Responses

Harappan seeds and agriculture: some considerations

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The systematic collection of archaeobotanical evidence through flotation at Harappa has the potential to make important contributions to our understanding of the subsistence base of the Indus civilization (Miller & Reddy 1990; Miller 1991). In the December 1999 issue of ANTIQUITY, Weber (1999: 813–26) presents a synthetic and interpretative article on agricultural change during the Harappan civilization drawing on his archaeobotanical work from Harappa, as well as his earlier work at the site of Rojdi (Weber 1991; 1993). Weber suggests that these sites showed parallel trends in agricultural change in the form of diversification in the number of crops cultivated, change in the dominant cultivar and general agricultural 'intensification'. Weber's article brings out some of the problematic issues surrounding the growing archaeobotanical database in South Asia that deserve critical discussion. These issues include confusing plant taxonomy, difficulties with identification, the role of crop-processing in forming assemblages and, finally, the definition and implications of 'intensification' and 'diversification' in Late Harappan agriculture. In opposition to Weber's suggestion of an increase in foddering and intensive land use around the sites of Harappa and Rojdi, I will suggest that in the case of Rojdi the Late Harappan transition is marked by a change in the social organization of crop-processing, whereas at Harappa the change in agriculture is less clearly demonstrated in the reported evidence.

Taxonomy and identification

While Weber's article focuses on cereals, a number of other taxa were found, including legumes. These taxa are listed only by scientific genus names, a format that leaves some doubts as to the actual crop taxa that are indicated. The nomenclature of pulses has undergone much revision, in particular *Dolichos, Vigna* and *Phaseolus* (Verdcourt 1970; Marechal *et al.* 1978; Smartt 1990), and their use in Weber's table 1 is ambiguous.

With regard to the cereals, Weber implies a potentially very interesting but still poorly documented regional trend in wheat and barley evolution. He refers to the presence of 'shot' wheat (*Triticum sphaerococcum* Perc.) and 'shot' barley (*'Hordeum sphaerococcum'*). Despite the frequent reports in the past of *T. sphaerococcum* in South Asian archaeobotany, the basis of such identifications is problematic, as it is not possible reliably to distinguish free-threshing tetraploid wheats (*Triticum durum* Desf.) from free-threshing hexaploid wheats (*T. aestivum* L. *sensu lato,* including *T. sphaerococcum*) on the basis of grains alone (see Miller 1992; Zohary & Hopf 1993; Hillman *et al.* 1996; Fuller 2000). Also one must keep in mind that the charring process tends to distort grains towards plumper, more spheroid forms (Renfrew 1973; Zohary & Hopf 1993). Although *'Hordeum sphaerococcum'* had been used by a few archaeobotanists to describe short, plump charred barley grains (e.g. Costantini 1983; Janushevich 1978), it remains an undefined taxon. Although the evolution of sphaerococcoid cereals in the Indus region would indeed be an interesting local process, it remains to be rigorously documented by published measurements and illustrations.

Additional reservations are necessary regarding the millets, as millet mis-identifications plague published archaeobotany from South Asia (for full details, see Fuller 2000). It appears from some published photographs that the cleaned grain of hulled millets (including *Setaria* spp, *Echinochloa colona, Brachiaria*

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Received 20 March 2000, revised 3 August 2000, accepted 24 November 2000

ANTIQUITY 75 (2001): 410–14

ramosa) have been mis-attributed to the free-threshing finger millet (*Eleusine coracana*). As a result the presence of *E. coracana* in prehistoric South Asia has been greatly exaggerated. This problem is significant as *E. coracana* originated in Africa, whereas the other taxa are Asian and include native species. There is thus a need for agreement amongst archaeobotanists on reliable criteria and publication of illustrations. A cautious view of the reported change from '*Eleusine*' to '*Setaria*' (Weber 1991; 1999) might be re-stated as simply a shift from de-hulled grains to hulled grains/spikelets (see Fuller & Madella 2000; Fuller 2000). The significance of this change can then be considered in terms of a change in crop-processing.

