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Climatic Fluctuations and Early Farming in West and East Asia

by Ofer Bar-Yosef

This paper presents a Levantine model for the origins of cultivation of various wild plants as motivated by the vagaries of the climatic fluctuation of the Younger Dryas within the context of the mosaic ecology of the region that affected communities that were already sedentary or semisedentary. In addition to holding to their territories, these communities found ways to intensify their food procurement strategy by adopting intentional growth of previously known annuals, such as a variety of cereals. The Levantine sequence, where Terminal Pleistocene and Early Holocene Neolithic archaeology is well known, is employed as a model for speculating on the origins of millet cultivation in northern China, where both the archaeological data and the dates are yet insufficient to document the evolution of socioeconomic changes that resulted in the establishment of an agricultural system.

Opening Remarks: Observations and Statements

The Neolithic Revolution, or the Agricultural Revolution, was a major "point of no return" in human evolution. After 2.6 million years of hunting and gathering, low population densities, and a series of dispersals to the edges of Eurasia and beyond to the Americas and Australia, human societies developed a new economic system that changed the course of prehistory. Instead of survival based on foraging with partial or full-time residential and logistical mobility, the appearance and disappearance of sedentary and semisedentary communities, and episodes of genetic "bottlenecks," the first farming villages in a limited number of regions led unintentionally to a revolutionary social upheaval. Although a few Late Pleistocene hunter-gatherers developed low-level food production, the people who started cultivating the wild species of the "winning" plants—those that feed the world of today (wheat, barley, rice, and corn)—were in retrospect responsible for the rapidly increasing world population that led to the Industrial Revolution.

Before delving into the particular cases of West and East Asia (fig. 1), where I believe the earliest manifestations of this socioeconomic revolution were triggered by the impact of the Younger Dryas (YD), several issues, such as small-scale societies in core areas and their reactions to abrupt climatic changes, require some brief statements and clarifications.

Although history was not recorded during the onset of the Neolithic Revolution, the foundations laid by early farmers unexpectedly led in due course to the invention of writing systems. Indeed, in an evolutionary sense it was a set of rapid socioeconomic changes. We should therefore refer to our data sets from the first half of the Holocene as the history of "people without names," and like all historical documents they are amenable to different interpretations.

Investigations into the reasons why people became farmers are not new. Since the nineteenth century, scholars have searched for "where," "when," "how," and "why" cultivation became an attractive survival strategy. Botanists such as Alfonse de Candolle, Nikolai Vavilov, and Jack Harlan explored the natural habitats where the wild progenitors of domesticated plants were found, assuming that these were the "centers" of plant domestications. The desire to find primordial locations is still pertinent, as recent investigations in the Levant (e.g., Zohary and Hopf 2000) or the efforts to find the location of millet progenitors in East Asia (e.g., Lu et al. 2009) demonstrate.

Historically, these natural habitats or their margins were thought by archaeologists to have been the "core areas" where cultivation and domestication occurred (e.g., Binford 1968; Braidwood 1952; Flannery 1973). What seems to be a feasible research target in the Levant because of its relatively small dimensions and the large number of different schools of archaeology involved in fieldwork is more complex in East Asia, where investigations began almost half a century later and where the core area is at least two to four times as large. Hence, using the primacy of the Levant, I discuss the role of "core areas" and refer to places into which agricultural systems

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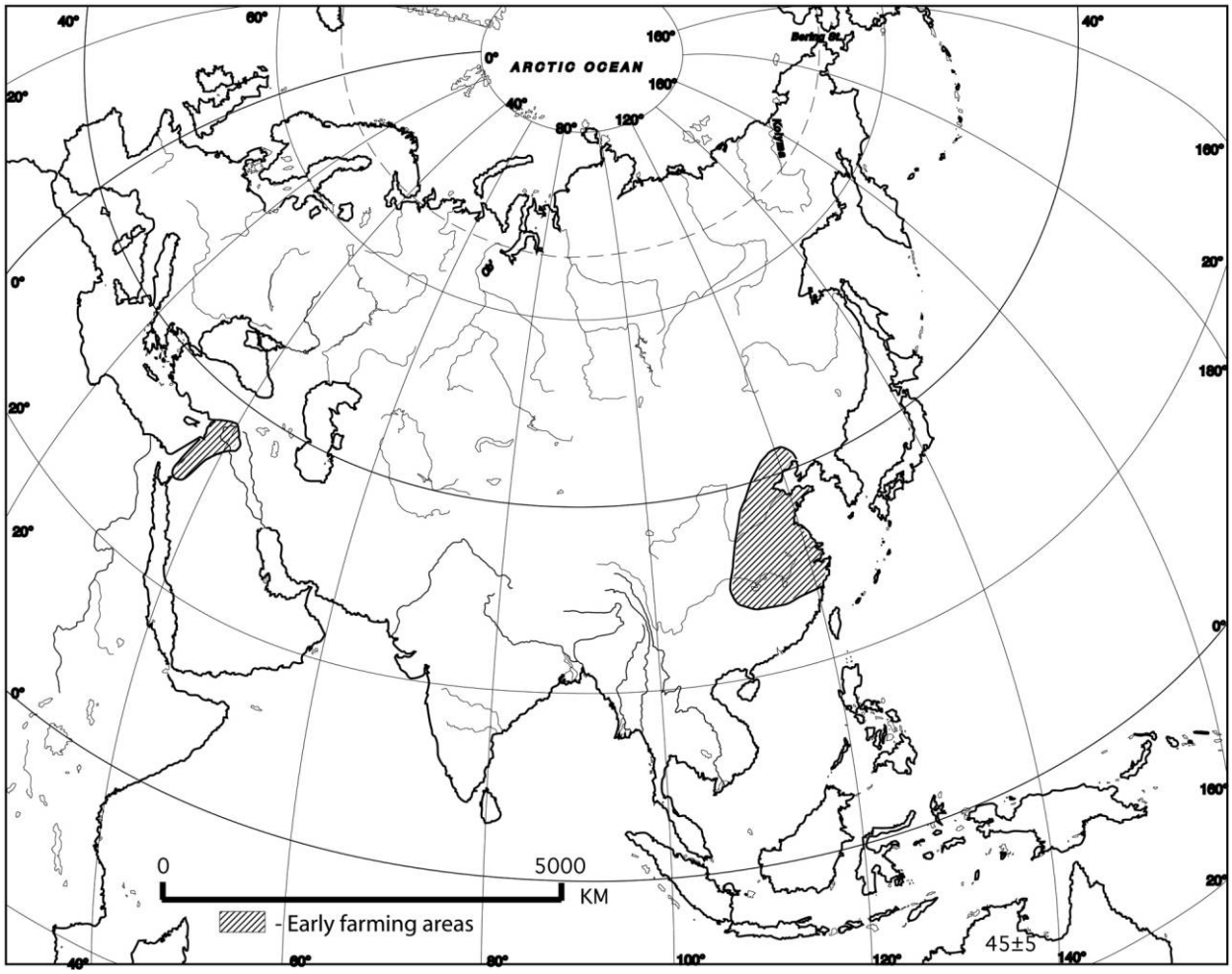

Figure 1. Regions discussed in the text: the Levant and China.

were transmitted to as "secondary core areas." For example, the Levant was the "core area" where the cultivation of wild cereals, also known as "predomestication cultivation" or "low-level food production" (e.g., Smith 2001) began and where these plants became the cultigens after more than 1,000 years of farming. These domesticated crops were introduced into Europe and the Nile Valley, both "secondary centers."

The archaeological evidence for the initiation of cultivation, the corralling of wild herd animals, and the ensuing transmission of knowledge, techniques, plants, and animals, as well as voluntary and/or forced movements of humans among village-based societies, is characteristic of interregional connections. Short- and long-distance interactions did not always occur under stable environmental conditions. Paleoclimatic proxies from the Terminal Pleistocene and Early Holocene record numerous fluctuations. Even minor shifts in local conditions, given the available technology and social structure of human groups, could make the difference between successful biological survival and failure.

