Archaeobotanical Evidence for the Beginnings of Agriculture in Southwest Asia

G. Willcox

Introduction

Over the past ten years much new evidence has to come to light which has enabled us to explain in more detail the transition from plant-gathering to plant production in Southwest Asia. It is now clear that this important change, which led ultimately to a significant increase in population, urbanism in Mesopotamia and Egypt, the civilizations of Greece and Rome and eventually industrialization, occurred gradually over a long period in a geographically wide area. Over 30 sites have provided a corpus of botanical evidence for the plants used during this period. These plant remains themselves have provided several hundred radiocarbon dates.

Archaeobotanical evidence indicates that the process of domestication may have been slow (Willcox 1995), and finds indicate that domestic and wild cereals occurred as mixtures on several early Neolithic sites over a period of at least a millennium (Table 1). Archaeobotanical finds and field studies show clearly that late Epipalaeolithic and early Neolithic distributions of wild cereals were much more extensive (Hillman 1996) and that the cereals collected differed on the various sites according to variations in local conditions which favored certain cereals (barley on poor dry soils, for example). These differences can be seen prior to and just after cultivation began. But once cultivation became systematic, favorable soils would have been chosen as would preferred crops. For example, emmer became more widespread at the expense of einkorn. Sites geographically separated with long sequences appear to show gradual evolution toward domestication, which may have occurred independently.

Methods

Archaeobotanical samples have been obtained from 35 sites (see Fig. 1) in southwestern Asia from the crucial period 20,000 to 8500 BP (non-calibrated). The quantity and quality of the archaeobotanical information vary considerably between sites. Because biological decomposition is rapid in the aerobic archaeological sediments of this area, archaeobotanists rely on plant materials which have been rendered stable through charring in hearths or other fires. These remains are recovered by flotation and sieving. Under the best circumstances large-scale flotation has obtained thousands of charred seeds, fruits and fragments of charcoal within the chronological framework of a site. At worst no sampling was carried out or only a few chance finds were collected. This makes comparisons between certain sites difficult.

Concerning the archaeobotanical criteria for morphological domestication and cultivation, not all archaeobotanists agree on the best criteria. The solid rachides in barley and naked wheats are clear indicators for archaeobotanists. However, the more primitive hulled wheats such as einkorn and emmer are more problematical. For the archaeobotanist the distinction between domestic and wild hulled wheats is based on the disarticulation scar left by the abscission layer. The break occurs in the same place on the rachis, and on domestic modern material it is rough or torn and on wild material it is smooth. However, with ancient carbonized remains the surface is very often too poorly preserved to allow this distinction.

Grain size is another criterion used, because domestic grains are generally more plump (van Zeist and Roller 1994). Plump barley grains, unknown in the wild, occur with fragile rachis fragments on a number of sites, e.g. at D'jade, Mureybit and Jerf el Ahmar. These are not considered to be evidence of domestication. However there is some reason to reconsider these finds in the light of modern semi-solid rachis barley which occurs in Syria. The author has collected specimens of semi-solid rachis, two-row 'black' barley near Bosra in southern Syria. The disarticulation scar is similar to that of wild barley, and the rachis fragments would be difficult to distinguish from wild types in carbonized material. This morphological type could explain why domestic-type grains occur with apparent wild-type rachis fragments.

As for evidence for cultivation, one might expect digging tools to provide the answer. However, for the moment this is not the case and it is possible that these tools were wooden and have not survived. Archaeobotanical research has concentrated on the presence of weed assemblages (Hillman *et al.* 1989; Colledge 1994). At present there are no solid results but sites with wild cereals are sometimes accompanied by an assemblage which resembles that of a weed flora. The most common taxa in these assemblages include the following: *Adonis, Aegilops, Astragalus, Avena, Bromus, Bupleurum, Camelina, Centaurea, Centranthus, Coronilla, Fumaria, Galium, Glaucium, Hordeum, Lathyrus, Lithospernum, Lolium, Malva, Papaver, Polygonum, Reseda, Silene, Valerianella* and *Vicia*. It is difficult to be sure that these taxa really represent a weed assemblage because these plants make up part of the original steppe flora, and identification at the species level is rarely possible. On the other hand, what one might expect is an increase in the frequency of these taxa at the expense of other steppe plants which were not preadapted to become part of the weed flora.

Archaeobotanical results

A summary of archaeobotanical results is given in Table 1. Several late Palaeolithic hunter-gatherer cultures have been recognized in Southwest Asia for the period 20,000-12,000 BP. Archaeobotanical evidence from this period is sparse because hunter-gatherers are mobile and thus archaeological deposits are superficial, which does not favor survival of carbonized plant remains. The early part of this period coincides with the glacial maximum in Europe. High-altitude pollen sites in Turkey and Iran indicate steppe conditions. Further south near the Mediterranean, conditions were more favorable. The earliest evidence for grain exploitation comes from widely separated sites: Ohalo II (Kislev *et al.* 1992) near the sea of Galilee, dated to 19,000 BP, is the earliest find (wild pulses, emmer and barley) and corresponds to the glacial maximum. Wild grasses were recovered from Wadi el-Jilat 6 (a little later in date) in the Jordan steppe. At Franchthi cave in Greece, dated to 12,500 BP, wild barley and pulses were found (Hansen 1991). These sites are all that has been found of what was probably a widespread phenomenon. It is probable that these hunter-gatherers roamed widely in the region. Wild cereals and pulses would have become more and more abundant during the late glacial climatic amelioration. Groundstone tools,

Table 1. *Presence of the major cereals, pulses and tree species from sites in the eastern Mediterranean (adapted from Nesbitt and Samuel 1996). There is considerable chronological overlap between sites, particularly for the later periods. Note that lentils are very frequent; domestication appears over a wide area during the last half of the 10th millennium BP. Oak is also well represented.*

