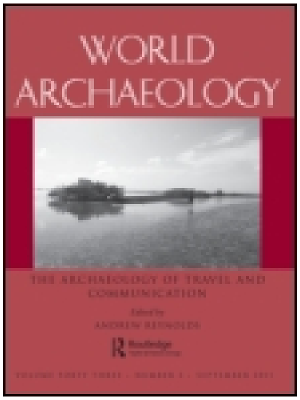

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Old World globalization and the Columbian exchange: comparison and contrast

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Nicole Boivin, Dorian Q Fuller and Alison Crowther

Abstract

A recent paper by Jones et al. (Food globalization in prehistory, *World Archaeology*, 2011, 43(4), 665–75) explores a prehistoric 'Trans-Eurasian' episode of food globalization characterized by the long-distance exchange of starch crops. Drawing upon a comparison to the Columbian Exchange, they emphasize the role of fast-growing crops in optimizing productivity, giving minimal consideration to other drivers. Here we re-evaluate the sequence and timing of the Trans-Eurasian exchange and give greater consideration to the social dimensions of plant translocation. We outline a model for thinking about plant translocations that highlights the way the conceptualization and use of introduced plants changes through time, with social factors frequently dominating in the early stages.

Keywords

Bronze Age; Eurasia; Africa; archaeobotany; crop exchanges; trade.

Introduction

The final years of the fifteenth century, which witnessed the sea voyages of Christopher Columbus and Vasco da Gama, mark for many scholars the beginning of an age of globalization that has culminated in the emergence of the intensively interconnected world of today (O'Meara et al. 2000). Challenging this more orthodox view, however, is the work of a variety of historians, archaeologists and others that traces processes of globalization and significant webs of connectivity into a deeper and often non-European past (Bentley 1993; Gills and Thompson 2006; Wolf 1982). Linked to the latter theme is a recent *World Archaeology* article by Jones et al. (2011) that focuses on the translocation of food crops as part of ancient trade networks and processes of 'food globalization' (Kiple 2007). In their

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paper, Jones et al. focus on documenting and explaining the movement of individual crops across central Asia, pushing the earliest exchanges back to the sixth millennium BC. Drawing upon a comparison offered by Andrew Sherratt (2006) between the movement of goods and species along these routes in the third to second millennium BC as part of what he termed 'the Trans-Eurasian Exchange' and the later 'Columbian Exchange' between the Old and New Worlds, Jones et al. attempt to shed more light on the putative earlier Silk Road crop exchanges by exploring the degree to which they are driven by a shared set of factors. In particular, they ask 'Why move starch?' (Jones et al. 2011: 667) to areas that already possess starchy crops; and offer three potential drivers, classed as ecological, economic and cultural. Their discussion, however, focuses mainly on ecological drivers, such as the advantages of fast-maturing crops, risk-minimization strategies and multi-cropping, and the other drivers contribute little to their examples or their overall model.

The Trans-Eurasian Exchange undoubtedly did have some parallels with the later Columbian Exchange, particularly in the sense that it involved the movement not just of goods, technologies and people, but also crops, animals and diseases. The comparison should not be taken too far, however. Regardless of what one's views are on precisely when 'globalization' began, it is increasingly clear to many scholars that processes of long-distance connectivity, interaction, exchange and mutual influence emerged in a gradual, fluctuating and uneven way in the Old World. With the Columbian Exchange, by contrast, the process began abruptly, and was complete in many respects in as little as a hundred years. This period, and the few hundred years that followed, saw the dislocation of millions of people, the extermination of many more in large part through the introduction of new diseases, and the expansion of cash-cropping on a remarkable scale (Crosby 2004; Denevan 1976; Mintz 1985). In contrast to the earlier trans-Asian exchanges, not only are the speeds and outcomes different, but also the processes and drivers, all of which problematize Jones and colleagues' attempt to draw upon the Columbian Exchange to offer insights into the earlier Old World exchanges. In this paper, we re-examine the drivers of early crop translocations and the data that Jones et al. present, and ultimately propose a more socially informed and complex model of crop translocations along the proto-Silk Road.

Crop translocations as a social process

Jones et al. (2011) focus largely on ecological explanations in answer to their question 'Why move starch?' In doing so they overlook another, perhaps more relevant, observation of Sherratt's: that the movement of crops reflects a *social* process. Sherratt argued that archaeologists need to move beyond a focus on subsistence and explore 'the tradable potential of many organic products' (1999: 14), and their place within 'the sphere of competition, emulation, negotiation, performance and communication' (1999: 30). Our own studies suggest that Sherratt's point is critical, particularly in the early stages of plant translocation, when exotic crops are first accepted into agricultural societies. The wider ethnographic and historical literature in addition provides many discussions, usually brief, on the ways in which plants are moved into new landscapes as part of broader social and economic processes in a range of societies of varying degrees of 'complexity'. Hugh-Jones and Posey, for example, observed that modern Amazonian forager-farmers, in the course of their travels, collected plants 'from near and far, not for gain but for curiosity, pleasure and value' (cited in Hastorf 1999: 39), which they then planted along local paths and in encircling kitchen gardens. In such a non-directed and experimental context, probably common in the past, acquiring starchy crops when one already has starchy crops makes sense. The addition of similar crops to a pre-existing repertoire also makes sense when the limitations of food processing technologies to the actual use of new crops are taken into account (e.g. Leach 1999). It was, furthermore, easier in many ways to adopt a crop that was in certain respects similar to crops one already had, because technologies of processing are often, as Sillar (1996) has argued, 'philosophical technologies' that reflect particular cultural 'ways of doing' that can be highly resistant to change (also Boivin 2008). Accordingly, prehistoric Chinese farmers processed wheat not into bread, but steamed or boiled grains whole (Bray 1984), reflecting a propensity to boil starchy crops rather than bake them in ovens (Fuller and Rowlands 2011).