In this paper, I suggest that at the two ends of the Asian continent, a climatic change was the main trigger for the onset of cultivation (i.e., growing the progenitors of wheat, barley, rye, millet, and other grains) in a context of "low level food production" (Smith 2001). This either evolved into major food production or failed (e.g., Weiss, Kislev, and Hartmann 2006; Weiss and Zohary 2011). Hence, before delving into the climatic, social, and economic evidence acquired from archaeological investigations, we need to examine briefly the past human experience in the face of abrupt climatic change.

More than once during the Pleistocene, humans faced environmental changes that improved, worsened, or did not affect their basic ecological conditions. While we sometimes tend to see these climatic changes as the causes for the extinction of particular populations or eventual dispersals, the overall picture is too coarse-grained. History, however, has taught us different lessons. Slow or abrupt shifts of environmental conditions that resulted in social and economic disasters have been recorded (e.g., Bell 1971; Hassan 2002; Shen

et al. 2007; Weiss and Bradley 2001). The impacts of droughts, harsh winters, flooding by rivers or the sea, failing harvests, famines, wars, spreads of disease, disturbances of the social order, and the demise of peoples are reasonably well documented. Some societies were able to cope with or to minimize disastrous effects, while others collapsed (Rolett 2008). The challenge for archaeologists is to find how humans handled a situation and either succeeded or failed in coping with the impacts of natural calamities (Rosen 2007). When biological survival is critical for individuals or a group of people—be it a band, a macroband, or a tribe (using an approximate scale of population size; see Binford 2006; Hawkes and Paine 2007; Marcus 2008; Roscoe 2008, 2009)—they will use a number of strategies within their knowledge, depending on the resilience of their social structure and cultural concepts, to insure their physical existence in the world.

The capacity to minimize risk, for example, can be increased by actively intervening in the natural environment when *K*-selected (e.g., large-bodied mammals) and *r*-selected (e.g., small-bodied mammals such as hare and tortoise, as well as fruits and seeds) resources decrease or when required foray distances increase. This can be accomplished by intensifying food-acquisition techniques such as tending particular plants, using fire to enhance the growth of wild stands of herbaceous vegetation, digging simple irrigation canals, and in some cases being involved in "low-level food production" (e.g., Binford 2006; Denham et al. 2003; Kelly 1995; Lewis 1972; Lourandos 1997; Roscoe 2009; Smith 2001).

The ability to handle the complexity of the social organization through the articulation of its members and the spatial distribution of the mating system under stressful circumstances is another strategy. The increased social cohesion by increasing group size (agglomeration) or reducing (fissioning) in face of natural disasters includes the perception of home territory and its ranges, incorporation of sacred localities, and the degree of preparedness of the group to pay for costly signaling of their ownership (e.g., Roscoe 2006).

The level of preparedness of those who inhabit ecologically marginal zones—for example, those with increased frequency of droughts or prolonged cold winters—when facing natural disasters is tested when and if they are ready to change or successfully move out (Kawecki 2008). Much depends on the survival skills, ability to mitigate relations with neighbors, and socioeconomic information transmitted through the "living memory" of the social unit (e.g., Minc and Smith 1989; Rosen 2007).

The ability of the population to sustain its biological survival for future generations within a large geographic region is tested in times of stress. The intervariability of the social organization, alliances with neighboring groups, and the history of conflicts often play an important role in adaptation to new conditions, although recovering all this information from the archaeological record is difficult (e.g., Marcus 2008).

As a result, when disasters strike, the options for all foragers are (*a*) to increase mobility by moving to another territory or increasing the distance of forays by task groups if neighboring territories are less affected, thereby facing foes or friends (in the best situation, kin relations); (*b*) to stay put and defend the reliable natural resources within their immediate territory; or (*c*) to actively intensify the yield of available plant resources through technological improvements, new inventions, part-time cultivation, the tending of fruit trees, and even the corralling of herd animals as pets and food. The sum of all these traits, or only a few, provide the "cultural filter" through which environmental changes are mitigated by the affected society or negotiated with its neighbors, whether they belong to the same culture (and speak the same language or the same dialect) or to a different society.

Many archaeologists are reluctant to accept the notion that climatic changes expressed in environmental degradation, reflected in climatic proxies, and seemingly of the same date of an observed cultural "break" in the archaeological sequence were the cause for turnover or crisis. They are right. Chronological correlation is not causation. Employing approximate chronological correlations as the basis for proposed interpretations is merely a hypothesis to be verified or falsified. This paper relies on that approach but advocates, even if it is not yet completely feasible, that sound interpretations should be grounded on precisely dated paleoclimatic information obtained from archaeological deposits and their contents (e.g., plants and animal bones). In addition, it should be stressed that proposals by nonarchaeologists that abrupt climatic changes resulted in a socioeconomic shift should incorporate an anthropologically oriented explanation for responding to the "why" question. However, this is rarely done.

Shying away from the impacts of climatic changes has marked the archaeological literature of the last decades. Preference has been given to explanatory models that involved social changes emanating from intra- and intersociety political pressures, physical conflicts and wars, rapid population growth, and fissioning of settlements attributed to "scalar stress" (Johnson 1982) or the "Irritation Coefficient" (Rappaport 1968; cited in Bandy 2004), although New Guinean ethnography offers an alternative model (Roscoe 2009). Indeed, the main question is how did foragers and farmers minimize the risk to survival (Rosen 2007)?

In studying human responses to environmental disasters, an important source of information comes from recent international relief programs, which are forced to identify the specific interactions between populations affected by calamities such as earthquakes, droughts, or floods in their immediate environments and within given political regimes. Some reactions are common across the human spectrum, while others express the individual nature of the impaired human group. In each case, anthropologists discover that the outcome resulted from previously held beliefs, social and political organization, and historical interactions with neighboring societies (e.g., Glantz et al. 1998).

Currently, information concerning changing past climates relies on speleothems, terrestrial and marine pollen cores, and

supporting evidence from long-distance correlations with the Greenland ice core (Greenland Ice Sheet Project 2 [GISP2]) for the following reasons. (1) Speleothems are found in many caves (whether occupied by humans or not) located in different types of environments (forest, parkland, steppe, arid). Mass spectrometers produce dates with calendar ages, and the basic isotopic information ($\delta^{18}O$ and $\delta^{13}C$) traces the sources and the amounts of local precipitation (e.g., Lachniet 2009). (2) Lake and marsh pollen cores provide information concerning vegetational fluctuations in their drained basins but do not always produce precise radiocarbon dates. Correlations with marine pollen cores may refute or substantiate the terrestrial sequences. (3) Ice cores provide the most detailed information concerning climatic changes, and studies of proxies from other regions compare their results to GISP2. However, in regions farther from the Arctic, the role of local conditions increases and time correlations become more tentative and less secure, although the major trends of climatic fluctuations remain the same. (Examples of each are given below.) Taking the above comments into account, I try to demonstrate below that the conditions imposed by the YD triggered cultivation in two subregions in West and East Asia (fig. 1).

The Levantine Paleoclimatic Sequence and the Onset of Intentional Cultivation

The Levant is a region located on the edge of the eastern Mediterranean basin, geographically bordered by the Taurus Mountains on the north, the Mediterranean Sea on the west, the Syro-Arabian desert on the east, and the Sinai Desert on the south (Cauvin 2000; also see Belfer-Cohen and Goring-Morris 2011; Goring-Morris and Belfer-Cohen 2011; Vigne et al. 2011; Weiss and Zohary 2011; Zeder 2011). Its optimal habitats for exploitation are within the Mediterranean and Irano-Turanian (steppic) vegetational belts, which stretch in parallel from north to south, have variable topography, and are watered from west to east in decreasing amounts of annual precipitation. Every model of optimal foraging should take these conditions into account. Under favorable climatic conditions, the Levantine flora and fauna expand mainly to the north, along the foothills of the Taurus and the Zagros arc and beyond the Euphrates, the Balikh, the Khabur, and the Tigris rivers (an area called "Upper Mesopotamia" that bears historic connotations irrelevant to the prehistoric northern Levant).