Site	Date BP non-cal.	einkorn w†	emmer w†	barley w†	einkorn d†	emmer d†	naked wheat d†	barley 2r d†	barley 6r d†	*Aegilops* w†	lentil ?†	pea ?†	bitter vetch ?†	oak w†	almond w†	*Pistacia* w†	flax ?†	Reference
Ohalo II	19,000	-	O‡	O	-	-	-	-	-	-	O	-	-	A‡	O	O	-	Kislev *et al.* 1992
Franchthi	12,400-9000	-	-	O	-	-	-	-	-	-	O	O	O	-	O	O	-	Hansen 1991
Hayonim	12,300-11,900	-	-	O	-	-	-	-	-	-	O	-	O	-	-	-	-	Hopf and Bar Yosef 1987
Wadi Hammeh 27	12,200-11,900	-	-	O	-	-	-	-	-	-	O	-	-	W‡	-	O	-	Willcox 1991a; Colledge 1994
Abu Hureyra 1	11,000-10,000	O	-	O	-	-	-	-	-	-	O	-	O	W	W	O	-	Hillman *et al.* 1989
Hallan Çemi	10,600-9900	-	-	-	-	-	-	-	-	-	O	-	O	-	O	O	-	Rosenberg *et al.* 1995
Mureybit I-III	10,200-9500	O	-	O	-	-	-	-	-	-	O	-	-	W	-	O	-	van Zeist & Bakker-Heeres 1984
Qermez Dere	10,100-9700	-	-	O	-	-	-	-	-	-	O	-	O	-	-	O	-	Nesbitt 1995
Netiv Hagdud	10,000-9400	-	-	O	-	-	-	-	-	-	O	-	-	-	-	-	-	Bar-Yosef *et al.* 1991
Jerf el Ahmar	9800-9700	O	-	O	-	-	-	-	-	O	O	O	O	W	O	O	-	Willcox 1996
M'lefaat	9800-9600	?‡	-	O	-	-	-	-	-	O	O	-	O	-	-	O	-	Nesbitt 1995
Tell Aswad Ia	9700-9600	-	-	O	-	?	-	?	-	-	O	O	O	-	O	O	-	van Zeist & Bakker-Heeres 1984
D'jade	9600-9000	O	-	O	-	?	-	-	-	O	O	O	O	W	O	O	-	Willcox 1996
Cayönü mr	9500-9200	?	?	-	-	-	-	-	-	-	O	-	-	W	O	O	-	van Zeist and de Roller 1994
Jericho PPNA	9500-9000	-	-	?	?	?	-	?	-	-	O	-	-	-	O	O	-	Hopf 1983
Mureybit IV	9400-8500	O	-	O	-	-	-	-	-	-	O	-	-	W	-	O	-	van Zeist & Bakker-Heeres 1984
Cafer Höyük XIII-X	9400-9000	O	O	-	O	O	-	-	-	-	O	O	O	W	O	O	-	Willcox 1991c; de Moulins 1993
Tell Aswad Ib	9300-8800	-	-	O	-	O	-	?	-	-	O	O	-	-	-	O	-	van Zeist & Bakker-Heeres 1984
Cayönü gp bp ch	9200-8500	O	O	?	O	O	-	?	-	-	O	O	O	W	O	O	O	van Zeist and de Roller 1994
Nevali Cori	9200	-	-	?	O	-	-	-	-	O	O	O	O	-	O	O	-	Pasternak 1995
Ain Ghazal	9000-8500	-	-	-	-	O	-	O	-	-	O	O	-	W	-	O	O	Rollefson *et al.* 1985
Jericho PPNB	9000-8500	-	-	O	O	O	-	O	-	-	O	O	-	-	-	-	O	Hopf 1983
Cafer Höyük IX-VI	9000-8400	O	-	-	-	O	-	-	-	-	O	-	-	W	W	O	-	de Moulins 1993
Nahal Hemar	9000-8200	-	-	-	-	O	-	O	-	-	O	-	-	A	O	O	-	Kislev 1988
Beidha	8900-8700	-	-	-	O	O	-	?	-	O	-	-	-	-	-	O	-	Helbaek 1966
Ganj Dareh	8900-8200	-	-	O	-	-	-	O	-	-	O	-	-	-	O	O	-	van Zeist *et al.* 1986
Ali Kosh BM	8800-8000	O	-	O	O	O	-	O	O	-	-	-	-	A	-	O	-	Helbaek 1969

Site	Date BP non-cal.	einkorn	emmer	barley	einkorn	emmer	naked wheat	barley 2r	barley 6r	*Aegilops*	lentil	pea	bitter vetch	oak	almond	*Pistacia*	flax	Reference
		w†	w†	w†	d†	d†	d†	d†	d†	w†	?†	?†	?†	w†	w†	w†	?†	
Jilat 7	8800-8400	O	-	O	O	O	-	-	O	-	-	-	O	-	-	O	-	Colledge 1994
Asikli	8800-8400	O	-	-	?	O	O	O	O	-	O	O	O	-	O	O	-	van Zeist and de Roller 1995
Abu Hureyra PPNB	8800-8000	O	-	O	O	O	O	O	-	O	O	-	-	W	W	O	-	de Moulins 1993
Tell Aswad II	8700-8400	O	-	O	O	O	O	O	-	-	O	O	-	-	-	O	O	van Zeist & Bakker-Heeres 1984
Ghoraifé I	8700-8100	-	-	O	-	O	O	O	-	-	O	O	-	-	-	O	O	van Zeist & Bakker-Heeres 1984
Abdul Hosein	8700-7500	-	-	-	-	O	-	O	-	-	O	-	-	-	W	O	-	Hubbard 1990; Willcox 1990
Halula	8700	?	O	O	-	O	O	O	-	O	O	O	O	W	-	O	O	Willcox 1996
Magzalia	8600-7800	-	-	O	-	O	O	O	-	O	O	-	-	-	-	-	-	Willcox, unpublished
Gritille	8500-7700	-	-	-	-	O	-	O	-	-	O	-	O	-	-	-	-	Voigt 1984
Can Hassan III	8500-7600	O	O	-	O	O	O	O	-	-	O	-	O	W	O	O	-	French *et al.* 1972
Jarmo	8500	O	O	O	O	O	-	O	-	-	O	-	-	W	-	O	-	Braidwood and Braidwood 1983

† **w**= wild, **d**= domestic, **?**= wild and/or domestic.