Of course, while a casual and fluid process of crop acquisition may explain some translocations, it is clear that on other occasions crops were deliberately sought out. Although this sometimes reflected a desire to increase agricultural stability and production, we suggest that crops were probably more frequently sought in ancient times for social, ritual, medicinal and particularly prestige, reasons. The link between the acquisition of crops from distant locales and social prestige is illustrated by various examples including, in Africa, historical accounts describing the import of mango and coconut trees from the East African coast to the interior as settlements sought to emulate socially superior Swahili coast towns. Growing these species of trees, which came to the Swahili coast from India and South-East Asia through the Indian Ocean trade, made interior settlements appear more cosmopolitan and provided exotic foodstuffs that served the display ambitions of local chiefs (Helms 1993). The general relationship between distance and power in a range of pre-industrial societies has been explored in some detail by Helms (1988, 1993), whose cross-cultural comparisons indicate that societies often place significant value, cosmological and otherwise, upon goods and substances obtained from outside their boundaries. Her work makes sense of paradoxical phenomena like the ancient spice trade, in which 'sovereigns pledged their prestige, and navigators risked their lives . . . to redirect the distribution of a few inessential and today almost irrelevant vegetable products' (Keay 2006: xi). Philosophers and geographers in both ancient China and the Roman Empire decried the vast amounts of money and resources that were wasted on obtaining spices, silks and other foreign luxuries of no real consequence beyond their social prestige value (Barfield 2001; Fitzpatrick 2011; Young 2001). Accordingly, as spices became most readily available from the seventeenth century, becoming less expensive and thus less exotic, their use in luxury cooking actually declined (Montanari 1994: 119; Turner 2004).

The close relationship between prestige, power and the translocation of exotic plants is clear from numerous other examples from the ancient world. The Egyptian queen Hatshepsut, in her second millennium BC temple at Deir el-Bahri, for example, boasts about her expedition to the distant land of Punt and the many exotic things, including cuttings of incense trees, that she has brought back (Kitchen 1993; Meeks 2003). Pollard (2009: 320), meanwhile, describes a similar form of 'botanical imperialism' that led elite Romans to transplant flora from across the Roman empire to the gardens of the Italic peninsula, including citrus fruit from the Far East, cherry trees from the Pontic region of

Asia Minor, peaches from Syria, and pomegranates from North Africa. The spread of spices, garden trees and vines to distant parts of the Roman Empire has accordingly been documented archaeologically (e.g. Livarda 2011; van der Veen 2011; van der Veen et al. 2008). Colonial gardens, filled with the fruits of war, conquest and trade, served as ideological statements about the power of the empire and its rulers. Watson (1983) also describes the importance of colonial gardens and the ways that rulers both sought and were presented with exotic plants from distant lands. He notes the role of exotic plants and plant products in defining social status in the Islamic world, and the processes of emulation that subsequently led to their wider use (Watson 1983: 101).

The value placed on exoticism in the ancient world is also attested to by the bizarre and outlandish stories that were frequently attached to certain highly sought-after plants. Herodotus, for example, described frankincense as being guarded by tiny winged serpents, and cinnamon as a plant collected by cliff-dwelling birds (Keay 2006: 4–5; Smith 2001). The important magical and medicinal uses of many early crops and spices (Turner 2004) can be understood in relation to these exotic and supra-normal features. Rice, for example, first known as an exotic from the east in Roman times, and found alongside imported spices at Red Sea sites (van der Veen 2011), came to be a medicinal crop in late Roman and early Medieval Europe (Decker 2009). Sugar, too, derived in particular from sugar cane, was regarded by the medieval apothecary as a powerful component of medicines (Dalby 2000: 27; Freedman 2008: 12). Other plants had magical and ritual roles, a pre-eminent example being the incense that was shipped and caravanned around the ancient world and played such an important role in fumigating temples and churches, and attracting gods (Neilson 1986). The unusual sensual qualities of these plants, particularly when burned, are obviously part of their power, but starchy crops can also feature in ritual. Various ritual and symbolic uses of the banana in Africa, to where it was imported from Asia, illustrate this point (e.g. Ngomou 2010; Wilson 1954).

The link between plants and identity is also relevant. Watson (1983) has stressed the unsung role of everyday peasants and people in shifting crops around the Islamic world as part of processes of conquest, pilgrimage, travel and resettlement, stressing the commonness of migration under the Islamic Caliphate. Carney and Rosomoff have meanwhile shed light on the overlooked role of West African slaves in translocating crops to the New World, leading to the Africanization of plantation foodways and the creation of 'fusion dishes and memory cuisines' (2009: 177). While crops moved as part of processes of resettlement undoubtedly played a role in subsistence, they also had a clear role to play in the creation and negotiation of memory and identity in new social contexts.

