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Evidence for plant exploitation and vegetation history from three Early Neolithic pre-pottery sites on the Euphrates (Syria)

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Abstract. Archaeobotanical results based on a limited number of samples from three aceramic sites dating from 9800 to 7800 B.P., which are under excavation in the valley of the Middle Euphrates, are discussed. The finds are presented simply by presence, and are compared to the contemporary vegetation and finds from similar sites. Carbonised plant remains recovered by flotation from levels dated to between 9800 and 9200 B.P. (Dja'de and Jerf al Ahmar) indicate that wild cereals (einkorn wheat, rye and barley) and pulses (lentils, pea and bitter vetch) were exploited. Other plants such as wild grasses, *Pistacia*, wild almond and oak, suggest that the local vegetation provided a rich diversity of resources. A study of possible weed taxa is being carried out in order to see whether this assemblage could be used to identify the cultivation of morphologically wild cereals for this period. Ninth millennium B.P. levels at Halula see the appearance of domestic crops such as emmer, naked wheat and barley, but wild-type cereals persist. The cultivars appear to have been introduced from elsewhere and later ninth millennium B.P. species include olive and flax. Ash, vine, maple, plane, alder and elm from the gallery forest, wild rye, wild einkorn, deciduous oak, wild almond, *Pistacia*, and *Pyrus*, from the hinterland, indicate cooler conditions.

Key words: Euphrates – Early Neolithic – Cereals – Natural vegetation – Palaeoclimate

Introduction

The three sites, Dja'de, Jerf al Ahmar and Halula, are of particular interest in tracing the beginnings of agriculture in the Old World because they span the period of transition from hunter/gathering to farming communities which resulted in cereal domestication and a production economy. Cultivation prior to morphological domestication has not been identified from plant remains in the Near East. However, it has been suggested for tenth millennium levels at Mureybet (all dates in non-calibrated ^{14}C years B.P.; Cauvin 1994). The scarcity of sites and material from the crucial period [Pre-Pottery Neolithic A (PPNA) and early Pre-Pottery Neolithic B (PPNB)], i.e. 10 000-9000 B.P., makes the archaeobotanical study of Dja'de and Jerf al Ahmar of particular interest for our understanding of the transition to cultivation and cereal domestication.

New evidence, such as the discovery of natural stands of *Triticum urartu* and *Triticum boeoticum* which are more widespread than previously supposed in Syria (Valkoun, 1993), could have been even more widespread in the Epipalaeolithic and Neolithic. Plant names follow Moutarde (1966-83), except for the genus *Triticum* where Miller (1992) is followed. New data on climatic conditions within a more precise chronological framework (Baruch and Bottema 1991; Moore and Hillman 1992) are helping to explain the environmental setting during the transition from hunter/gathering to farming communities. In addition, the confirmation of the presence of wild rye at a number of early sites (Hillman et al. 1993; see also below) is of significance both as an early wild cereal and as a climatic indicator because it is adapted to the cooler mountainous zone. A reassessment of the criteria and evidence for morphological domestication by Kislev (1989; 1992) suggests that evidence for plant domestication before the end of the tenth millennium is still slight. But more recent results from Anatolia appear to suggest domestication during the latter part of the tenth millennium B.P. (van Zeist and de Roller 1994; de Moulins 1993). Finally experimental studies are giving a theoretical indication of the lapse in time between the beginnings of cultivation and morphological domestication (Hillman and Davies 1990; Willcox 1991, 1992).

The three sites discussed are part of a wider project involving different disciplines. The archaeobotanical study has three themes as follows:
1. Identification of carbonised plants in order to understand their possible exploitation and the evolution of the plant economy.
2. Charcoal analyses in order to show the availability of woody species, and by extrapolation the vegetation history for the periods concerned.

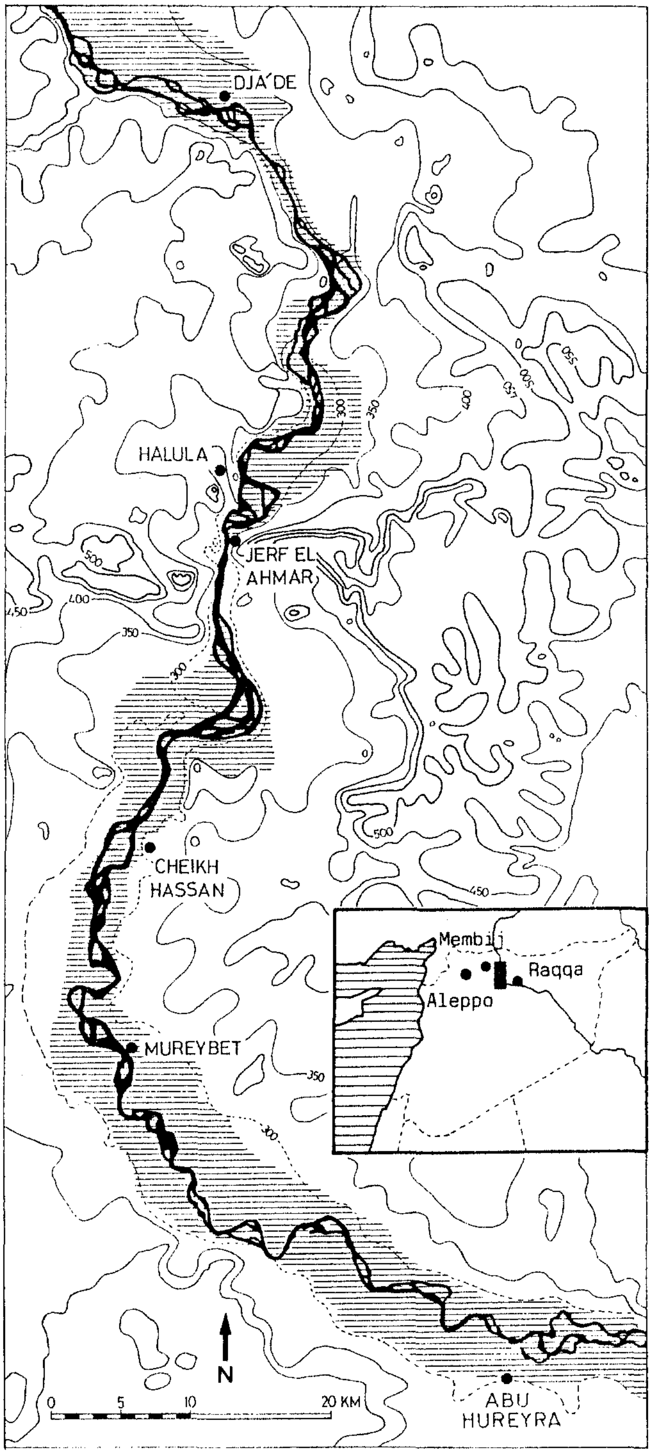

Fig. 1. Map showing the locations of Neolithic sites on the middle Euphrates. The shaded area marks the extent of alluvial deposits; contours are given in metres

3. Modern vegetation studies to provide data as an interpretative tool for the identification and interpretation of the archaeobotanical material from the region, which still remains problematic.