‡ O= present, ?= identification based on small number of poorly preserved finds, W= identification based on wood, A= acorn.

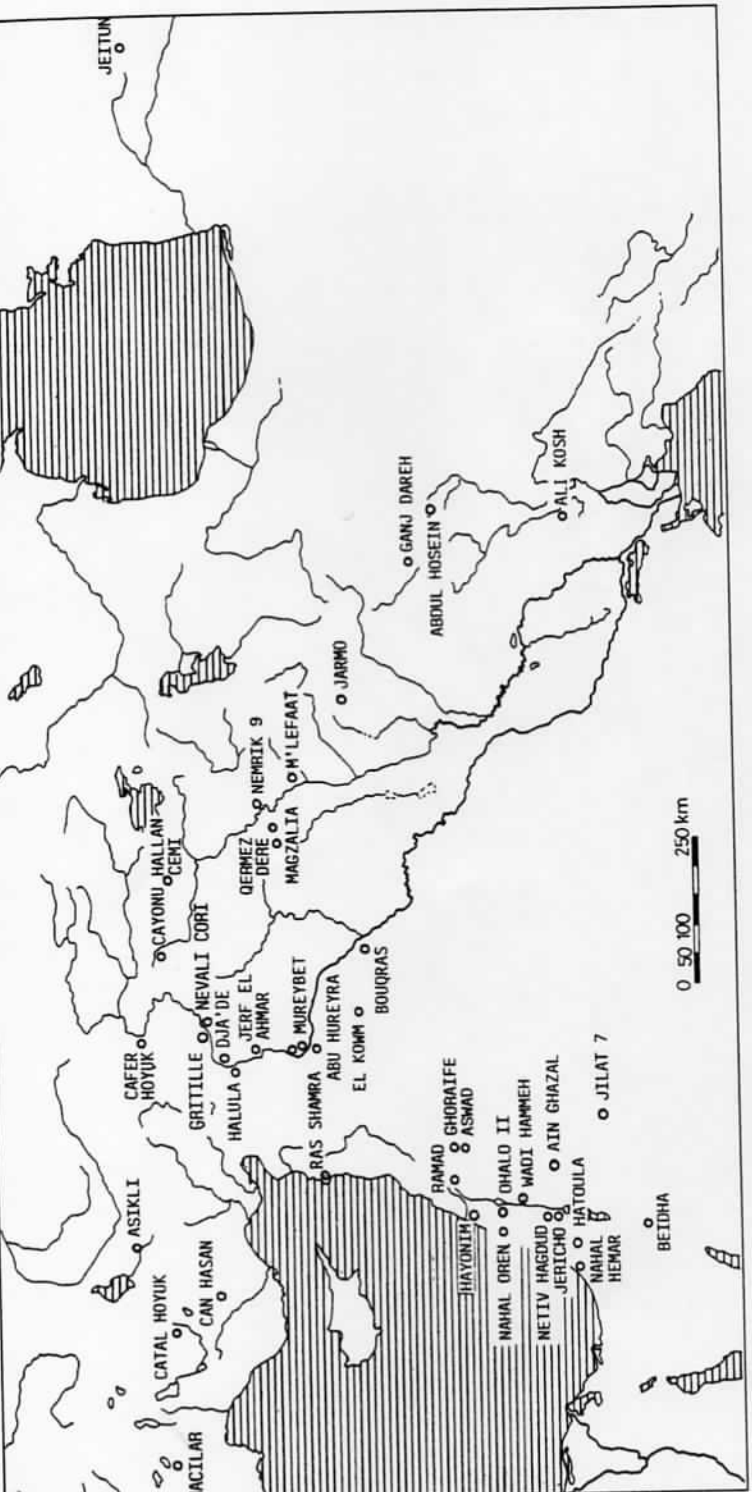

Fig. 1. Map showing the distribution of sites mentioned in the text.
The site of Franchthi cave in Greece is not included in the map for reasons of scale.

originally used perhaps for ochre, may have been adapted for cereal processing.

Food grains have the immense advantage that they can be stored. The wild grasses become ripe in late spring and promptly fall to the ground. They need to be harvested just before maturity. Given the dry climatic conditions, grains can be conserved or stored relatively easily. This facility for storage was one of the main advantages of seed-gathering which led to a more secure subsistence base and prepared the way for a sedentary way of life.

Increasingly favorable climatic conditions resulted in a rich environment for Early Natufian inhabitants of the western Mediterranean (12,000-11,000 BP). The climate appears to have been more favorable than at present or at any time since the Natufian. Archaeobotanical evidence indicates that the Syrian and Jordanian steppes had a much richer vegetation. This is indicated by the presence of forest steppe species, for example *Pistacia* and *Amygdalus*. Cultural factors such as an increased reliance on stored grain (although there is little archaeological evidence for this) permitted a sedentary existence, which is shown by the appearance of the first village sites consisting of what appear to be the first permanent dwellings. Sites such as Mureybit and Abu Hureyra on the Euphrates in Syria, Hayonim in Israel, Wadi Hammeh in Jordan, and a little later Qermez Dere, Nemrik 9 and M'lefaat in northern Iraq have round architecture, large hearths and groundstone equipment. On these sites the archaeobotanical evidence indicates that wild cereals were exploited together with a number of edible fruits and pulses (lentils occur on all sites). Charcoal and fruit remains indicate that these sites were situated within the forest/steppe with *Pistacia* and almond; in favorable conditions, deciduous oak was present. Archaeobotanical evidence clearly indicates that this vegetation penetrated further east into what is now arid steppe. This habitat provided wild cereals, pulses and an abundance of game. At sites where plant remains were not recovered, indirect evidence for the use of grasses comes from glossed flint tools indicating the harvesting of plants with high silica content at the Epipalaeolithic sites of Nahal Oren, Hatoula and Kebara in Israel and Beidha in Jordan (Anderson 1994, and pers. comm.).

