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Introduction

Two sets of forces have recurrently structured human history in the long term. On the one hand are the constraints imposed by environment and climate: biotic productivity, water availability and the predictability of annual cycles. On the other are the constraints of social history, those cultural traditions that shape how a society is organized and how human energy is expended to meet individual and group needs. At the interface between these two sets of forces are human subsistence practices. As climate structures the temporal and spatial availability of both wild and domestic plant foods, so traditions that mould the scheduling of subsistence activities adjust and overcome such constraints. Hence we find that humans organize subsistence strategies around the pooling and exchanging of labor (both animal and human) and through the storing and redistribution of key resources, such as the harvested crop, the seed grain, the land and tools. One of archaeology's major contributions to social science is in developing an understanding of the long-term dynamics of how the scheduling of labor, including that involved in food production, has changed, and how it has modified environments and been modified by new technologies and other social transformations.

Through the application of botanical knowledge and laboratory techniques to the study of archaeological questions, archaeobotany has the potential to provide insights into questions of social organization and change in the past. In examining past social organization, one of the most fundamental issues we need to address is how labor was organized and scheduled within that society. In this paper we will outline the reasoning and analytical implications of seeing most charred plant assemblages, with an emphasis on food or crop remains, as the product of incidental loss or waste disposal from recurrent, routine activities. Viewed as such, archaeobotanical assemblages have the potential to contribute to an understanding of how labor was deployed and scheduled on a site-by-site basis. Taken at a broader level they can then reveal varying patterns of how labor was organized in past societies, a point central to any conceptualization of greater societal change. In order to make this case, we will deal with the processes involved in the formation of archaeobotanical assemblages, focusing on possible routes to charring and how these can be distinguished. We consider the relationship between the archaeobotanical assemblage and the archaeological context from which it is recovered, and conclude that interpretations considering such a relationship to be socially significant are often misguided. Instead we argue that it is rather the internal composition – by which we mean all those seeds/chaff from a single flotation sample) - of the assemblage itself that is most informative. Through a consideration of this composition we address the vexed issue of the role of dung-burning in the creation of Old World seed assemblages. We then consider a range of case studies, from Pakistan, England, South Asia and Ireland, each briefly illustrating the utility of archaeobotanical evidence for inferring aspects of social organization, especially with regard to the deployment and scheduling of labor in food production and processing over the annual cycle (Fig. 1).

Breaking the Tyranny of Context: The Power of Content

Archaeologists like to talk about context, and the importance of context for interpretation, but there are two very different concepts meant by context. On the one hand there are ‘contextual archaeologies’, for example when finds or sites and their interpretations are understood in relation to the known social order of their time and place. This is essentially the ‘contextual’ archaeology of Hodder (1991). Or one might understand context in terms of its ecological and geomorphic landscape setting, as in the ‘contextual archaeology’ of Butzer (1982). Archaeological context, by contrast, is generally used to refer to the specific deposit from which archaeological finds are derived, that is the continuous unit of sedimentary matrix together with a range of artifacts of other evidence. This depositional context is the basic unit of most field excavation recording systems and also the starting point for many analyses of the significance of finds in terms of past human activities. Indeed, ‘context’ in this sense has been advocated as the key starting point for relating archaeobotanical remains to human activities (e.g. Dennell 1972; 1974; 1976a; Pearsall 1988; 2000, 241; Hastorf 1999; Miller 1991, 153). In Europe, this has been the case since the application of flotation, which produced significantly increased archaeobotanical evidence more widely across sites.

There is unfortunately a tendency to assume a direct relationship between activities that created an archaeobotanical assemblage and the excavated context from which it was recovered. The earliest examples of such beliefs were advocated by Robin Dennell (1972; 1974) in the early 1970s and have since been echoed on both sides of the Atlantic (e.g. Hillman 1981; Hastorf 1988; 1999). It should be mentioned that Gordon Hillman (1984a) was keen to draw attention to the different role context played within his own and Dennell’s approach. While Dennell would interpret archaeobotanical remains by ‘external’ reference to the past function of the context in which they were found, Hillman (1981, 1984a) advocated that the function of context itself could be understood by the examination of the ‘internal’ composition of the charred assemblage. It is not the aim of this paper to further this debate. Rather it is to question why we should assume any relationship between context and archaeobotanical assemblage at all.

The assumption that archaeologists can find a direct reflection of activities, such as cereal dehusking, on the basis of where remains are found, was widespread in archaeology prior to the rise of formation process studies (Schiffer 1987; La Motta and Schiffer 1999). Such misconceptions seem to persist in relation to archaeobotanical data. Thus we find that postholes from granaries are sampled to find out what crops they held, floor layers to examine the location of processing activities, and field ditches to see what crops grew within them. Although we may dismiss such thinking as entrenched in the naivety of field excavators, these issues are perhaps worthy of some archaeobotanical introspection. For while comparisons with modern crop husbandry have played a major role in the interpretation of charred plant remains (Hillman 1973; 1981; 1984a; 1984b; 1985; G. Jones 1984; 1987), the reasons as to how and why plant remains become charred and subsequently deposited within archaeological contexts have received comparably little attention.

Categorizing Charred Assemblages

To state the obvious, charred remains only become charred and preserved through virtue of having come into contact with fire. It is then surely impossible to interpret the relationship between context and charred plant remains without considering how both relate to the fire responsible for the assemblage's preservation. It is then perhaps surprising to find that this relationship is underplayed or sometimes even ignored within many of those studies that advocate the importance of archaeological context in the study of charred remains (e.g. Dennell 1972; 1974; 1976a; Pearsall 1988; Hastorf 1988). It is therefore essential that archaeobotanists are clear about the form of preservation (charred) and their assumptions or inferences about how it came to be charred and then deposited archaeologically. This amounts to a ‘behavioral context’ (*sensu* La Motta and Schiffer 2001) in which plant processing, burning and archaeobotanical evidence are linked. The ‘critical variables’ (ibid.) that structure these activities are to be found in the relationships of plant structure, edible versus inedible parts and the impact of charring on plant parts, which are determined by the characteristics of plants and thus transcend cultural variation.

One author who has addressed this issue on countless occasions is Richard Hubbard (Hubbard 1975; 1976a; 1976b; Hubbard and Clapham 1992; see also Wilkinson and Stevens 2003, 151-2). Within their paper on taphonomy, Hubbard and Clapham divide assemblages into three groups according to the relationship between context and assemblage. The first group (*class A*) is where the remains have been burnt within the context from which they were recovered. In this case, the context itself should display signs of burning. While this constitutes a case of primary deposition (*sensu* La Motta and Schiffer 1999), it is important to be clear that the material that entered the fire is not necessarily primary refuse.

The second group (*class B*) represents assemblages that come from one discrete burning event, but have then been moved to the context from which they were excavated (secondary deposition). In this case the context itself shows no signs of burning, and in some cases the source of the material may be directly evident on the site. For example, an assemblage recovered from a pit next to a kiln may contain waste from the firing of that kiln. Or, to give a well-cited example, large spreads of burnt material at the site of Assiros, in Greece could be traced to the burning of second floor storerooms located above the surface from which the remains were excavated (G. et al. 1986). It is quite possible, however, that the relationship between context and assemblage may be unfathomable.

To interpret charred assemblages from class B contexts, we must be aware that they are the product of at least three distinct groups of activities. The first are those activities that created the assemblage before it became charred; for example the collecting of firewood, as well as the growing, harvesting and processing of crops. The second are those that involve the burning of the assemblage, for example the lighting of the fire, the discard of waste into a fire, or the heating and accidental burning of cereals while drying. Finally, there are those activities involved in the deposition of the waste, for example, the throwing of material onto a midden, or the digging of a pit to bury midden material. Where the location of the fire in which the assemblage became charred is archaeologically invisible, then we must consider the nature of the relationship between the context and each group of activities (e.g. Kreuz 1990). We often do not know, however, how far the botanical material resulting from various activities has been transported before it reached the fire – it is possible that the waste from the fire was further transported before it became incorporated into an archaeological feature.

The final group (class C) was considered by Hubbard and Clapham (1992) to be the most ubiquitous of all. Class C assemblages differ from those of class B in that rather than coming from a single event, they are formed from many different charring events and so, by inference, many different activities (cf. Hubbard 1976a; 1976b). Hubbard and Clapham (1992) see these as the most difficult of all to interpret, a view that, as shall be seen, is not necessarily shared by the authors of this paper.

A curious point that arises from these categories is the validity of random sampling, so keenly advocated by many authors to archaeological sites (van der Veen 1984; Lennstrom and Hastorf 1992; for further consideration of sampling issues, see Lee this volume). The first premise behind random sampling must be that most assemblages relate to different activities and events, in other words of the class A and B varieties. The remains of plant-processing activities would therefore have to be disposed of and charred where the activities were carried out, or discarded into fires and then deposited without being mixed with residues of other activities. If this is the case, then patterns in the distribution of these activities should be detected by random sampling if enough samples are taken (Orton 2000, 14-39). Experience demonstrates, however, that class A and B assemblages occur only rarely in discrete locations throughout a site (cf. Miksicek 1987). In fact such assemblages are only likely to be recovered through judgmental sampling of these specific contexts as the excavator identifies them (cf. M. Jones 1991). Contrary to what proponents of random sampling propose, this sampling strategy will almost certainly fail to recover class A and class B assemblages. As we hope will be seen, experience often reveals most assemblages to be of the class C variety. From this perspective, random sampling is likely to produce, on the whole, similar homogenized assemblages, a point all too clearly demonstrated within van der Veen's initial study (van der Veen 1984). Similarly, a test of a blanket sampling approach demonstrated most contexts are very much the same regardless of context type, with only a few that stand out as atypical (Lennstrom and Hastorf 1995). Such homogenization often means that variation between samples is either related to different phases of occupation (cf. Pearsall 1988) or to post-depositional factors, such as proximity to the active soil horizon (Miksicek 1986; 1987).

Towards a prevalent taphonomy

Instead of using context as a means to study charred plant remains, we propose that it is the content of the assemblages themselves that is most informative about past human activities. The nature of most archaeobotanical evidence is such that its final resting place is usually only tenuously, if at all, connected to the activities that produced it. Just as archaeozoologists routinely look at the representation of body parts in relation to studies of differential utility, ethnographic butchery and survivability (e.g. Lyman 1994), archaeobotanists require an understanding of how the composition of closed assemblages – the proportions of different plant parts and species - represents past behavioral patterns. What we require is a methodological uniformatarianism (cf. Bailey 1981) for the creation of charred plant assemblages deposited on human occupation sites.

The presence of fires on human occupation sites is a universal phenomenon routinely employed within all societies. The ash and charcoal that is produced by such fires is equally routinely disposed of. Although disposal practices may be structured (e.g. Moore 1986, 109-110), fire waste can be expected to be deposited near settlements and, as such, are prone to redeposition and transport through wind, rain-wash, walking, animal trampling and sweeping, to finally accumulate within rubbish deposits, pits, against walls and in ditches. Due to the small size and light weight nature of charred plant remains, we can expect them to linger within the soils and sediments that are found upon human habitation sites. We can further expect that, in time, charred material will form a significant proportion of the general background noise of refuse, even if disposal practices lead to their concentration within certain areas or deposits. The preservation of this material will obviously be affected not only by deposition, but also by post-depositional factors. These may include destruction through trampling and weathering, with increased survival and preservation where such deposits are within soils and sediments that are subject to little bioturbation and have been rapidly buried. Such situations may be found within the basal deposits of deep pits, where mud-brick houses have collapsed and been leveled, or within fine, or rapidly silting, water-lain deposits. Thus, central to any archaeobotanical study of quantitative composition of charred assemblages is the question of how plants came to enter fires and how fire waste came to be disposed of.