The sites are situated in the Euphrates valley about 100 km east of Aleppo (Fig. 1). The sites are threatened by dam construction and are being excavated by the Institut de Préhistoire Orientale and the University of Barcelona. The present-day natural vegetation in the region is a degraded steppe, which is discussed below in relation to the archaeobotanical finds. The climate varies from north-west to south-east (Fig. 2).

The earliest site, Jerf al Ahmar, is situated just upstream from the dam on the east bank where the chalk hills rise out of the flood plain, and is PPNA in date (Cauvin and Molist 1991). Thirty kilometres to the north, on the east bank and situated on a conglomerate terrace which forms a promontory, is the early PPNB site of Dja'de (Coqueugniot, 1994). On the west bank, 4 km from the main Euphrates valley, on a side valley and opposite Jerf al Ahmar, is the site of Halula which is Middle and Late PPNB in date. The sites lie upstream from Lake Assad, formed some twenty years ago by the construction of the Tabqa dam which flooded a number of contemporary early agricultural sites such as Mureybet and Abu Hureyra. These were also the object of archaeobotanical studies (van Zeist and Bakker-Heeres 1984; Hillman et al. 1989).

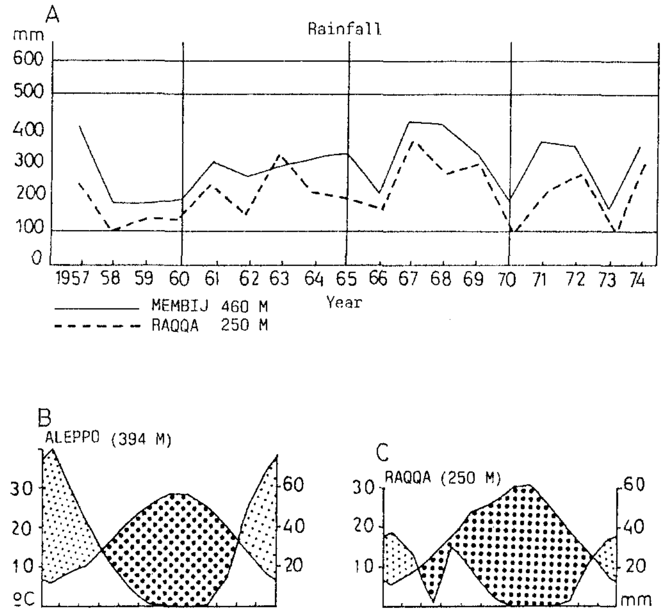

Fig. 2. **A** Annual rainfall at Membij and at Raqqa between 1957 and 1973 (adapted from Trabousli 1981). **B, C** climate diagrams for Aleppo and Raqqa, respectively (see Fig. 1 for locations). Concave curves, monthly rainfall (in mm); convex curves, monthly mean temperature (in °C) (adapted from Zohary 1973, Fig. 5). Altitude of each station is given in metres

Materials and methods

The materials in this study consist, on the one hand, of ancient carbonised material recovered from the sites and on the other hand, modern plant collections and ecological data that are used as a basis for identification and interpretation. Thus the archaeobotanical results are compared with the contemporary vegetation.

Preliminary carbon dating from the three sites has yielded the following results:

1. Jerf al Ahmar (two dates; T. McClellan, personal communication): 9740±60, 9800±60 B.P.
2. Dja'de (eight dates; E. Coqueugniot, personal communication): 8990±100 to 9610±170 B.P. (date range)

3. Halula, middle PPNB (one date; Molist et al. 1995): 8700±75 B.P.
4. Halula, late PPNB (five dates): 8655±75 to 7930±310 B.P. (date range)

Soil samples were treated using a standard flotation tank in the field with 0.3 mm (flotation) and 2.5 mm (wet) sieves. The samples were then dried slowly before transport and sorting. Where possible, material was compared with modern reference material which had been gathered from various locations in the Near East. Identifications at the specific level were rarely possible because of the wide variety of possible species in the region. The present-day flora of Iraq, for example, includes 128 species of *Astragalus* and lack of a complete reference collection made it impossible to exclude all possibilities. Further, changes and distortion brought about by carbonisation under varying conditions also prevented specific identifications of many taxa. Because of these difficulties we have illustrated some of the more important taxa.

At present three seasons of excavation have yielded 320 samples using the standard technique of flotation and wet sieving. Of these, only some 50 samples have been examined. The reason for this preliminary report is that it will be several years before the final results are ready for publication, and these new finds, which have so far been made, have wide implications.

Results

In this section a brief description of selected taxa is given and palaeoecological information is discussed in the light of the modern vegetation. Items identified only to family level are not discussed. Since only a limited number of samples has been examined, no quantitative analysis is presented here. A summary of the results is given in Tables 1, 2.

Morphologically wild cereals

Secale *sp (wild rye).* This taxon was identified from impressions in daub from Jerf al Ahmar. Carbonised grains of wild rye are difficult to separate on the basis of the morphology from wild einkorn. Chemical analyses of lipid residues obtained from carbonised grains indicate the presence of rye at Mureybet and Abu Hureyra (Hillman et al. 1993). Daub from the PPNA house at Mureybet also had impressions of rye spikelets which are identified by the presence of diagnostic cilia on the keel of the lemmas. Identification to specific level has not been attempted at this stage, but the probable species are *Secale montanum, S. cereale* ssp. *vavilovii* and *S. ciliatoglume*. *S. montanum* is the most widespread today. It is a perennial which grows at an altitude above 800 m on both limestone and acid soils, while the other species are restricted to higher altitudes and acid soils (Davis 1985). The presence of rye on Euphrates sites during the tenth and eleventh millennia B.P. would appear to indicate cooler and moister climatic conditions than today.

