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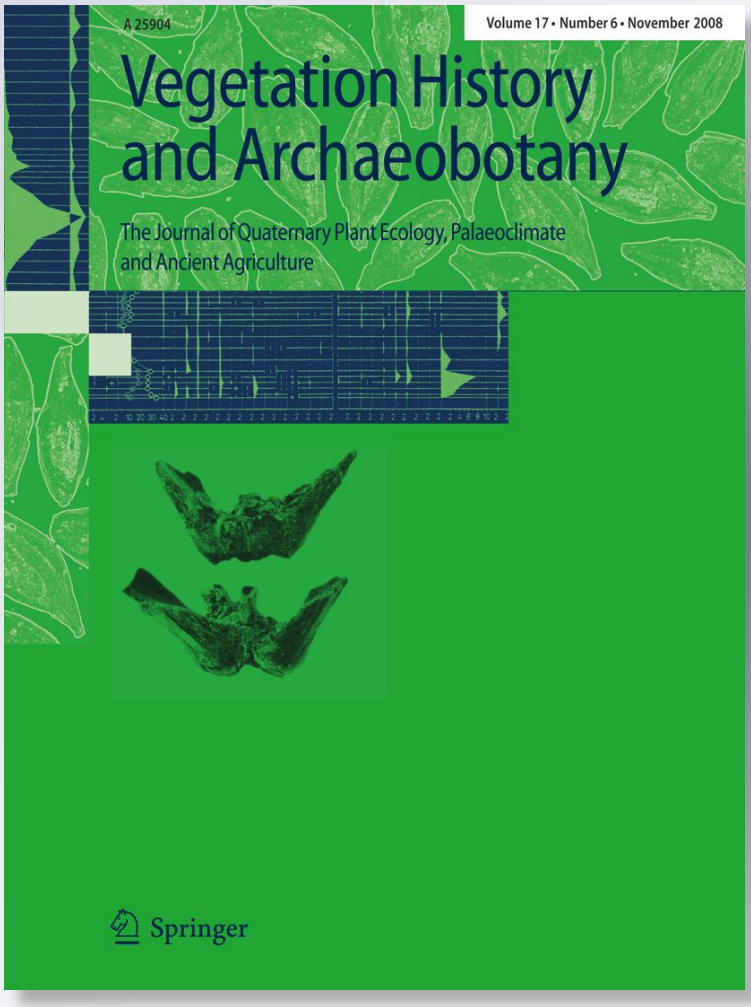

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SHORT COMMUNICATION

Searching for the origins of arable weeds in the Near East

George Willcox

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Abstract This short note adds to earlier attempts at identifying arable weeds on late Pleistocene/early Holocene sites in the Near East. Nineteen potential arable weed taxa that have no known use were selected. The occurrence of these taxa at sites with morphologically wild cereals was compared to sites with morphologically domestic cereals. The presumed arable weed taxa were as common on three PPNA (Pre Pottery Neolithic A) sites without domestication as they were on Middle PPNB (Pre Pottery Neolithic B) sites with domestication, which lends support to arguments for pre-domestic cultivation at the former sites. Arable weed taxa were less common at Natufian sites but their presence raises the question of whether they originated in cultivated fields or were the ancestors of weeds gathered accidentally alongside wild cereals in their natural habitat.

Keywords Weeds · Origins · Near East · Pre-domestic cultivation · Domestication · Agriculture

Introduction

Arable weeds have been evolving within agro-ecosystems since agriculture began. They have adapted to the agricultural niche in many different ways, by increasing seed numbers, by mimicking cultivars, by adapting their growth cycle, or by developing dormancy, to mention a few adaptive changes. Today's weed assemblages consist of species which came into the agricultural ecosystem from diverse regions and then spread around the world. Some common weeds are native to the Near East and their origin may be linked to the beginning of cultivation. Many weeds have evolved to such an extent we cannot recognize their wild predecessors in the natural vegetation, their habitat being restricted to the agro-ecosystem; these are the obligatory weeds (Zohary 1950). Many of the potential weed taxa discussed here are represented by known obligatory weeds.

