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Research Article

Taphonomy and labour at the Indus Valley site of Harappa (3700–1300 BC)

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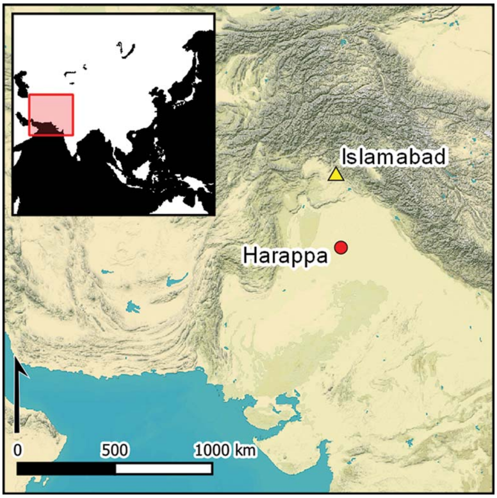

The emergence of early cities required new agricultural practices and archaeobotanical crop-processing models have been used to investigate the social and economic organisation of urban 'consumer' and non-urban 'producer' sites. Archaeobotanical work on the Indus Valley has previously identified various interpretations of labour and subsistence practices. Here, the authors analyse a large archaeobotanical assemblage from Harappa, Pakistan (3700–1300 BC), questioning some of the assumptions of traditional crop-processing models. The ubiquity of small weed seeds, typically removed during the early stages of crop processing, is argued to result from dung burning. This additional taphonomic consideration adds nuance to the understanding of Harappa's labour organisation and food supply with implications for crop-processing models in other contexts.

Keywords: South Asia, Harappa, Indus Civilisation, archaeobotany, crop-processing models, dung burning

Introduction

Excavated by the Harappa Archaeological Project (HARP) between 1986 and 2000, the site of Harappa, in modern Pakistan (*c.* 3700–1900 BC), is a remarkable example of early urbanism (Figures 1 & 2). The populations of urban sites such as Harappa required substantial food supplies. Ethnoarchaeological crop-processing models designed to assess scales of labour

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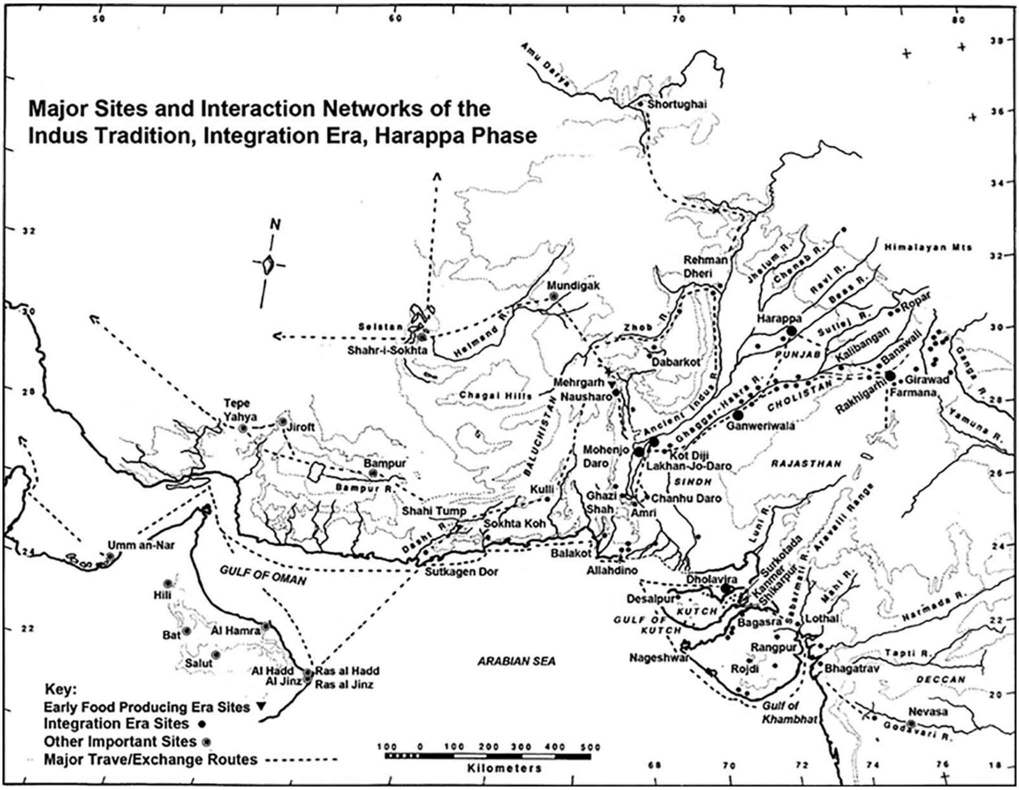

Figure 1. Map showing the major sites and interaction networks of the Indus Tradition (reproduced with permission from Kenoyer & Meadow 2016).

needed at harvest time have been developed for a variety of early urban contexts worldwide. Here, we report on the application of these models to the archaeobotanical assemblages from Harappa. Our results suggest that the daily practice of burning dung for fuel, contributed to the crop-processing patterns that characterise some Indus Valley sites, leading to taphonomic equifinality in archaeobotanical assemblages. Recent analysis of macrobotanical remains and phytoliths from small Indus village sites argues that the daily on-site processing of barley and wheat was carried out by individual families rather than under the centralised control of village sites by Indus urban centres (Bates *et al.* 2017). We compare these macrobotanical results to 1144 archaeobotanical samples from the Indus city of Harappa. Although there are striking similarities in patterning between the assemblages, we offer an alternative interpretation.

Crop-processing models

Archaeobotanical crop-processing models have proven invaluable in understanding past agricultural labour practices (Hillman 1973, 1984; van der Veen 1984; Jones 1987; Stevens 2003; Fuller *et al.* 2014; Bates *et al.* 2017). Although early models distinguished assemblages between 'consumer' and 'producer' sites (Hillman 1984), later iterations focused on the timing of crop storage to distinguish routine and seasonal harvests, and thereby the scales of available labour (Fuller *et al.* 2014).

To understand the point at which charred crop remains entered the archaeological record, these models rely on relative proportions of grain, chaff and weed seeds to infer the scale, organisation and methods used in ancient agricultural systems (Fuller *et al.* 2014; Stevens 2014). Harvesting practices remove weeds, chaff and other plant parts from a crop leaving clean grain and declining numbers of weed seeds as the crop moves through the processing sequence (Reddy 1997; Harvey & Fuller 2005; Fuller *et al.* 2014; Bates *et al.* 2017).