Triticum urartu/boeoticum *ssp.* thaoudar *(two-grained wild diploid wheat).* This taxon, which was recorded as impressions in daub from Jerf al Ahmar, was distinguishable from wild rye. No attempt has been made to distinguish *T. urartu* and *T. boeoticum* ssp. *thaoudar*. Present-day natural stands of *T. urartu* occur extensively on the Jebel Druze in southern Syria (Valkoun 1992) and in 1995 the author discovered stands of the same species only 25 km north of Dja'de. These previously unknown distributions suggest that only a very minor climatic change or even the removal of the agro-pastoral factor would allow these species to extend their distribution as far as the Euphrates. *T. urartu* was the donor of the AA genome: it hybridised with an *Aegilops*, probably *A. searsii*, to form the tetraploid wheats such as *T. dicoccoides* and *T. dicoccum* (Konarev and Konarev 1993; van Slageren 1994).

Triticum/Secale *(carbonised grains; Fig. 4).* As already mentioned, *Triticum* and *Secale* are difficult to distinguish when they occur as carbonised grains. Finds ascribed to this taxon were recorded at Jerf al Ahmar and Dja'de. Numerically, they are less common than barley at these sites, and they were not recorded from the Middle and Late PPNB at Halula.

Hordeum spontaneum *(wild barley).* This identification is based on both rachis and grain material. Wild rachis fragments occur in all periods. At Halula, they are found together with the solid rachis types of domestic two-rowed barley. Grains are more problematic from the point of view of identification. As has been found elsewhere, for example at Aswad, grains close in morphology to *Hordeum distichon* were found in association with wild-type fragile rachides. These grains lack the deep angular ventral furrow and the wedge shaped-apex. This morphological type may be explained, firstly, as the domestic-type morphology arising as a result of distortion during carbonisation, or, that these grains represent the wild ancestor which is extinct. Recent ribosomal DNA spacer analyses suggests the possibility that wild weedy forms of barley arose from an unknown (extinct?) ancestor which was also the progenitor of domestic barley (Ramamoorthy et al. 1994).

Triticum dicoccoides/dicoccum *(wild/domestic emmer; Fig. 4).* Identification of the hulled wheats was problematical. Wild emmer has not been reported from tenth millennium sites on the Euphrates. This taxon is well represented from the basal layers at Halula. Spikelet forks were common and characterised by morphological variability. One type was large with long segments and smooth disarticulation scars. Others seem to have a domestic-type morphology (Fig 4.1). Both types occur with domestic barley and appear to have been part of a crop. Wild emmer, like wild einkorn, is not found in the region of the middle Euphrates today. The absence of wild wheats in the present-day vegetation of the middle Euphrates can be explained by the low rainfall. Emmer grains of domestic type are common at Halula (early ninth millennium). Emmer appears to have been introduced as a crop if one accepts its absence from earlier levels as being significant, for example at Dja'de, Mureybet and Epipalaeolithic Abu Hureyra.

Table 1. Identified carbonised plant remains other than charcoal

Site Period Age range (B.P.) Taxa	Jerf PPNA 9800-9700	Djade PPNB 9600-9000	Halula - 8700-8600	Halula - 8600-8000
Wild cereals				
Secale spikelet impression	P	-	-	-
Triticum (diploid)/*Secale* grain	P	P	-	-
Triticum/Secale grain fragments	P	P	-	-
Triticum urartu/boeoticum spikelet	P	?	-	-
Triticum cf. *dicoccoides* spikelet	-	-	P	P
Hordeum spontaneum/distichon grain	P	P	P	P
Hordeum spontaneum rachis wild	P	P	P	P
Morphologically domestic cereals				
Triticum cf. *dicoccum* spikelet	-	-	P	P
Triticum cf. *dicoccum* grain	-	?	P	P
Triticum grain naked	-	-	P	P
Triticum naked rachis	-	-	-	P
Hordeum rachis domestic	-	-	P	P
Wild grasses (steppe/weed habitat)				
Aegilops grain	-	P	P	P
Aegilops spikelet	-	-	P	P
Hordeum small grain complex	P	P	P	P
Hordeum small spikelet	-	P	-	-
Hordeum bulbosum	-	P	P	-
Hordeum bulbosum rachis	-	P	-	-
Bromus	P	P	P	P
Avena	P	-	P	-
Stem/culm	-	P	P	-
Gramineae	P	P	P	P
Edible pulses				
Lens orientalis/culinaris	P	P	P	P
Vicia ervilia	P	P	P	P
Glycyrrhiza glabra	P	-	-	-
Pisum humile/sativum	P	P	P	P
Fruits				
Amygdalus	P	P	-	-
Pistacia terebinthus/atlantica	P	P	P	P
Olea europea	-	?	-	P
Pyrus	-	P	-	-
Vitis sylvestris	-	P	-	-
Linum	-	-	P	P
Steppe species				
Atriplex	-	P	P	P
Chenopodiaceae	-	P	P	-
Chenopodiaceae with spiral endosperm	-	P	-	-
Chenopod-type	-	P	-	-
Capparis	P	P	P	P
Arnebia (two types)	P	P	P	P
Possible weed assemblage (further identification required)				
Papaver (two types)	-	P	P	P
Adonis	P	P	P	P
Polygonum	-	P	P	P
Fumaria	-	P	P	-
Glaucium	P	P	P	-
Rumex	-	P	P	P
Silene (three types)	P	P	P	P
Brassica	-	P	-	-
Ranunculus	-	P	-	-
Galium	P	P	P	P
Camelina	-	P	-	-
Steppe/weed plants				
Centaurea	-	P	P	P
Lithospermum	P	P	P	P
Heliotropium	-	P	-	-
Small seeded legumes	P	P	P	P

P indicates a record; ? indicates uncertain identification

Table 2. Results of the charcoal analyses. These results form part of a wider study being undertaken by V. Roitel which includes samples form other Euphrates sites such as Abu Hureyra, Mureybet and Cheik Hassan

Site	Jerf	Djade	Halula	Halula
Period	PPNA	PPNB		
Sub-divisions within PPNB		early	middle	late
Forest/steppe species				
Quercus (deciduous)	P	P	P	P
Prunus	P	P	-	-
Amygdalus	P	P	P	P
Pistacia cf. *atlantica*	P	P	P	P
Rhamnus	P	-	-	-
Chenopod-type	-	P	-	-
Gallery forest species				
Populus euphratica	P	P	P	P
Fraxinus	P	P	P	P
Vitis sylvestris	P	-	-	-
Alnus	P	-	-	-
Salix	P	P	P	P
Tamarix	P	P	P	P
Platanus orientalis	-	P	P	P
Gallery forest/steppe				
Acer	-	P	-	-
Celtis/Ulmus	-	-	P	P

P indicates at least one record; ? indicates uncertain identification

Morphologically domesticated cereals. At present the land above the valley floor on both sides of the Euphrates is extensively used for dry cereal farming of wheat and barley. The plateau area, including much of the Jazira, is an area of cereal production and traditionally this occurs under dry farming conditions. The irregular rainfall results in occasional crop failure and while yields are inevitably low given that the annual rainfall is about 250 mm per annum (Fig. 2), this extensive-type arable farming is economically feasible.

