According to Bacus (2004:261) a Neolithic lifeway begins in the Phillipine archipelago with the small open air village site of Andarayan at around 1500 B.C.E. Though few villages are known for the period prior to 500 C.E., those that are known are small, such as the 1 ha site of Unto (Bacus 2004:266). I will assume that larger sites would be known if they existed. Large villages emerge as chiefly centers throughout the Phillipines during the Porcelain Period (500–1000 C.E.), coincident with the expansion of Chinese maritime trade in the Tang dynasty and the closure of overland Silk Road route (Bacus

2004:266–267). On Negros, the chiefly center of Yap emerges sometime in the eleventh century (Bacus 2004:275). The date used here will be 1000 C.E.

Northern Luzon, Phillipines

For the beginning of agriculture in the Phillipines, see the discussion of Negros Island, above. I will use Bacus's date of 1500 B.C.E. The earliest large village on northern Luzon mentioned by Bacus is located in the vicinity of Manila, and dates to "at least the eleventh century" (Bacus 2004:270). I will use the midpoint for the Porcelain Period – 850 C.E. – though I recognize that this is very approximate.

Bellwood (1997:219), citing the Dimolit site, prefers a much earlier date of "perhaps 2500 BC" for the beginning of the Neolithic in northern Luzon. I will use Bacus's date as a minimum. Adopting Bellwood's date would produce a longer interval between the agricultural transition and the appearance of large villages: 3350 as opposed to 2350 years.

Valley of Oaxaca, Mexico

The transition to agriculture took place in Oaxaca around 1500 B.C.E. (Kowalewski et al. 1989). The site of San Jose Mogote emerges as a chiefly center and large village sometime during the San Jose phase. The midpoint of the San Jose phase (1000 B.C.E.) will be employed here as the date of the appearance of large villages. Primary state formation takes place in Oaxaca at least by 100 B.C.E.

Olmec Heartland, Mexico

Agriculture begins around 1500 B.C.E. in the Olmec Heartland, as in much of Mesoamerica. According to Drennan (1991:264) San Lorenzo emerges as a chiefdom center and large village during the Bajío phase (1350–1250 B.C.E.). The phase midpoint – 1300 B.C.E. – will be used here.

Southeast Poland

Agriculture appears at the beginning of the LBK, locally 5380 B.C.E. (Milisauskas and Kruk 1993:65). Large villages appear as chiefly centers in the Baden period (3050 B.C.E.; Milisauskas and Kruk 1993:88); The largest site at this time is 18 ha. It is possible that a large village existed somewhat earlier, in the Funnel Beaker period. The largest site at this time was about 8 ha, but sites in this region have very low residential density (Milisauskas and Kruk 1993:88) and it is far from certain that this site had more than 300 inhabitants.

Southeast Spain

According to Gilman and Antonio (2001:61–64), there are no large villages in the Neolithic, Copper, or Bronze ages of Spain. Los Millares is the only exception, extending over approximately 5 ha. The Millaran copper age dates from 3500 to 2250 B.C.E. As Gilman notes, we cannot be sure to what part of this period the large occupation of Los Millares dates. I will employ the phase midpoint: 2900 B.C.E. Los Millares clearly represents some kind of regional capital, and is here interpreted as a chiefdom center and a Type 2 sequence. Chapman (1990:150) notes another large site, El Malagón, which he suggests may have had a population of about 1500, and covered perhaps

7.5 ha. He also suggests that Los Millares had a population of 1000. The Cardial Neolithic in southeast Spain begins at about 5500 B.C.E.

Thessaly, Greece

The Neolithic begins in Thessaly around 7000 B.C.E. (van Andel and Runnels 1995:497) with the arrival of colonists from Anatolia. According to Demoule and Perlés (1993:368–369; Perlés 2001:176–180) Early Neolithic (7000–6000 B.C.E.) and Middle Neolithic (6000–5500 B.C.E.) villages are small, in the 100–300 person range, though the estimation of village population remains a vexing problem. Tells continue in Thessaly during the Late Neolithic (Demoule and Perlés 1993:388), but apparently in Phase 4 (later Late Neolithic, or Late Neolithic II, around 4800–4500 B.C.E.) small hamlets are abandoned and population is concentrated into larger sites. It is at this point that large villages like Dimini emerge, probably as chiefly centers. Late Neolithic Dimini has a large "megaron" (a public structure, possibly a temple or elite residence) and is surrounded by fortification walls. I will employ 4800 B.C.E. as the date for the appearance of large villages in Thessaly.

Valdivia Valley, Ecuador

Agriculture and settled village life appear in the Early Valdivia phase, beginning around 4400 B.C.E. (Zeidler 2003; see also Marcos and Michczynski 1996). These are, of course, the earliest known farming villages in the New World. Early Valdivia villages in general are estimated to have had 150–200 inhabitants (Damp 1984a:582). In the Valdivia Valley, large villages are not present in the Early, Middle, or Late Valdivia periods (Schwarz and Raymond 1996). Large, nucleated villages of 3–6 ha emerged only in the following Machalilla phase, after 1400 B.C.E. (Schwarz and Raymond 1996:216). These appear to be the centers of small polities and therefore are interpreted as chiefly centers. This is a Type 2 sequence. It should be noted that this reconstruction applies only to the Valdivia Valley itself. Other nearby valleys, such as the Chanduy Valley, probably have a different settlement history, with large sites like Real Alto emerging much earlier in Early Valdivia (Damp 1984a). Unfortunately, no systematic data are available for their settlement systems.

Mimbres Valley, New Mexico, USA

Agriculture appears in the Early Pithouse Period (200–550 C.E.; Blake et al. 1986). Early and Late Pithouse Period (550–1000 C.E.) villages remain small, with a maximum population in the low hundreds (Blake et al. 1986:459). In the Classic Period (1000–1150 C.E.) aggregated pueblos appear, but none of these are larger than about 200 rooms, and therefore would have fewer than 200 inhabitants (Blake et al. 1986:460). Villages remained small in the following Black Mountain (1150–1300 C.E.) and Cliff (1300–1450 C.E.) phases, and thereafter. This is a Type 4 sequence. Large villages never appeared.

Wankarani, Oruro, Bolivia

Agriculture and villages begin together at around 2000 B.C.E. Large villages never appeared (McAndrews 2005). This is therefore a Type 4 sequence.

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Centralized Communities, Population, and Social Complexity After Sedentarization

Robert D. Drennan and Christian E. Peterson

Abstract The emergence of centralized supra-local communities followed a number of different pathways, and varied considerably in its pacing in different regions. The establishment of settled agricultural life often set the stage for the emergence of these larger scale and more complex societies by creating the larger, denser populations without which they could not have occurred. The variation observed in the degree and nature of centralization as well as the extremely long time lag between the onset of the Neolithic and the emergence of supra-local centralized communities in some regions, however, make it clear that regional demographic and political centralization is neither a unitary phenomenon nor an automatic consequence of the Neolithic demographic transition. Larger more centralized communities do, nonetheless, owe specific debts to initial Neolithic processes in their regions, since central aspects of their distinctive regional characters are already present in the earliest sedentary agricultural villages that precede them. At least some of these characteristics were quite possibly inherited, in turn, from even earlier hunting and gathering bands.

Keywords Regional settlement study · communities · demographic centralization · chiefdoms

Archeologists long ago grew accustomed to the notion that the initial development of complex social organization sprang quite naturally from early sedentary agricultural village life (e.g., Childe 1950, 1951). Close association with others when mobility has been eliminated from daily living patterns calls for the development of new means of conflict resolution; agricultural surpluses promote population growth; and an abundance of close neighbors encourages economic specialization and interdependence. These processes stimulate the spiraling development of complex societies, which soon expand to encompass more than just single villages and integrate populations on a larger regional scale into centralized supra-local

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communities. The emergence of such communities, organized according to hierarchical principles, is, for some, an essential threshold in human history (e.g., Carneiro 1981). Crossing it leads on to the development of even larger scale and more centralized sociopolitical integration.

This is, of course, a very simple and very general account. These things do not always happen once sedentary agricultural living is established, and at least some of them have happened where populations are not dependent on agriculture or where residence is not fully sedentary. When they occur, they do not always happen in the same way. Comparative study of this variability can be a path toward fuller understanding of the processes involved and of their interrelationships. This chapter takes such a path, focusing on one important feature of emerging complex societies: centralization in early supra-local communities. It complements previous comparative study that has focused on other aspects of early chiefdoms (Drennan and Peterson 2005, 2006), aspects that are consequently not much emphasized here. Recent research on the Neolithic demographic transition (Bocquet-Appel 2002; Bocquet-Appel and Naji 2006) has not altered the traditional recognition that most of the world's prehistoric populations at some point went through a fundamental transition involving plant cultivation and/or animal husbandry, population growth, and more sedentary residence patterns. This recent research does, however, offer deeper understanding of the dynamics of the demographic transition. Our exploration of centralization here similarly seeks deeper understanding of the developmental dynamics of the centralized communities that often emerged in the wake of the Neolithic demographic transition.

In this exploration, we ask several interrelated questions. How varied is the intensity of the regional demographic centralization that often follows the Neolithic demographic transition? How similar is the pacing of the centralization process in different regions? Does regional demographic centralization show a consistent relationship with regional demographic growth? How does centralization relate to local community structure, growth, and conflict resolution? How does centralization relate to regional political integration?

Measuring Centralization

Two analytical tools have been extensively utilized in the archeological study of regional centralization: site size histograms and rank-size graphs. Multimodality in histograms of site areas is often taken to indicate the tiers in a regional settlement hierarchy (e.g., Johnson 1972, 1980b; Fletcher 1986; Kowalewski et al. 1989; Liu 1996). If a single site stands out as much larger than all the rest, then that site is thought to integrate a highly centralized system. A histogram of site areas usually takes the form of a Poisson distribution with a very high peak at a small area value (most sites are small) and a long tail composed of smaller and smaller numbers of increasingly large sites. In such a distribution, a single site will, of course, almost always stand out from the rest as the largest, and purely random processes will create some bunching among other large site areas. The subjective judgments made about whether the largest site stands out enough to be the dominant center for the whole system or about whether bunches of other site areas really comprise separate modes or tiers, are seldom as unequivocal or reliable as most analysts seem to think. The significance of departures from the "expected" unimodal Poisson pattern is never evaluated, leaving the reader to wonder whether anything more than just the vagaries of sampling is at work. Most important for our purposes here, these histograms do not enable comparisons of just how centralized such systems may be.

Rank-size graphs have been used for precisely such comparative purposes (Blanton 1976; Johnson 1980a, 1981; Paynter 1982, 1983), and means have been suggested for minimizing the subjectivity of comparative judgments and for evaluating the significance of differences (Drennan and Peterson 2004). The units of analysis in rank-size graphs are typically archeological sites (as they are for site size histograms). This raises serious problems if there is no one-to-one correspondence between archeological sites and local human communities, although distance-interaction principles can be used to delineate meaningful units (Peterson and Drennan 2005). In some settlement distributions, however, definable local communities simply do not exist, even though centralized supra-local communities are unquestionably present (Drennan and Peterson 2005; Peterson and Drennan 2005). If there are no genuine local communities, then there are no meaningful units for rank-size analysis, and it cannot be applied. Rank-size graphs have been extremely useful in the analysis of large-scale political formations with extensive territories, well-defined capitals and subsidiary centers, and very large samples of settlements. The early regional communities or polities that concern us here, however, are much smaller; it is common for a single archeological study area to include a number of them. This is, of course, exactly what a convex rank-size pattern has been taken to indicate, and centralization within such small-scale regional communities can be pursued with separate rank-size graphs for each one. These small regional communities, however, may include so few separate local communities that rank-size graphs provide only a crude picture of centralization. Particularly at this small scale, then, other ways of approaching the measurement of centralization are needed.

Distance-interaction principles make it possible to recognize centralized regional organization, since centrally focused patterns of social interaction tend to draw populations toward a center. This creates central peaks of high population density separated by demographic valleys along which boundaries between regional communities can be drawn (Peterson and Drennan 2005). The demographic peaks may be very high and the valleys quite low, or the difference between them may not be so pronounced. Higher peaks presumably reflect stronger centralizing pulls, and this opens the door to a different way of characterizing the strength of centralization for comparison.

The Valley of Oaxaca (Mexico) provides a much studied and thoroughly described example of the emergence of an early centralized regional community (Flannery and Marcus, eds., 1983; Kowalewski et al. 1989; Marcus and Flannery 1996). By the Rosario phase (700–500 BC) this chiefly polity, with its center at San José Mogote, appears to have dominated other local communities in a substantial

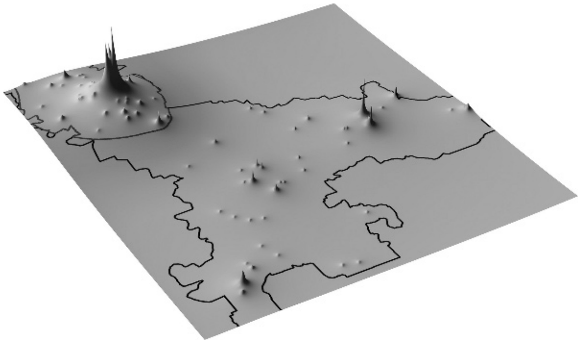


Fig. 1 A smoothed surface representing the demographic density across the Valley of Oaxaca during the Rosario phase (cf. Peterson and Drennan 2005). The survey area and the San José Mogote chiefdom within it are outlined

portion of the valley, forming the kind of demographic peak discussed above (Fig. 1), on the basis of which its limits have been delineated (Peterson and Drennan 2005). The degree of demographic centralization in the polity can be represented by a graph of the proportions of its population in a series of concentric rings radiating from this central peak. Figure 2 shows the division of the territory of the San José Mogote polity into 12 rings, each containing one-twelfth of the total area of the polity. Using Kowalewski et al.'s (1989) population estimates for each site, the estimated population of each ring is determined (Table 1) and expressed as a proportion of the total polity population. These proportions are graphed in Fig. 3. Not surprisingly, the central ring has by far the largest proportion of the polity's

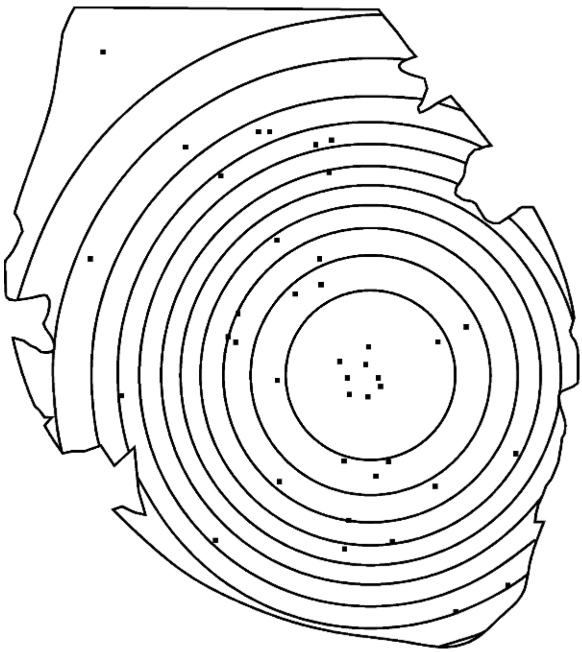


Fig. 2 The distribution of sites across the San José Mogote chiefdom's Rosario phase territory divided into 12 equal-area rings

Table 1 Calculation of *B* value for Rosario phase San José Mogote chiefdom in the Valley of Oaxaca

Ring	Estimated population	Population proportion	Cumulative proportion
1	707	57%	57%
2	117	9%	66%
3	97	8%	74%
4	38	3%	77%
5	0	0%	77%
6	8	1%	77%
7	8	1%	78%
8	177	14%	92%
9	54	4%	96%
10	31	2%	99%
11	0	0%	99%
12	14	1%	100%
Total	1251	100%	991%
B value			0.6196

population; successive rings have decreasing proportions out to about the seventh ring, where the proportion increases before trailing off to near zero values in the outer rings. The 90% confidence zone in Fig. 3 is produced from the 90% error ranges of the estimates of proportions for each of the 12 rings. In doing this we have taken the estimated number of households in the region as the sample size upon which the proportions are based. This seems a plausible idea of the number of observations on which the estimates rely, since the household is probably the fundamental decision-making unit in residential location. If the estimated number of households is inaccurate or the assumption about decision making invalid, the shape of the graph is not affected, only the breadth of the confidence zone.

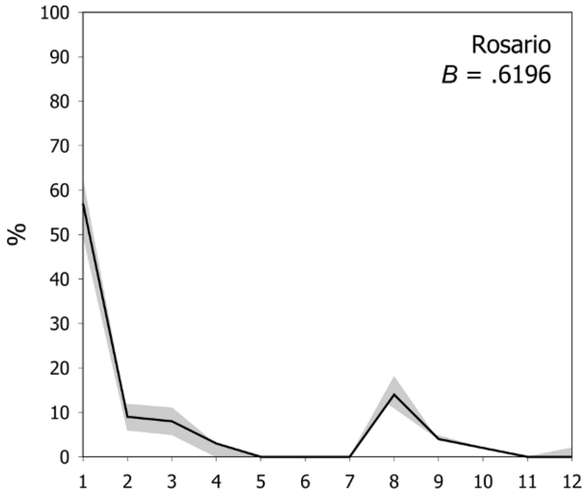


Fig. 3 Graph of the distribution of Rosario phase population across 12 concentric rings within the San José Mogote chiefdom in the Valley of Oaxaca. The rings are ordered from innermost to outermost (left to right), and a 90% confidence zone is shaded

Any regionally centralized community would produce the general pattern of a line higher on the left than on the right. The stronger the centralization, the higher the line would be at the left side of the graph, and, correspondingly, the lower it would have to be toward the right (since the proportions must total 100%). A measure of the strength of such centralization could be calculated by converting these proportions into cumulative proportions, as in the third column of Table 1, and summing them. The stronger the centralization, the greater the proportions of population in the inner rings will be and thus the higher the sum of the cumulative proportions will be. The ultimate in strong centralization would place 100% of the population in the innermost ring, and the sum of the cumulative proportions would be 1200% (Table 2). A perfectly even (entirely uncentralized) population distribution would place 8.3% of the polity's population in each of the 12 rings, and the sum of the cumulative proportions would be 650% (Table 2). The cumulative proportion sum, then, could range from as little as 650% for no centralization to 1200% for the strongest possible centralization. This sum could be expressed as a measure of centralization with the useful property of varying from 0 for no centralization to 1 for maximum centralization by subtracting 650 and dividing the remainder by 550 (Table 2). The value of this coefficient, which we will call B, for the Rosario phase San José Mogote chiefdom is 0.6196, suggesting strong centralization – exactly what we have already seen in Fig. 3. This is not news for the San José Mogote polity; a more familiar rank-size graph (Fig. 4) shows the primate pattern taken to indicate a strongly integrated system. Sociopolitical integration and demographic centralization are, of course, not exactly the same thing, although in this instance (as is quite often the case) they represent two sides of the same coin. The very strong integration of the San José Mogote chiefdom in the Rosario phase is effected through heavy dominance by San José Mogote, in its role as regional central place – central

Table 2 Example calculation of B value for maximum centralization and for no centralization

Ring	Maximum centralization		No centralization	
	Population proportion	Cumulative proportion	Population proportion	Cumulative proportion
1	100%	100%	8.3%	8%
2	0%	100%	8.3%	17%
3	0%	100%	8.3%	25%
4	0%	100%	8.3%	33%
5	0%	100%	8.3%	42%
6	0%	100%	8.3%	50%
7	0%	100%	8.3%	58%
8	0%	100%	8.3%	67%
9	0%	100%	8.3%	75%
10	0%	100%	8.3%	83%
11	0%	100%	8.3%	92%
12	0%	100%	8.3%	100%
Total	100%	1200%	100%	650%
B value	$(1200 - 650)/550 = 1.0000$		$(650 - 650)/550 = 0.0000$	

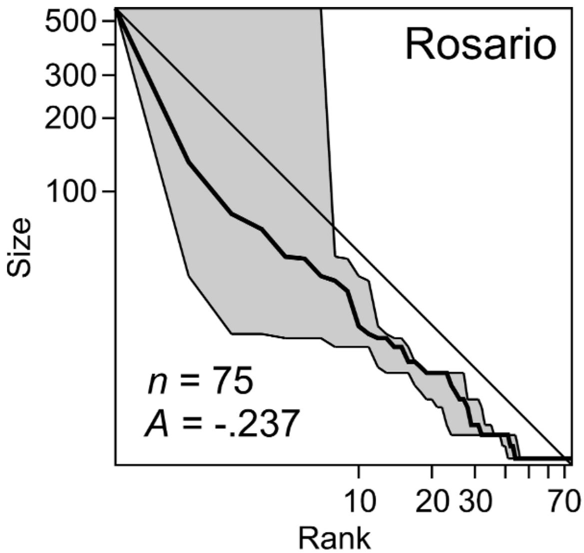


Fig. 4 Rank-size graph for the San José Mogote chiefdom in Rosario phase Oaxaca (Drennan and Peterson 2005). A 90% confidence zone is shaded

spatially and functionally. It is entirely conceivable that a primate "center" as revealed by a rank-size analysis might not be in an even remotely central location in its region. There are archeological cases in which this has actually occurred, underscoring the extent to which the impression given by rank-size analysis may diverge from spatial reality (Johnson 1981:177; Drennan and Peterson 2004:544). The ring graphs used here along with the *B* coefficient truly are an indication of regional demographic centralization, since spatial centrality is their foundation.

Regional Centralization and Village Life

Regional-scale demographic centralization also emerged in the Alto Magdalena of the Colombian Andes (Drennan 2000; Peterson and Drennan 2005; Drennan, ed., 2006), as can be seen in Fig. 5. The pattern is not exactly like the single dramatic demographic peak of Rosario phase Oaxaca, but by the Regional Classic period (1–900 AD) several broad demographic hills are separated by deep valleys where population density was lower. Each hill represents a population drawn toward a center of ritual and mortuary activities. One of these, Cerro Guacas, is the central place in the polity the analysis below will focus particularly on. The pattern of centralization at the regional scale is clear, although the structure of population distribution at the local scale is very different from that of Oaxaca. Instead of compact nucleated villages, the inhabitants of the Alto Magdalena lived in widely dispersed farmsteads or small groups of nearby farmsteads directly on the land that they cultivated, forming a virtually continuous distribution of occupation across the landscape. Although continuous, this distribution is of highly variable density, allowing for the formation of the hills and valleys seen in Fig. 5. Both the Regional Classic Alto Magdalena and

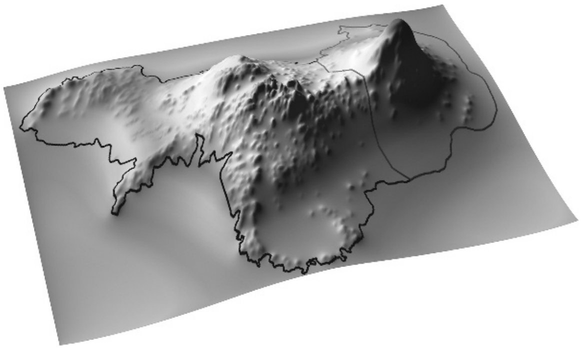


Fig. 5 A smoothed surface representing the demographic density across the western survey zone of the Valle de la Plata in the Alto Magdalena during the Regional Classic period (cf. Peterson and Drennan 2005). The survey area and the Cerro Guacas chiefdom within it are outlined

Rosario phase Oaxaca represent chiefly polities dating to some 1000 years following the establishment of sedentary agricultural life ($dt \approx 1000$). It is interesting to explore how the degree of regional demographic centralization might differ between these two cases. In strictly mechanical terms, rank-size analysis could be performed on the Alto Magdalena dataset; the delineation of archeological "sites" was part of the data collection procedure. These sites are not, however, villages; they are arbitrary partitions created for convenience in a continuous distribution of occupation. The pattern of discrete small local communities, so often taken for granted in regional settlement study, simply does not exist in the Alto Magdalena. There are thus no meaningful units of analysis upon which to base a rank-size graph. Regional centralization can, however, be characterized with a ring graph like the one for Rosario phase Oaxaca in Fig. 3 and its strength measured with the B coefficient. The ring graph for the Cerro Guacas polity (Fig. 6) is very similar to the one in Fig. 3. The proportion of the polity's population in the innermost ring is slightly lower, but the next several rings have higher values than for San José Mogote, and

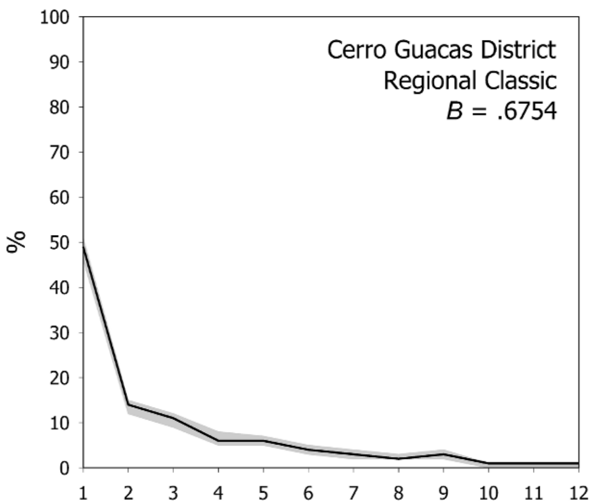


Fig. 6 Ring graph for the Regional Classic Cerro Guacas chiefdom in the Alto Magdelena in the western survey zone of the Valle de la Plata (90% confidence zone)

there is nothing resembling the largish community that creates a bump in the eighth ring in the San José Mogote graph. The *B* value of 0.6754 is somewhat higher than that for Rosario phase San José Mogote.

These two early chiefly polities, thus, appear to have created roughly similar degrees of regional demographic centralization within about a millennium after the beginning of agriculture and sedentism. Both show some of the commonly observed archeological indicators of early chiefdoms, such as public monuments, elaborate elite burials, etc. (Drennan and Peterson 2005, 2006). The San José Mogote chiefdom arose in the context of agricultural village life and poses no immediately obvious challenge to the simple general account of the emergence of complex social organization referred to at the beginning of this chapter (in some sense a "natural" outcome of the Neolithic demographic transition). In the Alto Magdalena, however, despite the presence of sedentary agricultural living, the absence of villages or any form of compact local community calls into question the intensity of several of the processes upon which that account relies.

Much has been made of the tendency of very early villages in several parts of the world to fission before they grow beyond a few hundred inhabitants (Johnson 1982; Marcus and Flannery 1996:71–73; Bandy 2004). This has been attributed to the incidence of conflict arising from interaction among growing numbers of closely spaced neighbors in the absence of established organizational means of resolving such conflict. The pattern of dispersed farmsteads in the Alto Magdalena reflects substantially lower levels of interaction between households; so, by the widely imagined dynamics of early village living, the incidence of conflict would be substantially less in dispersed farmsteads than in a compact nucleated village. In similar fashion, household dispersion does not encourage the economic specialization and interdependence often fostered in compact villages, and direct evidence of economic specialization is quite scarce for the Alto Magdalena compared, for example, to the Valley of Oaxaca (Drennan and Peterson 2006:3962). Regional demographic centralization in the Alto Magdalena by 1000 years after the onset of agricultural life was nonetheless quite strong (even stronger than in the Valley of Oaxaca), and, as in Oaxaca, it revolved around hierarchical social organization. Unlike Oaxaca, regional centralization in the Alto Magdalena did not take the form of very large villages as central places, and it could not have emerged as the automatic unfolding of life in farming villages.

The western Liao Valley of northern China contrasts strongly with the Alto Magdalena in that, at 1000 years after the onset of sedentary agricultural living, village life was highly developed (Zhongguo 1997; Shelach 2000; Chifeng 2003; Linduff et al. 2004; Neimenggu 2004). Some early villages were small, but the very earliest from around 6000 BC (Xinglongwa and Zhaobaogou times) include ones with populations over 200. These villages were as compact as those in Oaxaca (around 50 people per ha within the village), and substantially larger on average. Despite the vigorous development of substantial agricultural villages, there are at this point in the western Liao sequence none of the signs of regional centralization that we have been discussing. The large villages were not central places in integrated regional systems; they and their smaller contemporaries were separated by very large

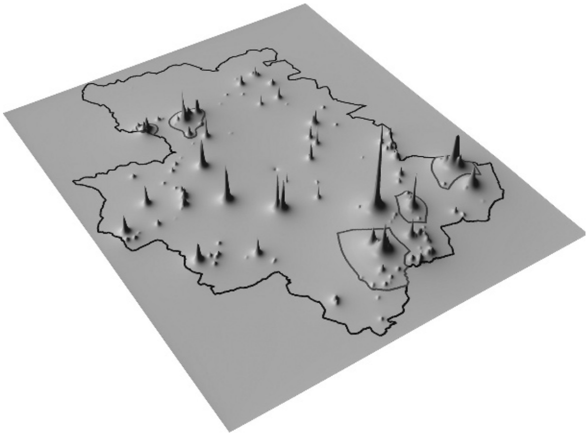


Fig. 7 A smoothed surface representing the demographic density across the Chifeng region of the western Liao valley during Hongshan times (cf. Peterson and Drennan 2005). The survey area and five of the Hongshan times (cf. Peterson and Drennan 2005). The survey area and five of the Hongshan chiefdoms within it are outlined

distances. Nor is there evidence of chiefly or hierarchical social organization. Public monuments were not being constructed. Such regionally centralized complex societies do not put in their appearance in the western Liao Valley until fully 2000 years after the beginning of sedentary life.

In the western Liao Valley, settlement study in the Chifeng region shows the emergence by around 4000 BC, during Hongshan times, of more than a dozen small regional polities, often separated by a considerable amount of open space (Fig. 7). *B* values can be reliably measured for five of these supra-local communities; they range from 0.3671 to 0.8812, with a mean of 0.6485. The ring graph in Fig. 8 is for a polity with a *B* value very close to this mean. As in both Oaxaca and the Alto Magdalena, centralized regional systems emerged in the western Liao Valley concurrently with hierarchical social organization, as evidenced in elaborate elite

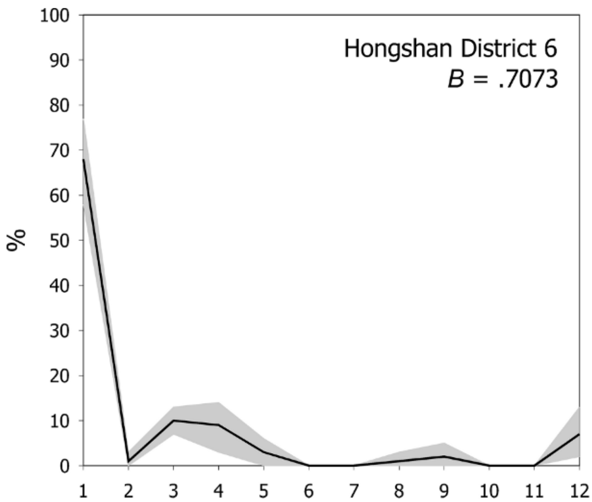


Fig. 8 Ring graph for a Hongshan period chiefdom in the chifeng region with a *B* value near the mean for five supra-local communities (90% confidence zone)

burials, public monuments, and domestic remains (Guo 2005; Drennan and Peterson 2006). In both spatial and demographic terms, the Hongshan polities of Chifeng were substantially smaller than those we have looked at in the Valley of Oaxaca and the Alto Magdalena. On average they show slightly weaker regional demographic centralization. And despite the rapid formation of sometimes quite large villages at the very beginning of sedentary agricultural life, these chiefly polities were extremely slow to develop, compared to those of the Alto Magdalena and the Valley of Oaxaca. Unexpectedly, as regional centralization first emerged in the Chifeng region, the degree of village nucleation relaxed in at least some cases. Fushanzhuang (Peterson 2006), the central place of one regional community, was a dispersed 40 ha village of some 200 people (or around 5 persons per ha within the village).

Regional Centralization and Demographic Growth

Demographic growth is often seen as a major force behind the development of regional centralization or at least as an important part of the picture. From such a perspective, one might attempt to account for the slow pace of social change in Chifeng by reference to overall regional population levels. As mentioned above, the earliest agricultural villages in the western Liao Valley were separated by large distances, and this, of course, is the accompaniment to very low regional population densities. Chronological resolution for the western Liao Valley is poor; it is possible to estimate regional population levels roughly for these long periods, but we cannot yet talk about population growth rates very meaningfully. The first two periods of settled agricultural living are each 750 years long. By the end of the first (Xinglongwa [6000–5250 BC]), population density in the Chifeng region can be estimated at about 0.3 persons per km^2. By the end of Zhaobaogou (5250–4500 BC), this had grown to about 1.5 persons per km^2. This amounts to an annual population growth rate of 0.25%, averaged over the period between 750 and 1500 years following the establishment of sedentary agricultural life. Given the length of the period, there were almost certainly one or more shorter episodes of more rapid growth interspersed with long periods of remarkable demographic stability. Along with supra-local community organization and social hierarchy come higher population levels. By the end of the Hongshan period (4500–3000 BC), regional population density had risen to about 8 persons per km^2 (an annual growth rate of 0.10%, again averaged over a very long period). Again, it seems much more likely that this very low rate of average population growth reflects a generally high degree of population stability punctuated by episodes of more rapid growth. It is certainly possible (though by no means certain) that Hongshan regional demographic centralization occurred in the context of such a growth spurt.

The extremely long time required for the development of social hierarchy and centralized regional communities in the western Liao Valley (some 3000 years after settled agricultural life began) was, then, characterized by very low rates of long-term average population growth. It is not the case, however, that regional populations finally arrived in Hongshan times at levels sufficient to produce crowding or resource competition, leading to more complex social organization. At around 8 persons per km^2, there would still have been abundant unoccupied territory and unclaimed resources in the wide spaces that often separated Hongshan polities. Crowding and resource competition might well have led to conflict in the Chifeng region, but only in later times. It was not until sometime during the Lower Xiajiadian period (2200–1000 BC) that regional population arrived at such levels. The Xiaoheyan period (3000–2200 BC) between Hongshan and Lower Xiajiadian is very poorly known, but it is certain that population density was no higher than during Hongshan times, and might have been substantially lower. Population growth accelerated considerably during Lower Xiajiadian, reaching an annual rate of 1.07%, averaged over the entire period. If, as seems likely, much of this growth occurred in a shorter span of time, then it would have been a much more dramatic growth episode than any that had occurred previously in the region. By the end of Lower Xiajiadian, population densities had reached some 100 persons per km^2; there were twice as many small polities in the Chifeng region; and there were no longer tracts of unoccupied prime territory between them (Fig. 9). Like the earlier Hongshan supra-local communities, the Lower Xiajiadian polities were usually less than 5 km across, although their populations numbered a few thousand each (compared to a few hundred apiece in Hongshan). Heavily fortified hilltop redoubts are conspicuous Lower Xiajiadian remains. It is plausible to postulate crowding, resource competition, and conflict as causes of Lower Xiajiadian demographic and political centralizations. *B* values for regional centralization within these polities are more consistent than for Hongshan and consistently higher. For eight polities with reasonably complete data, *B* ranges from 0.6274 to 0.9088, with a mean of 0.7648 (Fig. 10). This is not, however, a new pattern in Lower Xiajiadian but an intensification of a pre-existing

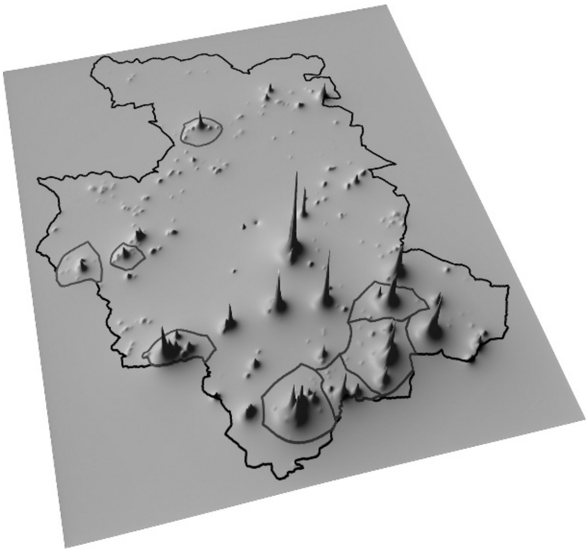


Fig. 9 A smoothed surface representing the demographic density across the Chifeng region of the western Liao valley during Lower Xiajiadian times. The survey area and eight Lower Xiajiadian districts within it are outlined

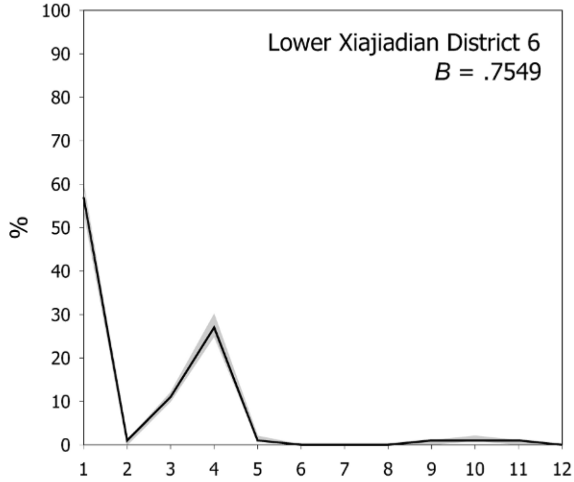


Fig. 10 Ring graph for a Lower Xiajiadian period district in the Chifeng region with a *B* value near the mean for eight supra-local communities (90% confidence zone)

one. Regional demographic crowding was not behind the initial emergence of regional centralization (Fig. 11), and both initial emergence in Hongshan times and intensification in Lower Xiajiadian were so many millennia after the establishment of sedentary agricultural life that they cannot be understood as simply the automatic unfolding of this transformation's demographic potential.

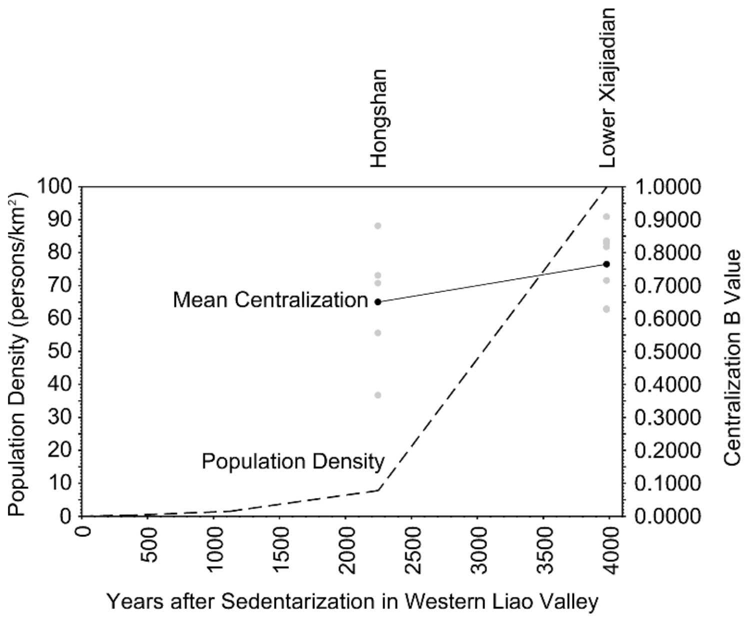


Fig. 11 Summary of changes in population density and centralization in Chifeng

More precise control of chronology would make a welcome contribution to the study of the western Liao trajectory, but it would not change the observation that centralized supra-local communities did not appear until more than 1500 years after the establishment of sedentary agriculture. A number of New World trajectories show much more rapid emergence of complex supra-local communities. The Rosario phase chiefdom in the Valley of Oaxaca discussed earlier had emerged before the end of the first millennium of settled agricultural living, and its antecedent regionally centralized communities go back to no more than 200 years after the first villages. These thousand years can be divided into four periods, providing a more detailed picture of a trajectory of more rapid social change than the western Liao Valley. Initial farming villages of the Tierras Largas phase (1500–1200 BC) in Oaxaca, like those of the western Liao Valley, were compact and nucleated, although most had quite small populations (50 people or fewer). From the very first, however, San José Mogote's population of about 200, while no larger than those of some Xinglongwa and Zhaobaogou villages in the western Liao Valley, was by far the largest in the Valley of Oaxaca. Moreover, San José Mogote served as the central place in a supra-local community composed of a number of nearby smaller neighbors (cf. Bandy, Global Patterns of Early Village Development). No such clusters of smaller neighbors are known for any large Xinglongwa or Zhaobaogou village; these do not form until Hongshan times. The Tierras Largas regional community appears to cover an area nearly 20 km across, much larger than the territories of Hongshan chiefdoms in the Chifeng region, although at about 350 inhabitants, it is demographically of similar size to Hongshan polities and of roughly similar regional centralization with a B value of 0.6422 (Fig. 12). The San José Mogote regional community in the Tierras Largas phase does not include all of the Valley of Oaxaca's early villages. There is a scatter of small villages elsewhere in the valley that do not seem part of this cluster, or of any other cluster. In contrast to the situation in Chifeng, San José Mogote heads the only supra-local community in Oaxaca. In even sharper contrast to the Chifeng region, the development of supra-local community organization in Oaxaca is almost instantaneous with the emergence of sedentary village life.

Regional population density by the end of the Tierras Largas phase was extremely low (at 0.15 persons per km^2 even lower than for Xinglongwa). Regional demographic growth from Tierras Largas to the ensuing San José phase (1200–900 BC) was rapid, averaging 0.59% per year (cf. Bandy 2005), but regional density was still quite low (at 0.90 persons per km^2, lower than that for Zhaobaogou). The San José Mogote regional community remained the only one in the valley, and most of the growth occurred at or near San José Mogote, producing much stronger regional demographic centralization in the San José phase ($B = 0.8308$, Figs. 12 and 13). At this point regional population growth came to a halt (or possibly even reversed slightly): the Guadalupe phase (900–700 BC) population density in the Valley of Oaxaca is estimated at 0.83 persons per km^2. Regional centralization also changed only trivially between San José and Guadalupe: the B value for the Guadalupe phase is 0.8448 (Figs. 12 and 13). Compared to the western Liao Valley, the immediate post-Neolithic trajectory of Oaxaca seems much more compatible with both the

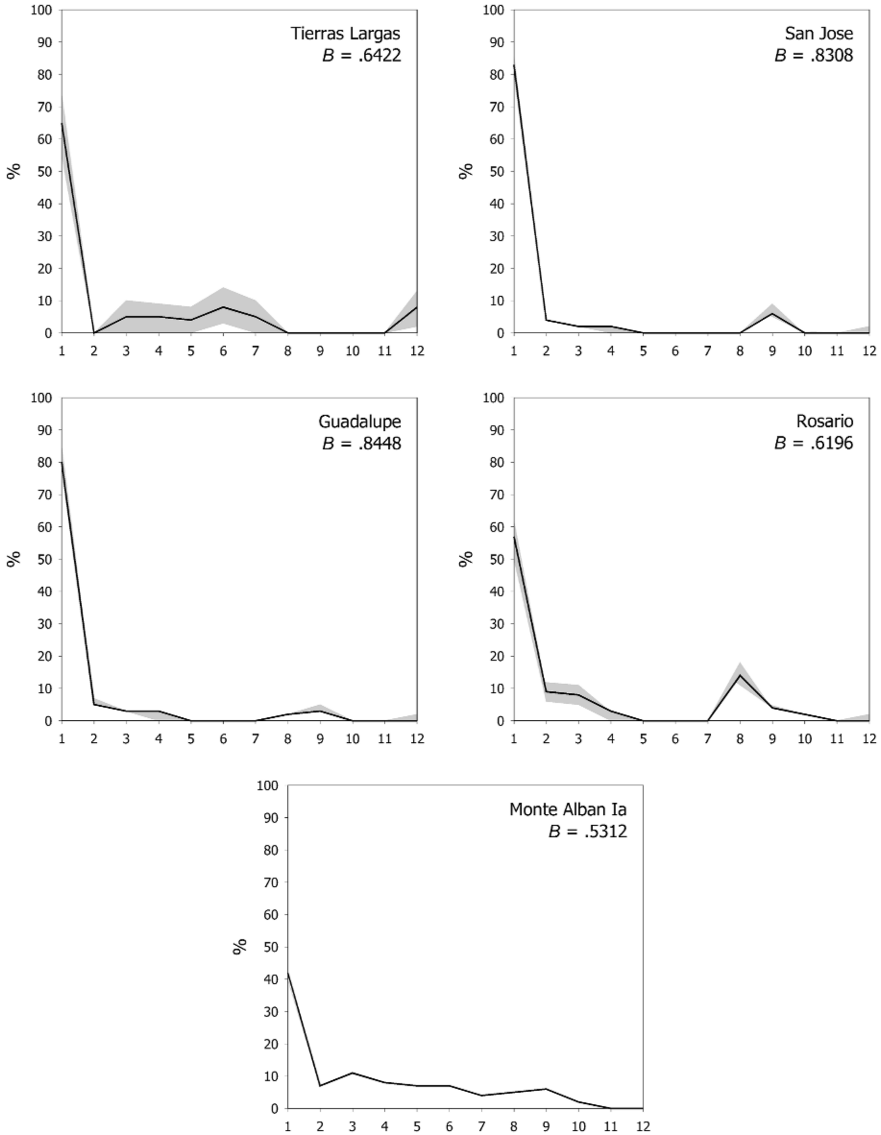


Fig. 12 Ring graphs for the single chiefdom in the Valley of Oaxaca through the sequence discussed in the text (90% confidence zone)

Neolithic demographic transition notion and the idea that early complex societies were an automatic consequence of its unfolding. Bandy (2005) has argued that the Tierras Largas to San José demographic growth was the last portion of the Neolithic population surge, which then leveled off in Guadalupe, as predicted (Bocquet-Appel 2002; Bocquet-Appel and Naji 2006). And it is clear that the initial emergence

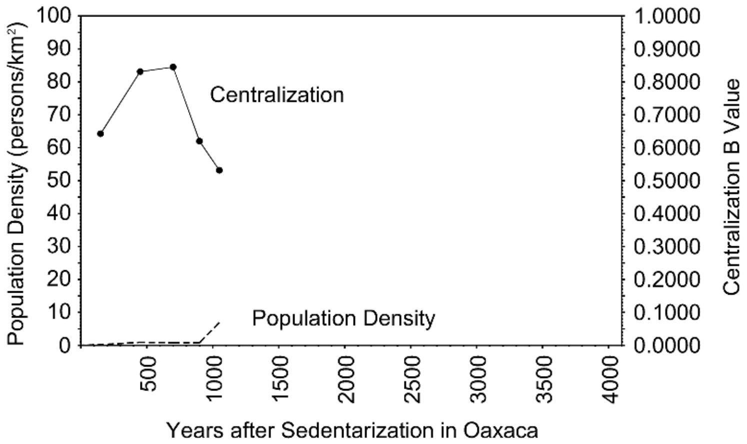


Fig. 13 Summary of changes in population density and centralization in the Valley of Oaxaca

of regional centralization and social hierarchy occurred in the context of an early post-Neolithic population surge. If these two things were connected in the Oaxaca trajectory, however, it cannot have been by way of conflict generated by regional crowding or resource competition because population densities were even lower than those of Chifeng, in a region with resources at least as rich. The compactness of Oaxaca villages and the large size that San José Mogote rapidly grew to, however, might well have generated levels of conflict that would require effective resolution to prevent community fissioning, and this could be the connection between Neolithic population growth and the emergence of social hierarchy.

The Guadalupe phase represents a plateau of stability, in terms of both regional demographic levels and centralization, following immediate post-Neolithic population growth. In terms of regional population levels, the plateau continues through the Rosario phase, but the degree of regional demographic centralization in the San José Mogote chiefdom, as discussed above, actually declined somewhat ($B = 0.6196$, Figs. 12 and 13). Since regional population held steady at this point (at 0.85 persons per km^2), the demographic change consisted of population redistribution within the region. San José Mogote itself shrank to a smaller percentage of the steady regional population, while both nearby and more distant villages grew. This decline in regional demographic centralization, however, does not reflect any decrease in San José Mogote's central place functions. Indeed, the degree of political integration of the polity appears to increase substantially at this time, with the appearance of new forms of elite residential architecture and sculptural evidence of coercive political control (Marcus and Flannery 1996). A major political threshold was crossed during the Rosario phase and it permitted, indeed encouraged, regional demographic *de*centralization. The changing form of the ring graph and the declining B coefficient, thus, should not be taken to indicate any waning of political control. On the contrary, it reflects ever more powerful means of regional political integration – ones that no longer depended on the closeness of dominated populations and made possible a broader and more economically efficient distribution of population across the regional community. A local community of the size that San José Mogote had grown to by San José and Guadalupe times would require a fairly sizeable catchment area to provide sufficient farmland to feed its population. As population spread more broadly during Rosario times, this catchment could be reduced, making possible shorter commuting distances for San José Mogote's farmers. Outlying communities, however, were clearly under ever more effective political control from a center now actively seeking to expand and in conflict with villages outside the bounds of the chiefdom.

In Monte Albán Ia (500–300 BC) the regional demographic stability came to an abrupt end, with a population explosion whose average annual growth rate of 1.04% exceeds that of the post-Neolithic surge. The political center of the Valley of Oaxaca shifted to the newly founded community of Monte Albán which rapidly came to dominate the entire valley, often through violent means (Spencer and Redmond 2001, 2003; Spencer 2003). As political integration of the growing regional population increased, regional demographic centralization decreased ($B = 0.5312$, Figs. 12 and 13), continuing Rosario phase trends. Essentially this same change has previously been observed in rank-size graphs (Kowalewski et al. 1989; Drennan and Peterson 2004), which show the development of a progressively more log-normal pattern out of the highly primate San José phase one in a regional polity whose population soared from about 2,000 to around 15,000 (some 6.8 persons per km^2). The political changes in this part of the Oaxaca trajectory were clearly well underway during the Rosario phase, but the demographic growth did not begin until Monte Albán Ia, strongly suggesting that the dynamics of political change drove the demographic processes rather than the other way around. To whatever extent initial regional centralization and social hierarchy grew directly from Neolithic demographic expansion, it is clear that by Rosario and Monte Albán Ia, new forces were at work – sociopolitical forces that disrupted the period of demographic stability.

