Veget Hist Archaeobot (2005) 14:534–541
DOI 10.1007/s00334-005-0075-x

ORIGINAL ARTICLE

George Willcox

The distribution, natural habitats and availability of wild cereals in relation to their domestication in the Near East: multiple events, multiple centres

Received: 30 August 2004 / Accepted: 11 February 2005 / Published online: 25 August 2005

Abstract In this article we examine the natural habitats and distribution of the six wild cereals: *Triticum urartu* (wild urartu wheat), *T. boeoticum aegilopoides* (single-grained wild einkorn), *T. boeoticum thaoudar* (two-grained wild einkorn), *T. dicoccoides* (wild emmer wheat), *Secale* spp. (wild ryes) and *Hordeum spontaneum* (wild barley). A comparison of late Pleistocene/early Holocene archaeobotanical assemblages in the Near East with present-day distributions of wild cereals shows a good correlation. The regional variation in the archaeobotanical cereal assemblages and the ensuing domestication provide evidence that different cereal species were domesticated independently in different areas. Some sites were not situated near wild cereal habitats and a few were located outside the limits of distribution, even accounting for moister climatic conditions. I argue here that current models which try to explain the shift to farming have tended to over-emphasize the effect of the Younger Dryas climatic change. First, it would have had only a minor effect on cereal availability. Secondly, agriculture appears to have been established after the Younger Dryas. Thirdly, there is no evidence for a single centre of origin; agriculture arose in widely separated geographic and climatic regions. And fourthly, agriculture depends on stable climatic conditions which were not established until after the Younger Dryas.

Keywords Wild cereals · Habitats · Domestication · Near East · Neolithic

Introduction

Availability of cereals is a key factor in the shift from gathering to farming. A knowledge of the ecology of wild cereals is essential for an understanding of the distribution and hence availability of these plants in relation to archaeological sites; however, information in the literature is sparse and even recent publications, for example Blumler (2002), are not based on first-hand field observations. Little distinction has been made between local habitat preferences and regional distributions. What we have are general distribution maps which can be misleading because they give only the geographical boundaries (Valkoun et al. 1998; Zohary and Hopf 2000) and do not evoke the limitations brought about by edaphic and climatic requirements. Past distributions may have shifted because of climate change, with wild cereals spreading during wetter conditions and retracting during periods of aridity (Hillman 2000), but here again the steep climatic gradients and preferences for soil types have been largely ignored. Wild wheats and rye are calcifuge plants and are excluded from large tracts of land within the limits of distribution. Availability of wild cereals is at the core of the determinist climatic model (Bar Yosef and Belfer-Cohen 2002; Grosman and Belfer-Cohen 2002), yet adherents of this model have tended to ignore the habitat requirements which affect their availability.

Current models also imply the concept of a centre with a single rapid domestication event and outward radiation of the domesticates. This model was developed in the early 90s, but over the last 10 years archaeobotanical and archaeological data have multiplied, putting some basic assumptions into question. Recent evidence favours polycentric evolution (Gebel 2004) with farming being very gradually adopted across a wide area, with multiple domestication events arising only after agriculture had been established for several centuries. These conclusions come largely from examination of archaeobotanical data (see Table 1 and for site locations Fig. 1) from 17 Near Eastern sites of the 10th millennium and earlier which show that ancient cereals had a pattern of distribution broadly corresponding with present-day distributions (Fig. 2). From regional differences and in the ensuing domestication events we can see that inhabitants chose local cereals to take into cultivation and that this led to independent domestication events (see also Nesbitt 2002; Willcox 2002). This botanical data, along with new ar-

G. Willcox (✉)
CNRS Archéorient UMR 5133,
Jalès, Berrias, F-07460, St-Paul-le-Jeune, France
e-mail: gwillcox@wanadoo.fr

Region	Site	units	Date B.P.	einkorn 1g	einkorn 2g	emmer	barley	rye	ca. cal B.C.
Southern	Ohalo II	1	19000	0	0	21	629	0	21000
Levant	Wadi Hammeh 27		12200-11920	0	0	0	p	0	12200-11900
	Netiv Hagdud	8	9900-9400	0	0	27 (4)	541 (8)	0	9300-8700
	Zad 2		9800-9500	0	0	p	p	0	9300-8800
	Iraq-ed-Dubb		9900	?	0	?	p		9300
	Aswad I	9	9300-9000***	0	0	23 (6)	32 (6)	0	8500-8200
Middle	Abu Hureyra	24	11500-10000	0	>500(21)	0	0	p	11500-9500
Euphrates	Qermez Dere		10100-9700	0	0	0	p		9700-9200
	Mureybet I-II	33	10200-9900	0	12	0	5	p	9800-9300
and	Mureybet III	27	9800-9400	0	> 2000	0	164	p	9300-8800
	M'lefaat	4	9800-9600	0	139	0	185	?	9300-8900
Iraq	Jerf el Ahmar*	430	9800-9400	67	2539	0	9641	p	9300-8800
	Dja'de*	225	9500-9000	265	1120	191	3763		8800-8200
	Göbekli Tepe	1	9550-9450	0	5	0	16		9000-8700
Eastern	Cafer Höyük XII XIII		9400-8800	p	p	p	0	p	8700-7900
Anatolia	Cayönü g, bp, ch		9250-8500	p	p	p	p		8500-7600
	Nevali Cori	1	9250-9000	661	p	129	89		8500-8200
West Syria	Tell el-Kerkh**		9250-9000	p		p			8500-8200
Cyprus	Mylouthkia/Shillourokambos		9250-9000	p	p	p	p		8500-8200