Recurrent influx to fire, and outflux to archaeological ‘fill’, is most likely to result from frequently conducted, routine activities (Fig. 2). This is undoubtedly true on the grounds of pure statistical probability. Disregarding for the moment the events leading to the deposition of charred material, charred plant components resulting from routine activities that are conducted day-in, day-out are 365 times more likely to be represented than the once-in-a-year or occasional event, for example the burning of old thatch, the cereal processing accident, the rare medical ritual or life-passage rite (Stevens 2003a; Fuller 2002, 264). It is often the case that wood charcoal makes up the bulk of archaeobotanical assemblages. Wood as fuel is intentionally burnt, in quantity, and thus wood charcoal is produced routinely in quantity. Seeds are generally a smaller proportion of the assemblage, but one of the remarkable features that every archaeobotanist will have experienced is the uniformity of samples from across given sites, cultures and phases. The recurrence of the same species and parts of species (e.g. grains, seeds, nut shells, glume chaff etc.), whether of wild foods, crops or probable weeds, can often be detected in a narrow range of proportions. What such a pattern implies is that within any region, during a defined period of time, not only is the same type of material routinely being burned, but that in all probability this material is being produced by a limited number of well-defined activities and that such activities are being repeated on a continuous basis.

It is our suggestion then that the most important source for seeds and chaff are routine, 'daily' activities of final crop-processing for food preparation, in which crops, and their contaminants, are taken from storage and processed towards consumption (Stevens 2003a). The waste and incidental loss of crop that results from these activities is then disposed of within the fire, whether as intentional fuel or rubbish disposal. The charred products from each of these different daily burning events will then become combined and in quantitative terms averaged, as material is first amassed in the fire and then mixed in subsequent disposal and reworking of rubbish and sediment. What we propose, therefore, is that rather than being related to one particular event or activity, charred assemblages signify something that is essentially tertiary, or at best secondary, refuse (in the terms of Schiffer 1972), reflecting average and recurrent patterns of activity. Crop-processing provides 'critical variables' (sensu La Motta and Schiffer 2001, 25), which allow us to compare post-storage processing between archaeological sites and ancient social contexts. What we shall now show is how these activities are still interpretable from the examination of the internal composition of these essentially class C charred assemblages.

Assemblage Content and Recurrent Activities

European archaeobotanists have been developing an understanding of the relationships between assemblage composition (content) and past human activities for more than three decades. As the application of sieving and flotation began to be more widely deployed, greatly increasing the volumes of archaeobotanical evidence, professional archaeobotanists became a reality of archaeological research (cf. Fuller 2002, 257ff.; Weber 2003). It was during this period that German archaeobotanists, Körber-Gröhne (1967) and Knörzer (1971), commented on the recurrent nature of archaeobotanical assemblages. In general, charred assemblages clearly represented a very limited range of the floristic diversity of the European flora. While many wild species were present, almost all were known from modern associations as weeds, with the exception of wild edible plants. Yet by far the most well represented remains were those of cereals, represented through both their grain and chaff. So with the exception of the remains of wild plant foods, most of this material could be seen as derived from arable plant communities rather than the environment at large. This had two significant implications for archaeobotanical analysis and interpretation. Firstly, the wild species present, if largely arable weeds, provided an important data set for inferring arable ecology and human practices of cultivation that created and maintained agricultural environments, such as tillage, manuring and irrigation. Indeed, this has been a continuing focus of archaeobotanical analysis for the past three decades (e.g. Knörzer 1971; Körber-Gröhne 1981; M. Jones 1978; 1981; 1985; Hillman 1981; 1991; Küster 1991; Behre and Jacomet 1991; Van der Veen 1992; G. Jones et al. 1995; 2000; Bogaard 2002). The second implication is that the composition of assemblages reflected the outcome of filtering processes imposed by activities employed in processing crops to obtain clean grain.

In order to understand the taphonomic effects of processing activities upon charred assemblages, Gordon Hillman undertook ethnoarchaeological work in Turkey in the early 1970s (see Hillman 2004, 77-78). As outlined by Hillman (1973), what ethnoarchaeology would provide was a link between assemblage composition and human activities, regardless of whether human activities could be inferred from archaeological context. Indeed Hillman even went as far as to suggest that the function of the context could be inferred from the charred assemblage itself (Hillman 1981). This represents an early example of the kind of behavioral archaeology promoted by Schiffer (e.g. 1976; La Motta and Schiffer 2001). This pioneering work (Hillman 1981, 1984a, 1984b, 1985) was followed by similar research by Glynis Jones (1984; 1987), who contributed the important insight of the significance of weed seed size and weight (aerodynamic properties) and more robust statistical assessment of such models. Since that time, valuable studies have been carried on a wider range of Old World crops, including millets (Reddy 1997; 2003; Young and Thompson 1999; D'Andrea et al. 1999; Lundström-Baudais et al. 2002) and pulses (Butler et al. 1999), with further investigations of wheat (Triticum spp.) and barley (Hordeum vulgare L.) (Viklund 1998; Peña-Chocarro 1999). While Hillman (1981), like Dennell (1974), emphasized the application of crop-processing assemblage signatures in the inference of activities, such an approach is misguided for reasons already outlined. Rather, the linkage of activities to recurrent patterns across assemblages and contexts provides a basis for meaningful social interpretation from archaeobotanical evidence.

The residues of crop-processing then need to come into contact with fire, and experiments have shown this is likely to have biased samples by destroying certain botanical components preferentially according to their physical nature (Wilson 1984; Boardman and Jones 1990; Viklund 1998). This bias favors the preservation of more robust items, such as cereal grains/grass caryopses and pulses, with poorer (or no) preservation of fragile associated elements (e.g. chaff, pulse pods, etc.).

Taken together, these studies indicate that traditional forms of non-mechanized crop-processing are constructed from a limited set of actions that structure assemblages in predictable ways. Crop processing can be divided into two basic sets of activities, those that break apart the crop-plant and those that separate out the various freed components. The first includes threshing to break apart cereal ears, or separate pods of some pulses. Another later stage for hulled crops is the dehusking to remove hulls and glumes still attached to the grain, and for ‘pod-threshing’ pulses, to remove the pod. Separation involves the removal of non-food items, such as chaff, stems, capsules, seed heads and weed seeds. A universal approach to separation is to rely on the physical properties of various components. Thus, winnowing separates elements according to weight and aerodynamics, while sieving separates according to size. Waste from various stages will therefore have characteristics of weight and/or size in common (G. Jones 1987; Stevens 2003a). As the harvested crop progresses through the crop-processing sequence, larger proportions of edible grain are retained relative to waste (mainly chaff and weed seeds); in addition remaining weed seeds will be closer in size and weight to cereal grains, i.e. large seeds will increase relative to small seeds (Fig. 3).

When we consider how crop-processing structures charred assemblages, alongside the implications discussed earlier in this paper concerning the bias of charred evidence towards routine activities (Fig. 2), an important implication logically arises. Following Hillman (1981; 1984a), the processing sequence can be divided into two groups of activities: those that precede storage and those that are conducted as crops are taken from stores. Those occurring prior to storage are usually conducted in bulk at harvest time, once or twice a year (depending on the local climate/latitude). These activities are less likely to contribute to the archaeobotanical evidence. Firstly, they are often conducted in the field or specially prepared threshing floors, understandably located away from fires (see also Reddy 1999, 69; 2003). Secondly, because of the limited number of times such activities occur within a single year, the waste from them may only be present for a few weeks. These processing activities stand in marked contrast to those activities carried out when a crop is removed from storage. Such stages are repeated regularly throughout the year, usually within settlements and so in proximity to fires. Hence, there is a high probability for charred waste to enter the record in an iterative, numerically significant fashion.

Thus, storage plays a crucial role in dividing crop-processing into the routine (post-storage stages), which will be present (predominately) in the archaeological evidence, and the seasonal (pre-storage, harvest processing) that will be either absent or rarely present (Fig. 4). Importantly, this dividing line of storage reflects a decision, arguably a strategy, on the part of past humans (agents) to carry out a certain amount of processing prior to storage and leave the remainder to be conducted from day-to-day. Such strategic decisions can be related to demands on labor. The organization and scheduling of the agricultural work force is therefore planned according to how much labor is available for processing at the time of harvest, when other activities also demand attention. This is, of course, further dependant on how much time there is to conduct such operations before crops need to be stored to stay ahead of the weather. If the time and person-power is available, processing can be taken further and reduce the work required throughout the remainder of the year until the next harvest. Alternatively, fewer helping hands would promote storage in a less processed state and the routine full processing of smaller amounts throughout the year (Stevens 2003a). In addition, the state at which crops are stored will determine how much storage space is needed, with grains taking less space than spikelets and considerably less than sheaths. Grain still in its spikelet is, however, more resistant to the attacks of pests (Hillman 1981; Reddy 2003, 77) and might therefore be strategically chosen as a way to store.

An example of how charred assemblages reflect storage patterns can be drawn from Bronze Age Assiros in Greece, where the collapse of burnt granaries could be inferred from archaeological features (G. Jones et al. 1986). In this case the structural, archaeological context demonstrates that we are dealing with grain stores, indicating storage as semi-clean spikelets of wheat. Had this fortunate chance of preservation not occurred, however, we could nevertheless infer the form of storage from the chaff, grain and weed assemblages that recurred in domestic contexts and fill layers on the site. These samples would differ from the catastrophically charred stores only in a lower proportion of grain, as further processing should have removed some grain into the human food chain. Even had the Assiros material been redeposited elsewhere on the site, the composition would still indicate storage as spikelets.

Dung: Don’t Be Distracted

Another potential source for charred seeds that is often discussed is burnt dung. While the use of dung as fuel has been considered a likely source for the Near-East (Miller 1984; 1991, 154; 1996; Miller and Smart 1984; Charles 1998), we expect it to be generally absent from sites in northwestern Europe due to climatic constraints on drying dung and the ready availability of wood fuels. Is it realistic in well-wooded environments to suppose that prehistoric populations dried dung, which during most seasons would have required fire to do so, as a fuel? Accepting that this is extremely unlikely, the derivation of charred remains directly from crop-processing waste, either used as fuel or incidentally disposed of in fire, seems likely. This source through recurrence provides the only logical explanation for common assemblages of northwest Europe. Is it logical to assume, as proponents of a dung-source for charred seeds do, that the explanation for the preservation of charred seeds in archaeological sites is different in the Near East (and perhaps southeast Europe) from that in northwest Europe? In New World contexts like prehistoric eastern North America, we confront a similar quandary: in the absence of large domestic fauna herds and abundant forest resources, how do we explain the recurrent presence of charred seeds? We contend that the simplest, and most widely applicable explanation is that charred seeds are derived from burnt waste generated during the regular processing and preparation of food. This is not to deny that other sources of charred seeds, such as the burning of dung, might not contribute to some assemblages, some of the time, but rather to emphasize that certain recurrent and cross-cultural practices, such as plant food processing, are likely to be the more quantitatively significant.

