

Reprinted from: Colledge, S. and Conolly, J. (eds.) 2007. *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*. University College London Institute of Archaeology Publications. Walnut Creek, CA: Left Coast Press, Inc.

Chapter 2

The adoption of farming and the beginnings of the Neolithic in the Euphrates valley: cereal exploitation between the 12th and 8th millennia cal BC

George Willcox
CNRS Jalès, France

2.1 Introduction

An exceptional body of archaeological and archaeobotanical data has been amassed from several early farming sites along the Euphrates valley over the last thirty years. These sites were the focus of a number of archaeological rescue operations prior to the construction of a series of dams (figure 2.1). At the earliest site, Natufian Abu Hureyra, small pit dwellings were uncovered; during the three millennia that followed there was a progressive increase in both the size of the sites and the complexity of the architecture, culminating in large sites, e.g., Halula, which is dated to the first half of the 8th millennium cal BC (Molist and Stordeur 1999; Moore et al. 2000; Stordeur 2000). The seven sites along the Euphrates belonging to the late 10th and early 9th millennium cal BC that are referred to in this paper exhibit considerable cultural coherence in terms of artefacts, architecture and symbolic representations, which implies that these societies likely shared similar beliefs and spoke the same language. The inhabitants of the sites were some of the earliest farmers in the Near East. Of the seven sites, five are in Syria and are located at regular intervals along the Euphrates, in some cases at distances of less than 25 kms. There is convincing evidence for contact between the sites as indicated by the movement of raw materials: for example, obsidian, chloritic stone, and cedar wood were imported to the Syrian sites from sources further upstream, in Anatolia.

Within the regional context of the Near East, the early Neolithic Euphrates sites in Syria differ from sites in the southern Levant and Anatolia because they are situated at regular intervals on a major river and are also a long way from present-day wild wheat stands. Archaeobotanical data from 17 sites across the Near East clearly show that other early agriculture sites are located in or near areas that are coincidental with present-day distributions of the cereals that have been identified in the archaeobotanical assemblages found on each site. So for other areas, for example the southern Levant and Anatolia, the past cereal distribution appears to have

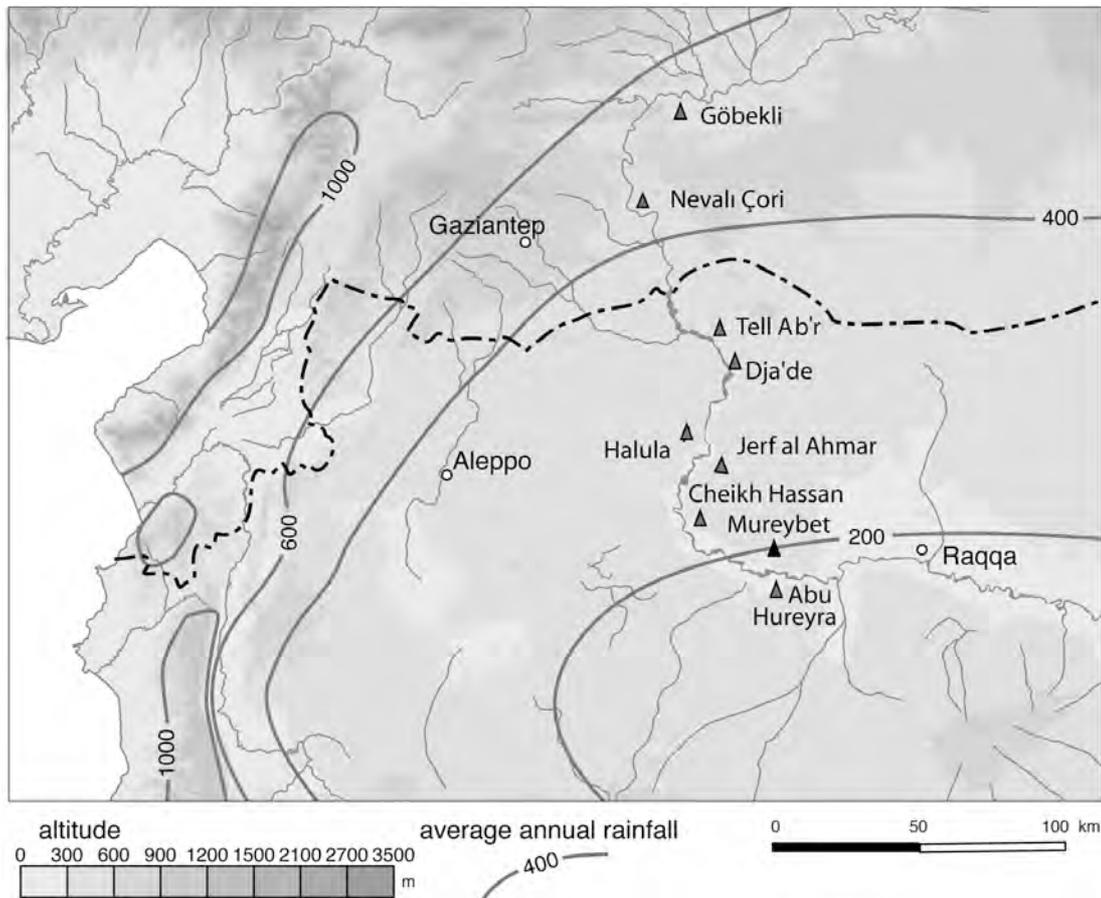


Figure 2.1: Map showing early farming sites on the Euphrates mentioned in the text with rainfall isohyets. So far no archaeobotanical remains have been published from Cheikh Hassan and Tell Ab'r. The site of Mureybet is situated at the very limit of the dry farming zone, yet at this site cereals were present during the Younger Dryas, which is a period considered to have been less humid than at present (irrigation would not have been possible due to the high flood levels that coincide with harvest time; see Willcox and Roitel 1998).

