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Botanical Evidence for the Adoption of Cultivation in Southeast Turkey

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INTRODUCTION

Over the last ten years a great deal of new information has emerged concerning the transition to farming in the Near East and particularly in Southeast Turkey. This has shown how important this area is for the origins of agriculture in the Near East. The most spectacular new finds are of course archaeological, and they are reported in this volume. Our understanding of the adoption of cultivation relies heavily on charred plant remains recovered from archaeological sites as direct evidence of plant use by the inhabitants. Fifteen years ago, the only archaeobotanical data available for the Early Neolithic in Southeast Turkey were from Çayönü and Cafer Höyük. Since then, four new reports have been published on charred plant remains from the following sites: Göbekli Tepe, Nevalı Çori, Hallan Çemi, and Demirköy (also known as Demirci). Körtik Tepe will be published in the near future. Evidence has also come to light at the sites of Dederiyeh, Jerf el Ahmar, Dja'de, Tell 'Abr, and Tell Qaramel, situated in Northern Syria (Willcox et al. 2008), and from M'lefaat and Qermez Dere, located in Northern Iraq (Savard et al. 2003; Savard 2005). This new information has allowed us to examine more thoroughly the changes and differences in plant assemblages from these sites, which has helped us to understand better how cultivation was adopted and to assess how the process of wild cereal domestication proceeded in the region. Recent results from DNA analyses of modern wild progenitors of cereals have provided additional knowledge with regard to the origins of domestic populations.

We tend towards the following premises:

1) Sedentary societies which predominantly collect and store seeds from annuals may have practiced small-scale cultivation but it would not necessarily be identifiable from archaeobotanical assemblages.

2) An incentive for this small-scale cultivation would have occurred if wild plants were not easily available in the quantities desired.

3) Gathering and cultivation may have been practiced simultaneously, and seed for sowing may have been regularly obtained from wild stands for an indeterminate period.

4) Predomestic cultivation would be recognized archaeobotanically only after major crops were systematically cultivated and gathering was rare.

5) Morphological domestication would not necessarily appear soon after cultivation started.

Prior to the magnificent tenth millennium finds from Göbekli Tepe (Schmidt 2003 and see Göbekli Tepe in this volume), there was little evidence that agriculture arose from societies that had high levels of cultural complexity. Only Mureybet and Jericho, isolated geographically, suggested this. The new evidence of large-scale communal buildings and a multifaceted symbolism from the first half of the tenth millennium indicate that PPNA societies were highly complex. Furthermore, we can define a cultural area, which includes Southeast Turkey, Northern Syria, and possibly Northern Iraq, where a cultural homogeneity or unity is indicated by a large number of common cultural attributes. Sites in this area provide evidence, be it non-continuous, for the transition from sedentary hunter-gatherers to farmers. In Southeast Turkey, the sites include Çayönü, Nevalı Çori, Cafer Höyük, Göbekli Tepe, Hallan Çemi, and Demirköy.

At the time of writing, there is not much evidence in Southeast Turkey for occupation which corresponds to the Levantine Natufian period (there are a few references to isolated finds, see http://www.tayproject.org/). Why this rarity of sites in Southeast Turkey during this period? Even allowing for differences in the intensity of survey work, this does not explain the difference between the Levant and Southeast Turkey. One hypothesis is that climatic conditions during this period were less favourable to human occupation in Southeast Turkey compared to those in the Southern Levant. Indeed, an unfavourable climatic episode, the Younger Dryas, which is dated to the Late Natufian, could explain the absence of sites in the Northern Levant during this period. A little farther south Abu Hureyra and Dederiyeh, situated in Northern Syria, are examples of two Late Natufian sites dated to the Younger Dryas. Whether or not climate was a major factor, the onset of improved climatic conditions at the beginning of the Holocene around 9500 cal. BC saw the first signs of sedentary occupation in Southeast Turkey at Hallan Çemi, Çayönü, and Demirköy.

EVIDENCE FROM CHARRED PLANT REMAINS FROM EARLY HOLOCENE SITES IN SOUTHEAST TURKEY

Archaeobotanical analyses have been carried out at six Early Holocene sites in Southeast Turkey: a brief summary of the results for each site is presented here.