The change from Hongshan to Lower Xiajiadian discussed above for the western Liao Valley involves remarkably similar rates of demographic increase following on the heels of relative stability. While the evidence does not make entirely clear what forces produced this upswing in population growth rates, it may be that their impetus lies in the political dynamics of small regional communities like those known for Hongshan times. The elites of such polities could have furthered their political ambitions by mobilizing more human resources toward such ends, and this would encourage population growth. In the Chifeng region, however, Lower Xiajiadian regional polities had territories no larger than their Hongshan predecessors, even though their populations had grown by an order of magnitude. Demographic centralization within these polities increased substantially, rather than decreasing as occurred in the lone Oaxaca polity, and overall, political fragmentation remained the order of the day. No Lower Xiajiadian polity shows any sign of outstripping any other in size or of dominating neighboring polities. Population densities more than an order of magnitude larger than those of Oaxaca raise the possibility that resource scarcity and competition were a fact of life in Lower Xiajiadian times – conditions that could generate inter-polity conflict and escalating growth and intra-polity demographic centralization. These last features of the Lower Xiajiadian period are not at all similar to Rosario and Monte Albán Ia times in Oaxaca. The politics of social hierarchy may well have driven demographic change in the western Liao Valley, as in Oaxaca, but the resulting political landscape was very different. The increasingly effective large-scale projection of political authority at the heart of change in Oaxaca was never accomplished in Lower Xiajiadian times. The western Liao and Oaxaca trajectories, then, both show initial development of social hierarchy and regionally centralized communities (very soon after settled farming life in Oaxaca, much slower in the western Liao Valley). This relative political and demographic stability is later ruptured by political change and dramatic demographic growth but with rather different outcomes in terms of scale and nature of political integration.

Demographic Centralization and Political Integration

As in Oaxaca, centralized supra-local communities are in evidence from the very beginnings of settled life in the Alto Magdalena at 1000 BC (Figs. 14 and 15). The Cerro Guacas chiefdom is readily recognizable in the Formative 1 period (1000–600 BC), with a B value of 0.4462. Through Formative 2 (600–300 BC) and Formative 3 (300 BC–1 AD), this increased to 0.5592 and 0.6610, respectively. Essentially the same level of regional centralization persisted into the Regional Classic Cerro Guacas chiefdom discussed above ($B = 0.6754$), when the Alto Magdalena's chiefly social organization was in full flower. The subsequent Recent period (900–1530 AD) saw regional centralization decline to 0.5017. This rising then falling arc of regional demographic centralization follows a pattern very like that of Oaxaca (compare Figs. 13 and 15). In both cases the initial rising arc reflects a process of drawing scattered regional population toward a central place where diverse activities were carried out by and for not only the residents of the center itself but also those of a surrounding area. It was interaction involving these centralized activities that created a recognizable supra-local community whose development can be tracked through two periods of increasing demographic centralization in Oaxaca and three in the Alto Magdalena. Demographic centralization then recognizably holds steady for two periods in each sequence. Although only one regional community in the Alto Magdalena provides enough information to measure changing centralization through time, the Cerro Guacas chiefdom was one of an undetermined number of developing polities in the larger area, whereas the San José Mogote chiefdom had no immediate neighbors undergoing changes of similar magnitude.

A rising arc of regional demographic centralization might well characterize early chiefdom emergence in the Chifeng sequence as well. Although the archeological periods are much longer, centralization can be measured for several separate Hongshan supra-local communities. As noted above, the B values for these communities cover a sizeable range. This may well reflect different stages of development in different Hongshan chiefdoms by the end of the period. Those with higher centralization values might well have begun drawing surrounding populations toward their centers at an earlier date. Those with lower centralization values might have gotten a later start and thus could represent earlier stages in the drawing-in process.

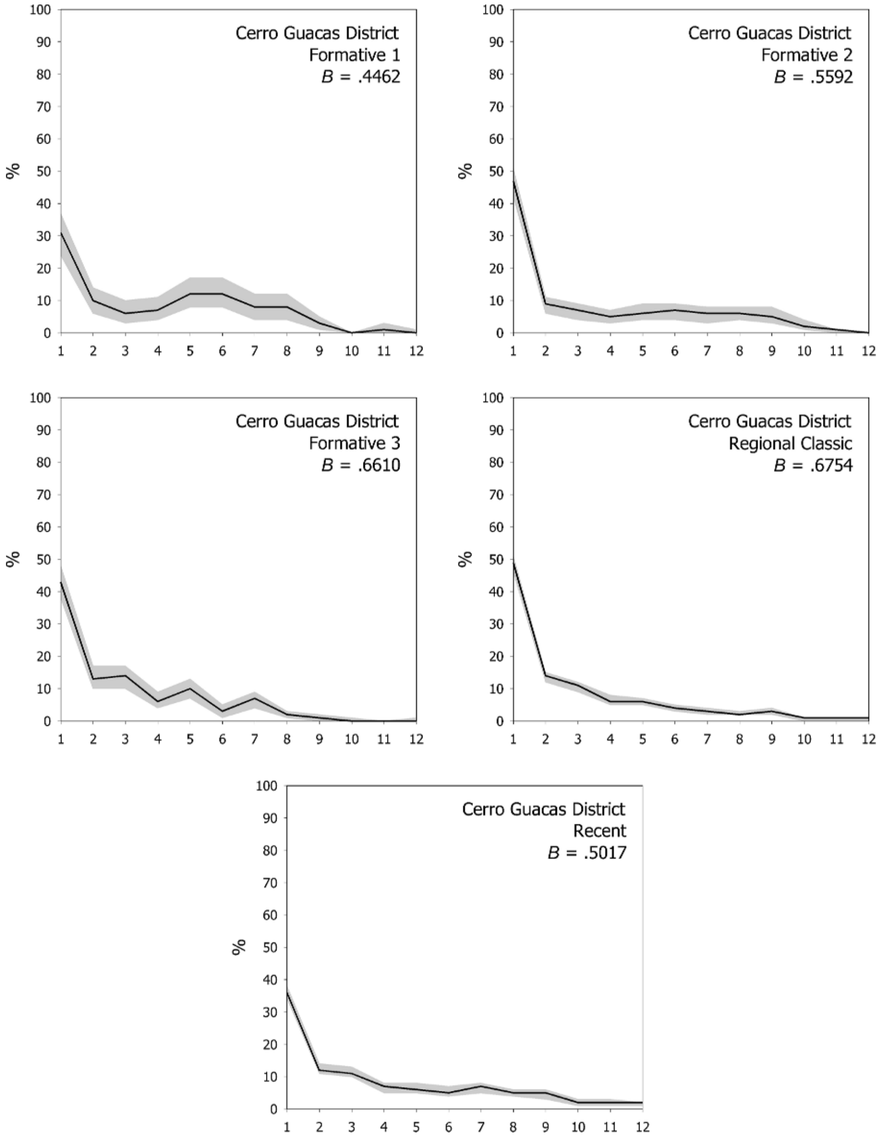


Fig. 14 Ring graphs for the Cerro Guacas chiefdom in the Alto Magdalenaa through the sequence discussed in the text (90% confidence zone)

In Oaxaca the rising then stabilizing part of the demographic centralization arc occupies the first 800 years of sedentary agricultural life; in the Alto Magdalena it takes 1900 years; and in Chifeng it takes fully 3000 years. Regional demographic centralization, however, has reached a structurally similar point in these trajectories at the end of the Guadalupe phase, the Regional Classic, and the Hongshan period.

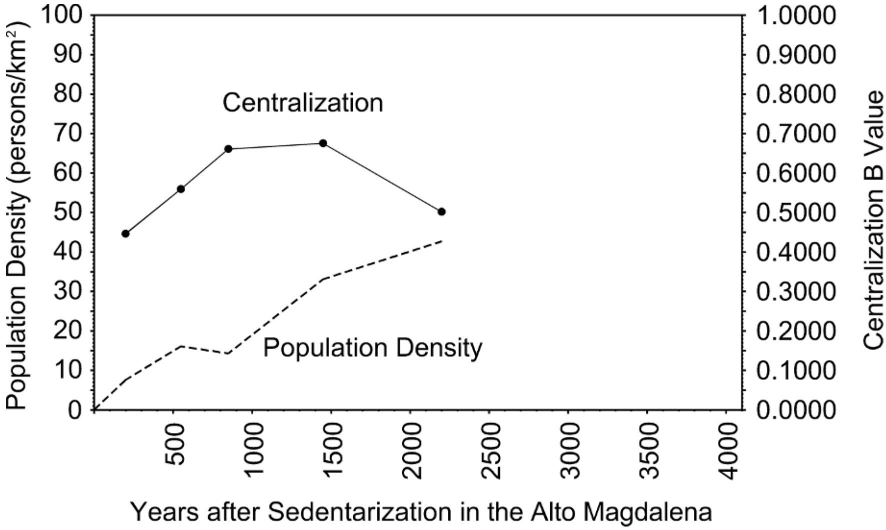


Fig. 15 Summary of changes in population density and centralization in the Alto Magdalena

The rising arc of demographic centralization in supra-local communities in Oaxaca begins during initial Neolithic population growth and continues during the subsequent demographic plateau. In Chifeng population growth is very slow, and the length of the periods makes it impossible to know whether there were episodes of more rapid change. For the Alto Magdalena, the average annual initial Neolithic growth rate between Formative 1 and Formative 2 is 0.25%, the same as the earliest Neolithic rate calculated for Chifeng and somewhat slower than that for Oaxaca. This rate soon slowed to effectively zero for Formative 3, and stayed quite low for the next 1500 years (0.09% for Regional Classic and 0.04% for Recent). It could be considered, then, that in all three regions, the rising arc of demographic centralization occurs during the postulated two-stage Neolithic demographic transition, although this would make the transition very protracted in the Alto Magdalena and glacially slow in Chifeng.

One might well imagine that these differences in pacing of regional centralization might be related to differences in demographic growth and population density levels. Oaxaca has the fastest initial Neolithic population growth rate of these three regions, and it is also the region with the fastest initial development of social hierarchy and supra-local communities. These communities, nonetheless, continue vigorous development even after the initial population growth levels off. But the difference in pacing of centralization between Chifeng and the Alto Magdalena does not correspond to a difference in the intensity of the initial Neolithic population surge, since the two regions have the same estimated rate for this stage. Surprisingly, it is the Alto Magdalena where the highest densities seem to prevail. The estimated population density for the very earliest period of sedentary living (7.6 persons per km^2 for Formative 1) is higher than that of Oaxaca 1200 years after the beginning of sedentary agricultural life and about the same level as Chifeng at 3000 years. By the time of the Regional Classic period chiefdoms, the estimated population density of 33.1 persons per km^2 in the Alto Magdalena was about four times that of Hongshan Chifeng and nearly 40 times that of Rosario phase Oaxaca.

The falling arc of regional centralization in the Alto Magdalena begins after the Regional Classic; Recent period centralization is at a level not much above that of Formative 1. The ceremonial central places of the preceding period might still have been known and used, but no new monumental construction occurred. This has sometimes been taken to indicate the collapse of the Regional Classic societies, but it is clear that centralized supra-local communities continued into the Recent period. Their demographic centralization, however, had weakened, and the nature of the centralizing forces may have changed. Ritual veneration of highly prestigious individuals is no longer evident in the archeological record; without the centralizing pull of such activities populations shift outward from the centers. The falling arc of regional demographic centralization in the Alto Magdalena, then, does not correspond, as it does in Oaxaca, to the emergence of new and more powerful forms of regional political integration.

The Alto Magdalena centralization trajectory is also unlike that of the Chifeng region, where demographic centralization continues to rise with the multiplication of competing polities up to 5000 years after the beginning of settled life. In Lower Xiajiadian times, a high level of conflict was an impediment to political consolidation, whereas in Oaxaca conflict was integral to the amalgamation of neighboring smaller communities into the expanding single dominant polity. Lower Xiajiadian conflict was not a constructive force in political development because it arose from localized population growth and resource scarcity. Population densities within these small highly centralized polities ranged up to nearly 600 persons per km^2, and were often above 300 persons per km^2. Larger polities faced more severe resource pressure and became more likely to fission as some residents moved away to found new polities in more sparsely occupied territory. Leaders would be more likely to further their political ambitions by raiding neighboring polities than by seeking the growth of their own polities, either through internal demographic increase or forcible incorporation of their neighbors. These were not propitious circumstances for the development of means of political incorporation that permitted effective control of less centralized populations. Nothing about this dynamics promoted the kind of forcible amalgamation through which larger scale political integration was achieved in Oaxaca.

A dynamic very different from that of Oaxaca or the western Liao Valley produced the Recent period political landscape in the Alto Magdalena. Oaxaca elites were motivated to expand their wealth and increase their power by bringing more people under their control through the forcible domination of smaller villages. In contrast, Alto Magdalena elites were not engaged in wealth accumulation; their power sprang solely from the supernatural; high population densities provided ample subordinate labor; and the dispersed residence pattern meant there were no small neighboring easily subjugated villages. This pattern appears to spring from a very high degree of economic redundancy and self-sufficiency among Alto Magdalena households – characteristics that seem already set at the very beginning of settled agricultural life. Greater differentiation in activities between Oaxaca households produced more intense interaction, and laid the foundations for the region's dynamics of elite exploitation. As in the Alto Magdalena, the fundamental character of household interaction in Oaxaca was in place at the beginning of settled life. The social dynamics of the Alto Magdalena led to slow population growth that continued right through the Recent period, reaching a level of 42.7 persons per km^2, far above the population density of the Valley of Oaxaca, even after the Monte Albán Ia (500–300 BC) surge. The rich resources of the Alto Magdalena, however, meant that even this large population did not create a pattern of resource scarcity (Drennan and Quattrin 1995). As Regional Classic polities moved into the Recent period, they thus did not enter the cycles of conflict with each other that led to a stalemate among a growing number of densely packed competitive Lower Xiajiadian polities. Although the populations of the Alto Magdalena's polities grew slowly, elite status shifted away from its strongly religious base, and the forces of centralization weakened (Drennan 1995).

A final comparison permits further exploration of the roles played in political development by different bases of power utilized by emerging elites. At about the same time that the San José Mogote chiefdom was emerging in the Valley of Oaxaca, broadly similar social developments were underway in the Basin of Mexico, some 400 km to the north (Sanders, Parsons, and Santley 1979). The Early Horizon (1500–1150 BC) represents the beginning of sedentary agricultural living at the same time as in the Valley of Oaxaca. Population density (1.3 persons per km^2) was slightly higher in this first agricultural period than in the other regions discussed. Like Oaxaca, local communities were not numerous, but some of them were extraordinarily large compared to the earliest villages in Oaxaca or the western Liao Valley – nearly half the known settlements had populations numbering several hundred or more. Initial Neolithic population growth was rapid (about 0.32% per year), resulting largely from an increasing number of ever larger local communities. By First Intermediate 2 (650–300 BC) there were six local communities numbering several thousand inhabitants apiece. Burial evidence for social hierarchy, together with public architecture and ritual spaces, suggests these were chiefdoms on a demographic scale similar to those of other regions, but they had very little of the supra-local community structure we have identified in other regions. Smaller settlements just did not cluster around these larger communities at all consistently (Drennan and Haller, 2007).

We have suggested that the formation of compact local communities could result from economic specialization and interdependence, and that this in turn could provide the basis for social hierarchy predicated on wealth accumulation. Of the regions we have discussed, the Alto Magdalena shows the least development of specialization and wealth accumulation and by far the most dispersed settlement pattern throughout the sequence. Hongshan chiefdoms exhibit stronger evidence of specialization and economic differentiation, occurring in recognizable but only moderately compact local communities. The considerably more nucleated villages of the Valley of Oaxaca sequence display still greater evidence of economic specialization and wealth accumulation. The remarkable degree to which social life

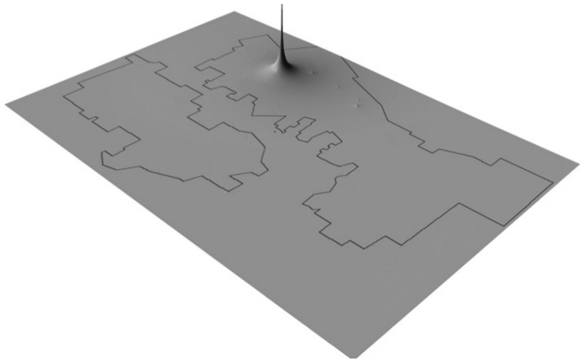


Fig. 16 A smoothed surface representing the demographic density across the Basin of Mexico during First Intermediate 4 times. The survey area is outlined

was concentrated into large, compact, local communities would place the Basin of Mexico still farther along this dimension – an unusual example, in fact, of large but compact single-community chiefdoms. If the same factors were involved in local community nucleation as in the other three regions, we might imagine that these chiefdoms showed even more elaboration of economic specialization and greater concentration of control over the local economy in the hands of elites.

In First Intermediate 3 (300–100 BC) regional population density exceeded 20 persons per km^2, and these compact chiefdoms came to number a dozen or more, even though the population growth rate dropped substantially (to 0.06% per year). With the emergence of urban Teotihuacan in First Intermediate 4 (100 BC–100 AD), there is firm evidence of the intensive craft specialization under elite control that might characterize earlier periods. As often recognized in rank-size graphs (Blanton 1976), Teotihuacan was an extremely compact primate urban state capital that had drawn in practically the entire population of the region (reflected in a *B* value of 0.9170 for First Intermediate Four, Figs. 16–18). These extreme characteristics of Teotihuacan are perhaps less surprising than they have sometimes seemed, when we

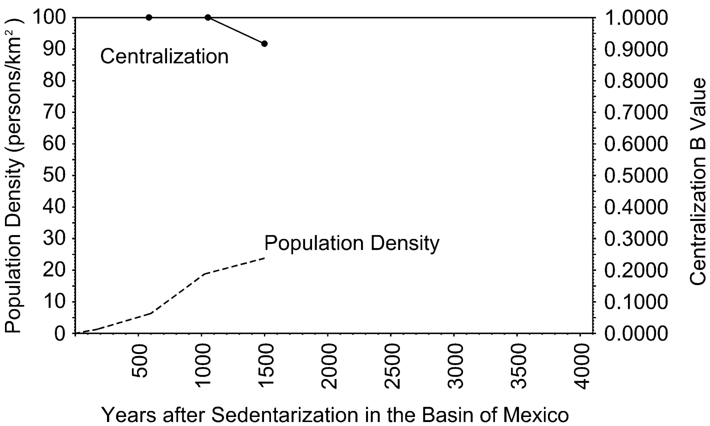
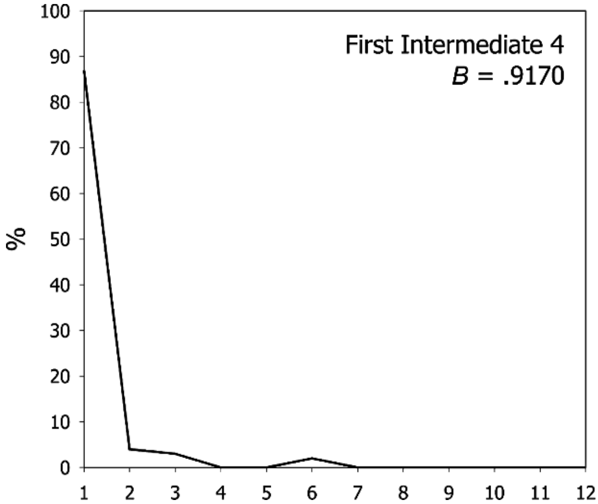


Fig. 17 Ring graph for the Basin of Mexico during First Intermediate 4 times (90% confidence zone)

Fig. 18 Summary of changes in population density and centralization in the Basin of Mexico



see them as the culmination of a long tradition. From very early on in the Basin of Mexico trajectory, entire social systems that in most regions would have had a strongly supra-local character, were encapsulated in unusually large single local communities (Drennan and Haller, 2007).

Developmental Dynamics

Broadly parallel developments followed the establishment of sedentary agricultural life in the four regions discussed here: hierarchical social relations became a fundamental principle integrating substantially larger communities than had existed before. In general terms, at least, the "Neolithic Revolution" did open the door to these developments. Most fundamentally, agricultural subsistence provided for sustaining relatively dense sedentary populations. The intensified social interaction within these populations provided both organizational challenges and new opportunities for individuals and groups. These challenges were faced and opportunities taken advantage of in highly varied ways in different developmental trajectories.

Centralization turns out to be a more complicated subject than usually thought. The emergence of hierarchical social organization does often lead to centralized supra-local communities, but sometimes the forces of demographic centralization are so strong, as in the Basin of Mexico, as to virtually overcome the supra-local character of these systems. More effective political integration is not always accompanied by greater demographic centralization. In the Valley of Oaxaca, as the San José Mogote chiefdom extended greater control over a growing territory, the regional centralization of the chiefdom decreased. Demographic centralization was extremely strong in the Basin of Mexico, but even the very high centralization values for early Teotihuacan should probably be considered a decrease from First Intermediate 1 and 2, whose large local communities had no easily recognizable supra-local manifestation and thus could reasonably be assigned maximal *B* values of 1.0000. The Alto Magdalena and the western Liao Valley conform better to simple expectations; the main trajectories of social development discussed here occurred in increasingly centralized supra-local communities. When the Alto Magdalena reached a falling arc of centralization, it was not a period of territorial consolidation, as in Oaxaca, but one of decreasing political integration.

Village living and consequent increased need for conflict resolution often accompanied agricultural emergence, but the development of complex social organization in the Alto Magdalena without any village structure shows that local crowding and conflict resolution are not essential ingredients. Neither are high levels of economic interdependence, as shown again by the Alto Magdalena with its poorly developed specialization. The interrelated absence of village life and weakness of economic specialization may have limited the possibilities for aspiring elites in the Alto Magdalena to mediate conflicts and accumulate wealth. Perhaps as a consequence, religious and symbolic sources of power loomed large in Alto Magdalena chiefdoms (cf. Earle 1997). The high regional population densities in the Alto Magdalena may also have had a hand in the emergence of complex social organization there. High levels of interaction provide a fertile matrix for elite activities – levels unlikely to be achieved in a dispersed settlement system unless regional population density is high and neighbors are thus closely spaced.

In contrast to the Alto Magdalena, the village organization of Oaxaca and Chifeng appears to have fostered specialization and economic interdependence, and the same may be true of the Basin of Mexico during the first millennium of sedentary life, as it was later on. In all three of these regions, but not in the Alto Magdalena, economic differentiation was an important part of chiefdom development. The local community matrix of economic interdependence may have provided the critical opportunity for some households to concentrate wealth and for this economic inequality to contribute to increasingly hierarchical organization, as it clearly did in the Basin of Mexico, Oaxaca, and the western Liao Valley. Religious sources of power, so central in the Alto Magdalena, were also important in elite activities in the other three regions, but the economic aspect of hierarchy was much more strongly developed.

Effective means of managing local conflict are especially important when economic interdependence is strong, as appears to have been the case in the three regions with compact local communities. This must be especially true for the Basin of Mexico, where villages of several hundred inhabitants or more were among those of the very first sedentary period. Within a millennium of agricultural beginnings, the Basin of Mexico had multiple single local communities with populations of several thousand – larger populations than entire regional chiefdoms like San José Mogote in Oaxaca. It is clear that very effective means of preventing large local communities from fissioning were in place in the Basin of Mexico from the beginning of the Neolithic. In such well-integrated communities, economic specialization could generate powerful centripetal forces drawing population into rapidly growing local communities. With Oaxaca's low regional population densities and small local communities, the demographic centripetal forces were weaker. Social growth came through progressive forcible amalgamation of neighboring communities, which remained spread across the landscape, and gave a much more territorial character to chiefdom organization in Oaxaca. In smaller local communities economic development would not be so strongly encouraged, problems of local conflict were less severe, political organization had a more supra-local character, and projection of coercive power at larger distances was more effective.

Oaxaca elites, in such a setting, could further their political ambitions through territorial expansion; conditions did not especially spur regional population growth, and the bulk of the social change of the first millennium of sedentary living occurred during centuries of little or no regional demographic increase. Basin of Mexico elites, on the other hand, thrived in large communities, where robust local population growth right through the first millennium of sedentary living steadily expanded economic opportunities. In contrast to both these sequences, the first millennium-and-a-half of sedentary living in the western Liao Valley saw very little demographic or social change. Demographic growth added up substantially through the subsequent three-and-a-half millennia, as small territorial polities emerged and multiplied. These all stayed below 1,000 inhabitants until they had filled the landscape, when demographic growth turned inward, producing supra-local polities of several thousand people that were still territorially quite small. Some 5,000 years of sedentary living in the western Liao Valley had produced regional polities of no greater population than single towns in the Basin of Mexico a mere millennium into the Neolithic.

The establishment of sedentary agricultural living, thus, did initiate a series of social changes that progressively unfolded in different regions. In some regions these changes were underway in the very midst of the Neolithic demographic transition; in others, they were so long delayed that it is difficult to place the Neolithic demographic transition in a causal role in the conventional sense (cf. Bandy, Global Patterns of Early Village Development). The changes also unfolded in different ways, producing complex hierarchical social organizations of persistently different flavors. These different flavors are detectable in the interaction structures of the earliest sedentary occupations, whether highly dispersed or compactly nucleated. The dynamics of the emergence of elites, and ultimately the nature of social power, depended on the ways in which these matrices of interaction presented different challenges and opportunities. Trajectories of complex society development were thus conditioned by the ways in which hunting and gathering bands formed the first Neolithic communities in different regions.

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Charming Lives: Human and Animal Figurines in the Late Epipaleolithic and Early Neolithic Periods in the Greater Levant and Eastern Anatolia

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Abstract Coincident with the processes that led to the development of agriculture and animal domestication, human and animal representations in clay, stone, and plaster were important constituents of the archaeological record across much of the eastern Mediterranean region. The bulk of the evidence comes from the Pre-Pottery Neolithic B (PPNB) period, but there are also important findings from PPNA and the Late Epipaleolithic sites that suggest an increasingly growing concern for the livelihood of expanding human populations in local environments that were becoming more and more influenced by human activities. Nevertheless, significant differences appear in the relative frequencies of animal and human figurines from various parts of the region. For animals there are clear reflections of local faunas, although the iconography is not correlated with the importance of species in their contributions to local diets. As for human depictions, pregnant females indicate the importance of providing future generations, but not all females are portrayed in this condition. Furthermore, where sex can be determined, the proportion of males and females ranges over a considerable span. This study provides a synthesis of research and attempts to explain the variability of these circumstances.

Keywords Natufian · PPNA · PPNB · Levant · Anatolia · figurines · symbols

Introduction

With the onset of sedentism, one phenomenon that is strikingly evident in the archaeological record is a substantial increase in material culture. In addition to permanent housing, utilitarian objects grow in number and density, and, to a great extent, non-utilitarian items appear, including three-dimensional images of humans and animals that can be subsumed under the general rubric of "figurines". Although there are well-documented exceptions, the emergence of sedentism is generally associated with food production (Neolithic) and its immediate predecessor, intensive

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foraging (Late Epipaleolithic). It is the intent of this study to examine the figurine phenomenon in the current state of research in the Levant and eastern Anatolia.

The term “figurine” should be defined, since there might be different ideas on what they entail. For the purposes of this chapter, figurines are any three-dimensional object of any size that can be interpreted as representing either zoomorphic or anthropomorphic entities; in its broadest meaning, “figurine” also refers to the often enigmatic cylindrical to globular objects (sometimes referred to as “stalk figurines” or the like) that turned up in many Neolithic sites. Size is also not an issue in the use of “figurine”, for larger three-dimensional images such as the engraved columns from Göbekli Tepe and Nevali Çori and the monumental statuary of animals and humans from these two sites and from Jericho and ‘Ain Ghazal are also included. What will not be included are two-dimensional images such as the MPPNB paintings on house floors at Haloula (Molist 1998), or Tell ‘Abr (Yartah 2004).

In general, the study focuses on the beginnings of sedentism in the Late Epipaleolithic and PPN period, but there will also be excursions into ceramic Neolithic settlements.

Some Evidence

The Late Epipaleolithic

The earliest figurines in the Near East come from the Late Epipaleolithic and represent both animals and humans in a variety of media (Fig. 1). At Early Natufian el-Wad a bone sickle haft was finished at one end with a carving of a “young deer” (Garrod and Bate 1937: Plate XIII-3; Garrod 1957: 218) or gazelle (Valla 1995: Plate 3) (although it was held by one author that the entire body of a gazelle is represented [Noy 1991: 567 and Fig. 6: 5]), and a small human head in calcite also came from the excavations (Garrod and Bate 1937: Plate XIII-4). A small calcite figure of two people embraced in a sensuous pose was found at Ain Sakhri in the desert (Garrod 1957: 219; but see Boyd and Cook 1993), and a broken (headless) ungulate was recovered from Umm ez-Zouteina, also in the desert (Garrod 1957: 218; cf. Cauvin 2000: Fig. 3: 4)

A small human head rendered in calcite also appeared at ‘Ain Mallaha, as well as a headless human torso in limestone and two stylized heads engraved on pebbles (Perrot 1966: Fig 23 and Photo 11); evidently no animal figurines were found since they are not mentioned by either Perrot (1966) or Valla et al. (2001).

Nahal Oren yielded several items, including a carved bone with an animal head at one end and human face at the other; a small head of a dog carved in limestone (broken); a complete figurine consisting of a carved head reportedly resembling an owl; and a broken piece of limestone with a clear effort to make a figurine which is supposedly an animal (Noy 1991: 563–564 and Fig. 5).

Kebara Cave produced two fragments of carved bone that probably represent animals (not identifiable) in addition to two complete bone sickle hafts as well as

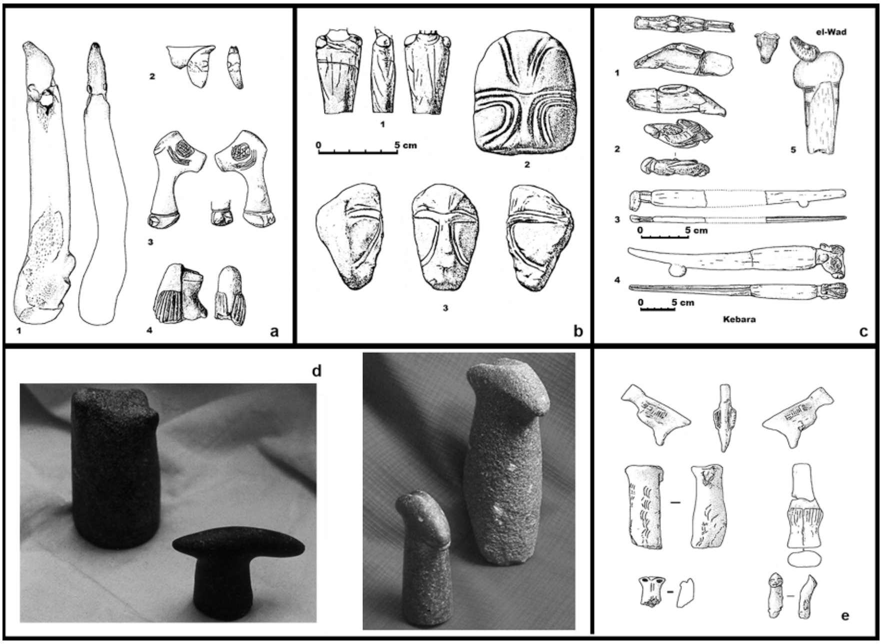


Fig. 1 Figurines from the Epipaleolithic of the Near East. **a**. Nahal Oren (after Noy 1990: Fig. 5); **b**. Ain Mallaha (after Perrot 1966: Fig. 23); **c**. Kebara and el-Wad (after Noy 1990: Fig. 6); **d**. Hallan Cemi (Rosenberg 1999: Figs. 14–15); **e**. Gilgal (after Noy 1989: Fig. 5)

several carved bone fragments representing animals that "are probably broken off from sickles" (Garrod 1957: 216) and represent "a deer and a horse" (Garrod 1957: 218). Of the complete sickle hafts, Garrod identified one animal head as a goat, while "the other [is] an unidentifiable creature which may just possibly be a wild ass, with ears laid back" (Garrod 1957: 216; cf. Noy 1991: Fig. 6: 1–4; Valla 1988: Fig. 2).

Hallan Çemi was occupied between 11,600 and 9,000 calBC (CANeW Project n.d.) and falls within the Late Epipaleolithic period and the subsequent PPNA chronological period. Excavations yielded a number of stone pestles sculpted at one end with stylized goat (gazelle?) heads, possible bovines, another mammal without horns (Rosenberg 1999: 28), and one carved bone appears to represent a snake (Rosenberg 1999: Fig. 11). Although not a figurine under the provisional definition, at least one stone bowl was incised with a non-horned mammal (a canid?) (Rosenberg 1999: Fig. 3). The subsistence economy relied on the hunting of a broad variety of wild species including sheep/goat, deer, canids, bears, small mammals, birds, reptiles, and fish; while there is no evidence of domesticated plants, Rosenberg asserts that pigs had been domesticated (Rosenberg 1999: 31).

Summary of the Late Epipaleolithic. As Cauvin noted earlier, anthropomorphic and zoomorphic representations in the Natufian were relatively rare, although his assertion that "Natufian art . . . was essentially zoomorphic" (Cauvin 2000: 25) might not be warranted in view of the numbers for each category, which (not counting the shaped pestles from Hallan Çemi) rank nine animal figurines versus seven humans, with one figurine indeterminate as to what it represented; I have not been able to find a count for the material from Hallan Çemi.

It should be noted that the identification of these figurines to the kind of animal that is depicted is not unanimously accepted. The differences among Garrod, Valla, and Noy have already been mentioned, and Cauvin is skeptical of the identifications for Nahal Oren and ‘Ain Mallaha (Are some of the “heads” actually human? Cauvin 2000: 25, endnote 10).

It is interesting that many of the animals decorate utilitarian tools that have nothing to do with hunting, although it is possible that some of the “loose” animal heads once adorned spear-throwers.

The PPNA Period

With the onset of agriculture, there are some possible shifts in emphasis in both the northern and southern parts of the Near East.

In the PPNA period, when wild animals still constituted the menu at Nemrik in Iraq, Kozlowski reported 29 “gods” in the form of long, thin limestone cylinders with terminations representing, in his estimation, vultures, eagles, bovids, a number of indeterminate bird images, several other indeterminate animals, and one female human “or other animal” (Fig. 2-a; cf. Kozlowski 2002: Table 6). In general, Kozlowski notes that in his opinion these images are similar in effect to cylindrical representations at Hallan Çemi (goat/gazelle), Abu Hureyra (cat), Jerf al-Ahmar (bird), Dja’ade, and Mureybet. Clay figurines at Nemrik were relatively rare (13 total, of which 5 are unidentifiable as to being either human or animal), but they included such animals as a domestic pig, a wild boar, a domestic sheep (how is domestication determined in these cases?), and an aurochs. Due to preservation problems at the site, 92% of the faunal remains could not be identified even to the genus level (Kozlowski 2002: Table 7). For Kozlowski, the figurines represent “individual deities connected to single houses” (Kozlowski 2002: 78) or “domestic deities.”

Other PPNA animal figurines from the northern Euphrates include a possible owl (with possible human attributes) in limestone from Mureybet (Pichon 1985) and five female human figurines (Fig. 4-a; one in stone and four in baked clay; Cauvin 2000: 44; Figs. 7 and 8); another small carved stone, broken at both ends, is attributed to being a figurine but there is little detail to indicate the sex (Cauvin 2000: Fig. 6:5). At Jerf el-Ahmar, small sculptures of human (and animal?) faces were recovered, but two impressive stelae representing some sort of bird (the beaks are missing, but they may be raptors) about 2 m tall adorn one building in the village (Stordeur et al. 2001: 40 and Fig. 11).

The tall Jerf el-Ahmar stelae foreshadow, perhaps, the monolithic art in Anatolia as the transition from the PPNA to the EPPNB took place. Göbekli Tepe has

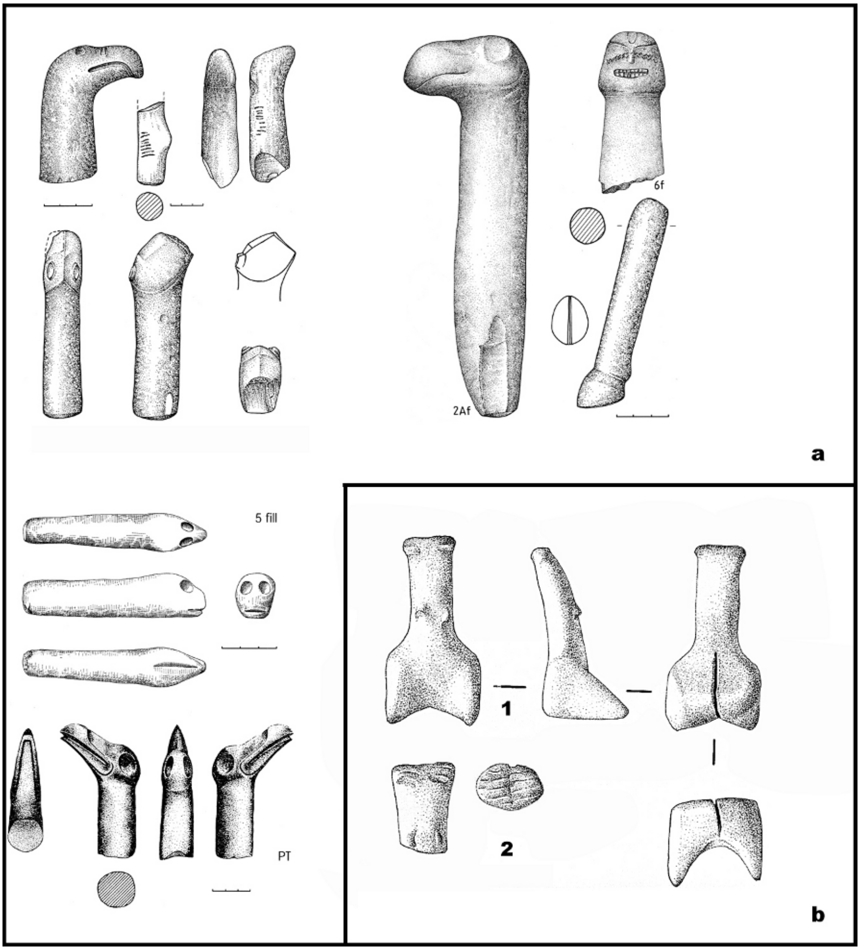


Fig. 2 Figurines from the PPNA in the Near East. **a**. Nemrik (after Kozlowski 2002: Plates 138–140); **b**. Netiv Hagdud (Bar-Yosef and Gopher 1997: Fig. 6–1.2)

provided a stunning array of animal motifs both as reliefs on massive columns and as free-standing sculptures (Fig. 4). The depicted animals on the T-headed limestone columns include aurochs, lions, cranes, crocodiles (?), fox, sheep, boar, wild ass, gazelle, bear (Schmidt 1995; 1998; Peters and Schmidt 2004), vultures, and scorpions (Anon 2006; Schmidt 2006). A headless male with an erect penis appeared on one column (Anon. 2006: 75), a free-standing ithyphallic male sculpture ca. 40 cm high also came from the site (Beile-Bohn et al. 1998: 72–73 and Abb. 34), and another human sculpture ca. 40 cm high was also found (Beile-Bohn et al. 1998: Abb. 31). In addition, there are three similar 1-m long phallus reliefs (complete with scrotum) in high relief in the nearby limestone quarry, which, as Schmidt points out, cannot be directly dated, but there is little other post-PPNA/EPPNB archaeological

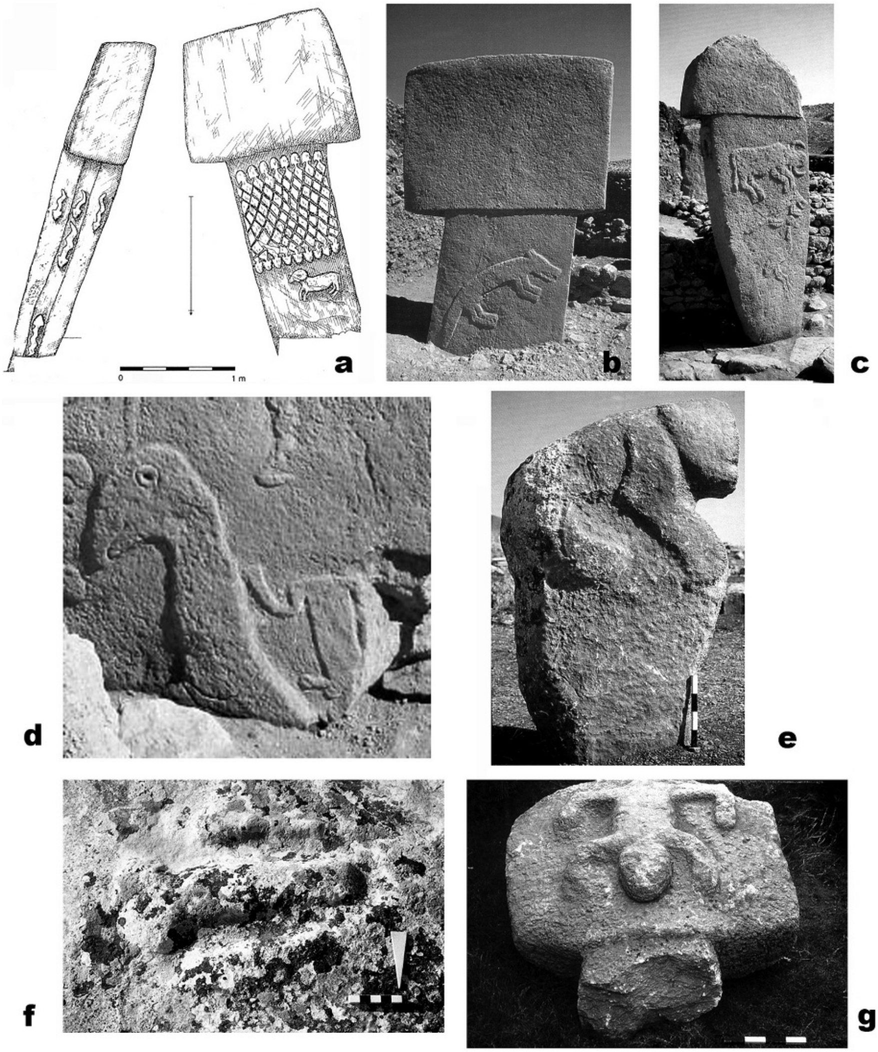


Fig. 3 Stone reliefs from Göbekli Tepe. **a**. “Snake Pillar”; **b**. fox; **c**. bull and birds; **d**. bird and headless male; **e**. lion; **f**. erect penis and scrotum; **g**. quadruped (d from Anon 2006; all others from Hauptmann 1999)

evidence in the area (Schmidt 1998: 29 and Abb. 7). Free-standing limestone sculptures also include a half-meter high lion (Beile-Bohn et al. 1998: Abb. 30), a poorly preserved bird ca. 30 cm tall, and the broken head of an unidentifiable carnivore (Beile-Bohn et al. Abb. 29).

There is no monumental art in the southern Levant during the PPNA, but small figurines occur in several sites. Highly stylized female figurines dominate the southern Levant, including a clay one from Netiv Hagdud (and the head of another

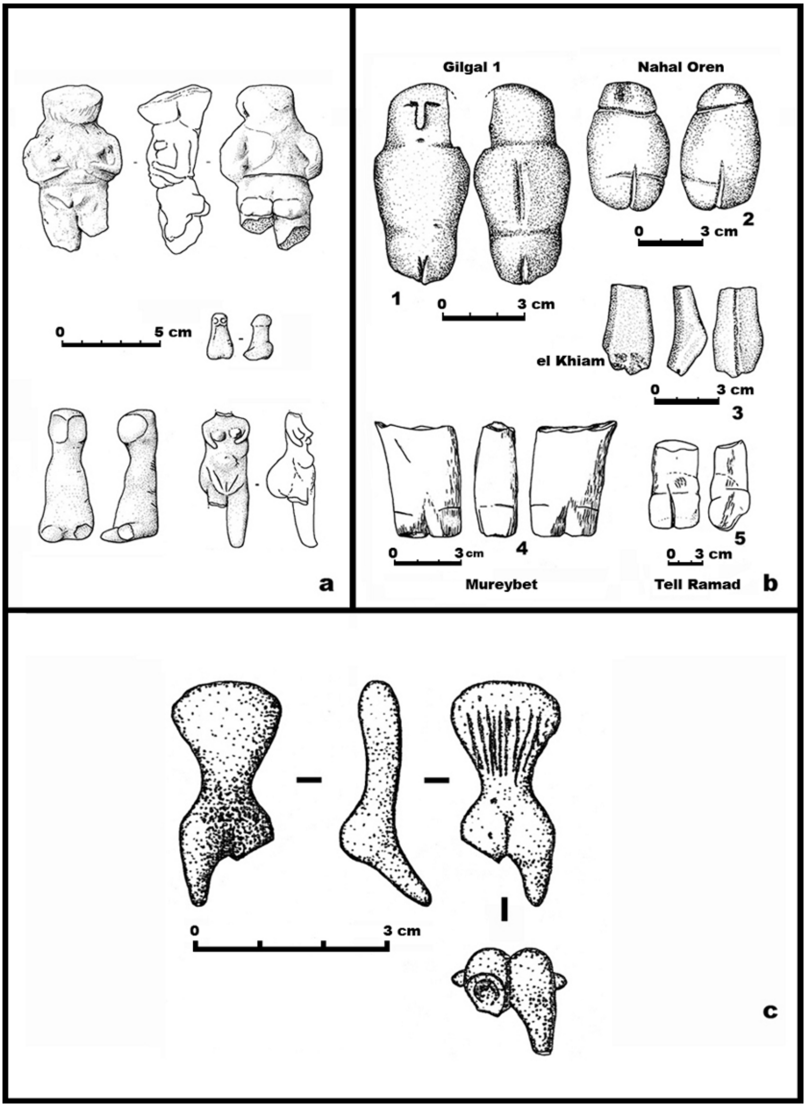


Fig. 4 Figurines from the PPNA of the Near East. **a**. Mureybet (after Cauvin 2000: Figs. 7 and 8); **b**. Gilgal, Nahal Oren, el-Khiam, Mureybet, and Tell Ramad (Bar-Yosef 1980: Fig. 4); **c**. Dhra' (Kuijt and Finlayson 2001: Fig. 2)

figurine) (Fig. 2-b; Bar-Yosef and Gopher 1997: 177–178 and Figs. 6.1.1 and 6.1.2), and stone statuettes from Salibiya IX (Bar-Yosef 1980: 195 and Fig. 3); Gilgal (Noy n.d.: 13, 15–16; Noy originally assigned this surface find to the Natufian, but it has been dated to the PPNA by others (e.g., Cauvin 2000: Fig. 6:4)); Nahal Oren (Stekelis and Noy 1963: 9 and Plate 2: F-H); El Khiam (Echegaray 1966: Plates 6–7, and Dhra' (Kuijt and Finlayson 2001: 14 and Fig. 2) (Fig. 3-b and 3-c). Figurines of both stone and clay were excavated from Gilgal, including four "pillared" (or stalk-like) figurines claimed to be humans of indeterminate sex, as well as a rare (for the southern Levant) bird figurine made of limestone (Noy 1989: 13, 17 and Fig. 5).

Summary of the PPNA Period. Overall, there is a perceptible change in figurine production compared to the Late Epipaleolithic. Animals tend to play an important role in the iconography of the north, while except for the bird from Gilgal, they do not appear at all in the southern Levant. Monumentality is introduced at Jerf al-Ahmar, which is taken to even greater lengths at the late PPNA/EPPNB ritual center at Göbekli Tepe in the form of reliefs on columns and free-standing sculptures. Where figurines are complete enough to determine sex, females are clearly present, but there are also complete human figurines whose sex is simply indeterminate, and some of the determinations by archaeologists are questionable (discussed more fully below).

The PPNB Period

Despite major changes in lithic technology and subsistence economy, the PPNB period demonstrates some continuity with the PPNA period in its figurine component, although there are also some changes that indicate an evolution of these three-dimensional images. Animal figurines are found at virtually all PPNB sites in the Levant, and human figurines are also relatively frequent. It is not possible to discuss them all due to the large number of sites reporting anthropomorphic and zoomorphic figurines, but some of the more intriguing examples will be mentioned.

Early/Middle PPNB Nevali Çori appears to be directly involved with the iconography of Göbekli Tepe, which is not very distant. One of the T-shaped pillars (Fig. 5a) of the cult building (which underwent at least two renovations) has arms and hands in relief on the sides and front edge of the pillar (the head is missing), and this detail mirrors a pillar fragment from Göbekli Tepe (compare Beile-Bohn et al. 1998 Abb. 28: 3 and Hauptmann 1993: Abb. 16). Large free-standing sculpture continued its importance at Nevalı Çori, with both humans and animals, but what is new here is the combination of both on the same piece and often as humans with attributes of animals, such as "hybrid" bird/humans (Fig. 5-d) and a snake climbing up the back of a human head (cf. Hauptmann 1999: Figs. 10–15); there is also a 1-m "totem pole" of at least two female busts with "hairnets" placed atop each other (Fig. 5-c), surmounted by a bird whose head is missing. Morsch's analysis of the clay figurines from Nevalı Çori (Fig. 6) revealed 169 seated females (2 "with child" and 8 pregnant), 179 standing male figurines; about 29 zoomorphic pieces, and 39 abstract items that might be either animal or human, all totaling 416 figures (Morsch 2002: 147–148 and Plates 1–4). Other sites with similar T-shaped pillars have been located in SE Anatolia as well, although they have not been investigated in any detail (e.g., Çelik 2000a, 2000b; 2006).