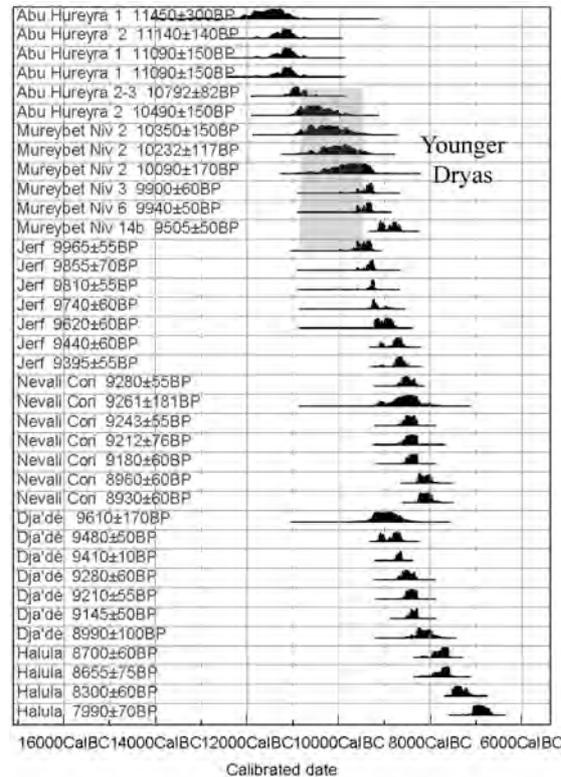


Figure 2.2: Range of selected radiocarbon dates from the Euphrates early neolithic sites using the Oxford calibration curve.

been similar to that seen today. The regional differences in ancient cereal assemblages provide evidence for independent domestication events. Thus in the southern Levant there is evidence for the domestication of barley and emmer, the only wild cereals found growing in the region; and rye and einkorn, which are absent in the south, were domesticated in the northern Levant. Barley and emmer occur in both areas and may have been domesticated more than once (table 2.1) (Willcox 2002c). These conclusions are based on archaeobotanical data and are supported by evidence from DNA analyses of modern cereal populations. (Badr et al. 2000; Özkan et al. 2002; Salamini et al. 2002; Heun et al. 1997; Ishtii et al. 2001; Tanno et al. 2002; Thuillet et al. 2002).

The charred plant remains from the Euphrates sites present a wealth of information about the adoption of agriculture by these early neolithic societies. In this paper I will examine the evidence from the seven sites in the Euphrates valley (see figure 2.1 for site location and 2.2 for dating) using data from published reports (Hillman 2000; Hillman et al. 2001; Neef 2003; Pasternak 1998; van Zeist and Bakker-Heeres 1986; Willcox 2002a, 1996; Willcox and Fornite 1999; Stordeur 2000) and also from my as yet unpublished work.

2.2 Past and present wild cereal habitats in the middle Euphrates and their availability in the past

Knowledge of the ecology of wild cereals is essential for an understanding of their distribution and availability of these plants in relation to archaeological sites; however information in the

Site	Units	Date bp	Einkorn 1g	Einkorn 2g	Emmer	Barley	Rye	cal BC
Southern Levant								
Ohalo II	1	19000	0	0	21	629	0	20500
Wadi Hammeh 27		12200-11920	0	0	0	p	0	12200-11900
Netiv Hagdud	8	9900-9400	0	0	27 (4)	541 (8)	0	9500-8800
Zad 2		9800-9500	0	0	P	P	0	9400-8900
Iraq ed-Dubb		9900	?	0	?	P		9500
Aswad I	9	9300-9000***	0	0	23(6)	32(6)	0	8600-8250
Middle Euphrates and Iraq								
Abu Hureyra	24	1150-10000	0	>5000(21)	0	0	p	11000-7000
Qermez Dere		10100-9700	0	0	0	p		10100-9300
Mureybet I-II	33	10200-9900	0	19	0	5	p	10200-9900
Mureybet III	27	9800-9400	0	>2000	0	164	p	9300-8800
Jerf el Ahmar*	430	9800-9400	67	2539	0	9641	p	9300-8800
Dja'de*	225	9500-9000	265	1120	191	3763		8800-8000
Eastern Anatolia								
Göbekli Tepe	1	9550-9450	0	5	0	16		8900-8800
Cafer Höyük XII XIII		9400-8800	p	p	p	0	p	8800-8000
Çayönü g, bp, ch		9250-8500	p	p	p	p		8200-7500
Nevalı Çori	1	9250-9000	661	p	129	89		8200-8000
West Syria								
Tell el-Kerkh**		9250-9000	p		p			8200-8000
Cyprus								
Mylouthkia/Shillourokambos		9250-9000	p	p	p	p		8200-8000

Units=number of samples; 1g=single grained; 2g=two grained; numbers not in brackets=absolute numbers of grains identified; numbers in brackets=number of samples in which taxa is present; 0=absence significant; 0=absence not significant; other **bold** entries=possible domestication;*=preliminary results from author's unpublished data; **=Ken-Itchi Tanno pers. com.; ***=based on new AMS dates (GrA-25913, GrA-25915, GrA-25916, GrA-25917) of emmer grains from phase Ia and Ib of the 1973 excavations.

Table 2.1: Cereal assemblages from different regions of the Near East. Presence/absence of cereal finds indicate that ancient regional distributions were similar to present-day patterns, but changes may have occurred on a local level. The differences also indicate that local cereals were first taken into cultivation in each region. The Syrian Euphrates sites are an exception because of the greater distance from wild stands of the cereals found in assemblages (einkorn and rye) compared to the equivalent distance for other sites.

literature is sparse and even recent publications (for example, Blumler 2002) are not based on first-hand field observations. Numerous field trips to Turkey, Jordan, Armenia and Syria over the past 30 years have enabled me to examine the ecology of the wild cereals. In southeastern Anatolia and northern Syria, for example, I have observed that the five wild cereals (*Secale* spp., *Triticum urartu*, *Triticum boeoticum*, *Triticum dicoccoides* and *Hordeum spontaneum*) growing in this region have different and distinct habitat requirements, particularly in terms of rainfall and soil tolerance. This is particularly clear in the Euphrates valley region as a result of the strong climatic gradient, where rainfall varies from >900 mm per annum in the north to <150 mm south (see isohyets figure 2.1 and Willcox and Roitel 1998; Helmer et al. 1998; van Zeist and Bakker-Heeres 1986). The distribution of the five cereals extends across the region, with those least tolerant of aridity occurring in the north and those most tolerant in the south. Ryes and wheats are calcifuge plants, thus today rye is restricted to volcanic soils in the Taurus mountains above 900 m and emmer extends to the lower slopes, in areas with a minimum of 400 mm of rain per year. Two-grained einkorns (*Triticum urartu* and *Triticum boeoticum thaouidar*), which are more aridity-tolerant than emmer (or single-grained einkorn) reach as far as the Syrian/Turkish border and are found just east of Ain al Arab on basalt soils in an area with 300–350 mm of rain per year. Barley, the most drought-resistant cereal, is tolerant of poor calcareous soils and occurs further south into the Syrian steppe, where it grows on the poor chalk soils of the middle Euphrates in areas with 200–250 mm of rain per annum. Wild barley grows in rich stands near Halula and Jerf el Ahmar where grazing is restricted, and it is commonly found even further to the south.