We believe that the importance of routine crop-processing waste for archaeobotany can be demonstrated through some simple interregional comparisons. For the periods of the Pre-Pottery Neolithic Near East, domestic animals are absent or recent enough adoptions as to be fairly minor contributors to the charred seed record, and the range of wild species that may be weeds is by-and-large the same as that of the Later Neolithic period, when domestic animals are an important part of the economy (Table 1). These lists are very similar and suggest that the addition of domestic animals did little to change the composition of the archaeological wild seed roster. This suggests continuity in what these wild seeds represent. We concur with Hillman et al. (1997) that late Pleistocene foragers are unlikely to have invested time to gather wild ungulate dung during an era when wood sources were abundant (contra Miller 1996; 1997). The general similarity in the weed floras represented within charred assemblages from both pastoral and pre-pastoral sites suggests recurrent processes, to which routine use of livestock dung is not a possibility in the case of the former. If dung was the most significant source of seed remains, then surely the adoption of livestock would be expected to register a more significant impact upon the archaeobotanical record. If we compare this to the wet environments in Europe, represented in Table 2 by weeds from British and Irish Bronze Age through Anglo Saxon sites, we see a general similarity. Differences can all be explained in biogeographic terms as more temperate species and genera replace related taxa of more arid environments. What all of these seed taxa rosters represent are predominantly fast-turnover, disturbance-adapted species - namely weeds.

Certainly dung is a fuel source, especially in semi-arid environments such as the Near East. Our point is, however, to make the case that the evidence from dung may well be swamped out numerically by the routine, or at the very worst just add noise to evidence of arable weed-chaff assemblages. In a targeted ethnoarchaeological study on crop-processing waste in India, where dung is a major fuel source, Reddy (1999; 2003, 158-160) found that crop-processing waste outnumbered seed input from dung when the charcoal from modern hearths was collected. The use of dung as fuel does not negate the need for households to carry out routine post-storage crop-processing, which is therefore likely to contribute to the archaeobotanical record (Samuel 2001). Thus, we should be justified in approaching charred assemblages with some of the same expectations derived from crop-processing models, and the expectations of routine waste as a reflection of recurrent labor deployment, wherever we study agricultural societies that must process cereal crops. Having made this point, it is nevertheless wise to consider each site and set assemblages on their own terms to assess the relative amount of noise added by dung-burning, as Charles (1998) has. Another way to do so is through multiple lines of evidence, such as using phytolith assemblages from the same archaeological fills, as these can suggest the input of dung-burning or other sources (Madella 2003). We briefly present such an example from a historical site in Pakistan.

Routine crop-processing and occasional dung-burning: the case of Hund, northwest Pakistan

The site of Hund, in Peshawar District (northwest Pakistan), is a substantial archaeological mound. At the end of the University of Peshwar excavation season in 1996-1997, Fuller was able to join the excavations to carry out a limited program of archaeobotanical sampling, including bulk flotation samples from layers, pit fills and ovens, as well as sediment samples for phytoliths from each of the same contexts. This site was formerly a significant regional city. While historical references are interpreted as indicating that this was the major river crossing of the Indus, along the major trade route from Kabul to India where Alexander the Great crossed the Indus, the occupation of the site excavated began slightly later in the second century BC. Stratigraphy and building phases continued through the sixteenth century AD, with a sequence readily datable by coin finds (Ali 1999). Analyses of plant macro-remains and phytoliths (Hassan 2000; Cooke 2002; Fuller, unpublished) provide a complementary picture of plant inputs to the site, with probable dung contributions being minor except for a few contexts that stand out from the norm.

Rare contexts with dung fragments also have charred culm nodes, different weed taxa and a phytolith assemblage higher in straw/culm morphotypes by comparison to most contexts dominated by spikelet phytoliths. This is illustrated in Figure 5, where the typical dendritic-phytolith dominated assemblage can be contrasted with the occasional smooth rod dominated assemblage. The high presence of spikelet phytoliths suggests that it is these parts that were most often produced and charred, even though charred macro-remains of wheat and barley chaff tend to be under-represented in comparison to grains. This may indicate the storage of wheat and barley ears or hulled barley spikelets, as the rachis segments of free-threshing wheat and barley are removed early in processing, whereas the harvested straw was removed prior to storage and utilized as fodder. It is the occasional context that sticks out from the typical macro-remains assemblage. While most assemblages are dominated by wheat and barley, with large-seeded weed species, a few contexts have lower seed densities, the presence of charred culm nodes (from straw) and fragments of charred dung.

This evidence warrants additional observations with regard to detecting dung-derived seed assemblages. It has been suggested (e.g. Miller 1984; 1991, 154) that the wood charcoal to seed ratio may reflect the likelihood or degree of burnt dung contributing to an assemblage, with less wood and more seeds reflecting more dung. In Hund flotation samples, however, those samples with burnt dung fragments, as well as culm nodes, actually have higher wood charcoal to seed ratios than those samples that represent routine processing, in which dung is absent and likely to a be only a minor contributor, if at all. In the samples with the highest seed to wood ratio (by either volume or weight), no dung is present and the seed assemblage is dominated by fully formed grains of the well-known cereal weed, *Lolium temulentum*. These samples that are high in seeds and low in charcoal, which Miller's approach would categorize as more-likely dung-derived, also contain quantities of grain remains and, in contrast to other samples, contained no charred dung or culm nodes.

Overall, two conclusions can be drawn from the example of Hund. First, while dung contributes to a few unusual contexts, most of the archaeobotanical seed remains are best interpreted as the results of day-to-day cereal processing for human consumption. The quantitative implication from Hund is that when all of the samples are tallied together, the overriding picture is one reflecting recurrent daily cereal processing, in this case involving the threshing of naked wheat ears (reflected in chaff phytoliths), fine sieving and final stages of hand-picking large weeds. The other remarkable feature relating to these data is that the evidence is consistent from the start of the site, at *c.* 200 BC, to the end of the sequence, *c*. 1600 AD. Although a few of the rare accidental plant inclusions, from fruits and oilseeds, may have changed through time, the predominant domestic crop-processing pattern for staple foods remained consistent. This is despite major political upheavals and religious changes (from Buddhist to Hindu rulers to Muslim military chiefs) to which this site was central, according to historical sources. In fact, relatively little changed within the organization of agricultural activities. This seems a testament to the conservative nature of domestic labor organization and food production, thereby providing a useful way to compare sites, regions and societies over the long-term and across world regions.

Community Traditions in Labor Mobilization: The Case of Iron Age Britain

Community traditions in the organization of crop-processing can be well documented in the Iron Age and Roman era of southern Britain. In this region numerous settlement sites have been subjected to flotation and archaeobotanical analysis. Examples from these sites show that individual sites display fairly consistent patterns in terms of weed, crop grain and chaff assemblages, but that not all sites are uniform. Thus, while some sites consistently show one pattern, in terms of the proportion of key elements, other sites show another, implying that different groups of sites have different systems for the organization of labor (Stevens 2003a).

Two patterns of archaeobotanical data with implied differences in labor organization can be illustrated by comparing three Iron Age hillfort sites with three smaller Iron Age settlements in the Thames Valley (for another case study where patterns in archaeobotanical data might be related to labor organization, see Walshaw this volume). The archaeobotanical data from these sites are plotted in Fig. 6. This plot shows the proportion of weed seeds to grains, against the proportion of large to small weed seeds. In general smaller weed seeds decline comparatively to grain and large weed seeds as we progress through the processing sequence (Fig. 3). Thus the lower right-hand side of the diagram contains samples that represent waste from only the last processing stages (Fig. 6). Hence they are indicative of crops stored probably as semi-clean spikelets or grain (Fig. 4). Samples falling in the top left-hand corner are then representative not just of waste from the earlier processing stages but, because they are also frequently rich in glumes (Stevens 2003a), of waste from the entire sequence. They are then representative of waste from crops that were stored relatively unclean, perhaps as partially threshed ears or even sheaves (Fig. 4).

What is striking is the separation of the two distributions, with a modal tendency. All of the samples from the Thames Valley sites clearly indicate more processing stages routinely contributing to archaeobotanical evidence, while those from the hillfort sites indicate less.

The implication of this is a division between these two groups of sites in terms of how processing was organized and how much labor was normally mobilized. At the three hillfort sites, with archaeological features indicating their importance as communal centers (Cunliffe 1984; Wainwright and Davies 1995), and a fortified site, crops were stored more fully processed and had therefore arrived on the site having undergone a greater amount of processing and hence labor input during the harvest period, probably due to the mobilization of a larger workforce. By contrast, at the Thames Valley sites, more typical of small, dispersed Iron Age settlements, the crop appears to have been stored as unclean spikelets/grains or even sheaths, with little additional labor being employed during the harvest period. This then led to the bulk of all of the processing stages, and thus a greater range of weed species (and chaff), being represented in the archaeobotanical samples.

This pattern has implications for the diversity of modes of labor organization in Iron Age Britain. Indeed, one might expect differences within each community in their ability to call upon labor in the increasingly complex and hierarchical social organization of this period. Whether through some centralized pull of labor or through different scales of household organization, these groups of contemporary sites differ. That this difference is highly embedded within social formations, rather than being either transient or regional, is suggested by the fact that both patterns are found in the Thames Valley and endure for the sites' entire occupations, extending for periods of up to a millennium (Stevens 2003a). One of the most intriguing implications of these data is that there are at least two alternative models on how co-existing communities organized labor and dealt with harvest and crop-processing. These approaches reflect different scales of labor mobilization, with more people and/or more time relative to the quantity of crop upon those settlements storing as semi-clean spikelets, versus those with less time and expendable labor storing as sheaths/ears. Furthermore, these approaches were consistent within communities and showed a remarkable consistency through time. Indeed, the conservatism of crop-processing/labor-mobilization patterns of particular communities is remarkable, and appears not to have been transformed by the political change that is Romanization (Stevens 2003a). As in the case of Hund, the case of Iron Age and Roman Britain suggests that sometimes changes in who is running a society may have little impact on how communities organize their most basic social routines.

Putting Labor in the Landscape: Ashmounds and Villages of Neolithic South India

A routine versus seasonal processing perspective on archaeobotanical remains can provide important insights into the wider social systems of an archaeological culture. We will take the South Indian Neolithic as an example, in which agricultural village sites with evidence of the cultivation and routine processing of native small millets and pulses occur contemporary to isolated 'ashmound' sites (Fig. 7) formed by cyclical accumulations and conflagrations of cattle dung (Korisettar et al. 2001a; 2001b; Fuller 2001; 2003; Fuller et al. 2001; 2004). These two kinds of archaeological sites are very different, but by considering them in terms of routine crop-processing versus seasonal mass-processing and redistribution, they can be understood as an integrated system in the scheduling of food production, labor, pastoral herd movement and ritual gathering.

The agricultural settlement sites were often located on the flat summits of granite tors (inselbergs) that break the flat plains of the Mysore Plateau. These hilltop sites include often deeply stratified archaeological deposits and have yielded much artefactual evidence, as well as structural features in the form of round huts. Bone refuse from animal consumption is frequent, as is charcoal including recurrent assemblages of crops and some weeds (Fig 8). The crops represent a Neolithic package domesticated within the region, consisting of two small millet taxa - browntop millet and birstley foxtail (*Brachiaria ramosa* and *Setaria verticillata*) - and two grain legumes - the mungbean (*Vigna radiata*) and horsegram (*Macrotyloma uniflorum*) (Fuller et al. 2001; 2004).