Table 1 Data on cereal remains from Near Eastern sites dated to the early 9th millennium B.C. and earlier where significant quantities of charred plant remains have been analysed. Presence/absence of wild cereal finds indicate that ancient regional distributions were similar to the distributions of present-day wild populations with the exception of the middle Euphrates valley. Grey: Possible domestication at these sites. Black: Absence significant. Units = number of samples, 1 g = single-grained, 2 g = two grained, numbers not in brackets = absolute numbers of grains identified, numbers in brackets = number of samples in which a taxon is present, *p* = present, not quantified, * preliminary results from author's unpublished data, **K. Tanno pers. com, *** for Aswad the newly acquired (2004) AMS dates (GrA-25913, GrA-25915, GrA-25916, GrA-25917) are used, these were obtained from emmer grains from phase Ia and Ib of the 1973 excavations

chaeological evidence for the introduction of cereals to Cyprus (Colledge, in Peltenburg et al. 2001; Willcox 2003a) during the mid 9th millennium B.C. and evidence for complex societies on the middle Euphrates and south eastern Anatolia were not available when the mainstream hypotheses on the origins of agriculture were being developed during the early 90s.

For the nomenclature I have followed the traditional classification for wheat and barley as defined by Zohary and Hopf (2000, Tables 3, 5). This system does not follow the modern grouping of biological species based on cytogenetic affinities, but it is generally used by archaeobotanists because it distinguishes between wild and domestic forms, a distinction which is not always possible in archaeobotanical material from early agriculture sites.

Present-day wild cereal habitats with particular reference to their occurrence in northern Syria and south eastern Anatolia

The following description is based on observations made by the author during numerous field trips to the Near and Middle East between 1972 and 2003.

Soil preferences

Wild wheats and ryes are calcifuge plants. A look at the geological map will help one locate wild wheat stands in the Euphrates basin because they correspond with areas with basalt bedrock or decalcified alluvial soils. Much of the area is covered by Eocene and Palaeocene chalk limestone which is unsuitable for wild wheats and ryes. The more acid soils which support wild wheat are less common and so the distribution of the wild wheat habitats is very patchy, which means that they may not have been locally available near the sites. Barley is tolerant of poor calcareous soils and is therefore much more widespread than the wild wheats, being found almost over the entire region.

Rainfall

The strong climatic gradient in the Euphrates drainage basin, where rainfall varies from north to south with >600 mm of rain per annum in the north and only <150 mm in the south (Helmer et al. 1998; Willcox and Roitel 1998; Van Zeist and Bakker-Heeres 1984), is a guide to how the wild cereals vary in their rainfall requirements. They extend across the area, with those least tolerant of aridity occurring in the north and those most tolerant of aridity further south. Mixed stands of *Triticum dicoccoides* and *T. boeoticum* are to be found in the north

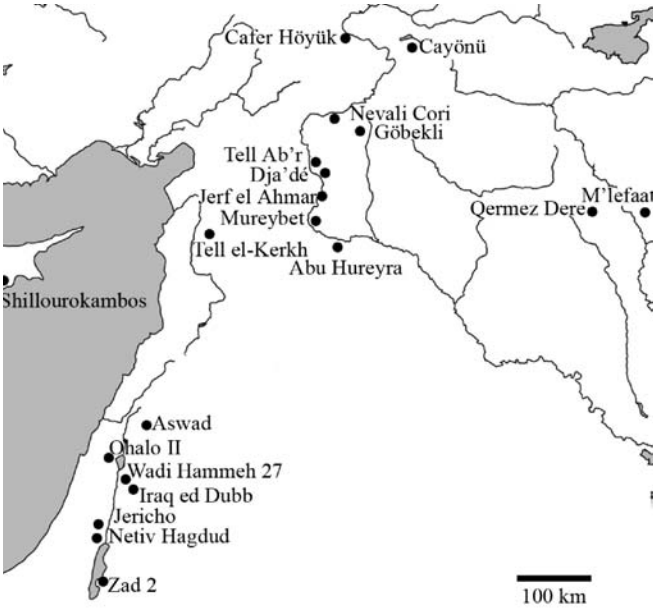

Fig. 1 Locations of Near Eastern sites dated to the 9th millennium B.C. and earlier from which significant quantities of charred plant remains have been analysed

on lower ranges of the Taurus, particularly the Karaca Dag region. As one descends southward, rainfall becomes less abundant and below the 400 mm limit *T. dicoccoides* is no longer present and the two most drought-resistant wild wheats, *T. urartu* and *T. boeoticum,* extend 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. Climate change would produce only minor shifts in distribution due to the strong climatic gradients.

Hordeum spontaneum is the wild cereal best adapted to arid climates. It extends much 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. Where grazing is restricted, rich stands of wild barley are to be found near Halula and Jerf el Ahmar and it is not uncommon to find it occurring even further south (Fig. 1). *H. spontaneum* was more widely available than the wild wheats, extending into the more arid zone but also into the Mediterranean region.