To understand the early history of the six wild cereal taxa (with the addition of single-grained einkorn), one has to take into account that in the area where they were found there was a strong climatic gradient, and also that the sites at which they were present spanned a period of climate change. What do we know about the effects of climatic change on the vegetation in this area? The only information we have is local in focus, based on the charred macro-remains that represent gathered plants. The Younger Dryas, which is interpreted as a period of climatic deterioration at the end of the Pleistocene, has been recognised in many parts of the world. In the Near East its effects on the vegetation can be detected in lakebed pollen diagrams from the Mediterranean zone at Ghab (Yasuda et al. 2000) and at Hula (Baruch and Bottema 1999), but they are not as obvious in pollen diagrams from lakes situated in the more continental regions. Indeed, Bottema states that during the Younger Dryas in these areas there appears to be little evidence for vegetation change (Bottema 1995), but notes a relative increase in cereal type pollen (Bottema 2002), thus contradicting the popularly held view that cereals became sparse during this period. The relative frequencies of selected taxa from archaeological sites along the Euphrates are compared in figure 2.3.

The reduction in *Stipa*, *Amygdalus* and *Pistacia* during the Younger Dryas may be the result of worsening conditions; however, it is significant that they are present before, during and after this period (figure 2.3) (Hillman 2000; Willcox 2002b; Roitel and Willcox 2000). This continuity would appear to indicate that the climatic deterioration was not a catastrophic event and may merely represent a period of cooler, less stable conditions, which did not result in radical changes in the vegetation cover. One important question to then ask is whether or not these late Pleistocene climatic conditions would have resulted in a more southerly distribution of the wild cereals; lower sea levels combined with lower temperatures at the end of this period could have led to a lowering of the altitudinal limits of the vegetation zones and to their subsequent southward extension. Indeed the presence of *Pistacia* and *Amygdalus* and even some of the gallery forest species, such as *Fraxinus* and *Platanus*, which are absent today, may be a sign of lower-altitude vegetation zones.

If past climates permitted a more southerly distribution of wild cereals, how important a factor was soil tolerance? Wild rye is rarely found growing on soils that aren't volcanic, while the

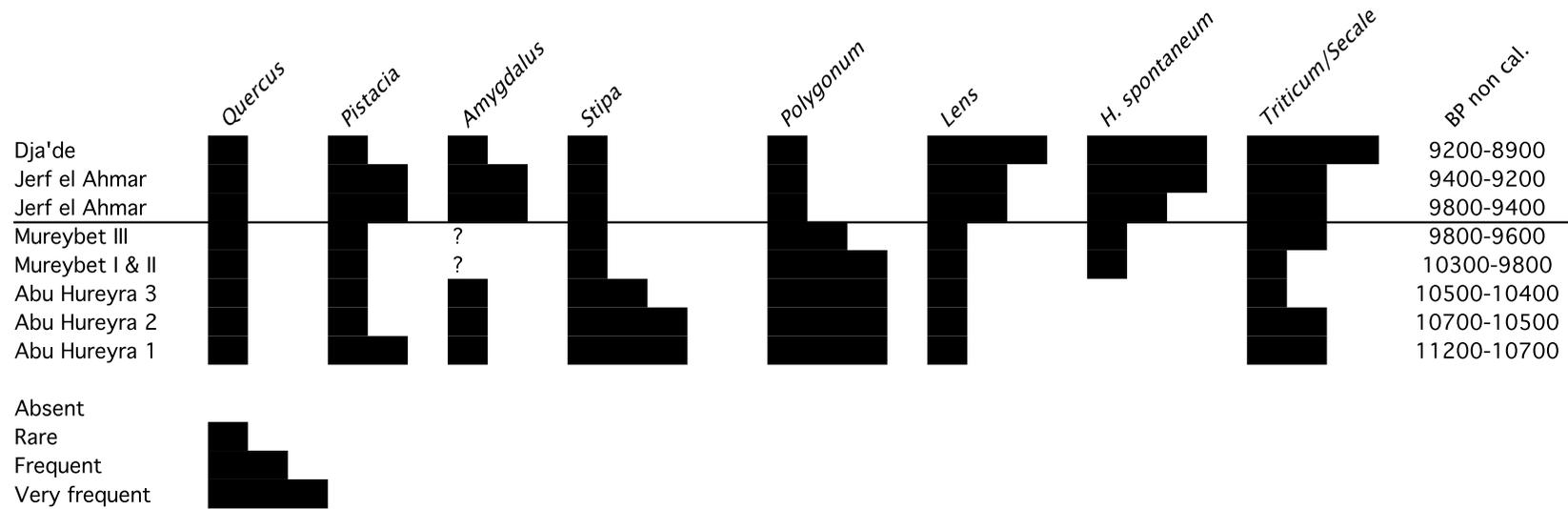


Figure 2.3: Presence/absence and estimated relative frequencies of selected taxa. Information derived from charcoal and charred fruits and seeds. Estimated relative frequencies were based on ubiquity for Jerf el Ahmar and Dja'de where sample numbers were high, thus: rare=present <20% of samples, frequent=present in >20% of samples and very frequent = present in >80% samples. For Abu Hureyra, where sample numbers were low, frequencies were based on Hillman's estimates (see Figure 12.7 Hillman 2000) and for Mureybet estimates were based on absolute counts (van Zeist and Bakker-Heeres 1986). Frequencies for the three tree species were based on fruit and charcoal identifications. Note that *Pistacia* persists throughout the sequence. *Stipa* and *Polygonum* tend to diminish while *Lens* increases. The major change occurs at the beginning of the Holocene (marked with horizontal line) and may coincide with increasing use of cultivation.