The numbers of glumes to grain decreases as the crop is cleaned through threshing and subsequent winnowing (Fuller *et al.* 2014). Smaller seeds, such as those from weedy taxa, are subsequently removed by fine sieving. Large weed seeds, whose size more closely mimics that of grain, are removed only through a final hand-picking stage. The availability of a large and co-ordinated labour supply for crop processing immediately after harvest should result in low numbers of small weeds and chaff alongside higher proportions of large weed seeds (Fuller *et al.* 2014; Stevens 2014). Alternatively, if crops were processed daily by individual families or small groups, we would expect to see large numbers of small weed seeds, high quantities of chaff and a high proportion of weed seeds to grain.

The specific composition of grains, weed seeds and chaff in an assemblage therefore forms the quantitative basis of these models and their interpretative significance. There are, however, long-running debates about the interpretation of archaeobotanical assemblages, focused on questions of taphonomy and when, exactly, seeds were charred and entered the archaeological record (Miller & Smart 1984; Fuller *et al.* 2014). The taphonomic expectations of crop processing models, combined with potential confounding effects due to the fragility of macrobotanical remains, may lead to site-specific, cultural and taphonomic problems of interpretation.

Crop processing at Harappa

Harappa, a large urban settlement in the upper Indus River Valley, has been continuously occupied since at least the fourth millennium BC, and the site is recognised as a critical example of early urbanisation (Kenoyer 1991, 2015; Dales & Kenoyer 1993; Figure 2). The notable absence of palaces and temples has led scholars to interrogate the potential lack of economic inequality at the site. Bioarchaeological investigations of human health (Robbins Schug *et al.* 2012; Valentine *et al.* 2015) and research on craft production (Kenoyer 2000) do, however, provide some evidence for social and economic inequality (Kenoyer 2015). In this context, crop-processing models provide a valuable means for understanding agricultural organisation. Evidence for the harvesting and processing of crops by large numbers of labourers near cities and villages could support arguments for economic centralisation or the seasonal organisation of Indus communities; evidence for family-scale harvesting, on the other hand, would make the centralisation of agricultural production or large-scale community harvesting unlikely.

Harappa grew from a village into a city of between 60 000 and 80 000 people over the course of roughly 1500 years (Kenoyer 1998, 2012). In this article, we use the overall chronology for the Indus Tradition established using radiocarbon dates from Harappa and other

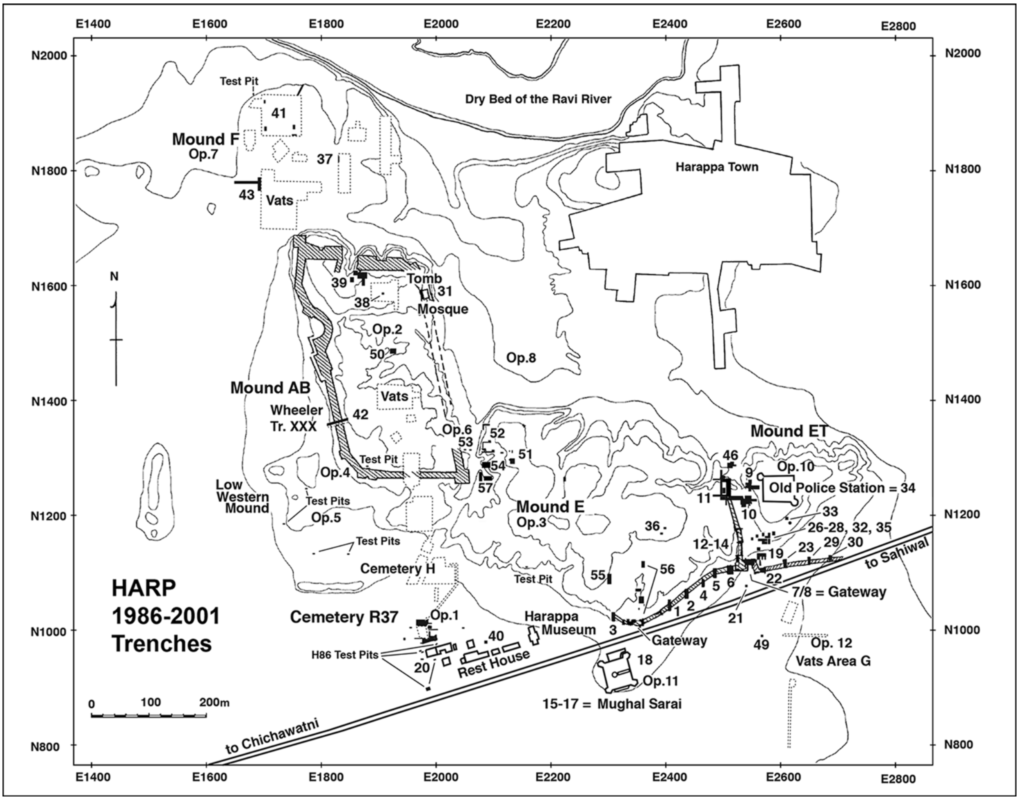

Figure 2. Site plan of the excavations of Harappa (figure by J. Mark Kenoyer).

sites (Meadow & Kenoyer 2005; Kenoyer 2024) and following the earlier model proposed by Shaffer (1992).The earliest Ravi phase (Period 1, *c.* 3700–2800 BC) occupation consisted of small huts with reed and clay-plaster walls, as well as some mud-brick structures (Kenoyer 1998; Kenoyer & Meadow 2000). During this time, it is possible that the inhabitants would have processed crops that were grown in the immediate vicinity of the site. During the incipient urbanisation of the Kot Diji phase (Period 2, *c.* 2800–2600 BC) and the subsequent urban Harappan phase (Period 3, *c.* 2600–1900 BC), craft production was concentrated in urban centres and households, and focused on external trade (Kenoyer 1998; Wright 2010: 189). During this labour transformation, grain may not have been processed in urban areas but rather brought in as clean grain from outlying homesteads where it was threshed and where weeds were removed.

At Harappa, and throughout much of the Indus Civilisation, people depended on two primary seasonal suites of crops. The summer crops (Kharif), grown from July to October, are dependent on rain from summer monsoons. The winter crops (Rabi) rely either on residual rain from the monsoons or on irrigation or floodplain cultivation drawn from the streams and rivers throughout the Indus Valley (Weber 2003; Miller 2006; Jones 2017; Petrie *et al.* 2017).