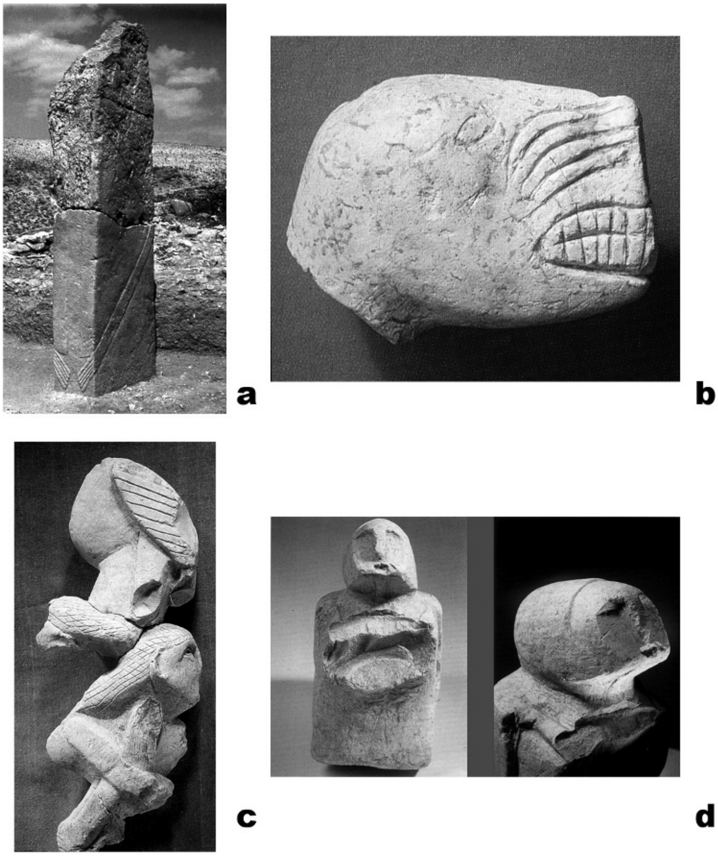


Fig. 5 **a**. Stone pillar with incised human arms and hands; **b**. lion; **c**. human-bird "totem pole"; **d**. bird-human sculpture (Hauptmann 1999)

Four clay human figurines were found together in a depression of a house floor at Cafer Höyük: three were female and one was male (Cauvin et al. 1999: 94 and Figs. 26–28). In addition, a composite clay figurine of a bird (with wings added to the body before firing) came from the upper levels of the site (Cauvin et al. 1999: 98 and Fig. 33).

Although clay female figurines began to show up in the PPNA layers at Çayönü, they do not become numerous until layers dated to the MPPNB; animal figurines are absent in the earlier layers, but they predominate in the MPPNB (Fig. 7-a and 7-b), with sheep/goat the most numerous; Özdoğan notes that the rarity of pig figurines is curious since the animals figured so heavily in the diet (A. Özdoğan 1999: 59). For the figurine samples collected up to and including the 1987 season, Broman Morales cites 11 sheep/goats, 1 steer, 3 possible dogs, 5 pigs, and 22 unclassifiable animal figurines. For human figurines, there are no identifiable males, but females can be detected among 14 highly stylized seated images, 20 "lady stalks", and 7 broken

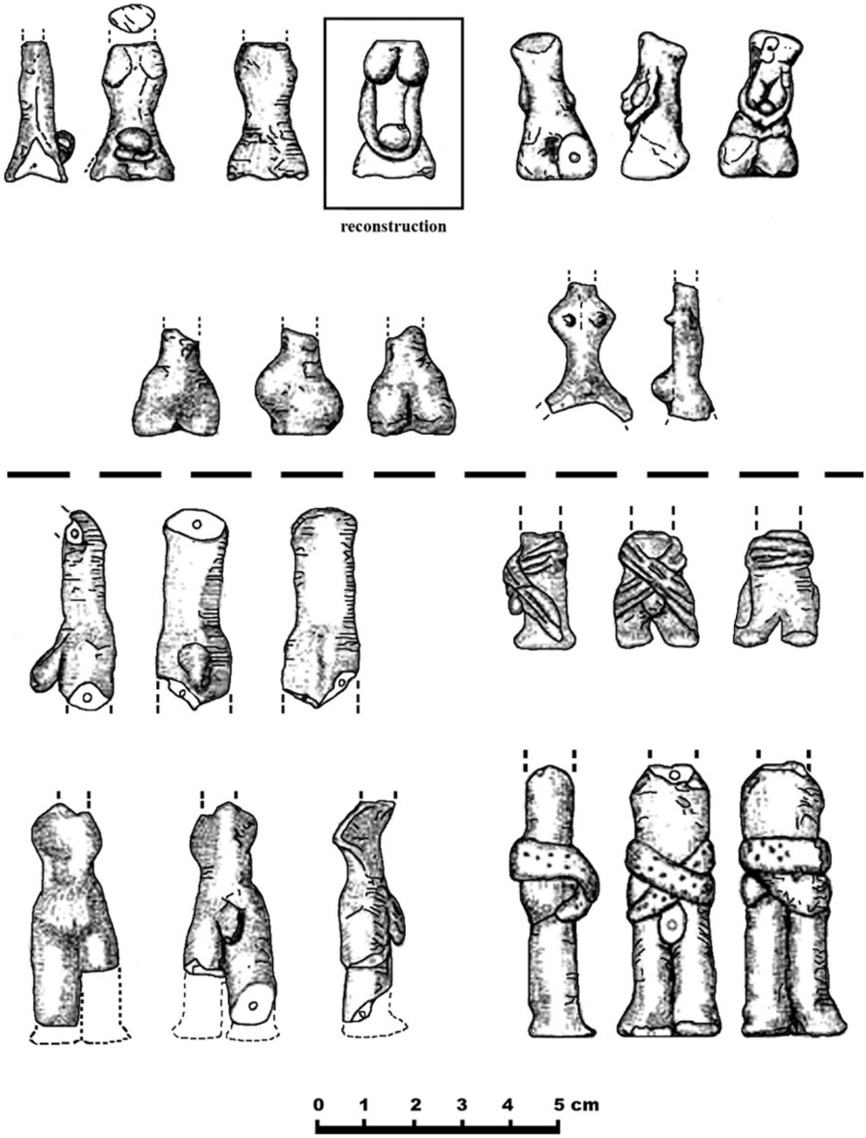


Fig. 6 Clay figurines from Nevali Çori (after Morsch 2002: Plates 1 and 3)

"composite" figurines; other clay "stalks" were not classified as anthropomorphic (Broman Morales 57–64 and Plates 19–25).

In post-PPNB occupation at Çayönü, there is no direct mention if figurines were found in the last phase (Large Room Building, PPNC) (cf. A. Özdoğan 1999: 59), but elsewhere in Anatolia M. Özdoğan reports numerous small limestone human figurines from Mezraa-Tleilat during a period that is described as transitional from

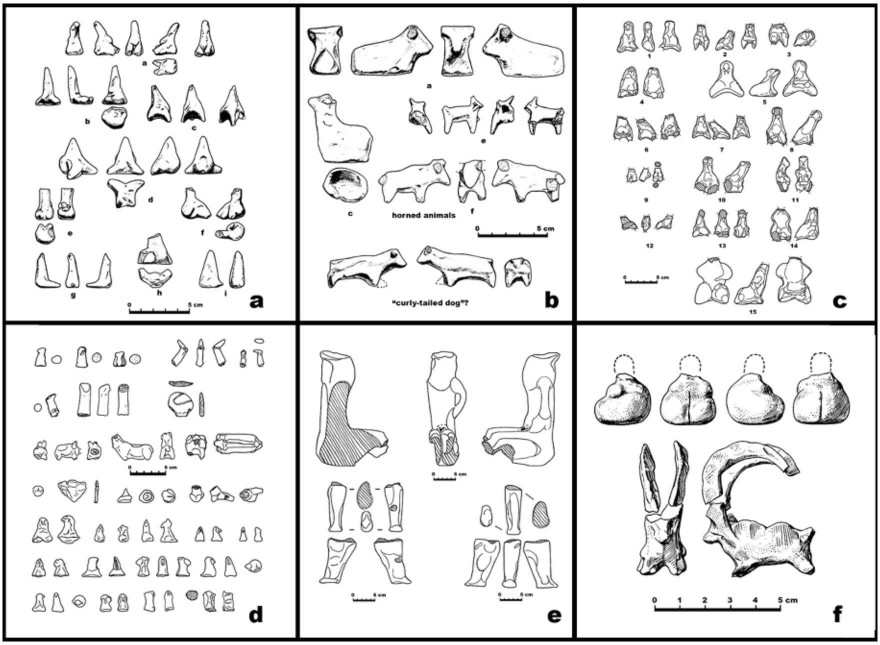


Fig. 7 **a**. “Stalk ladies” from Çayönü (Broman Morales 1990: Fig. 22); **b**. animal figurines from Çayönü (after Broman Morales 1990: Plates 19 and 21); **c**. human figurines from Tell Aswad (de Contenson 1995: Fig. 127); **d**. human and animal figurines from Tell Ramad (de Contenson 2000: Fig. 100); **e**. plaster supports to display modeled skulls at Tell Ramad (de Contenson 2000: Fig. 104); **f**. a human female and an ibex from Beidha (Kirkbride 1966: Fig. 4)

the Pre-Pottery to the Pottery Neolithic correlated with the PPNC (M. Özdoğan 2003: 514–515). The pieces consist of 29 seated figures, 2 standing humans, and 94 phalluses; no sex could be determined for the seated or standing figures (M. Özdoğan 2003: 515–517).

Farther south near Damascus, de Contenson reported numerous figurines, both human and animal, from Tell Aswad (Fig. 7-c), but most in a very fragmentary condition, so that horns, for example, constituted a large proportion of the total; among the identifiable animals, cattle seem to be present (de Contenson 1995: 181–182 and Fig. 125). Quite a number of the figurines assigned to the anthropomorphic category are cylindrical “stalk” examples, and there are many fragments such as heads and legs; de Contenson notes that for the human pieces, sitting figurines are “clearly” female (de Contenson 1995: 183). The same general situation pertains to de Contenson’s excavations at nearby Tell Ramad (Fig. 7-d), with many seated figurines and “stalk” or cylindrical pieces identified as human forms (de Contenson 2000: 179–189 and Figs. 100–103). Novel additions to the figurine inventory at Tell Ramad included headless statuettes (Fig. 7-e) of a pink clayey soil that served as bases for plastered skulls (de Contenson 2000: 217 and Fig. 104).

A later excavation at Tell Aswad also recovered some clay human figurines, including a male similar to the one from Cafer Höyük and another of indeterminate sex very like the beaded-eye figurines from Munhata (Stordeur 2003: 12 and Fig. 6: 1–2). Among the zoomorphic specimens recovered in the later excavations, many of the animals could be identified, with cattle the most frequent, followed closely by goats; sheep and pig were rare, and there was possibly a dog (Stordeur 2003: 13 and Fig. 6: 3–4).

Figurines from Jericho are surprisingly rare: there were 3 "human types" from PPNA layers and 14 from PPNB contexts (Holland 1982: 551–553 and Figs. 223–224), all of them in very fragmentary conditions. Animal figurines are likewise scarce, with only six reported from the PPNB period (Holland 1982: 553–554 and Figs. 224–225). Beidha also produced few figurines from the first five seasons, including a small "mother-goddess" (Fig. 7-f), an ibex, and a couple of probable cattle horns (Kirkbride 1966: 26 and Fig. 4); there have been no reports of figurines from the subsequent excavation seasons at Beidha.

Excavations at Munhata produced 19 (35%) anthropomorphic and 36 (65%) zoomorphic figurines from the MPPNB layers which, for the southern Levant, is a high proportion of human examples. Of the former category, nine females and one male "could be identified with certainty" (Garfinkel 1995: 54; Figs. 13–14 and Plates 2–4). Among the animals, there were at least four cattle, several sheep or goats, one pig, and a number of "maned animals" (Garfinkel 1995: 22 and Figs. 15–18). In the Yarmoukian layers, the percentages for human vs. animal figurines is exactly reversed (total n = 62 pieces).

'Ain Ghazal is especially rich in figurines. About 150 animal figurines made in clay, many of them fired, derive principally from MPPNB contexts (although there are also examples from the LPPNB, PPNC, and a few from the Yarmoukian Pottery Neolithic). By far, cattle dominate the animal inventory (McAdam 1997; Schmandt-Besserat 1997), accounting for 50% or more of the identifiable inventory. Other animals include sheep/goat, equids, pigs, possible reptiles (Schmandt-Besserat 1997: Fig. 5), dog (Rollefson 1983: Plate III: 7), and perhaps fox and cat. Among a sample of bovids that was recovered between 1982 and 1985, McAdam could distinguish between bulls, cows, and calves (McAdam 1997).

Of particular note among the 'Ain Ghazal aurochs category, 24 cattle figurines were found in a single cache, along with a lump of off-site clay from which they were made, discarded in a trash deposit in a courtyard (Fig. 8a); the singular cluster, together with a block of raw material, indicates that they were all produced at the same time and used in a single ceremonial episode (Schmandt-Besserat 1997: 52–53). The cache also tended to exhibit more burning (in the form of "blackening") on the rumps of the animals, suggesting that they may have been arrayed in an arc around the edge of a hearth with the hind parts toward the fire and the heads pointed outward (Schmandt-Besserat, pers. comm.).

It is interesting to note that among the cattle figurines at 'Ain Ghazal, several bore evidence of surface treatments that indicated haltering and perhaps slashing (Fig. 8-b; McAdam 1997: 134; Schmandt-Besserat 1997: Fig. 9). Two cattle were found buried side-by-side in a pit that cut through a house plastered floor (although it is not clear if this part of the house had been abandoned at the time) (Fig. 9a and 9b); both had been pierced in the ribs from the side and through the front of the

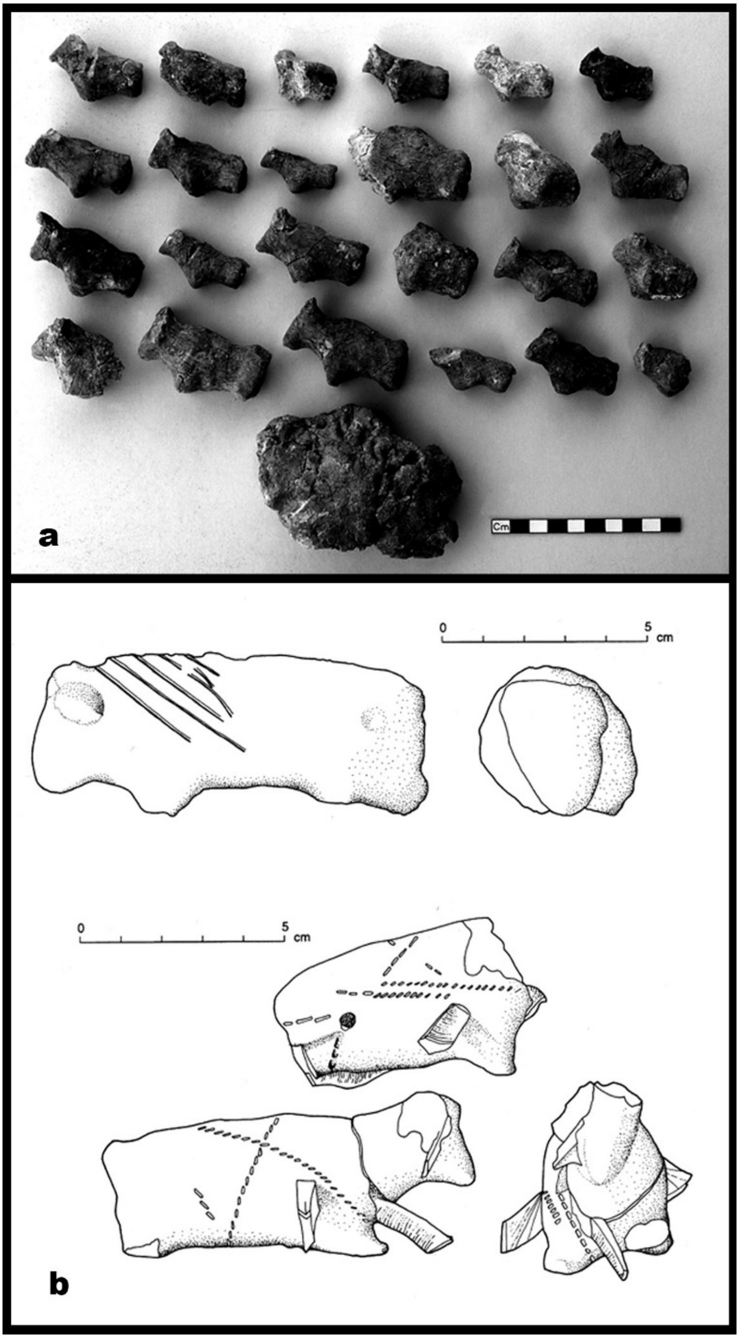


Fig. 8 **a**. Cache of cattle figurines from ‘Ain Ghazal (photo: C. Blair); **b**. surface markings on several cattle figurines from ‘Ain Ghazal (after McAdam 1997: Figs. 13–14)

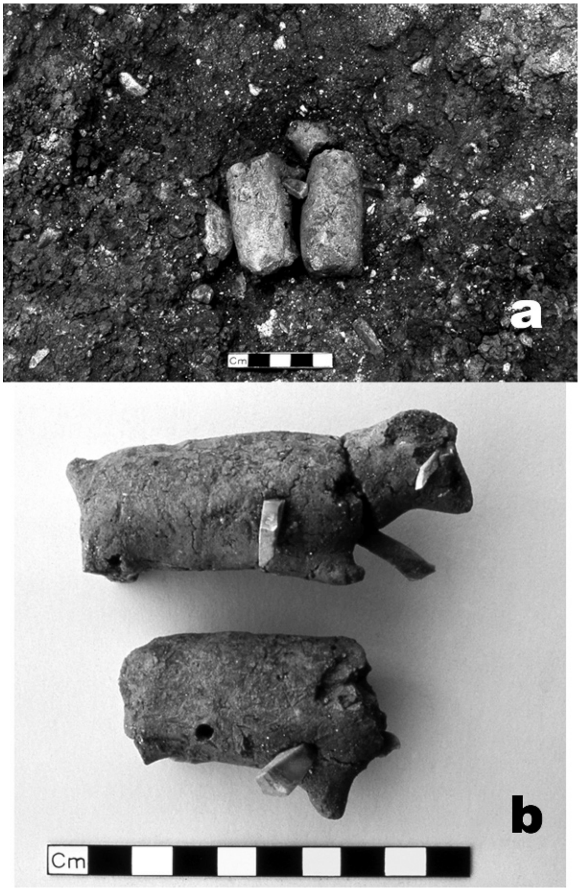


Fig. 9 **a**. "Killed cattle" in situ; **b**. "killed" cattle (photos by C. Blair)

chest with flint bladelets, and for the steer whose head remained intact, one eye was stabbed with another bladelet (Schmandt-Besserat 1997: Fig. 10).

A total of 43 anthropomorphic figurines has been catalogued for the PPNB period (Schmandt-Besserat n.d.), although many of these are fragments. In the same 1982–1985 sample mentioned earlier, McAdam noted that construction varied from pinching pieces of clay into shape to assembling "spare parts" to create the three-dimensional images (McAdam 1997). Female figurines were often easily identified, although sometimes there was some difficulty in making the decision (Fig. 10). An example might be cited where several specimens that were clearly female bore rocker-stamped, cord-impressed decorations (McAdam 1997 Fig. 2) so it is not impossible that several lumps of clay called "male genitalia" (McAdam 123 and Fig. 6) may in fact have been highly stylized females; additionally, a rocker-stamped, cord-impressed "object" may have been a pregnant abdomen "spare part" of a female figurine (McAdam 1997: Fig. 7). Many figurines could not be assigned a sex due to the nature of preservation.

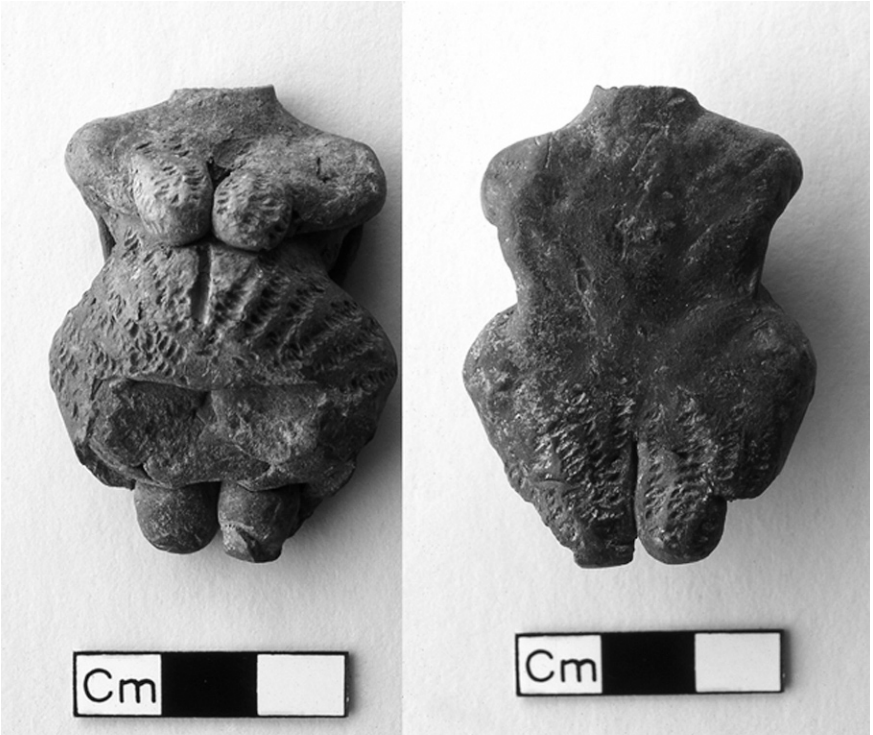


Fig. 10 Clay figurine of a pregnant female from ‘Ain Ghazal (photo: C. Blair)

More imposing human MPPNB images from ‘Ain Ghazal include the large plaster human statues (ca. 90–100 cm high) and busts (30–40 cm) that were excavated in two separate caches in the 1983 and 1985 seasons (Fig. 11; Rollefson 1983; 1986). Several females have been identified on the basis of the presence of breasts, but there are other relatively complete pieces that have no direct evidence of sex. The earlier cache consists of 13 full-standing statues and a like number of busts, while the later cache (badly damaged by bulldozer activity) includes five complete statues and busts (the latter are two-headed) and fragments of at least one more figure. Sex determination for the latter cache is especially difficult since it appears that the statuary was intended to be covered with robes between the neck and knees (cf. Grissom 2000: 43). There are strong parallels in facial cosmetic treatment between the statuary and plastered skulls at ‘Ain Ghazal, especially for the earlier cache, and it is likely that the statuary and plastered skulls are parts of the same iconographic canon. Statues similar in appearance and construction were also recovered (in very poor condition) from Garstang’s excavations at Jericho (Garstang 1935), and fragments of molded plaster that were interpreted to be plaster statue fragments also were found at Nahal Hemar (Bar-Yosef and Alon 1988).

In the southern Levant, at least, there may have been a major decrease in figurine production in the LPPNB, at least for animal figurines (particularly at “megasites”).

a

b

Fig. 11 Plaster statues and busts from ‘Ain Ghazal. **a**. From the 1983 cache (photo: P. Dorrell and S. Laidlaw); **b**. from the 1985 cache, including three two-headed statues (photo: J. Tsantes)

At ‘Ain Ghazal, two seasons of excavations (1983–1984) over ca. 200 m^2 of MPPNB deposits produced 40 human figurines (or identifiable fragments thereof), 61 animal figurines, and 93 clay figurine fragments that could not be assigned to either anthropomorphic or zoomorphic status, for a total of 194 figurines. Excavations in LPPNB layers over at least three times that area produced only 2 human figurines, 14 animals, and 3 unidentifiables, a total of 19; this represents less than 10% of the MPPNB total even though population had more than doubled in the LPPNB and the investigated area was more than tripled. In the ensuing PPNC, across a somewhat larger areal extent, there were 8 human, 9 animals, and 11 unknowns for a total of 28 figurines, despite the fact that population was probably only one-third or less of the LPPNB residents.

This general pattern might be generally characteristic of most LPPNB and later sites. Unfortunately there are few detailed reports, but the impression is that at LPPNB Basta, for example, figurines were not a prominent part of the material culture (Nissen et al. 1991: 29, where it is stated that “. . .several fired clay objects were found. Among them was an animal figurine”; cf. Hermansen 1997; 2004), and there is little indication of figurines from LPPNB Ba’ja (e.g., Gebel and Hermansen 2003; but see Gebel, Hermansen and Kinzel 2006: 15 for the mention of one anthropomorphic figurine), although these preliminary reports have tended to concentrate on architecture and lithic production. Excavations at LPPNB ‘Ayn Jammam in 1995 (Waheeb 1996) produced a total of one animal figurine and five “stalk” figurines from several hundred square meters that reached several meters depth (Rollefson 2005a: 22). An exception to this pattern appears to be the case at the LPPNB megasite of es-Sifiya, in west-central Jordan, where Mahasneh reports that 215 zoomorphic and 23 anthropomorphic (similar to “stalks”) figurine were recovered from a single 5 × 5m unit, which Mahasneh interprets as a figurine production area (Mahasneh and Bienert 2000: 3 and Figs. 8–10). Could this be taken to represent some kind of specialization in the ritual area?

In the Pottery Neolithic period figurines are also relatively rare. At ‘Ain Ghazal, the Yarmoukian Pottery Neolithic layers, which were sampled over more than 2000 m^2, or about ten times the area of the MPPNB sample, produced eight human figurines, nine animals, and three unidentified fragments. At Munhata, while the PPNB figurine counts were modest at 55 pieces (19 humans and 36 animals), all of the Pottery Neolithic layers combined yielded 45 clay figurines (21 human, 24 zoomorphic) (Garfinkel 1995: 15, 27, 47). The extensive excavations at Sha’ar Hagolan since 1989 (1800 m^2, Garfinkel et al. 2002: 189) have recovered abundant human and pebble figurines (Fig. 12), although no complete count is available, and 15 animal figurines have also been found; the ratio of anthropomorphs to zoomorphs is said to be about 2 to 1 (Garfinkel 2004: 195), suggesting that there are around 30 human figures. Anthropomorphic figurines at Sha’ar Hagolan are heavily dominated by the cowrie-eyed, cone-headed seated female that, to some, invokes the “terrible mother” (Cauvin 1972: 86) image, recalling in some ways the enthroned “goddess” from Çatal Höyük that also dates to the Pottery Neolithic (Mellaart 1967 183 and Fig. 52).

Summary of the PPNB and Post-PPNB Periods. With the onset of the PPNB, animal figurines become ubiquitous in the Near East, although human figurines – both

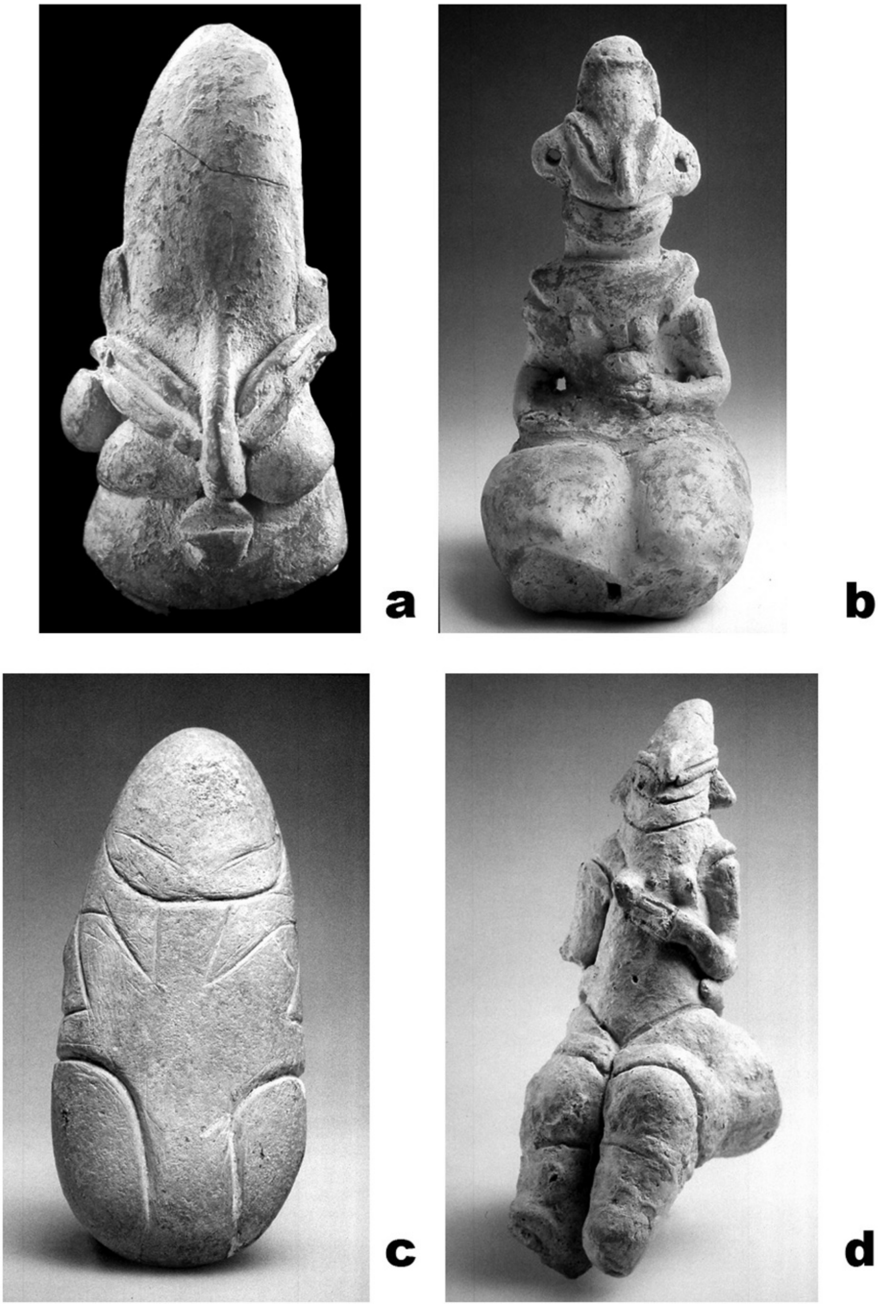


Fig. 12 **a, b**, and **d**. Yarmoukian clay female figurines from Sha'ar Hagolan; **c**. Yarmoukian incised pebble from Sha'ar Hagolan (all photos from Garfinkel 1999)

male and female – are also important, occasionally far outnumbering zoomorphs. Among the animal figurines, cattle are usually most numerous, although in places sheep/goats and birds are almost as frequent.

The monumental images so striking at Göbekli Tepe are maintained in several places in SE Anatolia, and monumental statuary (albeit on a reduced scale) appears in the central Levant at Jericho, ‘Ain Ghazal, and Nahal Hemar, an area where the plastered skull cult was characteristic of the ritual arena.

In general, figurine use seems to crescendo in the MPPNB, perhaps signaling a peak in social tensions associated with population growth. The statuary is possibly associated with an emphasis on social identity based on corporate kinship groups. By the Late PPNB figurine production in general seems to have waned, and females seem to dominate the anthropomorphic set. In the ceramic Neolithic, females are clearly the most abundant, but numerous pebble figurines are unclear in terms of their connotations of sexual identity. Nevertheless, the absolute numbers of figurines remains relatively low.

What Is with All These Figurines?

The meaning of figurines remains one of the most difficult and controversial aspects of understanding the material culture of the Neolithic people who made them. The problems lie in several areas, any one of which, if treated dismissively, could invalidate any chance of a clear understanding of the intent of the objects.

How Does One Approach the Problem?

Richard Lesure identified four schools of philosophical approaches to the study of figurines: (1) the iconographic approach investigates just what figurines were intended to represent; (2) the functional approach looks at how figurines were used and whether they were sacred or profane; (3) the social analytical perspective sees figurines as representations of social tension and political struggle; and (4) the symbolic school sees figurines as entailing far more than what they physically depict and investigates the more abstract elements about the subject matter (Lesure 2002: 589–594). Certainly, researchers are not necessarily confined to one approach or the other, but failing to understand the contributions that the alternative avenues of study can provide will likely result in limited perceptions at best, and wrong understanding at worst.

Location, Location, Location

One of the aspects of primary importance is the contextual associations of figurines, both spatial and temporal. Without this basic requirement, Marcus’ three components of ritual – (a) content, (b) locus of performance, and (c) performers – cannot be addressed: what happened, where, and by whom (Marcus 1996: 287). Of course, knowing all three aspects does not guarantee a correct interpretation, but without them an incorrect interpretation is virtually assured.

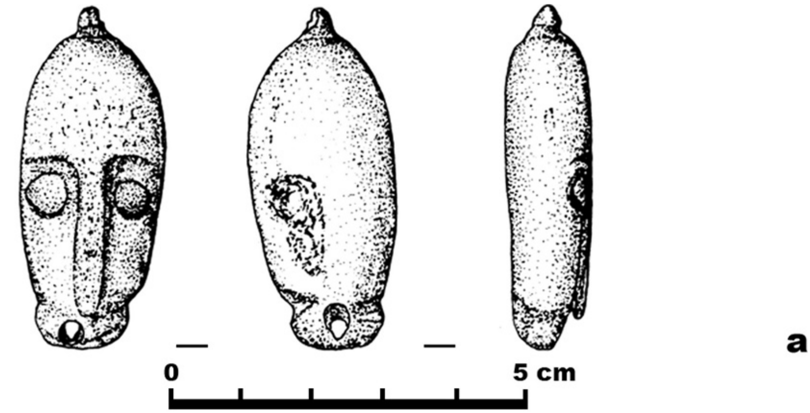
In this regard, it should be noted that few available reports so far include a consideration of context, and catalogues of inventory numbers, whether described according to species and sex or not, are simply that: catalogues of things. When it can be seen that small clay anthropomorphic and zoomorphic figurines are never found in ritual buildings at Çayönü (A. Özdoğan 1999: 59), for instance, there is a strong indication that however they may have been used, it was not in the context of public ceremonies. Nor have the figurines occurred as a common element in burials anywhere in the Near East, nor even in the Balkans (Bailey 2005: 11). It is also notable that when contextual information is provided, the clay figurines are almost always found in trash deposits, which suggests that the two "killed" cattle figurines buried in a subfloor burial pit at 'Ain Ghazal were something "more" than the odd cow, sheep/goat, or dog found among burned bones, flint debitage, and other detritus. But even here, a description of the trash association can be vital to insights of the disposable figurines: the 24 cattle discarded together in a midden demonstrate that the "herd" may have operated in a unit, and the implications of this clutch of animals probably are different than a single animal in the rubbish. As a final example, it has been suggested that the context of the disposal of the stone bust at Nevalı Çori indicates it is a deity since it was placed inside a cult building (Voigt 1991: 39); although there have been no cult buildings identified at MPPNB 'Ain Ghazal, would the careful burial of the "dead" statues at 'Ain Ghazal indicate that they, too, were deities?

Since the final resting place for so many of the figurines was in the trash (at Gritille, for example, all but one of the "nearly 50 clay figurines" were found in ash deposits (Voigt 2000: 265)) it seems that they were all one-offs: made for a specific purpose and then discarded once the objective had been satisfied; the importance was in the creation of the figurines, not in their maintenance (cf. Hamilton 1996: 283).

In the Eye of the Beholder

It is likely that the reader has read a report on figurines in a publication only to turn to the illustrations and raise an eyebrow while silently asking, "That's a pig?" Depending on the state of completeness, it is often possible to distinguish between figurines intended to represent animals and those that were supposed to be people, but there are also many times when the stylized renditions are too vague to be certain of species or sex. Hamilton is adamant in her view that analysts usually (always?) bring a lot of historical baggage with them, a "political context" they developed over their education and experience in their research, especially when it concerns the identification and interpretation of human figurines (Hamilton 1996: 282).

When criteria are explicitly stated for sorting figurines into this category or that category, the reader is able to make a judgment of the reliability of the criteria – and



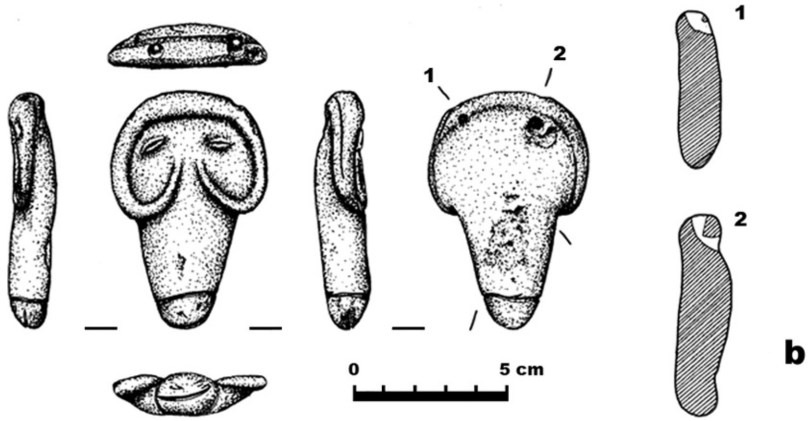


Fig. 13 **a**. Greenstone pendant from Basta in the shape of a head, or stylized penis and scrotum; **b**. stone pendant from Basta in the form of a ram's head or penis and scrotum (both after Hermansen 2004: Figs. 1 and 2)

therefore the reliability of the classification. Often no such criteria are expressed, or they are so vague as to be suspect. This problem is especially acute when it comes to the so-called stalk figurines, which in some reports might be assigned to one sex (or species) but in another publication to the other sex (or type), a pounding of square pegs into round pigeon holes in many cases. Bailey notes that figurines "are inclined to deceive" (1996: 292), usually by emphasizing some characteristics at the expense of others. The categories of animal vs. human may not be mutually exclusive in all cases, nor the distinctions between adult and child nor between male and female (Bailey 2005: 15). In other words, whatever the role of the figurine, it might simply involve an invocation of "something", not necessarily "that thing".

Bailey's "deception" by the figurine makers can involve intentional ambivalence or ambiguity concocted by the figurine maker. Two examples of this come from the LPPNB megasite of Basta in southern Jordan (Fig. 13). One green marble pendant ca. 5 cm long is roughly semi-cylindrical in shape and has, at first glance, a rather cartoonish (of "Kilroy was here" style) depiction of a human face, but on closer inspection the nose and eyes might depict a penis and testicles (Hermansen 1997: Plate 4: B). Another pendant of similar size made of limestone could be interpreted in three ways: (1) as a ram's head, with horns curving down from the top of the head to surround two "coffee bean" eyes, with a small horizontal slit along the bottom to represent the mouth (Hermansen 2004: 102 and Fig. 15: 2). (2) Alternatively, the curving features might represent arms rather than horns, and the "eyes" could also be seen as breasts of a female human, with the incision at the bottom setting off the pubic area from the rest of the body; note that in this view the figurine would be headless by design and execution). (3) Finally Hermansen also remarks that when this figurine is turned upside down, the figurine becomes a phallus and scrotum.

Gender Bias?

The myth that human figurines in Neolithic contexts in the Near East are overwhelmingly female has long held sway over the general public and many archaeologists alike. In part not only does this go back to Hamilton's "political/historical baggage", but also there have been concerted efforts to focus on the female images as representative of deities, no matter how they were used and discarded.

In Anatolia, at least, the situation is one where males and females are essentially equal in terms of representation in the PPNB period, and only later did an emphasis on females and pregnancy become apparent (Voigt 2000: 290). Male figurines also occur in the central and southern Levant, but in some cases the lack of effort to represent male genitalia explicitly may be a reflection of technological problems (for example, in the fashioning of the plaster statues at 'Ain Ghazal).

One focus of controversy has been the identification of the "Mother Goddess", a concept that was championed by Mellaart and exaggerated by Gimbutas (e.g., Gimbutas 1991). While there are still adherents to this notion throughout the archaeological community, there are also vocal opponents, perhaps most forcefully expressed first by Ucko (cf. Ucko 1996) and by a troupe of researchers since then (Tringham and Conkey 1998; Bailey 2005: 12; Haaland and Haaland 1996: 298).

Pregnant females are numerous everywhere, but especially in the southern Levant during the MPPNB period, when environmental and sociopolitical conditions appear to have intensified (e.g., Rollefson 1997). Pregnant females have usually been referred to as "fertility figurines", implying that women may have relied on them to become pregnant. Another viewpoint is that the gestation period, and especially the birth event itself, represent the most dangerous times in a woman's life, and that the pregnant females could have been fashioned to protect the mother through this crucial period (Rollefson 2000: 167–168; cf. Hershkovitz and Gopher, this volume, and Rolston in Rollefson et al. 1985: 106). In addition, if women were having more children over their lifetimes, the dangers would have been more frequent. (Of course, both purposes for fertility and protection were possibly in effect.) The latter interpretation would fit well with the assertions by the Haalands (1996: 297) and Bailey that "[the meaning of female figurines] emerges in the crises of the life cycle" (Bailey 1996: 16).

Familiarity Breeds Contempt

The proportional representation of certain animal species, if one can be confident in such an undertaking, often demonstrates that the figurines and diet are not necessarily correlated. Özdoğan decried the absence of pig figurines during the Round and Grill building subphases at Çayönü during the times that pigs figured so prominently in the settlement's food resources. Similarly, at 'Ain Ghazal, goats accounted approximately 50% of the animal bones during the MPPNB period, yet only one and perhaps two animals could be assigned to this category; cattle figurines, which were so predominant, were still morphologically wild (although the domestication process may have been well underway), accounting for only 8% of the animal bones (although this would have meant a sizeable contribution to the menu) (Köhler-Rollefson et al. 1993: Table 1). This might imply that some figurines were not especially imbued with any "power", such as goats and the dog at 'Ain Ghazal and pigs at Çayönü, and that such figurines may have been made as toys for (and even by) children (see also Voigt 1983: 187).

Size *Does* Matter, Probably, At Times

For the most part figurines of clay are relatively small, often in the 4–10 cm range for maximum dimension. At other times, relatively huge images are created, as was the case of reliefs and free-standing sculptures at Göbekli Tepe, Nevalı Çori, Jericho, and 'Ain Ghazal. It would seem likely that those people called on or allowed to view the large objects were expected to be impressed with them, and that this "awesomeness" had a very different dimension of meaning than, for example, small clay figurines. Even within the "monumental" statuary at 'Ain Ghazal, there is a clear separation of two sizes: the small busts and the standing statues (with legs and feet) that tower over the former. The stark contrasts, especially in the 1983 cache, certainly imply a distinction in what each group represents, and it has been suggested that this dichotomy might reflect mythical ancestral lines of both clan and lineage (or some similar divisions) connections of the inhabitants of the settlement (Rollefson 2005b: 7).

Who Is Involved?

Many of the ritual activities that took place immediately preceding and during the Neolithic were probably relatively democratic in the sense that some of the activities that involved "external" forces may have directly involved each person. Could some figurines have been made by the commoner in the village, or could figurines become "powerful" only through the intervention of shamans or, possibly associated with the cult rituals, full-time priests? Once a figurine was made, was it possible for an individual to keep it for some period (until its effectiveness was successful, perhaps) before discarding it? Every human figurine (except one) from 'Ain Ghazal (including a PPNC stone specimen) had been broken, and the pattern suggests intentional fracture, presumably (?) to release the "power" that inhabited the piece, and states of fragmentation are similar throughout the Near East (e.g., Voigt 1983: 187). (The exception at 'Ain Ghazal appears to be a small vignette that may have represented a personal commentary; cf. Rollefson 1986: 47.)

The personal or domestic use of figurines is supported to a great extent by the wear patterns on many of them (Voigt 1983), and their high numbers in many sites also supports this idea. Bailey notes that the small three-dimensional objects can be held and carried, which invokes a sense of intimacy when there is direct personal contact of the participant, a "physical interaction," with the spiritual world (Bailey 2005: 20).

Why Make Figurines?

The answer to this question may seem obvious, but there is more to it than simply saying "because the people felt that the figurines could help them." But why were the people in trouble to begin with? This question actually lies at the heart of the entire conference: the consequences of the Neolithic transition.

We cannot be certain that mobile Near Eastern Paleolithic hunter-gatherer groups did not make figurines; Upper Paleolithic groups in Europe clearly did manufacture small, portable figurines and images of both humans (usually females) and animals, and created wall carvings and veritable art galleries. To some extent, this visual expression of ritually oriented activity may have been associated with a semi-sedentary and even sedentary situation, as at Dolni Vestonice. In the Levant, cave walls appear to have been inappropriate for parietal art, and it is highly possible that archaeological visibility is playing its inevitable hand should the figurines have been made of organic materials (viz. the wooden figurines from Nahal Hemar; Bar-Yosef and Alon 1988).

But there are also clear examples of changes in social settings that began to emerge with the Natufian/Late Epipaleolithic period and flourished in the Neolithic. Sedentism and population growth are not necessarily consistent with the quality of life, even if food production could eventually establish a stable food supply. Day-to-day, face-to-face confrontations with growing numbers of people must have had some socio-psychological impact throughout the eastern Mediterranean, and the simple solution of leaving the crowded scene, which was so easily available among hunter-gatherers, was much more difficult with the investments individuals made in house construction and the direct connection with a particular piece of ground for food production, as well as for burials (of at least some members of the family) and what these aspects mean for social identity. Even with stable food supplies, life in the growing villages produced such drawbacks as trash accumulation and sewage disposal, both of which could become vectors for disease. The increasing reliance on, and intimate physical association with, domesticated animals was also a threat to health, as the cases of tuberculosis at PPNC ‘Ain Ghazal attest (Najjar et al. 1996). With the evident evacuation of the West Bank and the Jordan Valley at the end of the MPPNB, competition became especially intense for farmland, and the packing of populations into older highland Jordan settlements, as well as the founding of densely populated new settlements in previously under-populated areas in the southern Jordanian plateau, created circumstances where “strangers” inhabited one’s home town (cf. Kohler, this volume, where kinship became subordinated to civic solidarity).

The permanent architecture of farming settlements, whether of small PPNA hamlets or LPPNB megasites, portrays a superficial picture of stability and perhaps contentment. But life (and discomfort and disease and death) inside the settlements may have been much less satisfactory, and appeals to the spirit world to assuage – if not to correct outright – the situation could have been a principal focus of everyday life. Figurines, like modern placebos, may have been at least partially successful in a psychosomatic way, for their creation and use continued for millennia.

The NDT in the Perspective of Ritual Activity

Practices of religion and superstition (usually not easily separated) often reflect attempts to accommodate social needs with perceived threats in the natural and social environments. The situation at ‘Ain Ghazal might be instructive in how ritual activity was a response to strains that Neolithic society suffered, and how actions were taken to ameliorate those pressures. In terms of small, “personal”, or “domestic” images, in the earliest occupational phase at ‘Ain Ghazal (MPPNB) nearly 200 clay figurines were recovered, representing 40 humans and 155 animals.[1] In the succeeding LPPNB only 3 human figurines were recovered, as well as 15 animal figurines. PPNC contexts supplied 8 human and 20 animal figurines, and the Pottery Neolithic Yarmoukian deposits provided 8 human figurines and 12 animal representations.

These absolute counts by themselves are suggestive, but they become even more meaningful when consideration is paid to the amount of area/volume sampled for

[1] Although some of the figurines could be identified as females, many were obscure in terms of sex, a situation common in most archaeological situations in the Near East. Figures for other sites will not discriminate between males and females.

these periods. The MPPNB period at ‘Ain Ghazal was investigated over ca. 250 m^2 (and something like 300 m^3, although this has not been verified at this stage); for the LPPNB, almost 1, 200 m^2 have been sampled (and roughly 600 m^3), whereas PPNC layers were examined over more than 1, 500 m^2, and the Yarmoukian period over some 1, 200 m^2. However, these numbers conflate area and population density, which are definitely variable over the occupation of the site; cubic meters for both the PPNC and Yarmoukian periods are roughly equivalent to the areas sampled.

The comparisons of the numbers of figurines with the sampled areas/volumes are related to the population of the ‘Ain Ghazal settlement, although the correlation is certainly not one-to-one. Although MPPNB ‘Ain Ghazal began as a relatively large village (2 hectares? cf. Rollefson and Köhler-Rollefson 1989), it grew to about 5–6 hectares by 9,500 calBP, with perhaps 800–1,000 inhabitants by the end of the period. The sudden growth of the settlement at the beginning of the LPPNB (doubling in size and population in a few generations) resulted in populations that reached between 2,000 and 3,000 or more by 8,900 calBP, when population pressures on the environment resulted ultimately in a major depopulation of the town (and the region; cf. Rollefson 1997). The PPNC population had fallen to perhaps only several hundred residents, and during the final phase of permanent settlement at ‘Ain Ghazal, Yarmoukian residents perhaps ranged between 100 and 200 people. For ‘Ain Ghazal, then, figurine production and use were clearly most intensive during the MPPNB, after which these small images lost much of their significance in general domestic importance. A parallel to this reduction of physical ritual paraphernalia is seen by the sudden disappearance of the MPPNB plastered skull cult in the southern Levant and the disappearance of plaster statuary in the central Levant.