two wheat species do not tolerate calcareous soils but may be found on deep, decalcified terra rossa soils that occur in hard limestone areas (these are rare in the middle Euphrates region). Given the cooler conditions and a more southerly distribution of vegetation zones, the nearest potential habitat for wild rye may have been at Qara Perguel Dah, which is situated on the left bank of the Euphrates about 15 km south of the Turkish border. This basalt massif, rising to 694 metres, is a likely habitat for late Pleistocene stands of wild rye and wild einkorn. Further south, between Dja'dé and Jerf el Ahmar there is a small basalt lava flow near the village of Serine and this might also have been a favourable, if more restricted, location. In general the Pliocene chalks that cover most of the area give rise to very thin poor soils with high salt levels, and so it is highly improbable that they would have been suitable habitats for wild wheat or wild rye, and neither would the river terraces because of their limited surface area and regular inundation. This leads us to the inevitable conclusion that the cereals used at the Natufian sites of Mureybet and Abu Hureyra may not have been growing locally, which is why researchers such as van Zeist and Bakker-Heeres (1986), Cauvin (1994), Salamini (2000) and Willcox (2002c) have suggested it is likely that they were imported or introduced from further north. Trace element analysis is also being carried out to investigate whether rye was growing on volcanic soils to the north; at the time of writing, preliminary results show a marked difference in trace elements between barley and *Triticum/Secale*, which suggests they may have been growing under different edaphic conditions. However, before making conclusion we are awaiting further results.

2.3 Materials and methods

The data set available for the six cereal taxa from the area is given in table 2.2. Charred material was collected at the sites using standard flotation techniques (the number of samples and volume of sediment are also shown in table 2.2). Final reports have not yet been published for Halula, Dja'dé and Jerf el Ahmar but a sufficient number of samples have been examined for the purposes of this study.

Presence/absence of taxa is the most reliable indicator because frequencies may be biased by sampling methods and the presence of storage structures. The total number of individual identifications for all samples combined is given in table 2.2. Absence is considered to be real in the cases where the cells with zeros are in bold text, and this interpretation is justified given the large-scale sampling that these sites underwent. The presence/absence scores and frequencies show a coherent pattern from period to period that adds weight to the reliability of the data.

2.4 Results

2.4.1 Rye

Wild rye has been identified at the two Natufian sites of Mureybet and Abu Hureyra. The grains of wild rye and wild two-grained einkorn are difficult to distinguish from each other, however, evidence from spikelet bases suggests that rye was dominant during this period at Mureybet (figures 2.4 and 2.5) (Willcox and Fornite 1999). No spikelet bases were found at Abu Hureyra. Wild ryes may have had a more extensive distribution during both the last glacial period and the Younger Dryas, but the middle Euphrates with its dry chalk hills would have been an unlikely habitat even in the cooler conditions. Rye continues to be found in this area up to the early Holocene at Jerf el Ahmar, where spikelet bases are common in the early levels, but they become progressively less frequent in the later levels (Willcox and Fornite 1999; Willcox 2004) before disappearing altogether.

Taxon	Abu Hureyra 1	Mureybet I and II	Mureybet III	Jerf al Ahmar	Göbekli	Dja'dé	Nevalı Çori	Halula
Einkorn 2 grained/ <i>Secale</i> grains	>5000	19	>2000	2539	5	1120	0	0
<i>Triticum boeoticum/urartu</i> spikelet bases	0	0	0	5	0	9	P	0
<i>Secale</i> sp. spikelet bases	0	p	p	145	0	16	0	0
<i>Hordeum spontaneum/sativum</i> grains	0	5	164	9461	16	3763	89	151
<i>Hordeum spontaneum/sativum</i> rachis	0	0	6	3326	0	152	P	p
Einkorn 1 grained	0	0	0	67	0	265	661	P
<i>Triticum dicocum/dicoccoides</i> grains	0	0	0	0	0	191	129	47
Naked wheat grains	0	0	0	0	0	0	0	23
Total volume of sediment in litres	>10000	c.310	c.310	16600		>6000		>200
Number of samples	21	31	31	430	1	>225	267	>20

Table 2.2: Data from charred cereal remains from seven sites in the Euphrates region. The number of cereal taxa increases progressively with time (from left, Natufian through Khamian, PPNA, early PPNB to middle PPNB). This change is interpreted as due to increasing use of cultivation which may have resulted in the appearance of taxa previously absent such as barley, one-grained einkorn, emmer and finally, naked wheat. The bold 0 represents genuine absence; the 0 may not represent true absence and could result from shortcomings of sampling techniques.

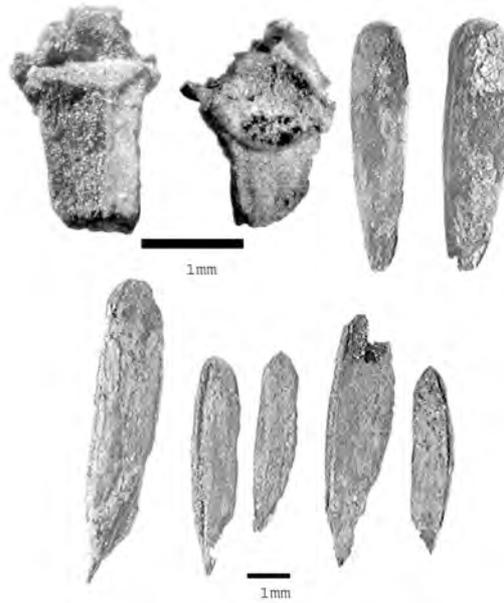


Figure 2.4: Digital photographs of (above) spikelet bases of rye and grains recovered from Jerf al Ahmar, and (below) rye grains recovered from pisé at Mureybet, which were associated with spikelet fragments shown in figure 2.5. I have included these photos because agronomists have questioned the presence of rye in this area on ecological grounds.