These are regarded as major foodstuffs, both because they are known crops today (some admittedly very rare crops) and because, as charred evidence, they are likely to reflect routine processing waste rather than dung. In addition to the general reasons already given above, dung can be excluded on the grounds of the extremely restricted taxa diversity (Fuller 2003). Two grasses recur in all samples, with very few other grass remains. This is despite being located in an ecologically zone rich with savannah grasses, including some 120 species, many of which are ecologically predicted to be much more common than the rare millets that have been selected as crops. In addition, charred dung fragments are absent. The small quantity of weed seeds points towards later processing stages, while the fact that the wild taxa encountered were consistently similar in size to millet caryopses suggests that these weeds accompanied the millets. A small percentage of the millet grains displayed fragments of husk adhering to them, indicating that these are grains that had been incompletely dehusked or were not yet dehusked, the kind of waste that develops around the outside of a mortar when dehusking. It is these accidentally lost, still hulled grains, as well as some lost dehusked grains, that are most likely to be swept up with other waste, like husks and weeds seeds, and thrown onto the fire. The lack of husks is simply a product of the greatly biased destruction of husks when burnt. Local dehusking is suggested by the numerous mortar-like depressions in the granite boulders that surround these sites. These millet waste groups have then become mixed with pulse waste, perhaps from the accidental loss of pulses in dry-roasting. On the whole, archaeobotanical assemblages are highly consistent through individual Southern Neolithic sites, and across sites (some 12 were studied by Fuller), and indicate the importance of summer (monsoon) grown crops, which were then processed throughout much of the year at the hilltop sites.

By contrast the evidence of ashmounds bespeak seasonal (or sporadic), shorter-term encampments. The role of pastoralism at these sites is clear from evidence for penning, dung accumulation and animal bones (Allchin 1963; Paddayya 1998), but plant food consumption is implied by the presence of a number of quernstones. Abundant charred remains of crops are, however, lacking. Although the lack of routine processing on these sites is confounded with the lack of densely stratified occupation layers, the ashmounds provide a clear contrast with the hilltop villages, where routine millet-dehusking and pulse roasting were conducted. The artefacts, plant assemblages and nature of archaeological deposits between settlements and ashmounds are highly dissimilar (Korisettar et al. 2001a). Nevertheless, due to contemporaneity, as well as shared ceramic and lithic repertoires, these sites should be linked into one social system, and thus the ashmounds can be interpreted as seasonal encampments and festival centers where staple plant foods are brought in small quantity from village sites in the regional settlement system, but not as sites of crop storage with routine post-storage processing.

Linking Productive Labor: Post-harvest processing and pottery production

As the South Indian and British cases illustrates, the organization of labor for crop-processing can be usefully considered in a regional and seasonal landscape context. Agricultural labor can be scheduled for particular times of the year and at particular places in the settlement system. So it is with other form of productivity, such as raw material procurement and activities of artifact fabrication. When all of these areas of activity can be linked, a more holistic understanding of ancient social organization should become possible. In the case of pottery production it may be possible to more directly link agricultural labor when agricultural products, and by-products such as chaff, are incorporated into ceramics. An illustrative case from Bronze Age Ireland will be explored (excluding evidence from Early Bronze Age sites due to the very small quantity of recovered assemblages dating to this period), with some brief comments on how the linkage in the monsoonal tropics may be necessarily different, conditioned by different climatic seasonality.

New research into arable agricultural systems of Bronze Age Ireland has highlighted the need for consideration of a range of archaeobotanical data in the reconstruction of cereal economies. Studies of arable agricultural systems throughout the world have regularly utilized data from seed and chaff impressions on ceramic vessels in the reconstruction of past economies (e.g. Jessen and Helbaek 1944; Helbaek 1952; 1959; Vishnu-Mittre 1969; Costantini 1983; Stemler 1990; Klee and Zach 1999). Cereal components can become incorporated into ceramic vessels during manufacture and may be preserved through charring, or may be destroyed during the firing of a pot, leaving morphologically identifiable impressions of the material remaining in the fabric of vessels. It has regularly been proposed in Ireland and Britain that the incorporation of cereals into the fabric of prehistoric ceramic vessels is a result of the presence of crops in manufacturing areas, whereby components are inadvertently incorporated (Jessen and Helbaek 1944, 10; Godwin 1975, 405; Cleary 1987, 35). The actual identification of chaff as a temper in Irish vessels has proved to be a contentious issue (Ó Ríordáin 1954, 327; Sheridan 1993, 49; Cleary 2000, 125-127). The intentional inclusion of cereals may, however, have occurred due to technical requirements of potters, for example in the use of chaff as a tempering agent (Boreland 1996, 22; Gibson 2002, 35; Gibson 2003, vi; Gibson and Woods 1997, 33; Ó Ríordáin 1954, 327), and may also have occurred as a result of symbolic, social or stylistic reasons (Schiffer and Skibo 1987, 596; Gibson 2003, vi; Darvill 2004, 204 n.2). Cereal components may even have represented a valuable commodity for ceramic manufacturers as tempering agents and also for use in fires. The utilization of mineral tempers and certain organic tempers, such as bone and shell, have, however, often received far more attention than cereals and grasses.

Previous studies have proposed that the frequency of various cereal types recorded from ceramic vessels represents the relative economic importance of each cereal type (Jessen and Helbaek 1944, 10; Helbaek 1952; Godwin 1975, 405; Costantini 1983; Possehl 1999, 459). Others have argued that a range of processes and behavioral patterns affected the ways in which cereals were incorporated into ceramic vessels, and that the predominance of certain cereal types at various times is unlikely to be related to their economic importance. Evidence from cereal impressions may reveal little about local agricultural systems, as ceramic vessels may have been deposited at a considerable distance from their location of manufacture (Dennell 1976b, 13). Hubbard (1975, 200) has suggested that the types of crops predominant in cereal impressions may reflect particular activities that incorporate various cereals, rather than their overall economic status, while M. Jones (1980) has noted that the absence of cereal impressions on particular pottery styles does not mean that crops were economically unimportant to the manufacturers and consumers of those vessels.

Until recently, seed and other plant impressions on ceramic vessels constituted the main macro-remains evidence for arable agriculture in Bronze Age Ireland (Jessen and Helbaek 1944; Monk 1986, 32-3). Jessen and Helbaek’s 1944 study of cereal impressions on more than twenty Bronze Age vessels indicated that barley - naked barley in particular - was by far the predominant cereal type recorded, with occasional evidence for hulled barley. Although we might now ascribe vessels to different sub-periods of the Bronze Age than those ascribed by Jessen and Helbaek, the general pattern that they encountered remained unchanged throughout the Bronze Age period. A small number of later publications noted the rare occurrence of wheat, naked where identified to wheat variety, as well as more evidence for barley (Hartnett 1957, 259; Ó Ríordáin and Waddell 1993, 113, 126). It seemed clear from these studies that wheat played a minor role in Bronze Age agriculture, while barley, particularly naked, was the focus of arable activity at this time (Fig. 9). The validity of Jessen and Helbaek's study in reconstructing arable economies of the period has occasionally been questioned (Monk 1986, 32-33), as the ceramic vessels originated from mainly funerary contexts in the north and east of Ireland only, rather than settlement areas throughout the island. It was also questioned if the preference for barley as a tempering agent may necessarily represent the economic predominance of this cereal. Such suspicions, until now, remained speculative.

The recent collation (by McClatchie) of around twenty published and unpublished archaeobotanical assemblages of charred macro-remains from Bronze Age sites in Ireland, many of which were associated with settlements that were distributed over many parts of the island, has provided a very different picture with regard to the economic status of various cereal types (Fig. 9). Wheat seems to have been much more significant, particularly during the Middle Bronze Age, than previously considered, and hulled barley also played a prominent role. It is clear that this new study does not correlate well with Jessen and Helbaek's findings from analysis of cereal impressions. The exclusive use of evidence from cereal impressions in ceramic vessels does not, therefore, seem appropriate in determining the economic roles of various cereal types in arable agricultural economies of this period.

The strong association of naked barley with ceramic vessels may be better viewed as representing a relationship between activities associated with the processing of naked barley and ceramic vessel production. It may be significant that naked barley, and in one incidence free-threshing wheat, are predominant in the cereals identified from seed impressions, while hulled barley and glume wheats are less well represented. It is possible that crops requiring a greater amount of processing to extract grains, such as hulled barley and glume wheats, were not fully processed before storage, being stored in spikelet or sheaf form. Indeed, the only incidence of hulled barley in the seed impression record is of a floret rather than a seed alone (Jessen and Helbaek 1944, 21). Processing crops to spikelet or sheaf stage would lessen their chance of being included as a tempering agent or inadvertently being incorporated into ceramic vessels, as they would have been unsuitable due to their mass. Free-threshing wheats and naked barley may have been more fully processed at an earlier stage, separating grains from lighter chaff, which would therefore have constituted more suitable material for tempering or unintentional incorporation.

The processing of naked barley and wheat to an advanced stage may have occurred when a large number of people were mobilized, for example at harvest time (Fig. 10). If the cereals were spring-sown, harvesting would have occurred during the autumn period. This also coincides with a time when the production of ceramic vessels would have been advantageous, coming at the end of the driest season, thus facilitating the preparation and firing of ceramic vessels, which need to first be slowly dried to the 'leatherhard' state, as well as the preparation of fuel (Arnold 1985, 61-77). Harvest time in temperate areas, such as Ireland, may have roughly coincided with ceramic production, the latter being to some extent a seasonal activity, with a concentrated production of vessels being scheduled to occur at a time around harvest.

It has previously been suggested that pottery production was a seasonal endeavor, as cereals were available for incorporation into fabrics at harvest time (Howard 1981, 25). Although this approach fails to recognize that cereals can be stored, and therefore utilized, over relatively long periods, the ready availability of cereals, particularly the recently-processed chaff of naked cereals, at harvest time represents another reason why pottery production would have more favorable at this time of year. While ceramic production could undoubtedly have been a year-round activity (Gibson and Woods 1997, 46-48), particularly when dedicated drying facilities were constructed, it does seem more beneficial to produce vessels around harvest time when environmental factors are advantageous for drying unfired vessels and fuel. At this time, large numbers people are mobilized for harvest and processing, and some proportion of them could also be involved in production and distribution of vessels. The potential scheduling conflict (Arnold 1985, 99; Kramer 1985, 80) might suggest that those people involved in potting were focused on this activity rather than agricultural labor, implying some degree of specialization, at least seasonally. A ready supply of cereal components would become available for use as temper (or, if inadvertently incorporated, would have been present in vessel manufacturing areas), but significantly only of those species that are more readily fully-processed into clean grain and light chaff components, such as naked barley. Hulled cereals - including hulled barley and emmer wheat (*Triticum dicoccum*) - are instead likely to have been stored as semi-processed spikelets or even as sheaths.