Triticum *cf.* monococcum *(domestic einkorn)*. This cultivar was tentatively identified at Halula but, since it was only a minor component and based on grain morphology, it could have been confused with runt emmer *(T. dicoccoides)*. This species does not seem to have been a major component on sites in the Levant as it was, for example, at Djeitun (Harris et al. 1992) or at European sites.

Triticum aestivum/durum *(naked wheat; Fig. 4)*. This naked wheat was identified from both rachis and grain material. It appears in samples from Halula but not from the earlier sites. The rachis fragment resembles that of the tetraploid *T. durum*, but this remains provisional until more material has been examined.

Hordeum distichon *(two row hulled barley)*. As already mentioned, many of the barley grains from the PPNA and early PPNB at Dja'de resemble present-day domestic two-row barley. The few rachis fragments recovered are of the wild type. Like emmer, domestic barley occurs throughout the sequence at Halula.

Wild grasses

Aegilops *cf.* tauschii. This wild grass was the donor of the D genome in the hexaploid wheats. It is common on Middle PPNB sites and is associated with domesticated wheats. Today, this species is found as a weed of cultivation in parts of northern Syria but seems to be at the limit of its distribution, it being more common further east.

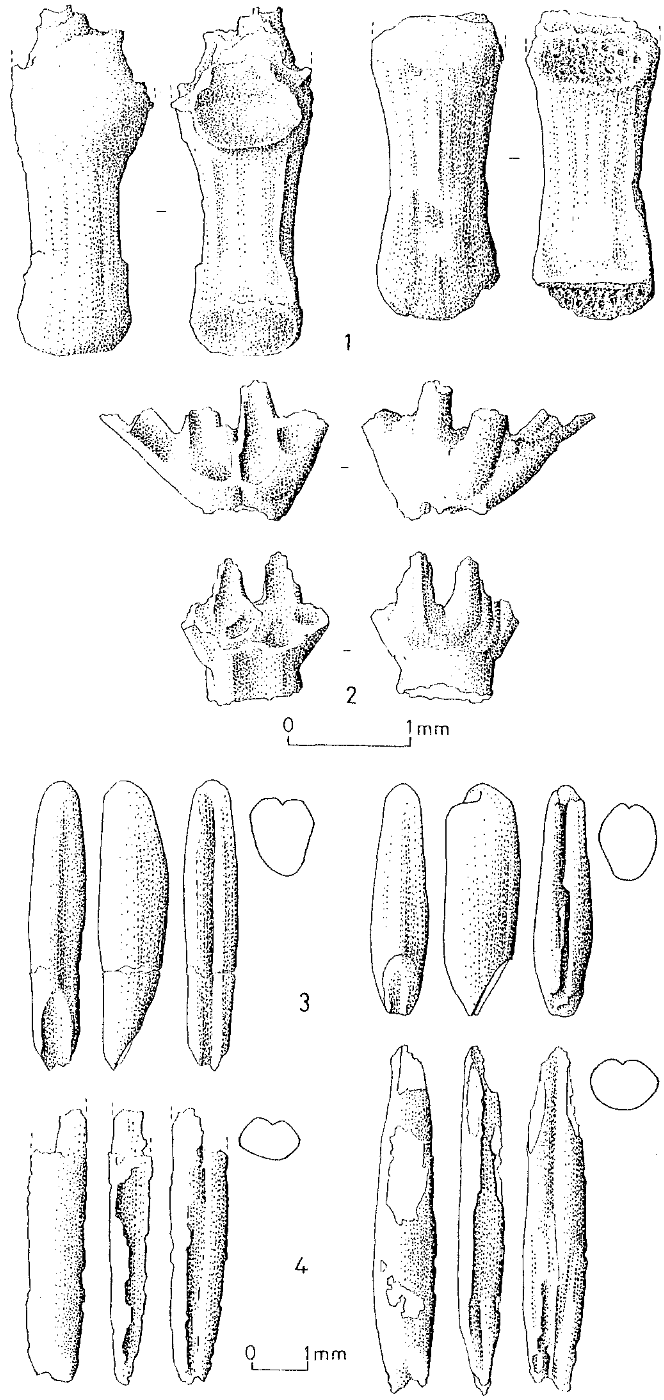

Fig. 3. 1 Dja'de (sample 37): rachis internode fragments of *Hordeum bulbosum*; **2** Dja'de (sample 37): basal spikelet fragments of *Hordeum*, type *murinum*, showing the base of rachilla of the lateral spikelet and the glume bases of the central spikelet; **3** Dja'de (sample 37): carbonised caryopses of *Triticum/Secale*-type; **4** Dja'de (sample 37): caryopses of *Bromus*-type