The processing requirements of domesticated crop species vary, requiring the use of different crop-processing models (Reddy 1997). The grain crop species most frequently recovered at Harappa are the Rabi hulled and naked barley (*Hordeum* sp.) and different wheat varieties (*Triticum* sp.). Some native millets are present, such as *Setaria pumila*, *Paspalum* sp. and *Eragrostis* sp., though few samples contain significant numbers of these grains (Figure 3, see online supplementary material (OSM) Table S1) (Weber 2003). Legumes include lentil (*Lens culinaris*), pea (*Pisum sativum*) and small quantities of vetch (*Vicia* sp.), cowpea (*Vigna unguiculata*) and chickpea (*Cicer* sp.) (Figure 3, Table S1). A variety of other oil and fibre (*Sesamum* sp., *Linum* sp., *Gossypium* sp., Brassicaceae) and fruit crops (*Phoenix dactylifera*, *Vitis* sp., *Ziziphus* sp.) have also been found at the site (d'Alpoim Guedes 2024, *pers. comm.*). Weed taxa include many different types of sedges (Cyperaceae), cf. *Medicago/Trifolium* and *Suaeda* sp. (Figure 4, Table S4). Specimens are frequently poorly preserved and unidentifiable to species. In these instances, designations represent the level of taxonomic certainty; for instance, if we were unsure if a partial cotyledon represented pea (*Pisum* sp.) or lentil (*Lens* sp.) these are combined into a single *Pisum/Lens* category. Uncertainty in identification is also indicated using cf. ('similar to').

As the archaeobotanical assemblage at Harappa is primarily composed of barley and to a lesser extent wheat (Table S2), we employ the models created for these crops. Although the models have been effectively used in a variety of contexts (Song *et al.* 2013; Fuller *et al.* 2014; Stevens 2014), it is important to consider the means by which charred material enters the archaeobotanical record (Miller 1984).

Dung burning

Though archaeobotanical assemblages may be created through accidental food spillage and crop waste, or may represent abandoned food stores, the burning of animal dung as fuel is a potential route through which crops may enter the archaeological record. Miller (1984) first noted the use of dung burned as fuel as a possible source of archaeobotanical materials and this recognition has since been integrated into case studies around the world (Miller & Smart 1984; Reddy 1997; Marston & Miller 2014; Spengler 2019). Roughly 15 per cent of barley fed to cattle passes through the digestive tract intact and remains viable for growth (Kaiser 1999). In modern South Asia, dung remains a significant fuel source and premade dung cakes for burning are available on Amazon.in (Singh 2016).

In an ethnographic study of dung burning in Central Anatolia, wild seeds dominated the dung of grazing animals, while animals with a mixed diet of grazing and foddering produced dung with an even ratio of wild seeds to cereal chaff (Anderson & Ertug-Yaras 1998). Cereal grains often do not survive the burning of a dung cake, though the hard-coated hulled barley proves an exception (Anderson & Ertug-Yaras 1998). Ethnobotanical analysis found goosefoot (*Chenopodium* sp.) and other wild species with small seeds (diameter <2mm) are overrepresented in botanical assemblages from Central Asian pastoral dung burning (Spengler 2019). The presence of small weed seeds in assemblages from pastoral communities are often assumed to be the result of grazing (Miller & Smart 1984).

Analysis of starch grains on cattle teeth at the Farmana site in Haryana (*c.* 2600–2000 BC), India, suggests that animals could have been foddered with left-over cooked human food, possibly including hulled barley (Kashyap & Weber 2010). More widely, livestock may be foddered not only with crops and crop-processing debris, but also with weeds