Plant impressions in ceramics, when considered both as temper and as crop-processing waste, provide important insights into the links between labor deployed in food production and another productive labor - potting. At the seasonal period of harvesting and mass-processing prior to storage, we expect that most societies will produce abundant straw and naked cereal chaff, while an even greater amount of labor would be required to fully clean hulled cereals, such as glume wheats. For this reason, we might expect glume wheats to be proportionately underrepresented in pottery impressions. Yet, a review of the Neolithic and Early Bronze Age impressions from England, identified by Helbaek (1952), provides a stark contrast to the evidence recovered from these periods since the application of regular flotation. In the ceramics, emmer wheat spikelet forks and whole spikelets regularly occur, suggesting that if this is the waste of post-harvest mass processing, hulled cereals were being dehusked. By contrast, most Neolithic seed assemblages, although generally poor, produce cereal grains without chaff (Robinson 2000), totally unlike the macro-remains evidence for later periods (e.g. the Iron Age and Roman period discussed above) and contemporary ceramic impressions (Stevens, in press). These contrasts between on-site flotation samples and ceramic impressions can be seen as indicative, however, of seasonal versus routine practices of cereal processing, with the seasonal constraints on potting coinciding with those of the agricultural season.

By contrast, under different seasonal constraints, the relationship between charred remains and pottery impressions may be markedly changed (Fig. 11). In India, where the summer brings monsoon rains that provide the basis for much cultivation, potting is impossible due to the rains and humid atmosphere. The mass, pre-storage processing of monsoon crops, both rice and millets, takes place at the end of the monsoon. Traditional potting in India occurs in the winter and spring months - the dry season (Arnold 1985; Kramer 1985). During these months, daily processing takes place. It should therefore come as no surprise that in monsoonal rice growing regions, such as the Ganges valley, vegetable-tempered ceramics, found at Neolithic sites like Senuwar, Mahagara and Koldihwa, are dominated by rice husks with the occasional whole rice spikelet (observations by Fuller; see also Vishnu-Mittre 1969; Sharma et al. 1980, pl. MGR XVI; Saraswat 2004), precisely the dehusking waste we would expect from daily processing during the dry season when potting is possible. This suggests that in wet-summer tropical regions, chaff temper in ceramics is more likely to derive from routine daily waste, whereas within temperate regions with wet winters and drier summers, the late summer or autumn harvest processing is more likely to be linked to ceramic-tempering. Such expected patterns, at least, provide a basis for developing a comparative analysis of the relationships between ceramic production and agricultural activities across periods and cultures.

Labor scheduling as an agenda for social archaeobotany

Archaeobotany can become an essential component of a contextual archaeology only once we accept that its interpretation does not rely on archaeological context. Standard charred archaeobotanical samples represent re-deposition from fire contexts, where plant remains may already represent secondary refuse. Archaeobotanical assemblages are unlikely to be readily interpretable from, nor contribute to, the understanding of particular depositional contexts in terms of human activities. This means that only very rarely will flotation samples contribute to studies of spatial patterning and activity areas on archaeological sites, except perhaps a very coarse scale on the very largest sites. Despite their tertiary nature, however, the recurrent patterns of archaeobotanical patterns across sites reflect recurrent practices in the past - the routine. As such, they provide an important window upon traditions of daily, household labor. These patterns of daily labor can then be compared between sites, between cultural phases and regional cultural traditions to build up a larger comparative perspective on the evolution on systems of human labor organization. In this way archaeobotanical evidence contributes to the contextualization of sites in terms of labor organization and food production strategies.

Productive activities related to food production or procurement and storage represent important scheduling decisions. It is obviously the case that the availability of many foods is seasonal. With the exception of modern, industrialized supermarket economies, seasonal patterns in food consumption are ethnographically and historically universal (De Garine 1994). The seasonality of labor needs in relation to agricultural production is an important arena that creates need for assistance between human groups, such as between households, and provides a recurrent situation in which relationships of social debt and reciprocity develop (see, e.g. Stone et al. 1990; Dietler and Herbich 2001; Peletz 1992). The size of households or other social groups that can be organized for harvest-period processing versus the daily labor requirement of food preparation in the household are reflected in archaeobotanical assemblages. Similarly, other productive activities, such as craft production, must be scheduled, either to avoid conflict with labor needed elsewhere or to take advantage of shared resources and weather conditions. With the rise of increasingly complex societies, more craft production might be supported by redistributed surplus sequestered from the labor of others, and increasingly craftsman are freed from immediate ties to the production and labor schedule of domestic food production. Archaeobotanical evidence, when analyzed through crop-processing models in relation to the social context of seasonal scheduling and scale of labor groups, has the potential to contribute to comparative studies of social structure and social evolution.

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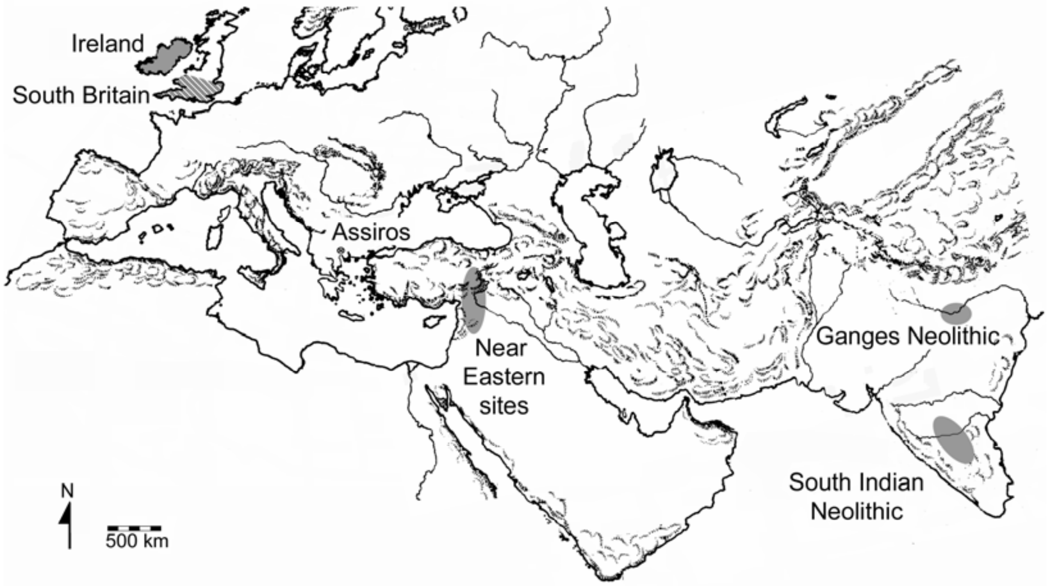


Figure 1. Map showing regions discussed in relation to archaeobotanical case studies in this paper.

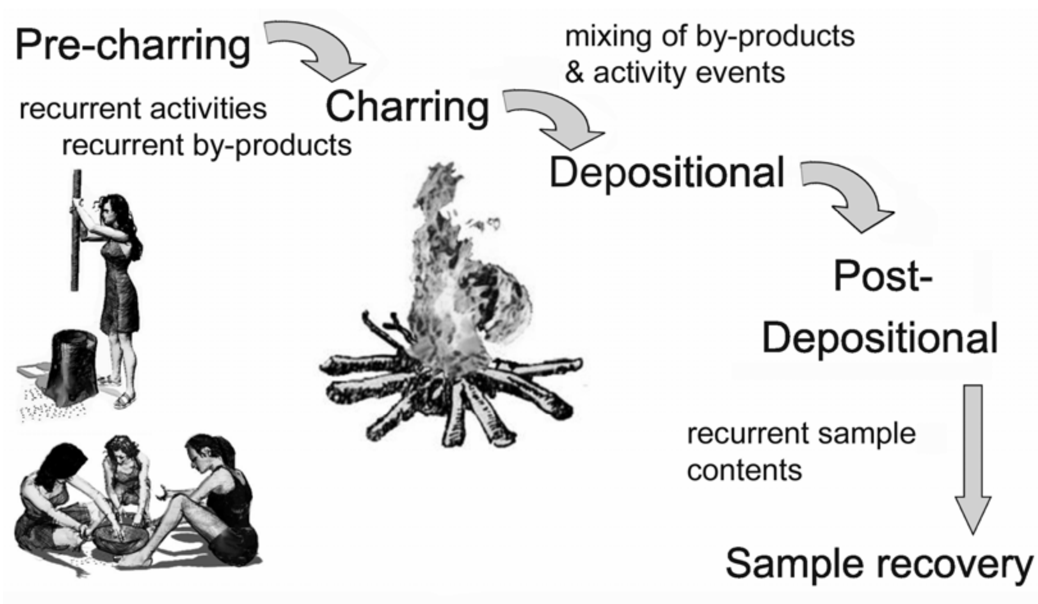


Figure 2. A simplified diagram of the major pathway towards preservation of charred seed assemblages in Old World agricultural societies. Any theory of archaeobotanical taphonomy must therefore take into account not only how human activities structure plant materials, but also how these are preserved and mixed in sedimentary deposition. Recurrent patterns in recovered samples must result from recurrent inputs and structuring during these previous stages.

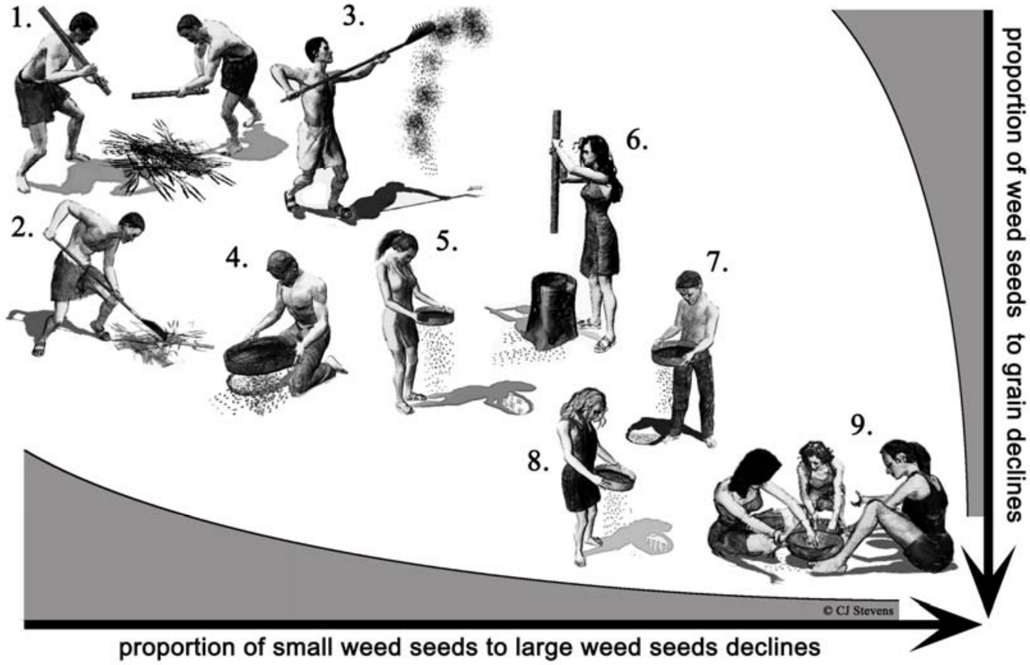


Figure 3. A diagrammatic summary of the effect of crop-processing on the composition of grain, chaff and weed assemblages. Through the course of processing, the proportion of weed seeds to grain decreases as more weed seed size/density categories are removed. Also, amongst the weed seeds, it is the species with smaller, lighter seeds that are removed earlier and the proportion of small weed seeds to large weed seeds also decreases. The main crop-processing activities are numbered in order: 1. threshing, 2. raking, 3. winnowing, 4. coarse sieving, 5. first fine sieving, 6. pounding, 7. second winnowing, 8. second fine sieving, 9. sorting