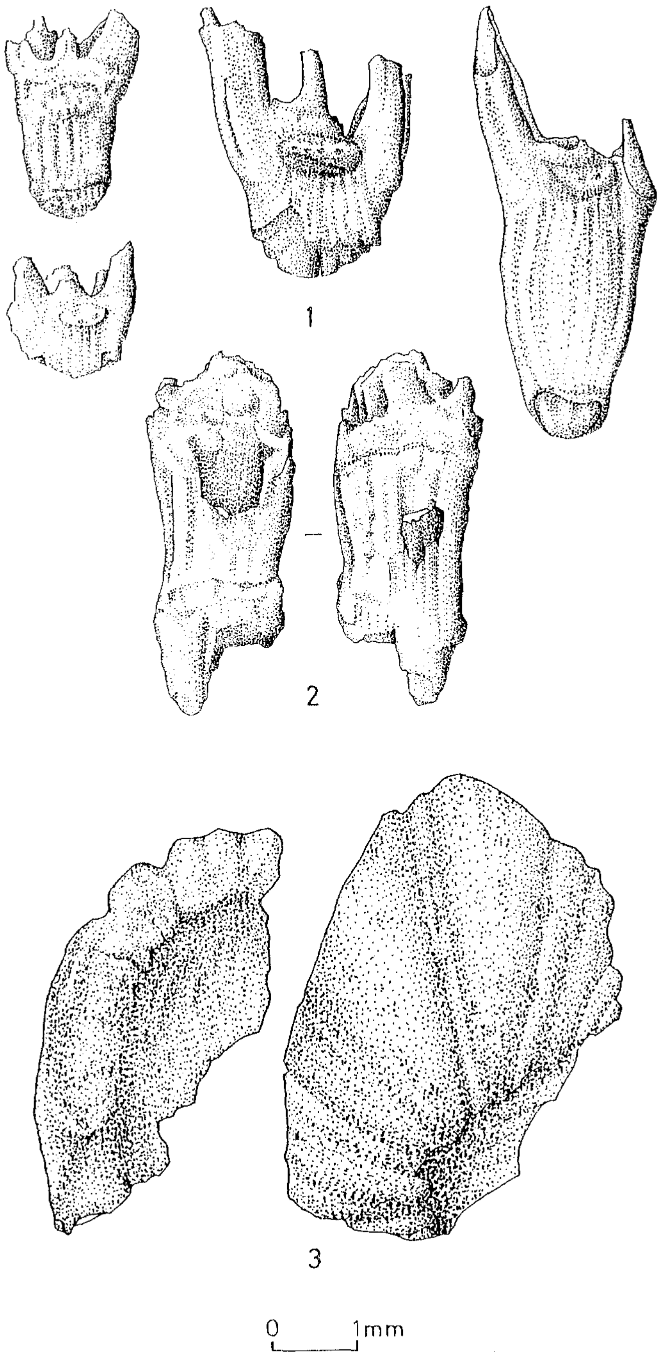

Fig. 4. 1 Halula (sample 3): problematic spikelet forks of hulled wheats; right, large robust form with smooth scar; left, small forms with rough scars. Given the morphological variability, and the possibility that ancient varieties have become extinct, taxonomical divisions are questionable; **2** Halula (sample 3): solid rachis of naked wheat *T. aestivum/durum*. The straight sides and the adhering glume bases suggest *T. durum*; **3** Halula (sample 15): endocarp fragment of an olive stone. The depressions formed by the vascular bundles are preserved, as is part of the basal opening.

Hordeum *(small-grained complex, Fig. 3)*. This taxon represents a group of wild barleys with similar grain morphology. The following closely related species, which may be placed in this group, are found in Syria today: *Hordeum murinum, H. leporinum, H. glaucum* and *H. geniculatum.* Some of these species occur as part of the steppe flora but they can also infest cereal fields.

Hordeum bulbosum *(Fig. 3)*. This perennial wild barley was identified from grain material and the identifications were confirmed by the occurrence of the characteristic rachis segments (Fig. 3). Today, this species occurs further west in moister habitats.

Pulses (gathered/cultivated)

Vicia ervilia, Lens orientalis/culinaris and *Pisum sativum/humile* were found to be common on all three sites. The wild equivalents of these three taxa do not occur as part of the natural vegetation in the area today. With regard to the archaeobotanical material, it is not possible to distinguish between cultivation and gathering of pulses at this stage of the study, but the strikingly high frequency of pulses at Dja'de suggests they became an important and perhaps specialised element in the plant economy. A similar situation was found at Neolithic Abu Hureyra (de Moulins 1994).

Edible fruits

Vitis sylvestris *(wild vine, Fig. 8)*. The vine would have been part of the gallery forest vegetation which is its natural habitat. It was recorded as seed at Dja'de and as wood charcoal at Jerf al Ahmar. Today, the vine has a more northerly distribution and does not penetrate along the river valleys into the steppe.

Olea europea *(olive, Fig. 4)*. A fragment of olive stone was found at Halula and a smaller fragment was recorded from Dja'de, but the latter requires confirmation before a definite identification can be assigned. These finds are

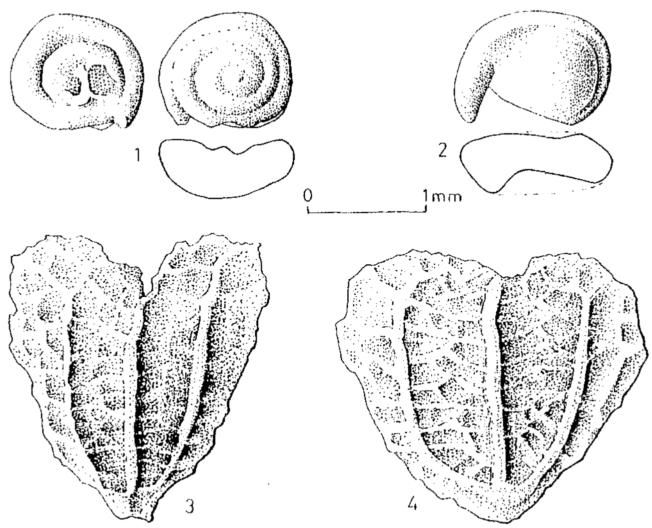

Fig. 5. 1 Dja'de (sample 37): carbonised seed of cf. *Salsola* with a spiral endosperm; **2** seed of *Atriplex*-type (sample 37); **3** fruits of *Atriplex*-type (sample 66). In some cases the bracts of modern specimens are covered with a thick layer of hairs