A significant Late Harappan change?

Weber suggests (1999: 821) that 'a significant shift from one existing taxon to another within the cereals category can be identified as occurring during the transition to the late period . . . At Harappa the shift from one taxon to another is seen in the wheat-barley record'. Wheat predominates during the Mature Harappan period, while in the Late Phase, barley 'once again becomes the dominant' cereal. While these changes do appear regardless of methods of quantification (ubiquity, frequency, density), they appear to be rather small shifts in emphasis. Indeed, one would like to see this trend explored through the consideration of the numbers of individual samples and stratigraphic sequences rather than broad, averaged phases. Such raw data could then be assessed on the basis of potentially different taphonomic histories of particular samples (Jones 1991). Despite minor fluctuations, wheat and barley were the staple crops at Harappa throughout the period of investigation, occurring in 85–90% of all samples, and accounting for some 34–41% of all seeds.

A notable change is the large decline in density of cereals overall at Harappa, i.e. charred plant remains became less common in the archaeological sediments of the late period. The significance of this decline in density remains unexplored, but may relate to decreased intensity of occupation or plant-processing activities. Might this indicate an increased reliance on pastoral production as Weber (1999) suggests? This is not convincingly indicated by an increase in 'fodder crops like barley' (1999: 823), however, as barley is well-documented human food in modern India, as well as ancient Sanskrit literature (Bakshi & Rana 1974). A similar though less drastic trend was found at Rojdi in which total seed density decreased by half from Period A to B with some further reduction in Period C (Weber 1991: 64).

By contrast, the data from Rojdi does show a clear change in millet types. As already noted, this indicates a shift in the state of preservation from de-hulled, with the dominance of free-threshing '*Eleusine*' as well as some de-hulled '*Panicum*,' to hulled '*Setaria*' (hull status is suggested by descriptions in Weber 1991: 73, 85, 89). The change might indicate a change in post-harvest processing practices rather than a significant change in cultivation practices. The fully-cleaned millet grains of the earlier periods would be expected to be accompanied by a minimal number and range of weed seeds as these would have been removed during processing (Reddy 1994; 1997). By contrast, hulled *Setaria* represents loss from an earlier processing stage, i.e. before final pounding, final winnowing and hand-picking, and we would expect a greater range of weeds to be present. Thus the increase in the richness of samples at Rojdi might just reflect a change in the organization of processing and crop-handling, rather than any actual agricultural change. Such a change can be made sense of when we take into account the likelihood that the archaeobotanical evidence, in general, derives from the composite evidence of material regularly charred in prehistory as the by-products of routine activities. The most logical source is the day-to-day removal of cereals from stores and their processing for consumption (see Fuller 2000). The contrast then becomes that of an earlier Rojdi phase in which crops were more completely processed *before* storage, perhaps on account of centrally organized mass processing after harvest. In the later phase in which crops were stored in less-processed form, they were more routinely taken through a larger number of processing steps, presumably on a smaller scale, such as at the household level.

Thus social change might explain the data as well as Weber's suggestion of an increasing use of dung fuel. Certainly, the burning of dung is a potentially important source of charred plant remains, incorporating fodder or graze species into the archaeological record, although demonstrating that this has been the case remains

a tricky aspect of archaeobotanical analysis (see Charles 1998). In order to argue convincingly that archaeobotanical assemblages increasingly came from fodder *via* dung-burning, discussion of some of the wild seed taxa in the samples and their potential relationship to crop-processing stages, their seasonality and habitat preferences could be useful. As already suggested, we might interpret this change as merely a shift in the stage at which crop-processing by-products were routinely disposed of in fires, at least at Rojdi. The nature of the equivalent change noted at Harappa remains unclear.