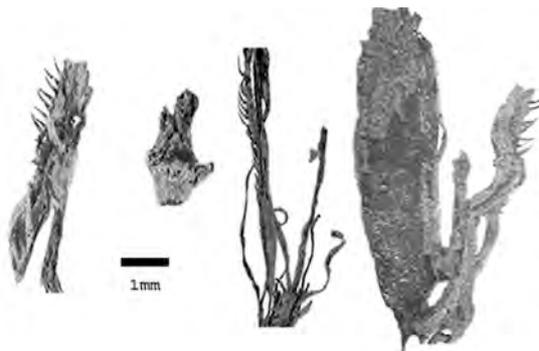


Figure 2.5: Digital photos of rye spikelets recovered from the pisé at PPNA Mureybet. These exceptionally fragile remains were preserved in building-earth that was baked when one of the houses was destroyed by fire.

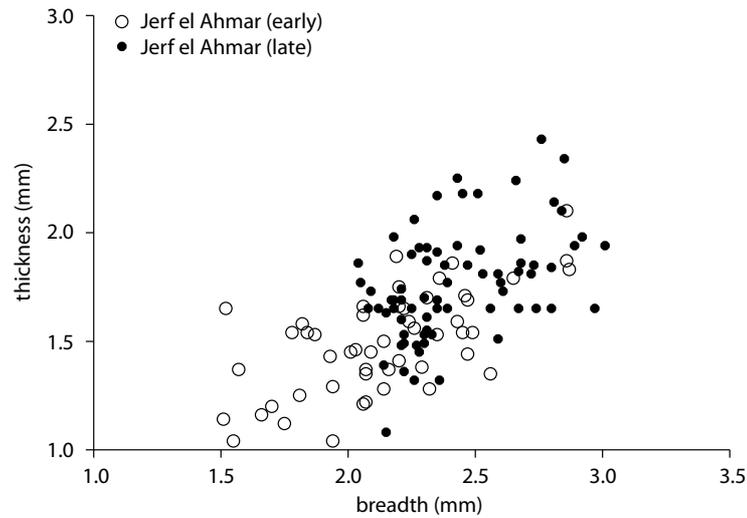


Figure 2.6: Scatter diagram of measurements taken from barley grains (*Hordeum spontaneum*) at Jerf el Ahmar, which show an increase in size between early and late levels. This may not be the result of domestication since rachis fragments are of the wild type, but cultivation using optimum growing conditions may have produced better-formed grains. Another explanation is the introduction of large-grained varieties. Some of the smallest grains may come from *Hordeum murinum* complex or *Hordeum bulbosum*.

2.4.2 Two-grained einkorn

The two species of two-grained einkorn (i.e., *Triticum urartu* and *Triticum boeoticum thaoudar*) cannot be distinguished if found in charred remains and their grains are difficult to differentiate from those of wild rye, although the latter are generally smaller. Two-grained einkorn was identified at Natufian Abu Hureyra and Mureybet from charred grains; at Jerf el Ahmar, where spikelet bases and grains appear to become common only in the upper levels; at Dj'adé, where spikelet bases are relatively more frequent than grains; and possibly at Nevalı Çori and Halula in small quantities.

2.4.3 Single-grained einkorn

The only site in our area where single-grained einkorn is dominant is Nevalı Çori. This sub-species (*Triticum boeoticum aegilopoides*) requires more rainfall than the other einkorn species, and so it is not surprising to find that it occurs only at the most northerly site where rainfall is higher. Both *Triticum urartu* and *Triticum boeoticum thaoudar* occasionally produce spikelets with one grain, thus it is only when the majority of the einkorn grains in an assemblage have a strongly convex ventral face that the single grained sub-species can be identified with certainty.

2.4.4 Barley

Wild barley (*Hordeum spontaneum*) is absent at Abu Hureyra and rare at Mureybet during the Natufian. It becomes progressively more frequent during the mid to late 10th millennium cal BC at Mureybet and Jerf el Ahmar, and is the dominant cereal at Dj'adé and Halula. An increase in grain size has been recorded at Jerf el Ahmar (figure 2.6), which is similar to the size changes noted at other sites in the Levant by Colledge (2001). This increase is probably due to the effects of cultivation but is not necessarily a consequence of the domestication process. During the 8th

millennium cal BC domestic two-rowed barley is the most common cereal at middle PPNB sites (as for example at Halula). Wild barley is the only wild cereal that today extends well into Syria (see above) and domestic barley is the only dry-farming cereal in this area, i.e., in the Euphrates valley. Further north in Anatolia at Nevalı Çori, barley is less common than wheat and this regional trend is confirmed by the results from Cafer Hüyük and Çayönü (van Zeist and de Roller 1994; de Moulines 1997).

2.4.5 Emmer

Emmer is absent from Natufian sites and from Jerf el Ahmar; it appears for the first time on the Syrian sites at Dja'dé and is present at Nevalı Çori. Four grains were found among the thousands of other cereal grains at Jerf el Ahmar, while at Dja'dé emmer is more frequent albeit still rare. Emmer is also present at Nevalı Çori. On middle PPNB sites on the Euphrates, for example at Halula, domestic emmer is the most common wheat.

2.4.6 Naked wheat

This wheat, found only as a domesticate, appears for the first time during the 8th millennium cal BC at the middle PPNB sites of Halula and Abu Hureyra.

2.4.7 Morphological signs of domestication

A few plump rye grains from Abu Hureyra have been identified as domestic (Hillman et al. 2001), however, the vast majority of grains are of the wild type and no spikelet material was recovered. At Mureybet only wild rye, einkorn and barley have been found and, similarly, at Jerf el Ahmar all spikelet remains were identified as wild types. Grain size was measured for einkorn/rye and for barley and an increase between the early and late levels was observed at Jerf el Ahmar (figure 2.6); this increase in size is not necessarily due to changes in morphology that are the result of domestication (Willcox 2004), but may merely be a consequence of cultivation under optimum growing conditions. The introduction to the site of large grained varieties is an alternative but less plausible hypothesis. The earliest incontestable evidence for morphological domestication on the Euphrates sites at the time of writing is demonstrated by the rough abscission scars occurring on einkorn spikelet bases recovered from Nevalı Çori, dated to end of the mid-9th millennium cal BC. The solid rachises of barley and semi-solid rachises of emmer, and naked wheat dated to the early 8th millennium cal BC at Halula, are clear signs of domestication.