Temperature

Secale and *Triticum boeoticum* occur in the more northerly areas and can be found up to 1500 m asl, tolerating colder conditions better than other wild cereals. *Hordeum spontaneum* is the least tolerant of cool conditions, probably because it ripens earlier than the other wild cereals. It has a more southerly distribution, particularly in the southern Levant where it is accompanied by *T. dicoccoides*.

Plant competition

Experiments in growing *T. boeoticum thaoudar* in southern France (Willcox 1999) have shown that this species (and it is probably true for other wild cereals) cannot compete with perennial grasses and the dense vegetation which develops in Mediterranean and moister regions. So in the more temperate areas it is not climate and soil conditions which limit wild cereals but competition from other plants. This in fact explains why wild cereals can be grown under conditions of cultivation well outside their natural habitats, because in this situation competition from perennials is removed.

Present-day regional distribution of selected wild cereals in the Near East

Having looked at the local habitats we can now turn to the regional distribution. Figure 2 gives the distribution limits of a combination of wild cereals in the Near East. This map is based on maps provided by Davies (1985), Valkoun et al. (1998) and Zohary and Hopf (2000) and on my own field observations. In practice the morphological distinction between *Triticum boeoticum aegilopoides* and *T. boeoticum thaoudar* is not clear, because the development of one or two grains per spikelet depends to some extent on environmental conditions. Thus the limits are somewhat arbitrary. The archaeobotanical assemblages (Table 1) coincide generally with the modern distributions, particularly if one takes into account the overlapping of the different species (Fig. 2); obvious exceptions are the middle Euphrates sites. It is important to note, as mentioned above, that in the case of the wild wheats this distribution is by no means continuous and depends very much on edaphic and climatic factors within the regional limits given here. Wild rye distributions, which do not appear on the map, are very limited in this area. They are to be found at above 1000 m asl in the Karaca Dag of south eastern Anatolia and at the same altitude on the Jebel Druze in southern Syria.

Evidence for independent domestication events for different species

Having examined the regional distribution of the wild cereals, we can compare them to the archaeobotanical finds. Table 1 gives finds of cereal grains from 17 sites dating to the 9th millennium B.C. or earlier. Each area has its own cereal assemblage and these assemblages coincide with the present-day distributions of wild cereals described above. This suggests that past distributions on the regional level were broadly similar to those of today. Therefore it is not surprising that in the southern Levant region, where the only wild cereals are *Hordeum spontaneum* and *Triticum dicoccoides*, we find evidence for their domestication there, while *Secale* and *T. boeoticum*, absent in the south, were domesticated in the north. *H.*

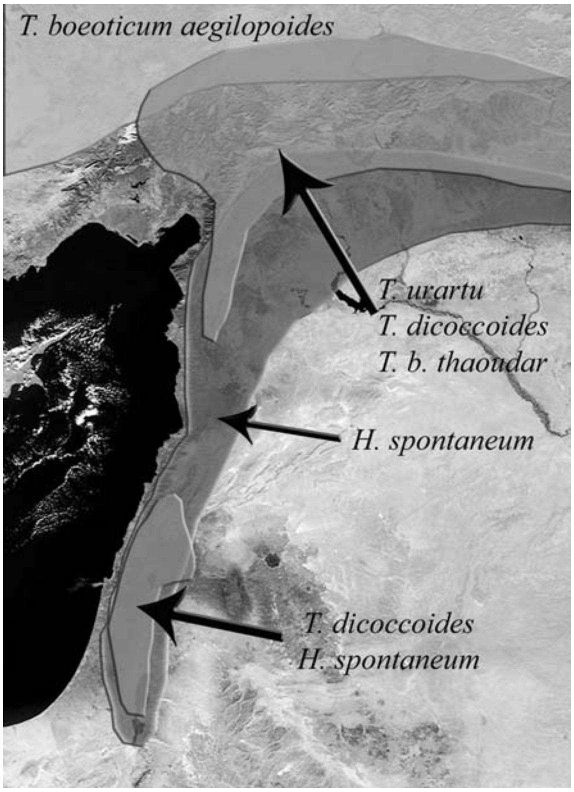

Fig. 2 The approximate present-day distribution limits for primary stands of a combination of wild cereals in order to show the overlaps in the northern and southern Levant. The distinction between the limits of *Triticum boeoticum. aegilopoides* and *T.b. thaoudar* is arbitrary because the separation of these two subspecies is based on the number of grains per spikelet which may be partly determined by the growing conditions. Stands of *T. urartu* occurring further north are not included. For the wheats this map gives the approximate limits, but does not take into account local habitat preferences. Within the limits suitable habitat conditions are rare, so the wild wheat stands are infrequent

Fig. 3 Sites which have evidence of early morphological domestication identified from rough abscission scars which indicate the presence of indehiscent ears. These sites are all dated to the 9th millennium B.C

spontaneum and *T. dicoccoides* occur in both areas, and indeed may have been domesticated more than once. The regional differences provide unequivocal evidence for multiple domestication events. The recent evidence from DNA analyses of modern populations of barley and emmer tend to bear this out (Badr et al. 2000; Heun et al. 1997; Ishii et al. 2001; Ozakan et al. 2002; Salamini et al. 2002; Tanno et al. 2002; Thuillet et al. 2002).

