The ripples of “The Big (agricultural) Bang”: the spread of early wheat cultivation


Abstract: Demographic expansion and (or) migrations leave their mark in the pattern of DNA polymorphisms of the respective populations. Likewise, the spread of cultural phenomena can be traced by dating archaeological finds and reconstructing their direction and pace. A similar course of events is likely to have taken place following the “Big Bang” of the agricultural spread in the Neolithic Near East from its core area in southeastern Turkey. Thus far, no attempts have been made to track the movement of the founder genetic stocks of the first crop plants from their core area based on the genetic structure of living plants. In this minireview, we re-interpret recent wheat DNA polymorphism data to detect the genetic ripples left by the early wave of advance of Neolithic wheat farming from its core area. This methodology may help to suggest a model charting the spread of the first farming phase prior to the emergence of truly domesticated wheat types (and other such crops), thereby increasing our resolution power in studying this revolutionary period of human cultural, demographic, and social evolution.

Key words: early wave of advance of Neolithic farming, genetic ripples, Neolithic revolution, origin of Near Eastern agriculture.

Résumé : L’expansion ou les migrations démographiques laissent une trace au niveau des motifs de polymorphisme de l’ADN dans les populations respectives. Pareillement, il est possible de suivre la propagation de phénomènes culturels grâce à la datation des découvertes archéologiques et la reconstruction de sa direction et vitesse. Une suite d’événements semblables s’est probablement produite suite au ‘Big Bang’ de l’expansion de l’agriculture dans le Proche-Orient Néolithique à partir de sa zone d’origine au sud-est de la Turquie. Jusqu’à maintenant, aucune tentative n’a été faite pour suivre le mouvement des ressources génétiques fondateuses des premières plantes cultivées hors de leur zone d’origine sur la base de la structure génétique des plantes d’aujourd’hui. Dans cette mini-synthèse, les auteurs réinterprètent des données récentes sur le polymorphisme génétique chez le blé pour détecter les ondes génétiques laissées par les premières percées de la culture Néolithique du blé hors de sa zone d’origine. Cette méthodologie aidera peut-être à élaborer un modèle de l’avancée de la première phase de l’agriculture avant l’émergence de types de blés (et d’autres espèces) véritablement domestiqués. Ainsi, cela améliorera la résolution dans l’étude de cette période révolutionnaire de la culture, démographie et évolution sociale humaines.


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Demographic expansion and (or) migrations leave their mark in the pattern of DNA polymorphisms of the respective populations (Cavalli-Sforza et al. 1994). Likewise, the spread of cultural phenomena can be traced by dating archaeological finds and reconstructing their direction and pace (e.g., Ammerman and Cavalli-Sforza 1971; Gopher 1989, 1994, 1999). A similar course of events is likely to have taken place following the “Big Bang” of the agricultural spread in the Neolithic Near East. It is now widely accepted that Near Eastern farming spread from its core area in southeastern Turkey in a rather dramatic manner radiating west, east, north, and south. This is evident from the spatial and temporal pattern of archaeobotanical remains throughout the Levant, Europe, and Central Asia (e.g., Heun et al. 1997; Lev-Yadun et al. 2000; Gopher et al. 2001; Zohary and Hopf 2000). However, unlike the pioneering work on radiocarbon dates (Pinhasi et al. 2005), no attempts were made to track the movement of the founder genetic stocks of the first crop plants from their core area based on the genetic structure of living plant materials. Herein, we re-interpret recent DNA polymorphism data (Özkan et al. 2005) to detect the genetic ripples left by the early wave of advance of Neolithic wheat farming.