It is clear that morphologically wild progenitors of Old World cereals and legumes were exploited for several millennia, before the appearance of their domestic counterparts. The geographical extent is impressive, stretching from northern Iraq to the southern Levant, Anatolia and even southeast Europe. During this period regional differences can be seen between Epipalaeolithic sites. Einkorn is dominant at Mureybit and Abu Hureyra, barley and some emmer are present at Ohalo II. Rye is also present at a number of these sites (Hillman *et al.* 1993), which indicates cooler climatic conditions.

During the Late Natufian there is wide evidence for climatic deterioration from about 11,000, usually referred to as the Younger Dryas (Baruch and Bottema 1991), which appears to have adversely affected settlements in the more arid zones of the Jordanian and Syrian steppe and the Negev highlands. With few exceptions, these sites were abandoned, and only sites situated near permanent water continued to be occupied into the next period.

During the following period, the Pre-Pottery Neolithic A (PPNA, 10,000-9600 BP), the climate became more favorable again. Charcoal evidence indicates that the Syrian steppe was at least partly wooded. But the sites continue to occur near reliable water sources. The architecture of small round houses is more substantial. Key sites are Jericho, Cayönü, Aswad, Mureybit, Jerf al Ahmar and Netiv Hagdud (Bar-Yosef *et al.* 1991). No unequivocal morphological evidence for domestication is forthcoming. For the very earliest levels at Aswad IA and Jericho, remains are numerically too meagre to be certain of domestication, but what is clear for this period is that the plant/crop assemblages vary remarkably between sites. Emmer is dominant at Aswad (van Zeist and Bakker-Heeres 1982), einkorn at Mureybit, barley at Jerf al Ahmar in northern Syria (Table 2). This suggests that the inhabitants of these sites were still gathering local cereals but this does not exclude small-scale cultivation as described by Harris (1996), using locally available wild cereals as seed stock. Lentils are common on most sites, even in the most arid zones. The controversial plump domestic-type barley grains (see Fig. 2) associated with wild-type rachis fragments occur during this period.

Sites such as Jericho, Cayönü, Mureybit, Abu Hureyra and Aswad which were established during this period or earlier show no clear-cut domestication in the lowest levels, but morphological domestication does appear at higher levels. These sites appear to have been occupied (probably continuously) over a very long period, more than a millennium. This would have led to degradation of the local vegetation within the catchment area of the site. Thus resource depletion could have been a contributing factor for the adoption of agriculture.

During the next chronological period (Early PPNB, 9600-9000 BP), architecture becomes rectangular and the transition is seen on a number of sites. Emmer domestication has been reported for sites such as Cafer Höyük and Cayönü in eastern Anatolia and for Aswad near Damascus (however, some researchers prefer to rely on the solid rachis in barley and the naked wheats as sure evidence for domestication, especially when sample size is small). At Aswad, between 9730 and 8560 BP (PPNA and Early PPNB), 26% of the barley rachis fragments are solid domestic types, but it is not clear whether they occur in the earliest levels. At D'jade (Willcox 1996) preliminary studies indicate that the cereals are not yet domesticated, but indirect evidence of weed associations strongly suggests the presence of cultivation, and similar assemblages are seen at Aswad, Cayönü and Cafer Höyük.

The Middle PPNB (9200-8600 BP) sites are more extensive, more frequent and cover a wider geographical area with expansion of agricultural communities into central Anatolia (Asikli Höyük) and Cyprus (Shillourokambos). Crop evolution and morphological domestication are clearly shown by the appearance of a solid rachis in barley and naked wheat, for example at Aswad West phase II (van Zeist and Bakker-Heeres 1982) and at Asikli (van Zeist and Roller 1995).

In the Euphrates Valley there is no evidence for *in situ* domestication unless we consider the plump barley grains from PPNA sites as domestic. Instead domesticates were introduced. Emmer absent in the area during earlier periods appears to have been introduced from elsewhere at Abu Hureyra and Halula together with a naked wheat (Willcox 1995, 1996). Flax was introduced at Halula.

At many sites during this period wild types remain at significant frequencies. We can see this at Cayönü, Cafer Höyük (wild wheats), Aswad, Ganj Dareh (wild barley), Halula and Azraq (wild wheats and barley) (Colledge 1994). These mixed finds can be interpreted in three ways: (1) as evidence of the exploitation of wild stands, (2) as unwanted weeds, and (3) as an integral part of the crop consisting of a mixture of wild and domestic cereals. The relatively high proportion of wild types

Table 2. Comparison of percentages of cereals at four PPNA sites. The differences indicate that the inhabitants were still using local cereals rather than introduced crops which start to appear in Middle PPNB.

	Jerf el Ahmar	Mureybit	Aswad Ia	Netiv Hagdud
Einkorn	15.8	96	0	0
Emmer	0	0	89.5	present
Barley	84.2	4	10.5	dominant

and the lack of pure finds of domesticates suggests that the wild plants may have been considered as a useful part of the crop, as opposed to unwanted weeds. This suggests cultivation of wild and domestic types together but does not exclude gathering from wild stands in a kind of mixed economy. Even during later periods (Late PPNB, 8600-8000 BP), for example at Ramad between 8210 and 7880 BP, domestic barley rachis fragments are only at 52%. A similar situation was noted at Magzalia. However at other contemporary sites such as Bouqras (van Zeist and van Waterbolk 1985) and Ras Shamra (phase Vc) wild types are rare or absent. These sites also contain naked wheat. During the Late PPNB, einkorn becomes a minor component and could be interpreted as a weed for most of the Near East. It reappears as a major component later at Jeitun in Central Asia (Harris *et al.* 1992) and at many sites in Europe.