The paleoclimatic information is derived from cave speleothems, Mediterranean marine pollen, and lake cores. The current interpretation of the terrestrial pollen cores is based on the correlations of vegetational zones within the marine cores (Rossignol-Strick 1995; van Zeist, Baruch, and Bottema 2009). Latitudinal and longitudinal shifts in several atmospheric systems dictate changing climatic patterns in this region (e.g., Enzel et al. 2008). Most of the storm tracks that transport the winter rain to the region originate in the Atlantic Ocean and cross the Mediterranean along different paths that determine their ^{18}O content (see, e.g., Kolodny, Stein, and Machlus 2005). Subregional ecological variability is fully expressed in the Levant because precipitation, the determinant factor, decreases dramatically from west (the sea) to east (the desert) and from north (the foothills of the Taurus and mountain areas) to south (the Negev and Sinai). Thus, a paleoecological mosaic of habitats should be taken into account when sites are discussed.

The speleothems, despite disagreements concerning the precise conversion of their fluctuating $\delta^{18}O$ and $\delta^{13}C$ contents to the amount of annual rainfall, reflect past centennial and millennial fluctuations (e.g., Bar-Matthews and Ayalon 2003; Frumkin, Ford, and Schwarcz 2000; Vaks et al. 2003). Speleothem data from Soreq Cave, on the western flanks of the central hilly ridge, and Ma'aleh Efriam Cave, on the eastern flanks (Bar-Matthews et al. 1999; Vaks et al. 2003; fig. 2), compare well with marine and lake cores from Greece and the Aegean Sea (e.g., Rohling et al. 2002).

The Late Glacial Maximum (LGM; ca. 24,000–18,000 cal

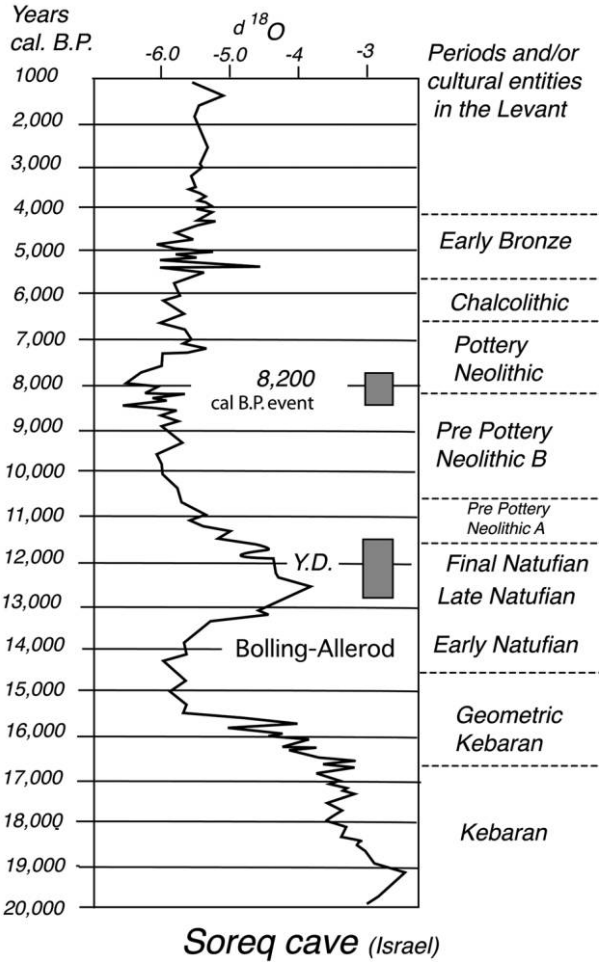

Figure 2. Paleoclimatic changes based on Soreq Cave speleothem (after information from M. Bar-Matthews and A. Ayalon, with permission).

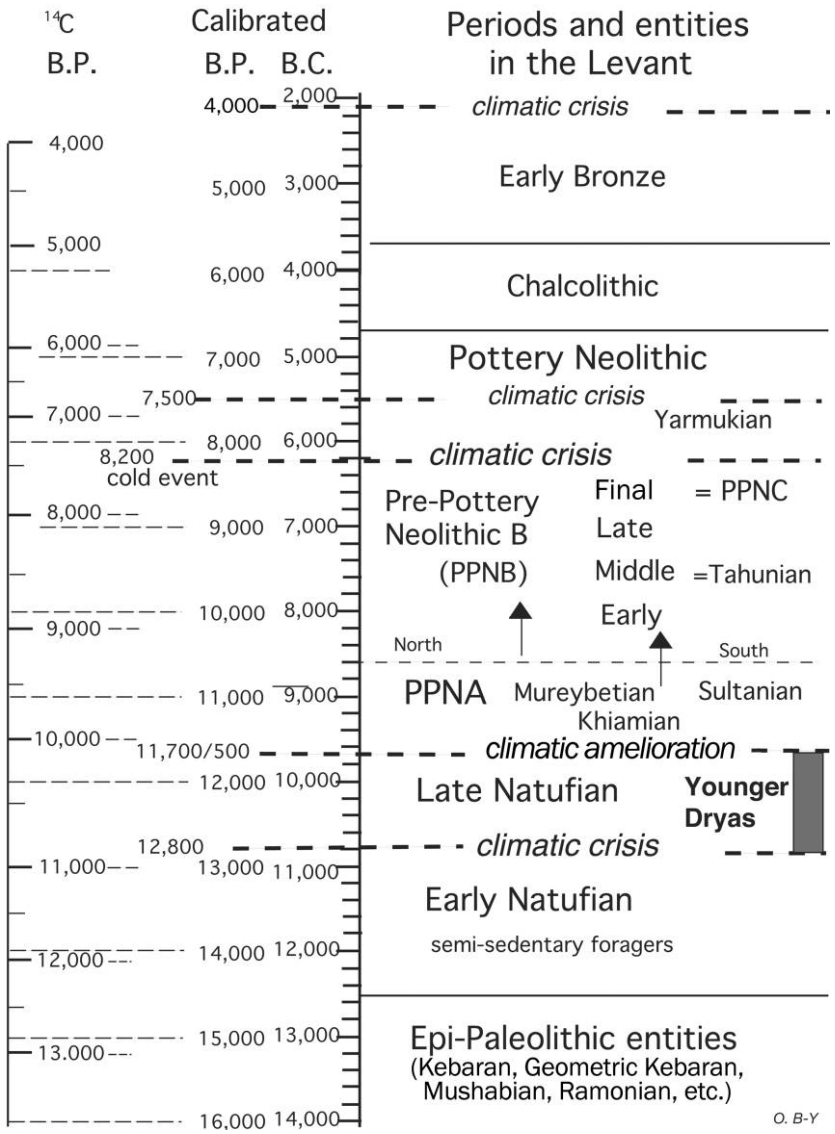

Figure 3. Chronological chart of Levantine late prehistory.

BP), as elsewhere, was a cold and dry period in the Levant, and its conditions are reflected in decreasing precipitation over the drainage basin of Lake Lisan, which began shrinking (Bartov et al. 2002). While this period witnessed a discernible reduction of global human populations in the higher latitudes, it affected the eastern Mediterranean less.