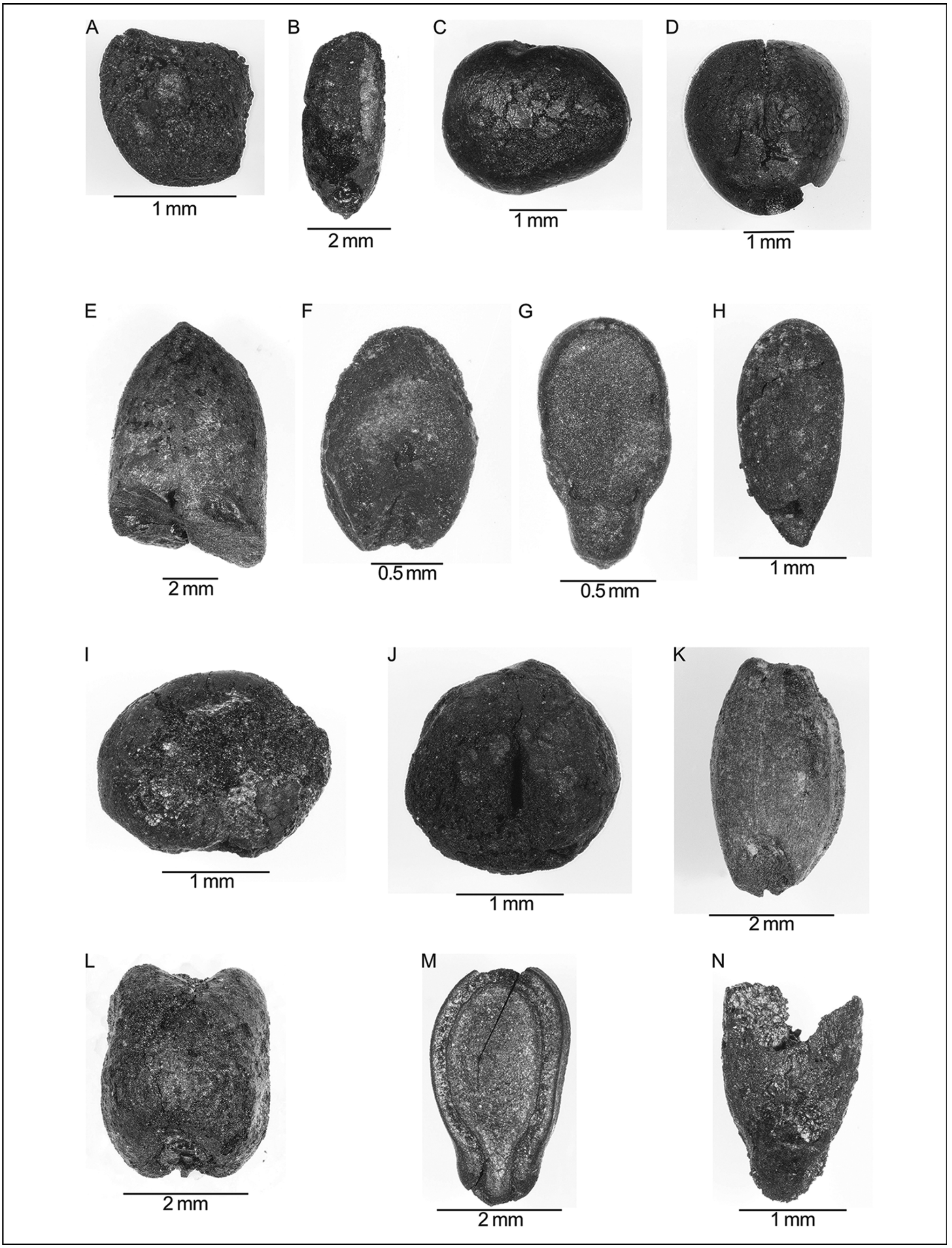

Figure 3. Key Harappa assemblage domesticate taxa: A) Cajanus *sp.; B) cf.* Avena *sp.; C)* Lens culinaris*; D)* Pisum sativum*; E)* Phoenix dactylifera*; F)* Setaria pumila*; G)* Sesamum *sp.; H)* Linum *sp.; I) cf.* Macrotyloma *sp.; J) cf.* Lathyrus *sp.; K)* Hordeum vulgare *(hulled); L)* Triticum aestivum*; M)* Praecitrullus *cf.* fistulosis*; N)* Melothria *sp. (figure by Jade d'Alpoim Guedes).*

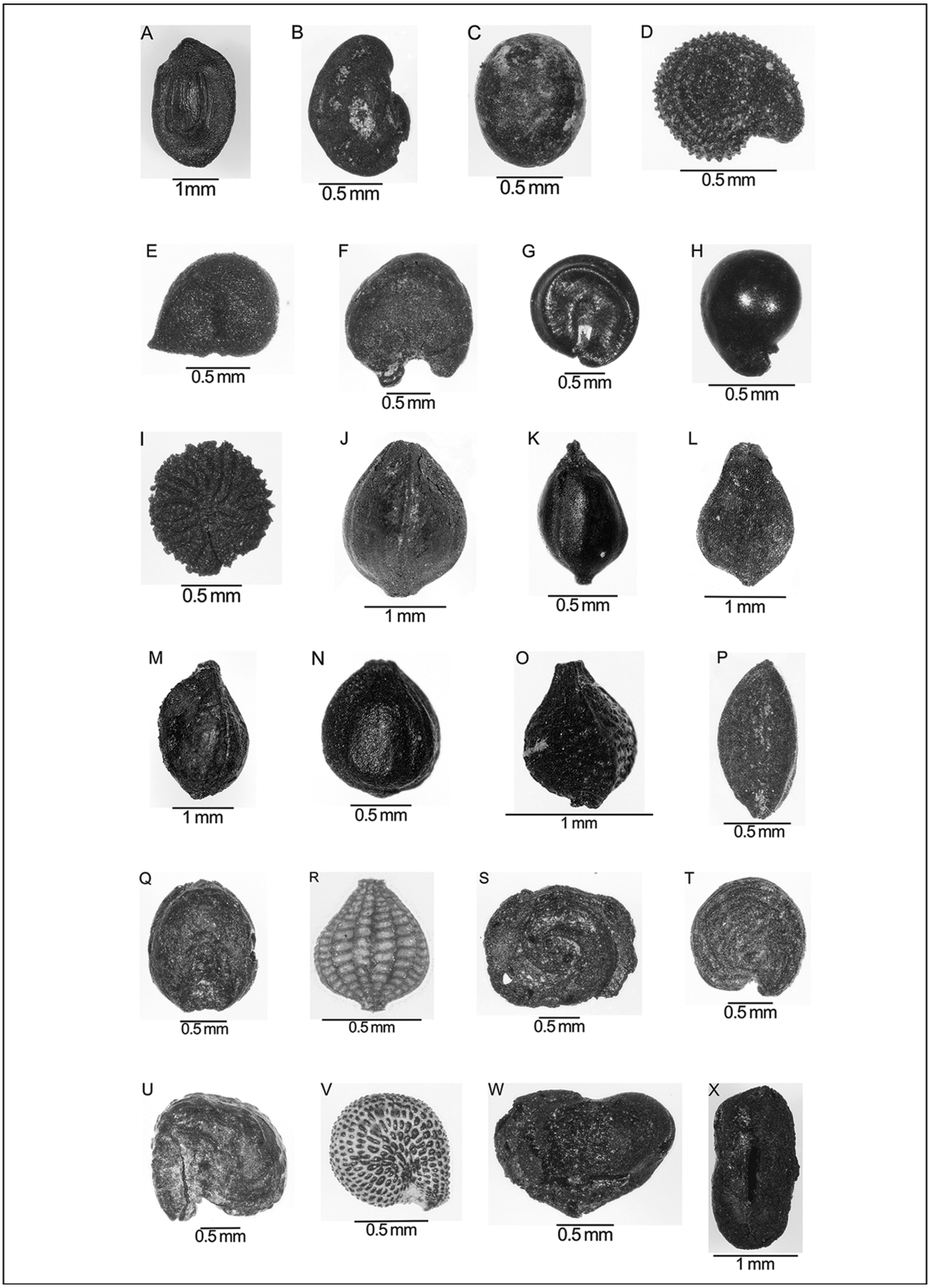

Figure 4. Key Harappa assemblage wild taxa: A) Acacia *sp.; B)* Astragalus *sp.; C)* Brassica *sp.; D & V)* Caryophyllaceae*; E) cf.* Cenchrus *sp.; F)* Abutilon *sp.; G)* Chenopodium *sp.; H)* Suaeda *sp.; I)* Cleome *sp.; J) cf.* Bolboschoenus/Schoenoplectus *sp.; K) cf.* Rumex *sp.; L) cf.* Carex *sp.; M) Cyperaceae type E; N) Cyperaceae type F* Bolboschoenus/Schoenoplectus*; O) cf.* Scirpus *sp.; P) cf.* Cyperus *sp.; Q)* Echinochloa *sp.; R)* Fimbristylis *sp.; S)* Salsola *sp.; T)* Trianthema triquetra*; U)* Trianthema portulacastrum*; W) small Fabaceae (cf.* Medicago/Meliotus/Trifolium*); X) cf.* Sophora/Sebania *sp. (figure by Jade d'Alpoim Guedes).*

(Reddy 1998; Kashyap & Weber 2010; Cappers *et al.* 2016; Spengler 2019). Research at Indus sites in Gujarat (Chakraborty *et al.* 2018; Chase *et al.* 2020), Rajasthan and Haryana, India (Lightfoot *et al.* 2020), indicates that cattle in these areas were predominately foddered with C4 plants such as millets. At Harappa, the predominant crops of wheat and barley are C3 plants, while weeds are a mix of C3 and C4 taxa (Table S4). Isotope analysis ($\delta^{13}C$) of human tooth enamel from Harappa indicates a heavily C3 diet (Kenoyer *et al.* 2013), though no corresponding analysis of Harappan cattle diets is currently available to assess whether similar foddering practices were practised.