Taking the data from the PPNA and the PPNB together, there is evidence for independent *in situ* cereal domestication at different sites. As we have seen, even sites in the same area had different cereal assemblages during the PPNA such as Jerf el Ahmar and Mureybit. The evidence from sites with long sequences such as Aswad, Mureybit, Cafer Höyük and Cayönü points to separate and distinct evolutionary trends. At Cayönü wild-type emmer grains are progressively replaced by domestic types (van Zeist and Roller 1995) and barley remains wild, whereas at Aswad and nearby Ghoraifé, as already mentioned, wild-type barley rachis internodes are replaced progressively by solid-type domestic rachis fragments (van Zeist and Bakker-Heeres 1982). The period of time necessary to recognize these changes appears to be about a millennium, that is to say between the early 10th and early 9th millennia. Other sites such as Mureybit show no evolutionary trends; however, taxa which are interpreted as weed assemblages at other sites are present. For example at Cayönü similar taxa are considered by van Zeist to be potential field weeds; these taxa also occur at other PPNA sites, suggesting predomestic agriculture.

Experimental results indicate that particular agricultural conditions are necessary for domestication to occur. As Hillman and Davies (1990) point out, both seed corn from the wild and that originating from fallen spikelets during the harvest must be kept apart, and in reality this is not easy. This could explain why significant mixtures occur over a period of at least a millennium and would appear to indicate that selective pressures stayed relatively low. If this interpretation is correct, then it follows that cultivation without domestication would have occurred for some considerable time prior to the appearance of the solid rachis. If this is indeed the case, then archaeobotanists need to look for indirect indicators. Hillman examined the possibility of identifying a weed assemblage from Epipalaeolithic Abu Hureyra (Hillman *et al.* 1989). His results were negative. Preliminary results from a later site, D'jade, on the Euphrates (Willcox 1996), look more promising.

Conclusions

Archaeobotanical evidence indicates that wild cereals were exploited in the Near East for several millennia before the appearance of domestic types. Specialized gathering and especially storage of cereals and pulses would have provided a secure subsistence base, making possible a sedentary existence. In the northern Levant it is not clear whether early 10th millennium cereals were domesticated. During the second half of the 10th millennium there is evidence of emmer domestication. However, a millennium after the appearance of domestication, wild types still persisted at frequencies which suggest they were part of the crop rather than unwanted weeds. Archaeobotanical and experimental evidence indicate that cereal cultivation of progenitors does not necessarily lead to rapid domestication and that gathering from the wild continued to be practised long after domestication. However, a number of scholars insist that domestication was a rapid process, suggesting that after the appearance of a given mutation the establishment of mutant lines could take place in a few years (McCorriston and Hole 1991; Zohary 1996). They therefore see the appearance of domestication as simultaneous with the beginnings of cultivation.

The area occupied by pre-Neolithic cereal gatherers is vast, which suggests the possibility that domestication could have occurred independently in different localities. Indeed genetic evidence points to at least two different origins for barley and according to Zohary, emmer and the pulses were taken into cultivation perhaps "once or at most only very few times" (Zohary 1996). However, still other varieties may have been taken into cultivation but subsequently died out or do not show up because of genetic modifications which have occurred over the last 10,000 years. As we have seen, the archaeobotanical evidence also indicates the possibility that the domestication process occurred independently at different sites.

The point at which people started to cultivate remains elusive, but small-scale or intermittent cultivation of pulses and perhaps cereals may have occurred over a long period (PPNA and earlier) without leading to domestication, as suggested by Kislev (1992). Not until large-scale cereal cultivation in the Middle PPNB do we see the appearance of domestic barley and naked wheat and the spread of emmer.

It would appear that the transition to a production economy was gradual, as there is no evidence for an abrupt change. During the period of transition there was little need for innovation in material culture. The tools for processing of gathered and cultivated cereals remain essentially the same. Storage, and storage structures, could be the same for both economic systems. During the late Epipalaeolithic one might consider the possibility that natural wild stands were to some extent managed to avoid overexploitation. Then occasional sowing was adopted. Inadvertent or accidental sowing around crop-processing areas during the collecting stage is inevitable and could hardly have been totally ignored. Later it would have become clear that sowing would be enhanced if the soil was worked, and it is possible that suitable tools already existed for other activities such as collecting earth for building or digging up roots and tubers.

Environmental change could have resulted from climatic change or human activities in the catchment area. This could have been a contributing factor in the transition from a subsistence system to a production economy in the Near East. The