Crop introductions and productivity increases: the (often) long delay

The Trans-Eurasian Exchange and other Old World crop translocations did alter and transform indigenous agricultural practices, productivity and resilience. We argue, however, that these kinds of transformations were by and large not the reason that crops were translocated as part of long-distance networks. If production of more calories had been a goal of acquiring new crops, we would expect rapid uptake and large-scale consumption of novel staples. Instead, there was often a delay – of centuries, if not in some cases millennia – between the introduction of a crop into a completely new environment and its growth on a significant scale. That the transformation of native agricultural systems did not occur until later periods indicates that it was an outcome rather than a goal of crop translocations. Old World equivalents of Hugh-Jones and Posey's forager-farmer gardens in the Amazon are probably where most translocated crops ended up, and stayed for some time – that or the edges of fields where established staple crops were growing. Crops planted in this way might come and go, and regional reintroductions were probably not uncommon. Gardens were not just for small-scale societies either; as the above examples from the Roman and Islamic worlds attest, gardens could be imperial warehouses of known biodiversity whose occupants might be grown for a long time as exotics before they came to be grown on any substantial scale around the empire.

A time lag between crop introduction and importance as a calorie source is illustrated by several historical examples. Rice's medicinal use in Europe began in late Roman times, and it only spread as a subsistence crop amongst the poor of Spain and Italy in the fifteenth century, when food shortages were increasingly common (Montanari 1994: 101–2, 131). A similar slow introduction of rice into established agricultural systems is seen on the African Swahili coast, where rice is initially found in single digit quantities from its first appearance in the seventh to tenth centuries, and only comes to be grown on a significant scale after the eleventh century, as part of processes of social change and Islamization (Walshaw 2010). Sugar, meanwhile, was introduced to Europe as an exotic spice by the Medieval period, but only became a widespread sweetener there with the rise of cash-cropping in the Iberian empires of the fifteenth century (Mintz 1985). Prior to this era, cane sugar was simply another exotic spice, of high value and potency. Andrew Watson's (1983) analysis of agricultural changes during the Islamic Caliphate highlights the complexity of processes of diffusion, including not just crop introduction, but re-introduction, import substitution and introduction failure. According to his analysis, rice, wheat, cotton, citrus fruits and watermelon were all introduced to western Eurasia and/or North Africa prior to the Islamic period, but their production was initially very limited (Watson 1983), and archaeological research demonstrates that their contexts of use in cuisine may also have differed (see van der Veen 2011, on watermelon, grape and *Citrus*). Scholars like Decker (2009) have critiqued Watson for not going far enough in recognizing the pre-Islamic use of a number of crops, but most of these critiques simply serve to underline the lengthiness of the process that moved crops and other plants from rare exotics to improved agricultural products.

In the sections that follow, we outline how this slow shift towards the use of new imported crops to increase production can also be seen for those crops at the heart of the Trans-Eurasian Exchange (sensu Jones et al. 2011). Linked to this, we make two additional and related points contrary to Jones et al. The first is that, as central to food globalization as starchy crops seem to be (Jones et al. 2011: 667), the movement of fruits, oil seeds and fibre crops was often just as early, and these plants provide important insights into the motivations behind crop translocations. Second, there is no clear evidence that order of translocation relates inversely to length of maturation, i.e. that it was the risk-buffering crops that were quick and easy to grow that spread first. The delay in the rise to importance of these crops, their accompaniment by unlikely staples and their highly varied ecologies and seasonalities argue against the primacy of the ecological and subsistence drivers of prehistoric crop exchanges posited by Jones and colleagues.

Wheat's two eastward trajectories: China versus India

The example of the arrival of wheat in China provides another important illustration of the delay that frequently occurred before an imported crop was grown on a significant scale (Fig. 1). By the Early Bronze Age, a range of wheat species were cultivated in central Asia, together with barley and winter-grown pulses like lentil and pea, as in the Indus valley and west Asia (Fuller 2011a; Miller 1999). In China at this time, by contrast, it is by and large only bread wheat (Flad et al. 2010) that can be found, divorced from the presence of associated winter pulses or barley but for a very small number of barley occurrences (Fig. 1). In a few cases, wheat is present in China by 2500–2400 BC, but more sites date to after 2000 BC. The quantities of wheat found in early China are extremely low in relative frequency and ubiquity, and samples are always dominated by millets and, at a few sites, rice (see, e.g. Crawford et al. 2005; Fuller and Zhang 2007; Lee et al. 2007). Barley is found entirely after 2000 BC, and mainly several hundred years later. If the aim was to adopt a crop that was more tolerant of dry and stressed conditions, then it would have been barley rather than wheat that should have been chosen from amongst available Central Asian starchy crops, as was ultimately the case in the Tibetan plateau (Bray 1984).