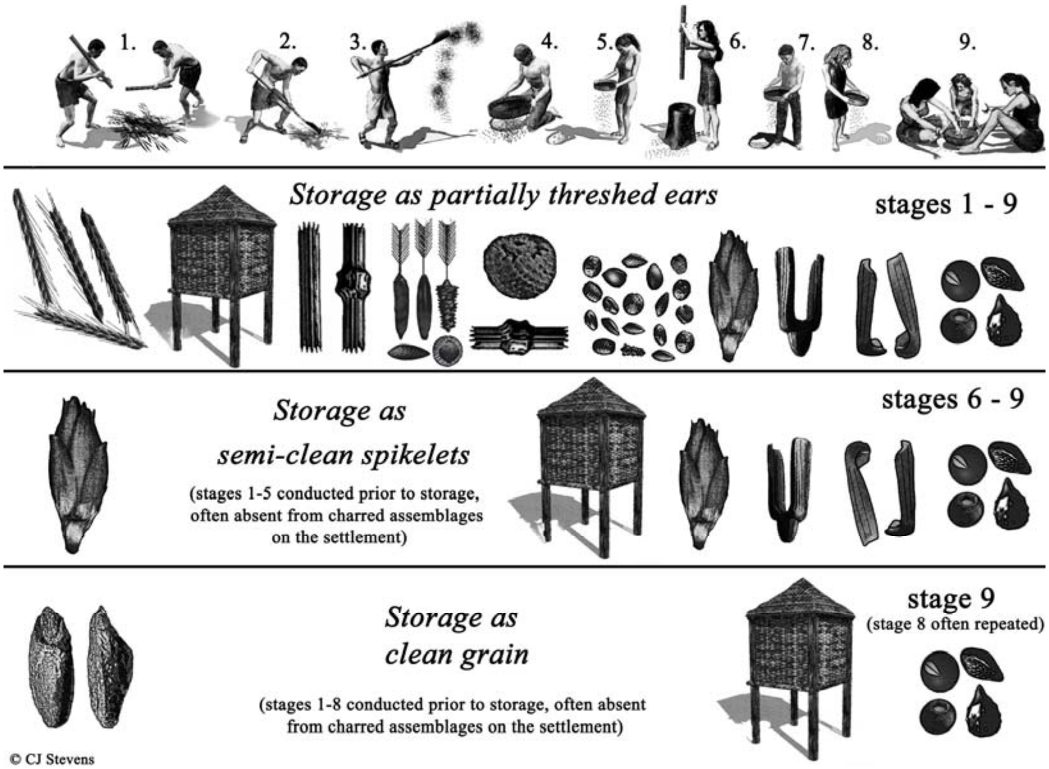
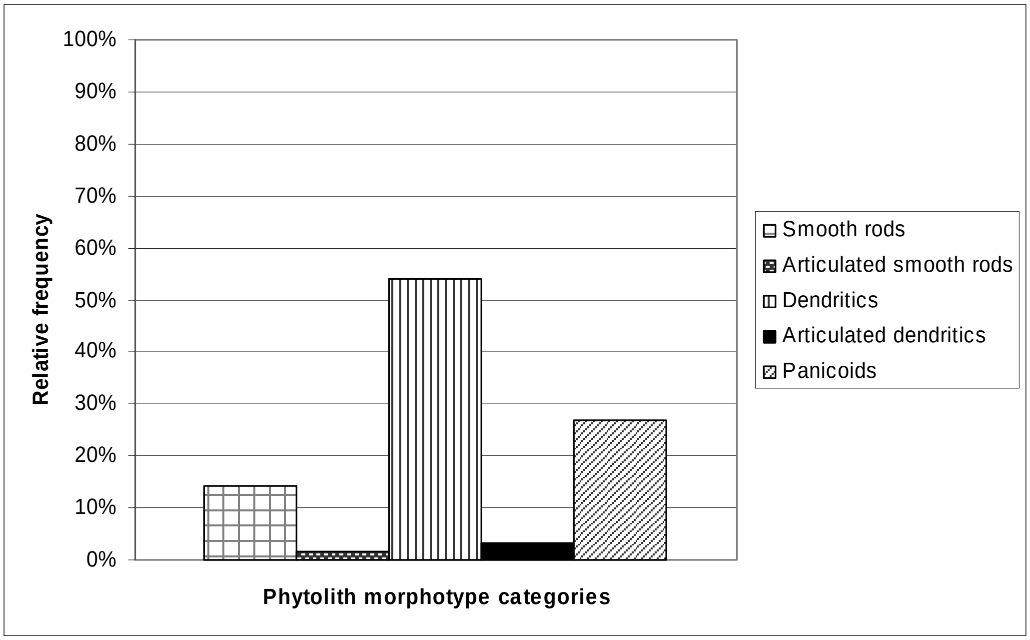


Figure 4. The effects of storage strategies on daily processing activities and recurrent assemblage formation. Three alternative storage strategies are indicated, each of which requires different degrees of labor mobilization during the harvest period, prior to bulk storage. This relates, therefore, to how many crop-processing stages, shown in the top row (numbered as in Figure 3), are achieved prior to storage.



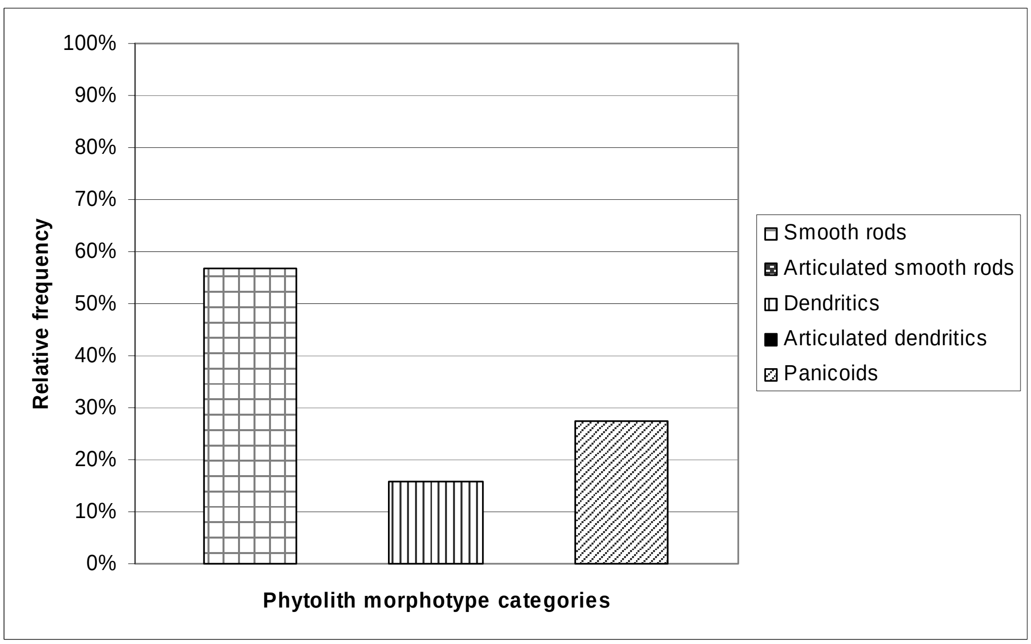


Figure 5. Relative frequency of phytolith morphotype categories in two selected samples from Hund. The graph at the top is typical of most samples from fills, whether inside or outside of structures, while the pattern shown at the bottom was found in very few, ‘special’ contexts, including an oven fill, and some pit fills. The pattern at the top is dominated by dendritics, which probably include cereal chaff, and therefore the waste from routine processing of ears. The pattern in the lower graph is dominated by smooth, long cells from grass straw and leaves, and suggests the incorporation of straw either through direct burning or through the burning of dung from animals with straw fodder.

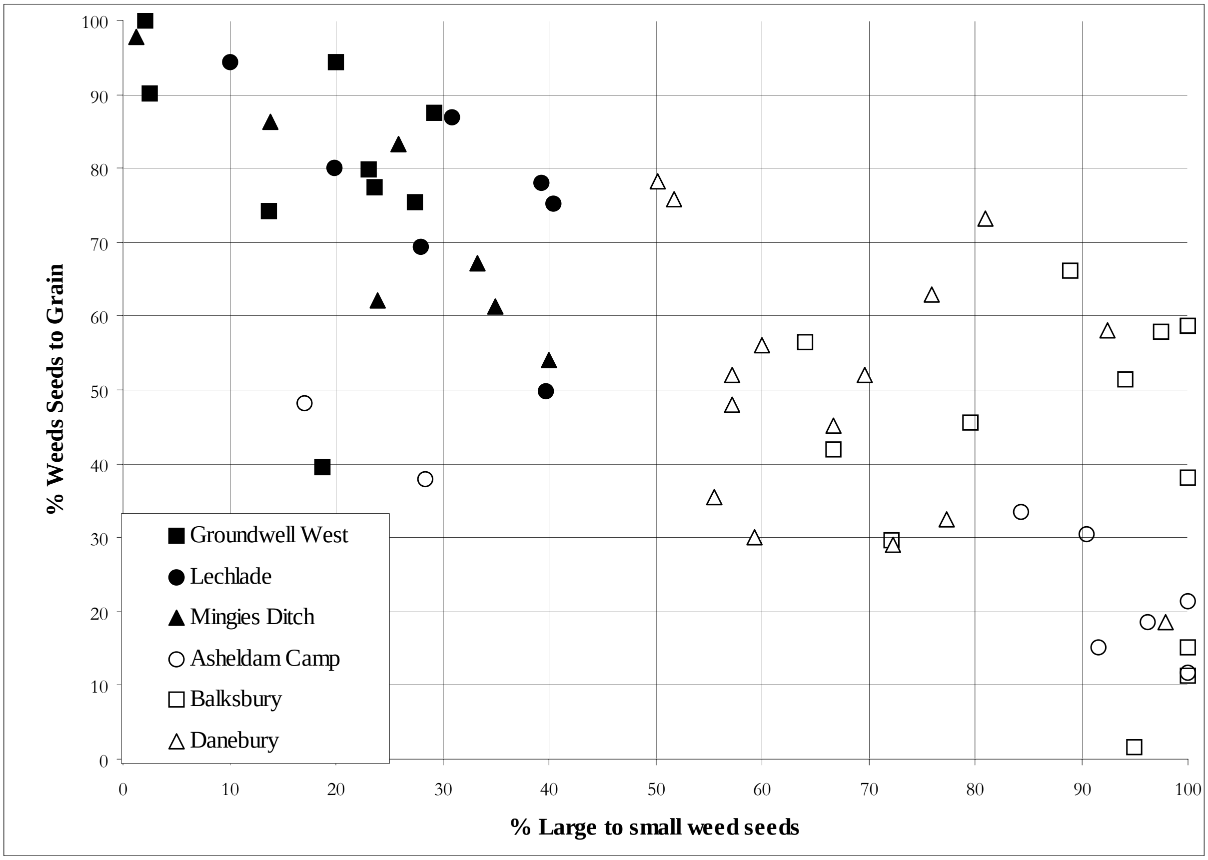


Figure 6. A plot of samples in terms of the crop-processing stage indicators of weed seed proportions, as outlined in Figure 3. Each plot represents an individual sample. Those three sites represented by black shapes have an archaeobotanical center of gravity in the less processed, upper left part of the diagram with higher proportions of weed seeds and a greater range of weed seed types (especially smaller seeds), while those sites represented by white shapes have an archaeobotanical center of gravity in the more-fully processed lower right part of the diagram, with fewer weeds and amongst those larger sizes. This implies that the communities represented by the hillfort sites of Asheldam Camp, Balksbury and Danebury were able to mobilize more labor for processing crops during the harvest period prior to storage. By contrast, Groundwell West, Lechlade and Mingies Ditch, which are smaller non-hillfort sites, suggest smaller-scale household labor moboliziation, requiring more stages of processing to be carried out routinely on site. Data sources: Danebury (M. Jones 1984), Balksbury (de Moulins 1995), Asheldham Camp (Murphy 1991), Groundwell West, (Stevens and Wilkinson 2001), Sherbourne House Lechlade, Gloucestershire (Stevens 2003b), Mingies Ditch (M. Jones 1993).