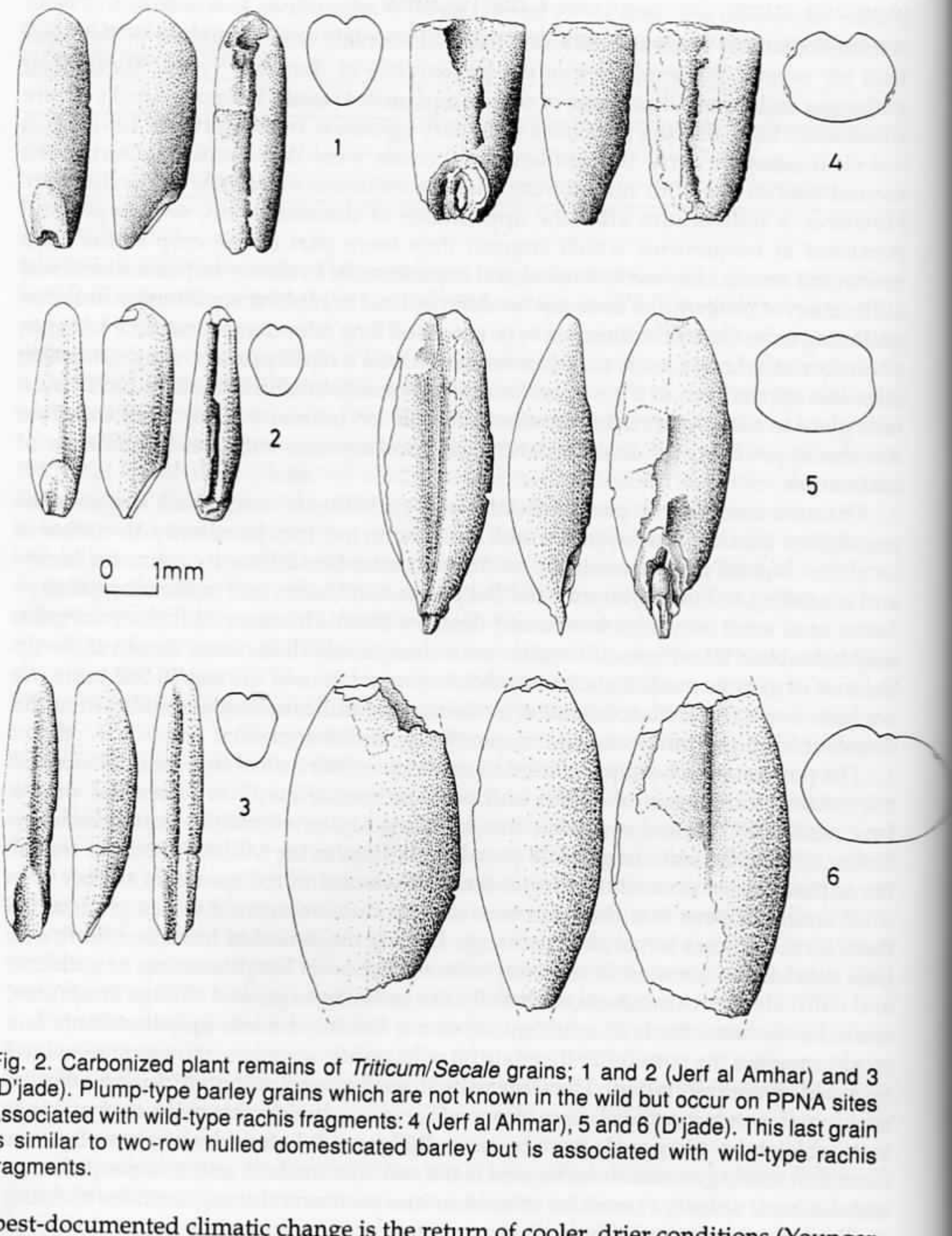

Fig. 2. Carbonized plant remains of *Triticum/Secale* grains; 1 and 2 (Jerf al Amhar) and 3 (D'jade). Plump-type barley grains which are not known in the wild but occur on PPNA sites associated with wild-type rachis fragments: 4 (Jerf al Ahmar), 5 and 6 (D'jade). This last grain is similar to two-row hulled domesticated barley but is associated with wild-type rachis fragments.

best-documented climatic change is the return of cooler, drier conditions (Younger Dryas) between 11,000 and 10,000 BP (Moore and Hillman 1992). Given the steep gradient in isohyets between the mediterranean vegetation zone and the interior steppe zone, even a small climatic change in the marginal areas would have a profound effect. This also means that populations could migrate in order to compensate for shifts in climate. Both major (Younger Dryas) and minor climatic episodes would have provided an impetus influencing communities to adapt in different ways. However, the evolution toward and the adaptation to a production economy with resulting domestication required certain preconditions. In other words it required a combination of complex circumstances leading to an evolutionary path which resulted in an economy dependent on cereal cultivation. On the one hand the plants already used by humans would have to have the right biological attributes (see Zohary 1996) and on the other, humans had to have prerequisite behavioral attributes. They would have to be sedentary gatherers of wild progenitors with a minimum village size and a storage system. A certain social organization could also have been a contributing factor. As pointed out by Cauvin (1994), humans would have to be culturally ready. Once all these conditions were fulfilled, small-scale farming could start and this would perhaps in certain circumstances develop into a full-scale farming economy (symbiosis). This would provide a subsistence system where production was guaranteed to supply demand (and/or surplus) in an expanding economy, ultimately leading to an irreversible process. We are not in a position to say whether cultural change played a more important role than environmental change. To assume that a single factor such as climatic change or a cultural attribute could have led to the adoption of plant husbandry is too simplistic.

One might speculate that the cultivation of pulses and cereals during the 11th and 10th millennia could have been an occasional option, but not necessarily systematically adopted. If occasional domesticates arose they may not have survived in the long term. Climatic change in some areas may have favored cultivation as opposed to gathering as wild resources became depleted. Ultimately social organization developed to a point where farming became more and more organized, leading to high selective pressures for domestic types. Archaeological evidence during the Middle PPNB indicates the simultaneous emergence of rectilinear architecture, considerable increase in village size, the consistent appearance of domesticated cereals and the domestication of sheep and goats. Could these changes be correlated with a more developed and organized sociocultural system which became increasingly reliant on a highly managed agricultural system? This could have coincided with the adoption of rectangular field systems. Ultimately the process led to irreversible domestication combined with a steep rise in population. It appears that these changes were gradual and occurred more or less simultaneously over a wide area, that is to say the Euphrates Valley, Eastern Anatolia, the southern Levant and the Zagros foothills. Differences in material culture over the area as a whole are slight and contact across the region between geographically widely separated populations has been shown to occur from finds of marine shells and obsidian, which were traded across vast distances. If the area as a whole went through the pre-domestic cultivation stage, then it is highly probable that domestication of the so-called founder crops occurred independently in different areas. However at some sites, for example at Mureybit, only wild cereals were exploited during the Middle PPNB, while at the majority of sites, for this period, domestic cereals were predominant.

Acknowledgments

I would like to express my appreciation and warm thanks to all members of the Antiquities Department of the Syrian Arab Republic who during my numerous visits to Syria gave me full backing and guidance. I would also like to thank J. Valkoun of ICARDA for showing me a large number of wild wheat populations in Syria, and J. Cauvin for his archaeological advice.