Hallan Çemi

The site of Hallan Çemi, now flooded, is located in Eastern Turkey, 50 km north of the city of Batman, on the west bank of the Sason Stream, a tributary of the Batman Stream, itself a tributary of the Tigris (Fig. 1). It lies at an elevation of 640 m asl in the foothills of the Western Taurus (Rosenberg and Redding 2000). The site is within the present-day vegetation zone of the open oak forest but which is more common at higher elevations in the surrounding foothills. Only very isolated trees or shrubs occur near the flooded river valley; however, remnants of a riparian forest along the Sason Stream were noted when it was being excavated (Rosenberg et al. 1998: 26).

Hallan Çemi was occupied year-round by fully sedentary hunter-gatherers and is considered to be the oldest sedentary village site known so far in Eastern Anatolia (Rosenberg and Redding 2000: 40). Plant and bone remains, and especially the growth bands on clam shells, (*Unido tigridus*) have shown that food was gathered and hunted year-round (Rosenberg et al. 1998: 34). A series of 19 new AMS dates on carbonised seeds suggests a relatively short occupation during the second half of the tenth millennium cal. BC (see Hallan Çemi in this book vol. 1).

The bone assemblage is dominated by wild ovicaprids, followed by red deer and boar. Rosenberg's team had suggested the possibility of early pig husbandry, along with the hunting of wild boar (Rosenberg et al. 1998: 32-33), but a recent study found no conclusive evidence of pig domestication (Starkovich 2005: 34). Charcoal analyses revealed that wood of the oriental terebinth (*Pistacia*), oak (*Quercus*), maple (*Acer*), and almond (*Amygdalus*) was gathered from the surrounding vegetation for fuel in addition to the common riverine species Poplar (*Populus*), willow (*Salix*) tamarisk (*Tamarix*), and ash (*Fraxinus*) (Rosenberg et al. 1998: 26). The plant assemblage, composed of 13,751 charred remains, is characterised by a large diversity of taxa.

The Hallan Çemi assemblage is largely dominated by sea club-rush (*Bolboschoenus maritimus* type), representing 32% of the assemblage, followed by dock/knotgrass (*Rumex/Polygonum*) representing 27% of the assemblage. In terms of ubiquity, the same two taxa dominate, both being present in more than 74% of the 175 samples (Savard 2005). These two taxa are interpreted as food plants (Savard et al. 2006: 189).

Legumes represent 9% of the assemblage, most being large-seeded legumes or pulses (scored as Vicieae, *Vicia* and *Lathyrus*). Other proportionally well-represented plants include mullein (*Verbascum* sp., 8% of the assemblage) and wild lettuce (*Lactuca* sp., 7% of the assemblage). Grasses represent less than 5% of the Hallan Çemi assemblage, with large-seeded grasses that are wild progenitors of cereals representing only 1,4% (Savard et al. 2006: tab. 1). No cereal chaff was recovered and there is therefore no evidence of plant domestication at Hallan Çemi but 39 wheat (*Triticum)* type grains were identified and 124 grains of wild barley (*Hordeum* cf *spontaneum*), suggesting that wild cereals were consumed.

While well-represented taxa have high ubiquity figures, other less well-represented taxa can significantly show high ubiquity figures: for instance, almonds and nutshell fragments of terebinth (*Pistacia), Taeniatherum caput-medusae,* and other small-seeded grasses each represent around 1% of the overall assemblage, or even less, but were found in half (or more) of the 175 samples.

The archaeobotanical results at Hallan Çemi suggest that a wide range of seeds from annuals were gathered and may have been stored. Some grass taxa including wild progenitors of cereals, although not proportionally well represented, have high ubiquity values suggesting that they were locally available. Finally, it appears that the subsistence strategy was not centred on grasses. Indeed, grasses, especially the wild progenitors of cereals, have often been considered as the staple resource that enabled a sedentary way of life, a prerequisite for the origins of agriculture (Savard et al. 2006). At Hallan Çemi it appears that two abundant valley bottom plants provided the principal storable food that allowed the inhabitants to live a sedentary existence (Savard 2005).