The minute quantities of wheat vis-à-vis native millets in northern China argue against any significant caloric role for this crop during its initial adoption (Fig. 1). In Bronze Age central China, wheat looks more like a minor companion crop, or a rare flavouring, than a serious staple crop. Selectivity is further highlighted by regional patterns within China. While early wheat finds have been reported from Shandong in the east and Gansu in the northwest, in the heartlands of China (Henan) – where the central state of the Xia-Shang-Zhou dynastic tradition emerged (Liu and Chen 2003) – wheat uptake was further delayed, suggesting some inherent resistance to uptake of the novel crop in China's most heavily populated region. Historical sources suggest that once adopted, wheat was initially (in the Late Bronze-Iron Age) something of a delicacy (Bray 1984: 459–77), although bread was probably unknown. It is only by Han times (ca 200 BC) that wheat and barley are both clearly present as important winter subsistence crops in China, rotated with summer millets, and mainly providing food for the poor. The development of rotary querns and flour production during the Han Dynasty saw the rise of new culinary forms featuring noodles and buns made of wheat flour, and coincided with a re-emergence of wheat as a status food in China (Yü 1977). On the whole, then, we see a trajectory from rare exotic, to subsistence broadening low-valued staple, to a more widely valued staple crop in the history of wheat in China.

This East Eurasian pattern contrasts markedly with the way wheat diffuses into northern and central India. There barley, wheat and lentil almost always occur together in quantity (high frequency and ubiquity relative to other crops, high co-occurrence in individual samples) from the mid to late third millennium BC; and other Near Eastern pulses (chickpea, pea, grasspea) are also frequent (Fuller 2002, 2011a). In these regions of India the quantities of wheat and barley alongside native species (like rice in the Ganges) do point clearly to their importance in broadening subsistence via two cropping seasons, certainly by 2000–1800 BC (Fig. 1), pointing to the ecological drivers of Jones et al. However, the contrast between South Asia and East Asia is instructive: bread wheat had little subsistence value in Bronze Age China, judging from contextual and quantitative