Dung burning at Harappa

Zooarchaeological cattle remains are ubiquitous at Harappa, as are representations and figurines of cattle and pastoral subsistence systems (Meadow 1996; Meadow & Patel 2003). Efforts to identify the presence of dung burning through the analysis of phytoliths and chemical traces indicate that this may be an important taphonomic consideration in the interpretation of the Indus archaeological record (Lancelotti 2010; Lancelotti & Madella 2012).

Chaff may be included as 'temper' in processed dung cakes (Cappers *et al.* 2016), as it increases their combustibility, but this lighter material is typically burned up in the process (Shahack-Gross 2011). Ethnographically, wheat chaff is used more often as a temper than barley chaff, which is relatively brittle and preferred as cattle fodder (Cappers *et al.* 2016: 745). When not burned directly, incidental charring has the potential to contribute large amounts of chaff to archaeobotanical assemblages (van der Veen 1992).

These relative proportions of grain to chaff are frequently used to determine the degree to which the crops have been processed (Fuller *et al.* 2014; Stevens 2014). In contexts where dung burning could influence the results of crop processing models, the reassessment of the variability of grain to chaff ratios, the ratio of large to small weed seeds and the proportions of weeds to grains, is necessary. If dung burning is represented in the archaeobotanical assemblages at Harappa, we expect to find the following signatures: 1) a high overall proportion of weed seeds, with samples composed predominantly of small-seeded weeds (smaller than 2mm); 2) evidence for dung-producing animals in the zooarchaeological record; 3) the presence of dung or fodder in the samples themselves; 4) the existence of hearths or associated features; and 5) proportions of weed seeds to grain in excess of 50 per cent (Miller & Smart 1984; Reddy 1998; Marston 2012; Marston & Miller 2014; Spengler 2019).

Archaeobotanical analysis

The botanical remains in this report were collected during fourteen excavation seasons, from 1986–1990 and 1993–2001. In each excavated 5m unit a stratified random sample was collated from a 1 × 2m area, within which all strata were sampled for sediments and artefacts. The amount of sediment sampled varied depending on the stratigraphy and what was available for sampling. Following sectioning and illustration, all large hearths were sampled stratigraphically in their entirety and selected floor areas in and beyond the proximity of each hearth were sampled to understand the distribution of remains on primary occupation floors. Samples of ash and charcoal were collected from inside and outside of all kilns and firings structures. Sediment samples were collected from post-holes, pits, drains and streets, as well as from different stratigraphic levels within these features to document deposition, and from burial fill and from inside and outside of coffins. Samples were also collected from ancient rodent holes that cut through multiple floors in the Period 1 (Ravi) and early Period 2 (Kot Dijian) levels to both identify and remove potential contaminants from the floor and hearth samples and to document the mixing present in the rodent holes.

The soil samples were between 3 and 20 litres in volume. A total of 1144 samples from the archaeobotanical collection from Harappa are analysed here. Samples were sieved through nested screens into 2mm, 1mm, 0.5mm, 0.25mm and smaller than 0.25mm (pan) fractions. Each fraction except for the pan was sorted and analysed. Wood charcoal from the 2mm fraction was pulled and weighed. Seeds were collected from all analysed fractions, and seed fragments sorted and weighed. Seeds were then identified using reference materials (Fuller 2006; Fuller & Harvey 2006; Jacomet 2006; Cappers *et al.* 2009; Cappers & Bekker 2013). Additional details on sample sorting and calculations are in the OSM.

Results

The proportion of weed seeds to grain in the samples is highly variable. Of the 715 samples with both grain and weed seeds, 382 have proportions of small weed seeds higher than 50 per cent and a noticeable lack of large weed seeds, and 201 have proportions of weed seeds to grain higher than 90 per cent. Crop-processing models suggest that these small weeds should have been removed in the earlier stages of processing, prior to transport to Harappa, through winnowing and sieving (Figures 5 & 6). This pattern is consistent across the majority of the 1144 samples. Of the 224 samples with proportions of grain to weeds higher than 50 per cent, only 41 samples have counts of grain higher than 10. Few of the samples contain chaff (Figures 5 & S2): 63 samples contain at least one rachis fragment and one sample accounts for almost half of the total chaff count (sample 1215, n = 108; see Tables S1 & S2).

The lack of chaff in most samples implies sufficient labour to process the crops off-site shortly after harvest (Figures 5 & 6). The high numbers of small weed seeds appear to contradict this interpretation, however, as these proportions are not typical for assemblages of clean grain and do not fit with the predictions of traditional crop-processing models. The pattern of low chaff, variable grain to weed ratios, the predominance of small weed seeds and corresponding lack of large weed seeds is consistent throughout all time periods (Figure 7, Table S1). The urban Harrapan period 3 (n = 680) comes closest to model expectations about clean heavily processed grain, with a cumulative proportion of 78 per cent grain (whole and fragmented) and 22 per cent weed seeds across all samples; yet, as with other time periods, there is relatively little chaff and the weed assemblage is still dominated by small weeds (Figures 7 & 8).