Demirköy

Demirköy is located just outside the city of Batman, on the west bank of the Batman Stream, about 20 km upstream from its confluence with the Tigris. It lies at ca. 560 m asl, on the edge of an eroding 10 m high terrace overlooking a large floodplain (Rosenberg and Peasnall 1998; Peasnall and Rosenberg 2001: 363-364). Two AMS radiocarbon dates on seeds suggest an occupation during the second half of the tenth millennium cal. BC (see Demirköy in this book vol. 1).

The results of archaeobotanical analyses at Demirköy are very similar to those of Hallan Çemi. However, the diversity of taxa is somewhat lower, with 36 taxa identified. This is likely to be due to a smaller number of samples (only 12) and a smaller number of scored seeds and fruits (906). Only 11 of the 36 taxa represent more than 1% of the remains. Sea club-rush (*Bolboschoenus maritimus* type) overwhelmingly dominates, representing 70% of the assemblage. With only 12 samples, ubiquity figures must be considered with caution; nonetheless, sea club-rush remains have been found in 11 of the 12 samples. The main differences between Demirköy and Hallan Çemi lie in the importance of dock/knotgrass (*Rumex/Polygonum*), which represents only 1% of the Demirköy assemblage.

Large- and small-seeded legumes represent respectively 5,6% and 4,3% of the assemblage. As at Hallan Çemi, grasses represent less than 5% of the assemblage, with wild cereals or large-seeded grasses consisting of wheat and barley (*Triticum* and *Hordeum*) representing only 0,8% (Savard et al. 2006: tab. 1). As at Hallan Çemi, no chaff was found; there is no morphological evidence for plant domestication, and inhabitants relied mainly on valley bottom species. Bone sickle hafts were found at Demirköy. These could have been used to harvest grasses, reeds, or equally sea club-rush. Indeed the site of Demirköy was most likely chosen because of the abundance of this resource.

Çayönü

Çayönü is located on a small tributary of the Upper Tigris, at an elevation of about 830 m (Fig. 1) (see Çayönü in this book vol. 1). Like Hallan Çemi and Demirköy, it is an open-air site with a round-house horizon located in the oak forest zone. Charcoal identifications were conducted on a few handpicked samples that were destined for radiocarbon dating. They attest the presence of oak (*Quercus*), oriental terebinth (*Pistacia*), Rosaceae, ash (*Fraxinus*), and matrimony vine (*Lycium* sp.) (van Zeist and de Roller 1992: 87). The zooarchaeological assemblage is composed of wild boar, red and fallow deer, cattle, wild sheep, and wild goat (Özdoğan 1999: 44).

Seed and fruit remains were scarce in the earliest round-house sub-phase and most samples contained few remains (van Zeist and de Roller 1992, 2003). Five *Triticum* spikelet bases, eight glume bases and four grains of wild barley were found with oriental terebinth nutshell fragments (*Pistacia* sp.). Sea club-rush (*Bolboschoenus maritimus* type) was also found with a few pulses. These finds may not be representative, but the presence of *Triticum* chaff and wild barley grains would appear to indicate that these grasses were a more important component of the diet than at Hallan Çemi or Demirköy.

The subsequent phases are characterised by the presence of cereals, einkorn and emmer wheat, and pulses, bitter vetch (*Vicia ervilia*), lentil (*Lens culinaris*), pea (*Pisum sativum*) and, probably, chickpea (*Cicer* sp.) and grass pea (*Lathyrus sativus/cicera*). In these phases, including those with rectangular structures, pulses seem to play a predominant role over cereals (van Zeist and de Roller 1992: 88-89; van Zeist and de Roller 2003: 143).

Göbekli Tepe

Despite extensive flotation, only small quantities of charred plant remains were recovered from the site of Göbekli Tepe (Neef 2003). This is probably because samples were taken from fill which was used to cover the monumental structures which may have been obtained at some distance from plant processing areas. Grains and chaff of wild einkorn were recovered, together with grains of wild barley. These were presumably the dominant taxa since only a few other plants were identified. Querns with advanced wear are very common on the site suggesting that regular processing of cereals was carried out.