A rapid post-LGM rainfall increase is recorded in speleothems, marine pollen cores, and lake pollen cores in the Hula and the Ghab valleys (van Zeist, Baruch, and Bottema 2009). These sources demonstrate that the return of wetter conditions from ca. 16,500 to 14,700/14,500 cal BP facilitated a pan-Levantine distribution of foragers, bearers of the microlithic Geometric Kebaran industry in every ecological habitat from the northern Levant through the Sinai Peninsula (Goring-Morris 1995; Goring-Morris and Belfer-Cohen 2011; fig. 3). More or less at the same time, the Mushabian and Ramonian entities were competing/coexisting with the Levantine foragers (Goring-Morris and Belfer-Cohen 2011). One interpretation suggests their origins in Northeast Africa, while another proposal has them originating from local Levantine groups. It is conceivable that additional groups of hunter-gatherers were attracted by the improving ecological conditions and penetrated the eastern Levantine marginal areas through the Syro-Arabian desert and/or the Taurus foothills.

By the end of these several millennia, there were groups of mobile foragers everywhere in the Levant. Most intriguing is the question of whether a short, cold climatic episode (known in Europe as Dryas I) caused a temporary retraction of the

steppic belt and triggered a relative "demographic pressure." It is at that point in time that certain groups established the Early Natufian hamlets, although none are as yet known in the northern Levant (e.g., Bar-Yosef 2002; Bar-Yosef and Belfer-Cohen 1989; Henry 1989). This initial formation of human agglomerations, departing from the old lifeway of residential mobility by building pit houses and burying the dead on site (Belfer-Cohen 1995) and by forming sedentary or semisedentary permanent camps, is indicated by the presence of commensals such as house mice, rats, and sparrows (Tchernov 1991). Accommodating a few families or even subclans within a settlement marked territorial ownership, expressed in intrasite cemetery areas, enabling the group to achieve a sense of security and defense either by force or by symbolic acts (see Roscoe 2009 and references therein).

The success of the Natufian as a well-organized society of foragers could be related to the wetter and warmer climatic conditions of the Bølling-Allerød (ca. 14,500–13,000/12,800 cal BP). The establishment of the Early Natufian sites is what we once referred to as a "point of no return" (Bar-Yosef and Belfer-Cohen 1989; Belfer-Cohen and Bar-Yosef 2000). Their small villages and hamlets were constructed from a series of brush huts built over circular stone foundations, sometimes with wooden poles. Larger structures could have served for special uses such as rituals and were the forerunners of the Pre-Pottery Neolithic A (PPNA)–Pre-Pottery Neolithic B (PPNB) "kiva"-type subterranean buildings (e.g., house 131 in Eynan [Valla 1989]; Stordeur and Abbès 2002; Stordeur and Ibáñez 2008). The on-site burials (often of different socially unexplained styles; Belfer-Cohen 1995); the rich lithic, bone, and horn-core objects, including incised items; the numerous marine shells and stone beads for body decoration; animal figurines; incised slabs; and much more are among the markers of this culture. Our knowledge of Natufian economy is limited to hunted, trapped, and gathered mammals, birds, and reptiles, with evidence of fishing in some sites. It is, however, obvious from sickle blades that bear the special sheen resulting from harvesting cereals and the mortars in which cereals were processed, in addition to cup holes and rare grinding slabs, that a considerable amount of plant food was consumed. Given the wealth of literature concerning the Natufian culture and the variable social interpretations, only a few selected references are mentioned here in addition to those above (e.g., Bar-Yosef 1998, 2002; Bar-Yosef and Valla 1991 and references therein; Belfer-Cohen and Bar-Yosef 2000; Belfer-Cohen and Goring-Morris 2011; Belfer-Cohen and Hovers 2005; Byrd 2005; Cauvin 2000; Edwards 2007; Goring-Morris and Belfer-Cohen 2011; Grosman, Munro, and Belfer-Cohen 2008; Henry 1989; Munro 2004; Price and Bar-Yosef 2010; Valla 1995, 1999; Valla et al. 2007; Weinstein-Evron 2009).

Currently, the radiocarbon dates for the cultural transition from the Early to the Late Natufian indicate that it occurred before the climatic crisis of the YD, which started ca. 13,000/12,800 cal BP in the northern latitudes. The worsening conditions in the Levant probably began somewhat later, ca. 12,600/12,500 cal BP (e.g., Mayewski et al. 2004; Rohling et al. 2002; Sima, Paul, and Schultz 2004). Thus, the duration of the YD in the Levant is still unresolved, but it could have been shorter than that indicated by the ice cores and as long as that in western Europe or eastern China (Liu et al. 2008), that is, about 1,000 years.

The Ghab pollen core in the Orontes River valley demonstrates a clear decline of arboreal pollen during the YD, with a major recovery of the oak-pistachio forests during the Early Holocene (van Zeist, Baruch, and Bottema 2009; van Zeist and Bottema 1991; Yasuda 2002). The reduction in arboreal pollen is less well marked in pollen cores from Anatolian lakes located in the steppic areas or from the coast of Mount Carmel (Kadosh et al. 2004; Lev-Yadun and Weinstein-Evron 2005). Localities close to the Mediterranean Sea were generally forested, and even a reduction of ca. 30% of annual precipitation had a minimal ecological impact.

The proxy data from marine cores across the eastern Mediterranean—from the Adriatic Sea, the Aegean, and Cyprus—support the overall picture described above. The temperature cline from the Atlantic Ocean through the Mediterranean, shown by the analysis of planktonic foraminifera (Kuhlemann et al. 2008), demonstrates the general time correlations of climatic fluctuations between the two water bodies. Comparisons between the oxygen and stable carbon isotopes from cave speleothems and those from the marine cores indicate that the same sequence of climatic changes occurred in the Levant (Bar-Matthews and Ayalon 2003). Hence, in spite of probable attenuation due to local conditions, proxies from neighboring regions within the Northern Hemisphere can be employed (e.g., Enzel et al. 2008; Willcox, Buxó, and Herveux 2009). Missing from the proposed paleoclimatic interpretations are the simulated impacts of reduced precipitation on the Mediterranean forests, open parklands, and steppic environments. The overall trend was marked by diminishing yields of wild plant seeds and annual fluctuations in the production of acorns and pistachio nuts, which were intensively collected or harvested by Terminal Pleistocene foragers, as well as changes in the spatial distribution of game animals. Thus, the impact in a land "full of people" was that those who occupied the better areas probably stayed put and intensified their food acquisition. Others increased their mobility.

The Late and Final Natufian sites in the southern Levant (ca. 13,000/12,800–11,700/11,500) produced poorer remains than the Early Natufian. It probably reflects the return in many of the exploited habitats to a mobility greater than their ancestors'. Flimsy dwelling structures characterize these sites, and the dead were rarely buried with adornments, but rich lithic and bone-tool assemblages were produced (Valla et al. 2007). The Late and Final Natufians increased consumption of low-ranked resources such as bone grease, juvenile gazelles, and fast-moving small game such as hare (Munro 2004; Stiner, Munro, and Surovell 2000). Two mounds, Abu Hureyra

(Moore, Hillman, and Legge 2000) and Tell Mureybet (Ibáñez 2008), provided the only Late Natufian archaeobotanical assemblages to be discussed below. In sum, in the face of the difficulties of the YD, the solutions triggered for risk minimization by Late Epi-Paleolithic societies were diverse and included the following:

1. Increased mobility and additional specialized adaptations to the mosaic ecology of the Levant. In the Negev and the northern Sinai, these led to the emergence of the unique Harifian culture and the invention of a typical arrowhead, the Harif Point (Goring-Morris 1991; see Belfer-Cohen and Goring-Morris 2011; Goring-Morris and Belfer-Cohen 2011).