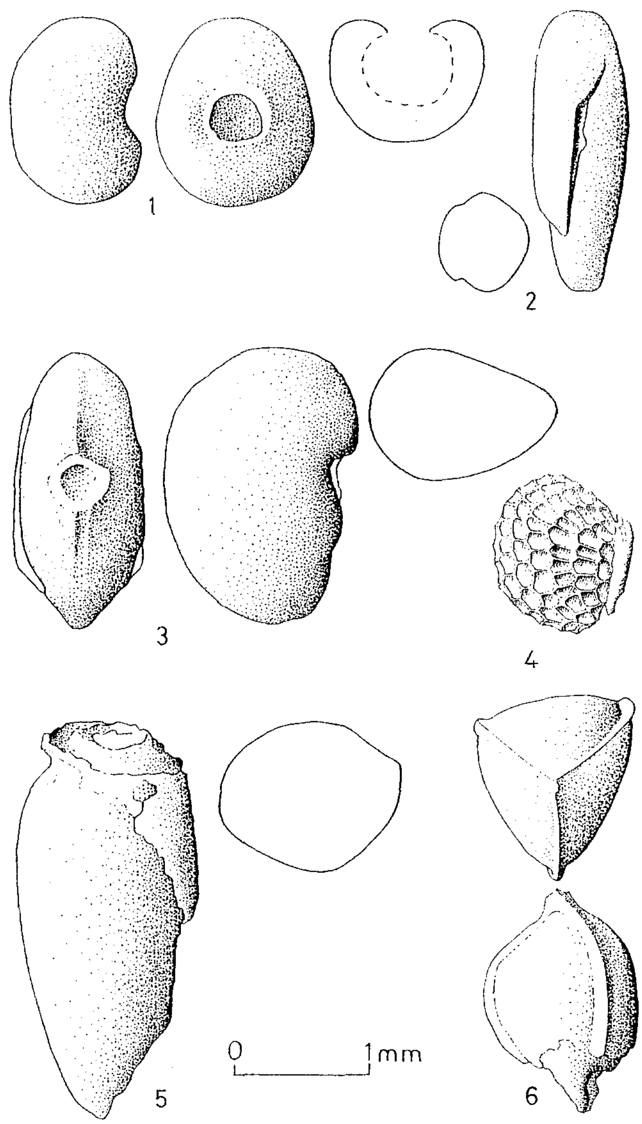

Fig. 6. Potential weed taxa from Dja'de. **1** Dja'de (sample 37): *Galium* sp.; **2** Dja'de (sample 69): Cruciferae not identified; **3** Dja'de (sample 69): small-seeded legumes, type *Astragalus, Trifolium, Melilotus,* etc.; **4** Dja'de (sample 37): *Glaucium* sp.; **5** Dja'de (sample 69): *Centaurea* sp; **6** Dja'de (sample 69): *Polygonum* sp.

surprising because, until now, Neolithic finds have come only from coastal areas, e.g. Ras Shamra, which is within the area of natural distribution.

Pistacia atlantica/palaestina. This taxon was found both as charcoal and as fragments of nutlets. The abundance of the latter suggests that it was gathered for consumption. The charcoal remains indicate that *P. atlantica* is the probable species.

Amygdalus *(wild-type almond).* This taxon was common among charcoal samples, and fragments of almond stones were frequent at Jerf al Ahmar. It would have been part of the local natural vegetation.

cf. Pyrus *(wild pear).* This taxon was identified at Dja'de. Like a number of other taxa it would appear to indicate a moister cooler climate.

Linum *sp. (flax).* Flax appears in the Middle PPNB at Halula. Being absent from earlier levels on sites in the region it could have been introduced. Measurements indicate that the process of domestication may have been already under way.

Forest/steppe assemblage and the hinterland vegetation

The steppe species are not well represented. Possible steppic taxa include *Capparis, Arnebia* and a number of chenopods; to these we could add some of the wild grasses. Charcoal analysis was particularly rewarding in showing the presence of *Pistacia* type *atlantica, Rhamnus* and *Amygdalus,* which points to a moist steppe with a mosaic of trees and shrubs. *Quercus* (deciduous oak) is also present from all periods but at low frequencies. It is probable that this species was restricted to the deep alluvial soils probably present in depressions and valley bottoms. Tree rings in many cases were found to be extremely narrow indicating environmental stress. Given the presence of oak and other trees, it is not surprising to find wild cereals which form part of the same plant association in the Near East today.

In comparison with the contemporary steppe vegetation, the archaeobotanical results indicate a moister, cooler, more continental vegetation found today at higher altitudes and more northerly latitudes. The present-day steppe is extremely rich in species and, following the rainfall pattern, it becomes more xeric towards the east. West of Jerf al Ahmar the steppe is relatively moister and is dominated by *Artemisa,* while, to the east on the other side of the hills, moist steppe gives way to dry steppe dominated by chenopods. Plants that resist grazing are often dominant and there is a great diversity of short-lived annuals. The following list includes a few of the most commonly encountered steppic plants which do not occur in the archaeobotanical samples. *Eryngium, Cousinia, Scorzonera, Salvia, Teucrium, Echinops, Phlomis, Gauginopsis mucronata, Heliotropium bacciferum, Artemisia herba-alba, Prosopis farcta, Crucianella, Lycium europaeum, Ephedra aphylla, Noea mucronata, Stipa* spp and *Aellenia glauca.*

Micro-habitats along the Euphrates valley support a few trees and shrubs. The following woody plants were collected within a 5-km radius of the site: *Celtis tournefortii* (found at Abu Hureyra during the early Natufian), *Pistacia palaestina, Crataegus aronia, Rhamnus palaestina, Prunus microcarpa, Ficus carica* and *Ficus palmata.* These species are rare, only occurring as isolated specimens along the Euphrates and its side valleys, growing in limited micro-habitats and restricted to north-facing cliffs where they are protected from grazing animals.

The archaeobotanical results show that the Neolithic vegetation resembles neither the surrounding steppe nor the Mediterranean vegetation to the west. It appears to correspond with more continental zones at higher altitudes such as the rare relics found in areas above 800 m on the Jebel Bishri, Jebel Aziz, Jebel Sinjar and the Jebel Abu Rujmayn. The relic-type vegetation at Jebel Aziz, which includes *Amygdalus orientalis, Pistacia atlantica, Crataegus azarolus* and *Prunus microcarpa,* would appear to correspond with that suggested by the results of the charcoal analyses for Jerf el Ahmar. The lowest limit of this vegetation type today, which is restricted to north-facing slopes, occurs at ca. 750-800 m.

Possible weed assemblage (Figs. 6, 7)

Taxa that are regarded as potential weeds of cultivation include *Adonis, Astragalus, Bromus, Camelina, Centaurea, Galium, Glaucium, Hordeum* type *murinum, Papaver, Polygonum, Reseda, Silene* and *Fumaria.* These taxa, which frequently form weed assemblages, are of interest because they may help to identify cultivation before domestication of crops. This approach was first attempted for Epipalaeolithic levels at Abu Hureyra (Hillman et al. 1989). As Hillman pointed out, these taxa and their precursors also occur as part of the steppe vegetation but, given the rarity of other steppe taxa in the seed material (see above), we have provisionally grouped these taxa as possible or potential weeds.