Nevalı Çori

Charred plant remains from Nevalı Çori (Pasternak 1998) situated in the Euphrates Valley and dated to the last quarter of the tenth millennium, are dominated by *Triticum* chaff remains. Of the *Triticum* grains, 661 were single-grained einkorn, and 129 were two-grained, and so could have been einkorn or possible emmer. Barley was found at much lower frequencies and was wild.

Cafer Höyük

The earliest levels from Cafer Höyük are approximately contemporary with Nevalı Çori. The site is situated on the Euphrates, 150 km upstream from Nevalı Çori. Sampling was extensive and yielded a wide variety of grasses, including both wild and domestic varieties of einkorn, emmer, and barley. Wild rye is also present. The cereals are represented by both chaff and grains (de Moulins 1997).

EVIDENCE FOR CEREAL DOMESTICATION IN SOUTHEAST TURKEY

Cereals were not necessarily the first plants to have been domesticated but cereal spikelet bases provide the most reliable morphological evidence of domestication compared to the indehiscent pods of pulses which are extremely rare. An increase in grain size is another possible source of evidence. In this section, we are concerned with identifying morphological domestication of cereals, as defined by the appearance of the semi-tough rachis, where spikelets are retained after the ear has matured, as opposed to wild types which shed their spikelets at maturity (Nesbitt 2002). Unfortunately, the abscission scar which is the diagnostic feature of a spikelet base is often damaged or missing. Only when this is preserved can the distinction between wild and domestic be made.

Because there was a long period of pre-domestic cultivation over a wide geographical area, there is a high probability that morphological domestication appeared more than once in Southwest Asia. Domestication arises from an indeterminate period of cultivation of wild progenitors. How long it took for tough rachis populations to emerge would depend on cultivation techniques (Hillman and Davies 1990; Willcox 1999). Under strict clinical conditions, this could have been a rapid process; recent work, however, seems to point to a rather slow emergence of the semi-tough rachis domestic types (Tanno and Willcox 2006; Fuller 2007).

So far, no PPNA sites from the Near East, including Southeast Turkey have produced evidence of morphological domestication. Domesticated emmer and einkorn was reported from Early PPNB levels at Çayönü (van Zeist and de Roller 1992) and at Cafer Höyük. For van Zeist all the spikelet bases from Çayönü were domestic. However, drawings of the specimens (van Zeist and de Roller 1992: figs. 8.1, 9.1) are not conclusive and appear to be of the "domestic tear-off scar" type (see below) and so should be treated with caution until further examination. At Cafer Höyük domestic emmer was identified in the earliest levels (de Moulins 1997: fig. 17) but no details are given of the criteria used. At Nevalı Çori einkorn domestication was reported based on observations made by Nesbitt, Pasternak and Willcox at the IWGP in Innsbruck (Pasternak 1998; Nesbitt 2002; Willcox 2005). They based the identification of domestication on the "tear-off scar".

In a recent examination of nearly 10,000 wheat spikelet bases, it was shown that the "tear-off scar" is not a criterion for morphological domestication, but rather a result of damage resulting from pounding during dehusking and perhaps charring (Tanno and Willcox 2006). The tear-off scar occurs at sites such as Tell Qaramel where there is no domestication. During this study the spikelet bases provided by R. Pasternak from Nevalı Çori were re-examined (Tanno and Willcox 2006) and shown to have low frequencies of undamaged domestic types.

Elsewhere in the Near East, for example at Aswad (8500 cal. BC), and Zarhat adh-Dhra (9000 cal. BC) there is evidence for barley domestication. On the island of Cyprus einkorn may have been domesticated by the Early PPNB at Krissonerga–Mylouthkia, and farther east at Ganj Dareh there is evidence that barley was domesticated at about the same date. At these sites wild types persist. Theoretically, once the tough rachis types appeared, selective pressure should have resulted in the domestic types taking over very rapidly (Hillman and Davies 1990). This did not happen; as an explanation we proposed that this occurred because early farmers frequently renewed their seed stock from wild populations, particularly after poor harvests, and they harvested before maturity, which would result in tough rachis plants with little advantage over those that shatter.