2. Increased sedentism for security and defense from other noncultivator groups of foragers. This is demonstrated in the establishment of the village of Hallan Çemi Tepesi (11,900–10,500 cal BP) on the banks of a tributary of the Tigris River (Rosenberg and Redding 2000). No cereals were found at this site (Savard, Nesbitt, and Jones 2006), indicating that during the YD the distribution of einkorn and barley did not extend farther east from its main western habitat. Barley (*Hordeum* cf. *spontaneum*) makes its first major appearance in this region farther east (Demirköy and Qermez Dereh) only during the PPNA (after 11,700/11,500 cal BP; Savard, Nesbitt, and Jones 2006).

3. Intensified hunting and gathering and part-time cultivation. This is evident in the presence of arable weeds, reflecting increased sedentism, and it emerges in Tel Qaramel west of the Euphrates valley, Mureybet, and Jerf el-Ahmar (Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008). Hence, wild cereals were available only along the western wing of the Fertile Crescent, as predicted by the conditions of the YD and the plant remains from the Late Natufian at Abu Hureyra and Mureybet (Hillman et al. 2001). Exploitation of small seeds was already known from the days of Ohalo II (ca. 23,000–21,000 cal BP) and probably from earlier times as well. The decision to include the cultivation of cereals in the economy of these foragers seems to have started in the northern Levant, probably before the end of the YD (ca. 11,700/11,500 cal BP), as in Tel Qaramel (Mazurowski, Michczynska, and Padzur 2009 and references therein; Willcox, Buxó, and Herveux 2009), and the idea spread rapidly southward. It has been suggested that the first appearance of green beads among Late Natufian body decorations marked the onset of beliefs related to the practice of cultivation (Bar-Yosef Mayer and Porat 2008 and references therein). Indeed, botanical evidence indicates that within a few centuries, the climatic conditions improved and farming became successful because there were stable and sufficient amounts of winter rain (e.g., Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008). The ensuing millennia of the Holocene enjoyed better climatic conditions, in spite of rapid climatic changes that had variable impacts on human communities as population increased and social structure became more complex (Weninger et al. 2009).

PPNA Communities and Early Farming

The PPNA communities (ca. 11,700/11,500–10,700/10,500 cal BP) are considered the direct descendants of the Natufians, although we lack evidence of their contemporaries who inhabited southeast Turkey because of a paucity of research, and they invested more energy and materials than their forebears in building houses. Circular and oval stone foundations continued to be the standard shape of the domestic unit, but quarrying of clay and hand-molding of planoconvex bricks for the walls, as well as the mounting of flat roofs that required supporting posts, represent an increased investment in creating the human space (Stordeur and Willcox 2009; Watkins 2006). Private and public storage facilities were erected (Kuijt and Finlayson 2009). The villages grew up to 2.5 ha in size, with populations of at least 150–300 people practicing a mixed economy of cultivating different suites of plants, according to their local ecology, and fig trees in the Jordan Valley (Kislev, Hartmann, and Bar-Yosef 2006). Hunting the common game in the area and gathering wild plants provided a major part of the diet (Willcox, Fornite, and Herveux 2008).

Interpretations of the archaeobotanical data indicate that initiation of intentional cultivation varied. In each subregion, a different set of wild plants were cultivated and were either successful or total failures (Weiss, Kislev, and Hartmann 2006). The first experiments in cultivation could have begun during the Early Natufian, but a step forward was made during the Late Natufian (Hillman 2000; Hillman et al. 2001). Most authorities agree that during the closing centuries of the YD or the first centuries of the Holocene, bearers of the earliest PPNA tool kits, defined as the Khiamian culture in the northern Levant, were the first farmers, because their carbonized plant remains contain the weeds that grow in tilled fields in addition to the cereals (Colledge 2001; Kislev, Hartmann, and Bar-Yosef 2006; Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008). The suite of plants grown by the first cultivators included rye (*Secale cereale*), einkorn (*Triticum boeoticum*), emmer wheat (*Triticum dicoccoides*), barley (*Hordeum spontaneum*), and oats (*Avena sterilis*). Several grass species, such as *Aegilops* and *Stipa*, may represent wild weeds that grew in cultivated fields or the results of gathering. Pulses such as lentils (*Lens culinaris*), peas (*Pisum sativum*), grass peas (*Lathyrus*), bitter vetch (*Vicia ervilia*), and common vetch (*Vicia sativa*) are well recorded, while chickpeas (*Cicer arietinum*) and faba beans (*Vicia faba*) first appeared during the PPNB (Lev-Yadun, Gopher, and Abbo 2002). Currently, the prevailing view is that systematic cultivation was carried out by several PPNA villages, including Tel Qaramel, where all the ^{14}C dates were produced by one laboratory (Mazurowski, Michczynska, and Padzur 2009).

According to several archaeobotanists, it took some 1,000 or 2,000 years of systematic cultivation of wild cereals (Fuller 2007; Kislev 1989, 1997; Tanno and Willcox 2006) before a major portion of the plants acquired the mutation of nonshattering ears and increased their grain size. This means that

without the continuous activities of sowing and harvesting, the domesticated plants would not have taken over in the fields. This is a process whose meaning is not fully understood by some archaeologists, for whom the terms "agriculture" and "cultivation" are interchangeable (e.g., Hodder 2007). An additional marker of intentional cultivation is the presence of typical wild weeds that grow annually in cultivated and harvested fields (Willcox, Buxó, and Herveux 2009). Therefore, the domesticated cereals that characterized the agricultural economy of PPNB villages were the result of a prolonged period of cultivation. One should refer to the historical use of terms such as "cultivation," "domestication," "agriculture," and others as clearly presented by Harris (2007). If the definition of "cultivation" incorporates the entire set of activities—such as tillage, sowing, irrigation, harvesting, and storage of seeds for consumption and next year's planting—then regardless of the genetically determined morphological traits of the plants, early cultivators were simply farmers. One may argue whether this is a fully "agricultural" subsistence system or an indication of "low-level food production" or that the definition should be retained for societies where husbandry of animals was part and parcel of annual subsistence activities (Vigne et al. 2009 and references therein). But farmers who grow tubers that are not fully domesticated are classified as "agriculturalists" and/or "horticulturalists," because it is the practice and not the state of "domestication" of the plants that counts when the economic system is categorized.

Finally, all PPNA villages in the Levant show the same crowded clustering that a millennium later became the hallmark of several PPNB sites. Calibrated radiocarbon chronology—mostly derived from short-lived, site-by-site samples—indicates that almost every village, including those situated next to a copious spring, like Jericho, or along the river banks, as in the Euphrates valley, was abandoned within a few centuries.

Terminal Pleistocene and Early Holocene Climatic Fluctuations in China

The basic assumptions for discussing the origins of cultivation in China are the same as for the Levant, namely, that Late Pleistocene–Early Holocene climatic fluctuations in North China played a similar role as in the Levant, triggering the transition to cultivation of wild millets for the intensification of a staple food. In this argument, I follow the footsteps of others who have already suggested, either partially or fully, the relationship between the impact of the cold and dry YD conditions on the survival strategies of mobile foragers and the primacy of millet cultivation (e.g., Barton et al. 2009; Bettinger, Barton, and Morgan 2010; Bettinger et al. 2007; Lu 1999, 2006; Shelach 2000). The emergence of rice cultivation, which followed during the Early Holocene (Cohen 2011; Zhao 2010, 2011), is briefly discussed below in relation to climatic fluctuations and resources in South China.

It is important to stress that the ongoing search for the origins of millet cultivation is focused in a large area of about 500,000 km^2, incorporating the middle and lower Yellow River basin (Cohen 2011; Zhao 2004). The number of sites where plant remains have been carefully recovered and reported is still small, and the cultural relationships among the different subregions is debated among archaeologists (Cohen 2011). Hence, we must first consider the overall geographic features of China and the current climate and then proceed to summarize the proxies for past climatic fluctuations before delving into the particular information concerning their impact on the local hunter-gatherers.