Figure 3 gives a selection of sites where there is evidence for early domesticated cereals based on the rough abscission scars of indehiscent ears, but as has already pointed out, this can be problematical (Kislev 1992; Nesbitt 2002); the lower edge of the abscission scar where one can see the torn ragged surface does not survive on the early Neolithic spikelet bases. The earliest known examples are dated to the early 9th millennium B.C. Some archaeobotanists have identified domestication on the basis of the grains but this method is considered less reliable (Willcox 2004).

Taking each domesticate separately, non-dehiscent forms of *Triticum boeoticum aegilopoides* (=*T. monococcum*) appear in south eastern Anatolia during the 9th millennium B.C. This taxon was found to be dominant at Nevali çori (Pasternak 1998), (the material was examined by M. Nesbitt and the author during the 1995 IWGP meeting in Innsbruck), and has also been found at Tell el Kherkh (Tanno 2004) and further north at Cafer Höyük (de Moulins 1997). On most early Neolithic sites *T. monococcum* is a minor component and only later in Europe, Cyprus and Central Asia does einkorn become a major cereal component. High frequencies of “einkorn” from Mureybet, Jerf el Ahmar and Abu Hureyra are represented by *T. boeoticum thaoudar/urartu* and or *Secale* sp. There is no evidence for domestication from spikelet fragments at these sites. However a domesticated two-grained diploid wheat appears much later in northern Syria at Tell Sabi Abyad (Van Zeist and Waterbolk 1996) and Kosak Shamali (Willcox 2003b). The finds from Kosak Shamali are exceptional because no grains from single-grained spiklets were found. In conclusion, there is good evidence for a minimum of two domestication events for the diploid wheats.

In the case of *Hordeum spontaneum* the situation appears more complex. The archaeobotanical evidence indicates that *H. spontaneum* is dominant at sites in the southern Levant, for example at Netiv Hagdud (Kislev 1997) at the end of the 10th-early 9th millennia B.C. where it was not domesticated, and at late 9th millennium B.C. Jericho where it was domesticated. Farther north, large amounts of rachis segments from sites in the Damascus basin provide evidence for a progressive increase in domestic types. Results from Aswad I and II and Ramad, now dated to between the early to mid 8th millennium B.C. and the mid 6th millennium B.C., indicate that wild fragile rachis types were very gradually replaced by solid forms (for new dating see Table 1). Of all the rachis fragments from Aswad, 62.5% are wild, 26.6% domestic and 10.9% unidentified. By the 6th millennium B.C. at nearby Ramad, 35.3% are wild, 48.8% are domestic and 15.9 are unidentified (van Zeist and Bakker-Heeres 1982). Allowing for approximately 10% of basal internodes in wild populations which do not shatter (Kislev 1992), the evidence from these sites demonstrates a gradual *in situ* selection for a solid rachis in *H. spontaneum*. The latter is rare or absent from early sites in south eastern Anatolia. Farther east in the Zagros area it is common, and the earliest domestic forms appear not much later than in the southern Levant. The distance between the two regions makes the possibility of two domestication events all the more probable.

Evidence for in situ domestication of *T. dicoccoides* is fairly strong at the site of Çayönü (Van Zeist and De Roller 1994). The earliest levels do not have diagnostic remains, but *Triticum* was identified. Spikelet fragments from later 9th millennium B.C. levels are reported as domestic, and in terms of the grains Van Zeist states that in the course of the occupation of the site, wild-type grains were replaced by forms with a distinct domestic grain morphology. 700 km further south, Aswad I has also produced finds of domestic *T. dicoccum.* New dates obtained by AMS from levels Ia and 1 b at Aswad show it to be contemporary with finds of domestic emmer from Cayönü (Table 1).

Secale sp was reported as domestic at Natufian Abu Hureyra on the basis of a few plump grains (Hillman 2000), but the majority have a wild-type morphology. At later sites in the area, for example Mureybet and Jerf el Ahmar, the plump-type grains are absent; thus if there was domestication in the Epipalaeolithic, it died out rapidly, but *Secale* was domesticated later in the Neolithic in Anatolia and later still in Europe.

Climate change and its effect on past cereal distribution

Now that we have looked at the evidence for domestication events, we will examine the possibility of changes in past distributions in the light of archaeobotanical finds of wild cereals which do not coincide with today's distribution and are to be found on sites situated in the arid steppe. As we have seen, the present-day distribution of wild cereals is limited by minimum annual rainfall. Climate change during the period of the transition to farming in the Near East could have altered the distribution limits. What do we know about the effects of climatic change on the vegetation in this area? The Allerød in the Near East is generally considered to have been somewhat moister than at present. This moist period was followed by the Younger Dryas (dated by most authorities to between 10700 and 9600 B.C.), which represents a period of climatic deterioration, and has been observed in many parts of the world. For the Near East it can be recognised in lake bed pollen diagrams from the Mediterranean zone at Ghab (Yasuda et al. 2000) and at Hule (Baruch and Bottema 1999), but it is not readily visible from lake data situated in the more continental areas (Bottema 1995). Following the determinist model for the origins of agriculture, the climatic deterioration of the Younger Dryas led to a reduction in the distribution and availability of wild cereals which produced the incentive for hunter-gatherers to start cultivating. However, hard evidence for a reduction in cereals is meagre, and according to Bottema there is no evidence for a decrease in cereal pollen during the Younger Dryas in the Near East (Bottema 2002). Similarly, the archaeobotanical information, meagre as it is, does not show any radical changes. For Abu Hureyra on the Euphrates, Hillman (2000) suggests a reduction in wild cereals; however, accompanying taxa such as *Stipa*, *Amygdalus, Quercus*, and *Pistacia* persist, occurring before, during and after the Younger Dryas, when we include identifications from Mureybet, Halan Çemi, and Jerf el Ahmar (Hillman 2000; Roitel and Willcox 2000; Willcox 1996; Willcox and Fornite 1999; Van Zeist and Bakker-Heeres 1984). This continuity would appear to indicate that this period of climatic deterioration was not a catastrophic event, and although it may represent cooler, less stable climatic conditions, which did not lead to radical changes in the vegetation cover. According to Hillman's reconstruction maps of past vegetation (Hillman 2000), with the onset of the Younger Dryas there would have been a retreat of wild cereals which would put Mureybet I and II at a considerable distance from the nearest stands of wild rye and einkorn which were found at this site during the Younger Dryas. But how important were the changes in distribution? The abrupt altitude (and hence climatic) gradients and the soil requirements of wild wheats and rye would mean that even a major climatic change would result in only small horizontal shifts in the distribution limits. If this is true of the middle Euphrates and south eastern Anatolia, then in the Jordan valley shifts would have occurred on an even smaller scale. The strong habitat requirements of the wild wheats make it difficult to argue in favour of the determinist model of reduced availability brought about by climate change, when gatherers were already gathering at some distance from the sites and regularly changed collection areas due to inter-annual variation in rainfall or over-exploitation.