It is not easy to compare the changes at ‘Ain Ghazal with what happened elsewhere in the Near East. First, many excavated sites did not entail as long as a Neolithic sequence, with many containing only one or two main subphases of the Neolithic. Second, for some deeply stratified sites, figurines are described but no mention is made of the strata from which they appeared; a case in point is Çayönü, although Özdoğan mentions that most of the figurines come from the “Second Stage” at the site (A. Özdoğan 1999: 59). Third, in many cases the numbers of figurines may be provided (but not always), but it is not simple to interpret these numbers without knowing the relative volumes of excavated sediments, nor with little indication of the numbers of people inhabiting settlements during particular Neolithic periods. Nevertheless, it seems that figurine manufacture reached a peak during the MPPNB, and that there was a major drop-off in production in the LPPNB and later times.[2]

[2] There is one principal exception to this pattern. Contenson’s excavations at Tell Ramad produced a total of 9 figurines (1 human and 8 animals) in layer 1 (dated to the MPPNB), while 474 figurines (270 humans and 204 animals) derived from layer II, ascribed to the LPPNB. Notably, Tell Ramad also has the only plastered skulls from the LPPNB (layer II).

Concluding Remarks

The issues surrounding figurine production remain obscure to a great degree, and much of what has been discussed above reflects at least some degree of consensus among prehistorians working in the Near East, but this should not be taken to mean that we "know" what those small (and large) pieces of clay and stone represent. One anecdote from the recent past serves as a cautionary tale. In 1990–1991 while on sabbatical in India, we revisited a village where Dr. Ilse Köhler-Rollefson was involved in a project that involved veterinary care of camels owned by local inhabitants. Within a few minutes of arrival, six or seven children came into the house where we were speaking with some of the camel owners and presented Köhler-Rollefson with six or seven sun-dried clay figurines of camels that these children had made, well formed and complete with string reins. These precious gifts are curated now, and third millennium AD archaeologists may have a field day explaining the cache they excavated from a central German farmstead, where the bones of camels are certainly unrepresented in the middens.

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Evaluating the Emergence of Early Villages in the North American Southwest in Light of the Proposed Neolithic Demographic Transition

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Abstract Between AD 760 and 880 villages of 70 to more than 400 people formed rapidly in the Mesa Verde region of the North American Southwest. The emergence of the earliest villages appears to be linked to rapid immigration of new populations into the region. Conflicts over patchily distributed, dense resources, and differing cultural identities, as well as the demands of specific economic intensifications, may have favored aggregation over the long term. Although these factors are substantiated in the archaeological record of the region, models incorporating our present data remain insufficient to explain the rapid emergence and relative instability of these earliest villages. Bocquet-Appel's identification of a global Neolithic Demographic Transition, characterized by dramatic increases in fertility rates in early Formative societies, suggests that intrinsic population growth may have played more of a role in the expansion and instability of early villages than we have so far allowed. New burial and excavation data from a relatively short-lived, but densely populated, locale in the Mesa Verde region support the proposal that part of the unexplained instability in our models is associated with an extremely high growth rate and its effects.

Keywords Mesa Verde · Pueblo I village · pit structure · kiva · violence

Introduction

We will cover three related topics relating to the earliest villages in the northern half of the American Southwest in light of the Neolithic Demographic Transition (NDT). First, we briefly review the early Pueblo chronology of the Mesa Verde region, with a particular focus on the period of the earliest villages. In comparison to some of

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the other regional studies presented in this volume (e.g., Kuijt or Shennan), our attention is on a relatively small region and a very short time period, but with a very large archaeological sample. This offers us the unique opportunity to understand some of the general characteristics of a number of potentially contemporary villages. Second, we highlight the variety we see within village organization at this time and how rapidly it changes. We are fairly confident that we have at least two to three different cultural groups who are strikingly different at the beginning of our sequence but after only a hundred years are distinguishable solely at the organizational level. Third, we consider the different factors that must be considered in understanding these emerging villages: their changing populations, their ecological settings and histories, and their potential for conflict. Throughout the chapter we will explore the possible threshold situations which may trigger the emergence of these villages. Our emphasis is on the particulars of initial village emergence. By concentrating on the changes seen at the level of a single human generation, it is possible to better understand how these early villages actually emerge. This is, of course, a different question than why they might persist.

Although villages have long been recognized as part of the formative transition from a dispersed hunting and gathering existence to an agriculturally based economy (Willey and Phillips 1958), there still is considerable variety in the explanations of how and why these villages form and thereafter break apart. One of the relatively new explanatory themes that we explore relates to the potential role of rapid population growth in the emergence and instability of early formative villages. In this chapter we consider the implications of Bocquet-Appel's (2002) proposed NDT using primarily mortuary data from the Animas-La Plata Project, an immense archaeological investigation which resulted in the excavation of two early agricultural villages in southwestern Colorado dating to AD 800.

The strengths of our data sets are primarily in their accuracy and precision. The ability to obtain tree-ring dates from certain timbers found at these archaeological sites allows us to date the structures at a number of the sites to the decade or even to the year of construction. This, along with an average village use-life of about 30–40 years, offers us a very dynamic view of these large settlements. In our general comparisons we integrate data from eight early villages that have been excavated out of the more than 40 known for the Mesa Verde region in this 150-year period (AD 750–900). Because we have good survey records for more than two-thirds of the remaining villages, we are able to document generational changes in social organization and settlement strategy. Granted our villages emerged only about 1200 years ago (AD 775), but they clearly are self-organized phenomenon and are a reasonable outcome that begins with the widespread adoption of agriculture in this area 800–1100 years before (300 BC–1 AD). The villages are well outside the influence of the nearest state system, which is almost 2000 km away, and emerge without outside nudging. Ours is a recent story compared to many of others discussed in this volume, but it is so rich in detail and so well dated that we think it is worthy of attention.

Pueblo I Villages in the Northern Southwest: Their Characteristics

Villages occur in this region in two distinct time periods, Pueblo I (AD 750–900) and Pueblo III (AD 1150–1300). The Pueblo III villages of Mesa Verde National Park are the far better known of the two, but the Pueblo I villages are of particular interest because they are the original conception of this settlement type and in some ways better illustrate the dynamics and instabilities of the rapid shift to aggregated settlements. Pueblo I villages are found in various locales within an area of approximately 21,000 sq km, or an area about twice the size of modern Lebanon or about the size of the state of Massachusetts. It is similar in size to some of the areas of the Levant with higher densities of Neolithic villages (Byrd 2005: Fig. 4).

Our Mesa Verde study area is primarily a semi-arid plateau which ranges from 1200 to more than 3200 m in elevation. It is bounded by the La Plata and San Juan Mountains to the northeast and has a single mountain, Sleeping Ute Mountain, and a high escarpment, Mesa Verde, in its center (Fig. 1). Vegetation ranges from sagebrush and saltbush in the arid lowlands to alpine forests and tundra in the wet uplands. The area is cut by rivers that drain the well-watered mountains

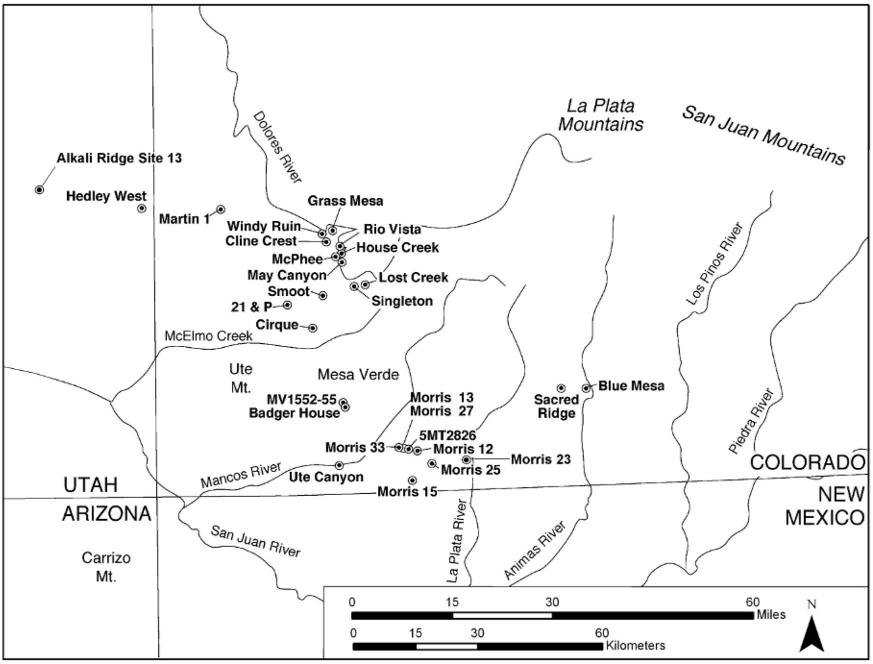

Fig. 1 Central Mesa Verde Region, with the locations of key Pueblo I villages. Based on a drawing in Wilshusen and Van Dyke 2006: Figure 7.2

and intermittent streams in deeply entrenched canyons that drain the plateau. The vast majority of Ancestral Puebloan occupation was in semi-arid areas with good agricultural soils, sufficient precipitation for maize agriculture, and nearby water sources and woodlands. Irrigated agriculture along the large drainages is difficult because cold air drainage from the nearby mountains creates freezing conditions in these locales well into the summer. Agriculture in the more temperate areas is made risky by the need for both adequate winter snows and summer rains to allow for suitable moisture to produce successful summer crops. Despite these risks, the area is sufficiently productive for agriculture to have had dense prehistoric populations at three different periods in the past.

We focus on just one of those periods, Pueblo I (AD 750–900) in our present discussion. We now have a sufficient sample of well-documented Mesa Verde region Pueblo I villages (Wilshusen 1999: Table 7-2) to characterize them and to set them into a historical context. These early villages appear to be a distinct and relatively short-lived settlement type that emerges under certain threshold conditions. Although we do not suggest the particular histories of the Mesa Verde region villages will be replicated elsewhere, we think there are some general characteristics of these villages that extend beyond the Mesa Verde case study and provide useful comparisons for analyzing other non-state villages. Because these early Southwestern villages in most cases did not go on to grow into larger towns of a thousand or more people, they present much clearer pictures of the nature of early villages than other Neolithic settings where the evidence of early villages is obscured and sometimes destroyed by later occupations.

Villages and Hamlets

In our discussion we will distinguish “villages” from “hamlets”. There are distinct settlement size differences between the two and little or no overlap. A settlement is either a hamlet, which is typically a residential site of one to four households (5–20 people) or a village, with at least 14 and typically 20 or more households (or more than 70–100 people). The average size of a Pueblo I village is 120–140 surface rooms and 15–16 pit structures (Wilshusen 1999:226). The largest villages appear to have over 400 rooms and 45 pit structures. In contrast, a typical small hamlet has about five rooms and a single pit structure. Larger surface rooms in the roomblock, as well as the pit structure, are the loci of domestic activities and smaller surface rooms serve as storage chambers for maize and other foodstuffs. A larger hamlet consists of 10–16 rooms and 1–4 associated pit structures (Fig. 2). A medium-sized hamlet has about the same floor area as a typical LBK house (Dobouloz, this volume).

In Pueblo I, it appears that contemporary hamlets and villages do not co-occur in the same locale. They appear to be incompatible settlement forms in these non-state systems. There are of course many contemporary hamlets found at 10 km or greater distance from a village, but they are often placed at some distance from a village. In some cases, after a village is abandoned and dismantled, one or more hamlets

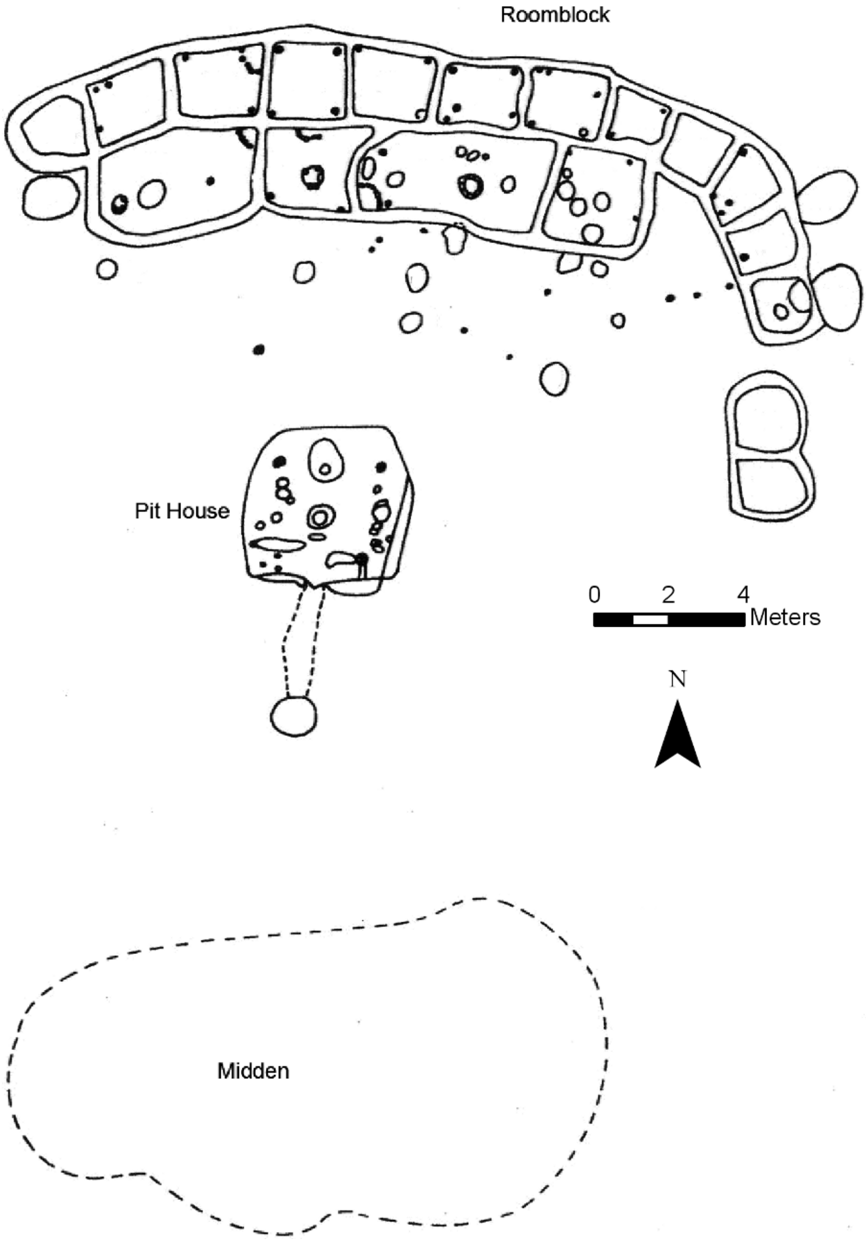

Fig. 2 Typical Pueblo I hamlet, Periman Hamlet, Colorado, ca. AD 800. Based on Wilshusen 1986a: Fig. 2.11

appear to have been partially built of salvaged timbers from that earlier village; so it seems that people may choose different settlement forms in different times, even in the same locale. Alternately, it is clear that many villages have earlier occupations in which a more dispersed settlement system of hamlets is evident.

Although we are only beginning to sort out the similarities and differences in household and community organizations in hamlets and villages, there is enough evidence to begin to consider this topic. In at least some hamlets, there is a great deal of evidentiary support for several extended households who share a number of tasks and tools amongst one another (Lightfoot 1994). This evidence, along with ethnographic models, suggests to some that a group with common ancestral links, such as a lineage, may be central to the formation and organization of hamlets. Although there are hints of lineal groups in some of the larger segments of a village, the surface rooms in villages appear to be less interconnected and more segmented into discrete stem, or nuclear, households. Some (Wilshusen 1989) have suggested that corporate functions in villages such as the control of agricultural land, redistribution of surpluses, and other economic and social tasks may be increasingly controlled by ritual sodalities or village-wide dual organizations. These early villages come together so quickly, and they are so large, that nearby kin-based lineages probably are insufficient to organize them. So a new village's households may be more interrelated by clan or moiety ties and ritual community organizations than by strictly lineal systems of kin-reckoning. Dual organization is a well-documented and simple mechanism that would allow a village to rapidly expand in size yet maintain a certain balance between various lineages in matters of local governance (e.g., Tuzin 2001). Lineages may not so much fade away in villages, but just become one layer within a multilayered dual organization. The one exception may be in cases such as village great houses (Schachner 2001; Windes 2004) where a particular lineage's power may be so preeminent as to be archaeologically visible. Whatever organization one reconstructs for Pueblo I villages, there is plenty of archaeological evidence that the nature of household and community organization changes in significant ways with the shift from hamlets to villages.

Village Longevity and Clustering

Non-state villages can be relatively short-lived settlements. With a few notable exceptions the first villages last no more than 25–40 years as individual settlements. It appear that it takes hundreds of years before the social ties that bind people into villages are sufficient to maintain them through difficult times. It is not until the second episode of village formation in the Mesa Verde region in the twelfth and thirteenth centuries that villages lasting longer than 50–80 years are evident. When we examine the ethnographic records of non-state societies there are varying social, economic, and ecological reasons for the short use-lives of villages (Wilshusen 1991). Read and LeBlanc (2003) and Shennan (this volume) have noted that populations will coalesce in those cases where resource density is high, but very patchily distributed. As population increases towards carrying capacity, household success is progressively more coupled to the success of the larger community in order to avoid conflict and keep order. As household mobility becomes less and less of an trouble-free option, then village stability and the viability of village organizational structures become ever more critical to individual household success. The short use-lives of Pueblo I villages suggests that there was a widespread perception that households were not necessarily dependent on village-based organizations for their ultimate success or safety.

A related aspect of settlement patterning is that early Southwestern villages tend to occur in clusters of two to seven contemporary villages which may represent a much larger socio-economic phenomenon. Villages are from 1–5 km from one another, but arranged so there is a distinct cluster of villages. Although these early Mesa Verde region village clusters have been noted (Wilshusen and Blinman 1992:265), they are still poorly understood. Similar, but better understood examples of village clusters have been noted for early historic contact village clusters in the Northern US Plains (Lehmer 1971) and the Great Lakes (Trigger 1976), as well as of Pueblo IV village clusters along the Rio Grande and in nearby areas (LeBlanc 1999; Spielmann 1994). Explanations of these clusters vary between those that favor warfare that drives people into larger and larger settlements for self-defense to those that propose cooperation and trade as the motivation for these settlement clusters. These issues will be further discussed in our last major section of this chapter.

It must be emphasized that overall regional population density remains surprisingly low (less than 1 person/sq km at the height of Pueblo I) for the whole region that we are looking at, even though the particular locales with the village clusters have extremely high population densities. The regional clustering of villages is intriguing because it appears to place even more strain on the ecological and social environment than a single village might. It is striking that clusters of villages form so quickly after the initial experiments with aggregated settlements. It is possible that clusters of villages characterize early Neolithic villages in other time periods and settings, but if this is the case, it is still not a widely recognized phenomenon.

Villages as Multi-cultural and Historical Phenomena

As we have acquired more and more data on these Southwestern Neolithic villages we have come to recognize that they come into being on a very intricate social and historical landscape. They are potentially much more hierarchical, multicultural, and much more aggressive than we originally assumed. Although some may suggest that these details are irrelevant to the larger evolutionary issues that drive village emergence, we argue that the historical context and the cultural choices people make within this context are critical to both understanding and explaining early Mesa Verde village formation, maintenance, and abandonment.

The earliest villages appear to have emerged in situations where recent immigrants were moving in on two edges of a region that had already been settled by agriculturalists for over 150 years. If anything, the recent immigrants to the east were less able farmers and architects than the original settlers of the region, but nonetheless some of the first large villages emerge in this newly settled area. Recent explanations (Wilshusen and Ortman 1999) of the changes of the next century emphasize the importance of different cultural and historical groups in both the form and organization of villages as they rapidly become more common. This will be explored in the next section.

The Emergence of Early Villages

There are four broad historical shifts in the short history that begins with the first known agricultural settlements and ends with the emergence and ultimate abandonment of these early villages: an initial period of agricultural development between BC 300 and AD 750 with a dispersed settlement pattern and considerable mobility, a period of rapid change between AD 750 and 800 when the first villages form on the eastern and western peripheries of the Mesa Verde region, a succeeding period from AD 800 to 850 in which the eastern and western peripheries are largely abandoned as well-formed and well-organized village clusters form in the central Mesa Verde region, and a final period after AD 850 in which the largest Pueblo I villages rapidly emerge and almost as rapidly are abandoned by AD 890 or so. After this, much of the Mesa Verde region is abandoned in the tenth century AD, and only thereafter reoccupied with a whole new sequence of aggregation and abandonment occurring in the eleventh and twelfth centuries. These are the much better-known Pueblo II and III sites of the Mesa Verde region and are outside of the scope of this discussion.

The historical particulars are not our focus here. Instead our objective is to emphasize the rapid development of villages and the broad sweep of organizational change in these early Pueblo I villages.

Setting the Stage for the First Villages: BC 300–AD 750

One of the key lessons of Mesa Verde archaeology in the last 30 years is the intermittent nature of the occupation of the region over the last 2500 years (Wilshusen 2002; Varien et al. 2007). Although the sequence was thought to be relatively continuous, as we have built up better survey databases and more precise histories of the region, we have come to understand that people have gone and come from the region much more regularly than we would have previously suspected from individual site records. Since 1995 we have been able to combine the survey data for 13,000 sites in this region with the very accurate tree-ring records from hundreds of excavated sites to see localized shifts in population within the region and to recognize significant depopulations of the region at certain critical junctures (Lipe et al. 1999). By achieving chronological precision that is often at the decadal level for excavated sites and at the 40–50-year level for surveyed sites, we see much more local and regional mobility than we previously expected.

For many semi-arid or arid areas, human occupation depends on a number of social, ecological, and economic factors remaining basically favorable. As population increases in particular regions, the tipping point for a group to decide to go or stay in a particular locale becomes more tied to these factors. We would not be surprised that with finer chronological controls, more intermittent local and regional mobility might also be evident in other Neolithic settings.

The appearance of the first agriculturalists in the Mesa Verde region dates to approximately 300 BC (see Kohler and Glaude's chapter in this volume for details), and it is likely they are immigrants from south of the San Juan River who brought maize with them. The movement of people with domesticated plants into new areas of the Southwest is comparable to the much earlier agricultural dispersals in the Old World (Bar-Yosef 2004; Bellwood and Oxenham, this volume). Population increases gradually over the next 600 years, yet regional population density is so low that we cannot confirm there is a continuous regional occupation during this interval. We just know that we have a number of single household to six household hamlets that are occupied between 300 BC and AD 400. Kohler and Glaude (this volume) argue persuasively that intensive maize use probably is not widespread in the region until AD 300, or about the time the first fired ceramic vessels appear in the region. Site use-lives are estimated to range from a few years to a few decades, with some sites showing periodic reuse. Food storage chambers are often located within domestic structures, which are non-contiguous shallow pit houses (Fig. 3). The burial sample and datable site sample from Mesa Verde region for this time period is too small to even hazard a guess at about the rate of population growth. In terms of material culture and subsistence, this period is roughly the Southwestern equivalent of the pre-pottery Neolithic A in the Southern Levant (Kuijt, this volume).

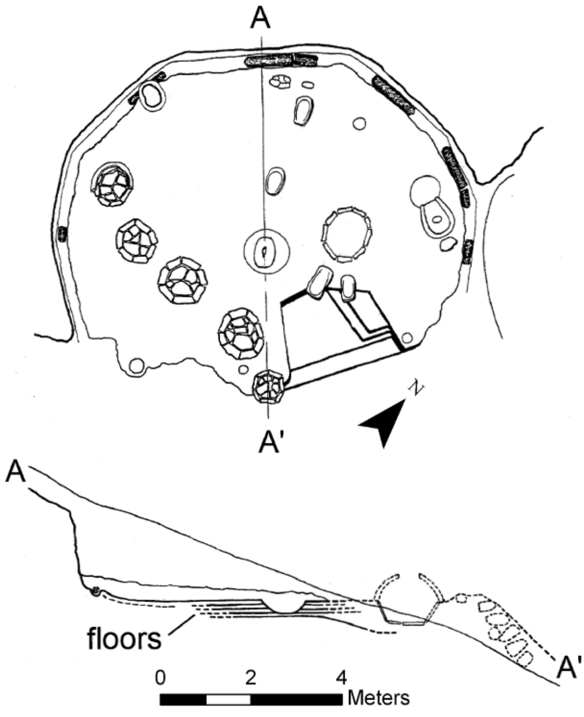

Fig. 3 Example of a Basketmaker II pit house, Talus Village, Colorado, ca. 200 AD. Based on Morris and Burgh 1954: Fig. 5

The region is largely depopulated between AD 400 and 600, and then sometime just before AD 600 there is a major wave of agricultural immigrants who populate the central area of the region. Residential sites consist of one to two household hamlets with the largest sites being surrounded by wooden stockades. Communities may be made up of clusters of five or more of these small farming hamlets spaced at 200–500 m intervals across a patch of good agricultural land, but this needs to be tested with more extensive excavation programs targeted at clusters of seventh century AD sites. Pottery vessels complement basketry and hence though we remain in the Neolithic, we are beyond the pre-pottery stage by AD 600.

By approximately AD 680 the local population had grown to at least 1750 people in various small communities spread over an area of about 8000 sq km. There is increasing investment in exterior food storage chambers and a move to using above-ground rooms in combination with pit houses for residential structures. People clearly are more invested in nearby agricultural fields and the long-term storage of maize. The largest sites must have been quite conspicuous, as they are often on small prominences and surrounded by wooden stockades that both delimited their domestic space and would have served as defensive redoubts in the case of attack.

The First Villages: AD 750–800

By AD 760 there is a surge of population on the eastern and western peripheries that almost certainly signals the immigration of hundreds of people into these areas. By AD 775 the earliest villages are being formed in these two areas. The shape and organization of these villages differ dramatically. The Durango village that has been most extensively excavated, Sacred Ridge (5LP245), is a circle of large pit houses surrounding a knoll with public architecture on top (Potter and Chuipka 2007). In contrast, the Alkali Ridge site (Brew 1946) in Utah is a rambling set of at least 150 above-ground apartment-like rooms with 12 associated pit structures arranged into four adjacent plaza groupings. There are other villages on the eastern and western peripheries and they are equally diverse in their arrangements with some looking like poorly designed trailer parks and others being apartment complexes that form a single tight circle almost 100 m in diameter. The Durango villages have a distinctive white ware pottery style and very rustic and idiosyncratic pueblo architecture. To the west, the Utah villagers constructed red ware pots unlike anything previously seen in the area and have a highly developed sense of the architecture that will be common in the villages that follow. The combination of above-ground residential and storage apartments with pit structures in the plaza will become the norm over the next century. Similarly red ware pottery will take on a special place in ceremony in these early villages, even though it is made of red-firing clays found only in the west of this region.

The first villages do not last very long. The village at Alkali Ridge (Brew 1946), in the western periphery of the region, is built sometime between AD 760 and 775. Its long run-on apartments probably lasted only 15–25 years, given the extreme winter conditions of this region. The combination of water and freezing tends to break down surface structure walls through a process of freezing and thawing of the outermost earthen construction material. So, the very levels of annual precipitation that allow these inhabitants to grow maize, beans, and squash are also partially the cause of the destruction of their houses. Based on both ethnographic and archaeological data it appears that an average structure's use-life was about 12 years. It is common to see structures rebuilt once and this would suggest a total use-life of about 20–25 years. In addition, the archaeological record shows that a population aggregate of 100–300 people can deplete nearby essential resources such as readily available firewood, wild game, and agricultural land, so that after 30–40 years (Kohler 1992; Kohler and Matthews 1988), it may be more profitable to move the village to an unspoiled setting than to rebuild the structures in it yet one more time. Many of the structures at Alkali Ridge were intentionally burned down upon their abandonment. There is little evidence of violence or natural wildfire, so the village appears to have been intentionally destroyed at its abandonment by its former habitants.

Two different villages in the eastern periphery, Morris Site 23 (Morris 1939) and Sacred Ridge (Potter and Chuipka 2007) are contemporary with Alkali Ridge Site 13 in the west. Almost 90 km separates the two areas with early villages and there are a number of differences immediately apparent between the two groups. Whereas Alkali Ridge has well-developed room blocks, surface rooms are rare and less substantial when present in the early eastern villages. Instead, the emphasis is on pit houses. There are at least three noteworthy aspects to these differences. First, it is clear that there is much less emphasis on the storage of maize in the east as compared to the west. The most secure rooms at Alkali Ridge are those small structures with no domestic features that are almost certainly granaries for maize and other food stuffs. It appears that almost from the start people in the west are able to store a year and half to two years' worth of maize in their surface storage rooms. Second, at Alkali Ridge it appears that most household domestic life is not centered in pit structures as appears to be the case in Sacred Ridge, as there are not nearly enough pit structures or even space for all the households represented by more than 150 surface rooms at Alkali Ridge. So, pit structures must begin to take on new functions such as being residences for special households, or being increasingly used as places for lineage or community rituals, or serving as men's houses in a matrilineal society. Third, over the next century, village layouts and architecture will draw upon both eastern and western aspects as villages become more and more well-developed and common.

Villages Begin to Take Shape: AD 800–850

By the late eighth or early ninth century, the villages on the peripheries are being abandoned and villages are beginning to form in the long-settled central region. As noted earlier, where villages form, hamlets rapidly disappear. Increasingly the villages are of two organizational types. One type of village has its largest room blocks built in the shape of a semi-circle or horseshoe and then enclosed by a stockade-like wall or a mound of refuse at the end. The other type has room blocks which consist of long rows of surface rooms with associated pit structures. Although we discuss these two different styles of village organization later, at this point we want to emphasize the apparent mixing of three different cultural traditions within villages of a generation's time span.

There are also different ways in which public architecture takes on a regular and expected presence in these villages. In some cases, immense pit structures that range between 10 and 20 m in diameter – great kivas – serve as the locales for community ceremonies or rituals (Fig. 4). These structures are built off to the sides of villages and do not appear to be owned by any one individual or lineage. They do not have many internal features, but instead serve similarly to ethnographically documented dance houses or community centers (Adler and Wilshusen 1990). In contrast, other villages have oversized square-shaped pit structures with diameters of about 8–9 m, but which are full of evidence of what appear to be the remains of altars, shrines, and special ritual features with analogs in the historic pueblos to the features in a kiva used by a village headman (Wilshusen 1989). The great houses associated with these structures appear to have controlled major community rituals and feasting and the household or lineage that controlled these structures would have exercised disproportionate power over community affairs (Schachner 2001). Drennan and Petersen (this volume) note that there are distinct differences in the organization of Neolithic villages in Oaxaca, the Colombian Andes, and northern China, but the Mesa Verde example is especially striking because two distinct contemporary types of village organization are evident within various communities in the same locale.

Finally, the pottery differences between east and west become muted and integrated in the villages built between these sub-regions. The red ware pottery becomes less common, but clearly highly valued and possibly associated with special or ceremonial uses. The poorly made white wares of the east are increasingly rare as the more highly symmetrical, emblematic, and well-executed designs of the central villages become the common serving ware. The villages in the center appear to draw in the populations from the hamlets that have long flourished in this sub-region as well as to be populated by the immigrants from the rapidly declining villages of the eastern and western peripheries. The evidence for these observations is far more evident in the more extensively excavated large villages of AD 850–900.

Fig. 4 Early Pueblo I rock art from Comb Ridge, Utah showing people gathering at a large circular structure, possibly a great kiva. Adapted from an original, and much more detailed, drawing by Ann Phillips. Used with permission

Florescence and Decline: The AD 850–900 Village Clusters

There are at least 21 villages with evidence that they were occupied in this period. These villages occur in four or five different clusters, and in this brief summary we will focus on the best-documented and most heavily populated of the clusters, those villages along the Dolores River. Two of these villages are well documented and well published and we briefly review Wilshusen and Ortman's (1999) comparison of the two.

In the case of McPhee Village there are several large horseshoe-shaped room blocks, with smaller room blocks bordering these great houses (Fig. 5). An over-sized pit structure with numerous ritual features, in some cases with ceremonial paraphernalia in place, was found at the center of the plaza of those excavated great houses. Red ware bowls, which are reminiscent of the pottery at the early village Alkali Ridge, are associated with the trash areas of the great houses and have been argued to have been vessels for ritual feasting. In the case of Dolores, it appears that the other three Pueblo I villages which are contemporary with McPhee and aligned with it on the west side of the Dolores River fit this same pattern.

These great houses appear to have greater storage, much greater involvement in ritual performance, and wield more social power than the smaller room blocks. This is particularly apparent when the village is abandoned and violent deaths are perpetrated on the adults who are buried in four different pit structures primarily in the smaller room blocks. In contrast, the key ritual structures in the great houses are purposefully burned down with ritual paraphernalia in place. Other structures appear to have just been walked away from.

On the east side of the Dolores the villages provide a subtle contrast in architecture, village layout, ceramic historic, and abandonment. These villages consist of long straight room blocks with poorly defined plazas and lack the over-sized pit structures which are analogous to historic community kivas in modern pueblos, but have great kivas either associated with the edge of or nearby a village. The earliest pottery in these villages is the lead-glazed white ware pottery type commonly associated with early villages to the east, such as Sacred Ridge. These villages appear to hang on for a decade or more after the abandonment of villages such as McPhee in AD 880, and only then are the pit structures in these villages burned down. It is striking that in the last decade of occupation the surface structures are abandoned and new small pit structures are built to weather the final years. This is remarkably suggestive of the dependence on pit structures for primary residences that we saw in the early villages of the eastern periphery.

These comparisons and other data make apparent that there are at least two and probably three distinct groups with differing cultural backgrounds and histories within these latest villages. There are communities organized in the great house pattern and others villages with much less hierarchy and potentially less dependence on surface storage. There are villages with historical ties to the early village pattern seen at Sacred Ridge and Blue Mesa and others with historic ties to the early western villages such as Alkali Ridge. Yet, we must not forget a third distinct cultural group was already in this area at the time that the earliest villages were forming

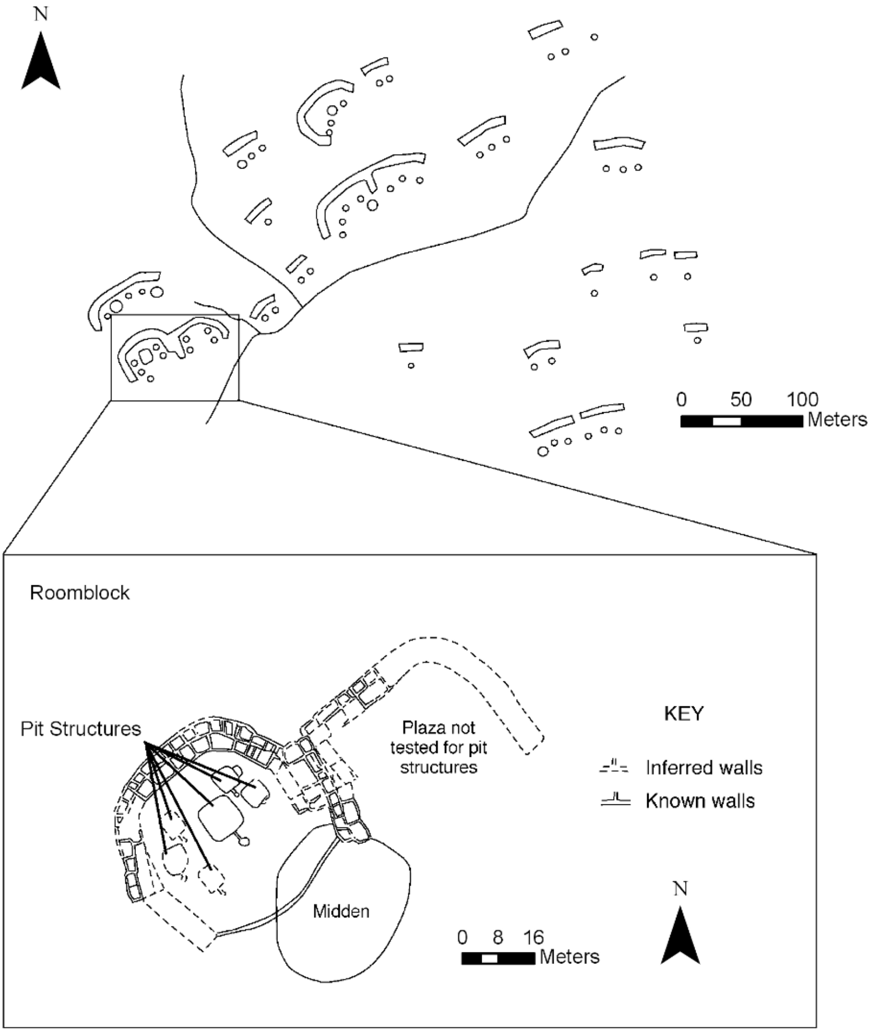

Fig. 5 McPhee Village, a late Pueblo I village with an estimated 400 contemporary rooms, Dolores, Colorado, ca. AD 860 (from Wilshusen and Van Dyke 2006: Figure 7.3). Reprinted by permission from *The Archaeology of Chaco Canyon*, edited by Stephen H. Lekson. Copyright©2006 by the School for Advanced Research, Santa Fe, New Mexico

to the eastern and western edges of the Mesa Verde region, so the latest Pueblo I villages in the Dolores area must represent a mix of two to three culturally and historically different groups. Villages must provide the opportunity or the outcome of the bringing together of these different peoples.

The history of villages we have recounted happens within a 120-year period following AD 760. Although recent articles on Neolithic villages have emphasized the rapidity of village emergence and the changes that occur (Byrd 2005, Petrequin et al. 1998), the history we have sketched is meant to demonstrate the truly dynamic nature of these early villages and the population movements that appear to accompany them.

Significant Factors in Village Formation

Aggregation clearly represents a remarkable change in settlement strategy and must be in response to either an unexpected opportunity or risk. We will deal with the opportunity possibilities in another paper, and examine here three commonly cited risks or pressures which might trigger aggregation: population pressures, competition for limited highly favorable ecological niches, and the increasing threat of social conflict due to clashes between different groups.

Population Growth

Bocquet-Appel (2002) and others have recently reminded us of the critical importance of escalating population pressure that comes with the adoption of agriculture and an increasingly sedentary life style. Ammerman and Cavalli-Sforza (1984) and more recently Bocquet-Appel (2002) and Bandy (2005) have further proposed that there is a two-stage demographic transition, with an initial period of dramatic population growth after the adoption of agriculture and sedentism and a second period of less dramatic, but still relatively high, population growth due to density-dependent risks such as increased contagious diseases (see Bocquet-Appel, Naji, and Bandy, this volume) and decreasing agricultural productivity. While our present study does not have the data to address the broad sweep of the NDT, we do have data to address the role of population pressure as a trigger to aggregation in the Northern Southwest during an initial period of demographic growth.

In the case of the initial villages in the Durango area, the villages formed so quickly after the immigration to the area – almost within a decade or two – it is not clear that local intrinsic population growth is the principal cause of the emergence of these villages. The population that arrived in the area was already in hundreds, and their relatively rapid move into an aggregated setting appears to be a reaction to other, more socially driven issues. Clearly the continued growth of regional population over the next 100 years (Fig. 6) helps to fuel continued population aggregation, but it does not appear to be the origin of it. Even at the highest population levels in Pueblo I, there is sufficient land for many more dispersed settlements than are ever found on the regional landscape at this time. So, what is the relationship between population growth and village formation in this particular case?

Preliminary analytical results from the Animas-La Plata Project in the Durango area allow us to consider how high population growth in early Pueblo I may promote a cascade of other pressures and contribute to an increasing movement of people into villages in this region. The Pueblo I cemetery sample ($N = 172$) is associated with early villages such as Sacred Ridge and shows many of the patterns expected in

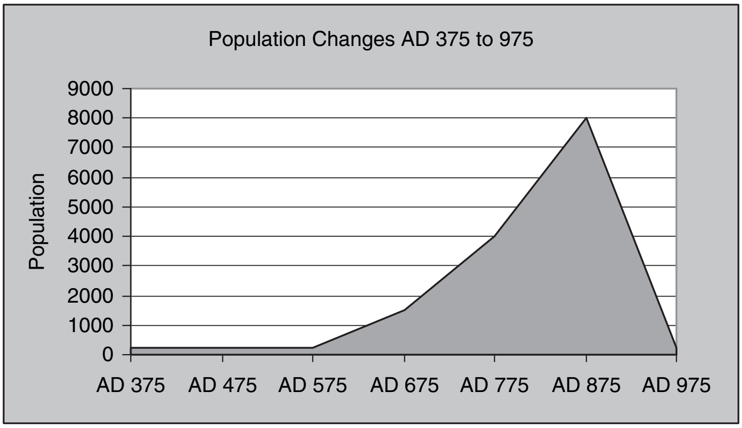

Fig. 6 Population changes

early agricultural societies (Fig. 7). Infant (age b-2) mortality is high (20%), but the survivorship curve shows that if an individual makes it to age 7, they have a high probability of surviving to age 35. Consequently, the potential survivorship for males and females through their primary reproductive years is relatively high, which allows for the possibility of a healthy reproductive rate. When one compares the proportion of immature skeletons (5–19 years of age) to the overall skeletal sample of all individuals 5 years old and above (or ${}_{15}P_5$), the result (.351) is remarkably similar to values Bocquet-Appel and Naji (2006) have documented in other

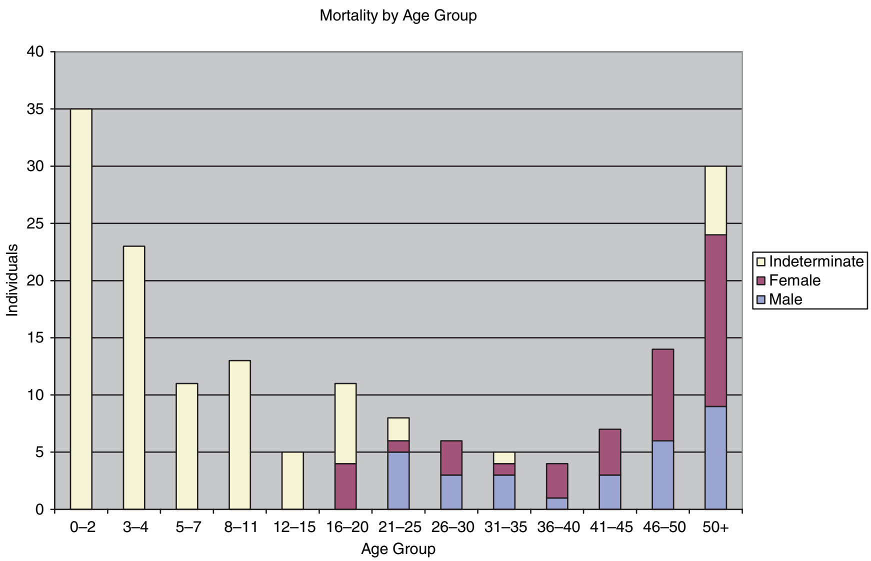

Fig. 7 Mortality by age group for Animas-La Plata Data Cemetery Data

paleoanthropological data from early farming societies worldwide. They persuasively argue that an increased ${}_{15}P_5$ ratio as represented in the Durango data is very likely indicative of an increased birthrate and population growth rate.

The Durango early Pueblo I data are surprisingly similar to composite Mesa Verde regional cemetery data ($N = 150$) for a much longer span of time from AD 600 to 1150 (Stodder 1987). Based on this sample Stodder derived an estimated maximum net reproductive rate (NRR) of between 2.11 and 2.56 percent/year (1987:424). Schlanger (1987:605–606) used comparable regional data to suggest a maximum growth rate of 1.5–2.4 percent/year. Either figure is an extremely high growth rate for prehistory (Weiss 1984) and roughly comparable to the NRR for the US population during the baby boom years (Stodder 1987:422). At a 2.0% growth rate population could double in as short a time as 35 years, and even if we consider Bocquet-Appel and Naji's (2006:350) estimate of a 1.26% growth rate for early farming societies, we still are looking at population doubling in 55 years. At such rapid doubling rates, areas such as Durango – which has relatively limited nearby agricultural lands – could be in a pinch for available farmland only four generations after the initial arrival of 300 immigrants.

Although the earliest villages form in areas that previously had low or no population, the rapid population increase due to both initial immigration and thereafter a high reproduction rate must have contributed to increasing concern and conflict over the finite resources of these areas. The abandonment of these initial village settlements after only 30–40 years time, and rapid spread of villages to more productive agricultural areas in the central Mesa Verde region suggest to us that the combination of rapidly growing populations within a region with dense, but patchily distributed resources set up a competitive struggle that favored increasingly aggregated settlements around the niches with the best access to good agricultural plots, forests for fuel and building materials, hunting areas, and good, year-round potable water.

Competition for Limited Ecological Niches

The rapid spread of early villages may either signal or cause an increasing competition for a limited number of ecological niches that are sufficiently well resourced to support a local community of 70–400 people. The increasing sedentism and long-term food storage strategies of early agricultural communities clearly limit a community's use of mobility as a means to deal with risk. While hunter-gatherers can move to new, less risky areas in times of stress without suffering great property loss, a major move by agriculturalists entails the potential loss of a great deal of their tangible assets. Consequently, agricultural communities often seek well-resourced areas and use long-term storage to buffer themselves from various environmental hazards. Their community organizations often serve to define and maintain access to these critical resource areas.

So, one possible explanation for early village emergence is that communities increasingly aggregate to lay claim to and defend their rights to areas with sufficiently secure water, rich agricultural soils, and forested reserves for a community's immediate and future needs. It is possible that the immigrants who form the earliest villages may be historically limited in their original choice of lands and this may add to the reasons for choosing to aggregate, but this explanation cannot be tested until we have a better understanding of the surrounding cultural landscape early in this sequence. From a purely ecological standpoint, there are immense tracks of land that appear to be under-populated in the mid-eighth century which are prime potential village real estate, but these lands are in the area of the central Mesa Verde which has been inhabited by a different cultural group for the prior 150 years. These lands may not be available to new immigrants without either risking deadly conflict or building connections with the other group over several generations time. By the time the early Durango villages are abandoned, it is clear the material culture of the Durango inhabitants increasingly is being influenced by the groups to the west.

As villages spread over the landscape in the ninth century, archaeological settlement pattern suggests that people are clustering at more than just the community level. In at least three cases, there are clusters of at least three to seven contemporary villages. So, instead of having just a single aggregate of 70–400 people on a particular piece of landscape, there are up to 1500–2000 people living within 10 km of one another. If one of the reasons for aggregation is for whole communities, as opposed to households, to lay claim to key resources, then it appears that this clumping of villages along major drainages close to some of the most productive resources and stable water sources in the region represents an even more intensified use of specific resources such as soil, woodlands, building materials, game reserves, and wild plant foods. Aggregated settlements become more common through the ninth century, so that by about AD 875 more than half of the estimated regional population is found in these village clusters. As higher percentages of the overall population settle into villages, it appears that large-scale violence in villages decreases over time; so it is possible that villages serve to constrain violent interactions over resources, territory, or identity.

Large Scale Social Conflict

A third possible reason for aggregation, one that appears to figure heavily in the move to aggregation in the later Pueblo III villages, is the threat of warfare, or large-scale social conflict (Kuckelman 2002; Glowacki 2006). The ethnographic and archaeological records certainly confirm that non-state societies with higher population densities, such as those found in villages, function partly to protect their inhabitants from external violence, as well as to threaten rivals with the potential for violence (Ember and Ember 1992). Although violence at the community level is a reason to maintain a village at a certain size and with a defensive position, it presently does not appear to be the original reason that villages emerge as a new settlement phenomenon. Once they do emerge, they are clearly under the threat of violence, based on the evidence at Sacred Ridge, one of early villages found near Durango (Potter 2006). Close to the end of its occupation, approximately 50 individuals are brutally killed and deposited in one of the structures in the village. It should be noted than no individuals from this mass violent death were included in the calculations for the Animas-La Plata paleoanthropological discussed earlier and illustrated in Fig. 7 (per criteria given in Bocquet-Appel and Naji 2006:342)

Although mass violent deaths are rare in the other 12 early villages which have been excavated, it should be noted that one of the latest Pueblo I villages showed evidence of the intentional slaying and intentional ritual burial of five pairs of adult males and females in four different pit structures. The source of this violence appears to be internal to that community, because the vast majority of the community is abandoned after the ritual burials, in an orderly manner, and with no other evidence of village-wide warfare. Although particular pit structures and surface structures are burned down at some Pueblo I sites in the Mesa Verde region, this often appears to be the result of ritual site "closure" (e.g., Wilshusen 1986b), rather than an act of warfare (c.f. LeBlanc 1999).

So, although raiding and group violence is a very real issue in the Northern Southwest dating to at least 600 years before in Basketmaker II times (Hurst and Turner 1993), widespread violence does not appear to be the precipitating cause of the earliest Pueblo I villages. Instead, group violence seems to have flared after the initial formation of these first villages and been centered on a particularly small and unusually designed village. After this event, villages become much more regular in their design and layout so that the boundary of each village is well defined, and in some cases very defensible. In some ways the threat of large-scale social conflict may have been more to do with the structure and maintenance of villages rather than their emergence.

Conclusions

We have considered three potential drivers for early aggregation – population pressure, territorial control, and the threat of group violence. The early Pueblo evidence demonstrates all three variables are deeply coupled with the conditions which lead up to the emergence of villages, but at present, initial village formation appears to be more driven by potential opportunities that villages present in an increasingly populated, resource-limited, and threatened landscape. The emergence of villages actually may be found in the opportunities that a new settlement phenomenon offers in restructuring households, reorganizing gender relations, intensifying the economy, and reinventing ritual and political organizations. There also may be more difficult-to-see issues related to redefining ethnic identity and the remaking of cultural landscapes. These very changes which will reshape villages as communities and remake the ecological and cultural landscape over the next century may ironically be seen as the original opportunities that draw people into a tight community... a new type of community that is larger than a single lineage, a hunter-gatherer band, or the number of people who might interact daily in a more dispersed agricultural community.