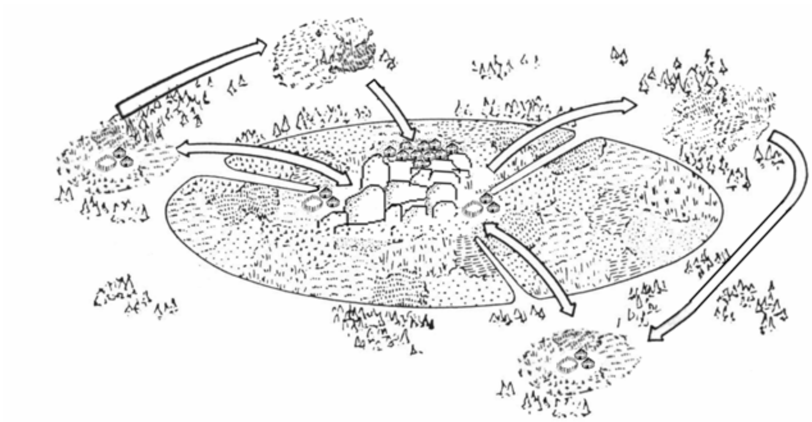


Fig. 7. Schematic representation of inferred seasonal movement pattern of transhumant pastoralists during the South Indian Neolithic. Permanent hilltop villages are the focus of agricultural production, especially during the monsoon, whereas scattered ashmound sites represent a subset of dry season pastoral camps that also became ritual locations. While tools for grinding imply grain consumption at ashmounds, hilltop sites include evidence for numerous dehusking hollows, as well as querns and abundant crop remains, implying post-harvest bulk processing in addition to routine processing at hilltop sites.

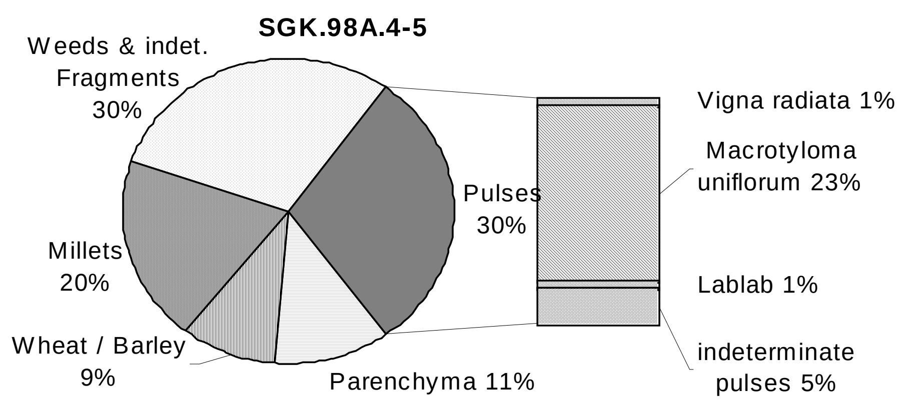
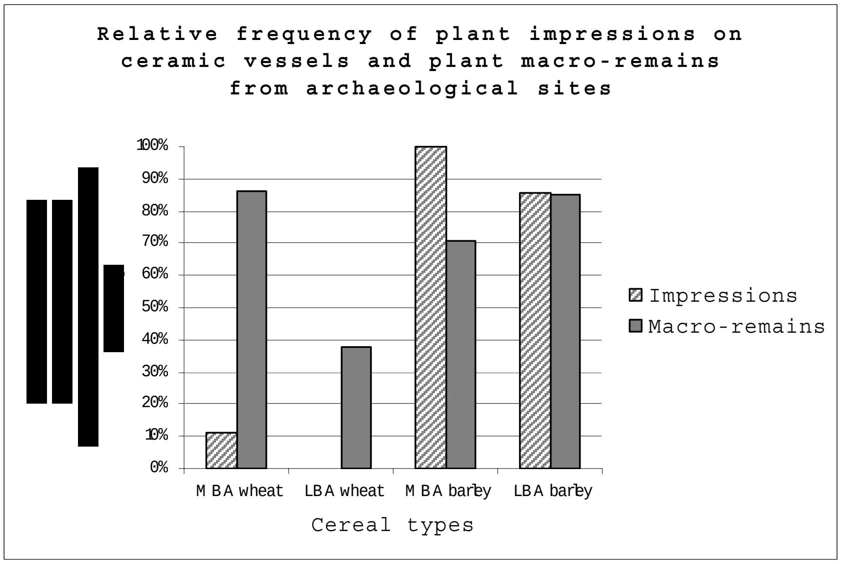


Figure 8. An example of a typical flotation sample from a hilltop village site in South India, in this case from Sanganakallu, represented as relative frequencies of major categories. Almost all samples from this and contemporary sites are dominated by pulses, followed by millets, weed seeds and parenchyma fragments. The dominant pulse varies between three species, although the example here is dominated by horsegram (*Macrotyloma uniflorum*). The recurrent presence of pulses of different shapes and sizes, as well as millets and millet weeds, and some wheat and barley indicates that these samples represent the mixed charred waste of different crop-processing routines.



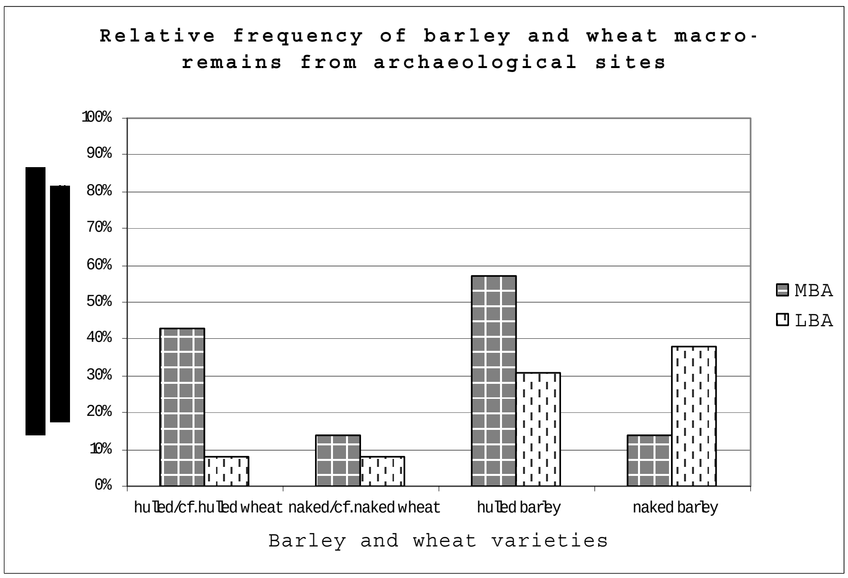


Figure 9. Ceramic impressions versus macro-remains: the chart at the top shows the relative frequency of major cereal types recorded as impressions on ceramic vessels from Middle and Late Bronze Age Ireland, as well as charred macro-remains recovered from archaeological deposits dating to the same period. Note the virtual absence of wheat from the impressions record, compared with its regular recovery in the form of macro-remains. The chart on the bottom provides more detailed information on the types of cereals recorded from macro-remains assemblages. Almost all of the MBA and LBA impressions were of naked barley grains, but the bottom chart demonstrates that hulled barley was significant in macro-remains assemblages. These contrasts suggest a distinction between the routine processing waste of charred assemblages and the seasonally restricted nature of crop remains incorporated in potting. Data sources for seed impressions: Jessen and Helbaek (1944), Hartnett (1957), Ó Ríordáin and Waddell (1993). Data sources for macro-remains: Brewer (2002; 2003; 2004), Church (n.d.), Collins (n.d. a; n.d. b), Doyle (2001), Johnston (2001a; 2001b; 2001c; 2002), McClatchie (in press a; in press b; in press c; forthcoming a; forthcoming b; forthcoming c), Monk (1987a; 1987b), Tierney and Hannon (2003), Weir (1996).

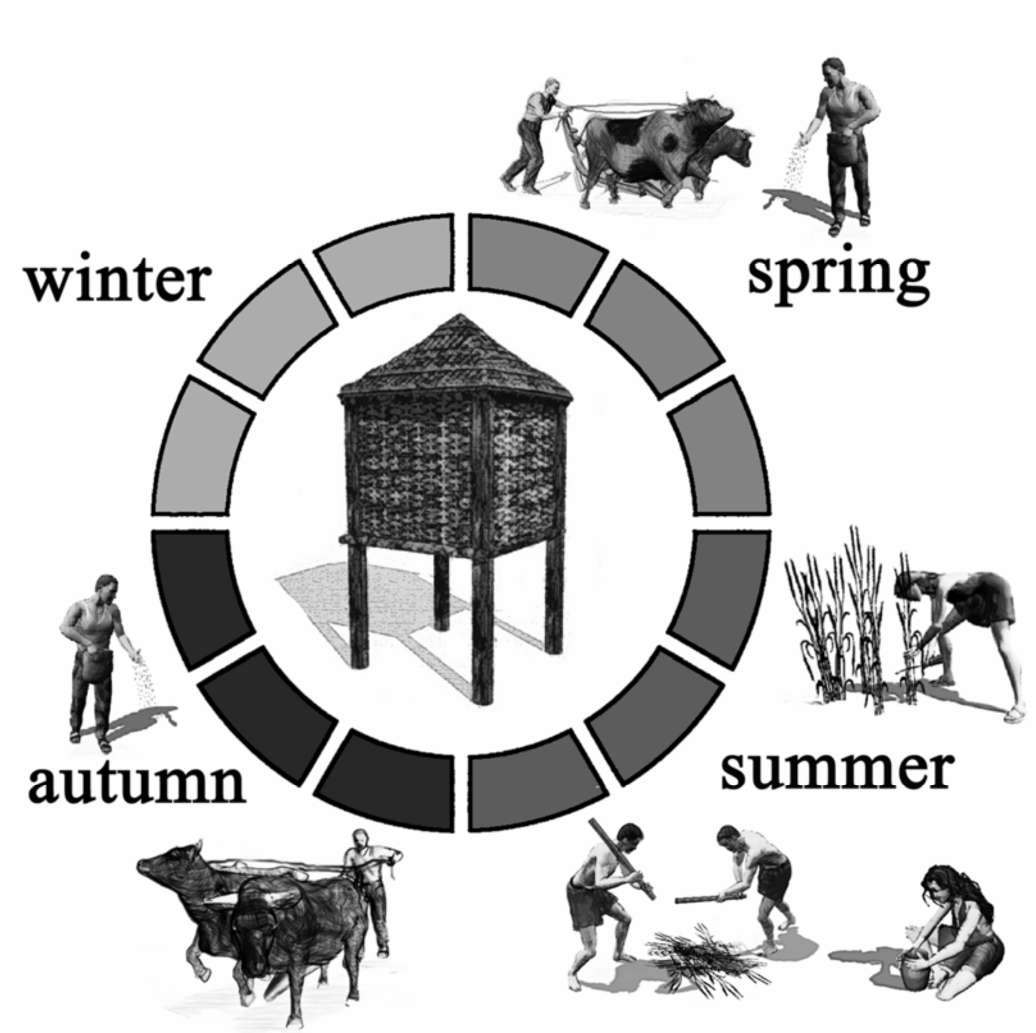


Figure 10. The inferred basic seasonal cycle for Bronze Age Ireland, with potting focused in summer during drier weather. The incorporation of by-products from post-harvest processing implies temporal juxtaposition of these productive activities.