The adoption of cultivation by sedentary societies in the Near East entailed tillage. This is essential for the successful cultivation of cereals and pulses. It removes competing plants and provides a seed bed. This working of the soil provided a favorable habitat not only for the cultivars but also for arable weeds.

During the late Pleistocene/early Holocene in the Near East, plants that were opportunistic colonizers that thrived on disturbed ground would have invaded and proliferated in early field systems. Pre-domestic cultivation of wild cereals and pulses dating from about 11,500 years ago at onset of the Holocene has been reported at 12 sites (Table 1). Morphologically domestic wheat and barley became established by about 10000 cal. B.P. and the earliest domestic cereals date to about 10500 cal. B.P. (Nesbitt 2002; Colledge et al. 2004; Fuller 2007). Several scholars have used weeds to identify pre-domestic cultivation (Colledge 1998, 2002; Hillman et al. 2001; van Zeist and Bakker-Heeres 1984; Willcox et al. 2008). Arable weeds are probably the best indicator of pre-domestic cultivation when the crops were morphologically indistinguishable from their wild ancestors. Other possible signs of pre-domestic cultivation, but which are not reliable on their own, include crops occurring far from their natural habitats (although this could result from highly mobile

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Table 1 Sites with wild cereals where pre-domestic agriculture has been proposed

Sites	Period	References
Mureybet, Syria	PPNA	Van Zeist and Bakker-Heeres (1984); Colledge (1998)
Cayönü, Turkey	PPNB	Van Zeist and de Roller (1994)
Netiv Hagdud, West Bank	PPNA	Kislev (1997)
Abu Hureyra, Syria	Natufian	Hillman et al. (2001), see also Colledge and Conolly (2010)
Zahrat adh-Dhra, Jordan	PNNA	Edwards et al. (2004), Meadows (2004)
Jerf el Ahmar, Syria	PPNA	Willcox et al. (2008)
Tell 'Abr, Syria	PPNA	Willcox et al. (2008)
Dja'de, Syria	PPNA/B	Willcox et al. (2008)
Gilgal, West Bank	PPNA	Weiss et al. (2006)
Dhra', Jordan	PPNA	Kuijt and Finlayson (2009)
El-Hemmeh, Jordan	PPNA	White and Makarewicz (2011) (this volume)

hunter-gatherer societies), a reduction in non-founder gathered plants, the introduction of new founder crops, large-scale exploitation of wild cereals and an increase in grain size. These signs reinforce arguments in favour of pre-domestic cultivation when found in conjunction with potential arable weeds (Willcox et al. 2008). Until now, research into early arable weeds in the Near East has concentrated on single sites with the exception of work by Colledge (Colledge 1998; Colledge et al. 2004; Coward et al. 2008) who demonstrated the spread of weeds and potential weed taxa with their crops from the Near East to Europe. Kreuz et al. (2005) identified arable weeds of Near Eastern origin among early Neolithic crop assemblages from the Linearbandkeramik and the Bulgarian Neolithic. The number of arable weed taxa and the frequencies of their charred seeds were similar at these European sites compared to the early Neolithic of the Near East. The low numbers of taxa compared with today's weed flora could be because early Neolithic weed assemblages represent the initial stages in the evolution of weed floras and that many taxa became incorporated into the agro-system at later dates.

In this brief report presence/absence of potential weed taxa was compared at sites with domestic cereals to sites with wild cereals. Domestication is defined by a partial loss of the dispersal mechanism and can be identified from the abscission scar on charred spikelet fragments (Tanno and Willcox 2011, this volume).