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Part IV
Population Growth and Health

Demographic, Biological and Cultural Aspects of the Neolithic Revolution: A View from the Southern Levant

Israel Hershkovitz and Avi Gopher

Abstract We present and discuss the life of people in transition from Natufian hunting and gathering to Neolithic farming in the southern Levant, as reflected in their bones and archaeological remains. Data on Natufian and Neolithic populations were derived from a series of available sites. Demographically, the transition to agriculture affected males and females differently; while females experienced a decrease in mean age at death in the Neolithic period, males experienced an increase. The distribution of female ages at death in the Neolithic period indicates that females may have given birth at an earlier age compared to Natufian females. Natufian women lived longer than males. Using the NDT model, ${}_{15}P_5$ shows that population growth was significant during the Late Natufian, the PPNA and the PPNC while it was much lower in the Final Natufian and the PPNB. No major changes in dental health between the two populations were observed. This indicates that Natufian and Neolithic people may have differed in their food procurement strategies, but consumed the same types of food. There is a clear increase in the prevalence of infectious diseases during the later parts of the PPN period. The magnitude (not the pattern) of physical stress was similar in Natufian and Neolithic populations although the MSM study suggests that certain daily activities in the Neolithic were more physically demanding than in the preceding Natufian. This may relate to new Neolithic activities such as making mudbricks, preparing lime-plaster, tree felling and grinding cereals. Neolithic females took over a greater proportion of the physical activities compared to Natufian females. Violent encounters were more common in the Natufian.

Keywords Levant · Natufian · neolithic · demography · neolithic revolution · diet · pathology · health · physical load · occupational disease · site formation processes

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Introduction

The transition from hunting and gathering to farming – the Neolithic Revolution – was one of the most significant cultural processes in human history that forever changed the face of humanity. Natufian communities (15,100–12,000 Cal BP) (all dates in this chapter are calibrated before present) planted the seeds of change, and the Pre-Pottery Neolithic (PPN) (ca. 12,000–ca. 8,350 Cal BP) people, were the first to establish farming communities. The revolution was not fully realized until quite late in the PPN and later in the Pottery Neolithic (PN) period.

We would like to ask some questions and comment on a few aspects emphasizing the linkage between biological and cultural developments during the Neolithic Revolution.

The biological issues addressed in this chapter are as follows:

☒ Is there a demographic change from the Natufian to the Neolithic?
☒ Is there a change in the overall health of the Neolithic populations compared to the Natufian?
☒ Is there a change in the diet and how is it expressed?
☒ Is there a change in the physical burden/stress people had to bear with?
☒ Is there a change in intra- and inter-community rates of violent encounters?

From the cultural perspective the leading questions will be:

☒ What was the change in the economy and when was it fully realized?
☒ Is there a change in settlement patterns and site nature and organization from Natufian to Neolithic?
☒ Is there a change in human activities and division of labor?
☒ How did social structure and social organization change?

Materials and Method

The skeletal populations studied: This study was carried out on the remains of 404 Natufian and 246 Pre-Pottery Neolithic individuals housed at Tel Aviv University.

The Natufian is subdivided into three parts following Valla (1984, 1995) and as presented by Bocquentin (2003) who studied Natufian skeletal remains: Early (15,100–13,200 Cal BP), Late (13,200–12,550 Cal BP) and Final (12,550–12,000 Cal BP). The PPN was also subdivided into three parts: PPNA (12,000–10,500 Cal BP), PPNB (10,500–8,900 Cal BP) and PPNC (8,900–8,350 Cal BP). Sample size was not, however, sufficient for detailed subdivisions and therefore we related to Natufian individuals from all phases as one biological/cultural entity and to all PPN phases as a single unit, unless otherwise stated. Grouping skeletons from sites covering a long time span and varied geographies may introduce biases to our results, especially when dealing with one of the most dynamic periods in human history. We do, however, assume that had there been general differences between the Natufian hunters and gatherers and the slowly establishing Neolithic farmers these would bear themselves out since the Neolithic sample has quite many skeletons dated to the Middle PPNB (MPPNB), Late PPNB (LPPNB) and the PPNC.

Representativeness of the populations: It is not clear to what degree the archaeological sites available for study are adequate representatives of their period – they were not randomly sampled; their excavations were motivated by various reasons, e.g., salvage excavations following modern development, a tendency to excavate impressive and large sites and a special attractiveness of cave sites; preservation is differential vis a vis climate, sediments, etc.; the size of the excavated area varies; human behavior toward the dead (burial customs) varies; etc.

Age and sex determination: Anthropologists not only vary in their methodology (mainly on age and sex determination), but also the accuracy of their methods was greatly criticized (Hoppa and Vaupel 2002, Bocquet-Appel and Masset 1996, 1982). To partially overcome this problem, we utilized only data collected either by the authors or their students and in each section we indicated the sample size and the sources from which it was derived. Data from other sources were used for supplementary purposes only.

Sex identification for all individuals over 15 years of age was based on the following methods: morphology of the skull and long bones (Bass, 1987), morphology of the innominate (Bass, 1987; Segebarth-Orban, 1980; Washburn, 1948) and the vertical diameter of the femoral head (Bass, 1987). For 63 Neolithic individuals (24.0%) and 64 Natufian individuals (29.5%), sex could not be determined. Age determination was carried out using the following criteria: metamorphosis of the auricular surface of the ilium (Lovejoy et al., 1985a), metamorphosis of the pubic symphysis (Brooks and Suchey, 1990), stages of tooth attrition (using standards modified from Hillson, 1986; Lovejoy, 1985), metamorphosis of the sternal end of the ribs (Loth and Iscan, 1989) and the presence of osteophytes and arthritic lesions on vertebral body (Nathan, 1962). For young adults, i.e., 15–25 years, the following additional criteria were used: closure of epiphyses on the long bones (Johnston and Zimmer, 1989) and closure of the sternal ends of the clavicles (Szlivassy, 1980). For the subadult class (under 15 years), we used the following criteria: the length of long bones without the epiphyses (Bass, 1987), stages of tooth eruption and development (Ubelaker, 1989) and closure of the epiphyses of long bones (Johnston and Zimmer, 1989). A final estimated age for each skeleton was computed by averaging the data obtained from the different aging methods. For 88 Neolithic individuals (33.5%) and 55 Natufian individuals (25.3%), age could not be determined.

Life-table construction: Calculating life tables is the most useful technique for dealing with mortality. Life tables were constructed using 5-year age intervals to age 20 and 10-year age intervals at older ages. Final life tables are presented in 10-year intervals (Ubelaker, 1974). All adult individuals for whom age could not be determined were divided into adult age categories according to the relative frequency of individuals found in each age group. This was based on the assumption that the observed percentage of the age groups represents the real mortality pattern of the population. We also smoothed the life tables using a five-parameter competing Hazard model developed by Siler (1979), using methods described in Gage (1988).

This model facilitates life-table construction without imposing a particular age pattern of mortality on the data. It can be applied to small populations and can "correct" defective data and smooth random variation in age-specific mortality resulting from small sample sizes (Gage 1988). Using the model by Siler (1979), we constructed life tables assuming stationary populations and assuming stable populations with a 0.5–1% growth rate. In general, stationary or very low population growth rates for hunter-gatherers is expected just prior to the advent of agriculture (Carneiro and Hilse, 1966; Hassan, 1981; Hershkovitz and Gopher, 1990).

The NDT model: Assessing the significance of the demographic data collected and the question whether a 'new demography' was established in the Neolithic period, we calculated the signal for demographic transition (NDT) as suggested by Bocquet-Appel (2002). This signal (delineated as ${}_{15}P_5$) measures the proportion of immature skeletons, 5–19 years of age, in the population at each site. Children under 5 years of age are excluded.[1] Considering the biases associated with skeletal representation in Natufian and Neolithic sites (see above), we included in this procedure only sites where: sample sizes were greater than 15 aged individuals, age was accurately determined, no evidence of violence was noted, the cultural context of the skeletons was clear and dating was secure. Additionally, sites where mass (commingled) burials were found (e.g., Kefar HaHoresh) were cautiously treated. While processing data for the NDT model we used sites we did not study on our own (unlike the procedure used for other parts of this study) referring to the original reports (e.g., Rollefson 1985 for Ain Ghazal; Rohrer-Ertl 1978 for Jericho) or overview studies such as Hershkovitz and Gopher (1990), Belfer-Cohen et al. (1991) or Bocquentin (2003). In certain publications, ages were not available at the required age classes for calculating ${}_{15}P_5$ (e.g., PPN Jericho). In these cases we calculated and presented the maximum and minimum ${}_{15}P_5$ values or the average. The case of Jericho PPNA where the N shows 63/235 indicates that we could use only 63 aged individuals out of the much larger sample. In cases with contradicting demography-related data sets in different studies, we either gave up the sample or presented a range of the results or an average; for Natufian data we preferred Bocquentin (2003).

Paleopathology: Reconstructing the health status of a prehistoric population is not an easy task for two main reasons: (a) not all diseases leave marks on the bones, and when they do, the 'mark' may be ambiguous (i.e., found in more than one disease) rather than pathognomonic or specific. To partially overcome this problem, we restricted ourselves to disease categories (e.g., inflammatory) rather than specific diseases (e.g., tuberculosis); (b) a high presence of pathological bones does not necessarily imply a lower health status of the population, sometimes it may even indicate the opposite (Wood et al., 1992). In the current study, in addition to the standard criteria (e.g., Ortner and Putchar 1981), two specific osseous changes have been used to identify the presence of infectious disease: numerous grooving of the endocranium (phenomenon known as Serpentine Endocrania Symetrica) and bony plaque on the long bones (known as Hypertrophic Osteo-Arthropathy) (Hershkovitz et al., 2002).

Statistics

All statistical analyses were carried out using StatView for Macintosh. *P* value was set to 0.05.

Data Processing

The anthropological analysis focused on identifying the demographic profile of each individual (sex, age), body structure, diseases, physical load, nutritional stress, occupational markers and signs of violent encounters. The archaeological observations related mainly to settlement patterns and site nature (location, size, density, architecture, etc.), work load and activities, health, specific material culture aspects, economy, subsistence economy and diet, social structure and organization, and burial practices.

The Biological Perspective

Demography

Demography is not just a statistical expression of various biological characteristics of a population; it is, in many ways, the key to an understanding of the complex interaction between past human populations and their natural, economic and socio-cultural landscapes. Methodological deficiencies and limitations of both the anthropological and archaeological aspects greatly hamper our ability to deduce significant information from the demographic data obtained. This part of the study presents and discusses characteristics associated with various demographic aspects of the Natufian (hunters-gatherers) and Neolithic (farmers) populations in the southern Levant.

Sample size and data source: The study of demography is based on 217 Natufian (15,100–12,000 Cal BP) skeletons and 262 Neolithic (12,000–8,350 Cal BP) skeletons from the southern Levant. Data are from Eshed (2001); Eshed et al. (2004a) and Hershkovitz and Gopher (1990).

Adult sex ratio: Sex ratio was slightly lower in the Neolithic period (1.89 females per one male) than in the Natufian (2.2 females per male).

Life expectancy: Assuming stationary populations, life expectancy at birth (e^0x) was 25.4 years for the Neolithic population and 24.6 years for the Natufian. If the Natufian population was stationary while the Neolithic population was growing at a 1% rate, life expectancy in the Neolithic would increase to 31.1 years (Fig. 1).

Adult mean age at death: The mean age at death for adults is 32.1 years in the Neolithic and 31.2 years in the Natufian population. Mean age at death for Neolithic males is 37.6 years and for females only 30.1 years. In the Natufian, the opposite was observed, 35.5 years for females and 32.2 years for males.

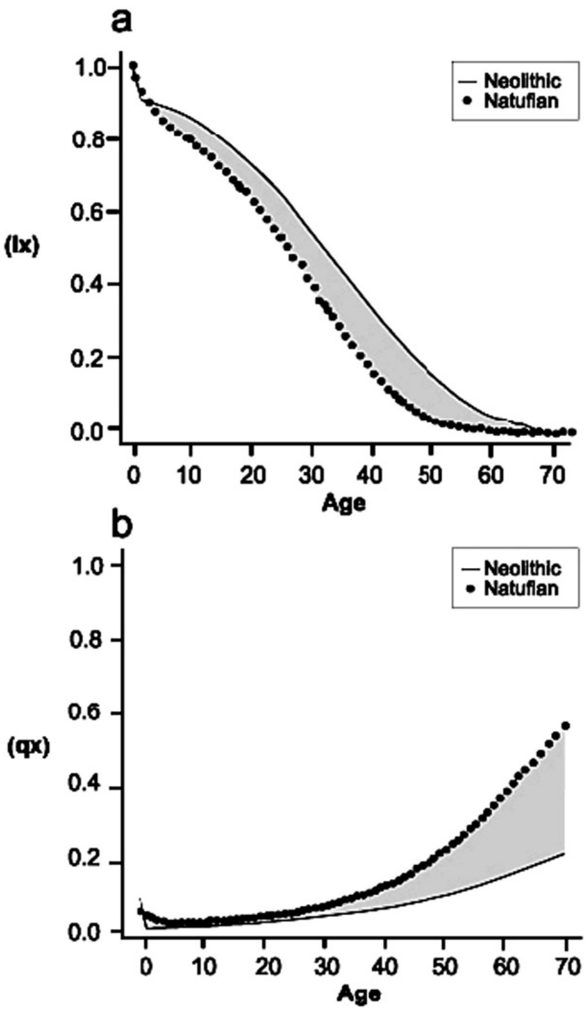

Fig. 1 Comparison of survivorship curve (lx) and mortality curve (qx) for Neolithic and Natufian populations, assuming stationary Natufian population and stable Neolithic population with 1% growth rate (after Eshed et al. 2004a)

Age at death distribution: The calculations below are based on our previously published demographic tables (Eshed et al. 2004a). Childhood mortality was highest among infants and young children (0–5 years) in both populations: 16.5% in the Neolithic and 13.9% in the Natufian. After age 5 years, mortality decreases steadily until age 15 years: for the age cohort 10–15 years, 4.5% in the Neolithic and 2.5% in the Natufian. The weight of child mortality, measured as N_{0-5}/N_{0-20} was 36.5% in the Natufian vs. 38.7% in the Neolithic. The rate of deaths between 20 and 50 years in the Natufian was 58.9 and 48.1% in the Neolithic. In older adults, over 50 years, the trend reverses, with more deaths in the Neolithic populations (9.7%) than in the Natufian (3%). Mortality by sex for the three first adult age cohorts (15–20; 20–30; and 30–40) differs between the Natufian and Neolithic populations. In the Natufian, until age 40 years, male mortality is higher than female mortality. The trend is reversed for adults over age 40 years, where male mortality was 19%, compared to females at 36%. In the Neolithic population, female mortality is higher than male mortality in the younger adult age category of 15–40 years (78 vs. 58.3%) and more males are found over 40 years of age. It is important to note that a considerable number of Neolithic females (24.4%) found their death at the earlier childbearing age (15–20 years) whereas in the Natufian only 3.3% of the females died at this age. This may imply an earlier age for first child delivery in the Neolithic.

The ${}_{15}P_5$ Index

The ${}_{15}P_5$ values for 15 Natufian and PPN populations are presented in Table 1. To increase resolution we divided the sites into smaller time-range categories. The Early + Late (*Ancien* + *Recent*) Natufian ${}_{15}P_5$ values ranges from 0.22 to 0.42. At

Table 1 ${}_{15}P_5$ values for Natufian and Neolithic sites/cemeteries

Time period and site	Dates Cal BP	N*****	${}_{15}P_5$
Early+Late Natufian	15,100–12,550		
Hayonim cave*	Early+Late	48	0.42
Eynan/Mallaha	Early+Late	66	0.33
El-Wad	Early+Late	61	0.26
Kebara	Early	30	0.27–0.33
Shukba	Late	39	0.28
Hayonim Terrace**	Early+Late	9	0.22
Late+Final Natufian	13,200–12,000		
Nahal Oren***	Late+Final	37	0.18
Final Natufian	12,550–12,000		
Eynan		25	0.16
PPNA	12,000–10,500		
Netiv Hagdud		35	0.52
Jericho		63/235	0.37–0.49
PPNB	10,500–8,900		
Abu Gosh		27	0.26
Kefar HaHoresh		40	0.20
Jericho		57	0.21–0.28
All combined****		196	0.23
PPNC	8,900–8,350		
Atlit Yam		49	0.32
Ain Ghazal		61	0.40

*Hayonim Cave calculated after Belfer-Cohen et al. (1991) shows a lower ${}_{15}P_5$ (0.30).
**Hayonim Terrace is presented although the sample has only 9 aged individuals to enable a view of the Hayonim complex as a whole.
***At Nahal Oren, it was not possible to separate Late from Final Natufian and thus it is presented independently (see Bocquentin 2003).
****Including data from additional small Neolithic samples not mentioned in the table.
***** N does not refer to the number of individuals found at the site but the number of individuals used to calculate the ${}_{15}P_5$ index.

Eynan (Mallaha), a separate calculation of ${}_{15}P_5$ for Early Natufian and Late Natufian shows an increase from 0.27 in the Early to 0.38 in the Late Natufian, indicating a relatively rapid population growth. The ${}_{15}P_5$ decreased sharply in the Final Natufian reaching a low value of 0.16 based on data from Eynan only. The PPNA ${}_{15}P_5$ value increased sharply ranging from 0.37 to 0.52. Yet, in the following PPNB, ${}_{15}P_5$ values decline to an average of 0.23 and increase again in the PPNC (0.32–0.40) (Table 1).

Demography: Major Conclusions

The transition to agriculture affected males and females differently; while females experienced a decrease in mean age at death in the Neolithic period, males experienced an increase. The distribution of female ages at death in the Neolithic period indicates that females may have given birth at an earlier age compared to Natufian females. Natufian women lived longer probably because of less frequent births, while Natufian males were more likely to die earlier, may be due to more intensive hunting activities and/or higher inter-social conflicts. The NDT model is discussed below.

Health

We assume that the transition to food production changed the type and intensity of elements that could induce health hazards. This refers to diet, physical burden, housing standards and settlement organization, presence of domesticated animals, intra- and inter-community violence, division of labor, social ranking, etc. Was the change significant enough to affect population health and if so, in what way?

Dental Health

In humans, the interrelationship between host and associated resident microbiota plays a critical role in health and disease (Fig. 2). Oral bacteria are involved in two of the most prevalent current diseases of mankind, i.e., dental caries and periodontal disease. As these two diseases became widespread only in post-Pleistocene populations (Hershkovitz, 1998), it is natural to ask whether the Neolithic Revolution triggered the change, or in other words, was the food in the Neolithic period more cariogenic?

Sample size and data source: The study of dental pathology was carried out on 1,160 Natufian and 804 Neolithic teeth (Eshed et al., 2006; Solell-Sharon, 1992; Hershkovitz, 1998). Other relevant data were derived from Smith (1970, 1972, 1989), Smith et al. (1984), El-Din Al-Abbasi and Sarie (1997), Lipschultz (1997) and Mahoney (2006).

Caries: Either analyzed as a group or by individual teeth, no significant differences in rate of caries between Natufian and Neolithic populations are evident. The prevalence of caries (all teeth combined) in the Natufian was 6.4% and in the Neolithic 6.7%. Noteworthy, Turner (1979) based on a worldwide population study,

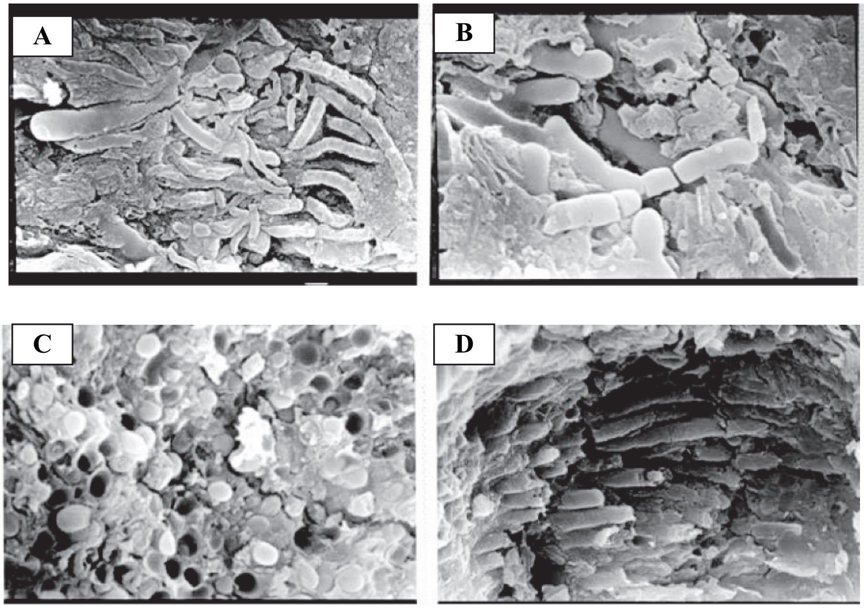

Fig. 2 Chips of supragingival calculi removed from Natufian and Neolithic teeth for microbiota study by Scanning Electron Microscopy showed no differences in bacterial composition. Eynan/Mallaha (**A, B**), Abu Gosh (**C**), Atlit Yam (**D**)

shows a 4.8% rate of caries in mixed economies (agriculture and foraging) and 8.6% in agricultural economies. When only the molars are considered, the prevalence of caries rises to 13.6% in the Natufian and 14.7% in the Neolithic populations. Smith (1991) reported on 16.5% of teeth with caries in the Natufian and 12% in the Neolithic.

Antemortem tooth loss (AMTL): Rate of AMTL in Natufian and Neolithic populations were similar, 3.7% and 4.5% respectively. The Natufians lost significantly more anterior teeth (incisors and canines) and the Neolithic population lost more mandibular molars. This is not surprising as dental avulsion of the incisors is a unique Natufian phenomenon observed at Eynan/Mallaha, El Wad and Nahal Oren. On the other hand, artificial striation on mandibular molars of a coastal PPNC population (Atlit-Yam) indicates that teeth were used to hold staves, possibly while making baskets or fishing nets.

Periodontal disease (PD): Rates of PD were significantly higher in the Natufian population (36.4%) compared to the Neolithic population (19%). This finding is not in accordance with the general notion that periodontal diseases increased in the Neolithic period (Clarke et al., 1986). Noteworthy is the higher rate of calculus (sub-gingival calculus is a principal cause of PD) in the Neolithic (Eshed et al., 2006). The two contradictory findings imply that neither difference in diet nor in oral hygiene is responsible for the observed differences in PD between the Natufian and Neolithic populations. It seems that in the southern Levant scenario, the extensive occlusal forces, generated by the highly developed masticatory system of the Natufians (Hershkovitz et al., 1995) to cope with their abrasive fibrous-like foods is a possible explanation.

Dental wear: In general, attrition is more pronounced in the Natufians (Eshed et al., 2006). This is in accordance with reports from other populations that experienced agricultural intensification (e.g., Kennedy, 1984; Lubell et al., 1994). The differences are more pronounced in the anterior (I1, I2, C) and first molar mandibular teeth (Figs. 3 and 4). Nevertheless, a large variability was observed among communities between and within periods, i.e., the coastal PPNC people of Atlit-Yam (8900–8350 Cal BP) manifested extremely worn upper and lower central incisors and first molars compared to other PPN populations. The Hatoula PPNA population manifested heavily attrited upper and lower premolars and molars. Factors promoting attrition in one community such as sand and dried fish at Atlit-Yam may be absent in another. The attrition severity in anterior teeth compared to posterior teeth observed in the Natufian population may be attributed to anterior teeth functioning as tools (may be for processing some kind of a material; animal skins?). This was likely in the Eynan/Mallaha population, where wear grooves were noted on the anterior teeth of several jaws. It is of note that the differences between Natufian and Neolithic populations relates not just to the intensity of attrition but also to the macro and micro wear pattern (Eshed et al., 2006; Mahoney, 2006).

Oral Health: Conclusions

A. No major changes in dental health were observed. This generally indicates that even if Natufian and Neolithic people of the southern Levant differed in their food procurement strategies (e.g., gathering wild plants vs. farming domesticated plants) they still basically consumed the same types of food.

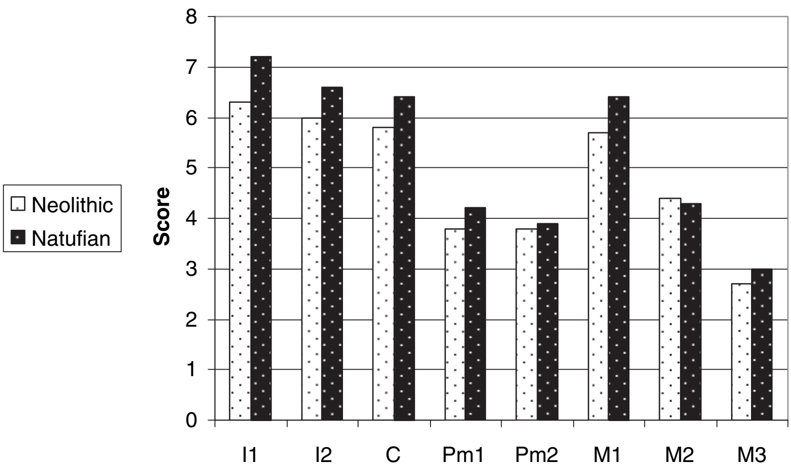

Fig. 3 Attrition rate in Natufian and Neolithic populations, mandibular teeth

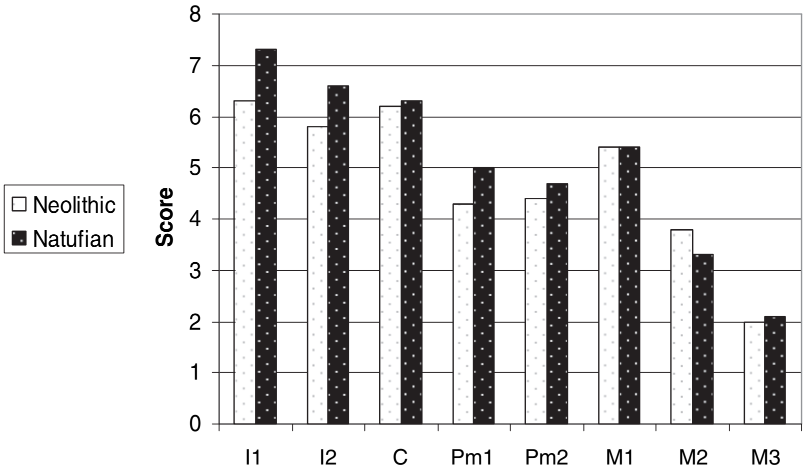

Fig. 4 Attrition rate in Natufian and Neolithic populations, maxillary teeth

B. Changes in food-preparation techniques and non-dietary usage of teeth explain much of the variation in tooth condition in Natufian and Neolithic populations in the southern Levant.

Environmental Disease

Anemia: For whatever reason (acquired or genetic) this disease is often expressed as a cluster of holes on the orbital bony roof known as cribra orbitalia (CO). It is sometimes accompanied by a phenomenon known as 'porotic hyperostosis' that relates to a radial growth of bony plates perpendicular to the internal plate of the skull ('Hair-On-End' phenomenon).

Sample size and data source: Unfortunately sample size is relatively small, with a total of 73 cases (17 sub-adults and 56 adults) for both the Natufian and the Neolithic.

The prevalence of CO was similar in Natufian and Neolithic samples (data controlled for age), 76.5 and 78.8%, respectively. When only moderate-to-severe cases are considered, the prevalence of CO in the adult populations decreased to 21.4% in the Natufian population and 28.5% in the Neolithic. CO remains very high (47%) in the young populations of both Natufian and Neolithic. The prevalence of porotic hyperostosis (mainly slight cases) was also similar in both populations (38.3%).

Environmental Diseases: Conclusions

Anemia is non-specific and can result from diverse causes such as climatic and environmental conditions, diet and inflammatory diseases (due to high population density, low sanitary conditions, proximity to domestic animals, etc.). All these or a combination of them can promote the development of pathogens (viruses, bacteria, parasites, etc.), associated with anemia. The lower rate of CO in Natufian–Neolithic compared to later Chalcolithic populations indicates that no significant new health

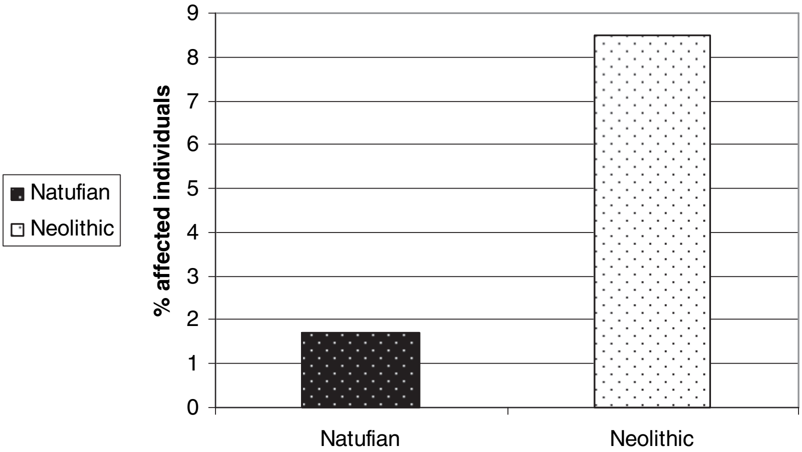

Fig. 5 Prevalence of infectious diseases in Natufian and Neolithic populations

hazard agent was introduced to Natufian and Neolithic populations. Furthermore, the lower prevalence of CO among the Natufian–Neolithic populations compared to later populations (i.e., Chalcolithic, Roman-Byzantine) of the region (Sameora 2006) may suggest less reliance on cereals (low nutritional value) and goat milk (preventing iron absorption in the intestine) in the earlier populations.

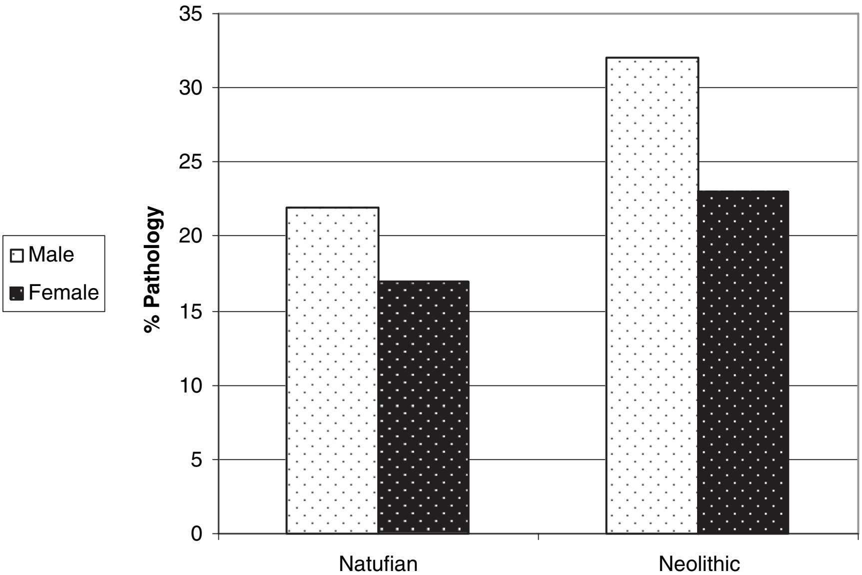

Fig. 6 Percentages of individuals with bone lesions (of any type) in Natufian and Neolithic populations, by gender

Infectious Diseases

It is generally accepted that many infectious diseases in humans have appeared with the advent of agriculture due to increased population size and density (allowing the maintenance of virulent pathogens) and the presence of domestic animals. This fundamental idea is deeply rooted in the Neolithic Revolution concept in spite of recent criticism (Pearce-Duvet, 2006; Caldwell and Caldwell, 2003).

Sample size and data source: The data presented below are based on 864 Neolithic upper limb bone fragments and 665 lower limb bones fragments and 1027 and 738 (respectively) Natufian bones (Eshed, 2001).

Prevalence: Infectious diseases were found to be more common in the Neolithic period (Fig. 5). This is mainly due to the impact of the sample from PPNC Atlit-Yam. When all lesions are combined (Fig. 6), the relative number of affected individuals is higher in the Neolithic populations (28.5%) than in the Natufian with 21%. Noteworthy is the different proportion of the various types of lesions: while in the Neolithic, lesions of inflammatory source are by far more common than the other types, in the Natufian it is trauma which is the most common, followed closely by arthritis (Figs. 7 and 8).

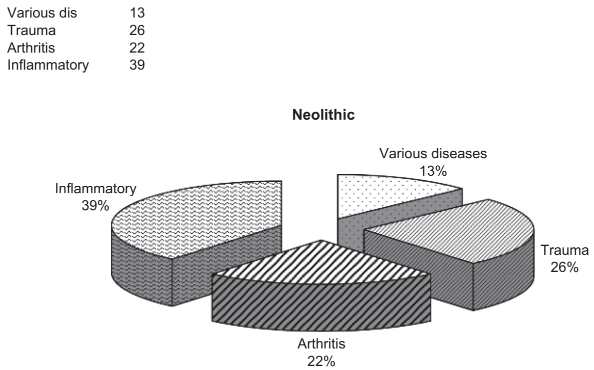

Fig. 7 Disease distribution (relative proportion) in the Neolithic population, gender and age combined

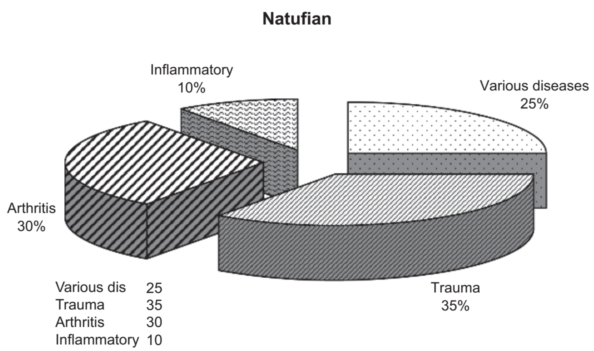

Fig. 8 Disease distribution (relative proportion) in the Natufian population, gender and age combined

Nutrition-Diet

Archaeological, botanical and zoological evidence indicate a shift in economic strategies and subsistence economy, from intensive hunting and gathering in the Natufian to farming in the Neolithic period. The domestication of plants such as wheat, barley, pea, lentil and chickpea and later of animals like sheep, goat, pig and cattle could be of major cultural significance and at the same time affect human biology. We reiterate that fully accomplished farming societies based mainly on domesticated plants and animals did not appear in the early part of the Neolithic period in the southern Levant.

Enamel Hypoplasia (EH)

Sample size and data source: Seventy-four central incisors (27 maxillary and 47 mandibular) of the Neolithic population and 87 (34 maxillary and 53 mandibular) of the Natufian population were studied.

Illness among children can be studied not only via the disease encountered in the child, but also in relation to timing, i.e., at what age were children more prone to the various stresses? Location of arrest lines on the tooth crown (EH) can serve as a clue to the onset of the disturbance due to factors such as a malady or the rigors of weaning. Based on the study of the central upper incisors, an increase in the prevalence of EH from Natufian (25%) to PPN (29%) was observed. The peak of hypoplastic activity was found in 2.5–5-year-old children for the I1, I2, C, Pm1, M1 and 5–7 years for Pm2, M2. Little of the defects observed occurred between 0 and 2.5 years. In most cases the hypoplastic lesions were located on the cervical third of the crown, with the exception of upper central incisors. Comparison of EH data between populations is in many ways hampered since researchers use different definitions for EH and apply different measurements.

Enamel Hypoplasia: Conclusion

The increase, albeit minor, in the prevalence of EH in Neolithic populations may suggest that a larger portion of Neolithic infants and children witnessed episodes of health and/or food stresses. Compared to later, post-Neolithic populations of the southern Levant, judging from EH alone, the child populations of the Natufian and Neolithic periods experienced a similar or even better health and nutritional conditions.

Physical Load

Deducing the diverse activities and the physical load people in the past were exposed to from their skeletal remains is rather complicated. We concentrated on physical load levels for which we used mainly muscle markings and mid-shaft cross-sectional geometry.

Sample size and data source: The study of the mechanical properties of the femur cross-sectional geometry (72 Natufian and 24 Neolithic; left and right combined) and in the humerus (66 and 23, respectively) was carried out by Knopp-Steinberg (2000). The study of the muscles marking of the upper limb bones was carried out by Eshed et al. (2004a) and of the lower limb bones (20 Natufian femora and 15 Neolithic) by Knopp-Steinberg (2000) and Russeva et al. (2006).

Stature

Reconstructed stature based on femur and humerus length appears in Fig. 9. While Natufian and Neolithic males are of similar height, Natufian females are significantly taller than Neolithic females. Noteworthy is the Belfer-Cohen et al. (1991) report on Natufian stature where in some Natufian site (Eynan, Kebara) males were 174 cm and females 162 cm, while in others (Hayonim cave, Nahal Oren, El-Wad), males were less than 170 cm and females less than 160 cm.

Mid-Shaft Cross-Sectional Geometrical Properties

Femoral cortical area: Cortical area is significantly larger in Natufian males compared to Neolithic males, while among females no significant difference was found (Fig. 10). When bone density is included, no difference was observed between the two populations (Knopp-Steinberg 2000).

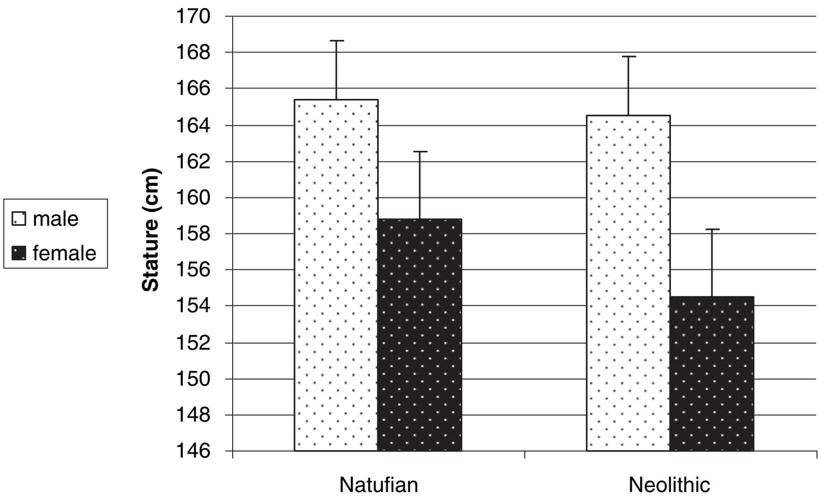

Fig. 9 Reconstructed body height for Natufian and Neolithic populations, by sex

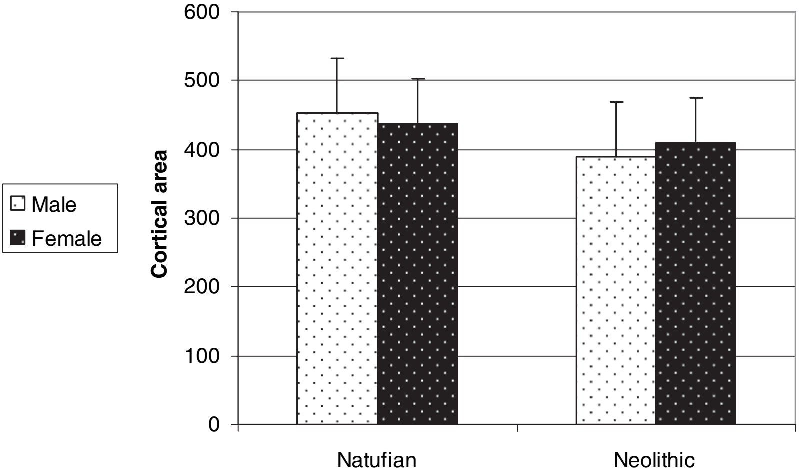

Fig. 10 Cortical area at femoral midshaft in Natufian and Neolithic populations, by sex

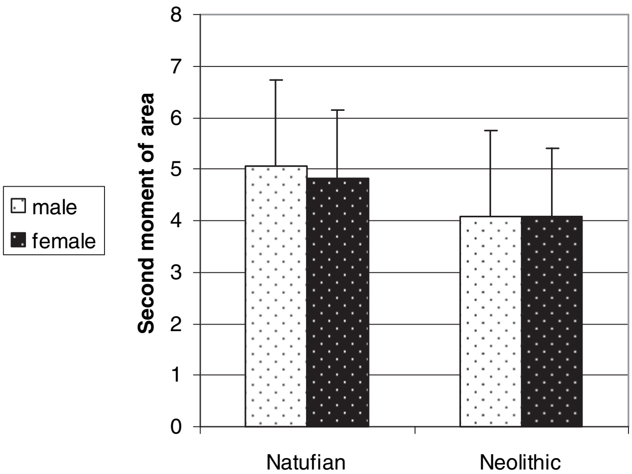

Fig. 11 Femoral second moment of area in Natufian and Neolithic populations, by sex

Femoral second moment of area: Although greater in the Natufian population (Fig. 11), differences were not significant between the two populations.

Femoral Midshaft ratio: While Natufian and Neolithic males manifest similar midshaft ratio (ca. 0.85), Natufian females manifest a lower AP/ML ratio compared to Neolithic females, indicating a shift from a triangular cross-sectional shape to a more rounded one (Fig. 12).

Humerus cortical area: Cortical areas in Natufian males and females are similar to those in Neolithic males and females (Fig. 13). In both populations cortical areas are significantly greater in males compared with females.

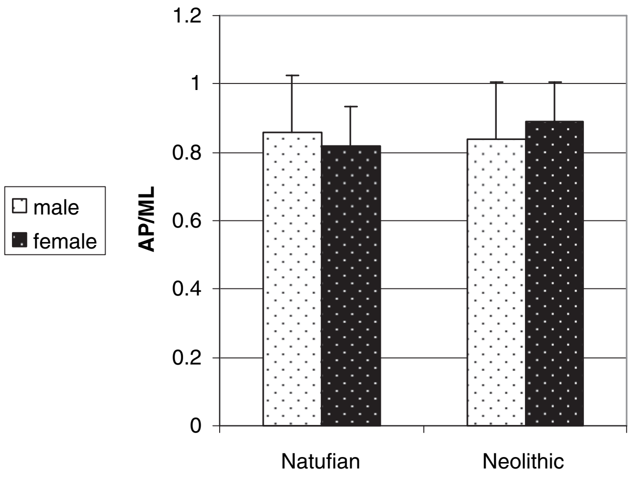

Fig. 12 Femoral midshaft ratio (anteroposterior/mediolateral) in Natufian and Neolithic populations, by sex

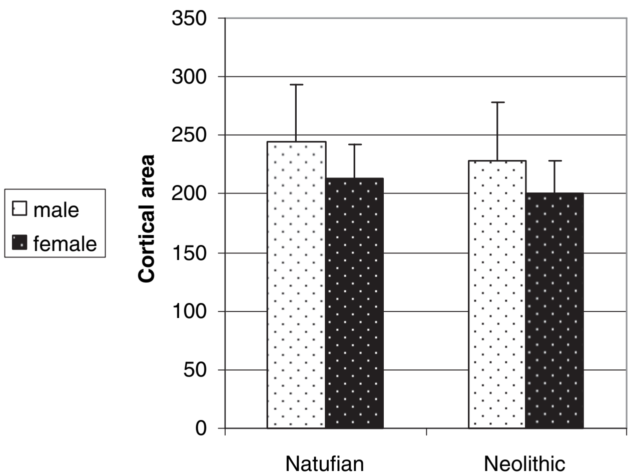

Fig. 13 Humeral midshaft cortical area in Natufian and Neolithic populations, by sex

Humerus second moment of area: No statistical difference was found in this parameter between Natufian and Neolithic populations. Nevertheless, both populations manifest a significantly greater value for the males compared to the females (Fig. 14).

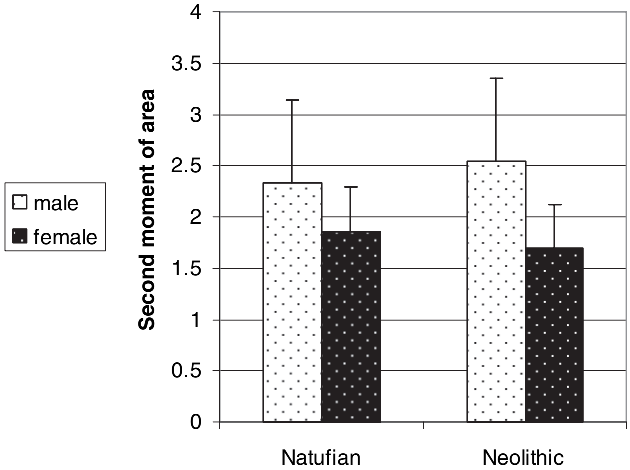

Fig. 14 Humerus second moment of area in Natufian and Neolithic populations, by sex

Muscles' Markings

Muscles' markings can be a diagnostic parameter for evaluating the level (and sometimes the type) of physical stress. A muscles marking analysis of the upper limb bones (Eshed et al. 2004b) suggested a higher physical load in Neolithic populations compared to the Natufian (Figs. 15 and 16), and that people in the Neolithic period were engaged in different activities and occupations compared to the Natufian. A detailed analysis of the MSM by sex led to the conclusion that the pattern

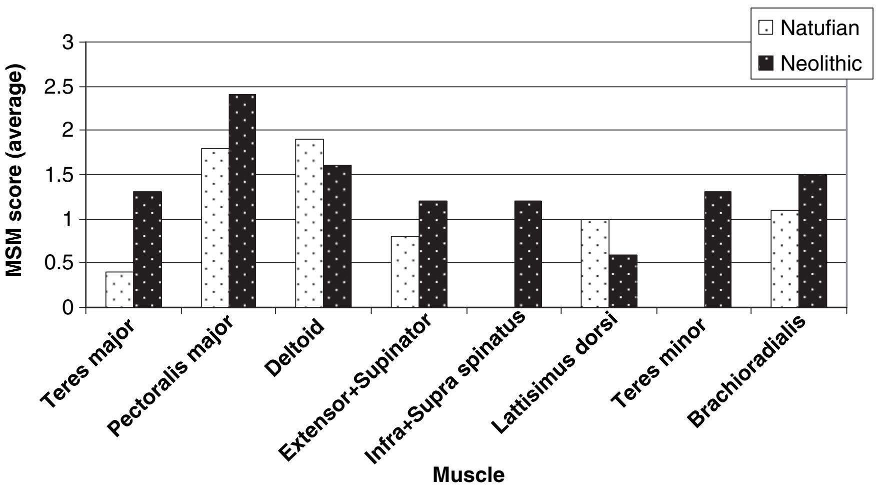

Fig. 15 Humeral MSM score for Natufian and Neolithic populations, females only

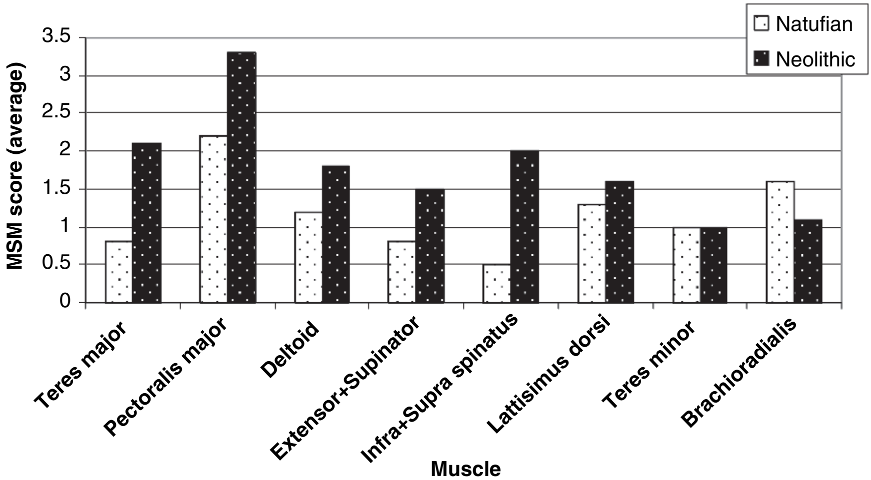

Fig. 16 Humeral MSM score for Natufian and Neolithic populations, males only

of the musculoskeletal stress markers (MSM) indicates a gender-based division of labor in both the Natufian and the Neolithic (Eshed et al. 2004b). Comparisons between Natufian and Neolithic lower limb bones MSM scoring distribution did not reveal any significant change in muscles' marking intensity, except for femoral gluteal tuberosity (Figs. 17 and 18). Epicondylar groove is an interesting trait that can provide information regarding strenuous activities of the quadriceps muscle, the major knee extensor muscle. The trait was present in 60% of the Neolithic femora population studied and in 84.6% of the Natufians. Nonetheless, due to the small

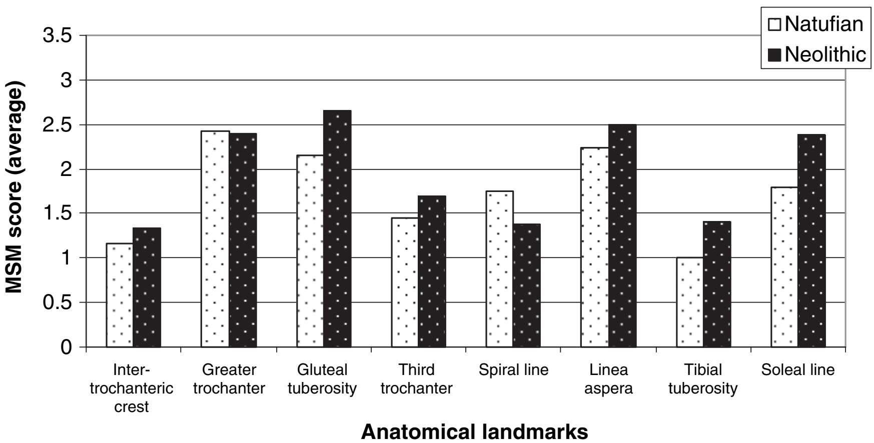

Fig. 17 Femoral and tibial MSM scores for Natufian and Neolithic populations, females only

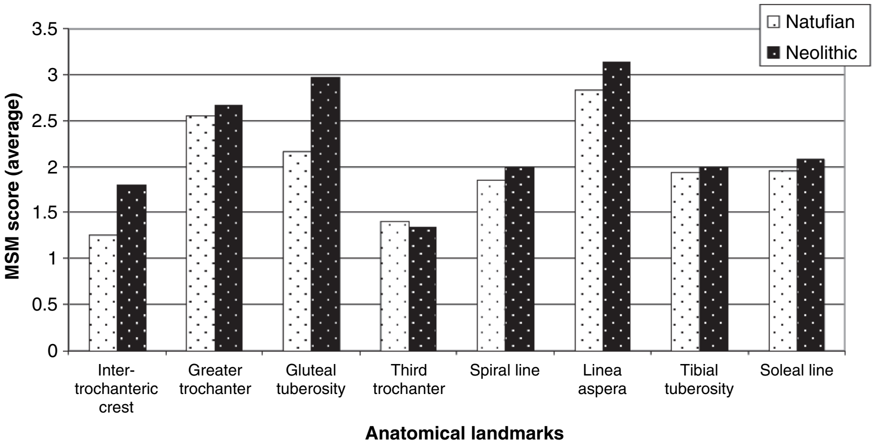

Fig. 18 Femoral and tibial MSM scores for Natufian and Neolithic populations, males only

sample size this difference in prevalence was not statistically significant. Extreme cases of this trait were found only in the Natufian. The trait is more common among males in both populations. Natufian females show the trait more often than Neolithic females (Fig. 19a).