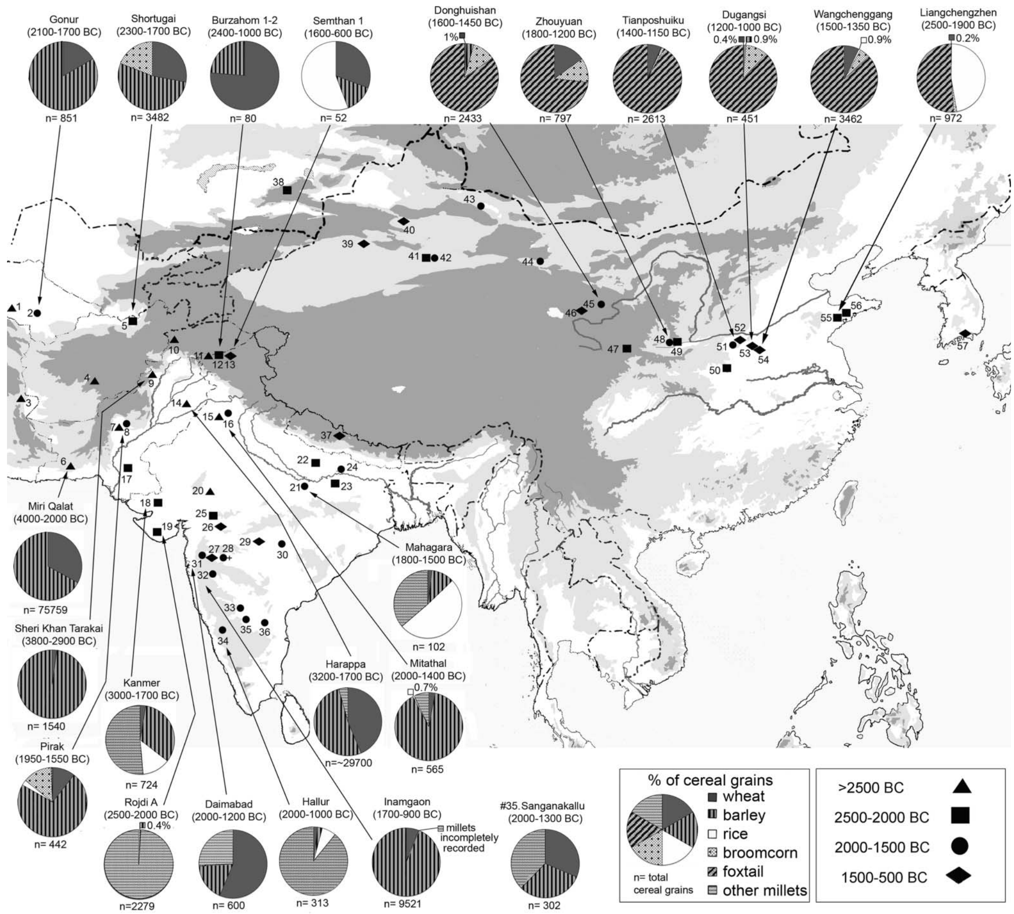

Figure 1 The spread of wheat and barley across Asia, with sites representing the earliest finds for each region shown. For a selection of sites with adequate data, the relative proportions of cereals (wheat, barley, rice, broomcorn millet, foxtail millet, and other millets) are shown in the pie graphs.
Sites key: 1. Anau; 2. Gonur; 3. Shahr-i-Sokhta; 4. Mundigak; 5. Shortugai; 6. MiriQalat; 7. Mehrgarh; 8. Pirak; 9. Tarakai Qila; 10. Ghalegay; 11. Kanishpur; 12. Burzahom; 13. Semthan; 14. Harappa; 15. Kunal; 16. Mitathal; 17. Chanudaro; 18. Kanmer; 19. Rojdi; 20. Balathal; 21. Mahagara; 22. Lahuradewa; 23. Senuwar; 24. Chirand; 25. Kayatha; 26. Navdatoli; 27. Nevasa; 28. Apegaon and Paithan; 29. Tuljapur Garhi; 30. Adam Cave; 31. Daimabad; 32. Inamgaon; 33. Piklihal; 34. Hallur; 35. Sanganakallu; 36. Hanumantaraopeta; 37. Mebrak cave; 38. Begash; 39. Qunbake; 40. Yanghai; 41. Gumugou; 42. Xiaohe; 43. Lanzhouwanzi; 44. Huoshaogou; 45.Donghuishan; 46. Fengtai; 47. Xishanping; 48. Zhouyuan; 49. Zhaojialai; 50. Baligang; 51. Zaojiaoshu; 52. Tianposhuiku; 53. Dugangsi; 54. Wangchengang; 55. Liangchengzhen; 56. Zhaojiazhuang; 57. Nam River.

archaeobotanical data, but Near Eastern winter crops as a group provided a major broadening of agriculture and diet in India at this time. It seems possible that the few rare finds of wheat and barley in the Ganges basin in the later third millennium BC (2400–2000 BC) meanwhile represent their earlier introduction as exotic or status foods (Fuller 2011a). Evidence for new culinary culture (pot types, probably for serving liquid) that accompanied wheat and barley may indicate a social motivation for their adoption as well, such as for beer production (Fuller 2005).

Chinese millets outside China

At the heart of Jones et al.'s subsistence argument for early Trans-Eurasian crop dispersals are the Chinese millets, especially broomcorn millet (*Panicum miliaceum*) and perhaps foxtail millet (*Setaria italica*), both of which are drought tolerant and suited to marginal soils. Of these, broomcorn millet is often the more rapidly maturing and is therefore a traditional crop of the dry and more northerly parts of China (e.g. inner Mongolia). While both of these species were certainly established in northern Chinese cultivation by around 6000 BC (Bettinger et al. 2010; Zhao 2011), it is less certain that broomcorn millet dispersed at this time from China to Neolithic Europe as inferred by Jones et al. (2011). While there are reports of broomcorn grains in single digit quantities on a few Neolithic sites in Europe, it is unclear that these were cultivars. Quantitatively one or a few millet grains must be set against the several thousands of wheat and barley grains that were also present at these sites, and as such, archaeobotanists have often suggested that these *Panicum* finds represent rare weeds, perhaps a local wild broomcorn millet (e.g. Bakels 2009: 66; Kohler-Schneider and Canepelle 2009: 67; Kreuz et al. 2005). The earliest substantive evidence for cultivation of millets in Europe comes in the form of significant quantities of broomcorn millet along with a few foxtail millet grains at sites of the Jevišovice culture in Austria, ca 3000 BC (Kohler-Schneider and Canepelle 2009: 67). By contrast, it is not until Bronze Age times, after 2000 BC, that both broomcorn and foxtail millets are widely found in quantity in western Europe (Bakels 2009: 100), where they can often be found in ubiquities of >35 per cent or even 65 per cent of samples (Rosch 1998). This points to a significant delay between the translocation of millet and its growth on a significant scale. It should be noted that it also remains possible that domesticated broomcorn millet appears in Europe as a result of local domestication rather than translocation from the east. A parallel domestication of broomcorn millet in western Eurasia (perhaps in eastern Europe; see Fig. 2) has been hypothesized (see Zohary and Hopf 2000: 86). Genetic patterns in modern millet cultivars indicate a strong east–west division, but it is unclear whether this relates to an early bottleneck or two origins (Hunt et al. 2011).

Evidence from central Asia, the north-western margins of the Indian subcontinent, and further afield in Yemen and Sudan, points to the major dispersal of the Chinese millets, and in particular broomcorn millet, through central Asia to the south and west from the end of the third millennium BC to the early second millennium BC (Boivin and Fuller 2009; Fuller et al. 2011). A key starting point for this process is suggested by evidence from the site of Begash in eastern Kazakhstan, where finds of broomcorn millet and wheat from ritual contexts (burials) have been directly dated to 2300–2200 BC (Frachetti et al. 2010). This is almost as early as the earliest wheat finds in China and marks a point along the eastward journey of wheat, as well as providing a secure point in the westward departure of millet from China. Broomcorn millet arrives in north-western India as part of a broader 'Chinese horizon' (Fuller and Boivin 2009: 21), which also brought peaches and apricots, hand harvesting knives, *Cannabis*, and probably foxtail millet and *japonica* rice varieties