Materials and methods

Choice of taxa

An initial choice of taxa was based on analyses carried out at the PPNA (Pre Pottery Neolithic A) Euphrates sites of Jerf el Ahmar and Dja'de, where it was concluded that pre-domestication cultivation had taken place and where a weed assemblage was identified (Willcox et al. 2008). At these sites 97 taxa were identified of which 35 were potential weeds; however some of these could have been wild species that were gathered because they were edible, for example *Alyssum*, small seeded grasses, *Vicia*, *Polygonum* and *Chenopodium.* Others were ruderals and may have grown around habitations rather than in fields, such as *Androsace maxima*, *Hyoscyamus*, *Peganum harmala* and *Tribulus terrestris*. These taxa were eliminated from the study, leaving 19 taxa which have no known use for their seeds but which are recognized as arable weeds on later Neolithic and Bronze Age agricultural sites. The only plant in the list which has a use, but only for its leaves, is *Valerianella* (corn salad). The 19 taxa (Table 2) may appear to be few compared with the numbers of weed taxa found in fields in the Near East today. However, this small number corresponds to the number of taxa found on Bronze Age sites in the Near East (Van Zeist 1993) and European Neolithic sites (Kreuz et al. 2005) when excluded taxa are taken into account. Rare taxa occurring at only one site were not used. These include: *Ononis*, *Camelina*, *Lithospernum*, *Malva*, *Reseda*, *Convolvulus*, *Bupleurum*, *Neslia*, *Melilotus*, *Carthamus*, *Euphorbia*, *Isatis*, *Medicago radiata*, *Moluccella*, *Kickxia*, *Ranunculus* and *Turgenia*.

The chosen assemblage consists of taxa identified to genus level. The reasons for this restricted level of identification are due to morphological variability within species, poor preservation, lack of adequate reference material and because many of the genera have high species diversity with several morphologically similar species that are difficult to distinguish (Table 2). Most of the taxa selected represent genera that have obligatory weed species. The progenitors of obligatory weeds are not known, which may be another reason that specific identifications are problematical. Photographs of charred specimens are available at http://g.willcox.pagesperso-orange.fr/archaeobotanical%20images/index1.htm.

Table 2 The criteria for the selected taxa were (1) they had no known use for their seeds, (2) they were interpreted as arable weeds on later agricultural sites

Potential weed taxa	JA 1	JA 2	DJ	Extant weed species
Adonis	17	38	48	*A. microcapa*[a], *A. dentata*
Bellevalia	107	72	27	*B. warburgii*[a], *B. egii*, *B. macrobotrys*[a], *B. longipes*[a], *B. trifoliata*, *B. kurdistanica*
Centaurea	2	17	338	*C. procurrens*, *C. verutum*[a], *C. verutum*
Coronilla	2	1	4	*C. scorpioides*, *C. repanda*
Crucianella	1	1		*C. herbacea*
Erodium	20	13	66	*E. moschatum*, *E. cicutarium*
Fumaria	6	2	24	*F. densifolia*, *F. micrantha*, *F. tenuiflora*, *F. parviflorum*[a]
Galium	68	118	67	*G. uropetalum*[a], *G. tricorne*[a], *G. tricornutum*
Glaucium	1	12	288	*G. corniculatum*[a], *G. leiocarpum*
Heliotropium	14	4	19	*H. europaeum*[a], *H. villosum*, *H. rotundifolium*, *H. bovei*
Onobrychis	5	1	107	*O. squarrosa*
Ornithogalum	13	1	2	*O. narbonense*[a], *O. brachystachys*, *O. neurostegium*
Papaver	1	1		*P. rhoeas*[a]
Silene/Gypsophila	126	372	148	*S. muscipula*[a], *S. colorata*, *S. damascena*[a], *S. longipetala*
Teucrium			4	*T. spinosum*[a], *T. parviflorum*
Thymelaea	9	9	5	*T. hirsuta*
Trigonella astroites	15	15	10	*Trigonella*
Vaccaria			1	*V. segetetalis*[a]
Valerianella			2	*V. coronata*[a], *V. vesicaria*[a]
Totals	407	677	1,160	

Absolute totals from the lower levels at Jerf el Ahmar (JA1), from the upper levels at Jerf el Ahmar (JA2) and from Dja'de (DJ). Note the increase in totals between early and late levels at Jerf el Ahmar. Extant weed species corresponding to the genera, after Zohary (1950)

[a] Indicates obligatory weed, that is arable weeds not known outside cultivation

Choice of sites

Sampling and preservation of charred material vary from site to site. Pre-domestication sites were chosen that had over 10,000 identified items, with the exception of Netiv Hagdud. The total number of items (excluding charcoal) identified for each site is given in Table 3. Many early Neolithic sites were excluded because they were poorly sampled, for example Nevali Çori, Cayönü, M'lefaat, Mureybet, Zahrat adh-Dhra and Ganj Dareh.