Fig. 19a Type of strenuous activity among Natufian females that could promote MSM developments associated with the Deltoid and Latissimus dorsi muscles

Fig. 19b Type of strenuous activity among Neolithic males and females that could promote over expression of the third trochanter, gluteal tuberosity and attachment area for the Quadratus femoris muscle

(C)

Fig. 19c Type of strenuous activity among Neolithic males and females that could promote MSM developments associated with the Teres major, Pectoralis major and Extensor muscles

Occupational Diseases

Physical load and fitness may also express themselves in various pathologies, mainly arthritis. The rate of arthritis was relatively low and similar in both populations; 5.2% in the Natufian and 4.7% in the Neolithic.

Physical Load: Conclusions

A. Based on the assumption that the quantity and distribution of cortical tissues of long bone cross-sections (as measured by cross-sectional areas, second moment of area and polar moment of area) are functionally associated with the level and pattern of habitual mechanical loading (e.g., Ruff, 2000), we can postulate based on the above data that the magnitude (not the pattern) of physical stress was similar in Natufian and Neolithic populations. The MSM study, however, suggests that daily life in the Neolithic period was more physically demanding than in the preceding Natufian. Both parameters suggest a change in the sexual division of labor, whereby Neolithic females took over a greater proportion of the activities compared to Natufian females.
B. The MSM study of the lower limb bones suggests that the Neolithic population could have been engaged in more strenuous static activities compared to the Natufian (Fig. 19b,c). These activities must have been carried out with the body in a flexed forward position most of the time. This position posed considerable stress on the gluteus maximus and the hamstring muscles (for a different case related to specific activities, see Molleson, 1994, 2000).
C. Physical load in the Natufian seems to have derived from more mobile-related activities as reflected through the high prevalence of epicondylar groove.
D. Only a small decline in stature was noted among Neolithic males compared to Natufian males. Neolithic females, however, are significantly shorter compared to Natufian females.

Health and Welfare

Welfare was rarely discussed in relation to prehistoric populations, perhaps because we perceive welfare as a modern phenomenon. Yet, it is an important aspect and it may tell us about group solidarity, social organization level and the economic level of a community. Skeletal remains can provide indirect evidence in this respect and raise some questions. For example, to what extent did a fracture of a given leg bone disabled an individual rendering it difficult or impossible for him/her to engage in normal activities? What do the healed fractures tell us about the attitude toward members of the group with temporary physical impairment? Welfare may also be expressed indirectly, through the reaction of a population to congenital defects. One way to gauge this aspect is via differential burial and age at death of these individuals (did they survive to adulthood?).

Sample size and data source: Neolithic: 396 fragmented upper limb bones and 392 fragmented lower limb bones; Natufian: 487 bones of the upper limb and 469 of the lower limbs. The results presented here are based mainly on a study by Eshed (2001).

Bone fractures – prevalence: In the Neolithic population, only three bones (0.8%) of the upper limb (a humerus, an ulna and a clavicle) and two (0.5%) of the lower limb (a femur and a calcaneous) manifested a healed fracture. A similar rate (0.2%) of fractured bones was found among the Natufians upper limb bones (one ulna). The rate of lower limb bones fracture was significantly higher (1.3%) in the Natufians but is still low (4 femora, 1 tibia and 1 fibula). Among femoral bones, 3.6% manifested a healed fracture in the Natufians and only 0.7% in the Neolithic.

Bone fractures – medical intervention: Pathological bones provide information not just about the diseases encountered in the populations, but also on medical know-how and the attitude toward sick people in general. It appears that the art of medical intervention reducing a fracture and immobilizing the affected bone was well known to both Natufian and Neolithic people. The few fractured bones available for study had healed without marked angulations or significant reduction in length.

Bone fractures – behavioral aspects: Fracture rate may also be studied in relation to settlement patterns, subsistence economy and mobility patterns. For example, decreased fracture frequency (number of fractures/number of individuals) is to be expected due to a change from a mobile mode of life to a more sedentary mode. This may be the case but the data are limited.

Dental mutilation – medical and social aspects: Dental avulsion is evident only in the Natufian sample (at El Wad, Nahal Oren and Shukba). Its presence may reflect the Natufian manner of curing diarrhea and fever in children, or tetanus (by creating an aperture through which food could be passed in the event of 'lockjaw'), as demonstrated by present-day tribal societies (Nanji, 1998).

Welfare: Conclusions

Prevalence of fractures is similar and low in both Natufian and Neolithic populations. While in the Neolithic upper limb bone fractures are more common than lower limb bone fractures, the reverse was observed for the Natufian. The Natufian custom to extract the maxillary central incisors disappeared in the Neolithic. This may imply a change in treating health hazards (had it have to do with such hazards).

Violence

Opinions as to whether hunters-gatherers or farmers produce more hostile encounters (violent activity) are divided among anthropologists (Lambert, 1997; Martin, 1997; Walker, 1989, 1997). In the case of the southern Levant populations, the questions should be phrased as follows: were Natufian hunters-gatherers hostile in protecting hunting territories? Has Neolithic social cohesion and solidarity (collective identity endorsed through ritual practices) acted to mitigate intra-group violence? Did the new economy promote inter- and intra-social competitions thus promoting aggression? Has social inequality emerged and had power and authority been differently practiced in PPN communities (Kuijt and Goring-Morris, 2002) triggering intra-group violence? Was population growth involved in inter- and intra-group conflicts in both the Natufian and the Neolithic? We have no answers yet to these questions, partially because many believe that violence was rare among both Natufian and Neolithic populations (e.g., Kuijt and Goring-Morris, 2002). Yet, no extensive study was carried out to elucidate this issue. War-like inflicted injuries are not always easy to differentiate from accidental trauma, interpersonal violence or inter-group conflict. Despite the methodological problems, there are certain clues that might help determine the nature of a visible trauma, namely, differences in type and frequency of trauma among the sexes, age distribution of the afflicted individuals, location of the trauma (right or left side of the skull), etc.

Following Eshed (2001), the rate of trauma was similar in both Natufian and Neolithic populations (Figs. 20 and 21). Nevertheless, when skulls alone are studied, the rate of trauma is significantly higher among the Natufians. This may suggest that the Natufian population was exposed to a higher rate of violence compared to the Neolithic.

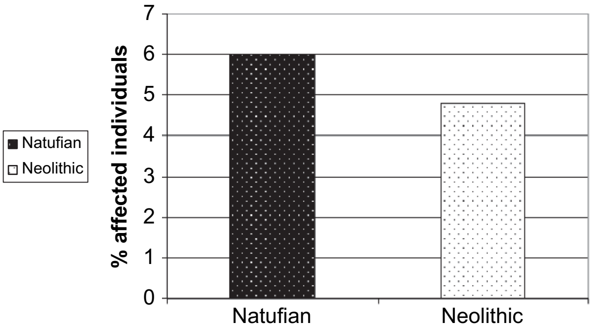

Fig. 20 Rate of trauma in Natufian and Neolithic populations, all bones combined

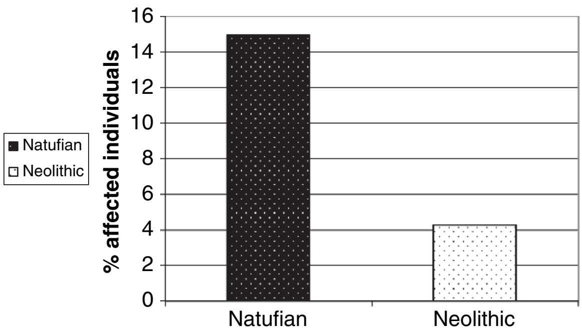

Fig. 21 Rate of trauma in Natufian and Neolithic populations, skull only

The Cultural Perspective

Nature of Sites and Settlement Patterns

The density of sites (per km^2) in the landscape and their characteristics (size, density of architectural features, duration, etc.) have often been used to assess demographic patterns.

Natufian sites are spread mainly in the Mediterranean zones of the southern Levant with minor presence in arid areas (Fig. 22). Natufian settlement viewed within a 'logistic mobility' model include 'base camps' – sedentary or semi-sedentary relatively large sites and 'temporary', 'task specific', short-lived small sites. Within such a framework and being hunters-gatherers, one could estimate that their activities would 'produce' relatively many archaeological sites (by a relatively small population), mostly task-specific sites and fewer base camps. However, while base camps are major in our Natufian data base, only a few sites of the temporary type are known. Natufian base camps vary in size from hundreds of square meters up to 1000–2000 m^2 and in a few cases occupy caves and terraces in front of caves (which may in itself cause a bias induced by the tendency to excavate prehistoric caves). These sites can be densely packed with architecture like in the case of Eynan (Mallaha) or Hayonim Cave and Terrace (in some cases representing a palimpsest of a long and phased sequence); they can have sparse architecture (e.g., Hamma 27); or they can include only single architectural units if at all, like for example in the case of the caves and terraces of Kebara and El Wad. Special sites such as Hilazon Cave (Grossman, 2003) should also be considered.

In general, Natufian sites are sparsely dispersed over the geography of the southern Levant and must, in general represent a low-density population considering the time span they cover (some 3000 years). A general decline toward the end of the Natufian described in some summaries (e.g., Belfer-Cohen, 1991; Bar-Yosef, 2001; Valla, 1995) may indicate an even lower population density for the later parts of the Natufian.

The beginning of the Neolithic, considering the Khiamian as the earliest PPNA entity, provides a vague picture with very few sites and no adequate archaeological data for the characterization of sites' nature or an assessment of settlement patterns. The Khiamian being the entity directly following the Natufian, this may provide yet another hint in favor of a sparse population in the very end of the Natufian and the very beginning of the Neolithic period.

The Sultanian (PPNA) of the southern Levant is better known with some sites showing a major leap in size compared to the Natufian, reaching 20–30, 000 m^2 like Jericho and Netiv Hagdud. Other sites may spread over a few thousands (e.g., D'hra, Gilgal I, WF 16, ZAD 2) or a few hundreds m^2 (e.g., Nahal Oren, Gesher, Iraq ed-Dubb, Ain Darat) (Fig. 22, and see Kuijt, 1995; Bar-Yosef, 2001). It is of note that the large and some of the medium-sized sites are in the Jordan rift valley area while PPNA Sultanian is practically unknown in the Transjordanian plateau, in the mountainous ridge west of the Jordan, in the coastal plain of Israel and in the arid

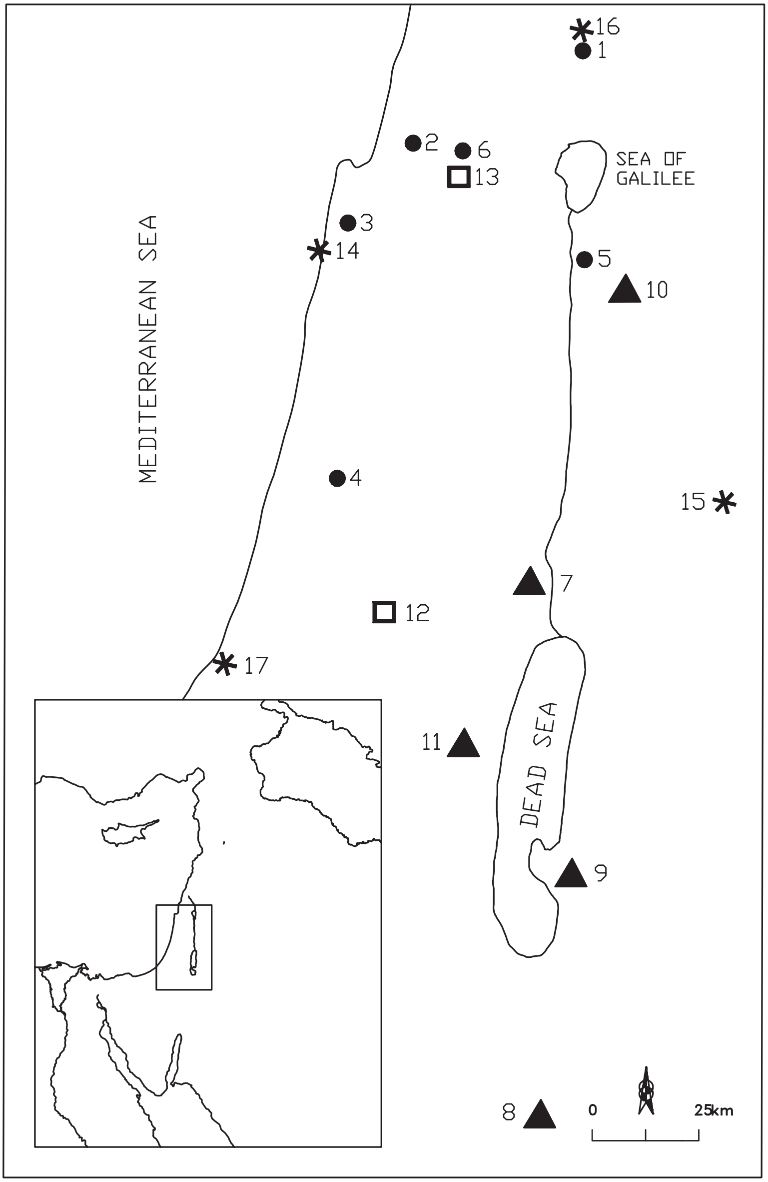

Fig. 22 Sites mentioned in Table 1 and in text. Natufian, *Full black circle*: 1. Eynan/Mallaha, 2. Hayonim Cave and Terrace, 3. El Wad, Kebara, Nahal Oren, 4. Shukba, 5. Hamma 27, 6. Hilazon Cave; PPNA, *Full triangle*: 7. Netiv Hagdud, Jericho, Gilgal I, 8. WF 16, 9. Dhra', ZAD 2, 10. Iraq ed-Dubb, 11. Ain Darat; PPNB, *Empty square*: 12. Abu Gosh, 13. Kefar HaHoresh; PPNC, *Star*: 14. Atlit-Yam, 15. Ain Ghazal, 16. Hagosherim, 17. Ashkelon

areas of southern Israel – a Mediterranean zone entity. The Neolithic is usually viewed as a food producing, sedentary village system. Within such a framework one would expect it to produce a small number of archaeological sites by a relatively large population compared to a hunter-gatherer system (like the Natufian). In fact, PPNA Sultanian site density (number of sites per km^2) in the southern Levant shows no major difference from the Natufian although it might be somewhat higher. The size of small (and some medium) Sultanian sites may find parallels in the Natufian site size range while the two large sites – Jericho and Netiv Hagdud are exceptional. There may be more of these large sites, buried under the accumulating alluvial sediments of the Jordan valley or the outlets of wadi systems where Sultanian sites tend to have been located, but for now, this is the evidence at hand. Had these large-size sites, been fully occupied at one moment in time (which still has to be shown), they represent a qualitative change in community size compared to any Natufian site. The architecture in these sites is abundant and dense. It is hard to assess whether a 'theoretical representative' population of a 'theoretical representative' dunam (1000 m^2) in a Sultanian site was significantly or at all different than in a Natufian base camp (with architecture) but, assuming the difference was minor, Sultanian large sites must have hosted larger populations than any Natufian site. They also contain some features of a scale unknown before, such as the tower, wall and ditch of Jericho, indirectly indicating larger communities. This reconstruction is not easy to assess in terms of population size. Nevertheless, the archaeological data at hand suggest, at least in a general way, that there is a potential for a larger PPNA Sultanian population compared to the Natufian.

The data available for the beginning of the PPNB (EPPNB) in the southern Levant are meager and allow no valuable comparative comments (see Gopher, 1996a; and for a different view Kuijt and Goring-Morris, 2002).

In the MPPNB, especially in its later parts, and most conspicuously in the LPPNB, large settlements (Mega sites, Neolithic towns) appear reaching an area of 100,000 or even 150, 000 m^2 (Fig. 22). Some of these Mega sites (e.g., Ain Ghazal, Basta) show dense architecture (probably including two storey houses), possibly representing large communities. However, one should not automatically translate site area to population size since there are sites of large size that show a sparse spatial distribution of built households (like PPNB Beisamoun). At such sites, a representative theoretical dunam (1000 m^2) would host less people than in a dense site (like Jericho or Ain Ghazal). It is of note that Mega sites only appear east of the Jordan – either on the eastern slopes of the rift valley or on the Transjordanian plateau. They might represent an aggregation of smaller sites related to changes in socio-economic patterns. Considering the fact that the PPNB (mainly Middle) has also witnessed a major spread of small settlements into desert areas, both in the southern and eastern parts of the southern Levant (either task-specific sites or independent hunter-gatherer communities) may also relate to the above line of thinking. Generally, the number of sites known, the new territories occupied and the scale of some of the sites indicate a population growth.

In the PPNC, the picture has changed but the information available is limited and confusing. On the one hand, the Mega site phenomenon continues in the

Transjordanian plateau and, on the other hand, only very few PPNC sites are known in the southern Levant (Fig. 22). A few newly established PPNC sites include large–medium-sized settlements such as the specialized fishermen village of Atlit-Yam (Galili et al., 1993, 2002; Galili, 2005), the site of Hagosherim (Getzov, 1999) or the small size site of Ashkelon Marina (Garfinkel et al., 2005). Some of these sites contain dense architecture and are organized as in the PPNB. The PPNC settlement pattern is, however, far from being clear and so is the estimation of population size. For example, a suggestion was made by Rollefson to view the large PPNC site of Ain Gahzal as a 'fluctuating population center' meaning that a part of the inhabitants has been away from the site for long parts of the year. Yet they kept their 'citizen rights', their houses and their belongings while away. This reconstruction is based on the fact that domesticated animals are major in the economy of the PPNC and if accepted could significantly have a bearing on population estimates based on site size and architecture density.

Work Load and Activities

The Neolithic period has seen a few innovations that may have significant influence on the work load people had to bear with. Naturally, the obvious one would be working the land (tillage, the harvest, the transport and the processing of crops) which we conceptualize as a major component in the newly developing Neolithic culture. We know very little about the agro-technology of Neolithic farmers and have no evidence for soil tillage or any of the procedures mentioned above. The idea that bifacial stone (usually flint) tools including the polished ones were used for tilling the soil is not supported by use-wear studies of these tools, all showing signs of wood working and wood working only (e.g., Yerkes et al., 2003; Yerkes and Barkai, 2004; Barkai, 2005). Even if agriculture could have imposed heavier work loads on Neolithic farmers, this is not relevant for PPNA or EPPNB (and possibly much of the MPPNB) populations in the southern Levant that were still heavily relying on hunting and gathering. However, there are additional innovative technologies and activities that could have imposed a heavy work load on Neolithic people that were not relevant in the Natufian.

- Making and using mudbricks: Mudbrick material is a major component in the sediments creating some of the large, tell-like Neolithic sites. Making mudbricks would need soil and water and some vegetal material or small stones as temper. A general simulation of the Jericho PPNA (tower area) as a test case would show the following: 7 m of sediment accumulation multiplied by the specific gravity (for soil estimated at 2; for stone it is higher) would result in 14 tones of sediment per 1 m^2; or 14,000 tones per 1000 m^2 (one dunam); for an estimated population of 25 people per dunam this would mean 560 tones per person; if the PPNA sequence represents (with gaps, etc.) some 500 years, this means over one tone of sediment per person per year. Considering those unable to take part (babies, young children, and pregnant women, old and sick people) and a possibility that not all able people were engaged, this activity could be a significant work load for some people (not mentioning the construction itself).

- Making lime plaster on a large scale: This would imply collecting the limestone needed, collecting wood for fire – both in very high quantities per one tone of lime plaster (e.g., Garfinkel, 1987; see also Kuijt and Goring-Morris, 2002); transportation and the application of lime plaster – again, implying strenuous activities. While the use of lime plaster was sparse in the PPNA, it became a much larger scale industry in the PPNB.
- Tree felling: For land clearing, for construction, for fire wood, for pyrotechnological industries like lime plaster production, etc. was another heavy load activity. It is now quiet clear that tree felling is a Neolithic phenomenon that was not practiced in the Natufian as an everyday activity. The PPNA small, light and unpolished flint tranchet axes were only suitable for delicate wood working and not large scale tree felling (Barkai, 2005). This implies that tree felling became a dominant activity only in the PPNB.
- Quarrying for flints: Although this was an old ‘profession’, with deep roots in the Paleolithic (e.g., Barkai et al., 2006), it was in the Neolithic that the need for high-quality bifacial tools for tree felling and wood working necessitated quarried, high-quality, homogeneous flint.
- Grinding seeds: In the Natufian, pounding was the major activity in preparing vegetal material, while during the PPNA, B and C grinding became dominant. Grinding cereals is a time-consuming heavy load activity performed in a way that imposes stress on the body, especially the joints (Molleson, 1994, 2000).

An activity that has continued from the very deep past of humankind to the Neolithic is hunting. Yet, even in this case there is an interesting and somewhat confusing story in the context of Natufian–Neolithic dynamics. Natufian people hunted using composite tools with inserted microliths; they had no arrows and bows. Neolithic people had arrowheads from the very beginning and probably used bows too. However, a quick look at the percentage of arrowheads in the various assemblages would show a clear pattern of change through time: while the percentages of microliths in Natufian assemblages are rather high, in the PPNA the percentage of arrowheads is very low (usually in the order of 1–5% of the tools). In the PPNB, arrowheads constitute between 10 and 30% of the tool assemblage, and in some southern sites even more. PPNB arrowheads are of better quality (made on straight blades), typologically more diverse in shape and larger in size (and heavier) than the PPNA arrowheads. Did the PPNB people hunt more intensively than PPNA people? Did they hunt larger animals? The record does not confirm such suggestions, on the contrary, toward the end of the PPN it seems that hunting is on the decline and the diversity of hunted species is decreasing. What then are the large amounts of arrowheads for? Had arrowheads become social items? Or, had they become weapons used in intra- or inter-community violent encounters?

Health

People in the Neolithic lived in densely built landscapes, sometimes in large village sites. They also came into close contact with plant and animal species that were previously wild and could influence their health. We shall comment on the animals only. Previous studies attribute the ‘declining’ health in the Neolithic, amongst other factors, to close contact with domesticated animals (due to zoonoses diseases as measles, pertussis, smallpox, tuberculosis, etc.). We would like to point out the fact that such contacts have already started in the Natufian, with commensal animals approaching the newly founded human niche (Tchernov, 1991). Commensal animals (rats, mice, birds) and wild animals may pose a significant health risk to human populations (e.g., plague, brucellosis, yellow fever, etc.). Animal domestication has gained momentum in the Neolithic starting with goats and sheep, then cattle and lastly pigs. Yet, the faunal record indicates that in the MPPNB, early indications of domestication hardly appear in the southern Levant. Domestication was established only in the LPPNB and the PPNC. Close contact with domesticated animals (being exposed to parasites they carry), eating their meat and probably using their milk, increase the potential danger to be infected with a disease.

Diet

Cereals, legumes and fruit were consumed by men in the southern Levant long before the Natufian or the Neolithic (e.g., Lev et al., 2005; Nadel, 2002). What was the difference between the Natufian and PPNA Sultanian vegetal food (assuming that there were no domesticated species) is too early to tell, it was probably, however, not significant. We should note that even if the idea of cultivation in the PPNA Sultanian (or for that matter much of the PPNB too) is accepted (wild plants displaced and grown by man) – it is still the same species eaten. The decreased spectrum of plants in the diet as a result of farming is only relevant for the later parts of the PPN. As for meat, the story is much the same. PPN people in the southern Levant continued hunting, mainly gazelle, as did the Natufians before them. Hunted animals continued to appear in the archaeological record throughout the PPN but their diversity decreased in the later parts of the period. This trend continues into the PN period and hunted animals diminish to an actual disappearance in the later PN. Thus, it was not until very late in the PPN sequence (and in the PN) that domesticates provided significant portions of the consumed diet. The tempo of dietary changes was slow as domesticated species (plants and animals) replaced the wild ones gradually.

Social Structure and Symbolic Behavior

Hunters-gatherers are considered egalitarian societies with no structured ranking. However, the Natufian, especially the Early Natufian was a relatively large, well-organized society possibly with some sort of ranking. This is expressed, for example, in the fact that only some 6% (including children) of the hundreds of burials had grave goods or rather body ornaments and small ‘gifts’ (Arensburg et al., n.d.; and see Gopher, 1996b). In the PPNA and later in the PPNB there are claims for an attempt to integrate an ethos of equality by intensive ritual activities (Kuijt, 1996; Kuijt and Goring-Morris, 2002). If accepted, this would, in our opinion indicate a rising tendency to inequality – some kind of a pressure from the community for ranking and realizing the economical (surplus) and political power accumulating in the hands of successful individuals or households. The separation of adults' skulls as opposed to those of children in PPNB burials and the later treatment of selected adults' skulls could indicate a tradition of ancestral ritual that may, again, be related to some sort of social ranking. The new data on grave goods in PPNB burials and the differential treatment of the graves (e.g., Kfar Hahoresh, Goring-Morris, 2000) can also be taken as a possible hint for differentiation or ranking in PPNB communities. The suggestions to see some architectural features in the PPNB as temples and some sites as specific burial sites further indicate a well-organized society and potential ranking.

In his seminal study of the origins of religion and the Neolithic Revolution, Cauvin (2000a, b) suggested a change in symbolic expressions from the Natufian, mainly animal images to the Neolithic human images (mainly women). Cauvin suggested the establishment of a religious ideology in the PPN that found expression not only in art but also in social and economic structure. Accepting this scenario would bear out yet another indication for an institutionalized system that may be relevant for ranked societies.

Discussion

This chapter presents a series of questions that we consider relevant to demographic developments following the Neolithic Revolution in the southern Levant. A plethora of methodological difficulties and hesitations as to whether the skeletal samples used are representative were discussed relating both to our potential resolution as well as to the statistical viability of the results. We finally referred to Natufian and Neolithic populations, each as one population. Clearly, this procedure may mask some of the demographic, biological and cultural trends and we are aware of it. On the other hand, the analyses should enable a glance into the basic processes.

No major shift in population structure and demography was noticed between the Natufian and the Pre-Pottery Neolithic. It seems that a similar fertility–mortality balance was maintained in Natufian and Neolithic populations. There is only indirect evidence to suggest that some of the factors that could promote population growth (i.e., young age at first birth giving and shorter birth intervals) changed slightly from the Natufian to the Neolithic period. We did not succeed in tracing clear evidence for a PPN major rise of mortality – it seems to show similar rates for Natufian and Neolithic, yet the factors causing mortality may have changed. An increase in health risk factors during the Neolithic, mainly of infectious diseases, could partially neutralize population growth. In our view, the establishment and full realization of the Neolithic Revolution were long-term cultural and biological processes; hence population growth in the southern Levant Neolithic had taken a 'bumpy' road (see Hershkovitz and Gopher, 1990; Eshed et al., 2004a).

Based on the $_{15}P_5$ values calculated for different Natufian and Neolithic site populations, the following conclusions can be reached:

a. There are marked fluctuations in the demographic structure of the populations along the Natufian and the Pre-Pottery Neolithic periods.
b. A clear population growth (a demographic peak) was observed in the Early +Late Natufian (15,100–ca. 13,000 Cal BP);
c. Population growth declined considerably toward the end (Final) of the Natufian period.
d. The PPNA period witnessed a rapid population growth. Yet, our data are based on the analysis of only two large nearby PPNA sites.
e. During the PPNB period, when prominent economic changes related to the Neolithic Revolution have already started to establish themselves, population growth is unexpectedly quite low (much lower than in the PPNA). Sites attributed to the Middle and Late PPNB period do not show the expected Neolith Demographic Transition (NDT).
f. A clear demographic change to a growing population is seen only in the PPNC, following the full establishment of plant agriculture and animal husbandry. This, however, is based on two sites only and is not in accordance with the ‘accepted’ view of the known archaeological record as a whole.

The lack of data from the Pottery Neolithic period is critical and blocks any attempt to properly establish the zero (dt) point for the NDT process in the southern Levant.

In general thus, there is no consistency in the correlation between the archaeological record and the demographic data as presented in Table 1. While the PPNA archaeological record shows growth compared to its predecessors as well as demographic growth, the case with the PPNC is different showing a ‘poor’ archaeological record but a clear demographic growth. The case with the PPNB is yet another pattern showing a rich and varied archaeological record representing growth and expansion but following the data we have, a demographic low.

The skeletal and dental analyses offer no indication of a major shift in dietary components in the transition from the Natufian to the Neolithic. The differences observed suggest that the Natufians and PPN people of the southern Levant may have differed in their ecosystem management but in general consumed similar types of food. Changes in food-preparation techniques and non-dietary usage of teeth explain much of the variation in tooth conditions in populations before and after the Neolithic Revolution in the southern Levant. Furthermore, the increase, albeit slight in enamel hypoplasia in the Neolithic may suggest more frequent episodes of malnutrition or deficiency in vitamins A or D.

There is a clear reduction in health status from the Natufian to the Neolithic period. Nevertheless, there is no clear evidence to suggest that the increasing presence of inflammatory diseases in the Neolithic period reflects animal husbandry (domestic-origin hypothesis). The increase in inflammatory diseases may rather take place due to anthropogenic modification of the environment.

Physical load (stress) was similar for both Natufian and Neolithic populations. Nevertheless, the pattern was different, suggesting different occupational stress.

Much of our data are in support of Armelagos et al., 1991 claiming that the increase in population following the development of agriculture is not due to improvement in health and nutrition (in fact they claimed the contrary: increase in infectious disease and nutritional deficiencies, as we have shown here too), but rather due to reduced birth spacing which not only compensated for the increased mortality, but also supported (a modest?) population growth (see also Hershkovitz and Gopher 1990: 33–35).

Major changes in site nature and settlement patterns can be detected in the late Pleistocene and early Holocene in the southern Levant. From small, semi-sedentary or sedentary Natufian base camps, to Neolithic Mega sites or towns in the LPPNB and PPNC culminating in complex societies and urban centers after the Neolithic period. This was accompanied by a change in the local food producing economy to an agricultural system fully based on domesticated plants and animals. This, however, was a long process. Each component of the above process necessitated accompanying changes in technologies, materials, social and labor organization, etc. The Neolithic Revolution and especially the change in economy should thus better be seen as a multi-facetted socio-cultural process involving a variety of agents and possibly significant political struggle. New activities, unknown in the Natufian were introduced following the changes in economy and in settlement nature during the Neolithic. The Neolithic era, as reflected in material culture indicates heavy load activities – massive construction projects, extraction of heavy loads of raw materials, possibly clearing land for farming, etc. This may in turn bring about a new division of labor that can be assessed by biological and archaeological data or ethnographic parallels. Some of the new activities related to the Neolithic period, like the daily grinding of cereals to flower or spinning and weaving are considered monotonous women's work performed on-site (Brown, 1970). The present study as well as few previous ones (e.g., Molleson, 1994; 2000; Eshed et al., 2004b; Peterson 1994) lend support to such a scenario. On the other hand, it is not clear whether women, men or both performed farming chores in the field.

In a general perspective, declarative in nature, one could argue a continuous demographic growth from Paleolithic to Neolithic and later Chalcolithic and Early Bronze Age. This population growth and expansion may be viewed as 'the' major success of *Homo sapiens*, coming out of Africa and filling up the old and new worlds in a relatively short time. Borrowing Braudel's historical 'long duree' logic for prehistoric large-scale processes, we may say that population growth was the undercurrent, i.e., the basic condition of modern human existence.

The NDT model, discussed in this volume, was tested against data sets worldwide and produced a valuable general pattern of demographic growth relating to the domestication of plants. Our study has focused on the southern Levant as a specific case. Considering the demography-related factors we presented above, as far as we could take them, no major demographic shift from the Natufian to the Neolithic is seen.

The southern Levant case of the late Pleistocene and Early Holocene does, however, raise a few questions related to various aspects of the NDT model: was there a significant increase in birthrate following the Neolithic Revolution and consequently a rise in population size? The answer is a reserved yes. If we choose to look at a few of the PPNB populations, and especially at the PPNC Atlit Yam, we can trace an increase in birthrate. One should remember that even a small rise in birthrate (an access of half a child per woman), if long enough (thousands of years), is sufficient in promoting significant population growth over time. The basic structure of Natufian and Pre-Pottery Neolithic skeletal populations did not change much. It is interesting to note that even in the Chalcolithic and later Early Bronze Age periods, populations in the southern Levant continue to grow more or less in the same tempo. The case of the Chalcolithic cemetery at Peqi'in (Gal et al., 1997), with a sample of almost 500 individuals yielded crucial information in this respect (Nagar, Pers. Comm. 2006).

When do we start the counting for the years of the NDT, or where do we set the 0 point? And, is the process in the southern Levant similar in time scale to other parts of the world? Neolithization processes in primary domestication centers were multifaceted, revolutionizing human life, behavior and perceptions. It is true that these centers are located in regions with suitable conditions and where high-potential species for domestication are available (Diamond, 1997). However, the process of making the right choices of plant (and animal) species for domestication; making the right step to manipulate them; investing the time, effort and knowledge to perform the genetic selection of the most successful and efficient varieties; developing the knowledge and agro-technologies for dealing with these species in their new state; learning how to harvest the new crops; how to process them so that they can be stored; inventing the storage facilities needed; learning how to prepare these for consumption, etc. are not merely technical issues. They are in many ways, a milieu of new technologies and patterns of behavior, organization and perception that had to be introduced, fought for and assimilated into the existing system. The transition from hunting and gathering to farming when looked at as a cultural process would mean a major ideological change relating both to how one perceives the world and life in it. It also means giving up deeply rooted traditions such as meat sharing that was a major social institution. Thus, once the economical change toward a food producing economy had been accomplished, successful hunters were replaced by successful farmers.

Unlike primary centers of domestication, secondary centers that have adopted farming confronted a full, already cohesive package of selected species that went through all stages of trial and error and needed only readjustments to the new context. The struggle over the assimilation of such a package to the new context might have been faster (and may be fiercer).

In the southern Levant the shift toward a diet based mainly on domesticated plants and animals was not established, based on the archaeological record, prior to the very end of the PPN or the Pottery Neolithic period (around 8,000 years Cal BP), and most probably post 7,500 Cal BP (Gopher and Gophna 1993; Gopher, 1995). This means that farming was only in its initial phase in the PPNA and most of the PPNB period if at all. Thus comparing Natufian to early Neolithic (PPN) populations as a potential reflection of the impact of the Neolithic Revolution on mankind is not fully justifiable. The "Revolution" then, if one seeks for a point of a fully accomplished new economy, diet, activities and all that comes with this package, took place some 4,000 years after the beginning of the Neolithic period and was fully realized only in later urban societies.

Population growth may take one of few possible courses, following models like the NDT (Bocquet-Appel, 2002) or the "Logistic" model of Ammerman and Cavali Sforza (1984). The general concept, however, assumes a short and fast population growth at the beginning of the Neolithization process. The "Fluctuating" model suggested by us in the past for the southern Levant (Hershkovitz and Gopher, 1990) also assumed an increase in population size, yet this growth was not linear. Various factors, such as food shortage, pestilence and inter-social conflicts arrested and even decreased growth rate, causing changes in population size through the Neolithic. Although we are still far from possessing an explanation for these fluctuations, they seem to be well reflected in the data presented in this chapter and in the ${}_{15}P_5$ values calculated. Population growth in the southern Levant Neolithic was a complex process, revealing its nature only when looked at in a long-term historical perspective. The Natufian and Neolithic cultures, together spanning over 8000 years do represent a 'laboratory' time in which crucial social, economic and demographic developments took place.

Note

1. The exclusion of the 0–5-year-old individuals from the calculation can bias the demographic picture considerably. It is an over simplification to just generally say that it is a matter of preservation of the archaeological record.

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Implications of the NDT for World Wide Health and Mortality in Prehistory

Mark Nathan Cohen

Abstract This chapter discusses the significance of the NDT model in particular and of broad explanatory hypotheses in general. Various questions are raised about the aspects of the model, particularly about the timing of the NDT, the causes of increasing fertility, and the resulting pattern of increasing mortality. Data are presented demonstrating diminishing returns for labor in bringing food to the table in economies preceding and accompanying the adoption of agriculture. Also discussed are data from paleopathology indicating that health commonly declined during the same transitions.

The chapter discusses the problem of reconciling the robust evidence of diminishing economic returns and declining health with the dramatic increase in fertility at the NDT. It also suggests that the Neolithic Transition represents a far more profound change in human strategy than has hitherto been recognized.

Keywords Paleopathology · mortality · fertility

NDT theory is, at its core, recognition of a very widespread pattern of change in the distribution of individuals by age-at-death in prehistoric cemetery populations. The change toward a higher percentage of juvenile skeletons combined with other archaeological evidence is interpreted as a fairly abrupt increase in human fertility resulting in a marked increase in population growth rates, in the period of about 600 years from the onset or emergence of farming in each location. The NDT has alternatively been attributed by Bocquet Appel, Naji and Bandy (2006) to any of several factors loosely associated with the appearance of sedentary agriculture: crop domestication; various quantitative degrees of dependence on cultigens (one distinction being made between incipient cultivation and more intensive farming) and sedentism itself. The period of growth is thought to have ended when rates of mortality increased to balance fertility. As used in the NDT model, I will use the

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words “Mesolithic” and “Neolithic” to cover the trends occurring in both the New and the Old Worlds.

The model makes a significant contribution to methodology by *quantifying* comparative time-scales, rather than merely placing events in absolute time or in parallel “stages” of development. Comparative analysis of prehistoric events has a long history, but it has lacked the temporal precision that the NDT studies involve.

As a worldwide and cross-cultural hypothesis, the NDT model has a number of strengths that exceed those of more localized analysis.

First, this very broad perspective makes things visible that are not visible in individual or local archaeological sequences. Comments in Bocquet-Appel and Naji (2006) and some of the chapters in this book show that it has forced many archaeologists to study their own archaeological sequences in new ways.

Second, although most archaeologists apparently believe that the most robust conclusions come from infinite pains with the details of individual sites, it is a broad, comparative view and not those details that provide the most robust conclusions about prehistory (Cohen 1977). The comparative view tends to avoid sampling errors and untestable inferences about idiosyncratic local conditions that provide no means to use correlation to explore possible causation or to verify the explanation offered. In an individual sequence, one must often rely solely on interpretations embedded in intellectual fads, schools of thought, and the personalities of the individuals involved. One of anything is not worth much. Moreover, chapters in Kennett and Winterhalder (2006) demonstrate that the quality of data on a local scale often does not enable serious testing of hypotheses. Replication of results, as is inherent in the NDT model, contributes significantly to the robusticity of a conclusion.

Third, the broad perspective limits the range of explanations that can be offered. A proposed cause needs to have the same distribution as (i.e. correlate with) the result it attempts to explain (Cohen 1977). If the distributions do not match, the theory is wrong. Both the NDT and the economic events that precede it (Cohen 1977; Kennett and Winterhalder 2006) display remarkable interregional parallelism. The idiosyncrasies of each region can be explained by complex local variations, as has been fashionable, and as the various chapters in this book demonstrate; but the repeated pattern demands an equally broad explanation that must of necessity be fairly simple. Geographic and climatic patterns that are zonal cannot explain the common pattern of change. Changes in social or cultural patterns [such as that offered by Hayden (2003)] cannot explain the parallel occurrence of events across cultures, unless parallel occurrence of the cultural changes can be shown to have a common explanation, i.e., the social changes must be proximate mechanisms enacting a broader general cause. A recent survey by Barker (2006) suggests that no common explanation has ever been demonstrated in the realm of culture per se. This point has been reiterated by Winterhalder and Kennett (2006). I remain convinced that the cultural changes must be embedded in common ecological, demographic, or economic factors, that they involve a “demand side” economic theory, and primarily involve a “push” not a “pull.” [Piperno and Pearsall (1998) describe a “pull” into a new economy of domestication, but simultaneously point out that the “pull” does not come into effect until the efficiency of wild resource use has dropped far enough to make the "pull" of domestication attractive.] The forces involved, I think, resemble some facets of the "population pressure" model that I once espoused, a model defined as "an imbalance between a population, its choice of foods, and its work standards, which forces the population either to change its eating habits or to work harder (or which, if no adjustment is made can lead to the exhaustion of certain resources." (Cohen 1977:50.))

But, I clearly overstated the role of population growth and flux in that processes. I now agree that the decline of choice resources resulting from Holocene climate change played a bigger part in generating the pressure than I once believed. This model means that there need not have been rapid (or even any) population growth leading up to the origins of agriculture (which many people deny), if, in fact, resource availability was declining as it clearly was.

In addition, despite the unfortunate title of *The Food Crisis in Prehistory* I actually argued that no crises ever need be involved, simply changes in resource strategies related to changes in people/resource ratios. (See also Shennan, Population processes and their consequences in Early Neolithic Central Europe.) I now also agree that the mechanism that I called population "flux" cannot have been powerful enough to even out pressure on the scale I envisioned (cf. Richerson et al. 2001), and that in fact the end of the Pleistocene "reset the clock".

Most hypotheses connecting climate change to changing economies have failed to notice that a common pattern is occurring across many climate zones, eliminating climate variables per se as possible triggers

At least two non-zonal climate/ecological changes at the end of the Pleistocene have now been described: changes in the concentration of CO_2 in the atmosphere and a decline in the frequency of marked and very rapid changes in temperature (Richerson et al. 2001). But, even within the Holocene, despite this common pattern, climate change seems to have had very different effects in different regions: greater warmth, altered monsoon patterns, increasingly moist climates and so forth – all resulting in a remarkably parallel sequence of economic changes. (See chapters in Kennett and Winterhalder 2006.) There must still be a common factor involved. It is also clear that the Holocene climate "amelioration" actually had an immediate negative consequence for foragers, judging by their health and behaviors described by Piperno and Pearsall (1998) as discussed below.

Fourth, recognition of a global pattern to some extent reverses the burden of proof and forces people to focus on explaining the *exceptions* to the rule. Why do some groups *not* fit the pattern? Why *did not* some people adopt agriculture or go through the NDT.

Fifth, recognition of a broad pattern of events sets broad quantitative limits on certain variables. Most important in this context, a very broad view of average, near-zero post-Neolithic population growth between 10,000 and 500 BP[1] sets significant limits on the interpretation of the demography of the NDT and subsequent events in prehistory as I will discuss below. Particularly it means that any increase in average fertility *had* to be offset by increasing mortality as the NDT model suggests – although, as I suggest below, the direction of causality between increasing fertility and increasing mortality may at least in part have been the opposite of that assumed by the NDT model. This means that the *average* (although not necessary local) long-term improvement in "fitness" often associated with the adoption of agriculture was very near zero until very recent, perhaps even post-Columbian, times. (I think that in any case, individuals who seek fitness motivations in the economic changes under discussion may be ignoring the fact that fitness is ultimately served through proximate mechanisms that, like the modern taste for sweets, may not be accurate reflections of fitness needs.) Changes in food technology were motivated more by diet and efficiency than by direct fitness considerations or measurements. In any case, efficiency, diet, and fitness must all clearly have *declined* before any fitness advantage could be achieved, raising questions about whether fitness concerns actually motivated economic changes.

Some Specific Comments and Questions about the NDT Hypothesis

The Timing of the NDT

Bocquet-Appel and Naji (Bocquet Appel 2002; Bocquet Appel, Naji and Bandy 2006) theoretically work from a point defined by its relative position in a specified sequence of events revolving around the adoption of agricultural economies in different regions. One problem, as many commentators have noted, is that of pinpointing the zero date and of associating that date with a consistent stage in the Neolithic process. At what common point does one start the count? What piece of the "Neolithic Revolution" triggered the increased fertility.

The fact that the NDT has such a broad distribution means that it cannot be associated with different pieces of the Neolithic "Revolution" – sedentism, domestication, cultivation, agriculture, etc. – in different places. To see varied causes, even on this fairly minute scale, for this super-regional event, demands a level of coincidence that defies the imagination, i.e., it is too much of a coincidence that a fertility surge occurring in broad parallel over many regions can be explained by sedentism here, but by domestication there, by cultivation in a third place, and full-fledged agriculture in a fourth. We need to be able to tease out a replicable combination of events. If various explanations of the NDT focus on completely different aspects of the transitions, some of the archaeological sequences demand a further look.

We will not know which sequences need reinvestigation until we have a sense of a prevailing pattern. The problem is that in many or even most regions of the world there was actually an enormous time gap between initial cultivation and the adoption of full fledged farming economies (chapters in Kennett and Winterhalder 2006). In fact the transition was so long – often longer than subsequent periods – that the term "transition" is a misnomer (Diehl and Waters 2006).

There is a further complication in the nature of archeological sequences that is not being considered sufficiently by either the proponents of the NDT model or those interpreting individual local sequences. Archaeological samples are relatively rare snapshots of ongoing processes. Because of the vagaries of differential preservation and recovery, different archaeological sequences provide *different* snapshots representing different parts of the sequence in different places (Cohen and Armelagos 1984). This may account for the fact that the NDT, and perhaps also downward trends in economic efficiency and health, may appear correlated with different aspects of economic change in different regions.

Note also that the pattern of diminishing returns for labor and declining health, which I will discuss and document below, means that the adoption of new economies, at least in their original hearths, would have been grudging and gradual changes, producing a pattern of slow quantitative or percentage changes, not the kind of abrupt pattern that would have accompanied a newly invented and desirable strategy. It also means that the new technology would have been resisted by indigenous populations in areas of contact, as long as they were able to withstand the political onslaught of the farming groups. The spread of the new farming economy was about power, not about improved efficiency, health, or quality of life.

Fertility

Bocquet-Appel and Naji rely on a reduction in breastfeeding (reducing its contraceptive effects) to explain the marked increase in fertility that they observe. I consider this a very plausible hypothesis, if perhaps incomplete, because nursing is, by modern consensus, the most important natural regulator of fertility. This is often attributed to changing patterns of close contact between mother and child that resulted from sedentism. As Warrick (2006) suggested, reduced breastfeeding and increased birth spacing may also have resulted from the availability of new, plentiful but inferior weaning foods in the form of cereal gruels.

It is also worth noting that Ellison (1990; Ellison et al. 1993) suggests that a woman's system is a complex, multi-stage mechanism for adapting to dietary shortfall, that may in the long run improve her fitness. Fertility is turned off to varying degrees depending on the availability of calories (or the balance between caloric intake and energy output) and the length and severity of dietary shortfall, a point reiterated by Sullivan (2006). Breast feeding is an enormous caloric drain on the mother, far more so than pregnancy.

The mechanism seems to be most attuned to calories. It has now been clear for some time, moreover, that the age at menarche is very sensitive to the accumulation of fat in a woman's body, which is why the age at menarche has declined very substantially in the very recent past as diets have gotten richer (Frisch 1978). The reduction in the age of menarche, 6–7 years or more in the modern context, would have been sufficient by itself to permit two or three additional successful pregnancies. Hunter-gatherers although qualitatively well nourished, are typically very lean. A reduction of the age at menarche is likely also to have occurred at the NDT, although on a smaller scale. The adoption of sedentary farming might easily have permitted an additional pregnancy without any change in nursing habits.

The human body is generally much more sensitive to caloric deprivation than any other. Our bodies do not tell us very clearly if we are short of a particular vitamin or mineral. We get “hungry” for calories but not for other nutrients. The body can become quite anemic or vitamin deficient without triggering any early warning device. The reason is fairly simple. In prehistory, vitamins and minerals were, for the most part, readily available if food itself was available. It was most often calories that were limiting on health and growth, so it was calories that needed active monitoring. The adoption of farming fairly clearly reduced the quality of dietary intake, and increased vitamin and mineral losses to parasites (Cohen 1989). But caloric intake apparently increased, which is what women’s bodies responded to. This sensory imbalance might explain why populations so easily traded dietary quality for quantity as needed. And if it is true that the farming economy provided a more steady supply of calories (which I doubt – see below) that, too, would have helped increase fertility, since, according to Ellison it is not just caloric shortage but weight-loss *trends* starting from any level of body fat that can trigger a shutting down of women’s reproductive systems. No matter how plump a woman is to begin with, weight loss is taken as a warning of hard times to come.