The physiography of China (ca. 9.6 million km^2) is commonly subdivided into three topographic landforms, each with its own regional variability. These are defined by elevation above sea level (a.s.l.): (1) the Tibetan Plateau, some 4,000–5,000 m a.s.l.; (2) the central mountain plateau area, ca. 1,000–2,000 m a.s.l., incorporating Inner Mongolia, the Loess Plateau, the Sichuan Basin, and the Yunnan-Guizhou Plateau; and (3) the plains and seacoast, generally below 200 m a.s.l. and crossed by numerous copious rivers. This region is strewn with hilly areas, mostly south of the Yangtze River, that can reach ca. 500 m a.s.l. (Zhao 1994).

The climate of China is characterized by the tropical and subtropical Pacific and Indian Ocean summer monsoons. The arrival of the monsoon marks the onset of the rainy season, starting in the south and advancing northward from early March to June–July (fig. 4). Later, the rains retreat to the south and may last from late August through September and October. During the winter, the entire landmass is dominated by Siberian-Mongolian high-pressure systems that often produce strong winds. But the winter monsoon carries some moisture from the Pacific into eastern China, and the northwest enjoys the westerlies that bring some precipitation from western Eurasia. Winter temperatures are close to or below 0°C in the north, while summer temperatures may rise to above 30°C, particularly in the south, and higher in the western deserts. Topographic variability within each of the schematically averaged levels results in a mosaic distribution of precipitation and temperature and thus of flora and fauna (Zhao 1994).

The Last Glacial in China was characterized by significant and frequent oscillations well recorded in a suite of proxies such as the Himalaya ice cores, loess sediments, pollen cores, marine cores, and cave speleothems (e.g., Cosford et al. 2008; Lin et al. 2006; Yu, Luo, and Sun 2008; Yu et al. 2000; fig. 4). Unfortunately, the distribution of caves with studied speleothems is uneven, and most are located in southeastern and central China and in Tibet, where karstic landscapes prevail (fig. 4). Hence, most of the paleoclimatic information for the western and northern regions are drawn from lake and marine pollen cores, loess sequences, and deep-sea cores in the East China Sea (e.g., Wen et al. 2010; Yi et al. 2003). The different data sets reflect the impacts of the Pacific and Indian Ocean monsoons and show some differences between the strengths of the two systems as well as the impact of the westerlies.

Figure 4. Location of Chinese caves with studied speleothems mentioned in the text.

Among the eastern sites, Hulu Cave, near Nanjing (Wang et al. 2001), produced a long paleoclimatic curve that best fits the GISP2 ice core. Other caves include Dongge (Dykoski et al. 2005), Heshang (Hu et al. 2005), Qingtian (Liu et al. 2008), Sanbao (Wang et al. 2008), Songjia (Zhou et al. 2008), and Timta in Tibet (Sinha et al. 2005). It should be stressed that all speleothem sequences demonstrate similar trends but that not all correlate well chronologically. In addition, the transition from one climatic stage to another (e.g., from the Allerød to the YD) took 1 or 2 centuries longer than the comparable transition recorded by the Greenland ice cores (Liu et al. 2008). However, detailed discussion of these issues is beyond the scope of this paper.

LGM conditions in North China were cold and dry, and except for a few protected habitats, most of these steppic-desertic environments were desolate landscapes (Yu et al. 2000). By ca. 16,000 cal BP, climatic amelioration was witnessed in slowly rising temperatures, increasing rainfall, and a moderate return of forest habitats to the loessic areas, as judged from the evidence for the earliest Holocene (e.g., Cai et al. 2010; Ren and Beug 2002). As the monsoon system became stronger, it penetrated farther north, particularly during the Bølling-Allerød (ca. 14,500–ca. 13,000/12,800 cal BP), and facilitated the spread of foragers within this region.

Several researchers have reported information concerning the environmental conditions that facilitated the growth of human populations, producers of the microblade (microlithic) industries, before the YD (e.g., Bettinger, Barton, and Morgan 2010; Bettinger et al. 2007; Chen 2007; Madsen et al. 1998; Wünnemann et al. 2007). Most sites from this period are small and ephemeral and reflect varying degrees of mobility. Series of such occupations with microblade industries have been sampled and studied (e.g., Chen 1984, 2007; Cohen 2003; Madsen et al. 1998). Xiachuan is one of the important clusters of sites where a few radiocarbon dates indicate the presence of at least two major occupations rich in microblades (ca. 25,000 and ca. 15,000 cal BP) and a large number of grinding slabs (Lu 1999). Lu (2002) reports siliceous sheen on several flakes that resemble her experimental pieces employed in harvesting foxtail grass panicles. Another multilayer cluster of sites excavated at Shizitan, where occupational horizons were interspersed with loess accumulations several meters thick (Shizitan Archaeological Team 2002, 2010), is dated to ca. 20,000–ca. 9,000 cal BP. On the whole, microblade industries occur at several hundred sites across North China, southern Siberia, Korea, and Japan (Chen 2007; Kajiwara 2008; Kuzmin, Keates, and Shen 2007). Larger tools were often made from local raw material, such as quartz or quartzite. Grinding slabs and rubbing stones are a common component in these sites, indicating small-seed grass processing. In addition to plant resources, this vast region, dissected by the large Yellow River valley and numerous smaller ones, was frequented by several species of deer, equids, wild boar, and a few carnivores.

It seems that the penetration of the westerlies during the Bølling-Allerød increased the potential for hunter-gatherers to expand their populations into previously arid or semiarid habitats in western China. Thus, the abrupt change to the YD (e.g., Liu et al. 2008), from around 12,800/12,500 cal BP until 11,700/11,600 cal BP, was a major calamity. This natural crisis provides early testimony to the problems that North China has faced through history from fluctuations in the monsoonal system (Shen et al. 2007).

The Role of the YD in North China

Understanding the impact of the rapid climatic change of the YD on social systems is first appreciated from historical records. The absence or paucity of summer rains is not an isolated phenomenon. This can be seen in every historical review that documents droughts; droughts begin in the north, as a recent review of major droughts during the past five centuries in China indicates (Shen et al. 2007). The effects were dramatic, because anthropogenic activities had already altered the local environments. Exceptionally severe droughts occurred in AD 1586–1589 (when Taihu Lake, the third-largest freshwater lake in China, dried up), in AD 1638–1641, and in AD 1965–1966. More frequent droughts were recorded in tree rings in the Tien Shan area (Li et al. 2006). All these events were caused by a weak summer monsoon, together with the westward and northward movement of the western Pacific subtropical high.

We therefore expect a sudden increase in dryness across North China to have caused the same reactions as observed in the Levant. Unfortunately, the archaeological literature is not sufficiently detailed, and accelerator mass spectrometry (AMS) dates for localities where humans stayed during the YD are rarely available. On the other hand, we have more information concerning Early Holocene conditions, including reconstructed vegetation maps based on pollen records. These may help us speculate about what happened during the previous period (e.g., Ren and Beug 2002; Wen et al. 2010).

Hunter-gatherers retreated to more favorable habitats, including river valleys, as in Shizitan, and probably established semisedentary communities and increasingly intensified exploitation of resources arising from their reduced mobility, causing "population pressure" and increased competition for resources. Hence, during the YD and in particular during the first two millennia of the Holocene (11,500–9500 cal BP), we note the appearance of larger sites as agglomerations of families and possibly subclans reflecting the need for security and territorial defense, in view of real or imaginary enemies (Roscoe 2009). Earlier ephemeral occupations in sites such as Donghulin, Nanzhuangtou, and Zhuannian date to the YD and/or Early Holocene and are of variable sizes (Cohen 2011). These are sites of foragers who successfully survived in the region (fig. 5).