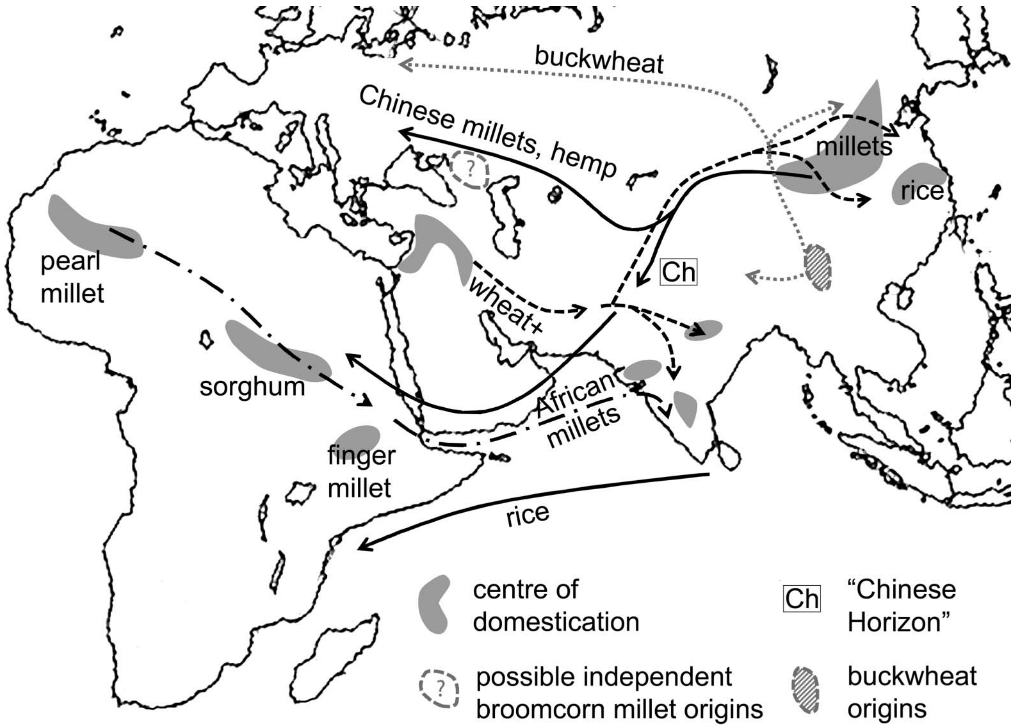

Figure 2 Crop movements between major agricultural centres in Africa and Eurasia discussed in this paper.

(Fuller 2011b). The co-transfer of perennial fruit-trees and water-intensive rice undermine any argument that crop diffusion of this era was driven by a caloric imperative or the seeking of drought-resistant crops. The possible ritual and/or prestige context of wheat and broomcorn millet at Begash highlights the potential that cereals, both shorter season and long-season, moved as high-value exotica, as well as the fact that the agents of their dispersal through central Asia were mobile pastoralist societies, who provided indirect, down-the-line connections between the urbanized population centres of the Oxus, Indus and Yellow rivers. In contrast to the Colombian Exchange, urbanized states of the Trans-Eurasian Exchange probably had little role to play in the actual translocation of crops and other plants, which reached them through indirect routes.

Lateness of buckwheat

Buckwheat (*Fagopyrum esculentum*) is another crop suggested to move at an early date across Eurasia (Jones et al. 2011: 669–70). Buckwheat is an important crop of marginal lands that spread widely in Eurasia from origins on the eastern margins of the Tibetan plateau in the uplands of western Sichuan and Yunnan (Ohnishi and Konishi 2001). Evidence for its very early dispersal, by the fifth millennium BC, as argued by Jones et al. (2011: fig. 1), remains problematic. The evidence most often cited for an early spread in eastern Asia comprises a solitary carbonized nutlet from the apparently Early Jomon Hamanasuno site in Hokkaido, Japan (Crawford et al. 1976). This single specimen has subsequently been directly AMS-dated and found to be intrusive (160 BP, Beta-176046; Obata 2011: 168). Apart from this single (and now refuted) seed, evidence consists of a few reports of buckwheat pollen from several millennia later at Late Jomon sites in the second millennium BC (Fujio 2004). An arrival in Japan after 2000 BC is in keeping with some palynological evidence from peripheral China, including from the Liaohe river basin in north-east China after ca 2400 BC (Li et al. 2006), and Xishanping in Gansu to the north-west, where pollen could be ca 2500 BC but owing to stratigraphically inconsistent AMS dates might only be about 1000 BC (Li et al. 2007); this co-occurs with one of China's earliest wheat finds. Palynological evidence from the Lower Yangzte could indicate some buckwheat cultivation in the hills south of the Yangzte as early as 2500 BC (Yi et al. 2003). A few nutlet finds can be placed in the first millennium BC, including from central Nepal (Knorzer 2000) and at Haimenkou, Yunnan (D. Q. Fuller, unpublished data). Linguistic evidence indicates that the Chinese name for buckwheat was borrowed from eastern Tibeto-Burman speakers to the south-west of the Han Chinese sometime in the last two thousand years (Bradley 2011). Thus some dispersal around the peripheries of Chinese civilization may have started as early as 2500 BC, but buckwheat's importance as a more widespread staple crop is mainly in the last two thousand years only.