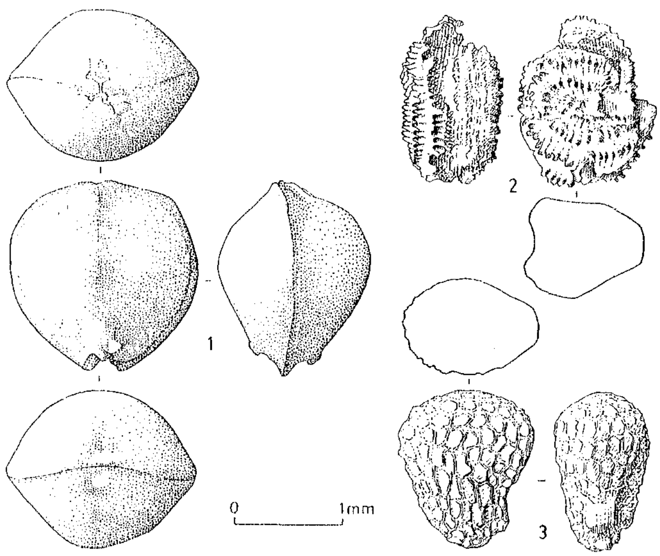

Fig. 7. Potential weed taxa from Dja'de. **1** Dja'de (sample 63): *Fumaria* sp.; **2** Dja'de (sample 67): *Silene* sp.; **3** Dja'de (sample 47): cf. *Papaver*

Flood plain species

The archaeobotanical results indicate that the flood plain vegetation was much richer during the Neolithic. Most of the charcoal, by far, is of species from this habitat. Taxa such *Populus euphratica, Salix* and *Tamarix* were common but *Alnus, Fraxinus, Platanus orientalis* and *Vitis sylvestris* were also present. Two taxa, *Acer* and *Celtis/Ulmus,* are more difficult to interpret. *Acer* could come from either the forest/steppe or the gallery forest and *Ulmus* would have been associated with a high water table, while *Celtis* comes from a drier habitat. Seed of plants from this habitat were not common but included the following: *Vitis sylvestris, Glycyrrhiza glabra, Carex* sp. and *Scirpus* sp.

The contemporary flood-plain vegetation is degraded due to over-exploitation and even *Populus euphratica* is becoming rare. *Tamarix,* on the other hand, regenerates more readily. *Salix* spp., *Tamarix, Typha, Phragmites australis, Glycyrrhiza glabra,* and *Polygonum* sp. could be archaeobotanical indicators. These plants are economically useful and provide rhizomes, wood for fuel, reeds for building and matting, and edible seeds.

Palaeoclimatic evidence

The occupation of the sites coincides with the latter part of the period of global warming following the Younger Dryas (Baruch and Bottema 1991). Thus it is probable that present-day temperatures are higher than those which occurred during the Neolithic. There are no reliable data on precipitation for this period (cf. Rossignol-Strick 1993).

The contemporary climate indicates the potential for dry-farming (cf. Kerbe 1987); archaeobotanical results indicate that conditions were more favourable during the Neolithic. The area defined by the Middle Euphrates has a climatic gradation from the north-west to the south-east (cf. Traboulsi 1981). Thus the further we proceed towards the east, the drier and more continental the climate becomes and the vegetation changes from a moist steppe to a dry steppe. Figure 2 gives the annual rainfall between 1957 and 1974 for Membij to the north-west of our area and Raqqa to the south-east. The rains in this region fall essentially in winter and spring which is ideal for cereal cultivation. During the hot summer months of June, July, August and September, rains are extremely rare.

During the Neolithic, the presence of wild einkorn and particularly wild rye indicates cooler, moister conditions. This is confirmed by gallery forest species, identified by charcoal analyses, such as ash, vine, elm and plane which, today, are only found much farther north in Turkey and Greece. Similarly, almond, *Pistacia* and deciduous oak, which nowadays only occur at higher altitudes in the region, also suggest that conditions during the Neolithic were cooler and moister.

Vegetation degradation through human impact, particularly grazing, rather than climatic change must account for some of the differences between the vegetation of the early Neolithic and that of the present day. This makes it difficult to evaluate precisely the effect of climatic change on the vegetation.

Discussion and conclusions

Regional trends are obvious when one compares sites. Tenth millennium levels in Anatolia at Cayönü (roundhouse phase) and Cafer Höyük (period XII) are rather poor in cereal remains (van Zeist and de Roller 1994; de Moulins 1993) and ^{14}C dates are scarce, but evidence for domestication at these sites, beginning at some time during the second half of the tenth millennium, increases higher in the sequence. At Aswad, in the Damascus basin, there appears to be a gradual increase in domestic barley at the expense of wild types which continues into

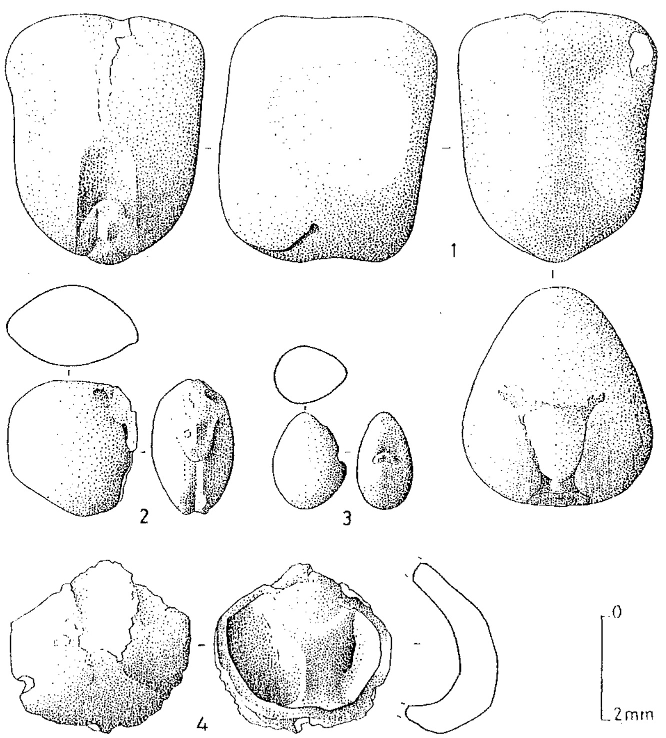

Fig. 8. 1 Dja'de (sample 28): *Lathyrus* sp.; 2,3 Dja'de (sample 19): small seeded legumes; 4 Dja'de (sample 63): fragment of *Vitis sylvestris.*

the ninth millennium (van Zeist and Bakker-Heeres 1982). At Cafer Höyük, which is later than Cayönü, emmer is reported to be domestic from the earliest levels. At these two sites, emmer is the major component in contrast to the Euphrates sites where wild einkorn and barley dominate. Emmer is not recorded until the beginning of the ninth millennium in the middle Euphrates region when domesticated cereals appear abruptly at the base of Halula. At present, there is no evidence of domestication at Dja'de, Mureybet or Jerf al Ahmar. Another difference between the Euphrates and eastern Anatolia is that barley is common on all sites on the Euphrates and at Aswad, but at Cayönü and Cafer Höyük it is rare and consists of the wild type.

On a more local level the preliminary results allow us to make the following comments.