References

Anderson, P.C. 1994. Insights into plant harvesting and other activities at Hatoula, as revealed by microscopic functional analysis of selected chipped stone tools. Pages 277-293 *in* Le gisement de Hatoula en Judée occidentale, Israël (M. Lechevallier and A. Ronen, eds.). Memoires et travaux du centre de recherche Français de Jerusalem No. 8. Association Paléorient, Paris, France [in French].

Baruch, U. and S. Bottema. 1991. Palynological evidence for climatic changes in the Levant ca. 17,000-9,000 B.P. Pages 11-26 *in* The Natufian Culture in the Levant (O. Bar-Yosef and F.R. Valla, eds.). International Monographs in Prehistory, Archaeological Series 1. Ann Arbor, Michigan, USA.

Bar-Yosef, O., A. Gopher, E. Tchernov and M. Kislev. 1991. Nativ Hagdud: an Early Neolithic village site in the Jordan Valley. *J. Field Archaeol.* 18:405-426.

Braidwood, L. and R. Braidwood. 1983. Prehistoric archaeology along the hilly flanks. University of Chicago Oriental Institute Publications, vol. 103.

Cauvin, J. 1994. Naissance des divinités: Naissance de l'agriculture. CNRS Editions, Paris, France [in French].

Colledge, S.M. 1994. Plant Exploitation on Epipalaeolithic and Early Neolithic Sites in the Levant. PhD Thesis, University of Sheffield, UK.

French, D., G.C. Hillman, S. Payne and J.R. Payne. 1972. Excavations at Can Hassan III 1969-1970. Pages 181-190 *in* Papers in Economic Prehistory (E.S. Higgs, ed.). Cambridge University Press.

Hansen, J. 1991. Excavations at Franchthi cave, Greece. Fascicule 7. The Palaeoethnobotany. Indiana University Press, Bloomington, Indiana, USA.

Harris, D.R. 1996. The origins and spread of agriculture and pastoralism in Eurasia: an overview. Pages 552-574 *in* The Origins and Spread of Agriculture and Pastoralism in Eurasia (D.R. Harris, ed.). UCL Press, London, UK.

Harris, D.R., V.M. Masson, Y.E. Berezkin, M.P. Charles, C. Gosden, G.C. Hillman, A.K. Kasparov, G.F. Korobkova, K. Kurbansakhatov, A.J. Legge and S. Limbrey. 1992. Investigating early agriculture in Central Asia: new research at Jeitun, Turkmenistan. *Antiquity* 67: 324-38.

Helbaek, H. 1969. Plant collecting, dry-farming and irrigation agriculture in prehistoric Deh Luran. Pages 383-426 *in* Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan (F. Hole, K.V. Flannery and J.A. Neely, eds.). Memoirs Museum Anthropology No. 1. Ann Arbor, University of Michigan, USA.

Helbaek, H.H. 1996. Pre-Pottery Neolithic farming at Beidha. *Palestine Exploration Quarterly* 98:61-66.

Hillman, G. 1996. Late Pleistocene changes in wild plant-foods available to hunter-gatherers of the northern Fertile Crescent: Possible preludes to cereal cultivation. Pages 159-203 *in* The Origins and Spread of Agriculture and Pastoralism in Eurasia (D. Harris, ed.). UCL Press, London, UK.

Hillman, G. and S. Davies. 1990. Measured domestication rates in wild wheats and barley under primitive cultivation, and their archaeological implications. *J. World Prehistory* 42:157-219.

Hillman, G., S. Wales, F. McLaren, J. Evans and A. Butler. 1993. Identifying problematic remains of ancient plant foods : a comparison of the role of chemical, histological and morphological criteria. *World Archaeol.* 25:94-121.

Hillman, G.C. 1996. Late Pleistocene changes in wild plant-foods available to hunter-gatherers of the northern Fertile Crescent: possible preludes to cereal cultivation. Pages 159-203 *in* The Origins and Spread of Agriculture and Pastoralism in Eurasia (D.R. Harris, ed.). UCL Press, London, UK.

Hillman, G.C., S.M. Colledge and D.R. Harris. 1989. Plant-food economy during the Epipalaeolithic period at Tell Abu Hureyra, Syria: dietary diversity, seasonality, and modes of exploitation. Pages 240-268 *in* Foraging and Farming – The Evolution of Plant Exploitation (D.R. Harris and G.C. Hillman, eds.). Unwin Hyman, London, UK.

Hopf, M. 1983. The plants found at Jericho. Pages 580-621 *in* Excavations at Jericho. V (K.M. Kenyon and T.A. Holland, eds.). British School of Archaeology in Jerusalem, London, UK.

Hopf, M. and O. Bar-Yosef. 1987. Plant remains from Hayonim Cave, Western Galilee. *Paléorient* 13: 115-120.

Hubbard, R.N.L.B. 1990. Carbonised seeds from Tepe Abdul Hosein: results of preliminary analyses. Pages 217-221 *in* Tepe Abdul Hosein: A Neolithic site in Western Iran. Excavations 1978 (J. Pullar, ed.). BAR International Series 563.

Kislev, M.E. 1988. Nahal Hemar Cave, desiccated plant remains: an interim report. *Atiqot* 18:76-81

Kislev, M.E. 1989. Origins of the cultivation of *Lathyrus sativus* and *L. cicera* (Fabaceae). *Econ. Bot.* 43:262-270.

Kislev, M. 1992. Agriculture in the Near East in the VIIth millennium B.C. Pages 87-94 *in* Préhistoire de l'agriculture: nouvelles approches expérimentales et ethnographiques. Monographie du CRA No. 6, Centre de Recherches Archéologiques (P.C. Anderson, ed.). CNRS, Paris, France.

Kislev, M.E., D. Nadel and I. Carmi. 1992. Epipalaeolithic (19,000 BP) cereal and fruit diet at Ohalo II, Sea of Galilee. *Isr. Rev. Palaeobot. & Palynol.* 73:161-166.