Other hypotheses, involving changing conscious strategies, have been proposed at various times relating to the increasing marginal utility of children after the adoption of farming and hence relaxation of birth control. I would also argue that conscious relaxation of fertility regulation might have been stimulated because of the needs of parents for increased “social security” as I will discuss below, and of sedentary communities for competition and defense both across and within settlements, protection being largely dependent on the size of the family or community. I think that intentional relaxation of birth control after the adoption of farming must have accompanied changes in patterns of natural regulation.

Armelagos and Maes (2006) point out the possibility that people may have actively shortened the inter-birth interval by reduced breastfeeding, or simply by reducing contraception as a response to increasing infant mortality. Increased fertility would also be a natural consequence of high infant mortality, because the latter would reduce the interval of post-partum sterility related to nursing. On the other hand, intentionally decreasing breastfeeding to offset infant mortality may be counterproductive, because the resulting increase in child mortality might offset the increasing fertility.

We can get a better handle on explaining the NDT if we can get direct biological signs of increasing fertility by studying the skeletons of mothers from different time-periods. It seems intuitive that there must be ways to quantify pregnancies using physiological changes recorded in the skeleton at the time of a pregnancy and/or nursing; but to my knowledge, no certain method for *quantifying* such episodes has been found. One possibility has been proposed that may provide evidence of changing fertility rates, at least in terms of *relative* numbers of pregnancies, among women before and after the NDT although no absolute number of pregnancies can be estimated.

John Lukacs (personal communication from a paper not yet published) makes the following points. The frequency of dental caries is known to increase quite regularly with sedentary farming. Caries also have long been known to be more common in women than in men; and folk wisdom has long connected tooth loss with pregnancy. We now know that pregnancy does indeed alter the saliva content of a woman's mouth in ways that reduce her protection against dental caries. And we now know that caries increased in frequency far more among women than among men during the transition to farming. The inference is that we are probably observing an increased number of pregnancies for women after the economic transition, although we still have no means to quantify the change.

Aside from these specific questions there are two major points that need to be made, because they describe the context in which the NDT must have been embedded, and that must be accounted in any theory.

Efficiency Studies

The emergence of Mesolithic and Neolithic economies and their New World counterparts preceding the NDT is generally described in terms of the following trends: the decline in the quantitative importance of big game hunting in favor of smaller game, shellfish, exploitation of secondary plant resources; and the ultimate exploitation of small seeds followed by their domestication. There is now very clear evidence that this is a sequence of diminishing returns as measured by caloric returns per hour of labor (Cohen 1989; Kennett and Winterhalder 2006). The efficient use of human labor (calories produced per unit of labor) was gradually exchanged for efficient use of land (i.e., more calories per hectare).

As Hockett and Haws (cited by Armelagos 2005) have pointed out in several publications, *caloric* efficiency is not a sufficient measure of "efficiency," which should also focus on dietary quality.

Modern behavioral ecology studies – or "optimal foraging studies" – do focus very heavily on caloric returns to the exclusion of other nutrients. Some attention is now being paid to changes in the availability of protein as a factor in efficiency calculations; but, to my knowledge other than the model proposed by Keene (1981) who argues that other nutrients may in fact be the ones that limit success, few studies, have yet discussed efficiency in terms of possible deficiencies of specific vitamins, particularly of the B complex and C, or specific minerals such as calcium, iron, zinc, or iodine. [Potential shortage of vitamin C, important not only in its own right but also in the absorption of iron, suggests that the cultivation of chili peppers may have had more than the marginal importance suggested by Piperno and Pearsall (1998).] But the transition to a cereal-based diet is also clearly associated with declining dietary quality in these and other nutrients (Cohen 1989) and probably declining desirability as judged by the tastes of many modern populations. The fact that cereals are high-density producers of calories along with the fact that they can readily be stored may be their only virtue. People sacrificed dietary quality and most often labor efficiency for the ability to produce more calories and support more people per hectare.

The Evidence of Paleopathology

There is also evidence from paleopathology demonstrating that the adoption of Mesolithic and Neolithic economies commonly involved diminishing returns in another sense: the declining quality of nutrition, health and life, and, almost certainly, increasing mortality and declining life expectancy.

In 1984, I and George Armelagos (1984; based on a 1982 conference) published a collection of 18 regional sequences of trends in paleopathology (mostly from the New World, where most work had been done) focusing as much as possible on the adoption and intensification of agriculture. The precise moments of change (which of course in any case are not momentary) were hard to identify and were in fact often missing in the rare snapshots of ongoing change that limited archaeological samples provided. In 1989, I published a single authored compendium of those studies and additional studies between 1982 and 1987.

The body of data has greatly expanded since 1989. Data were reviewed again by Larsen (1995). In 2002, Steckel and Rose published the seminal work, *The Backbone of History* a further compendium of studies from the New World. Using the *Bibliography of Paleopathology*, through supplement eight (2005), I collected further studies (Cohen 2007b) that are briefly summarized in the introduction to a new book, *Ancient Health*. That book represents the results of a conference of paleopathologists in 2004 to be published by the University Press of Florida (Cohen and Crane-Kramer 2007a, b). The new volume also contains 20 new studies with emphasis on the Old World, including previously under-reported regions such as Bahrain and the UAE and Israel in the Middle East as well as studies from East and Southeast Asia – Mongolia, China, Thailand, and Malaysia. (Unfortunately, for our purposes, many of the studies in this new collection do not focus on the period that most interests us.).

The results in each collection are somewhat mixed in various ways (e.g. whether, when, and in what skeletal indicators trends of declining health were observed, and in what categories of people by age and sex they were found). But, in combination, they all tell a very similar story. Health, measured by various skeletal indicators, declines rather than improves through time in most parts of the world. However, two studies from Thailand and one from Malaysia tend to suggest that a decline in health did not occur with the adoption of farming. In fact, in these studies, some pathology frequencies suggest improvement in health. The authors of these studies suggest that this reflects the fact that rice is a healthier staple than those of the Western Old World and the New World (Krigbaum 2007; Dommett and Tayles 2007; Toomay-Douglas and Pietrusewsky 2007). In contrast, maize, as a staple in the New World, may have been particularly unhealthy, perhaps accounting for the fact that the declining health associated with intensifying agriculture seems clearest in the Americas.

Bocquet-Appel et al. (2008) also see evidence of increased health stress across the NDT, although they consider it to have appeared only with some delay after the spurt in population growth, accounting for the later leveling off at after the surge.

In some archaeological sequences however, such as the description of incipient cultivation in the southern Levant provided by Smith and Horwitz (2007) increasing pathology is clearly associated with the earliest phases of the transition. The chapter by Wittwer-Backofen and Tomo (this volume), presents results concerning Europe – with specific reference to the LBK populations that figure so largely in the population expansions under discussion. In this study, LBK populations show higher rates of most pathologies than either the preceding Mesolithic populations or those of the Later Neolithic. In Later Neolithic populations, pathology declined again but remained above Mesolithic levels. Bennike and Alexandersen (2007) also found the early Neolithic population to be the most stressed of those in her Scandinavian sample. Other samples in Cohen and Armelagos (1984) also suggest that increases in pathology were associated with early stages of economic change. So some other studies challenge the assumption of delayed increases in mortality.

Stature

In all of the collections just listed, estimated stature, where recorded, most commonly declined beginning well before the adoption of agriculture as also been noted by Bocquet Appel, Naji, and Bandy (MS) and by Wittwer-Backofen and Tomo with reference to the LBK culture. This has been interpreted by some as an evolutionary response to the changing size of prey. But in fact it is a very plastic response to nutrition as evidenced by the fact that stature rebounded rapidly in all of the affluent regions of the world after about 1880, as health and nutrition improved (Cohen 1989, 2007b). (In the last century, in reaching what is called our "genetic potential," we have, in fact, just about returned to Paleolithic statures.) Up until recently stature decline has mostly been recorded in the Old World; but Steckel and Rose (2002) and Doran (2007) demonstrate that the trend is also widespread in the New World.

I would add that class differences in ethnographic and archaeological populations are fairly clearly reflected in differential stature, in the expected direction, tending to support the interpretation that stature reflects diet and health (unless the upper class can consistently be shown to be taller conquerors from another region, which only occasionally seems to be the case). (For summary see Cohen 2007b.)

Bocquet-Appel et al. (2008) use sexual dimorphism of the femur as a proxy for stature. The authors note a general decline in sexual dimorphism suggesting declining health across the NDT. Most often, as these authors note, sexual dimorphism should decline in poor conditions, because male growth is affected more than female, collapsing on female values in hard times, increasing more than female values in good times. They use sexual dimorphism because they find stature estimates unreliable. I quite agree that femur length is a far better measure than "stature" for comparison, because the latter involves calculations using formulae of varying precision and with large margins for error. But, absolute femur lengths are better indicators than sexual dimorphism because sexual dimorphism can be an ambiguous indicator. Cohen and Armelagos (1984) found in some of their studies that declining sexual dimorphism could result from increasing female stature as well as from declining male stature, raising questions about the direct correlation of sexual dimorphism and nutrition, unless the pattern can be interpreted as reflecting differential improvement in female nutrition.

Tooth Size

Where reported, tooth size (almost?) always gets smaller along the same timeline. Studies are summarized in Cohen (2007b). Again, although often interpreted as an evolutionary trend, changing tooth size, like stature, is apparently a plastic response to nutrition, because it occurs relatively rapidly in some sequences, and because it too has rebounded very fast in the last century. New studies by Bennike (2007) and Smith (2007) among others reach the same conclusion. Of note is the fact that, in a reverse twist, at one site in India, Lukacs (2007) describes an *increase* in tooth size over a very short period when farmers reverted to hunting and gathering. He too argues that the change resulted from improved nutrition in the hunter-gatherer economy.

Infection

Armelagos (2005) has recently called attention to genomic data suggesting that some human diseases may have a longer history than once thought and that some once considered products of Neolithic economies may not actually be so. He suggests that some diseases shared by people and domestic animals may actually have spread in a direction opposite to that usually assumed. However, rates of infection in paleopathological studies go up everywhere fairly uniformly, and major identifiable diseases such as TB, leprosy, and treponemal infection (yaws and syphilis) are concentrated very late in almost all archaeological sequences. In these patterns, Southeast Asia resembles other parts of the world. The trends presumably represent variables such as synergism between declining nutrition and increasing parasite load, higher population densities, more nucleated communities, sedentism, critical population thresholds, animal domestication, the creation or expansion of microenvironments favoring mosquitoes, and the increased efficiency of trade networks, which are common avenues of disease spread.

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis and cribra orbitalia (porosity and thickening of the cranial vault and the eye sockets, respectively), indicative of iron deficiency anemia and/or scurvy, increase in frequency almost everywhere with farming – a trend also noted by Bocquet Appel and Naji (MS) and by Wittwer-Backofen and Tomo for the LBK. Iron deficiency might well increase as a result of any of several causes, alone or in combination. Meat is the best source of usable iron and its contribution to the diet probably declined. Dietary vitamin C helps the absorption and a probable decline in its availability would have contributed to the increasing deficiency. Cereals are poor sources of usable iron and have anti-absorptive properties. Hookworm, a parasite that robs the body of iron, spreads much more effectively in sedentary communities because one stage of its life cycle must be carried out in the soil.

Porotic hyperostosis might also increase in response to bacterial infections because the human body withdraws iron from circulation, effectively making itself anemic, as a way to fight infection. Scurvy (vitamin C deficiency) would have increased because the dry storage of food tends to destroy the vitamin. Cribra orbitalia (porosity of the eye sockets), interestingly enough, does not always parallel frequencies of porotic hyperostosis, a fact also noted by Bocquet Appel and Naji, although the two symptoms usually are thought to represent the same problems. The difference may reflect slightly different causes or differing ages of onset with cribra orbitalia commonly appearing earlier in life.

Enamel Hypoplasia

Rates of enamel hypoplasia (lines or areas of deficient enamel formation on teeth) are the best indicator we have of episodic growth disruption in children, and are particularly important in later discussion. In most areas, they increase in frequency and/or severity through time including in the LBK culture (Wittwer-Backofen and Tomo 2006). Lukacs (2007) notes that hypoplasia declines in his "reverse" transition when farmers revert to hunting and gathering. Lukacs (personal communication) also notes that the frequency of localized EH correlates with reduced tooth size and with a third measure, fluctuating asymmetry of teeth, also thought to reflect developmental stress. The correlation reinforces the interpretation of each measure.

Caries

Caries commonly increase in frequency through time. Bocquet-Appel et al. (2008) reject the hypothesis that the trend can be explained simply by increasing life expectancy. The larger pattern of data says that they are almost certainly correct. Caries continue to remain high or increase further in frequency on a very broad geographical scale, after the adoption of farming, although life expectancy cannot possibly have increased in a similar broad spatial and temporal pattern, and as noted, must most have commonly declined.

Mortality

Mortality must certainly have increased and life expectancy decreased, on average, as populations approached and passed the transition point for reasons I have discussed. But, I have questions about the nature of the mortality transition that clearly occurred. Was the mortality transition occurred actually so much later than the fertility transition? (The interpretation to this may depend on how clearly the post-Neolithic surge in population growth can be demarcated by independent means.)

If the rise in mortality was markedly delayed, why so? If the delayed increase in mortality is attributed primarily to domestication of animals, then we are stuck explaining why the onset of increased mortality was similar in the Old World where new domesticates are clearly responsible for a large number of new diseases, and the New World where domesticates were few and significant transferred diseases probably even fewer, judging from the failure of New World disease to infect the old in the sixteenth century. Neither did New World populations experience the major epidemics that plagued populations in the Old World, until the sixteenth century, long after the events and patterns that interest us here.

It is also important to reiterate that signs of major diseases such as tuberculosis, leprosy, and syphilis visible in skeletons, generally cluster very significantly toward later parts of all archaeological sequences, although TB (now known to have infected people independently the Old and New Worlds) has been identified occasionally at earlier times. And the major epidemic diseases that skeletons do not record, although possibly derived from domestic animals or other earlier sources, would not have circulated significantly even among Old World groups until populations and settlements larger than those of the Neolithic were achieved.

There is a far more significant contributor to childhood mortality that may account for the parallel occurrence of increasing mortality. The major killer of children in modern Third-World countries has long been enteric infection in childhood which commonly spreads from person to person particularly in dense sedentary groups, and catches first (and thereafter) when children are exposed to human feces and garbage particularly when it occurs in synergy with malnutrition. Given the probability that the major epidemic diseases children now catch must all be relatively recent because they rely on civilized population densities and transportation networks to thrive and spread, enteric childhood infection and diarrhea must have accounted for even a larger percentage of deaths at the time of the NDT.

The hypothesis of reduced breastfeeding implies that children are less protected by maternal antibodies that would otherwise help protect them from disease, and that they are put on the ground sooner, at which age mortality increases dramatically. The degree of filth on the ground also increases sharply when populations settle down. The pattern of increasing stress and death at that age may be reflected in the appearance of the first enamel hypoplasia in a child's mouth. In fact, working backward, the onset of hypoplasia is often taken in skeletal studies to indicate the age of weaning. It is worth noting that Armelagos and Maes (2006) use first hypoplasia as an indicator of weaning in precisely this manner – and note that the apparent age of weaning, by this measure, declined through the archaeological sequence at Dickson Mounds in Illinois. It would be interesting to note whether there was a corresponding change in peak infant/juvenile mortality, although the visibility of this pattern is marred, of course, by the difficulty of quantifying infant death in skeletal samples. More important for our figures, illness and poor growth in earliest childhood are likely to have reduced the development of immature immune systems and general disease resistance, possibly increasing mortality in older children.

The mortality of young children (particularly but not exclusively for those ages not included in the NDT calculations) is thus quite likely to have increased fairly quickly as groups settled down and women changed their nursing habits. I suggest that the post Neolithic surge in juvenile individuals in cemeteries (which in this context admittedly do not include infants or very young children) partly represents an actual increase in mortality at those ages as well as an increase in fertility. Death profiles in a cemetery cannot be used to determine actual mortality, but, that does not preclude the possibility that some mortality figures might be embedded in what are now usually read as fertility trends.

Some Problems of Interpretation: Reading Prehistoric Mortality and Morbidity ii

The idea that cemetery samples accurately reflect the once-living population from which they were drawn has been called in question. Thanks to Sattenspiel and Harpending (1983) and Bocquet-Appel and Masset (1982) among others, cemetery death profiles are no longer read as life expectancy tables for the once living populations, rendering mortality measures very difficult, if not impossible, to obtain for prehistoric populations, except under special circumstances. Any statements I have made about mortality levels depend entirely on theory and the constraining mathematics of population growth after 10,000 BP with no reference to cemetery populations.

A more controversial question is whether visible skeletal pathologies in cemetery samples can be read as direct indicators of morbidity in the living population that produced the cemetery (e.g. Ortner 1992, 1998; Wood et al. 1992.). However, I have shown to the satisfaction of many paleopathologists that quantitative estimates of population morbidity from skeletal samples do reliably reflect their host populations, as long as we are talking about replicated comparisons of *relative* pathology/morbidity at two or more sites. The arguments are recapitulated in footnote[2,3]

The Relative Stability of Foraging and Farming Economies

The fact that farmers commonly display *more* signs of growth disruption calls in question the common assumption, shared by Bocquet Appel et al. (2008) and many others, that farming brought increased dietary stability and homeostasis in health. This may be a critical point. There are, in fact, several arguments to suggest that in theory, homeostasis should decline with sedentary farming. Domestic crops are more vulnerable than wild ones, particularly when moved out of their natural habitat; crowding of crops promotes crop diseases; storage systems themselves very often fail. As some prehistorians have pointed out (e.g. Diehl and Waters 2006) the invention and spread of pottery vessels would have increased the ability to store crops significantly. But they would hardly have been up to the whole job. Some estimates suggest that as much as 30% of stored food is lost even in the most modern and sophisticated systems. In fact, studies in the Middle East and Africa document such failure among subsistence farmers and point to hunger periods as severe as those of hunter-gatherers although the latter are now relegated to environments which are much poorer in food resources than those occupied by their prehistoric forbears. In addition, both minor and major epidemics that can rob people of nutrients as well as upsetting the body's equilibrium in other ways undoubtedly became more likely as populations grew and settled in nucleated communities. Most importantly, tied first to their fields and then to their stored food, farmers cannot move away from crop or storage failure, or their own filth as foragers do; nor can they move away from other groups trying to steal their stored food. Stored resources and prepared fields are vulnerable to intra-group predation as well; and they make populations much more vulnerable to conquest. All the latter are likely to generate severe intermittent problems of nutrition and food supply.

Some Final Suggestions About the NDT

I can summarize by noting some of the implications of these thoughts.

One implication, as I and others have suggested, is that the transition may have been neither as dramatic nor as exuberant as the original thesis indicates, particularly in areas where agriculture was initially developed.

A second is that, to the extent that curbs on fertility were intentionally relaxed, it may well have been done for defensive reasons, and the security of family property, or calculated marginal utility or social security resulting from increased risk, not merely because a cap on production had suddenly been lifted.

A third is that the increase in mortality is likely to have begun somewhat sooner than the original thesis suggests, accompanying the common visible decline in nutrition and health.

The fourth implication is that the success of the transition and the related expansion of some farming populations was probably based on the competitive success of relatively dense populations at a time when war power meant manpower, rather than based on improving quality of life, health, or survivorship. To the extent that the new economy spread by diffusion, I suspect that it spread on a basis of need, to populations already pushing the limits of their existing resources, which would not otherwise have accepted the new technology.

Reconciling the NDT Model with the Data from Efficiency and Paleopathology Studies

The problem is reconciling the NDT with patterns of declining health and high fertility. I offer one possible means of reconciliation. At least in the modern world, high fertility is associated not with affluence but with economic hardship and uncertainty. One reason is that with economic uncertainty, parents are concerned about having enough surviving children to care for them in old age. This is the only social security or means of saving they have. I believe that economic risks increased after the adoption of sedentary farming for reasons I have described. Moreover, if mortality was in fact increasing during and after the NDT, there would have been a strong incentive to increase fertility. In short, moderate fertility/moderate mortality populations were replaced by those with high fertility, lower life quality, and high mortality, a pattern that combined with Neolithic expansionist trend is reminiscent of a movement from relatively K-selected strategies to relatively r-selected ones as commonly defined in the literature on population ecology.

In some sense, the spread of farming communities was probability based on *instability* as much or more than on "success." Competitive increases in population densities appear largely to have been a Holocene/farming, not a Pleistocene Hunter/gatherer phenomenon (Richerson et al. 2001). Human economies changed from those of relative, although imperfect, pre-Neolithic balance with environmental resources that was maintained by some combination of natural and cultural mechanisms population control – which, however, leaked as described by Cohen (1977) – to economies inherently out of balance with their environments resulting in constant and accelerating population growth. In effect, we are seeing a transition from K-toward r-strategies involving instability, higher rates of fertility and mortality, decreasing care of children, and rapid colonization of new territories.

The Neolithic revolution may have produced a more profound change in human strategy and a more profound effect on subsequent events than the new economy and technology per se.

Notes

1. No more than 0.1% by the mathematics of a compound "interest" formula from an estimated terminal pre Neolithic population of 5–10 million at 5–10,000 years ago to a commonly estimated half-billion at the time of Columbus. If the pre-Neolithic population was larger, as many assume, then the growth rate was even smaller. No reasonable combination of population sizes and the time period involved produce a substantially different result.
2. (Adapted from the appendix to Cohen 2007a) Despite recent criticisms, straightforward interpretations of *relative* pathology frequencies in two or more past populations can generally be made from their cemeteries without concern for paradoxical interpretations.

   Ortner (1992, 1998) notes that visible pathology forms slowly in bone. As a result, a skeleton without visible pathology might represent an individual who never suffered a particular disease, or one who suffered so severely that (s)he died before the pathology affected the skeleton. Individuals displaying pathology might paradoxically be healthier and long lived than those who display no pathology. Visible pathology in cemeteries might increase not because more people got sick, but because more people lived long enough for pathology to register in their skeletons.

   The "osteological paradox" (Wood et al. 1992) argues that cemeteries are not necessarily fair samples of the living populations from which they are derived, because chance, differential frailty, and selective mortality may all affect the cemetery samples; hence, frequencies of pathology in cemeteries have no predictable relationship to the pathology of populations they represent. If this were true, no conclusions about pathology in a prehistoric population could be drawn from its cemetery.

Several arguments can be offered in rebuttal of both propositions, at least where comparisons between populations are attempted.

First, Goodman (1993) and Wright and Yoder (2003) suggest that using multiple independent lines of evidence may circumvent the problems of the "paradox." Good candidates are ethnographic observation and uniformitarianism. Cohen (1989) provides summary paleopathological data (as directly interpreted), modern epidemiology, and uniformitarian logic used to reconstruct ancient disease patterns. The three lines of evidence converge on the same conclusions, strengthening conclusions from the direct interpretation of skeletons. Skeletal pathology frequencies largely in accordance with expectations from other lines of analysis, suggesting that neither Ortner's argument nor the "Paradox" apply.

Second, the "Paradox" overstates the importance of differential frailty and selective mortality on cemetery populations, at least with regard to the relatively chronic conditions that appear in skeletons and that may contribute to the probability of death without themselves being lethal.

Those with a specific pathology in any cemetery come from one of two groups: individuals whose deaths are hastened ("selected") by their chronic condition; and those whose deaths are random *relative to a particular pathology*. For example, if individuals with or without pathology are killed by bad luck or "outside events" with no regard to differential frailty (e.g., a cave roof collapses) those dead will be a random sample of the living and will, on average, reflect their rates of pathology accurately. But those dying "selectively" will also reflect the frequency of pathology among the living because the selected group reflects the strength of selection *multiplied by the original frequency of the pathology in the population*. Despite selective mortality, the original pathology frequency in the living population exerts a powerful influence on its frequency in the cemetery. (Cf. Wright and Chew 1998.)

If the strength of selection changes dramatically from population to population this argument might not hold. Epidemics of acute disease that kill rapidly without scarring the skeleton are prone to "paradoxical" interpretation. No skeletal pathology may reflect rapid death. But these diseases have widespread effects only relatively late in prehistory. Therefore, the skeletal invisibility of epidemics should result in *under-estimation* – rather than negation – of the pattern of declining health commonly observed in history.

We can interpret stress markers of childhood stress events, like enamel hypoplasia, in the same way. High frequencies of hypoplasia could indicate a high frequency of stress episodes. Hypoplasia can also be considered an indication of good health as implied by Ortner, because they reflect survival through stress episodes. In this case, low frequencies of LEH in a population of adults could actually reflect high childhood mortality not health. But they do not.

Adults who show no hypoplasia cannot have died before the stress marker could form. That adult must not have experienced the stress. When *adults* are compared, few hypoplasias mean few stresses; more hypoplasias mean more stresses. Ortner would argue that the absence of hypoplasia among adults, however, reflects high childhood mortality not health. But it does not. The assumption that more LEH means more health problems, not survival, is almost certainly correct. Which is more likely – that children died of stresses that adults did not even record in teeth – or that they died of stresses that others survived but recorded? Surely the latter is more probable. More hypoplasia in adults must mean higher, not lower, childhood mortality.

Third, if cemetery populations are misleading samples, where are the paradoxical results? There ought to be many results that make no sense vis-à-vis results of theoretical expectations. But paleopathological data repeatedly match the expectations of data from ethnographic studies and uniformitarian assumptions. Skeletal signs of anemia and infection (including tuberculosis, syphilis, and leprosy) increase when and where we would expect.

If Ortner were correct, we should find higher rates of visible pathology and in upper class populations, living and prehistoric in prehistory. If the "Paradox" were correct, we might expect average statures to be smaller in upper class populations. But neither is the case. Taller stature and relatively low rates of visible pathology are routinely found in upper classes (Tristan et al. 1982; Betsinger 2002; Danforth 1999 and references cited in Danforth et al. this book; Goodman 1998; Goodman and Martin 2002; Goodman et al. 1991, 1992; Harris et al. 2001; Hatch and Willey 1974 and references cited; Lucaks and Joshi 1992; Powell 1988, 1991; Rathbun and Scurry 1991; Zhou and Corrucini 1994).

For these reasons, we argue that broad patterns in quantitative paleopathology, at least when comparisons between populations are intended, *do* fairly represent the relative frequency of pathology in the populations from which the cemeteries were created.

3. Most estimates of the efficiency of hunting of big game have ranged from 4000 to 15,000 kcal per man hour, depending on the size of the prey and the ease with which they can be found.

 In contrast, values reported for small-game hunting and trapping in various regions are more typically 500–800 kcal per man hour; from shellfish, 1000 kcal; from vegetable gathering 3200 by one study, 1125 and 1740 in other studies; and from small seeds such as cereals, 700–1300 kcal. One source suggests that small seeds were not even exploited until other resources are in very short supply. [Data and Sources are provided in Cohen (1989) and largely reiterated in Kennett and Winterhalder (2006).] One study by Kenneth Russell (1988) suggests that in the Middle Eastern cradle of agriculture, domestication of wild cereal would probably result in a further decline in efficiency. Perhaps, more importantly, in almost every instance studied, from desert to rainforest; relative returns from hunting large animals are higher than those from all other strategies. In short, when they can be found within a few hours or even a couple of days, large game animals are enormously efficient to exploit.

 One problem with using big game as a resource is that it demands relatively large territories for group exploitation (but available territories apparently often got smaller in the Mesolithic). A second point as suggested is that the efficiency of hunting large game depends how scarce they are—or how scarce they gradually become. As the encounter rate goes down (i.e., the longer it takes to find an animal) obviously, so does the efficiency. Smaller game, fish shellfish, and particularly small seeds requiring extensive processing and storage would not have been exploited (and commonly *are* not) until more desirable resources have exhausted, or until the problems of finding large game were such that the overall efficiency of hunting fell to or below that of other strategies. A key point is that it is the availability of the large animals, not the availability of other resources that determines whether the other resources will be utilized. The amount of wild wheat available or the amount of domestic wheat that can be grown is irrelevant to the equation. Russell suggests, in fact, that the cereals may have gone in and out of use possibly several times, depending on the availability of better resources. The advantages of cereals is the enormous caloric density in which they can grow (and the fact that many of the plants in question "like to settle" near people).

 It is important to note that these models are *predictions* that resource use should follow a particular sequence – all else being equal if caloric return per man hour is the primary thing to be optimized. We should note, however, that relative qualitative nutritional value of foods, and food preferences commonly expressed by people around the world, generally reinforce trends predicted from the measures of caloric efficiency. Meat is a relatively rich source of protein, vitamins, and minerals, particularly iron although in wild form, animals may not have been rich sources of fats. For various reasons, cereals are not rich sources of these nutrients, and they are not what people typically prefer. But they produce large numbers of calories per hectare

 The models set up expectations that do in fact match the generalities of most archaeological sequences, leaving local exceptions to be explained. The predictions do not necessarily match the details of every archaeological sequence, which can be skewed for any number of reasons. For example, the sequence of preferences might be skewed by relative dangers of hunting different species, or by cultural preferences for various kinds of foods. In parts of the New World, maize seems to have had ceremonial and prestige value, presumably altering the sequence of its adoption, before it was used for subsistence.

 We know that large game has exhausted many species to the point of extinction, during periods of early human hunting on each continent. Scholars do not agree whether or in what combination this resulted from human over-hunting or other natural causes. But for this purpose it makes little difference. The imbalance was there, whether as a result of human over-exploitation or of declining supplies of game; and the result was the "broad spectrum revolution." People were not changing their resource base because they had invented new things; they were changing because preferred resources had become so scarce, and search times so long that their efficiency as resources had fallen below that of lesser foods. People were essentially forced to change. It is in this context, that prehistoric people are telling us of population pressure. It is for this reason that I argue that climate changes more often decreased the range of available resources rather than increasing it.

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From Health to Civilization Stress? In Search for Traces of a Health Transition During the Early Neolithic in Europe

Ursula Wittwer-Backofen and Nicolas Tomo

Abstract Under the assumption that the health status of a population is closely connected to its living conditions (Steckel and Rose 2002; Cohen and Armelagos 1984) the aim of this study is to track changes in signs of pathology during the transition period from foraging to farming societies in Europe. The NDT is expected to be related to a major shift in health parameters from Mesolithic to Early Neolithic populations. This hypothesis is followed by studying European LBK skeletal populations and by comparing their health status to earlier Mesolithic as well as to Late Neolithic samples, roughly following the site list composed by Bocquet-Appel (2002). A selection of skeletal populations was examined depending on the availability of data relevant to health. A database was built up including around 600 skeletons. The major limitations were given by the facts that (1) skeletal indicators connected to health factors were only available for a smaller part of the relevant skeletal samples, that (2) frequencies of pathological signs could not be obtained due to incomplete individual data published and that (3) coding systems differed significantly from each other. Representativeness for Mesolithic or LBK populations cannot be assured as the database is characterised by a few larger samples who lived under locally specific conditions. As a consequence, the data could not be broken down to a comparison of males and females.

With these limiting factors in mind selected health parameters are collected following the "Global History of Health" Project database. In most studies, however, only few of these health parameters were included with a varying selection of indicators. This is the reason why this study is limited to a comparison of a few health indicators which show a clear tendency of health decline during the transition phase. The "general health index", which from the Western Hemisphere already proved to be a significant indicator for the health status in past populations (Steckel and Rose 2002; Steckel et al. 2002), could not be applied to the actual database.

Compared to the long transition phase of experience in the Near East, European populations seized the new way of life quickly. They might have faced severe problems

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in coping with the new set of pathogens, changing diet and variable situation of available resources. This might contribute to an explanation complex of the significant health decline in the European Early Neolithic skeletal material.
These preliminary results should be supported by a systematically collected database to be constructed in the next future by going back to the skeletons rather than relying on data from the literature.

Keywords Agriculture · central Europe · Foraging · health · mesolithic · neolithic · neolithic demographic transition (NDT) · nutrition · pathology · skeletal markers · stress

The Neolithic Transition in the Light of General Health

The Neolithic Transition has been a major topic in the twentieth century anthropological research. It appeared in different decades and on increasing levels of archaeological evidence in changing light. Especially the demographic changes of a considerable increase in the proportion of immature skeletons, indicating a raise in birth rates and referred to as Neolithic demographic transition (NDT), argues for change in the population structure with the shift from foraging to early farming societies (Bocquet-Appel and Naji 2006; Bocquet-Appel 2002). A remaining question is whether this might have been a dramatic shift of the general living conditions and therefore concerned all areas of life. The study of the health situation in the concerned populations can contribute to this area of research.

The Tempo Effects

The initial assumption of a rapid, revolutionary change from pre-agricultural forms of living to a sudden abolition of hunting and gathering and the fast distribution of sedentism and farming (Childe 1925; Braidwood 1948), has changed during the decades. The idea of population pressure, which suggested that food shortage and spatial limitations may have played a role in the slow and difficult process of the Neolithic Transition in the regions of the Near East first changed our idea of early sedentary life from a rapid change of the technological basis of food production to a long lasting transition and a long coexistence of Mesolithic hunting tradition and early farming experiments (Cohen and Armelagos 1984).

In contrast to the Near East where the transition phase took place over a long time, European Mesolithic cultures faced a forced dynamic towards the transition to agriculture. Archaeological evidence documents a fast spread of early settlements starting from southeast Europe, quickly expanding westwards (Christensen et al. 2006; Lenneis 2004; Scharl 2004). While the Near East populations could have developed coping strategies with the new challenges parallel to the stepwise change in living conditions, European populations may have failed in adapting quickly and therefore could have been overwhelmed by the changing situation. This was the starting point of the idea that the tempo in which the Neolithic transition took place in different regions of the world, might have affected the population adaptation process, including the health situation.

Thus, the hypothesis underlying the present study is that there was a general decline in health during the transition to the Neolithic culture, supposing a stronger effect for European Early Neolithic cultures compared to the Near East.

It is an obvious idea to reopen the somehow theoretical and speculative question of the driving forces behind the Neolithic Transition under these new circumstances (Scharl 2004; see chapter "Implications of the NDT for World Wide Health and Mortality in Prehistory" by Cohen, this volume).

The Nutritional Situation

In addition, newer research indicates that early forms of farming led to a decrease in the quantity of food supply and food quality and therefore, to a degradation of the general health situation (see chapter "Implications of the NDT for World Wide Health and Mortality in Prehistory" by Cohen, this volume).

A basic theoretical approach was provided by the early raised argument that a special constellation of environmental factors supported the development of agricultural techniques. One assumption was that agriculture did not originate from a growing or chronic shortage of food. It argued that people, living in the shadow of famine, do not have the means or time to undertake the slow and leisurely steps out of which a better and different food supply can be expected in a somewhat distant future (Hahn 1908; Sauer 1952).

From the late 1960s, this clear attribution of early settlement to the explorative and inventive skills of our predecessors continuously changed towards a less embossed picture. Agriculture was regarded as an economic strategy, forced by an increasing density of hunter-gatherers and/or by declining wild resources (Cohen 1977; Barnicot 1969; Yudkin 1969). Above that, Cohen argued that the environmental force that pushed people into developing agricultural skills, led to a decrease in food quality: "A good deal of evidence is accumulating, which suggests rather uniformly that the diet of hunting and gathering populations may be calorically quite adequate, and at the same time richer in food variety, vitamins, minerals and above all protein, than that of agriculturalists." (Cohen 1977:27).

Major considerations concerning the change of the health status during the Neolithic transition deal with the emerging subsistence strategy of food storage, especially concerning grain. The most significant difference between these cultures is the domestication of plants and animals, conducted in Europe by "Linearbandkeramik" (LBK) groups. Emmer and Einkorn wheat (millet in a few settlements, later barley) are supposed to be the first grain types that were domesticated. This enables a certain and effective subsistence by overcoming seasonal fluctuations. On the other hand, extreme storms or the affection with vermins could have had destructive effects on sowings, harvests and food inventory. Lots of examples in recent populations show the highly dynamic factor of the dramatically developing humanitarian catastrophes. With the increase of early farming including grain production and animal domestication, the meaning of wild resources in the nutrition decreased and was almost undetectable in the two early and middle Neolithic settlements of Germany (Dürrwächter et al. 2003). Besides food quantity the composition of food components plays a major role for the health situation during the transition phase from foraging to farming. The actual discussion keeps the reduced variety of grain and the concentration to domesticated cattle, sheep and goat in mind, with decreasing importance of hunting, limited to a few favoured animals like elk, deer and boar. The analysis of stable isotopes in Mesolithic and Neolithic skeletons suggests a significant decrease in food quality for the earliest sedentary people (Richards et al. 2003). However, stable isotopes analysis in human skeletons from different Neolithic phases showed that in Late Neolithic times meat procurement appears improved and that the dietary spectrum broadened compared to Early Neolithic times (Aman et al. 2006).

A reduced quality of food, which in times of bad harvests could have forced up to a reduced amount of food per capita leads to the hypothesis of declining health for the first sedentary LBK people caused by malnutrition and a change to better adapted living conditions in the Late Neolithic period.

The Spread of Neolithic Settlements and Population Density

The LBK differs in remarkable ways from the earlier Mesolithic cultures, as far as foraging and food production are concerned. They settled on fluvial terraces and in the proximities of rivers, instead of naturally protected spots, with a quick access to wooded hunting grounds (Cohen 1977).

The transition to the neolithic subsistence strategy in most parts of Central Europe took place during the second half of the sixth millennium and is described by the age of the oldest "Linearbandkeramik" (LBK). The transition presumably was preluded by short distance migrating farmers as well as by the acculturation of local foraging populations (for the spatial models of agricultural frontiers see Zvelebil 1986). Signs for such a scenario of combined local and migration processes have recently been shown by aDNA data from Mesolithic and early Neolithic skeletons (Bollongino et al. 2006; Burger et al. 2006) or by new archaeological contact zone analysis (Gronenborn 2006).

An advantage of farming is the adaptive power of agricultural living expanding to areas which were not occupied by Mesolithic hunter/gatherers. While Mesolithic groups were supposed to live in rare spots of environmental wealth, farming enabled humankind to conquer larger inland areas and to form the landscape to a limited degree. This also means as well that with the population pressure which is discussed as a driving force for the fast cultural spread of the Neolithic way of life over central Europe (Shennan, this volume) new areas were colonized. It can be assumed that in the first population wave most attractive areas for farming were chosen, whereas later population aggregation was accompanied by the evasion into less favourable regions.

In densely populated areas with rapidly growing populations, infectious disease is more likely to have been spread quickly and with reasonable demographic effects compared to the Mesolithic lifestyle of scattered small tribal bands with lower infection risks. This supposes a lower rate of infectious disease in the Mesolithic compared to the Neolithic expecting different patterns of physiological stress markers in the skeleton (Schultz 2001).

Due to raising population density, Neolithic populations also might have quickly developed additional problems of hygiene, including fresh water supply or waste management.

Physical load due to a raise of mechanical stress on the body connected with agricultural activities such as the use of grinding mills is another problem, producing degenerative joint diseases. In addition, the general high workload requires raising calorie intake and therefore an additional amount of food with increasing risks of malnutrition.

In general, environmental constraints caused by limited resources and several other stressors of changing living conditions could have had various effects on the health condition of people, depending on their physiological resistance or cultural buffering systems which may have been developed parallel to the emerging stress situation. The exposure to such risks can be detected in the rate of disease burden measured by indicators manifested in the skeletal remains. The present study is based on this cause–effect model.

An important and interacting point is the before-mentioned speed in which the transformation took place. Long-term changes are supposed to be better negotiated than short-term changes which make high demands on the adaptability of the human body.

Several ideas about the process of the Neolithic transition in the different regions of the world were developed in the book of Cohen and Armelagos (1984). It has been shown that the European material suffered from a small database with regard to health relevant data (Meiklejohn et al. 1984).

The basis for an approach is a statistical comparison of early Neolithic LBK populations compared to older (Mesolithic) cultures and Late Neolithic populations in Europe, based on health relevant characteristics in skeletal remains.

A desired second aspect of this study is to describe the data in statistical and chronological aspects and thus provide a first basis for discussing the results and their implications.

However, it has to be taken into account that the Neolithic transition is a complex phenomenon and cannot be measured by examining few skeletal markers alone. The first step with this specific analysis is to track a few selected aspects over a larger region of central Europe, mainly Germany. However, this analysis needs to be interpreted in the light of different disciplines, as this started with the NDT conference, whose results are presented here. A deeper understanding of which challenges and problems the populations during the NDT faced is therefore only possible in intensive interdisciplinary discussion, to which this may contribute.

Skeletal Markers as Indicators for Reconstructing Health Profiles

The specific aim of the study of following the health situation in a chronological way covering the Early Neolithic populations is based on a paleoepidemiological approach. This field of research studies the prevalence of diseases, their distribution, manifestation and aetiology in premodern populations and therefore works on a population-based consideration. In this approach living conditions can be reflected which deliver valuable insights into the quality of life of ancient populations. For this purpose it is helpful to define specific health relevant markers in the skeletons as a reaction of the human body to underlying conditions which can be regarded as health indicators.

A major challenge in the beginning of this investigation was the selection of meaningful anthropological categories. Morphological changes, the distinction of ethnic groups or demographic changes were the main focus of anthropological investigations up to this point. The question for the search of health relevant markers at the skeletons is a newer emergence within the field (Dastugue 1980; Buikstra 1991; Larsen 2002). A review on the literature of paleoepidemiology, the study of disease in past human populations during the last decades, can be found in Goodman and Martin (2002). Stringent concepts for the evaluation of the health status of a past population have been developed meanwhile, suggesting the collection of specific skeletal indicators, which for specific epidemiological questions already proved as suitable inventory (Steckel and Rose 2002; Buikstra and Ubelekaer 1994; Goodman et al. 1984).

Health parameters are closely connected to mortality and fertility. Frailty of individuals and morbidity on the population level contribute to the shape of mortality patterns (Hoppa and Vaupel 2002; Milner et al. 2000) and therefore, paleodemographic data may be used as indicators of the health status. In this study, however, the focus is not on paleodemographic data of age at death distribution, distribution by sex or estimation of fertility parameter, etc. One reason is that paleodemographic analysis requires different aspects of data collection from those guided by the aim of reconstructing health parameters. Additionally, paleodemography is in the focus of different contributions in this project.

The chance of reconstructing the health status of skeletal populations depends on several factors of which the selection effects are far from being understood. A first and general aspect is given by the fact that with the exception of traumatic lesions only long-term processes showing manifestations in the skeleton can be detected. Additionally, taphonomic diagenesis may contribute to a significant shift in the frequency of reported health relevant data compared to the real health burden in the population.

By now, the study is limited to the extraction of data from the literature. Therefore only those skeletal populations could be used, that scored at least a few of the ‘Global History of Health Project’ variables (Steckel et al. 2005) and were also studied in an adequate way (see below). The literature survey revealed the poor data situation in that regard and forced us to record a much smaller number consisting of only those indicators which were investigated in a number of individuals suitable for an analysis.

The concept on which the 'Global History of Health Project' is based gave the initial idea for data collection in the present study including several health parameters. The health relevant skeletal markers as used in the present study are shortly described in the following.

Stature

Adult stature can be regarded as an indicator for unspecific stress. Although stature is under genetic control it can be shaped by environmental plasticity (Steyn et al. 2002; Wurm 1983; Haidle 1997). It mirrors the results of growth spurts, retardations and catch-up growth during the growth phase mainly shaped on food supply with carbohydrates and proteins, hygienic conditions or chronic diseases. Especially sensitive phases are between four and six years of age (Stinson 2000). Besides anthropometric population studies the interrelation between stature, nutrition and ecological conditions has been in the focus during the last decade by anthropologists, historians and especially economists who detected a close correlation between the socioeconomic situation and body height (Steckel and Floud 1997; Komlos 2000).

Subadult long bone lengths together with the dental age are much more suitable to specify stress phases during childhood. At this time the database includes adult stature only.

Transversal Enamel Hypoplasia

Transversal tooth enamel hypoplasia are macroscopically detectable defects (Fig. 1) manifested during the tooth crown formation phase if stress periods occur in the relevant age span during the first year for deciduous teeth and up to about 7 years for permanent teeth (Goodman and Martin 2002; Schultz 1988). Causes can be malnutrition, undernutrition, metabolic disturbances due to infectious diseases (Roberts and Manchester 2005) or stress during the weaning phase (Moggi-Cecchi et al. 1994). The multiple aetiology of the occurrence of enamel hypoplasia suggests an

Fig. 1 Maxilla of an adult female with multiple enamel hypoplasia (Photo U. Wittwer)

interpretation as unspecific health indicator. As tooth enamel does not face remodelling after its formation is finished, enamel hypoplasia keep stable over the whole lifetime as long as teeth are still present in the jaws. This opens the field for an interpretation of age-specific morbidity and mortality when comparing frequencies between subadults and adults.

Dental Health

The condition of the periodontium delivers information mainly on the hygienic conditions and nutrition aspects and therefore can be regarded as a significant indicator of the general health situation and the socioeconomic situation (Minotti 2003). Signs of periodontal diseases are coded in the database.

Dental caries is closely connected to the diet. A high amount of carbohydrates supports the caries incidence. In a diachronic comparison starting from the Mesolithic until the nineteenth century England a high correlation between the consumption of carbohydrates, grinding techniques of wheat and the caries intensity was found (Roberts and Cox 2003). Additionally higher infection rates for females in historical populations have been calculated, suggesting a higher amount of carbohydrates in their nutrition compared to males (Larsen 1997). Besides these factors, hygienic factors, trace elements or highly abrasive elements in the diet also play a role shaping caries intensity in populations. Dental caries is among the most often observed health relevant skeletal markers in historical populations and can be regarded as indicator of overall health.

Porotic Hyperostosis

Porotic hyperostosis is affecting bones involved in the production of red blood cells and therefore is commonly associated with anaemia. The possible aetiologies mainly include deficiency anaemia by nutritional disorders based on iron deficiency, infectious diseases or affection with parasites besides genetically based traits (Stuart-Macadam 1998; Sullivan 2005; Roberts and Manchester 2005). An initial anaemic cause can be a chronical vitamin C deficiency, which leads to a decrease of iron absorption in the body. Lesions occur as cribra cranii or as cribra orbitalia in varying intensities (Fig. 2). Subadults and females are most vulnerable due to their high metabolic need for iron. Because the lesions in most cases cannot be traced back to the underlying cause, it was suggested to interpret the macroscopic diagnosis as unspecific stress marker (Larsen and Sering 2000; Schultz 2001). According to Wapler et al. (2004) around 43 per cent of the cases under study could be traced back to any kind of anaemia in adult skeletons and the presence of cribra orbitalia indicated that the individuals experienced some kind of chronic health problems although it may not have been anaemia.

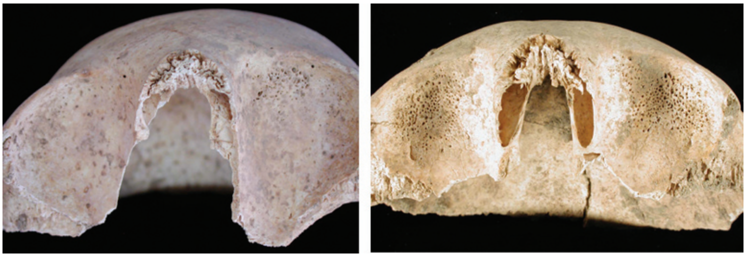


Fig. 2 Orbital roof of a 5-year-old child with moderately expressed cribra orbitalia (*left*) and orbital roof of an adult female with symmetric occurrence of heavy cribra orbitalia (*right*) (Photo S. Braun)

A major aspect for epidemiological studies is the fact that porotic hyperostosis can be remodelled in adulthood and a crisis situation during childhood might be no more detectible in higher age.

Harris Lines

Harris lines describe a specific bone reaction to unspecific stress situations during the growth phase of an individual (Grolleau-Raoux et al. 1997; Larsen 1997). During the acute physiological stress situation the bone proliferation is reduced, followed by a phase of recovering with intensified growth which produces a layer of dense mineral apposition. The positions of the Harris lines detectable in X-rays of long bones, mainly tibia, femur or radius indicate the age at which the basic stress occurs. Major causes are chronic malnutrition or infectious disease during childhood or critical ages such as the weaning phase (Hummert and VanGerven 1985; Roberts and Manchester 2005). Similar to porotic hyperostosis, complete resorption may occur so that the basic stress phase may no more be detectable.

Degenerative Joint Disease

Degenerative joint diseases represent a summary of non-inflammatory alterations of the joints due to physical activity, working load, genetic disposition or diet (Bridges 1994; Steyn et al. 2002). In the affected joint the subchondral bone is exposed and reacts with producing marginal lipping or erosion, in severe cases with eburnation and leading to the ankylosis of a joint (Roberts and Cox 2003). This represents a significant disturbance in the contribution to social life and individual living quality. Degenerative joint disease can be classified by defined scoring systems (Schultz 1988; Steckel et al. 2005). The interpretation is mainly based on the reconstruction of physical activities, including the observation of specific joints affected, which could be used for the reconstruction of specific activity patterns in a population.

General Description of the Sample and Coding System of Health Parameters

The database consists of 593 individuals. The data were acquired from various sources (see Table 1, Fig. 3). It was divided into three chronological groups, each corresponding to a specific form of agricultural or pre-agricultural food resource and subsistence strategy (Mesolithic/Early Neolithic (LBK)/Late Neolithic). A main basis for the sample composition was directed by the lists supplied by Bocquet-Appel and Naji (2006) and Bocquet-Appel (2002), which was collected for the purpose of demographic data analysis to demonstrate major population situations connected to the NDT. However, demographic situation is not in the focus of the present study.