Results

The presence of taxa at the selected sites is given in Table 3, Fig. 1 plots diachronically the number of taxa per site. Taxa increase from two for the Upper Palaeolithic site, six for the two Natufian sites and between 9 and 16 out of the 19 for the PPNA sites. Early Neolithic sites with domestic cereals have between 12 and 17. All nineteen taxa were present and frequent on Bronze Age sites (Table 2).

PPNA sites with wild cereals have a similar number of taxa, and in some cases more than later agricultural sites with domestic cereals. This lends support to the arguments in favour of pre-domestic cultivation at PPNA sites. The number of taxa is higher than would be expected at PPNA Hallan Çemi where no pre-domestic cultivation was suspected (Savard et al. 2006). With regard to the Natufian sites the numbers are also relatively high; however, we cannot be sure that the frequencies from only two sites are representative. It is possible that these represent weed progenitors which grew alongside wild cereals or pulses in their natural habitat and were accidently gathered with them. This is presumably the case for the two taxa found at Ohalo II. The increase in the number of taxa at later sites suggests the gradual evolution of an arable weed flora. However, changes in the number of taxa may be affected by differences in the intensity of sampling and regional variation in the local vegetation. The latter was noted by Colledge (Colledge 1998; Colledge et al. 2004). Harvesting and processing techniques may also affect the presence of weed taxa. Low numbers of taxa at fully agricultural sites such as Çatal Höyük and Abu Hureyra 2 could have occurred if techniques were developed to control weeds, but at other agricultural sites weeds may be under-represented due to low level sampling. Taphonomic factors also play a role. Hard,

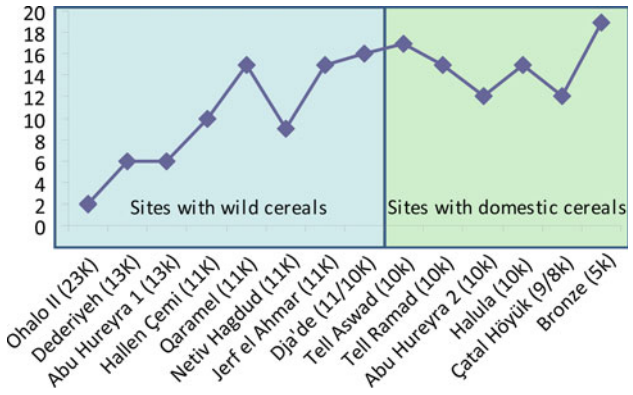

Fig. 1 Numbers of potential weed taxa (*vertical axis*) present at selected Near Eastern sites (*horizontal axis*) with their approximate dates (kyrs cal B.P.). Sites without domestication are on the *left*, those with domestication on the *right*

Table 3 Presence of potential weed taxa on selected sites and total items identified for each site

	Ohalo II (23K)	Abu Hureyra 1 (13k)	Dederiyeh (13K)	Netiv Hagdud (11K)	Hallen Çemi (11K)	Qaramel (11K)	Jerf el Ahmar (11K)	Dja'de (11/10K)	Tell Aswad (10k)	Tell Ramad (10k)	Abu Hureyra 2 (10k)	Halula (10k)	Çatal Höyük (9/8k)	Bronze (5k)
Potential weed taxa														
Adonis			p	p	p	p	p	p	p		p	p	p	64
Bellevalia		p		p	p	p	p	p	p	p		p	p	32
Centaurea			p	p	p	p	p	p		p	p	p		72
Coronilla						p	p	p	p	p		p		63
Crucianella			p			p	p			p		p	p	18
Erodium	p	p		p			p	p	p	p	p		p	4
Fumaria				p	p		p	p	p	p	p	p		63
Galium	p	p		p	p	p	p	p	p	p	p	p	p	180
Glaucium						p	p	p	p	p	p	p	p	40
Heliotropium		p		p	p	p	p	p	p	p	p	p	p	68
Onobrychis		p		p			p	p	p	p	p	p		28
Ornithogalum						p	p	p	p	p	p			33
Papaver			p			p	p	p	p		p	p		30
Silene/Gypsophila		p	p	p	p	p	p	p	p	p	p		p	106
Teucrium					p			p		p	p	p	p	41
Thymelaea					p	p	p	p	p				p	43
Trigonella astroites			p			p	p	p	p	p		p		43
Vaccaria					p	p		p	p	p		p	p	64
Valerianella						p		p	p			p	p	83
Total items identified per site	60,000	19,753	12383	> 10,000	13,750	12,247	34,067	32,964	> 10,000	> 10,000	14,996	< 10,000	> 10,000	> 10,000