Diversification and intensification

In summing up his discussion Weber argues for 'efforts at broadening and intensifying agricultural strategies' (1999: 824). On the one hand, intensification, which should probably be restricted to strategies to increase yields from a particular area of land (Boserup 1965; Morrison 1994), finds no clear evidence in the reported data. On the other hand, the increase in number of species and the number of probable crop plants could indicate diversification, which can serve to buffer against potential failure of any individual crop species. Indeed, the increase in weed taxa at Rojdi might suggest cultivation in a larger range of habitats (Fuller & Madella 2000), a form of environmental diversification. As already noted, however, clear demonstration that the increase in weed diversity is not a product of different processing practices is needed. In the case of Harappa, the proposed diversification is not laid out in detail, although in another publication there is an indication of the addition of new crop species, especially summer crops, at Harappa after *c.* 2200 BC (Weber 1997).

Archaeobotanical evidence from the broader region of northwestern South Asia, in general, suggests that temporal diversification through the addition of cropping seasons was occurring at many sites during and after the Mature Harappan period (Fuller & Madella 2000). It is not clear, however, how synchronous this process was, with new summer crops already present at Harappa by *c.* 2200 BC (Weber 1997; Meadow 1998), whereas the evidence for significant crop additions at Rojdi occurs after 2000 BC (Weber 1991). This temporal diversification can be particularly important in overcoming labour 'bottlenecks' (see Stone *et al.* 1990) and hints at decreasing potential for large labour mobilization at any one harvest time. This decrease in labour mobilization could also account for the change in crop-processing evidence, discussed above, and might be attributed to processes of political decentralization of the Late Harappan period. The extent to which climatic change, or human-induced environmental degradation, has anything to do with these changes, as Weber suggests, remains unconvincing (Possehl 1997; Fuller & Madella 2000).

Concluding remarks

Weber's article, despite some of the concerns outlined above, is a testament to the growing importance of archaeobotany in South Asian archaeology. I am not convinced that the data from these two sites, over 1000 km apart with subsistence based on different staple crops, reflect the same trends. That changes in the organization of agricultural production occurred at these two sites and others is clear, and one can certainly look forward to future analyses that focus on disentangling the pathways of plant preservation and the nature of agricultural differences between Harappan regions and periods.

Acknowledgements. I am grateful to a number of colleagues who commented on drafts of this paper, including Eleni Asouti, Ann Butler, Sue Colledge, Helen Lewis, Marco Madella, Mary Anne Murray, Victor Paz, Chris Stevens and two reviewers.

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Seeds of urbanism revisited

After carefully reading Dorian Fuller's response to my 1999 article in ANTIQUITY, I am mostly encouraged because it demonstrates the growth and maturity of paleoethnobotanical research in South Asia. To be debating the interpretation of large systematically collected data bases of carbonized seeds is indeed a worthwhile enterprise. I do feel a few comments and points of clarification are needed based on his response to my article.

Fuller's response can be divided into two categories: issues with my data and issues with my interpretation of this data. I acknowledge his concern for a more complete presentation of the archaeobotanical assemblage, with accompanying taxonomic identifications. My original paper was specifically written as a synthetic and interpretive article, not a report necessitating full and exhaustive presentation of botanical data. I didn't discuss the nomenclature of the pulses or many other plant categories because they were not important to my argument about 'Tier-I plants'. These data have appeared — or will appear — in other publications. However, I am happy to add some clarifications in this response.

Regarding Fuller's concern for cereal identification, I am aware of the difficulties in distinguishing specific types of wheat and barley grains. I decided to reference the range of types believed to be occurring at Harappa and then focus my discussion on the broad categories of wheat and barley. The millet issue is a different story. While I strongly agree that millets are often misidentified and need to be more carefully documented, I do believe that I correctly identified the grains from Rojdi. Full descriptions of all seeds from Rojdi and Harappa have appeared in press, or are forthcoming.