Discussion

Three broad patterns emerge from the Harappa archaeobotanical assemblage: 1) variable proportions of weed seeds to grain; 2) a lack of large weed seeds that mimic wheat and barley; and 3) relatively high proportions of small weed seeds. This is contrary to the expectations

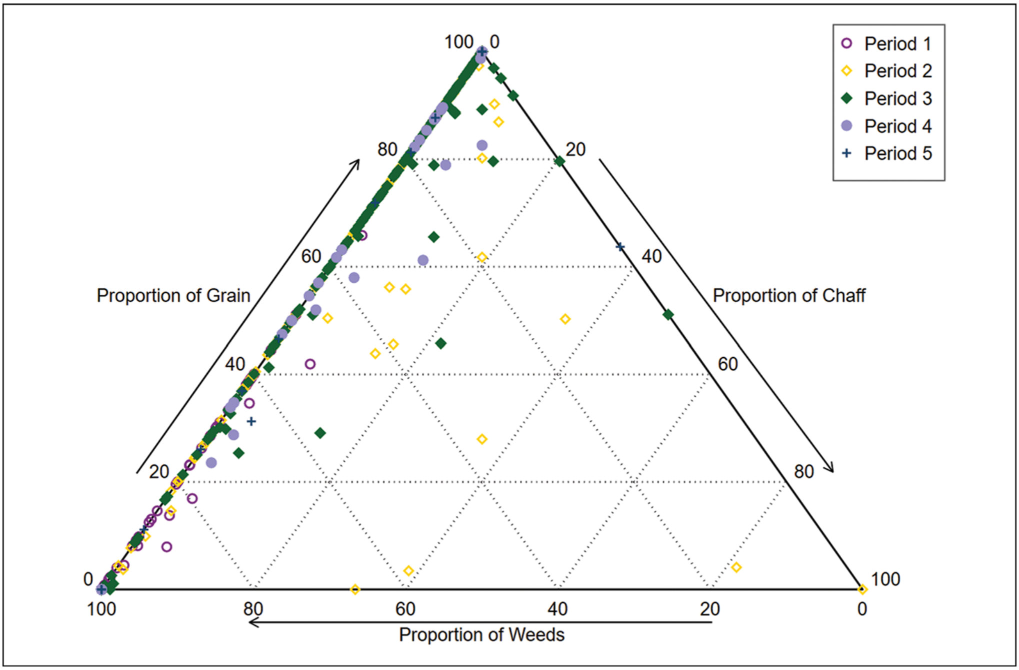

Figure 5. Triplot of cumulative proportions of chaff, grain and weeds by time period within each sample. Weeds includes all weed seeds in the assemblage. Most samples indicate high proportions of weeds, no chaff and varying proportions of grain. Arrows indicate increasing proportions of grain, chaff and weeds within each individual sample. Number of samples = 1144 (figure by Nathaniel James).

of macrobotanical crop-processing models, which assume urban 'consumer' sites such as Harappa had access to a large pool of labour at harvest.

It is important to acknowledge analytical decisions that might impact these results. We note, for example, that we do not include the high numbers of *Suaeda* sp., in our analysis, whose modern and ancient carbonised seeds look indistinguishable unless broken (Table S4), as these were a mix of modern and ancient seeds. Conversely, our counts of grain include fragmented wheat, barley and Cerealia, significantly inflating our counts of clean grain, particularly in the case of the highly fragmented Cerealia (approximately 17 703 additional estimated grains, Table S1). These heavily charred Cerealia fragments are commonly found together with large numbers of small, charred seeds in household contexts (Table S2). Given the temperatures needed to produce such heavily charred fragments, we expect a proportional impact on small weed seeds. These decisions cumulatively inflated the numbers of grain and weighted the analysis against the existing high numbers of small weeds. Despite this, the presence of so many small weed seeds contradicts the expectations of crop-processing models (Hillman 1984; Jones 1990; Stevens 2003; Fuller *et al.* 2014). Yet, the presence of samples (n = 41) with high numbers of clean grain and an absence of weeds does suggest that highly processed crops were, in some instances, brought into the city (Table S3).

Macrobotanical samples from non-urban Indus village sites also demonstrate an absence of large weeds and chaff alongside large numbers of small weeds (Bates *et al.* 2017). This

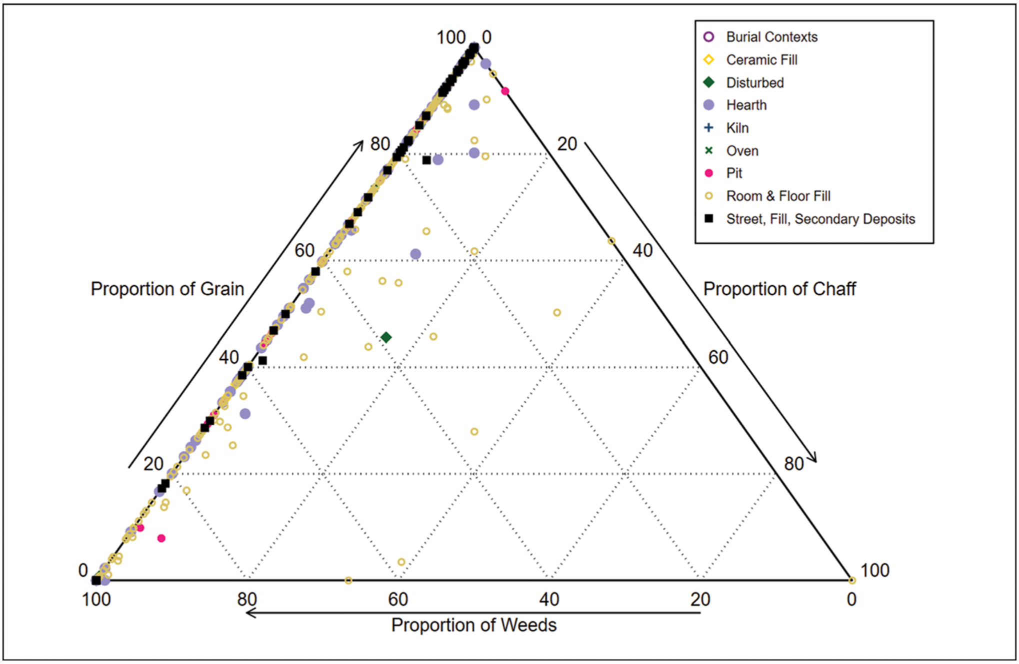

Figure 6. Triplot of cumulative proportions of chaff, grain and weeds within each sample by context. Weeds includes all weed seeds in assemblage. Arrows indicate increasing proportions of grain, chaff, and weeds within each individual sample. Number of samples = 1144 (figure by Nathaniel James).

absence of large weeds is interpreted as the result of handpicking and the discarding of large weeds before waste burning, while the relative absence of chaff is suggested to result from the burning of crop-processing debris. Samples with large numbers of small weeds are therefore the result of burning crop processing waste. Under this interpretation the Indus village assemblages indicate a phase of storage after the winnowing or coarse sieving stage, with the final processing of crops taking place incrementally and the waste subsequently burned. The proposed interpretation is therefore one of ongoing, household-level crop processing, rather than centrally or collectively organised, large-scale processing (Bates *et al.* 2017).