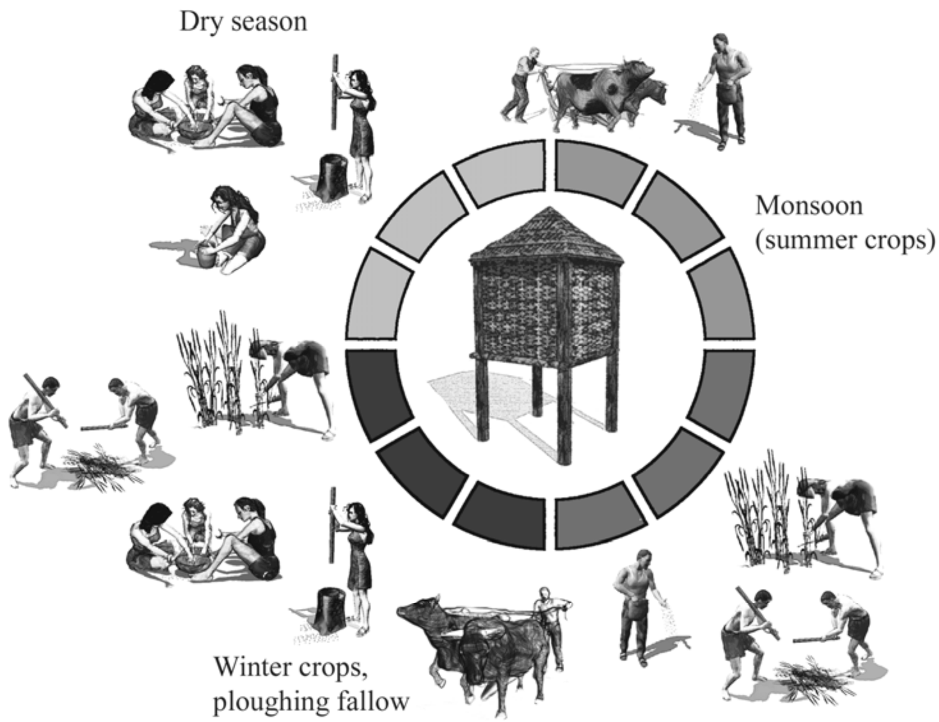


Figure 11. The inferred basic seasonality for monsoonal India, such as the Ganges Neolithic, in which the wet summers preclude potting, the subsequent autumn and winter remain busy with agricultural activities, and potting is therefore more likely to focus on the dry season. The addition of vegetable temper sources is likely to derive from daily processing waste (dehusking), rather than bulk processing.

Potamogetonaceae
Potamogeton sp.

Liliaceae
Asparagus sp. *
Asphodelus sp.
Bellevalia sp. *
Liliaceae sp.

Juncaceae
Juncus sp.

Cyperaceae
Carex divisa type
Cyperus sp. *
Eleocharis sp. *
Scirpus sp. *

Poaceae
Aegilops crassa *
Aegilops sp. *
Avena sp. *
Bromus sterilis
Bromus sp. *
Cynodon sp.
Dratsa type *
Echinochloa crus-galli
Eremopyrum sp. *
Horduem sp. (wild) *
Lolium sp. *
Phalaris sp. *
Phragmites sp. *
Secale sp. *
Setaria sp. *(incl. viridis)
Stipa sp. *
Taeniatherum sp.
Triticum boeoticum *

Ranunculaceae
Adonis sp. *

Fumariaceae
Fumaria sp.

Papaveraceae
Glaucium sp. *

Caryophyllaceae
Gypsophila sp. *
Saponaria type *
Silene sp. *
Stellaria sp. *

Chenopodiaceae
Atriplex sp. *
Chenopodium album L. *
Chenopodium sp. *
Suaeda sp. *

Amaranthaceae
Amaranthus sp.

Aizooaceae
Aizoon sp. *

Portulaceae
Portulaca sp. *

Polygonaceae
Polygonum sp. *
Rumex sp. *

Geraniaceae
Erodium sp. *

Fabaceae
Astralgus sp. *
Hippocrepis sp. *
Lathyrus cicera
Lathyrus nissolia
Lupinus sp. *
Medicago sp. *
Melilotus sp. *
Prosopis sp. *
Trifolium sp. *
Trigonella astroites type
Trigonella sp. *
Vicia sp.
Vicia/Lathyrus sp. *

Lythraceae
Alkanna

Brassicaceae
Alyssum *
Capsella type *
Lepidium type

Malvaceae
Malva sp. *

Thymeleaceae
Thymelaea *

Primulaceae
Anagallis sp. *
Androsace maxima *

Solanaceae
Hyoscyamus sp. *
Solanum sp.

Convolvulaceae
Convolvulus sp. *
Cuscuta sp.

Boraginaceae
Arnebia decumbens *
Arnebia linearifolia *
Arnebia/Lithospermum sp. *
Buglossoides arvensis
Echium sp. *
Heliotropium sp.*
Lithospermum arvense *
Lithospermum tenuifolium *

Rubiaceae
Crucianella sp. *
Galium sp.(small) verum/ palustre/ mullugo *
Galium aparine/ tricornutum *
Galium spurium *
Galium sp. *

Plantaginaceae
Plantago sp. *

Scrophulariaceae
Verbascum sp.

Lamiaceae
Ajuga sp. *
Micromeria sp.*
Stachys type
Teucrium sp. *
Ziziphora sp. *

Apiaceae
Foeniculum type *
Torilis arvensis/ japonica *

Dipsacaceae
Cephalaria sp. *

Linaceae
Linum sp. *

Valerianaceae
Valerianella sp.

Asteraceae
Centaurea sp. *
Helianthemum sp. *

Table 1: Recurrent wild weed species in the Near East that are likely weeds on (#) earlier Neolithic sites prior to the adoption of livestock in mid-Pre Pottery Neolithic B and (*) later Neolithic sites after the adoption of livestock from the mid-Pre Pottery Neolithic B through the ceramic Neolithic. (Helbaek 1969; van Zeist and Buitenhuis 1983; van Zeist and Bakker-Heeres 1984; van Zeist and Waterbolk-van Rooijem 1985; van Zeist and de Roller 1995; Willcox and Fornite 1999)

Juncaceae
Juncus sp.

Cyperaceae
Carex sp.
Cladium mariscus
Eleocharis sp.

Poaceae
Anisantha sterilis (1)
Arrhenatherum elatius
Avena sp.
Brizia media/ Glyceria maxima/ Milum effusum
Bromus sp.
Dactylis glomerata (1)
Danthonia decumbens
Deschampsia sp. (1)
Festuca/Lolium sp.
Horduem sp. (wild)
Lolium sp.
Phleum sp.
Poa sp.
Sieglingia decumbens (1)

Ranunculaceae
Adonis annua (1)
Ranunculus sp.

Fumariaceae
Fumaria sp.

Papavaraceae
Papaver sp.

Caryophyllaceae
Agrostemma githago
Cerastium sp.
Dianthus deltoides/ armeria (1)
Lychnis flos-cuculi (1)
Scleranthus sp.
Silene sp.
Spergula arvensis
Stellaria sp.

Chenopodiaceae
Atriplex sp.
Chenopodium album
Chenopodium ficifolium
Chenopodium polyspermum
Chenopodium urbicum
Chenopodium sp.

Portulaceae
Montia fontana

Polygonaceae
Fallopia convolvulus
Polygonum sp.
Rumex sp.

Euphorbiaceae
Euphorbia sp.

Violaceae
Viola arvensis/tricolor (1)

Fabaceae
Lathyrus sp.
Lotus sp. (1)
Medicago sp.
Trifolium sp.
Vicia hirsura/tetrasperma
Vicia tetrasperma
Vicia sp.

Rosaceae
Aphanes arvensis (1)
Potentilla sp.

Urticaceae
Urtica sp.

Brassicaceae
Brassica sp.
Lepidium sp. (1)
Raphanus raphanistrum
Sinapsis alba/arvensis

Malvaceae
Malva sp.

Primulaceae
Anagallis sp. (1)

Solanaceae
Hyoscyamus niger

Boraginaceae
Lithospermum arvense
Myosotis arvensis (1)

Rubiaceae
Galium aparine/tricome
Galium sp.
Sherardia arvensis

Plantaginaceae
Plantago sp.

Schrophulariaceae
Euphrasia/Odontites verna
Odontites vernus
Rhinanthus sp. (1)
Veronica sp.

Lamiaceae
Clinopodium acinos/Mentha sp. (1)
Galeopsis sp.
Lamium sp. (1)
Mentha sp.
Prunella vulgaris L. (1)
Teucrium cf. chamaedrys (1)

Apiaceae
Aethusa cynapium (1)
Daucus carota
Torilis sp.

Valerianaceae
Valerianella sp.

Asteraceae
Anthemis cotula
Anthemis sp.
Centaurea sp.
Cirsium/Carduus sp.
Lapsana communis
Tripleurosperum inodorum

Table 2. Recurrent weed species in British and Irish archaeobotany. Those species marked with (1) occur only once in the dataset examined, while other species occur more than once. Data from the following sites and periods, England: Barton Court Farm (NEO, IA, RB), Coburg Rd (MBA, LBA), Dairy Lane (MBA, RB), Fengate (NEO), Glanfeinion (MBA), Gravelly Guy (NEO, EBA), Hinxton (EBA, RB), Mount Farm (NEO, EBA, LBA, IA, RB, AS), Plas Fogerddan (NEO), Scotch Corner (IA, RB), St. Giles (IA), Sutton Common (IA), Tewkesbury (IA), Tewkesbury (RB), Watsons Lane (IA, RB), Yarnton (IA, RB, AS); Ireland: Ballyglass (LBA), Ballypriorbeg (LBA), Ballyveelish (MBA, LBA), Ballyvelly I (LBA), Cappamore (LBA), Chancellorsland A and C (MBA), Cloghers (LBA), Crossreagh East (MBA), Curraghatoor (LBA), Dun Aonghasa (LBA), Dundalk (MBA), Haughey’s Fort (LBA), Kilmahuddrick (LBA), Lough Gur (LBA), Mannin Bay 2 (LBA), The Heath (MBA). Periods: NEO Neolithic, EBA Early Bronze Age, MBA Middle Bronze Age, LBA Late Bronze Age, IA Iron Age, RB Romano-British, AS Anglo Saxon.