The claims for early buckwheat in north-eastern Europe near the Baltic Sea also rest on pollen evidence, but these finds are few (Janik 2002). At two sites in Latvia, such pollen occurs after 2500 BC, in line with the period of buckwheat's early dispersal in eastern Asia. Just two pollen cores (from Moldavia and Poland) and one 1950s archaeological report from Denmark have potentially earlier dates, but a critical reconsideration of these data, and the need for confirmation of morphological identification and direct AMS-dating, are called for. Systematic archaeobotany in Scandinavia in recent years (reviewed by Robinson 2003) has failed to support the claim for Neolithic European buckwheat. Instead, systematic sampling and reliable identification of buckwheat in western Europe occurs from the thirteenth and fourteenth centuries (e.g. Ansorge et al. 2003; Kühn and Akeret 2002), which is in agreement with written sources that suggest introduction in the Middle Ages (Montanari 1994: 102). The claim for a fifth millennium BC westward dispersal of buckwheat via the northern steppe, as a short season subsistence crop, is therefore questionable. Buckwheat, like the other crops discussed, therefore does not support the argument presented by Jones et al. (2011: 669) that antiquity of dispersal 'relates inversely to the length of their growth cycle'.

Discussion: classifying transformations in crop value and productivity

There is a growing recognition that, by the Bronze Age, materials sometimes moved considerable distances between cultural areas. Food crops were amongst these items (Boivin and Fuller 2009; Fuller et al. 2011), and as recognized by Jones et al. (2011) this ultimately did contribute to the diversification of local agricultural subsistence. However, there are a number of non-direct trajectories by which crops have become either risk-buffering crops or favoured staple foods, and these subsistence outcomes rarely seem to have been amongst the motivations of the initial translocation processes. We agree with Jones et al. that there is strong archaeobotanical evidence for novel crop combinations in several regions of the Old World in the second millennium BC, and suggest the likelihood that translocation processes began in the second half of the third millennium BC. As we have shown, however, the earlier translocations, especially of broomcorn millet and buckwheat, by 5000–4000 BC, are not supported by systematic archaeobotanical sampling, quantitative studies or direct AMS dates. Yet it is these earliest translocations that are suggested by Jones et al. (2011: 669–70) to set a precedent for the dispersal of shorter growth season crops as risk-buffering extensions to caloric production. If we stick to the well-supported evidence for later dispersals, however, there is no evident preference either for shorter growing seasons or caloric staples.

In reviewing the evidence of crop translocations, we find a number of alternative trajectories by which crops have become either risk-buffering crops or favoured staple foods. Systematic comparison of these pathways necessitates classification of crop-use types and changes through time, and we propose one possible system in which such broad categories as 'cash-crops', 'spices/exotica', 'risk-buffering crops' and 'staple foods' are distinguished (Fig. 3). We can draw upon these categories to abstract three spectra of interacting variables: the social-value placed on a crop, from lesser to greater; the scale of production of a crop, from lower to higher intensity; and the distance from which a crop is obtained by direct trade for consumption, from local to more distant. In general, we expect things obtained from more distant locales to have higher values. If these were produced in bulk, we can regard them as cash crops, whereas if they remained at low production levels (including gathered from wild sources), or were traded at low levels, they can be regarded as exotica/spices. When possible these may be taken up for local small-scale cultivation, for example in experimental gardens, but this is likely to have been part of a transition towards increased production either as higher-value cash crops or with lowered value as the exotic association wears off. When local production expands but local

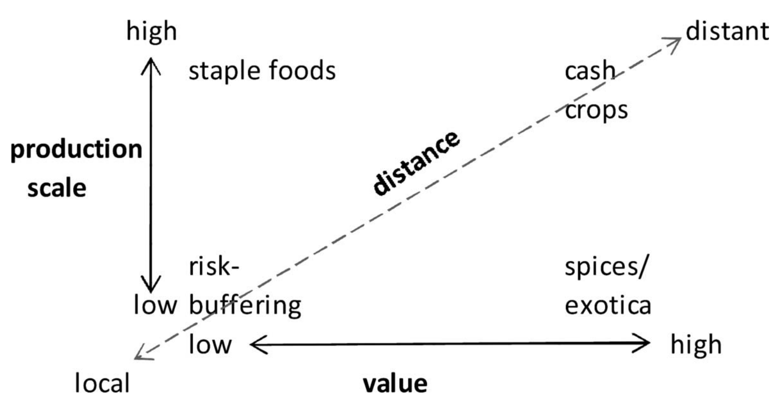

Figure 3 Schematic representation of relationship between basic crop use categories (cash-crops, spices/exotica, risk-buffering crops and staple foods) and three interacting variables: the social value placed on a crop (from lesser to greater), the scale of production of a crop (from low to high), and the distance from which a crop is obtained by direct trade for consumption (from local to more distant), against which the historical trajectories of introduced crops can be charted (see Fig. 4).