McCorriston, J. and F. Hole. 1991. The ecology of seasonal stress and the origins of agriculture in the Near East. *Am. Anthropol.* 93(1):46-69.

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. *Am. Antiquity* 57:482-494.

Moulins, de D. 1993. Les restes de plantes carbonisées de Cafer Höyük. *Cahiers de l'Euphrate* 7:191-234.

Nesbitt, M. 1995. Clues to agricultural origins in the northern Fertile Crescent. *Diversity*: A news journal for the international genetic resources community 11(1&2):142-143.

Nesbitt, M. and D. Samuel. 1996. From staple crop to extinction? The archaeology and history of the hulled wheats. Pages 41-100 *in* Hulled Wheats. Promoting the Conservation and Use of Underutilized and Neglected Crops. 4. Proc. of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy (S. Padulosi, K. Hammer and J. Heller, eds.). IPGRI, Rome, Italy.

Pasternak, R. 1995. Die botanischen Funfe aus Nevali Cori, Türkei (Akeramisches Neolithikum) -Ein Vorbericht. *In* Res archaeobotanicae: International Workgroup for Palaeoethnobotany Proceedings of the ninth Symposium Kiel 1992 (H. Kroll and R. Pasternak, eds.)0 Herausgegeben von, Kiel.

Rollefson, G., A. Simmons, M. Donaldson, W. Gillespie, Z. Kafafi, I. Kohler-Rollefson, E. McAdam, S. Ralston and K. Tubb. 1985. Excavations at the pre-pottery Neolithic B village of 'Ain Ghazal (Jordan), 1983. *Mitteilugen der Deutschen Orient-Gesellschaft zu Berlin* 117:69-116.

Rosenberg, M., M. Nesbitt, R.W. Redding and T.F. Strasser. 1995. Hallen Cemi Tepesi: some preliminary observations concerning early Neolithic subsistence in eastern Anatolia.

Antolica 21:1-12.

Valkoun, J. 1992. Exploration mission for wild cereals in Syria. Pages 16-18 *in* Genetic Resources Unit Annual report for 1991. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.

van Zeist, W. and G.J. de Roller. 1994. The plant husbandry of Aceramic Çayonü, SE Turkey. *Palaeohistoria* 33/34:65-96.

van Zeist, W. and G.J. de Roller. 1995. Plant Remains from Asikli Höyük, a pre-pottery Neolithic site in Central Anatolia. *Veget. History & Archaeobot.* 4:179-185.

van Zeist, W. and J.A.H. Bakker-Heeres. 1982. Archaeobotanical studies in the Levant, 1: Neolithic sites in the Damascus Basin: Aswad, Ghoraifé and Ramad. *Paleohistoria* 24:165-256.

van Zeist, W. and J.A.H. Bakker-Heeres. 1984. Archaeobotanical studies in the Levant, 3. Late-Palaeolithic Mureybit. *Palaeohistoria* 26:171-199.

van Zeist, W. and R. van Waterbolk. 1985. The palaeobotany of Tell Bouqras. *Paléorient* 11(2):131-147.

van Zeist, W., P.E.L. Smith, R.M. Palfenier-Vegter, M. Suwijn and W.A. Casparie. 1984. An archaeobotanical study of Ganj Dareh Tepe, Iran. *Palaeohistoria* 26: 01-224.

Voigt, M. 1984. Village on the Euphrates. Excavations at Neolithic Gritille in Turkey. *Expedition* 27(1):10-24.

Watkins, T. (ed.) 1994. Qermez Dere, Tell Afar, interim report no. 3. Project Paper 14, Dept. of Archaeology, University of Edinburgh.

Willcox, G. 1990. Charcoal remains from Tepe Abdul Hosein. Pages 223-227 *in* Tepe Abdul Hosein: A Neolithic site in Western Iran. Excavations 1978 (J. Pullar, ed.). BAR International Series 563.

Willcox, G. 1991a. Exploitation des espèces ligneuses au Proche-Orient. *Paléorient* 17/2:117-126.

Willcox, G. 1991b. La culture inventée, la domestication inconsciente: le début de l'agriculture au Proche-Orient. Pages 9-31 in Rites et rythmes agraires (M.C. Cauvin, ed.). Travaux de la Maison de l'Orient, Lyon, France [in French].

Willcox, G. 1991c. Cafer Höyük (Turquie): Les Charbons de bois néolithiques. *Cahiers de l'Euphrate* 5-6:139-150. Editions Recherche sur les Civilisations, Paris.

Willcox, G. 1992. Archaeobotanical significance of growing Near Eastern progenitors of domestic plants at Jalès (France). Pages 159-178 *in* Préhistoire de l'agriculture: nouvelles approches expérimentales et ethnographiques. Monographie du CRA No. 6, Centre de Recherches Archéologiques (P.C. Anderson, ed.). CNRS, Paris, France.

Willcox, G. 1995. Wild and domestic cereal cultivation: new evidence from early Neolithic sites in the northern Levant and south-eastern Anatolia. *ARX World J. Prehistoric & Ancient Studies* 1(1):9-16.

Willcox, G.H. 1996. Evidence tor plant exploitation and vegetation history from three early Neolithic pre-pottery sites on the Euphrates (Syria). *Veget. Hist. Archaeobot.* 5:143-152.

Willcox, G. Unpublished. Charcoal analysis and vegetation history in southern Syria. Quaternary Studies Reviews.

Zohary, D. 1969. The progenitors of wheat and barley in relation to domestication and agricultural dispersal in the Old World. Pages 47-66 *in* The Domestication and Exploitation of Plants and Animals (P.J. Ucko and G.W. Dimbleby, eds.). Duckworth, London, UK.

Zohary, D. 1996. The mode of domestication of the founder crops of Southwest Asian agriculture. Pages 142-158 *in* The Origins and Spread of Agriculture and Pastoralism in Eurasia (D.R. Harris, ed.). University College of London Press, London, UK.