2.5 Sickle blades, querns and harvesting techniques

Glossed flint sickle blades and querns are present from the Natufian levels at Abu Hureyra and Mureybet but are rare (M.-C. Cauvin, pers. com.). By the mid-10th millennium (that is, on PPNA sites) there is a significant increase in both size and numbers of the glossed flint blades. The use of sickles for harvesting was also suggested by the presence of basal spikelets which occurred among the archaeobotanical remains. At Jerf el Ahmar and Dja'dé future work on grain size, wild/weed assemblages and the chaff remains may give us more insight into the evolution of harvesting techniques. The apparent absence of chaff on the Natufian sites and the abundance at Jerf el Ahmar may well be linked to different methods of harvesting and/or crop processing.

2.6 Conclusions

The questions most frequently asked concerning the origins of farming are how and where were cereals first taken into cultivation. The explanation frequently expounded over the last fifteen years (Moore and Hillman 1992; Bar-Yosef and Belfer-Cohen 2002) is that diminishing wild cereal resources during the Younger Dryas climatic deterioration (10700–9600 cal BC) favoured the adoption of cultivation by hunter/gatherers in core areas. Within these areas the cultivation of wild cereals led to rapid domestication and subsequent diffusion of better adapted cultivars. In the light of recent evidence from across the Near East this explanation appears too simplistic. It is now clear that agriculture developed very gradually among societies dispersed over a wide region with diverse climatic and environmental conditions. Depending on the specific area, a different set of local cereals was taken into cultivation quite independently. This leads us to the conclusion that the process by which societies abandoned gathering in favour of cultivation may have varied from one region to another.

The Syrian Euphrates sites appear to have been situated outside the areas of natural distribution of the wild progenitors of rye and probably also the wheats. Finds of emmer at Zad 2 (Edwards et al. 2001) in the lower Jordan valley are an example from the southern Levant, but in this case the distance from potential wild habitats is far less than that for the sites along the Euphrates. It would appear, therefore, that cereals were transported down the Euphrates valley into areas where they could not have grown naturally because of unsuitable edaphic and climatic conditions. The appearance in the archaeobotanical record of barley, which was well-adapted to local conditions, may mark the point when the inhabitants started to rely on resources in the immediate vicinity of their sites and this may coincide with greater reliance on cultivation. Cultivation of the less well-adapted wheats could have taken place in favourable micro-habitats.

By examining the presence and, to some extent, the frequencies of the six cereal taxa on sites within the Euphrates valley over a period of some 3,500 years we can attempt to trace the developments that turned simple gatherers into fully-fledged cultivators. But we must accept that given the time span involved and the coverage of samples, clearly what we are left with is a very discontinuous chronological sequence from a few widely dispersed sites. The cereal remains alone provide a one-sided picture of the sequence of events, however, if we combine the archaeobotanical and archaeological data certain patterns emerge. Figure 2.7 gives a schematic representation of how cereals came into and went out of use in the Euphrates valley and also how this relates to the periods during which the different sites were occupied.

The earliest inhabitants of Abu Hureyra were undoubtedly gatherers. In the summer they relied on seeds collected from the flood plain and in the late spring they gathered cereals, mainly rye, from wild stands, possibly at some considerable distance to the north. There was global climatic change during the occupation of the site. We do not know how this area of the Near East was affected, but it is probable that the eastern Mediterranean coast with the elevated coastal range provided a buffer zone, which may have moderated the worsening conditions in the interior. The persistence of *Pistacia atlantica* throughout the Younger Dryas in the Euphrates basin would appear to be evidence of this (figure 2.3). The first two phases at Mureybet show remarkable similarities with Abu Hureyra; however, the assemblages differ in that at the former site barley is present (but rare) and *Stipa* is absent. Both sites have sickle blades and querns.

At the beginning of the Holocene (that is, during the PPNA), data from both Mureybet phase III and Jerf el Ahmar show an increase in barley, lentils and in some of the weed taxa (Colledge 1998), but a decrease in grains gathered from the flood plain (for example, *Polygonum* [figure 2.3], and also *Scirpus*). These changes coincide with an increase in the number of sickle blades, saddle querns, storage structures and the appearance of more uniform well-developed cereal grains. These combined changes appear to be the first indication of cultivation, yet there are no morphological signs of domestication, perhaps because gathering continued alongside cultivation

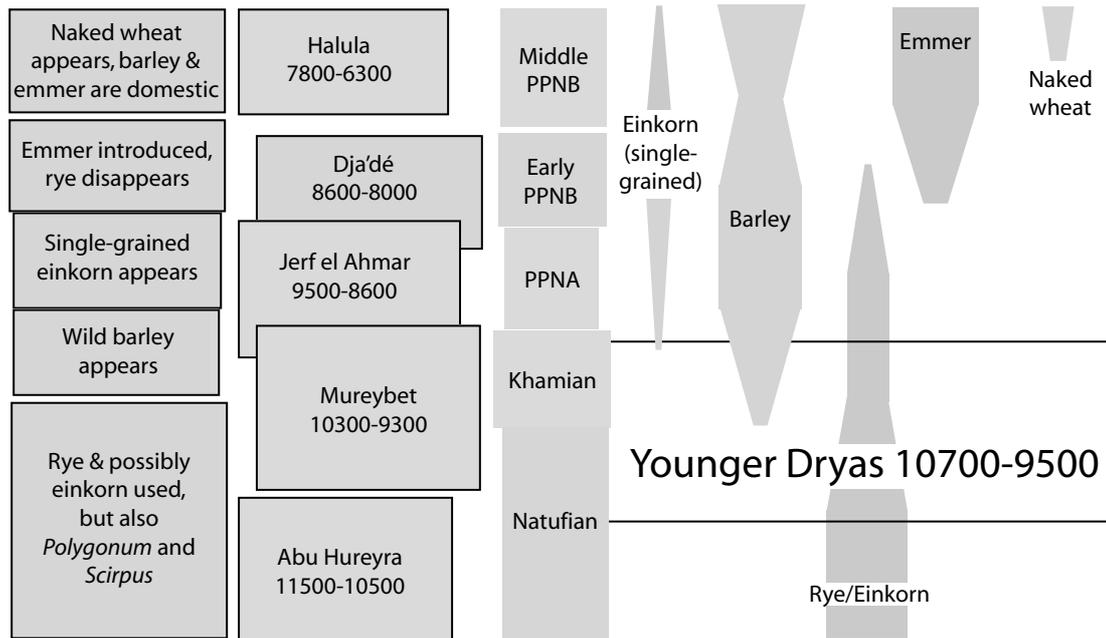


Figure 2.7: A schematic diagram giving changes in cereal use during a 3,500 year period at sites on the Syrian Euphrates (dates cal BC). Barley, emmer and naked wheat are absent from the earliest levels, and then increase to become the dominant cereal crops at the expense of einkorn and rye, which were progressively abandoned.

and reduced the probability of a domestic population becoming established. There may well have been cultivation before this date, which did not leave any detectable signs in the archaeobotanical record, however, the evidence does indicate that there was increasing management of crops. This is exactly at the point when we see the onset of more stable conditions, which were more favourable for growing cereals than the unstable conditions of the Younger Dryas.