A major limitation for the use of skeletal data in the present study is the lack of scored health-relevant biomarkers in many of the skeleton samples published so far. The main problem was that neither skeletal markers relevant for the present study could be observed at all in the major number of samples, which is mainly the fact for materials published before the 1990s nor special interest was taken in specific characters which were rather a subject of an isolated evaluation than of a holistic view of a population-based health status. For several skeletal samples under consideration, individual data were not available in a way that could be used for statistical analysis. This is true, for example, for the important samples of the Mittelelbe-Saale region which are studied in detail but lack information whether a specific trait was not scored due to the fact that the trait was not expressed or the relevant skeletal part was absent (Bach 1978). Finally, the scoring systems often differed between the authors. Data could only be used if definitions concerning the occurrence of a trait were comparable. If definitions on the intensity of a skeletal reaction given as stages of a trait were not compatible to each other, we decided to score just the occurrence of the trait. An abstraction from the intensity of various criteria and a pure investigation of the frequency of their appearance was the only way to work with such data. Several sites represent scattered bones which could not be composed to individual skeletal units and therefore were not qualified for a statistical analysis.

Thus, the data selected so far represent a compromise between the aim of exploring a maximum number of health relevant skeletal traits, a high sample size and the comparability of data. This led to the set of variables as described in Table 1. Body height was chosen instead of long bone length, as varying bone measurements were given in the literature, mostly depending on the state of preservation. Body height as given by the authors was used when a calculation formula for unaccelerated populations was applied.

The age distribution of the whole sample suffers from the under-representation of subadult individuals, which predominantly were evaluated in a single study in the database, comparing health indicators in Neolithic children's skeletons (Carli-Thiele 1996). The sex distribution in the sample is almost balanced. In the literature on Early Neolithic skeletal material sex estimations for several subadult skeletons were given, which in this study was ignored for all children below the juvenile age group. Altogether, this data set appears suitable for a general comparative study.

Table 1 Mesolithic and Neolithic skeletal samples analyzed

			Number of skeletons						Pathology									
Site	Source	Time	Adult	Subadult	unknown	Total	AGE	SEX	HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Ostorf, Germany	Patolla & Henke (Mainz 2006)	Meso.	44	14	6	64	X	X	X		X	X	X	X	X	X	X	X
Skateholm all sample	Larsson (ed.) (1988)	Meso.	59	21	1	81	X	X	X									
Vlasac, Serbia	Garasanin (1978), Grünberg (2000)	Meso.	90	29	2	121	X	X	X			X	X				X	X
Mesolithic All			193	64	9	266												
LBK sites																		
Aiterhofen	Carli-Thiele (1996)	LBK	0	27	0	27	X			X	X	X	X	X	X	X	X	X
Wandersleben	Carli-Thiele (1996)	LBK	0	37	0	37	X			X	X	X	X	X	X	X	X	X
Wiederstedt	Meyer at al. (2000)	LBK	2	8	0	10	X	X	X		X	X	X	X	X	X	X	X
Essenbach	Haidle, M. (1997)	LBK	7	4	0	11	X	X	X	X	X							
Dillingen-Steinheim	Haidle, M. (1997)	LBK	13	0	0	13	X	X	X	X	X							

Table 1 (continued)

			Number of skeletons						Pathology									
Site	Source	Time	Adult	Subadult	unknown	Total	AGE	SEX	HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Talheim	Wahl (pers.comm.)	LBK	18	7	0	25	X	X	X							X		
Didenheim	Wittwer-Backofen (unpub.)	LBK	3	6	0	9	X	X	X	X	X	X	X	X	X	X	X	X
Bietigheim-Bissingen	Orschiedt, J. (1998)	LBK	2	2	0	4	X	X	X		X	X	X		X	X	X	X
Brackenheim	Orschiedt, J. (1998)	LBK	1	1	0	2	X	X	X		X	X	X		X	X	X	X
Brackenheim-Meinsheim	Orschiedt, J. (1998)	LBK	1	2	0	3	X	X	X		X	X	X		X	X	X	X
Brackenheim-.Hausen	Orschiedt, J. (1998)	LBK	0	0	1	1	X	X	X		X	X	X		X	X	X	X
Eppingen-Kleingartach	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Gerlingen	Orschiedt, J. (1998)	LBK	1	1	0	2	X	X	X		X	X	X		X	X	X	X
Heidelberg	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Klingenberg	Orschiedt, J. (1998)	LBK	3	4	0	7	X	X	X		X	X	X		X	X	X	X
Königschaffhausen	Orschiedt, J. (1998)	LBK	0	2	0	2	X	X	X		X	X	X		X	X	X	X

Table 1 (continued)

Site	Source	Time	Number of skeletons				AGE	SEX	Pathology									
			Adult	Subadult	unknown	Total			HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Langenau	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Mannheim-Vogelstang	Orschiedt, J. (1998)	LBK	2	4	0	6	X	X	X		X	X	X		X	X	X	X
Mannheim-Wallstadt	Orschiedt, J. (1998)	LBK	1	4	0	5	X	X	X		X	X	X		X	X	X	X
Neckargartach	Orschiedt, J. (1998)	LBK	1	1	0	2	X	X	X		X	X	X		X	X	X	X
Pfäffingen	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Poppenweiler	Orschiedt, J. (1998)	LBK	1	1	0	2	X	X	X		X	X	X		X	X	X	X
Reusten	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Schwaigern	Orschiedt, J. (1998)	LBK	5	4	0	9	X	X	X		X	X	X		X	X	X	X
Bischoffingen	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Eltingen	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Hofen a. N.	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X

Table 1 (continued)

Site	Source	Time	Number of skeletons				AGE	SEX	Pathology									
			Adult	Subadult	unknown	Total			HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Lauffen a. N.	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Leingarten-Großgartach	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Leiselheim	Orschiedt, J. (1998)	LBK	0	0	1	1	X	X	X		X	X	X		X	X	X	X
Markgröningen	Orschiedt, J. (1998)	LBK	2	0	0	2	X	X	X		X	X	X		X	X	X	X
Murr	Orschiedt, J. (1998)	LBK	1	0	1	2	X	X	X		X	X	X		X	X	X	X
Fellbach-Oeffingen	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Pleidelsheim	Orschiedt, J. (1998)	LBK	0	0	1	1	X	X	X		X	X	X		X	X	X	X
Rottenburg	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Ditzingen-Schöckingen	Orschiedt, J. (1998)	LBK	1	1	0	2	X	X	X		X	X	X		X	X	X	X
Schwieberdingen	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Stuttgart-Mühlhausen (Vies.Hof)	Orschiedt, J. (1998)	LBK	2	0	0	2	X	X	X		X	X	X		X	X	X	X

Table 1 (continued)

Site	Source	Time	Number of skeletons						Pathology									
			Adult	Subadult	unknown	Total	AGE	SEX	HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Stuttgart-Mühlhausen (Mittl.Lerch.)	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Stuttgart-Mühlhausen (Wanne)	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Stuttgart-Mühlhausen (Mönchsfeld)	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Stuttgart-Zuffenhausen (Pliensäcker)	Orschiedt, J. (1998)	LBK	1	0	0	1	X	X	X		X	X	X		X	X	X	X
Stuttgart-Zuffenhausen (Rothweg)	Orschiedt, J. (1998)	LBK	0	1	1	2	X	X	X		X	X	X		X	X	X	X
Tauberbischo-fsheim-Dittigheim	Orschiedt, J. (1998)	LBK	0	1	0	1	X	X	X		X	X	X		X	X	X	X
Waiblingen	Orschiedt, J. (1998)	LBK	4	1	1	6	X	X	X		X	X	X		X	X	X	X
Zaisenhausen	Orschiedt, J. (1998)	LBK	0	0	1	1	X	X	X		X	X	X		X	X	X	X
LBK all			83	124	7	214												

Table 1 (continued)

			Number of skeletons						Pathology									
Site	Source	Time	Adult	Subadult	unknown	Total	AGE	SEX	HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Late Neolithic sites																		
Bad Mergentheim-Althausen	Dresely, V. (2004)	Neol.	2	2	0	4	X	X	X		X	X	X	X	X	X	X	X
Dittigheim	Dresely, V. (2004)	Neol.	23	35	2	60	X	X	X		X	X			X	X	X	X
Gerlachsheim	Dresely, V. (2004)	Neol.	4	10	0	14	X	X			X	X						X
Grünsfeld	Dresely, V. (2004)	Neol.	1	0	0	1	X	X	X		X	X	X	X	X	X	X	X
Impfingen	Dresely, V. (2004)	Neol.	10	17	0	27	X	X	X		X	X			X	X	X	X
Tauber	Dresely, V. (2004)	Neol.	7	5	0	12	X	X	X		X	X			X	X	X	X

Table 1 (continued)

			Number of skeletons				Pathology											
Site	Source	Time	Adult	Subadult	unknown	Total	AGE	SEX	HI	HL	TRS	CA	PA	PALE	CCI	COR	ARKN	SO
Mesolithic sites																		
Weikersheim	Dresely, V. (2004)	Neol.	1	0	0	1	X	X	X			X			X	X	X	X
Wehrbach-Wenkheim	Dresely, V. (2004)	Neol.	0	0	2	2	X	X			X	X			X	X		X
Late Neolithic all			48	69	4	121												
			324	250	19	593												

(Meso=Mesolithic; LBK = Linearbandkeramik; Neol. = Late Neolithic; HI = Stature; HL = Harris Lines; TRS = Enamel Hypoplasia; CA = Dental Caries; PA = Periodontal diesease; CCI = Cribra cranii; COR = Cribra orbitalia; ARKN= Degenerative joint disease; SO = Other pathologies

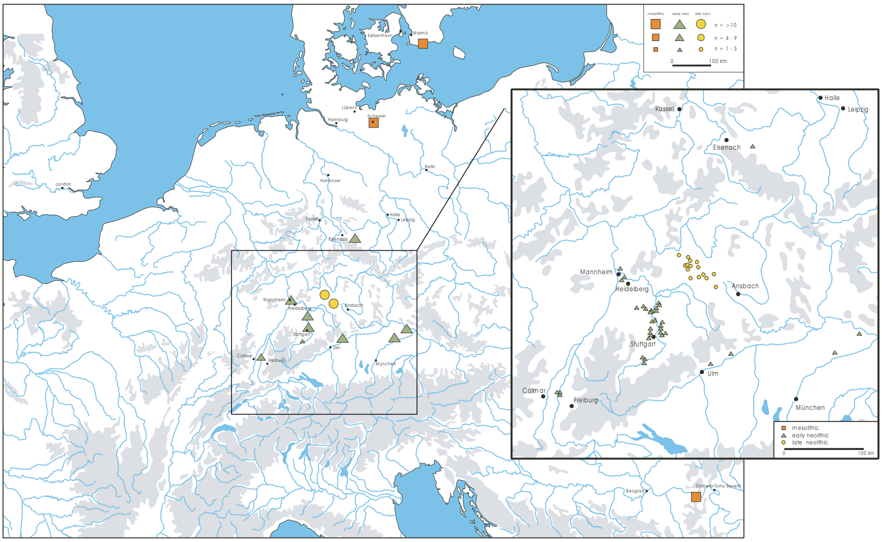


Fig. 3 Geographical distribution of the sites in the study (including groups of sites with small individual numbers)

Diseases in the Mesolithics

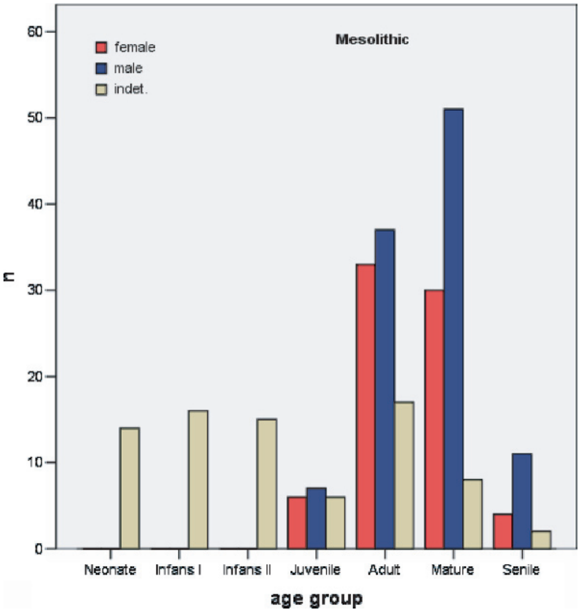
A total of 266 individuals from Mesolithic cultures were evaluated. The age and sex distribution (Fig. 4) shows a suitable number of adults, roughly expressing representative population composition.

The largest subgroup of 117 individuals came from the habitat of Vlasac in Yugoslavia (Garasanin 1978; Grünberg 2000). The colony was located at the southern bank of the Danube river that borders former Yugoslavia and Romania in this area. The spot was very well chosen, as far as available food resources were concerned: The nearby river provided fish, while the forested areas in the south were promising hunting grounds with a rich faunal variety (Boric et al. 2004). The living conditions for the Vlasac population were regarded as favourable, based on a large variety of food resources (Srejovic 1973).

According to archaeological findings, the area was inhabited between 6000 and 5400 BC. It is also assumed that "they did not know any productive, but just the acquiring way of life" (Srejovic 1973). The climate conditions of this area are known to be comparatively moderate. Heavy rain falls or big temperate changes could not be observed in the past and there are no ecological findings that this changed at any time after the last ice age. The skeletons were in a moderate state of preservation, thus pathological changes in the bones could be observed.

Another 81 individuals came from the Skateholm I and II sites at the Baltic coast of southern Sweden. The habitat was placed at the inland side of a large lagoon, containing a rich variety of species. Long and warm summer periods made this spot appear very attractive as far as climate conditions are concerned. The supply situation

Fig. 4 Sex and age distribution of the Mesolithic skeletal sample



must have been quite similar to the one in Vlasac: promising hunting grounds and a good access to fresh water. The archaeological age of this habitat is between 5300 and 5000 BC. The living conditions must have been outstanding there and have been the subject of earlier research: "The fact that so few pathological changes were encountered in the material and that several individuals achieved relatively high ages suggests that living conditions were favourable for both the two Mesolithic populations at Skateholm." (Larsson 1988). Additionally, a high robusticity was observed on the skeletons which, besides genetical factors, suggests a food supply rich in proteins. This, however, comes true for the Vlasac individuals as well.

The third sample in the study consists of 64 Late Mesolithic individuals from the Baltic coast of Germany, from the site Ostorf on the island of Tannenwerder in the lake Ostorf. Similar to the sites described before, a large variety of hunted animals was observed at Ostorf, whereas there was only little archaeological evidence for fishing tradition. Although situated in a region which already turned to the Neolithic way of life, the Ostorf population still remained in the Mesolithic tradition of hunting and gathering but in a locally fixed settlement. Only for the later habitat phases the domestication of cattle can be assumed, but no signs of agricultural production were found (Bastian 1961).

Pathological changes in the skeletons are in the focus of a recent study (Henke and Patolla 2006) and deliver a detailed data background. The authors conclude that the low rates of pathological changes, especially of degenerative joint diseases, fit the hypothesis of a good health condition of Mesolithic populations.

These three populations of Vlasac, Skateholm and Ostorf provide the databases for the Mesolithic period in this investigation and therefore the outstandingly good living situations shape the Mesolithic sample. Whether this mirrors a representative situation for Mesolithic habitats, can only be decided through an archaeological point of view. When regarding the populations known so far, it can generally be stated that the Mesolithic habitats were found in special locations with outstanding good environmental conditions. There are ongoing discussions within the scientific community, whether archeologically invisible Mesolithic groups, possibly in less favored living conditions, might have coexisted with Neolithic groups. Such groups of Mesolithic foragers very likely would have left virtually no traces of their existence. It is therefore possible that the present data is not representative for the whole epoch and this was the reason for us to refer to our results only as tendencies and indications.

For the whole Mesolithic subsample, the following distributions of the health-relevant skeletal markers were achieved (Table 2).

The occurrence of Transversal Dental Hypoplasia reveals that one quarter of all subadults faced at least one severe crisis situation affecting the enamel formation. More than half of the skeletons affected (19 out of 36) expressed at least two hypoplasia defects, even more than 10 signs were observed in several cases. Nearly every second skeleton among the adults showed these signs of general stress. The difference between the subadults and adults may be explained by the low number of studied skeletons and by the fact that a few of the infants did not yet complete the formation of permanent dental crowns.

The small amount of Cribra cranii – only slight cases of level 1 (after Schultz 1988) were observed – and the absolute missing of Cribra orbitalia suggests that the supply with vitamins, minerals (mainly iron) and protein must have been adequate.

Dental caries shows a low incidence rate and is rising with age. The rates are based on the analysis of intact alveolar bones only, not including intra vital tooth loss and, therefore, are hardly comparable to those calculated in other studies. This fits to the supposed composition of Mesolithic nutrition with low amounts of carbohydrates. In addition, this corresponds to the relatively high amount of periodontal disease caused by intensive attrition of the teeth opening the pulp chamber, as this contradicts high caries frequencies by the fact that attrition inducing factors help avoiding dental caries.

Degenerative joint diseases are observed with an intensity typically rising with age. Among individuals with an age of death above age 40 nearly every third skeleton was affected. Supposing that this is particularly caused by stress pun on the joints during physical activity, one has to take into account that the Mesolithic era almost did not know anything about transport devices and for sure did not know the wheel. Therefore it appears likely that a lifetime of carrying heavy stocks left its markings in the Mesolithic skeletons.

Data about the occurrence of Harris Lines are not available in the Mesolithic sample.

Summarizing the results achieved so far, it can be stated that Mesolithic populations suffered from degenerative joint disease and showed general stress markers as transversal enamel hypoplasia but were healthy with respect to dental caries and nutrition-based changes such as cribra orbitalia and cribra cranii.

Table 2 Frequencies of health parameters by age group in the Mesolithic sample

	Ratio of dentitions affected by dental caries (n)	Ratio of dentitions affected by periodontal disease (n)	Ratio of skeletons affected by degenerative joint disease (n)	Ratio of skulls affected by cribra cranii (n)	Ratio of skulls affected by cribra orbitalia (n)	Ratio of dentitions affected by transversal dental hypoplasia (n)	Ratio of skeletons affected by Harris lines (n)
Neonate							
Infans I						0 (0/3)	
Infans II						0.5000 (1/2)	
Juvenile	0.0910 (1/11)			0 (0/6)	0 (0/6)	0.6360 (7/11)	
Adult	0.0890 (4/45)	0.7500 (3/4)	0.1702 (8/47)	0 (0/12)	0 (0/12)	0.5220 (12/23)	
Mature	0.228 (13/57)	0.8640 (19/22)	0.3521 (25/71)	0.0968 (3/31)	0 (0/31)	0.4710 (16/34)	
Senile	0 (0/10)	0 (0/1)	0 (0/10)	0 (0/3)	0 (0/3)	0 (0/5)	
All adults	0.1518 (17/112)	0.8148 (22/27)	0.1710 (33/128)	0.0652 (3/46)	0 (0/193)	0.45516 (28/62)	
All subadults	0.0910 (1/11)			0 (0/6)	0 (0/6)	0.2500 (8/16)	

Diseases in the Early Neolithic Linearbandkeramik (LBK)

For the statistical comparison, the total amount of 214 individuals was taken into account. The individuals came from different habitats in the area of today's Germany (see Table 1). The subadult age groups are well documented (Fig. 5). which is mainly due to a specific study of health parameters in the Early Neolithic skeletal populations of Aiterhofen and Wandersleben (Carli-Thiele 1996). These two sites provided 64 skeletons from the early LBK and therefore represent the largest subsamples within the LBK materials (see Table 1). Both settlements Aiterhofen and Wandersleben were located with quick access to nearby rivers, which is assumed to be a vital condition for prehistoric settlements in general. Two other habitats are Essenbach and Steinheim (Haidle 1997). The living conditions in all these sites are homogeneously described as based on agriculture predominantly producing grain and raising cattle, sheep and goat (Vigne, this volume). Family structures developed as economic unions using food storage systems. It is supposed that the climatic conditions were facing an Atlantic cool and wet period (Bouzek 2001).

A special site is represented by the mass grave of Talheim where inhabitants of a Neolithic settlement were killed in a massacre (Wahl and König 1987). The LBK sample is completed by several smaller burial site groups and single graves. Most of the sites in the sample are studied in a standardised scheme provided by Orschiedt (1998). He collected data from sites which delivered between one and nine skeletons excavated within the settlements.

The age distribution of the whole LBK sample is formed by the specific study of children skeletons (Carli-Thiele 1996). Since children are easily affected by an

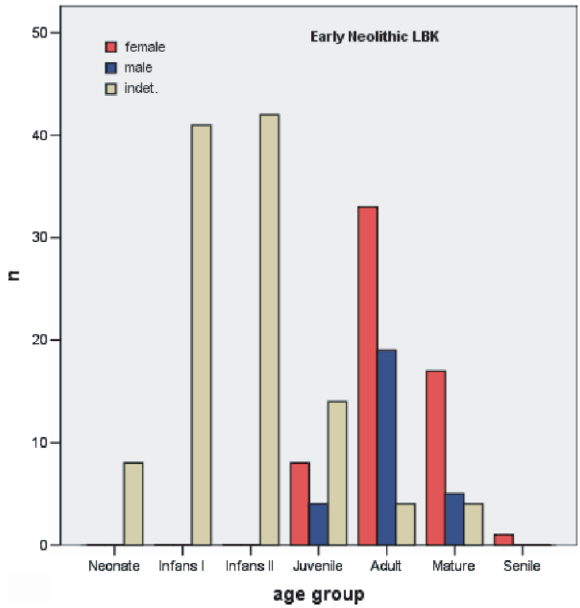


Fig. 5 Sex and age distribution of the LBK skeletal sample

insufficient supply situation, this sample maintains a certain significance for the question of health changes during the NDT.

Among the adult age groups predominantly females were studied. The male subgroup of the whole era is composed of less than 30 individuals. Therefore the representation of the Early Neolithic populations is far from being satisfactory.

A high percentage of skeletons in the sample is affected by Cribra orbitalia (Table 3). Already neonates are affected to a high degree of 40 per cent, indicating that already intrauterine supply was disturbed (Schultz 1993). For all individuals of settlement graves, which have a proportion of 38 per cent of all individuals in the LBK sample, a similarly high frequency of 34 per cent among infants II children was reported (Orschiedt 1998). This, however, throws a specific light on the general living conditions in the Early Neolithic indicating that general stress must have been a severe problem that even women during pregnancy must have suffered from.

Among all subadults 60 per cent of the individuals were affected by Cribra orbitalia and the changes are still observable in nearly every fourth adult skeleton. This lower amount of Cribra orbitalia within the adult age group may be explained by a selection effect due to a high risk of dying for diseased children and the survival of unaffected healthy children. In addition, the bone remodelling might lead to the fact that the orbital roof signs of Cribra orbitalia formed during childhood might be no more diagnosed in adult age.

This high amount of Cribra orbitalia coincides with an extremely high number of individuals showing growth stop lines. Out of all children 85 per cent expressed Harris lines detected by X-rays, among them several individuals with multiple signs. This is an amazingly high amount regarding the fact that all available tibiae of subadults in the study were treated by X-rays and not only the individuals under risk, defined by other macroscopically detected traces of growth disturbances. This indicates high stress situations during childhood, leading to death before reaching the adult age group in most of the cases.

Enamel hypoplasia was observed to a high degree in all age groups documenting subsequent events of physiological stress situations by showing multiple transversal lines in several teeth of different tooth formation age.

Such an intercorrelation of the unspecific stress markers of Cribra orbitalia and Harris lines manifested at the skeleton are noted for Neolithic populations (Carli-Thiele and Schultz 2001) as well as for bronze age populations (Schultz 2001) before. The interpretation of this complex of disease, its underlying causes, the interdependence of the physiological reactions as well as a linkage to specific parameters of the living conditions, however, is not well understood up to now.

Cribra cranii is observed to a lower degree compared to Cribra orbitalia but appears in the LBK with a notable frequency of 15 per cent among the adult skeletons whereas the Mesolithic material was affected to less than half of this burden.

Dental caries was present to a moderate amount of 32 per cent among all adults (caries intensity). The sample of Orschiedt (1998) reports a higher proportion of 46 per cent, which compares to the populations of the Mittelelbe-Saale region (Bach 1978). The problem here is a low number of available data for adults, although

Table 3 Frequencies of health parameters by age group in the Early Neolithic sample

	Ratio of dentitions affected by Dental caries (n)	Ratio of dentitions affected by periodontal disease (n)	Ratio of skeletons affected by degenerative joint disease (n)	Ratio of skulls affected by cribra cranii (n)	Ratio of skulls affected by cribra orbitalia (n)	Ratio of dentitions affected by transversal dental hypoplasia (n)	Ratio of skeletons affected by Harris lines (n)
Neonate				0 (0/5)	0.4000 (2/5)		
Infans I	0.0430 (1/23)			0 (0/19)	0.6110 (11/18)	0.3333 (10/30)	0.7143 (5/7)
Infans II	0.2260 (7/31)			0.0714 (2/28)	0.6957 (16/23)	0.5000 (17/34)	0.9167 (11/12)
Juvenile	0.1250 (2/16)	0.0590 (1/17)		0 (0/11)	0.4440 (4/9)	0.8180 (18/22)	1.0 (1/1)
Adult	0.1880 (3/13)	0.2220 (4/18)	0. 1000 (2/20)	0.2273 (5/22)	0.2730 (6/22)	0.6000 (18/30)	
Mature	0.400 (2/5)	0.1670 (1/6)	0.2500 (3/12)	0.0667 (1/15)	0.2000 (3/15)	0.7140 (10/14)	
Senile	1.0 (1/1)	1.0 (1/1)		0 (0/1)	0 (0/1)		
All adults	0.3158 (6/19)	0.1667 (7/42)	0.1563 (5/32)	0.1579 (6/38)	0.2368 (9/38)	0.6363 (28/44)	
All subadults	0.1429 (10/70)			0.0385 (2/52)	0.6000 (33/55)	0.5232 (45/86)	0.8500 (17/20)

dental caries is among the most often scored health data in prehistoric skeletal samples. The same comes true for degenerative joint diseases. Most data given in the literature were not useful here, as besides the description of affected joints in most samples the number of unaffected joints was not given, making the data useless for the present study.

The results indicate that during the LBK the growth phase was intensively shaped by multiple and severe stress phases. They may lead to death by the metabolic problems connected to the bone change directly, by consecutive infectious diseases leading to the bony changes or by diseases additionally occurring together with nutritional deficiencies such as infectious diseases. This can lead to death in an already weakened body more easily compared to a healthy childhood situation adequately supplied by all necessary components such as nutrition, hygienic conditions and other parental investment strategies.

Diseases in the Late Neolithics

The Late Neolithic period is represented by a sample of 121 individuals, all studied in a comparative analysis performed by Dresely (2004). This is the smallest subgroup which mirrors the situation of skeletal remains in this chronological phase. In general, settlements are rarely represented for the Late Neolithic, with the exception of the very late "wet soil settlements" known. Especially the Corded Ware People (Schnurkeramik) are mainly represented by graves, together with the Bell Beaker People (Glockenbecherkultur) a large sample of around 1500 skeletons just from the Middle Elbe-Salle region is known (Bruchhaus and Neubert 2001). However, few of these skeletons could have been studied concerning pathological changes. Due to the aggressive soil, body decomposition in the known cemeteries occurred what might have led to the disappearance of bone surfaces needed for pathological investigations.

The larger samples come from Impfingen and Dittingen, near Tauberbischhofsheim in Germany. It is remarkable how these settlements differ especially from the Mesolithic ones in various aspects. Although these spots were chosen carefully as settlements, they did not come along with the numerous advantages of the Vlasac or Skateholm settlements: although the nearby rivers Isar and Danube provided sources of fresh water, they also were potentially dangerous to the inhabitants of the flat valleys. Heavy autumn floods could destroy houses and harvest, leaving the survivors without a reasonable chance to get through the upcoming winter. These groups in this area belong to the so-called Schnurkeramik ('Corded Ware' culture). The Schnurkeramik culture is assumed to have settled in central Europe during the third and the second millennium BC and it differs from the older LBK culture in important aspects:

The wheel appears to be fully established in this time and the full domestication of the horse is documented. These inventions enabled members of this culture to transport goods of any kind over larger distances with less effort. A new important criterion for choosing settlements was a nearby connection to flat and less wooded terrain. The isolated and naturally protected rare spots of environmental wealth were replaced by more easily accessible settlements. The flat and fluvial areas were predestined for farming. Altogether, the picture of a changed diet emerges from these observations, depending more and more from the production of grain and established domesticated animals. The sedentary people of the Late Neolithic could increase their food production to a significant degree by opening up new areas for farming.

The low number of individuals above an age of 20 years does not allow to present results in a representative form for this chronological group. Especially senile and late adult ages are virtually not represented (Fig. 6). The Late Neolithic is better represented by 69 subadults. The state of preservation, however, did not allow the inclusion of all markers into the sample. Thus, besides a few data on Cribra orbitalia, cribra cranii and enamel hypoplasia almost no data are available (Table 4). Among the children a significant amount of cases with cribra orbitalia was observed. Each second child was affected. In addition with 26 per cent among the subadults and 29 per cent among the adults a relatively high prevalence of enamel hypoplasia was established. The multiple sequences of enamel hypoplasia in the affected individuals show subsequent stress events in some cases but no general chronic childhood stress is documented, taking the number of teeth present per individual as reference.

Dental caries was observed in a moderate frequency. Further data on dental health are not available.

Degenerative symptoms can be observed in a new magnitude, but based on few individuals.

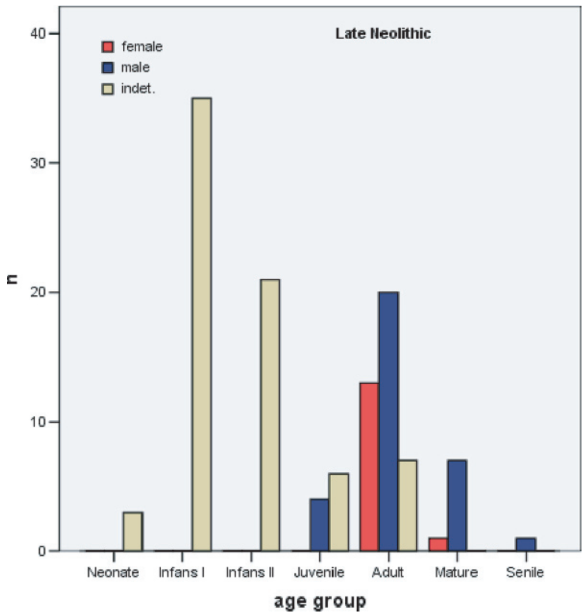


Fig. 6 Sex and age distribution of the Late Neolithic skeletal sample

Table 4 Frequencies of health parameters by age group in the Late Neolithic sample

	Ratio of dentitions affected by Dental caries (n)	Ratio of dentitions affected by periodontal disease (n)	Ratio of skeletons affected by degenerative joint diseases (n)	Ratio of skulls affected by cribra cranii (n)	Ratio of skulls affected by cribra orbitalia (n)	Ratio of dentitions affected by transversal dental hy-poplasia (n)	Ratio of skeletons affected by Harris lines (n)
Neonate					0 (0/2)	–	
Infans I	0,0630 (1/16)			0.1430 (1/7)	0.2000 (1/5)	0.2500 (4/16)	
Infans II	0 (0/10)			0 (0/6)	0.5710 (4/7)	0.1540 (2/13)	
Juvenile	0 (0/4)			0.3330 (1/3)	0.6666 (2/3)	0.6000 (3/5)	
Adult	0.3700 (10/27)		0.2000 (4/20)	0.0430 (1/23)	0.0830 (2/24)	0.3333 (9/27)	
Mature	0,4290 (3/7)		0.8000 (4/5)	0 (0/5)	0 (0/6)	0.1430 (1/7)	
Senile	0 (0/1)				–	–	
All adults	0.3714 (3/35)		0.3200 (8/25)	0.0357 (1/28)	0.06666 (2/30)	0.2941 (10/34)	
All subadults					0.4666 (7/15)	0.2647 (9/34)	

Health Transition from Mesolithic to Late Neolithic

A comparison over the three chronological phases has been performed on the basis of frequencies for each of the chronological groups and by age. In addition, the small number of representative sites does not allow to present health relevant data on a relative chronological scale, indicating *d*t as the time span linked to the starting point of sedentism and agriculture, as this can be performed with paleodemographic data or with health relevant data for other regions (see chapter "Explaining the Neolithic Demographic Transition" by Bocquet-Appel, this volume; see chapter "the signal of the Neolithic Demographic Transition in the Levant" by Bocquet-Appel et al. this volume). Therefore, the three groups defined here do not separate by sharp archaeologically defined chronology but by the definitions of the living conditions for each of the sites included in the sample.

Males and females were not separated because of too small subsample numbers with the exception of stature (see Table 5). Several studies of specific skeletal samples, however, revealed significant sex disparities. Further test statistics are not applicable to the sample. It has to be clearly stated that the data provided show tendencies of health development, but based on a small sample of possibly not representative populations.

When regarding the development of dental caries in the sample, the incidence of affected individuals raises for younger adults as well as for the older adult age group. The higher frequency for the age group above age 40 makes the data plausible

Table 5 Stature in chronological comparison

	Bruchhaus and Neubert (2001)		Frayer (1980)*		Meiklejohn et al. (1984)		Current authors	
	x	**N**	x	N	x	N	x	N
Early Upper Paleolithic								
Male			174.2	10				
Female			161.3	5				
Late Upper Paleolithic								
Male			174.4	10	170.4	19		
Female			156.7	4	156.7	10		
Mesolithic								
Male			164.8	26	167.7	46	167.9	52
Female			153.9	15	155.6	36	156.7	53
Neolithic (all)								
Male					167.3	102	164,3	25
Female					154.1	88	155,9	40
Early Neolithic(LBK)								
Male	165.8	–					165.2	12
Female	156.9	–					155.5	31
Late Neolithic								
Male	170.0	–					163,6	9
Female	160.0	–					157,1	9

*–Data after Meiklejohn et al. 1984

considering the higher exposition risk for the older age group. The raise of dental caries intensity from the Mesolithic over the LBK to the Late Neolithic (Fig. 7) fits to the change in diet supposing higher amounts of carbohydrates in the Neolithic groups.

The prehistoric breakup towards a high frequency of dental caries with nowadays over 90 per cent might be fixed to the NDT phase as the tendency observed in the present study match the results achieved in a dataset from the Mittelelbe-Saale region (Bock and Bruchhaus 2003) in a much broader chronological comparison. In addition, sex disparities in dental caries intensity were observed in Early Neolithic Populations. Females were more affected than males, supporting the hypothesis of sex-specific diet with higher intake of proteins by males and a compensatory amount of carbohydrates by females (Dürrwächter et al. 2003).

A plausible and illuminative result comes from the comparison of general symptoms of deficiency diseases in the different eras (Fig. 8). This was defined here in a very broad sense. An individual was assumed to have suffered from a quantitative or qualitative insufficient supply situation if the skeleton showed at least one of the following symptoms: Cribra cranii, Cribra orbitalia, Harris Lines or enamel hypoplasia.

Due to the fact that the underlying databases contained many gaps, this metavariable is composed to a varying degree of information on the different markers. Harris line diagnosis was not provided by most evaluations whereas results about dental hypoplasia as a non-invasive and macroscopically observable marker was much more represented in the dataset. Over 80 per cent of all cases affected with at least one

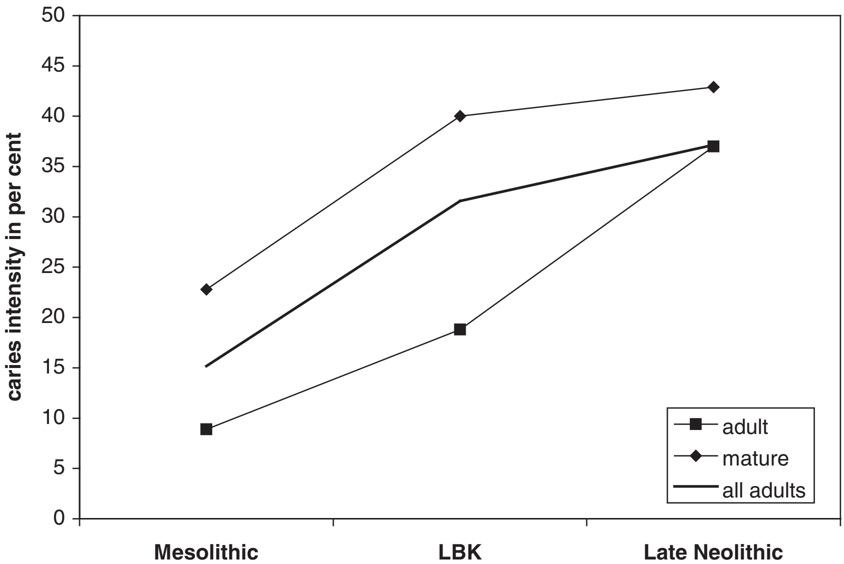


Fig. 7 Dental caries intensity (per cent of dentitions affected) by age group in chronological comparison

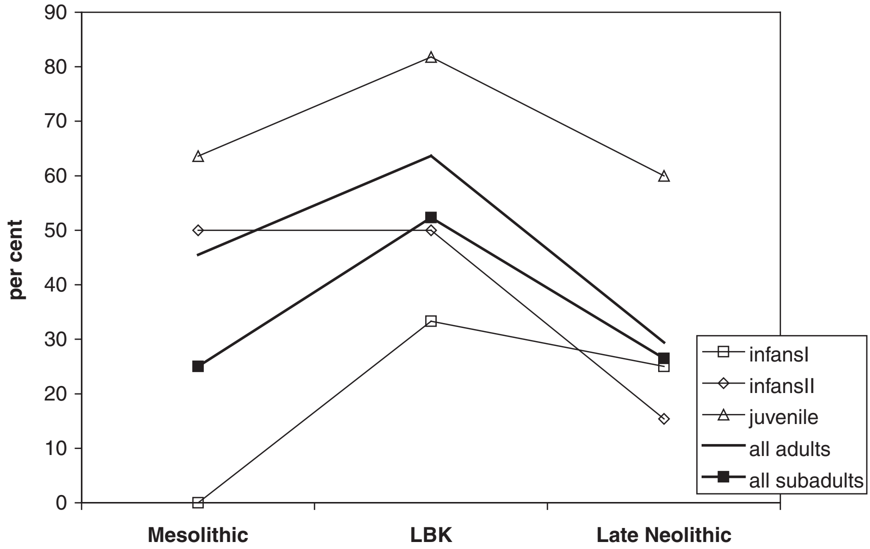


Fig. 8 Symptoms of general deficiency diseases in chronological comparison

of the skeletal indicators showed dental hypoplasia. Because of its stable expression over lifetime and post mortem stability dental hypoplasia might be interpreted as a health indicator which is most suitable for comparisons and can be regarded as a reliable indicator for general shortcomings in the supply situation.

With this health indicator the expression of the different traits in the age groups, such as remodelling with age, cumulating risk with age, selective mortality, etc., is implemented, making the interpretation more complex, depending on the age distribution for each of the implemented traits. A clear advantage of this health complex, however, is the larger number of individuals included.

According to this the LBK data deliver more than three times high disease burden of deficiency diseases compared to the Mesolithic. The situation seems to slightly reduce with a still high level in the Late Neolithic.

As expected, the isolated reflection of the development of dental hypoplasia documents this trend clearly although less dramatically (Fig. 9) by the combined health index. The trend of high numbers of crisis phases documented by enamel hypoplasia in LBK skeletons and a reduced occurrence of such stress events in the later Neolithic material has also been stated by Haidle (1997). It expresses more stable health situations over longer periods during the growth phase for the late Neolithic period.

A plausible explanation for the tendency in the data is that the initial phase of agricultural living might have been extremely hard, possibly due to yet unfamiliar and at the same time ineffective techniques of farming, overpopulation in respect to the given resources and low adaptive capability, which improved later during the Neolithic towards a more balanced and reliable supply situation and developed coping strategies.

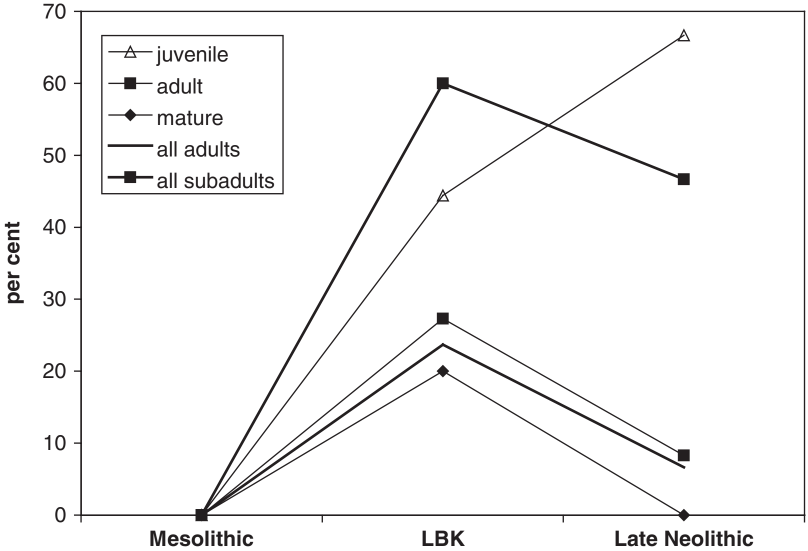


Fig. 9 Frequency of enamel hypoplasia in chronological comparison

With Cribra Orbitalia (Fig. 10) as another general health indicator which was observed and which is predominantly connected to a group of causes of the large complex of anaemia, chronic nutritional deficiency besides inflammatory processes and hemorrhagic processes (Schultz 1993). Its frequencies in chronological comparison show the same pattern as the other factors before with the exception that Cribra orbitalia was not detected at all in the Mesolithic skeleton sample but appears first

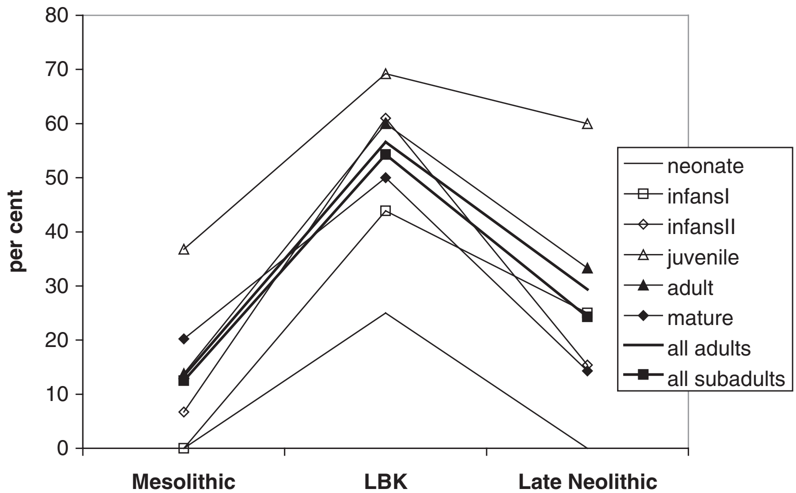


Fig. 10 Frequency of skeletons affected by cribra orbitalia in chronological comparison

with an already high frequency in the LBK sample. Whether the absence of Cribra orbitalia represents a unique pattern for the Mesolithics, cannot be decided from the database used here. No other studies concerning that question are available yet. But even under consideration of moderate occurrence of porotic hyperosis in the earliest phase under study it can be stated that the frequencies of cribra orbitalia suggest a scenario of health effective burden due to general mal- and under-nutrition as well as to infectious diseases in the LBK and it seems that this population frailty model coincides with the NDT.

The situation is not clear for degenerative joint diseases which might have been treated in an insufficient differentiation in the present study that does not mirror the impact of labour exposure to specific joints. The frequency of joint diseases seems to be reduced during the NDT compared to Mesolithic populations but raises again in the Late Neolithic period.

As expected, an age dependency can be followed by observing higher frequencies in the old adult age group compared to younger adults in all chronological groups.

The analysis of each of the large joints in an enlarged sample might illuminate the situation better as can be done here by observing the general absence or presence of bone changes in the joints.

Stature has been analysed on the methodological basis applied by Meiklejohn et al. (1984) and added by further data (Table 5). All data including the present study are based on the same method of calculating height from long bone measurements using regression formula for unaccelerated populations. This permits a comparison of all skeletons with any relevant long bone measurements. Each of the chronological series represents a regional approach.

The results confirm earlier studies which stated a significant decrease in average stature from the Upper Paleolithic through the Neolithic with a stronger trend for females (Meiklejohn et al. 1984). The data in the actual study represent different samples, especially including sites from Germany. With the actual data the trend of stature depression can be confirmed for both males and females, even though based on very few authentic data. We observed the same sex-specific effect as in the former study suggesting that females might have reacted more sensitively to the general stress situation during the NDT, burdened by extensive fertility and/or sex-specific diet.

Conclusion

Conclusions from the sample studied by collecting health relevant data from the literature are limited by a complexity of factors concerning the comparability of data. This has already been discussed above. In the following, we tried to embed the data achieved so far into the picture drawn by hypothesis on the living conditions for the Early Neolithic and by data published before.

While hunting and gathering appear as fully sufficient nutritional strategy for Mesolithic populations, which enabled people to maintain a good overall health, to reach comparatively high ages and to spend time on developing skills of secondary importance, the early Neolithic groups show traces of a more difficult supply situation. A total amount of nearly 50 per cent of these individuals shows at least one symptom of malnutrition (Transversal enamel hypoplasia, Cribra orbitalia, Cribra cranii, Harris lines), compared to just 20 per cent of the individuals within the Mesolithic sample. This may indicate an insufficient nutritional supply during the growth phase and/or high load of infectious disease.

Here a major aspect has to be stressed again. Nutritional deficiency is just a single aspect that proves to be a complex interaction of numerous factors. The undersupply with a single nutritional component (such as iron or vitamin C), on the one hand, mirrors a general idea on the supply situation (low protein intake or vegetables/fruit) and, on the other hand, can have a number of consequences for the human organism and can possibly cause further diseases. If several essential nutritional components are missing concurrently, diseases can affect each other and lead to critical situations, which might be particularly seen for anaemia.

If the increase in the caries frequency is taken into account additionally, both factors of dental health and deficiency signs indicate the change from foraging to the sedentary way of life: The rich and adequate nutrition and its richness in vitamins and protein had been replaced mainly by grain as the basis of alimentation. This led to an increase of caries, due to its higher glucose level. Another argument rises from the increased fertility rates during the NDT, which might represent a further risk of dental caries the way that pregnancies affect the mother's mouth flora making it more vulnerable to dental caries (Lukacs, after Cohen, this volume).

Coevally, the supply with the necessary variety of food components might have dropped under a level that covered the need of individuals especially during the growth phase ("Too less balanced" alimentation model). In addition, different weaning ages between nomadic and sedentary people might contribute to the specific health decline in infants (see chapter "Explaining the Neolithic Demographic Transition" by Bocquet-Appel, this volume).

It is also possible that bad harvests or other extraordinary situations might have led to temporal bottlenecks within a supply situation, which was in principle sufficient ("Temporal undersupply model"). Favouring one of these models would require a deeper insight into the medical and living condition of these individuals, and therefore lies beyond the chances of this investigation. The remaining conclusion is that the initial phase of agricultural living must have faced serious problems in covering the needs of alimentation constantly and satisfyingly. Nevertheless, this situation seems to improve during the course of Neolithic and can be found in less extreme forms in the later culture although the low protein ratio seems to continue shaping the food resources in the Late Neolithics, where no significant signs of hunting were detected in the faunal remains of several settlements (Dürrwächter et al. 2003). The improvement of agricultural technology, a physical adoption to the new situation or the balancing influence of more successful hunting could have played a role in this process. Such a picture of the Neolithic appears likely on the basis of our data.

The analysis of the fragmented data collected so far shows a pattern of pathological changes during the Neolithic Transition which supports the idea of decreasing health during the NDT phase, especially the large amount of LBK children affected with markers of disease documenting health problems during the sensitive growth phase. This opens discussion about the occurrence of food crisis in a significant manner which could have led to a dramatic increase in child mortality. Compared to the slow development of the Neolithic transition in the Near East the changed living conditions were adopted quickly in central Europe. The causal factors for this quick cultural drift is not yet clear, but the impact on the health situation seems to be verifiable and can be observed for the Neolithic health transition in Scandinavia (Bennike 1985) as well as for central Europe.

The idea that the sudden change in the subsistence strategy hit unprepared populations in Europe seems to consolidate taking the results of the Near East health transition into account. The health situation of Near East populations during the NDT does not show such dramatic increase in nutritionally based diseases as seen in the European materials. The lack of dietary stress (Hershkovitz and Gohper, this volume) argues for a slow transition phase in the Near East and fitting to the tempo effects discussed before.

Another support for the health decline pattern during the NDT can be deduced from the observation of improving health when farmers go back to the hunter/gathering way of life (Lukacs 2007). The broad pattern of health decline which can be seen in different regions of fast transition together with the exposure to health risks, increased fertility and at least partly insufficient food supply leads to the conclusion that sedentary farmers are more vulnerable to economic crisis situations than foragers (see chapter "Implications of the NDT for World Wide Health and Mortality in Prehistory" by Cohen, this volume).

Indeed, under the light of the data structure, detailed view into specific health characteristics to be interpreted within the whole complex of Neolithic living conditions is not possible without new data collections going back to the skeletons again. A standardised scoring system should be used, which is compatible to the global History of Health project in order to integrate data into an even larger view than just the populations of the NDT phase. In addition, new methodological challenges such as the sequence of stress phases in the adults by irregularities of tooth cementum annulations (Kagerer and Grupe 2001; Wittwer-Backofen unpublished) should be seized. This will help open comparison to different regions facing the NDT. The demand for such a project can be regarded as the major outcome from this first look at the available data, which at the moment do not allow a further statistical approach than just on a rough descriptive level suggesting trends of a decreasing health condition accompanying the NDT.

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