While this interpretation is possible, we argue that, at Harappa, the similar low counts of chaff and resulting ratios of chaff to grain in all time periods imply off-site processing and late-stage storage by a large enough labour force to process the crops immediately after harvest (Figure 5). The presence of high numbers of small weed seeds, which within crop processing model expectations should have been removed, we argue, is the result of dung burning.

The archaeobotanical data from Harappa are consistent with existing expectations from dung burning assemblages, including high weed to grain ratios and high numbers of small weed seeds that cannot otherwise be explained solely by crop processing (Table S5; Miller 1984; Marston 2012; Spengler 2019). The use of dung as a critical fuel source at Harappa, for both domestic and industrial purposes (e.g. in pottery or faience kilns) could explain the patterning (Miller & Smart 1984; Kenoyer 1994; Reddy 1998; Meadow & Patel 2003). Simultaneously, the presence of some samples with very few small weed seeds and high numbers

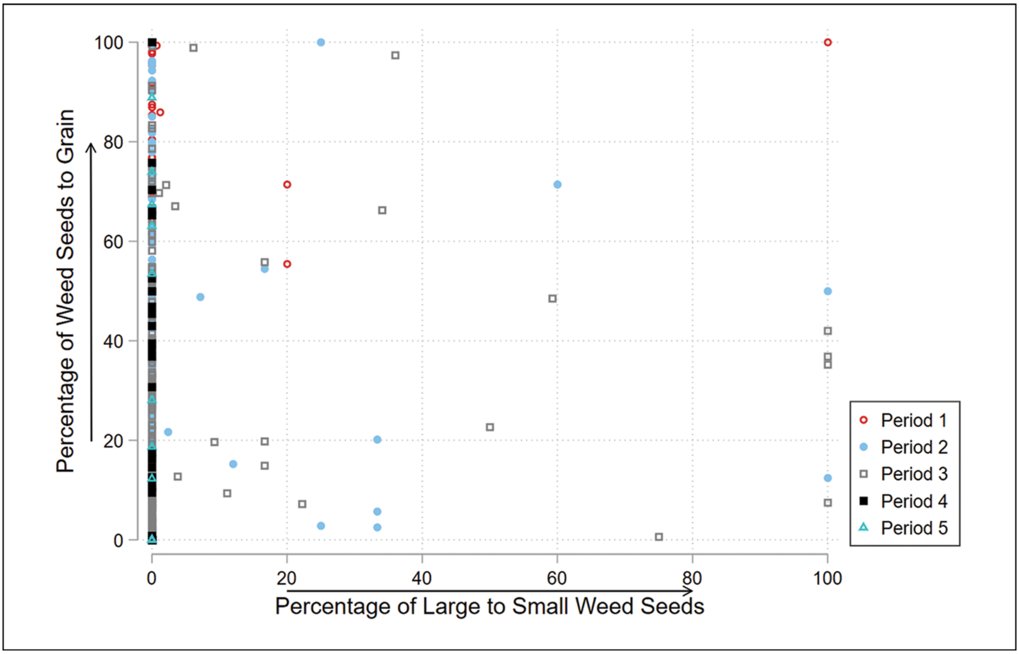

Figure 7. Biplot of large weed:small weed ratios and weed:grain ratios, expressed as percentages. Most samples contain almost no large weeds, with the overall assemblage dominated by small weeds, but there is large variation in the proportions of weed seeds to grain. Number of samples = 1144 (figure by Nathaniel James).

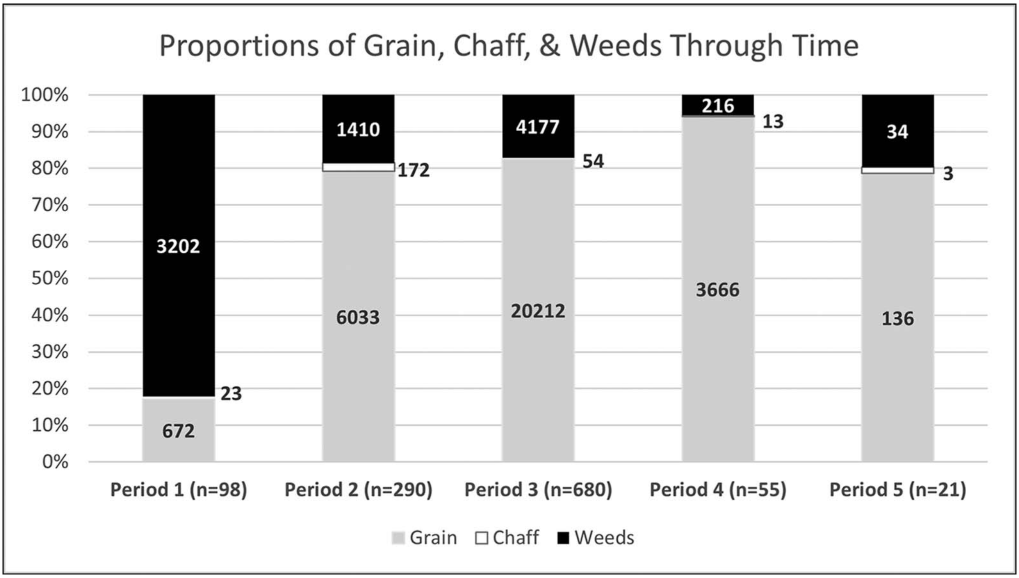

Figure 8. Proportions of grain, chaff and weed seeds in Harappa assemblages through time, with raw counts displayed. Number of samples = 1144 (figure by Nathaniel James).

of grains (Table S3) means that a single explanation for the Harappa assemblage is unlikely. Rather, a combination of all three activities—dung burning, crop processing and accidental food waste—was at work, in concert with a variety of depositional and taphonomic processes.

Many of the weed taxa in the Harappa assemblage are weeds of cultivation such as *Chenopodium*, *Suaeda* sp. and *Trianthema* sp., as well as various sedges (Cyperaceae) and grasses (Poaceae) that may have been consumed by ruminant livestock (Hillman 1991; Marwat *et al.* 2013; Spengler 2019) (Figure 4, Tables S1 & S3). Sedges, a major class of weeds in the Harappan assemblage, may have been consumed by cattle grazing along the riverbanks and marshes around the site (Simpson 2010: 200), or as fodder (Shaheen *et al.* 2020). Other weed seeds, including low-growth habit legumes such as vetches (*Vicia* sp.) and medick/alfalfa (cf. *Medicago/Meliotus/Trifolium* sp.), could also derive from fodder (Miller 2006; Cappers *et al.* 2016).