Data on weed taxa was provided by S. Colledge; G. Willcox et al. 2008; R. Buxo unpublished results 2007; K. Tanno personal communication (Dederiyeh). Right hand column gives presence of taxa on Bronze Age sites, data obtained from the Archaeobotanical database of Eastern Mediterranean and Near Eastern sites, University of Tübingen http://www.cuminum.de/archaeobotany/

resistant seeds such as *Galium*, *Adonis* and *Erodium* were more frequent in terms of absolute totals than fragile, oily seeds such *Papaver*, *Fumaria* and *Glaucium*.

Discussion

The interpretation of the data is limited because identifications are only to genus level, which at present precludes the analysis of functional attributes (Jones et al. 2005, 2010). In addition, the 19 genera contain species common in the Irano-Turanian and Mediterranean phytogeographical regions of the Near East, which in turn precludes the identification of a specific region or habitat from which the weeds might have originated.

An assemblage of potential weed taxa appears to have been established by the PPNA, lending weight to arguments for pre-domestication cultivation during this period. For a weed flora to develop cultivation would have been carried out regularly on the same plots. Hallan Çemi (Fig. 1) had low frequencies of cereals and relatively high frequencies of pulses, suggesting the possibility that the arable weeds at this site may have come from pulse cultivation. Low frequencies at Netiv Hagdud may be due to regional differences; indeed this site had a similar composition to Zahrat adh-Dhra (Meadows 2004) which is also situated in the Jordan valley. The frequencies at the Natufian sites of Abu Hureyra and Dederiyeh are low but nevertheless present. Because of this we should not totally discount the possibility of cultivation at Natufian sites.

We cannot ignore the possibility that sedentary Natufian societies were capable of growing crops. What are the arguments for this? Humans who rely on gathering have a detailed knowledge of the ecology and biology of a large number of plants and they may apply this knowledge to encourage the reproduction and multiplication of edible tubers or seeds to avoid exhausting resources and assure future supplies. Ethnographic examples of plant nurturing by gatherers who had little or no contact with agriculture have been documented for native Australians, the Bushman of the Kalahari and Native Americans (Harlan 1995; Steensberg 1986; Harris 1977). Because this practice occurs across three continents it is plausible to hypothesize that it was common knowledge and part of the collective memory among *Homo sapiens,* having been passed down for generations. Arguably this collective memory and cultural tradition for tending plants may go back to the Palaeolithic, which could explain why humans adopted cultivation independently in at least 10 centres (Diamond 2002) and perhaps as many as 20 (Purugganan and Fuller 2009) in diverse regions around the world. Thus we should not underestimate Natufian societies who may have possessed the knowledge to carry out cultivation.

Conclusion

This short note complements earlier attempts at identifying arable weeds at pre-domestication sites in the Near East.

The establishment of a more dependable list of potential taxa demonstrates that the Neolithic weed flora was already established by the PPNA. In the middle Euphrates area this was over a millennium before the appearance of morphological domestication. However this present study is too incomplete to draw firm conclusions with regard to the origins and spread of arable weeds. I hope these modest results will encourage future studies to include more sites and to achieve species identifications. Specimens from different regions and sites need to be closely compared. This should hopefully lead to more refined identifications, which would allow more potential arable weed taxa to be included such as rare taxa and useful taxa which are not considered here. With more precise identifications it should be possible to identify regional differences and apply functional attribute analysis which would undoubtedly add to our understanding of the origin and spread of arable weeds in the Near East.

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