Nanzhuangtou (Hebei) contained some rare microblades, no pottery, and a rich bone and antler assemblage, including the remains of deer, dog, pig, wolf, chicken, softshell turtle,

Figure 5. Partial map of China with all the early farming sites and the locations of several of the main caves with speleothems. The list of sites is from Cohen (2011). *1*, Yuchanyan; *2*, Chengtoushan; *3*, Pengtoushan; *4*, Bashidang; *5*, Xianrendong and Diaotonghuan; *6*, Shangshan; *7*, Kuahuqiao; *8*, Xiaohuangshan; *9*, Hemudu and Tianluoshan; *10*, Dadiwan; *11*, Shizitan; *12*, Xiachuan; *13*, Jiahu; *14*, Peiligang; *15*, Cishan; *16*, Yuezhuang; *17*, Xiaojingshan; *18*, Houli; *19*, Nanzhuangtou; *20*, Yujiagou; *21*, Zhuannian; *22*, Xinglongwa; *23*, Jiahu.

and shellfish (Cohen 2003; Underhill 1997). Only the recovery of plant remains by flotation will clarify whether the late foragers in the north were only collectors or were also part-time cultivators, growing broomcorn or foxtail millet or even both.

At the site of Donghulin, dated to ca. 10,500–9600 cal BP, the excavations and additional field research exposed a pit house, numerous stone artifacts (including microblades), pottery, grinding stones, faunal remains, and three burials, one of a woman decorated with 68 sea shells (Cohen 2011; Hao et al. 2001; Zhao et al. 2006).

In spite of a relative paucity of excavations that have provided reliable assemblages of plant remains and radiocarbon dates (some of which may represent the use of wood for building), the next phase is represented by the cultures or the cultural groups named Huoli, Cishan, and Peiligang (fig. 5; further details in Cohen 2011). The bearers of these different groups (identified by their pottery types) emerged as cultivators of millet within the middle and lower Yellow River basin (Crawford 2006, 2009; Lu et al. 2009; Zhao 2004, 2011). It seems that they started as dryland farmers of broomcorn and foxtail millets (Zhao 2004, 2010), and they are possibly incorporated in the primary "core area" where agriculture (in terms of the set of activities as defined above) was established. The first farming communities are characterized as 1–2 ha in size with semisubterranean rounded houses; a large number of storage pits (some containing abundant millet grains); garbage pits; distinct cemetery areas; abundant pottery, stone adzes, axes, and spades; and four-legged grinding stones best known from Cishan. The architectural change to rectangular houses marks a second phase within the developing sedentary communities.

A new biomolecular study of plant remains from Cishan suggests that broomcorn millet (*Panicum miliaceum*) was first cultivated/domesticated by ca. 10,300–8700 cal BP (Chang 1986; Cohen 2011; Crawford 2009; Lu et al. 2009), although the earliest radiocarbon dates in this study are older than the lowermost reported layer of the village. Northward (such as to the Xinglongwa culture in Inner Mongolia) and southward to the Peiligang area, dispersals of early farming probably occurred during the second millennium of the Holocene (ca. 10,500–9500 cal BP; Cohen 2011). If this scenario is supported by new evidence, we may suggest that cultivation of wild varieties of millet possibly started during the last centuries of the YD and probably during the first millennium of the Holocene and that millet became domesticated some 1,500–2,000 years later. If such a scenario is supported by additional evidence, we may conclude that it is an interesting coincidence that the impact of the YD on populations in both North China and the northern Levant led to the onset of wild-plant cultivation (see also Shelach 2000).

Isotopic analysis of human bones from the Xiaojingshan site (ca. 8000 cal BP) suggests that millet made up only 25% of the diet of both males and females (Hu et al. 2008). Hu et al. (2008), supported by the isotope analysis from Jiahu (Hu, Ambrose, and Wang 2006), propose that only about 1,000 years later did millet become a predominant component in daily consumption. In Xinglongwa-type sites (ca. 8100–7200 cal BP), $\delta^{13}C$ values in human bones that mark the consumption of millet (a C_4 plant) reflect the presence of both species (broomcorn and foxtail), probably indicating the level of agricultural development (Barton et al. 2009). Interestingly, flotation samples from a Houli culture site—Yuezhuang (Jinan, Shandong), with one AMS date of 7900 cal BP—demonstrate the presence of 40 broomcorn seeds and one foxtail millet seed along with 26 rice seeds, indicating an unexpectedly early arrival of the latter plant in the Yellow River area (Crawford, Chen, and Wang 2006).

Animal domestication in North China is an issue raised by several authors in spite of the paucity of detailed zooarchaeological studies (Flad, Yuan, and Li 2007; Yuan and Flad 2002; Yuan, Flad, and Luo 2008). Given the relative scarcity of fish in the Yellow River (when compared with the Yangtze River) and the abundance of nondomesticated species such as deer and carnivores (including wolves), the best candidate was the wild boar. There is little doubt that pigs were the first animal to be adopted by farmers, who continued to hunt. The process, possibly similar to the one in the Levant, began with "cultural control" of individuals attracted to the garbage dumps of villages such as Cishan, at least by 8000 cal BP. By 6000 cal BP, pig meat was 60% of consumed mammal tissues (Yuan, Flad, and Luo 2008).

The two domesticated varieties of millet, *P. miliaceum* and *Setaria italica*, were identified in Xinglongwa from about 8200/8100 cal BP as well as at Dadiwan (7800–7300 cal BP) in the Laoguantai area, which is located farther west and in a higher altitude. The geographic location of both and their rectangular houses mark the later phase of the Early Neolithic (by contrast with the rounded ones that characterized the earlier phase) and indicate that they are situated within a "secondary core area." Archaeological observations in Inner Mongolia have already led Shelach (2000) to suggest that millet cultivation must have started earlier than at the Xinglongwa site. In addition, the well-ordered rectangular-square houses oriented in the same direction, often attached or very close to one other and surrounded by a trench, hint at a social hierarchy (represented by a central house and a burial with jade earrings) that indicates further changes within farming societies. The location of the site on top of a low hill indicates that the trench was probably not to prevent water from flooding the site but rather to physically and/or symbolically deter real or imaginary enemies. Warfare among agricultural tribes is a well-known phenomenon (e.g., Keeley 1996; Roscoe 2009). If long-distance similarities are meaningful, then the arrangement of the houses at Xinglongwa resembles sites such as Aşıklı and Çatalhöyük in Anatolia that belong to the second phase of the Neolithic Revolution in the Levant, and cultivation had already been practiced in this region for some 2,000 years.

The Role of Paleoclimate in South China

South China stretches from south of the Qinling Mountains and the Huai River to the south and southeast coast, and although it enjoyed somewhat better climatic conditions than the North, several fluctuations are clearly recorded in cave speleothems and in the South China Sea. Not surprisingly, these are correlated with Timta Cave in Tibet. However, the origins of rice cultivation and domestication, currently debated among scholars (e.g., Fuller, Harvey, and Qin 2007; Liu et al. 2007; Zhao 2011), are sought in three geographic basins south of the Yangtze River, namely, the Lake Dongting area (Hunan), the Lake Poyang area (Jiangxi), and the lower Yangtze River. It should also be remembered that the sea rise during the post-LGM reduced the coastal belt by at least 250 km. Hence, the region we briefly examine is about 400,000–500,000 km^2.

The Late Upper Paleolithic sites in South China (ca. 23,000/20,000–11,500 cal BP) preserved the old tradition of cobble tools such as choppers; cores and flakes; small cup holes on cobbles; perforated cobbles; and bone, antler, and shell tools. This region produced the earliest evidence for pottery making, which dates to ca. 18,000–17,000 cal BP in Yuchanyan Cave (Boaretto et al. 2009) and probably to an earlier time in Xianrendong and Diaotonghuan (MacNeish et al. 1998); the pottery may have been used to make special liquids, to cook bones for grease extraction, or for storage and undoubtedly had special social meaning (Pearson 2005). Rice phytoliths found in these Terminal Pleistocene cave deposits are now considered evidence of gathering or of first experiments in cultivation (Zhao 2010).