Fuller is right in that archaeologically recovered seeds may reflect different human activities and may be impacted differently during the formation process of the archaeological record. For this reason three different methods of quantification were presented. While these methods are valid and reproducible their interpretive value needs to be closely monitored. In fact, it is on issues regarding the interpretation of these quantitative results that we differ the most. Let us therefore focus on interpretation and examine our different explanations of the proposed changes or shifts in the archaeobotanical record at Harappa and at Rojdi, and then see if any connection between the two exists.

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Fuller sees my data from Harappa as implying only 'small shifts in emphasis' with 'minor fluctuations' in wheat and barley. While he concludes that changes in agriculture is not 'clearly demonstrated', he admits there are changes. In contrast, I strongly believe that regardless as to the extent or cause, one cannot ignore the fact that the late period more resembles the early period. Over the last year I have had the opportunity to analyse dozens of additional samples. These trends continue, supporting the argument that they are not a result of 'different taphonomic histories of particular samples' as suggested by Fuller, but rather indicative of change over time. Further, when one looks at the complete archaeobotanical record from Harappa, over and above the subset I chose to focus on in my original paper, the Harappan Period (Period 3) material is unquestionably different from other periods.

In contrast to the data from Harappa, Fuller clearly agrees with me that there is a change in the archaeobotanical record from Rojdi. We differ in the interpretation of shifts in the occurrence of millets, not whether changes occur over the occupation of the site. Fuller's interpretation that this 'shift might indicate a change in post-harvest processing practices rather than change in cultivation practices' is an interesting and worthwhile argument. At this point, the explanation as to the cause for the change is less important than our agreement that it occurred, in that his model could also support the argument for regional events affecting many sites.

It is with reference to region-wide influences and whether there is a connection between changes at Rojdi and events at Harappa, that we most strongly differ. While Fuller has attempted to show flaws in my analysis and interpretation of my data, he has not added additional data to the debate. He states that there was 'no clear evidence in the reported data' for intensification. But if one includes in the analysis the secondary crops, or Tier-II plants, there is strong evidence for an increased reliance on a multi-season cropping strategy at each site. This clearly fits Fuller's definition for intensification — to 'increase yields from a particular area of land'.

Still, the main premise of my article — that changes in agricultural production and cropping strategies are linked to corresponding shifts in the material record at both sites and that these may in turn be due to regional trends — has not been successfully disproved. By stating that 'changes in the organization of agricultural production occurred at these two sites' he has simply moved the argument from one of change in agricultural strategies to one of change in processing practices, leaving open the debate as to a connection between the two sites.

Incorporating Fuller's comments and concerns into my interpretation of the data, however, suggests a new, but comparable model for change. Let us start with Fuller's suggestion that the Rojdi data may reflect a change in crop processing, one that might be the result of a shift from 'centrally organized mass processing' to processing at the 'household level'. Next, we use the decline in seed density that occurred at both sites and consider Fuller's statement that this might 'relate to decreased intensity of occupation or plant-processing activities'. Finally, we can add to this the idea that changes in the appearance of wheat and barley at Harappa (a contention that is unchallenged) was a result of changes in post-harvesting processing practices. If changes in crop processing at Harappa were a result of a shift away from centrally organized crop processing activities, then, might these two seemingly separate events at two unrelated sites be connected? Might region-wide socio-economic or socio-political events have an effect on crop processing practices at each site, though expressed with different plants? What I am attempting to show is that even with Fuller's critique, there are still some likely connections between events at these two independent sites.

Finally, let me reiterate what I stated in my original article, that changes occurring at these sites 'may only coincidentally seem similar, and by themselves only represent local processes'. And that 'similar patterns of change at two far-flung sites . . . is a circumstance that should be debated and tested'. I am not foolhardy enough to believe I am yet able to prove beyond question that widespread, regional trends were at work. What I do believe is that while Fuller has admirably added to the debate, he has failed to disprove that what we see happening at Rojdi and Harappa could not have been influenced by a similar set of region-wide events. It is only through the collection of additional data that we will be able to test the idea that changes in the agricultural systems seen at specific sites throughout the northwest region of South Asia, at around 2000 BC, were indeed related.