Based on nuclear AFLP similarity data, Heun et al. (1997) suggested the Karacadağ range in southeastern Turkey as the most probable site of einkorn (*Triticum monococcum*) wheat domestication. In line with this, Lev-Yadun et al. (2000) combined other plant genetic (e.g., wild stocks of domesticated lentils), geobotanical (e.g., the natural distribution of wild chickpea), and archaeological data to define the same region as the “core area” of Near Eastern agriculture. A recent study of nuclear DNA of wild tetraploid (*Triticum dicoccoides*) and domesticated emmer wheats (*Triticum dicoccum* and *Triticum durum*) (Özkan et al. 2002) demonstrated the close similarity between domesticated and wild populations of emmer wheat from the very same core area in southeastern Turkey. On the other hand, based on chloroplast DNA polymorphism, it was suggested that wild populations from the Kartal region (280 km west of Karacadağ, at the fringe of the above core area) donated to the domesticated gene pool 1 of its 2 major haplotypes, implying that the Kartal region is also a probable site of emmer domestication (Mori et al. 2003). These findings support (at least theoretically) the idea that emmer wheat domestication may have occurred at least twice. In an attempt to resolve the apparent discrepancy between the scenario depicted by nuclear DNA similarity data (Özkan et al. 2002) and conclusions based on plastome polymorphisms (Mori et al. 2003), Özkan et al. (2005) have re-analyzed both their original stocks and the wheat collection of Mori et al. (2003). An interesting pattern emerges from the study of the combined collection. The wild lines mostly related to domesticated tetraploid wheats were sampled in southeastern Turkey as well as in Iran–Iraq to the east of the suggested core area. Analyses based on the AFLP database of tetraploid wheats, although in line with a common origin of hulled and free-threshing domesticated forms, do not exclude the possibility of a diphylectic domestication (Özkan et al. 2005; Salamini et al. 2004). The Özkan et al. (2005) paper attempted to reconcile the apparent discrepancy at the local geographical scale (chloroplast DNA data pointing to the Kartal area, whereas nuclear AFLP suggests the Karacadağ range as the putative site of tetraploid wheat domestication) by either ancient introgression events or stochastic behavior of the ancestral lineages. Özkan et al. (2005) conclude by restating their conviction that the core area of Lev-Yadun et al. (2000) played a major role in the domestication of tetraploid wheat without ignoring the difficulties involved in tracing a more precise location(s) within this small area. Bearing in mind the complexity of reconstructing ancient genetic (and (or) cultural) events, we offer a new scenario that may help resolve the above inconclusiveness and shed new light on the dynamics of the founder genetic stocks during the first expansion stages of Near Eastern farming.

The early farmers must have used seeds of wild species populations in their first intensification–cultivation attempts (e.g., Moore et al. 2000). The emergence of domesticated (non-shattering spike) types in the cultivated fields is assumed to have occurred at a later stage depending on the harvest methods and (or) intentional or unintentional selection practiced by ancient farmers (e.g., Hillman and Davies 1999; Zohary 2004). Although different models have shown that such a mutation towards domesticated types may establish itself within a few decades of repeated sowing and harvest of essentially wild forms (Hillman and Davies 1999), changing the underlying model assumptions, for instance, harvesting of partly immature spikes or gathering disarticulated dispersal units from the ground may have prolonged this time frame considerably (e.g., Kislev et al. 2004).

The spread of raw materials (e.g., obsidian; Renfrew et al. 1966) and new cultural traits (e.g., flint arrowhead types, flint core-and-blade technology; Gopher 1989, 1994) across vast tracts of land occurs through interaction–exchange networks and (or) migration (Ammerman and Cavalli-Sforza 1971; Cavalli-Sforza et al. 1994). Under whatever proposition for the initial cultural spread from the core area to other parts of the Fertile Crescent, it is feasible that the first decades, or even centuries, of farming still involved wild-type (shattering) wheat genotypes. According to this scenario, where local strains of wild wheat (*T. dicoccoides*) were present at the fringes of cultivated plots or as companions of the newly imported seed stocks fetched from the core area, intermingled populations may have persisted until the emergence and establishment of the domesticated (non-shattering) types at one or more locations. The nearly universal phenomenon of founder effect in plant domestication (Ladizinsky 1985) indeed suggests that once established, such non-shattering mutants spread and replaced the seed stocks employed by ancient farmers.

Taking into account the pattern of genetic relatedness between wild and domesticated emmer (Mori et al. 2003; Özkan et al. 2002, 2005) in conjunction with the scenario of incipient wheat cultivation may help track the genetic ripples of early Neolithic cultural expansion of wheat farming. We propose that the close genetic affinity between domesticated stocks and wild emmer from the Karacadağ and the Kartal (to the west on the one hand) and Iran–Iraq (to the east on the other hand) defines the area within which such mixed cultivation of imported and local wild types may have taken place prior to the emergence of the non-shattering mutant(s). Once established in the incipient seed stocks, such mutants
may have later spread across the Neolithic cultural horizon of the Near East and beyond, but now incorporating a significantly narrower genetic spectrum based on the allele repertoire of the newly evolved non-shattering type(s). Indeed, Israeli, Syrian, and Jordanian wild emmer bear less genetic similarity to domesticated wheat than their Turkish, Iranian, and Iraqi counterparts (Özkan et al. 2005). This model not only reconciles apparent discrepancies concerning wild emmer domestication, but at the same time corroborates the theory regarding the hub of the Neolithic “Big (agricultural) Bang” in southeastern Turkey (Lev-Yadun et al. 2000; Gopher et al. 2001).

As shown by independent analyses of material culture traits in Neolithic sites throughout the geographic range of wild emmer, there were several elements “diffusing” from the core area reaching the southern Levant (Lebanon, Israel, Jordan) after several centuries. Hence, it was possible to reconstruct the temporal pace of movement of material culture traits such as flint arrowhead types (Gopher 1989, 1994), flint core-and-blade technology (naviform cores), and ground stone tool types (Gopher 1994, 1999). This spatial approach may help suggest a model charting the spread of early farming in Europe. Man, 6: 674–688.