Open-air sites of Late Pleistocene foragers that may represent early rice exploitation within the basin of the Yangtze River and its small tributary valleys are rare and mostly buried under the rapid Holocene alluviation. Therefore, caves are regarded as the main sources of information. The most cited are Yuchanyan Cave (Hunan), Xianrendong and Diaotonghuan (Jiangxi), and Miaoyan (Guangxi).

The recently studied deposits of Yuchanyan Cave (Boaretto et al. 2009; Prendergast, Yuan, and Bar-Yosef 2009; Yuan 2002) represent many events of building fires with wood during the early Bølling-Allerød period. Rice phytoliths identified in the first round of research (Zhang 2002) probably reflect gathering in the natural wetlands during fall. Most revealing are the animal bones, frequently of several deer species, with a few macaque, hare, small carnivores, and large rodents, particularly bamboo rat (Prendergast, Yuan, and Bar-Yosef 2009; Yuan 2002). Identified birds such as heron, tern, crane, goose, and others winter in the area, while the ducks were all wetland taxa. Fish included carp and catfish. In sum, it seems that the young age of the deer and the presence of wintering wetland birds (whose breeding grounds are in North China, Mongolia, or Siberia) indicate that Yuchanyan Cave was ephemerally occupied by a small group mainly during early fall and winter and possibly early spring.

A somewhat similar picture emerges from the reports on Xianrendong and Diaotonghuan (MacNeish et al. 1998). The caves were abandoned by the end of the Bølling-Allerød and the early YD (i.e., 13,700–12,300 cal BP), and thus direct cultural connection with the early villages of the Middle Yangtze basin is unknown. Early Holocene conditions were improved, with more stable monsoonal systems that allowed foragers to carry on their gathering and hunting activities for several millennia (Cohen 2011; Zhao 2011). However, the impetus for the onset of cultivation of wild rice is unclear, and we should regard as among the potential triggers the social connections through the river network with the north, where millet was already grown. An additional option is the local "demographic pressure," which can hardly be imagined in an area rich in plant and animal resources, and some social mechanism related to competition with other foragers. In spite of the huge areas discussed, long-distance connections in the Chinese landmass were enormously facilitated by river transport. Simple craft could be made from a bunch of bamboo tied together, and the early making of canoes is evidenced in Kuahuqiao.

Rice exploitation predates the available evidence of phytoliths and carbonized plant remains obtained in Xianrendong Cave (Jiangxi: Zhao 1998), Bashidang (Hunan, ca. 8150–7600 cal BP: Zhang 2002; H. Gu, personal communication, 2008), Kuahuqiao (ca. 7900–7300 cal BP) in the Lower Yangtze basin (Zheng, Sun, and Chen 2007; Zong et al. 2007), and Tianluoshan (by 6600/6400 cal BP; Fuller et al. 2009). Although the plant evidence is missing, quite possibly the subsistence system of Pengtoushan (Hunan, ca. 9300–8300 cal BP), an early village in the Dongting area, was partially based on rice gathering and perhaps cultivation. By ca. 8000–7000 cal BP, at least half of the rice recorded in Kuahuqiao was already of the domesticated variety (Zheng, Sun, and Chen 2007). The presence of rice in Jiahu and Yuezhuang in the Yellow River basin may indicate that there were long-distance interactions by ca. 8000 cal BP (Zhang and Wang 1998). While the overall impression may be of the simultaneous emergence of two farming systems, I believe that detailed scrutiny of the available calibrated radiocarbon dates may still raise the interpretation that the middle and lower Yangtze River basin could have been a "secondary core area" influenced by the Yellow River "primary core area" (Zhang and Hung 2008; Zhao 2010, 2011).

Concluding Remarks

When viewed from the perspective of a *longue durée*, subsistence strategies adopted by foragers during the Terminal Pleistocene in western and eastern Asia have much in common. In a land "full of people," the winning option was to stay put and intensify the exploitation of plant resources—this meant starting to cultivate in suitable ecological niches. The strategy worked best within the natural habitats of the cereals in the Levant and North China. None of the early farmers aban-

doned the gathering of wild plants, hunting, trapping, fishing, or, particularly in China, collecting land snails, freshwater mollusks, and water plants. The evidence from the Japanese archipelago indicates that the mixed strategy of low-level food production with broad-spectrum exploitation of the surrounding natural environment also characterized the Jomon people (Crawford 2008). We may label these foragers as "incipient farmers" or "affluent foragers" who practiced cultivation, and we should be fully aware of their entire gamut of subsistence resources. In the Levant and North and South China, "incipient cultivation" resulted in the domestication of the harvested species and the stable, steady provisioning of staple foods under favorable climatic conditions; this led to the rapid increase of local populations and the development of full-fledged farming and herding economies.

Over the first four millennia of the Holocene (ca. 11,700/11,500–8200 cal BP), the process of annual cultivation in the Levant ended in the domestication of several species of cereals as well as a suite of other plants (e.g., legumes, flax). Corralling of selected animals (goat, sheep, cattle, and pig) caused their domestication, and together with the plants, these species provided the foundations of the agropastoral societies of later periods. The rapid population growth in Southwest Asia resulted is what is known as the "Neolithic demographic transition" (e.g., Bocquet-Appel 2011; Bocquet-Appel and Bar-Yosef 2008 and references therein). The same phenomenon is observed across other regions during the Holocene, and it makes clear that farming was a winning economic strategy and that its consequences were disastrous to hunting-and-gathering groups.

In light of the Late Pleistocene paleoclimatic and archaeological information from North and South China, it seems that the middle and lower Yellow River basin was prone to droughts much more frequently than South China, and given the reconstructed demography of mobile hunter-gatherers in this region, we should expect that the establishment of millet cultivation preceded the earliest rice cultivation by a millennium or two. There is clear evidence for the attenuated impact of the YD in South China on the local vegetation. However, Holocene conditions ranged from subtropical to tropical, with high frequencies of rainfall brought by the monsoons, and therefore the impact of the YD is not easily detectable. In both regions, there was probably a long time between the cultivation of the wild progenitors and the establishment of domesticated, nonshattering varieties as the dominant plants in the fields (e.g., Crawford, Chen, and Wang 2006; Fuller, Harvey, and Qin 2007; Fuller et al. 2009; Lee et al. 2007; Liu et al. 2007; Lu 1999, 2006; Zhao 2011; Zheng, Sun, and Chen 2007).

Attributing the incipient cereal and millet cultivation to the impacts of the YD is theoretically couched in several behavioral options that hunter-gatherers had when trying to minimize risks to their survival and create economic buffer conditions. The decision to start cultivation as a planned food-acquisition strategy had its own consequences, as much as the decision to settle down. Other options were available, and the final choice was made within the social arena. The viable option to move to other people's territories in China could have taken place in a vast region were waterways were the prehistoric highways. Facing intergroup conflicts and minimizing mobility was a Levantine solution that would be favored where walking was the common means of crossing the landscape.

Thus, the processes in both China and the Levant were reasonably similar, and sedentism was the common group strategy. The building of domestic dwellings followed the same pattern, starting with round pit houses and shifting gradually to square and rectangular ground plans. Materials varied. In China, wood and bricks became the standard building materials, while in the Levant, undressed and dressed stones played a major role, joined by bricks. Earlier small-scale farming was additionally supplemented by gathering and hunting, a strategy that lasted longer in South China than in either North China or the Levant. While rapid climatic change served as a trigger during the closing centuries of the YD, such changes continue to punctuate the Holocene sequences of both regions, a subject beyond the scope of this paper (e.g., Berger and Guilaine 2009; Chen et al. 2008; Weninger et al. 2009).

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