Possible evidence for the transport of cereals as demonstrated by finds outside present-day distributions limits

Having attempted to assess the possible changes in the distribution of wild cereals at the end of the Pleistocene/ beginning of the Holocene we can now examine cases of cereal finds occurring outside present-day habitats. The most obvious example is the introduction of founder crops to Cyprus (Willcox 2003a; Peltenburg et al. 2001). On the mainland at three middle Euphrates sites, Abu Hureyra, Mureybet and Jerf el Ahmar, *Triticum boeoticum thaoudar* and *Secale* sp. were found well outside their natural distributions. The two most southerly sites are situated at more than 100 km from present-day wild wheat stands, and much further from those of *Secale* spp. Even with optimal climatic conditions extending the limit southward, it is improbable that these cereals could have grown locally due to the poor soils. As we have seen, even during the arid Younger Dryas these cereals occur at the site of Mureybet. It is possible that these wild cereals grew nearer the sites when climatic conditions were favourable. Given cooler and moister conditions leading to a lowering of vegetation zones, the nearest potential habitat for wild wheat and rye may have been at Qara Perguel Dah which is situated on the left bank of the Euphrates about 20 km south of the Turkish border. This massive basalt outcrop, rising to 694 m, is a likely candidate for late Pleistocene wild einkorn or even rye stands. Further south still, between Dja'dé and Jerf el Ahmar, there is a small basalt lava flow near the village of Serine which might also have been a favourable habitat. But the chalk which covers most of the area provides very thin poor soils which are extremely improbable habitats for wild wheat or rye, even taking into account more favourable climatic conditions. This leads us to the inevitable conclusion that the cereals used at the Natufian site of Mureybet, which is contemporary with the Younger Dryas, may not have been growing locally, which is why researchers such as Cauvin (1994), Salamini (2000), Van Zeist and De Roller (1994) and Willcox (2002) have already suggested that these cereals may have been imported or introduced from farther north.

Transport of raw materials across considerable distances is well known in the Near East, adding weight to the argument that cereals were also transported. The Euphrates river, with its late 10th and early 9th millennium B.C. sites such as Nevali Cori, Tell Ab'r (Willcox unpubl.), Dja'dé, Jerf el Ahmar, Cheik Hassan and Mureybet located regularly along its course, is an obvious route. Figure 4 gives the lines of exchange for various rare materials, to which I have added cereals. The fact that it was necessary to import was in itself an incentive to start cultivating in favourable protected microhabitats near the sites. Under cultivation when competition from other plants is removed, cereals are more tolerant of climatic and edaphic conditions.

As we have seen *Hordeum spontaneum* is the most widespread wild cereal, being well adapted to arid conditions. This means that of the wild cereals, barley is the least likely to have been transported. It is absent at Natufian Abu Hureyra and only appears for the first time on the middle Euphrates sites towards the end of the Younger Dryas and then increases in frequency. There are probably several factors involved in the appearance of *H. spontaneum*. One is that climatic improvement could have permitted its expansion. The second is that with cultivation, it was either introduced or it was brought into cultivation from the local flora.

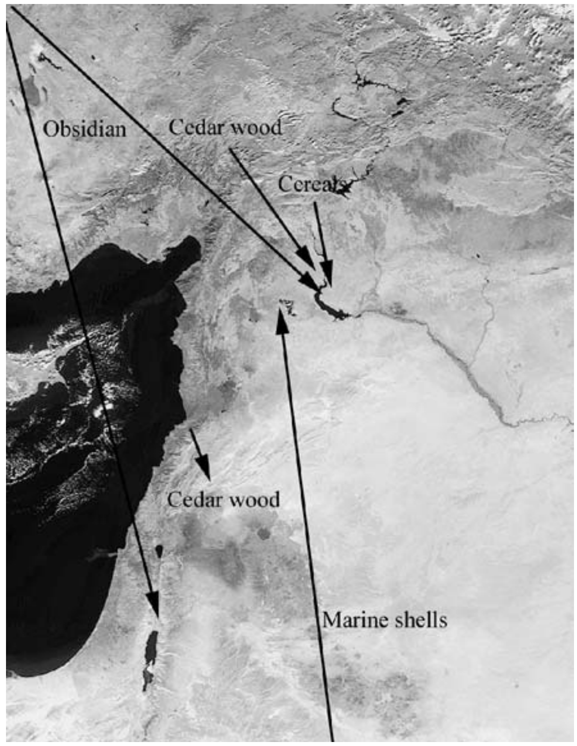

Fig. 4 Lines of exchange as defined by the importation of raw materials during the late Pleistocene/early Holocene in the Near East. Recent finds of cedar wood charcoal from Aswad and Jerf el Ahmar were identified by Pessin (2004)