During the 10th millennium at Jerf el Ahmar, the frequency of barley increases progressively, while that of rye and einkorn decreases. There is an increase in size of barley grains (figure 2.6) and possibly also einkorn grains, which is considered to be yet another indication of cultivation but not necessarily of domestication (Willcox 2004). Emmer is introduced at Dja'dé during the early part of the 9th millennium cal BC (figure 2.7), whereas the situation at this time further north is different and at Nevalı Çori, which is well within the natural habitat of einkorn, single-grained einkorn was dominant. Another important difference is that there is the first appearance of spikelet bases with rough abscission scars characteristic of the domestic species. Barley and emmer were also present but at low frequencies.

There is a significant development in architectural styles towards a more complex architecture from the 12th millennium to the end of the 10th millennium cal BC, for example, from the small pit dwellings at Abu Hureyra to the monumental structures at Nevalı Çori, together with a progressive increase in the surface area of each site (Molist and Stordeur 1999). These developments culminate during the first half of the 8th millennium cal BC with the standardized dwellings, as shown by eight excavated houses which have identical plans at Halula (M. Molist pers. com. 2004)—a site which, like the contemporary levels at Abu Hureyra, covers several hectares. At these sites there were domestic species of cereals (including naked wheat), sheep, goats and cattle. Although we cannot estimate the number of inhabitants at these sites we can

safely assume that there was a population explosion during the first half of the 8th millennium cal BC and it seems reasonable to postulate that gathering must have become a very minor activity, and that these societies were completely dependent on production farming for their subsistence.

Acknowledgments

My thanks go first to Gordon Hillman, friend and colleague, whose enthusiasm, knowledge and immense contribution to Near Eastern archaeobotany helped make this article possible. My thanks also to the many French and Syrian colleagues who made my studies at Jerf el Ahmar and Dja'dé possible, in particular Linda Herveux and Sandra Fornite, who are working with me on the charred plant remains, and to the European Commission who contributed financial support under contract ICA3-CT-2002-10022. Last but not least, my thanks to Sue Colledge and James Conolly for making many helpful suggestions to the first draft of this article and for a most rewarding conference.

References

- Badr, A., K. Müller, R. Schäfer-Pregl, H. El Rabey, S. Effgen, H. H. Ibrahim, C. Pozzi, W. Rohde, and F. Salamini (2000). On the origin and domestication history of barley (*Hordeum vulgare*). *Molecular Biology and Evolution* 17, 499–510.
- Bar-Yosef, O. and A. Belfer-Cohen (2002). Facing environmental crisis. societal and cultural changes at the transition from the Younger Dryas to the Holocene. In R. T. J. Cappers and S. Bottema (Eds.), *The Dawn of Farming in the Near East*, Studies in Near Eastern Production, Subsistence and Environment 6, pp. 55–66. Berlin: Ex oriente.
- Baruch, U. and S. Bottema (1999). A new pollen diagram from Lake Hula. In H. Kawanabe, G. W. Coulter, and A. C. Roosevelt (Eds.), *Ancient Lakes: Their Cultural and Biological Diversity*, pp. 75–86. Ghent, Belgium: Kenobi Productions.
- Blumler, M. A. (2002). Changing paradigms, wild cereal ecology, and agricultural origins. In R. T. J. Cappers and S. Bottema (Eds.), *The Dawn of Farming in the Near East*, pp. 95–111. Berlin: Ex oriente.
- Bottema, S. (1995). The Younger Dryas in the eastern Mediterranean. *Quaternary Science Reviews* 14, 883–891.
- Bottema, S. (2002). The use of palynology in tracing early agriculture. In R. T. J. Cappers and S. Bottema (Eds.), *The Dawn of Farming in the Near East*, Studies in Near Eastern Production, Subsistence and Environment 6, pp. 27–38. Berlin: Ex oriente.
- Cauvin, J. (1994). *Naissance des Divinités, Naissance de l'Agriculture: La Révolution des Symboles au Néolithique*. Paris: C.N.R.S.
- Colledge, S. (1998). Identifying pre-domestic cultivation using multivariate analysis. In A. Damaia, J. Valkoun, G. Willcox, and C. Qualset (Eds.), *The Origins of Agriculture and Crop Domestication*, pp. 121–131. Aleppo, Syria: ICARDA.
- Colledge, S. (2001). *Plant Exploitation on Epipalaeolithic and Early Neolithic Sites in the Levant*. BAR International Series 986. Oxford: John and Erica Hedges Ltd.