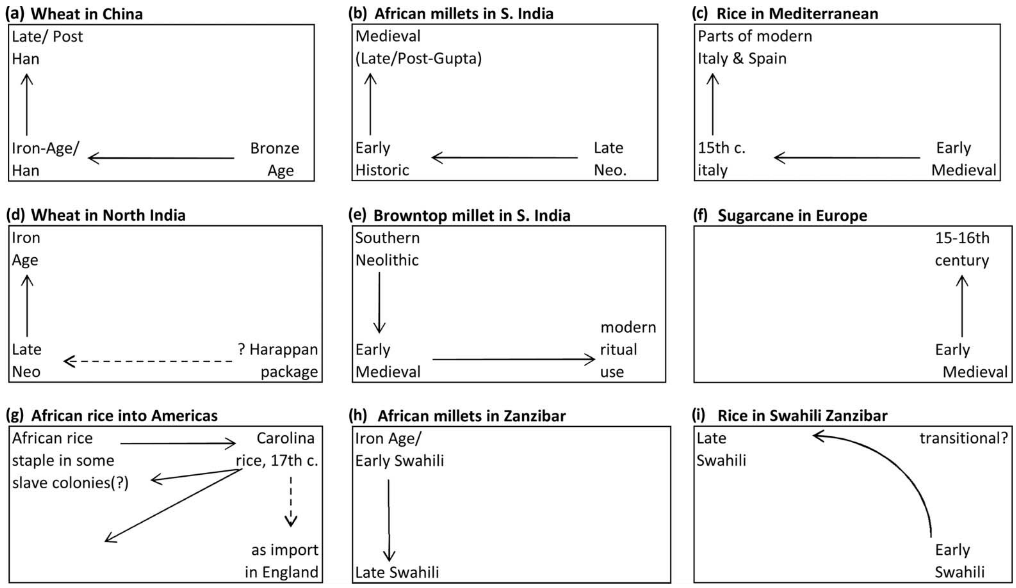

Figure 4 Regional historical trajectories of various translocated crops (see Fig. 3 for key to interacting variables).

use values are low, we have risk-buffering caloric crops, whereas staple foods are generally valued reasonably highly and produced in large quantities.

Although the above variables define a three-dimensional space, this can be flattened into four basic crop categories, and the historical trajectory of translocated species can be mapped across these (Fig. 4). From the species discussed above as well as some additional examples, we can see that there are recurrent pathways from the exotic to risk-buffering crop to staple crop, a trajectory followed by wheat introduced to China (Fig. 4a), African millets into India (Boivin and Fuller 2009; Fuller et al. 2011; Fig. 4b), rice into the western Mediterranean (Fig. 4c) and, albeit more tentatively, wheat into northern India (Fig. 4d). A reverse trajectory is followed in the case of browntop millet in southern India (Fig. 4e), with this species declining in importance through time relative to the rise of African millets (Fuller 2011a). An alternative pathway is for something exotic to become a cash crop produced in bulk for trade. This was a common trajectory in the Colombian Exchange, followed for example by sugar (Fig. 4f) and, later, chocolate, tea, coffee and other crops. We have no clear examples from the Bronze Age Trans-Eurasian Exchange for the equivalent shift. The case of Carolina rice, a component of the Colombian Exchange, provides yet another trajectory (Fig. 4g), studied in detail by Carney (2001).

The issue of food globalization in prehistory discussed by Jones et al. (2011) is an important one that has come into focus with the accumulation of archaeobotanical evidence from a greater number of sites and regions. That ecological, economic and social motivations have all played a role in this process seems clear, but we have taken issue with the emphasis of Jones et al. on ecological and caloric concerns as the initial driver for the earliest cereal translocations. Instead, we have emphasized a role for the prestigious, cosmological and medicinal qualities of exotic plants obtained from distant regions, which applied not just to the so-called 'spices' of antiquity – the aromatic and strong-tasting plants and their products whose extraordinary features enticed and seduced the senses – but also the everyday crops, or at least the crops that we think of today as mundane and everyday, including starchy staples. We would also emphasize the role of more mobile, non-agrarian societies (be they mobile pastoralists, sea nomads, etc.) in the actual movement of the materials and species that travelled along ancient trade networks, including plants. These societies probably account for the poor archaeological visibility of the earliest exchanges noted by Jones et al. (2011: 671), but we doubt that there were three or four millennia of invisible crop translocations. The paucity of information on these mobile societies and their plant remains emphasizes the need for further archaeobotanical work in the Eurasian Steppe. The lesser role of such intermediaries (though see Carney and Rosomoff 2009) for the more centralized and wide-reaching 'food empires' (Fraser and Rimas 2010) of fifteenth- and sixteenth-century Europe emphasizes again the contrast between the Trans-Eurasian and Columbian Exchanges. The variations between the two exchanges emphasize their fundamental dissimilarity, and highlight the extraordinary connectedness of the vast and ecologically variable Old World over many millennia. This long-term, slow-growing network of connections and exchanges, amongst other factors, helps to explain the devastating impact of Old World contact on the New World. Armed with a remarkable range of technologies, species and perhaps particularly diseases acquired over millennia of interaction and exchange, Old World populations were uniquely situated, from a bio-cultural perspective, to transform the New World in as little as a few centuries in ways that really had no earlier parallel.

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