In the southern Levant *Triticum dicoccoides* was found at Aswad, situated in an area with less than 100 mm of rainfall per annum. The nearest potential wild *T. dicoccoides* habitats are 40 km from the site. Whether agriculture was practised near the site would have depended on the ability of the inhabitants to exploit the waters of the river Barada or the Holocene lake. In the Jordan valley, sites like Netiv Hagdud, Zad 2 (Edwards et al. 2001) and Jericho are in very dry zones but only a few km from higher rainfall areas due to the sharp climatic gradient on the Jordan valley slopes. Thus in these areas, even with major climate change, the limits of wild *T. dicoccoides* and the distance of wild stands from the sites would shift only a few km.

Cultural complexity and incentives to cultivate

Until recently, evidence for socio-cultural complexity has not been forthcoming for late Pleistocene/early Holocene sites, with the exception of Jericho; but for recently excavated sites such as Jerf el Ahmar, Göbekli, and Nevali Cori this is no longer the case. I will not go into the archaeological data here, but refer the reader to original sources (Schmidt 2003; Stordeur 2000, Stordeur et al. 2000). Social considerations such as the accumulation of wealth, social stratification, ownership and exchange can no longer be ignored as incentives to cultivate. A recent and eloquent contribution to these aspects has been made by T. Watkins (2004), who argues for the importance of the co-evolution of human cognitive faculties and culture on the development of society. The question is, did these social developments occur as a result of agriculture, or did hunter-gatherers develop socio-cultural systems which produced incentives to cultivate? This question is difficult to answer because social and economic systems evolved in an interdependent way. As we have seen, due to the patchy occurrence of wild wheat habitats, many sites, at least on the Euphrates, did not have wild stands in their backyards. With increasingly complex village life and regional rivalry for access to wild stands, the adoption of cultivation near a village would be a distinct advantage. Significantly the only late 10th/early 9th millennium B.C. site which has no habitations and appears to be a major ceremonial centre, Göbekli (Neef 2003; Schmidt 2003), is situated within view of Karaca Dag, a basalt massif with the most extensive stands of wild wheats and rye in south eastern Anatolia. Perhaps the site of Göbekli represents some kind of claim over this valuable region, whose resources may have supplied sites to the south situated on the Euphrates.

Conclusions

The change from gathering to cultivation was a gradual process (Kislev 2002). Hillman suggests that it had already started on a small scale in the Natufian, and a knowledge of planting may go back even farther. During the initial stages early farmers may have been obliged to frequently replenish their seed stocks from wild stands, which would slow the domestication process. It is not until the end of the 9th millennium B.C. that we see the appearance of well-established farmers with fully-fledged agriculture which produced conditions favourable for the selection of domestic traits and in particular the indehiscent ear.

But a millennium earlier, at the end of 10th millennium B.C., agriculture appears to have already started, probably independently in at least two areas, one in the south eastern Anatolia/middle Euphrates area, the other in the southern Levant. While there is good evidence for a Natufian homeland in the south, sites are rare in the north, although there is evidence of origins in the north-east (Aurenche and Kozlowski 1999). If we take into account the distances between sites, for example M'lefaat (Savard et al. 2003) in the east, Cayönü in the north and Zad 2 in the south, multiple origins appear to be a very real possibility. The use of the term polycentric origins employed by Gebel (2004) now appears more applicable than 15 years ago. As for multiple domestication events, these are no longer in doubt and it is probable that more will be identified as DNA testing and archaeobotanical research progress.

The proximity of a perennial water source was the main priority when choosing a settlement location, not the proximity of wild cereal stands. Settlement sites are all situated near a river, spring or lake, with the exception of Göbekli. Due to the patchy distribution of the two wild wheat species, many sites were situated at some distance from the wild stands. In the case of the middle Euphrates this distance may have been considerable, while in the Jordan valley it was less. This meant that cereals were transported. As socio-cultural systems became more complex, there were obvious advantages in introducing and cultivating wild wheats and rye near the sites. With the beginning of the Holocene, climatic amelioration favoured agriculture and allowed the early farmers to plant cereals under stable climatic conditions in areas where previously they could not have grown. Thus cultivation became the only viable subsistence option.