In conclusion, domestication appears in Southeast Turkey during the early PPNB. This is contemporary with sites from other areas of the Near East. We need more sites and existing material needs to be re-examined for the question of domestication in Southeast Turkey to become clearer.

DNA ANALYSES OF MODERN POPULATIONS OF WILD PROGENITORS OF CEREALS

Several genetic studies have tried to locate wild populations which represent the common ancestors of domestic crops (Heun et al. 1997; Badr et al. 2000; Salamini et al. 2002). Others have provided more general information (Ishii et al. 2001; Özkan et al. 2002; Tanno et al. 2002; Thuillet et al. 2002). In studies carried out on einkorn, barley, and emmer by Salamini and his colleagues, populations were compared using amplified fragment length polymorphisms (AFLPs) from a large number of loci. The results give an estimate of genetic similarity between wild and domestic populations; the wild population closest to the domestic populations being the assumed ancestor. The validity of this method has been questioned (for a recent debate see Allaby et al. 2010).

Einkorn was seen as having a single ancestor in Southeast Turkey where rapid domestication occurred soon after cultivation started (Heun et al. 1997). This fitted the model of Daniel Zohary which suggested monophyletic origins and rapid domestication. Results from other crops give a more complex picture, and new work now sees the situation as being far more complex, with the possibility of multiple domestications over a wide geographical region (Jones and Brown 2007; Kilian et al. 2007; Reeves and Richards 2007; Özkan et al. 2011). DNA studies rely on present-day populations which are not representative of the historical spectrum, because over the past 10,000 years many cereal varieties became extinct. This occurred when new improved crops were adopted, pushing out less productive varieties. Not surprisingly, archaeological remains of wheat that represent extinct varieties have been found (Kislev 1980; Jones et al. 2000). In addition, wild progenitor habitats have been reduced through human impact. These genetic impoverishments would have been particularly strong within the area of the Fertile Crescent. Future studies will no doubt assess better the evidence from DNA.

THE HABITATS OF WILD EMMER, EINKORN, RYE AND BARLEY IN SOUTHEAST TURKEY

Southeast Turkey is one of the richest areas in the Near East for the wild progenitors of cereals and pulses; others include Northwest Syria and the Jebel Druze in Southern Syria. These areas are favourable thanks to the relatively high rainfall and large expanses of basalt (Davies 1985; Valkoun et al. 1998). The wild wheats and rye are calcifuge plants growing best on volcanic soils, however the former can be found on deep decalcified terra rossa soils in limestone areas (Willcox 2005). Massive stands of wild einkorn, emmer, and rye are found today on basalt soils. An area where wild cereals and pulses are particularly well preserved is the basalt mountain of Karacadağ, which rises to 1800 m and is situated between Urfa and Diyarbakır. Basalt areas in Southeast Turkey would have provided massive wild stands. In contrast, the Pliocene chalk which makes up most of the Euphrates Basin in Northern Syria has poor thin soils, which are not suitable habitats for wild wheat or rye. If more humid conditions combined with lower temperatures are taken into account, wild wheat and rye may have grown farther south than the present-day wild stands. Hillman (Hillman 2000) argues that wild stands of rye and einkorn were growing not far from Abu Hureyra, in the Middle Euphrates, before the Younger Dryas and that the climatic deterioration of the Younger Dryas caused the cereals to decline. However, during or after the Younger Dryas it is improbable that wild einkorn and rye grew extensively in Northern Syria in the area between Dja'de and Abu Hureyra. This has led researchers such as van Zeist and Bakker-Heeres (van Zeist and Bakker-Heeres 1986), Cauvin (Cauvin 1994: 86), Salamini (Salamini 2000) and Willcox (Willcox 2002a, 2005) to suggest that wild rye and einkorn found on sites such as Mureybet and Jerf el Ahmar were brought in by man because they could not have grown wild in the area.