- de Moulins, D. (1997). *Agricultural Changes at Euphrates and Steppe Sites in the Mid-8th to the 6th Millennium B.C.* Oxford: British Archaeological Reports.
- Edwards, P., S. Falconer, P. Fall, I. Berelov, C. Davies, J. Meadows, C. Meegan, M. Metzger, and G. Sayej (2001). Archaeology and environment of the Dead Sea Plain: preliminary results of the first season of investigations by the joint La Trobe University/Arizona State University project. *Annual of the Department of Antiquities of Jordan* 45, 135–157.
- Helmer, D., V. Roitel, M. Sana, and G. Willcox (1998). Interprétations environnementales des données archéozoologiques et archéobotaniques en Syrie du nord de 16000 bp à 7000 bp, et les débuts de la domestication des plantes et des animaux. *Bulletin of the Canadian Society for Mesopotamian Studies* 33, 9–34.
- Heun, M., R. Schäfer-Pregl, D. Klawan, R. Castagna, M. Accerbi, B. Borghi, and F. Salamini (1997). Site of einkorn wheat domestication identified by DNA fingerprinting. *Science* 278(5341), 1312–1314.
- Hillman, G., R. Hedges, A. Moore, S. Colledge, and P. Pettitt (2001). New evidence of Late Glacial cereal cultivation at Abu Hureyra on the Euphrates. *Holocene* 11(4), 383–393.
- Hillman, G. C. (2000). Plant food economy of Abu Hureyra. In A. M. T. Moore, G. C. Hillman, and T. Legge (Eds.), *Village on the Euphrates: From Foraging to Farming at Abu Hureyra*, pp. 372–392. Oxford: Oxford University Press.
- Ishtii, T., N. Mori, and Y. Ogihara (2001). Evaluation of allelic diversity at chloroplast microsatellite loci among common wheat and its ancestral species. *Theoretical and Applied Genetics* 103, 896–904.
- Molist, M. and D. Stordeur (1999). Le moyen Euphrate Syrien et son rôle dans la neolithisation: spécificité et évolution des architectures. In G. del Olmo Lete and J.-L. Montero Fenollos (Eds.), *Archaeology of the Upper Syrian Euphrates in the Tishrin Dam Area*, pp. 395–412. Barcelona: AUSA.
- Moore, A. M. T. and G. C. Hillman (1992). The Pleistocene to Holocene transition and human economy in Southwest Asia: the impact of the Younger Dryas. *American Antiquity* 57, 482–494.
- Moore, A. M. T., G. C. Hillman, and T. Legge (2000). *Village on the Euphrates. From Foraging to Farming at Abu Hureyra*. Oxford: Oxford University Press.
- Neef, R. (2003). Overlooking the steppe forest: preliminary report on the botanical remains from early neolithic Göbekli Tepe (southern Turkey). *Neolithics* 2, 13–15.
- Özkan, H., A. Brandolini, R. Schäfer-Pregl, and F. Salamini (2002). AFLP analysis of a collection of tetraploid wheats indicates the origin of emmer and hard wheat domestication in southeast Turkey. *Molecular Biology and Evolution* 19, 1797–1801.
- Pasternak, R. (1998). Investigations of botanical remains from Nevalı Çori PPNB, Turkey. In A. Damania, J. Valkoun, G. Willcox, and C. Qualse (Eds.), *The Origins of Agriculture and Crop Domestication*, pp. 170–177. Syria: Aleppo.
- Roitel, V. and G. Willcox (2000). Analysis of charcoal from Abu Hureyra. In A. M. T. Moore, G. C. Hillman, and T. Legge (Eds.), *Village on the Euphrates: From Foraging to Farming at Abu Hureyra*, pp. 544–547. Oxford: Oxford University Press.
- Salamini, F. (2000). La première céréale cultivée. *Pour la Science* 274, 58–63.

- Salamini, F., A. B. H. Özkan, R. Schäfer-Pregl, and W. Martin (2002). Genetics and geography of wild cereal domestication in the near east. *Nature Reviews Genetics* 3, 429–441.
- Stordeur, D. (2000). Jerf el Ahmar et l'émergence du néolithique au Proche Orient. In J. Guilaine (Ed.), *Premiers Paysans du Monde: Naissance des Agricultures*, pp. 33–60. Paris: Errance.
- Tanno, K., S. Takeda, K. Takeda, and T. Komatsuda (2002). A DNA marker closely linked to the *vrs 1* locus (row-type gene) indicates multiple origins of six-rowed cultivated barley (*Hordeum vulgare* L.). *Theoretical and Applied Genetics* 104, 54–60.
- Thuillet, A.-C., D. Bru, J. David, P. Roumet, S. Santoni, P. Sourdille, and T. Bataillon (2002). Direct estimation of mutation rate for 10 microsatellite loci in durum wheat, *Triticum turgidum* (L.) Thell. ssp durum desf. *Molecular Biology and Evolution* 19(1), 122–125.
- van Zeist, W. and J. Bakker-Heeres (1986). Archaeobotanical studies in the Levant 3. Late Palaeolithic Mureybet. *Palaeohistoria* 26, 171–199.
- van Zeist, W. and G. de Roller (1994). The plant husbandry of Aceramic Çayönü, E. Turkey. *Palaeohistoria* 33/34, 65–96.
- Willcox, G. (1996). Evidence for plant exploitation and vegetation history from three early neolithic pre-pottery sites on the Euphrates (Syria). *Vegetational history and archaeobotany* 5, 143–152.
- Willcox, G. (2002a). Charred plant remains from a late tenth millennium kitchen at Jerf el Ahmar (Syria). *Vegetational History and Archaeobotany* 11, 55–60.
- Willcox, G. (2002b). Evidence for ancient forest cover and deforestation from charcoal analysis of ten archaeological sites on the Euphrates. In S. Thiébaud (Ed.), *Charcoal Analysis: Methodological Approaches, Palaeoecological Results and Wood Uses. Proceedings of the Second International Meeting of Anthracology, Paris, September 2000*, BAR International Series 1063, pp. 141–145. Oxford: Archaeopress.
- Willcox, G. (2002c). Geographical variation in major cereal components and evidence for independent domestication events in western Asia. In R. T. J. Cappers and S. Bottema (Eds.), *The Dawn of Farming in the Near East*, Studies in Near Eastern Production, Subsistence and Environment 6, pp. 133–140. Berlin: Ex oriente.
- Willcox, G. (2004). Measuring grain size and identifying Near Eastern cereal domestication: evidence from the Euphrates valley. *Journal of Archaeological Science* 31, 145–150.
- Willcox, G. and S. Fornite (1999). Impressions of wild cereal chaff in pisé from the tenth millennium at Jerf el Ahmar and Mureybet: northern Syria. *Vegetational History and Archaeobotany* 8, 21–24.
- Willcox, G. and V. Roitel (1998). Rapport archéobotanique préliminaire de trois sites pré-céramiques du Moyen Euphrate (Syria). *Cahiers de l'Euphrate* 8, 65–84.
- Yasuda, Y., H. Kitagawa, and T. Nakagawa (2000). The earliest record of major anthropogenic deforestation in the Ghab valley, northwest Syria: a palynological study. *Quaternary International* 73/74, 127–136.