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Can a functional ecological model reliably reveal the nature of early plant management in southwest Asia?

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George Willcox

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A recent publication in *Nature Plants* presents a new approach to elucidate the origins of agriculture in southwest Asia. This approach uses a functional ecological model that attempts to measure soil disturbance on the basis of charred remains of crop-processing by-products[1]. This approach was developed to recognize the period when humans cultivated wild cereals before selection led to the evolutionary adaptation of the non-shattering ear[2–5]. To identify this period, referred to as pre-domestic cultivation, research has focused on identifications of charred plant remains that may correspond to arable weeds. However, these potential arable weeds also grow among wild cereals in their natural habitat. To test whether crop-processing by-products were derived from tilled cultivation or from harvests in wild habitats, Weide et al.[1] attempted to estimate levels of soil disturbance by comparing flowering durations of selected taxa from seven late Pleistocene/early Holocene sites. The following is a discussion of the reliability of this study with particular reference to two archaeological sites, Jerf el Ahmar and Dja'de.

Unsuitable taxa

Weide et al. do not provide the names of the taxa used in the analysis. This may be justified in present-day field studies in which the plant lists were obtained from precisely known habitats. But it is not justified if the habitat is unknown, as in this case. The authors obtained the taxa from an unpublished PhD thesis[6]. Eighteen taxa were chosen for Dja'de and Jerf el Ahmar. Five are unlikely to have originated in either arable or wild-cereal habitats in northern Syria for ecological reasons (see below). Nine taxa were not identified to species, and because flowering duration can vary from species to species within the same genus, these poorly identified taxa may provide imprecise durations.

The following unsuitable taxa were used for the analysis of charred plant remains at Dja'de and Jerf el Ahmar in northern Syria:

(1) *Androsace maxima* and spiny *Tribulus terrestris* are common prostrate ruderals that are not usually associated with either arable habitats or wild-cereal habitats. *A. maxima* is found in northern Syria in wild and ruderal habitats in which soils are often saline. *T. terrestris* has notoriously dangerous spines and would be avoided by harvesters.

(2) *Bolboschoenus glaucus* grows in moist habitats and is not representative of either dry-farming arable habitats or wild-cereal habitats in northern Syria.

(3) *Polygonum aviculare* is a prostrate summer annual identified as *Polygonum/Rumex* in the original Willcox et al. publication[2]. *P. aviculare* is a cosmopolitan weed whose original wild distribution is not known. It is unlikely to have occurred in either the dry-farming habitats or the wild-cereal habitats in northern Syria because it would not have tolerated the arid conditions in this region. *Polygonum* spp. and *B. glaucus* could have grown on the Euphrates flood-plain; however, wild or cultivated winter cereals cannot survive in this habitat due to late spring rains combined with ice melt in eastern Turkey, which cause violent annual flooding just at the time when cereals would be ripening[7].

(4) For Jerf el Ahmar, the analysis includes four *Bromus* taxa out of a total of 18. Only *Bromus* sp. is mentioned in Willcox et al.[2]. *Bromus* seeds have morphological overlap due to charring distortions, making identification problematic. Only two taxa are species-level identifications: *B. danthoniae* and *B. sterilis*. They are also listed as merged taxa, resulting in the possibility that these taxa were included twice in the analysis. This is also true for the two *Adonis* taxa.

The taxa chosen for Çatalhöyük in central Anatolia are more suitable, with the notable exceptions of *Phragmites australis* and *Androsace maxima*, because they cannot be considered plants of either wild-cereal or arable habitats.

Flowering duration, a functional trait

The use of flowering duration rather than multiple traits in a functional ecological model clearly has limitations. Flowering duration and timing can vary depending on environmental factors such as altitude, photoperiod, ambient temperature, ambient CO_2 concentration, water availability and soil nutrient availability[8]. In southwest Asia,

CNRS Archéorient, Lyon, France. e-mail: willcox.george@neuf.fr

flowering duration is linked to altitude zoning and latitude and so will vary depending on location. Harvests on the high Anatolian plateau (Çatalhöyük) occur at least a month later than in the south, which would favour a longer flowering duration in the north. As the authors point out, flowering duration in weeds evolved under cultivation, beginning in the early Holocene. Present-day flowering durations obtained from the *Flora Palaestina*[9] may not correspond to those of the early Neolithic because they would have evolved over the past 10,000 years.

Finally, a large-scale study of 1,383 weed species and 998 non-weed species demonstrates that there is considerable overlap between weeds and non-weeds in regard to their flowering duration[10], which suggests that the use of flowering duration as a criterion to distinguish arable from wild-cereal habitats in an archaeological context is questionable.

Archaeological samples and crop-processing by-products

Weide et al. assume that the samples chosen contained remains of crop-processing by-products. Their choice is based on a comparison of some modern ethnographic observations of crop-processing of domestic cereals[11] with early Neolithic charred samples containing wild cereals. This assumes a direct ethnographic parallel. The samples from Dja'de and Jerf el Ahmar were taken from archaeological contexts such as hearths, demolition layers, pits or dump layers that consisted of sediments accumulated from multiple activities. The samples contained charred remains (not mentioned by the authors) such as charcoal and the fruits of *Pictacia atlantica* and *Amygdalus* and other charred remains from various habitats. It is thus by no means certain that the taxa used in the analysis were derived from crop-processing by-products.

Concluding remarks

The lack of certainty that the taxa used in the analysis came from crop-processing residues and the inaccuracy concerning flowering duration place doubt on the reliability of the study for Jerf el Ahmar and Dja'de. An alternative approach, based on observations that potential weed taxa are relatively infrequent in wild-cereal habitats but thrive in cultivated tilled soils, could be rewarding. A promising research topic would thus be to search for evidence of a possible proliferation of weed taxa. However, given the accidental nature of the preservation of plant remains through charring and the fortuitous sedimentation of archaeological deposits, any information obtained from charred plant remains may contain an element of doubt.

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Competing interests

The author declares no competing interests.

Additional information

Correspondence and requests for materials should be addressed to George Willcox.

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