Acknowledgements My thanks to R. Buxo, S. Fornite, D. Helmer, L. Herveux, M. Molist, D. Stordeur, E. Willcox, and colleagues at the Department of Antiquities, Damascus. Part of this ongoing work was financed by the European Union contract ICA3-CT-2002-10022. Thanks also to S. Jacomet, M. Kislev, F. Bittmann, and an anonymous reviewer for their corrections and helpful suggestions

References

Aurenche, O., Kozlowski, S. (1999). La Naissance du Néolithique au Proche Orient. Errance, Paris

Badr, A., Müller, K., Schäfer-Pregl, R., El Rabey, H., Effgen, S., Ibrahim, H.H., Pozzi, C., Rohde, W., Salamini, F. (2000). On the origin and domestication history of barley (*Hordeum vulgare*). Molecular Biology and Evolution, 17, 499–510

Bar Yosef, O., Belfer-Cohen, A. (2002). Facing environmental crisis, Societal and cultural changes at the transition from the Younger Dryas to the Holocene. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern Production, Subsistence and Environment 6. Berlin, ex oriente, pp 55–66

Baruch, U., Bottema, S. (1999). A new pollen diagram from lake Hula, climate and anthropogenic implications in ancient lake. In: Kawanabe, H., Coulter, G.W., Roosevelt, A.C. (eds) Ancient Lakes: their cultural and biological diversity. Kenobi Productions, Belgium pp 75–86

Blumler, M. (2002). Changing paradigms, wild cereal ecology and the origins of agriculture. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern Production, Subsistence and Environment 6. Berlin, ex oriente, pp 95–112

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: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern production, subsistence and environment 6. Berlin, ex oriente, pp 27–38

Cauvin, J. (1994). Naissance des divinités: Naissance de l'agriculture. CNRS Editions, Paris

Davies, P.H. (1985). Flora of Turkey and the Aegean Islands, Vol 9. Edinburgh University Press, Edinburgh

Edwards, P.C., Falconer, S.E., Fall, P.L., Berelov, I., Davies, C., Meadows, J., Meegan, C., Metzger, M., Sayej, G. (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

Gebel, H.G. (2004). There was no centre: The polycentric evolution of the Near Eastern Neolithic. Neo-lithics, 1/04, 28–32

Grosman, L., Belfer-Cohen, A. (2002). Zooming on to the Younger Dryas. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern Production, Subsistence and Environment 6. Berlin, ex oriente, pp 49–54

Helmer, D., Roitel, V., Sana, M., Willcox, G. (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. Canadian Society for Mesopotamian Studies, Bulletin, 33, pp 9–34

Heun, M., Schäfer-Pregl, R., Klawan, D., Castagna, R., Accerbi, M., Borghi, B., Salamini, F. (1997). Einkorn wheat domestication identified by DNA fingerprinting. Science, 278, 1312–1314

Hillman, G.(2000). Plant food economy of Abu Hureyra. In: Moore, A., Hillman, G., Legge, T. (eds) Village on the Euphrates, from foraging to farming at Abu Hureyra. Oxford University Press, New York, pp 372–392

Ishii, T., Mori, N., Ogihara, Y. (2001). Evaluation of allelic diversity at chloroplast microsatellite loci among common wheat and its ancestral species. Theoretical Applied Genetics, 103, 896–904

Kislev, M. (1992). Agriculture in the Near East in the VIIth millennium B.C.. In: Anderson, P. (ed) Préhistoire de l'agriculture. Monographie du CRA n°6, Editions CNRS, Paris, pp 87–94

Kislev, M. (1997). Early agriculture and palaeoecology of Netiv Hagdud. In: Bar-Yosef, O., Gopher, A. (eds) An early Neolithic village in the Jordan valley. Part 1. The archaeology of Netiv Hagdud. American School of Prehistoric Research Bulletin 43, Peabody Museum, pp 209–236

Kislev, M. (2002). Origin of annual crops by agro-evolution. Israel Journal of Plant Sciences, 50, 85–88

de Moulins, D. (1997). Agricultural changes at Euphrates and steppe sites in the mid-8th to the 6th millennium B.C.. BAR International Series 683

Neef, R. (2003). Overlooking the steppe forest: preliminary report on the botanical remains from early Neolithic Göbekli Tepe (southern Turkey). Neo-lithics, 2/03, 13–15

Nesbitt, M. (2002). When and where did domesticated cereals first occur in southwest Asia?. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern production, subsistence and environment, 6. Berlin, ex oriente, pp 113–132

Ozakan, H., Brandolini, A., Schäfer-Pregl, R., Salamini, F. (2002). AFLP Analysis of a collection of tetraploid wheats Indicates the Origin of *T. dicoccoïdes* and hard wheat domestication in southeast Turkey. Molecular Biology and Evolution, 19, 1797–1801

Pasternak, R. (1998). Investigations of botanical remains from Nevali Cori PPNB, Turkey. In: Damania, A., Valkoun, J., Willcox, G., Qualset, C. (eds) The origins of agriculture and crop domestication. Syria: ICARDA, Aleppo, pp 170–177

Peltenburg, E., Colledge, S., Croft, P., Jackson, A., McCartney, C., Murray, M.A. (2001). Neolithic dispersals from the Levantine corridor: a Mediteranean perspective. Levant, 33, 35–64

Pessin, H. (2004). Stratégies d'approvisionnement et utilisation du bois dans le Moyen Euphrate et la Damascène. Approche anthracologique comparative de sites historiques et préhistoriques. Doctoral thesis, Université de Paris 1

Roitel, V., Willcox, G. (2000). Analysis of charcoal from Abu Hureyra. In: Moore, A.M.T., Hillman, G., Legge, T. (eds) A village on the Euphrates. Oxford University Press, pp 544–547