1. Wild einkorn, wild rye, the wild pulses, deciduous oak, wild almond, ash and wild vine were present during the early Neolithic but no longer occur in the area. This suggests cooler perhaps moister conditions and more favourable human conditions than those of the present-day degraded steppe.
2. A potential weed assemblage is associated with the wild cereals. The taxa involved were probably also part of the natural steppe vegetation.
3. During the middle PPNB, the first fully morphologically domesticated cereals occur at Halula. Rapid evolution of domestic wheats is indicated by their diversity, which makes their taxonomic status problematic.
4. Wild and domestic barley and probably wheat co-existed together for some considerable time into the late PPNB. This has been confirmed from other sites such as Ramad, Goraife, Cayönu (van Zeist and Bakker-Heeres 1982; van Zeist and de Roller 1994), Magzalia (Willcox, in preparation), Cafer Höyük (de Moulins 1993) and Abu Hureyra (de Moulins 1994).
5. Oil plants *Olea europea* (olive) and *Linum* (flax) appear for the first time in the PPNB.

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References

Baruch U, Bottema S (1991) Palynological evidence for climatic changes in the Levant ca. 17,000-9,000 B.P. In: Bar-Yosef O, Valla F (eds) The Natufian culture in the Levant. International Monographs in Prehistory, Ann Arbor, pp 11-20

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

Cauvin MC, Molist M (1991) Prospection néolithique sur le Haute Euphrate Syrien. Ann Arab Syriennes 37/38: 78-90

Coqueugniot E (1994) L'industrie lithique de Dja'de el Mughara et le début du PPNB sur l'Euphrate syrien (sondages 1991 et 1992). In: Gebel HG, Koszlowski S K (eds) Neolithic chipped stone industries of the Fertile Crescent. Proceedings of the First Workshop on PPN Chipped Lithic Industries. Berlin 1993. Berlin studies in the early production subsistence and environment. Zaklad Graficzny, Uniwersytet Warszawski, Warsaw, pp 313-330

de Moulins D (1993) Les restes de plantes carbonisées de Cafer Höyük. Cah l'Euphrate 7: 191-234

de Moulins D (1994) Agricultural change at Euphrates and steppe sites in the mid-8th millennium B.C. Ph.D. thesis (unpublished), University College, London

Davis PH (1985) Flora of Turkey and the Aegean Islands, Volume 9. Edinburgh University Press, Edinburgh

Harris DR, Masson VM, Berezkin YE, Charles M, Gosden C, Hillman GC, Kasparov AK, Korobkova G F, Kurbansakhatov K, Legge AJ, Limbrey S (1992) Investigating early agriculture in central Asia: new research at Jeitun, Turkmenistan. Antiquity 67: 324-38

Hillman G, Davies S (1990) Measured domestication rates in wild wheats and barley under primitive cultivation, and their archaeological implications. J World Prehist 4: 157-219

Hillman GC, Colledge SM, Harris DR (1989) Plant food economy during the epi-palaeolithic period at Tell Abu Hureyra Syria : dietary diversity, seasonality and modes of exploitation. In: Harris DR, Hillman GC (eds) Foraging and farming: the evolution of plant exploitation. Unwin and Hyman, London, pp 40-268

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

Kerbe J (1987) Climat, hydrologie et aménagements hydro-agricoles de Syrie. Presses Universitaires de Bordeaux, Université de Bordeaux III, Talence

Kislev M (1989) Pre-domesticated cereals in the pre-pottery neolithic A period. In: Hershkovitz I (ed) People and cultural change. BAR, International Series 508 (1), Oxford, pp 147-151

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 6, Editions du CNRS, Paris, pp 87-94

Konarev AV, Konarev VG (1993) The use of genome-specific antigens and prolamin electrophoresis in the evaluation of wheat and its wild relatives. In: Damania AB (ed) Biodiversity and wheat improvement. Wiley, Chichester, pp 259-272

Miller T (1992) A cautionary note on the use of morphological characters for recognising taxa in wheats (genus *Triticum*). In: Anderson P (ed) Préhistoire de l'agriculture. Monographie du CRA 6, Editions du CNRS, Paris, pp 249-254

Molist M, Anfrunus J, Catala M, Helmer D, Faura JM, Mateau J, Palmomo A, Sana M, Willcox G (1995) Tell Halula (Siria), un poblat dels primers agricultors I ramaders des VII millenia la vall de l'Efrates. Tribuna d'Arqueologia 1992-1993 (Server d'Arqueologia, Generalitat de Catalunya, Barcelona): 49-61 xx

Moore AMT, Hillman GC (1992) The Pleistocene to Holocene transition and human economy in south-west Asia: the impact of the Younger Dryas. Am Antiq 57: 482-494

Moutarde P (1966-83) Nouvelle flore du Liban et de la Syrie, Vols 1-3. Dar el-Machreq, Beyrouth

Ramamoorthy J, Chong D, Chinnappa C (1994) Comparative assessment of genetic diversity in wild and cultivated barley using ribosomal DNA spacer length variants. Israel J Plant Sci 42: 115-123

Rossignol-Strick M (1993) Late Quaternary climate in the eastern Mediterranean region. Paléorient 19: 135-151

Traboulsi M (1981): Le climat de la Syrie: exemple de dégradation vers l'aride du climat méditerranéen. Thèse du Troisième Cycle, Université de Lyon 2, Lyon

Valkoun J (1992) Exploration mission for wild cereals in Syria. Genetic resources unit, annual report 1991. International Center for Agricultural Research in Dry Areas, Aleppo, pp16-18

van Slageren MW (1994) Wild wheats: a monograph of *Aegilops* L. and *Amblyopyrum* (Jaub. & Spach) Eig. Agricultural University Wageningen, Wageningen

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

van Zeist W, Bakker-Heeres JA (1984) Archaeobotanical studies in the Levant. 3. Late Palaeolithic Mureybet. Palaeohistoria 26: 171-199

van Zeist W, de Roller G (1994) The plant husbandry of aceramic Cayönü, SE Turkey. Palaeohistoria 33/34: 65-96

Willcox G (1991) La culture inventée, la domestication inconsciente: le début de l'agriculture au Proche Orient. In MC Cauvin (ed) Rites et ryhmes agraires. Travaux Maison L'Orient 20: 9-31

Willcox G (1992) Archaebotanical significance of growing Near Eastern progenitors of domestic plants at Jalès (France). In: Anderson, P (ed) Préhistoire de l'agriculture: nouvelles approches expérimentales et ethnographiques. Monographie du CRA 6, Editions du CNRS, Paris, pp 159-178

Zohary M (1973) Geobotanical foundations of the Near East. Fischer, Stuttgart