Dung burning does not appear to have been necessary due to a lack of wood, as analysis of wood charcoal at Harappa indicates the extensive use of both locally available scrub and riverine woods, as well as the importation of mountain pine (Lancelotti 2010). Dung burning was, as it is today, a cultural practice that allowed for a slow steady heat for cooking and made use of a readily available fuel. Small pieces of dung identified during excavation and in palaeoethnobotanical samples further support the practice of dung burning at Harappa (Table S5). Multi-proxy approaches that incorporate phytoliths and faecal spherulites have also demonstrated both the presence of dung (Lancelotti & Madella 2012) as well as chaff (Bates *et al.* 2017) at Indus sites that might not have been preserved in the macrobotanical record, which means that a microbotanical analysis at Harappa is critical to confirming and expanding on our understanding of the patterns we report here.

We argue that the daily burning of dung was a sufficiently pervasive practice at Harappa to impact on the ability of traditional crop-processing models to effectively assess labour organisation or the timing of crop storage. This does not argue against the potential applicability of these models but underscores the need to account for taphonomic processes that potentially shape the formation of archaeobotanical assemblages. Our analysis indicates that crops likely arrived at Harappa in a highly processed state, with subsequent dung burning introducing large numbers of small weed seeds to depositional contexts across the site.

Conclusion

Two alternative interpretative models have been advanced to explain the patterns found in Indus archaeobotanical assemblages, each with its own significant implications for understanding the interactions between rural and urban food supplies. Bates and colleagues (2017) have recently argued that the predominance of small weed seeds at Indus villages indicates crop processing at a household level at regular intervals. In contrast, Weber (2003) asserts that crops were likely processed away from Indus cities like Harappa by a workforce large enough to process and store the clean crop before transportation to the city (Stevens 2014). Here, we have analysed 1144 archaeobotanical samples from Harappa; the relative lack of chaff across the assemblage supports the latter interpretation. Moreover, we argue that the Harappan archaeobotanical assemblage was heavily impacted by dung burning, reflected in the high numbers of small weed seeds. Similarities in the compositions of macrobotanical assemblages from Harappa and from non-urban contemporaneous Indus sites (Bates *et al.* 2017) are intriguing as they imply that cultural practices may have been the same at sites that were very different in scale and organisation. The crop processing patterns identified here also exhibit strong continuity over time (Figure 9). Despite the various political and economic transformations of urban Indus settlements (Possehl 1997; Kenoyer 2005), subsistence systems and agricultural practices seem to have continued much as they were at the height of Harappan urbanisation (Weber *et al.* 2010).

Fuller and colleagues' (2014) extension of earlier crop-processing models argues that the sum of macrobotanical remains from a site reflects the dominant daily activities performed there. They emphasise that crops processed at a site by a large workforce before storage would potentially be charred and preserved, while crops processed after storage on a small scale would likely represent daily household food preparation. Into both of these possibilities we would add the need for consideration of the contribution of dung burning, a key practice at many sites in South Asia and around the world. Archaeological assemblages and models therefore need to be parsed for the contribution of each of these different processes.

Through the findings presented here, the archaeobotanical assemblage from Harappa helps sharpen understanding of the social organisation of this site and the wider Indus Civilisation. Ongoing work at sites historically framed as 'peripheral' to core urban centres is crucial for informing questions of social organisation throughout the Indus region (Petrie *et al.* 2017; Nayak *et al.* 2021). Our results contribute to a growing awareness of commonalities of practice at sites of dramatically different social and economic scales, and to wider

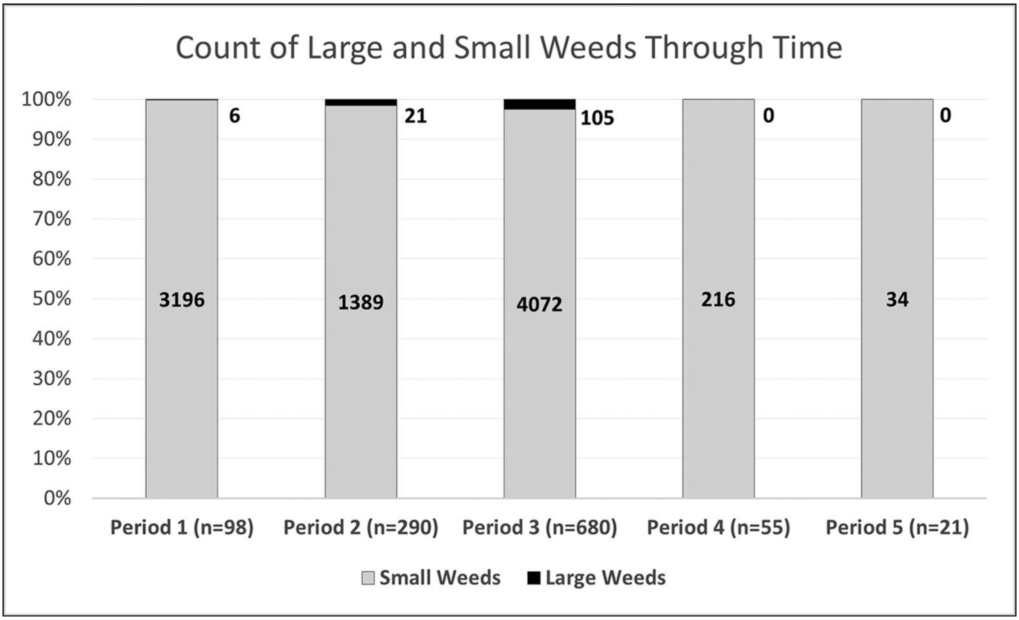

Figure 9. Relative proportions of large (>2.00mm) and small (<2.00mm) weed seeds through time. Number of samples = 1144 (figure by Nathaniel James).

understandings of food supply logistics in early cities and relationships between urban and non-urban populations, both in the Indus Valley and throughout the world.

Acknowledgements

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Online supplementary materials (OSM)

To view supplementary material for this article, please visit https://doi.org/10.15184/aqy.2024.196 and select the supplementary materials tab.

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