Salamini, F. (2000). La Première céréale cultivée. Pour la Science, 274, 58–63

Salamini, F., Özkan, H., Brandolini, A., Shäfre-Pregl, R. Martin, W. (2002). Cereal domestication in the Near East. Nature Reviews Genetics, 3, 429–441

Schmidt, K. (2003). The 2003 Campaign at Göbekli Tepe (Southeastern Turkey). Neo-lithics, 2, 3–8

stordeur, d. (2000). New discoveries in architecture and symbolism at Jerf el Ahmar (1997-1999 Syria). Neo-lithics, 1, 1–4

Stordeur, D., Brenet, M., Der Aprahmian, G., Roux, J.-Cl. (2000). Les bâtiments communautaires de Jerf el Ahmar et Mureybet. Horizon PPNA. Syrie. Paléorient, 26, 29–44

Savard, M., Nesbitt, M., Gale, R. (2003). Archaeobotanical evidence for early Neolithic diet and subsistance at M'lefaat (Iraq). Paléorient, 29, 93–106

Tanno, K. (2004). Identification of PPNB plant remains from Tell El-Kerkh, Northwest Syria. IWGP-Symposium Girona 2004, Abstracts

Tanno, K., Taketa, S., Takeda, K., Komatsuda, T. (2002). A DNA marker closely linked to the vrs1 locus (row-type gene) indicates multiple origins of six-rowed cultivated barley (*Hordeum vulgare* L.). Theoretical Applied Genetics, 104, 54–60

Thuillet, A.-C., David, P., Roumet, P., Santoni, S., Sourdille, P., Bataillon, T. (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, 122–125

Valkoun, J., Giles, J., Waines, J., Konopka, J. (1998). Current distribution and habitat of wild wheats and barley. In: Damania, A., Valkoun, J., Willcox, G. Qualset, C. (eds) The origins of agriculture and crop domestication. Syria: ICARDA, Aleppo, pp 293–299

Watkins, T. (2004). Building houses, framing concepts, constructing worlds. Paléorient, 30/1, 5–24

Willcox, G. (1996). Evidence for plant exploitation and vegetation history from three Early Neolithic pre-pottery sites on the Euphrates (Syria). Vegetation History and Archaeobotany, 5, 143–152

Willcox, G. (1999). Agrarian change and the beginnings of cultivation in the Near East: Evidence from wild progenitors, experimental cultivation and archaeobotanical data. In: Hather, J., Gosden, C. (eds) The Prehistory of food. Routledge, London, pp 479–500

Willcox, G. (2002). Geographical variation in major cereal components and evidence for independent domestication events in the Western Asia. In: Cappers, R.T.J., Bottema, S. (eds) The dawn of farming in the Near East. Studies in Near Eastern Production, Subsistence and Environment, 6. 1999. Berlin, ex oriente. pp 133–140

Willcox, G. (2003a). The origins of Cypriot farming. In: Guilaine, J., Le Brun, A. (eds) Le Néolithique de Chypre. Actes du Colloque International Organisé par le Département des Antiquités de Chypre et l'Ecole Française d'Athènes. Nicosie 17–19 mai 2001. Bulletin de Correspondance Hellénique Supplément 43, pp 231–238

Willcox, G. (2003b). Chalcolithic carbonised cereals from Ubaid burnt storage structures at Kosak Shamali. In: Nishiaki, Y., Matsutani, T. (eds) Tell Kosak Shamali vol. II. University Museum the University of Tokyo, Monograph, pp 267–270

Willcox, G. (2004). Measuring grain size and identifying Near Eastern cereal domestication: evidence from the Euphrates valley. Journal of Archaeological Science, 31, 145–50

Willcox, G., Fornite, S. (1999). Impressions of wild cereal chaff in pisé from the tenth millennium at Jerf el Ahmar and Mureybet: northern Syria. Vegetation History and Archaeobotany, 8, 21–24

Willcox, G., Roitel, V. (1998). Rapport archéobotanique préliminaire de trois sites préceramiques du Moyen Euphrate (Syria). Cahiers de l'Euphrate, 8, 65–84

Yasuda, Y., Kitagawa, H., Nakagawa, T. (2000). The earliest record of major anthropogenic deforestation in the Ghab valley, northwest Syria: a palynological study. Quaternary International, 73/74, 127–136

Zeist, W. van, Bakker-Heeres, J.H. (1982). Archaeobotanical studies in the Levant 1. Neolithic Sites in the Damascus Basin: Aswad, Ghoraife, Ramad. Palaeohistoria, 24, 165–256

Zeist, W. van, Bakker-Heeres, J.H. (1984[1986]). Archaeobotanical studies in the Levant 3. Late Palaeolithic Mureybet. Palaeohistoria, 26, 171–199

Zeist, W. van, Roller, G.J. de (1994). The plant husbandry of Aceramic Cayönü, E. Turkey. Palaeohistoria, 33/34, 65–96

van Zeist, W., Waterbolk-van Rooijen, W. (1996). Cultivated and wild plants. In: Akkermans,P. (ed) Tell Sabi Abyad: the later Neolithic settlement. Nederlands Historisch-Archaeologisch Instituut, Istanbul, pp 521–50

Zohary, D., Hopf, M. (2000). Domestication of plants in the Old World, 3rd edn. Oxford University Press, Oxford