In Southeast Turkey, high rainfall and rich soils allowed the development of vast stands of wild progenitors of cereals. Thus the occupants of sites such Göbekli Tepe, Nevalı Çori, or Çayönü would have had much less incentive to cultivate than the occupants of the Syrian sites such as Jerf el Ahmar (Willcox and Fornite 1999; Willcox et al. 2008), Abu Hureyra, and Mureybet, all situated farther south in a region which lacked the ecological requirements necessary for wild wheat and rye, but not so adverse that they not be cultivated. Experimental cultivation at Jalès in Southern France has shown that both rye and einkorn can be cultivated on calcareous soils (Willcox 1999). This may be because, under cultivation, competition from other plants is removed.

Wild barley has different ecological requirements than wheat and rye. It ripens earlier than wheat, so it is better adapted to lower, warmer latitudes, and it can grow on the poor chalk soils of the Middle Euphrates. Barley is a minor component on tenth millennium sites and later sites in Southeast Turkey and is in some cases absent. It becomes more common in later periods. In contrast, it is a major component of sites in the Southern Levant (Willcox 2005).

Some authors have argued for a core area in Southeast Turkey based on the overlap distribution of present-day wild progenitors. This hypothesis does not fit the data. For example all progenitors with the exception of chickpea occur naturally over a wide area of the Near East and were indeed exploited during the Natufian and PPNA in areas far from Southeast Turkey. The earliest finds of chickpea come from sites far from their present-day natural habitat. The distribution of wild progenitors has been reduced over the last 10,000 years due to human impact on the vegetation and to climate change, so that what we see today are relics in isolated areas.

CONCLUSIONS

Southeast Turkey falls within the oak/pistachio open forest zone, most of which has succumbed to deforestation since the Early Holocene (Willcox 2002b). At the two earliest sites, Hallan Çemi and Demirköy, which are considered sedentary hunter-gatherer sites, wild progenitors of cereals are rare. The plant assemblages are dominated by two valley bottom species and nuts such as *Pistacia* and almond. There is no evidence for cultivation and there are no cereal chaff remains. On the other hand, as stated above, small-scale cultivation would not be recognisable in the archaeobotanical record, so perhaps we should not totally exclude this option; for example, the pulses do not produce extensive wild stands so cultivation might have been preferred over gathering.

There is a striking similarity between the two sites in Southeast Turkey, Hallan Çemi and Demirköy and the Middle Euphrates sites of Mureybet 1 and 2 and Abu Hureyra 1. This similarity is seen in the relatively high frequencies of *Rumex/Polygonum* and club-rush (*Bolboschoenus maritimus* type). At Abu Hureyra, Hillman suggested that rye cultivation started as a response to a decline in cereals during the Younger Dryas (Hillman et al. 2001: 386, 390). These sites are not dominated by cereals. Large-scale use of cereals appears earlier in Northern Syria at sites such as Tell Qaramel, Jerf el Ahmar, and Mureybet than in Southeast Turkey. Colledge (Colledge 1998: 130) and Willcox's group (Willcox et al. 2008) argued for pre-domestic agriculture at these sites whereas this phase is not so clear in Southeast Turkey. This may in part be due to the lack of good data. An alternative explanation is that the inhabitants of the sites in Northern Syria may have been encouraged to cultivate at an earlier date than those in Southeast Turkey because they lived in areas where wild cereal stands were either far from settlements or limited in their extent. This is in contrast to Southeast Turkey where, at Göbekli Tepe and Nevalı Çori, massive wild stands would have been locally available. Farther east at Qermez Dere and M'lefaat (Savard et al. 2003), small-seeded grasses outnumber the wild progenitors of cereals. So unless the small grass seeds are over-represented, being the unwanted residue, inhabitants were not selective in their gathering (for exact proportions see Savard et al. 2006: tab. 1).

Recent findings concerning the adoption of cultivation in Southwest Asia demonstrate that each region developed specific characteristics in terms of crops, weeds, and cultural attributes. Neither archaeobotany nor archaeology point to a single centre of origin for cultivation and domestication from which agriculture could have spread by linear diffusion. Southeast Turkey has been cited as being the "core area" for the origins of agriculture in the Near East. While its key geographical position and the spectacular archaeological developments during the PPNA are of paramount importance to the understanding of the origins of agriculture, we cannot ignore that communities far to the south and east or on the island of Cyprus adopted cultivation independently and that in these areas mixed farming became established independently.

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