

comes from the Harappan period at Mohenjo Daro (Gulati and Turner 1929; Janaway and Coningham 1995), and subsequently in the Chalcolithic of Maharashtra as Navdatoli (Gulati 1961). Cloth impressions which are presumed to be cotton have been found further south on the Peninsula at the sites of T. Narsipur and Pikhlihal from Late Neolithic/Iron Age levels, that could date back to the latter second millennium BC (Janaway and Coningham 1995; earlier dating based on Devaraj et al. 1995). Unfortunately archaeobotanical finds of cotton seeds, or better yet capsules, to indicate local cultivation have been rare from prehistoric sites. The Late Harappan site of Hulas (1800-1300 BC?) has produced cotton seeds (Saraswat et al. 1992; Saraswat 1993).

5.7.5 The Spread of Rice

Rice appears to have a northern origin (or an early diffusion from South-East Asia into the Ganga) and subsequently diffused into the rest of the continent (Fig. 7; Section 5.4 and 5.4.1, above). By the mid to late third millennium rice was cultivated in the region of Harappa (Fujiwara et al. 1992; Weber 1997; M. Madella: personal communication). Contemporaneous or earlier evidence comes from regions further east, in Haryana (Willcox 1992) and the upper Ganga Valley (Saraswat 1992) and in Gujarat and Rajasthan, where some sites have yielded rice impressions on pottery, although this is yet to be corroborated by charred grains (Vishnu-Mittre 1969; Vishnu-Mittre and Savithri 1982; Kajale 1989c). It is not clear whether rice was widespread or had a significant subsistence role in Gujarat since it is missing from well sampled archaeobotanical sequences in the region (e.g. Rojdi, Weber 1991; Balakot, Reddy 1994, 1997; and Kuntasi, Dhavalikar 1995). In general, it appears that rice was slow to become established on the Indian Peninsula, with well-reported finds coming from Iron Age and later sites (cf. Kajale As wild rice populations exist in south India in the coastal regions (Kumar 1988), which have yet to be studied archaeobotanically, it remains possible that rice was independently domesticated here as well, although there is no evidence as yet.

5.7.6 A Case of Synthesis: Maharashtra Chalcolithic Villages

Evidence from the Chalcolithic villages of Maharashtra in the early second millennium BC indicates a synthesis of crops in terms of both geographical sources and seasonal regimes (cf. Kajale 1989c). Sites like Daimabad (Kajale 1977a; Vishnu-Mittre et al. 1986a), Inamgaon (Kajale 1988b), and Kaothe (Kajale 1990c) indicate that Near Eastern cereals and pulses were grown in the same regions as African millets, indigenous(?) millets and tropical pulses (from both India and Africa). Possehl's (1986) suggestion that African millets were important for opening up peninsular India to agricultural settlement seems controverted on current evidence. Understanding the ways in which different agricultural systems, including diverse crops and cropping systems were integrated in Maharashtra during the late third millennium and early second millennium BC remains a challenge to be addressed in future archaeobotanical work.

6. EMERGING DIRECTIONS AND OTHER DATASETS

Although the focus of most archaeobotanical research are charred seeds from which the spread of crops is reconstructed, there are several other kinds of archaeobotanical evidence. In the sections that follow five other kinds of archaeobotanical evidence are briefly reviewed. First, there is the interpretation of non-crop seeds found in assemblages of agricultural practices. Second, there is the identification of ancient wood remains, including wood charcoal and fragments preserved by other means. Third, there is the study of charred parenchyma fragments which have hitherto been overlooked in research on charred plant assemblages. Three other aspects of archaeobotanical work rely on non-charred, microscopic remains. One micro-remain which has been traditionally utilized is the study of pollen from archaeological sediments. Finally I turn to two largely untapped areas of research, phytoliths, and the extraction of ancient DNA preserved in archaeological plant specimens.

6.1 Findings from Wood Identification

The most frequent macrobotanical remains from archaeological sites are fragments of wood charcoal. Wood charcoal is likely to represent primarily the wood which was used to fuel fires, although the burning of other cultural products, such as artefacts or structures, may also contribute. Thus in contrast to seed remains which represent chance/incidental burning, wood is generally considered to be the product of intentional burning (Pearsall 1983, 1989: 203). Since most fuel is likely to come from the vicinity of the site it should provide some reflection of the surrounding vegetation, and numerous studies have utilized changes in the composition of wood taxa to examine changes in the landscape, or to compare the woodland types associated with different archaeological sites (e.g. Minnis 1978; Smart and Hoffman 1988; Pearsall 1983, 1989; Thiebault 1988, 1989, 1992; Lone et al. 1988, 1991; Thompson 1994; Saraswat et al. 1994). Admittedly, this reflection will be filtered by cultural processes, such as preferences for certain kinds of wood, and avoidance of others (such as fruit trees, or sacred trees). Indeed, wood choice can relate to political and social concerns as shown by study in Incan Peru (Hastorf and Johannessen 1991: 140-1). Social patterning in the use of fuels, including choices related to the pyrotechnology of different craft activities, can be studied through the analysis of samples from various context on large site excavation, such as that at Harappa (Miller 1991). Despite these biases major changes in woodland composition should be detectable, related in turn to clearance, grazing, or climatic factors. The charcoal record thus combines environmental availability with cultural practices of exploitation. It is difficult to interpret quantification of wood charcoal, even more so than for other charred remains, since large numbers of fragments could originate from the same log or trunk. Nevertheless, relative percentages of different taxa are usually compared (Thiebault 1988, 1989; Lone et al. 1993; Thompson 1994).

In the early decades of Independence, a large number of haphazard, hand-collected

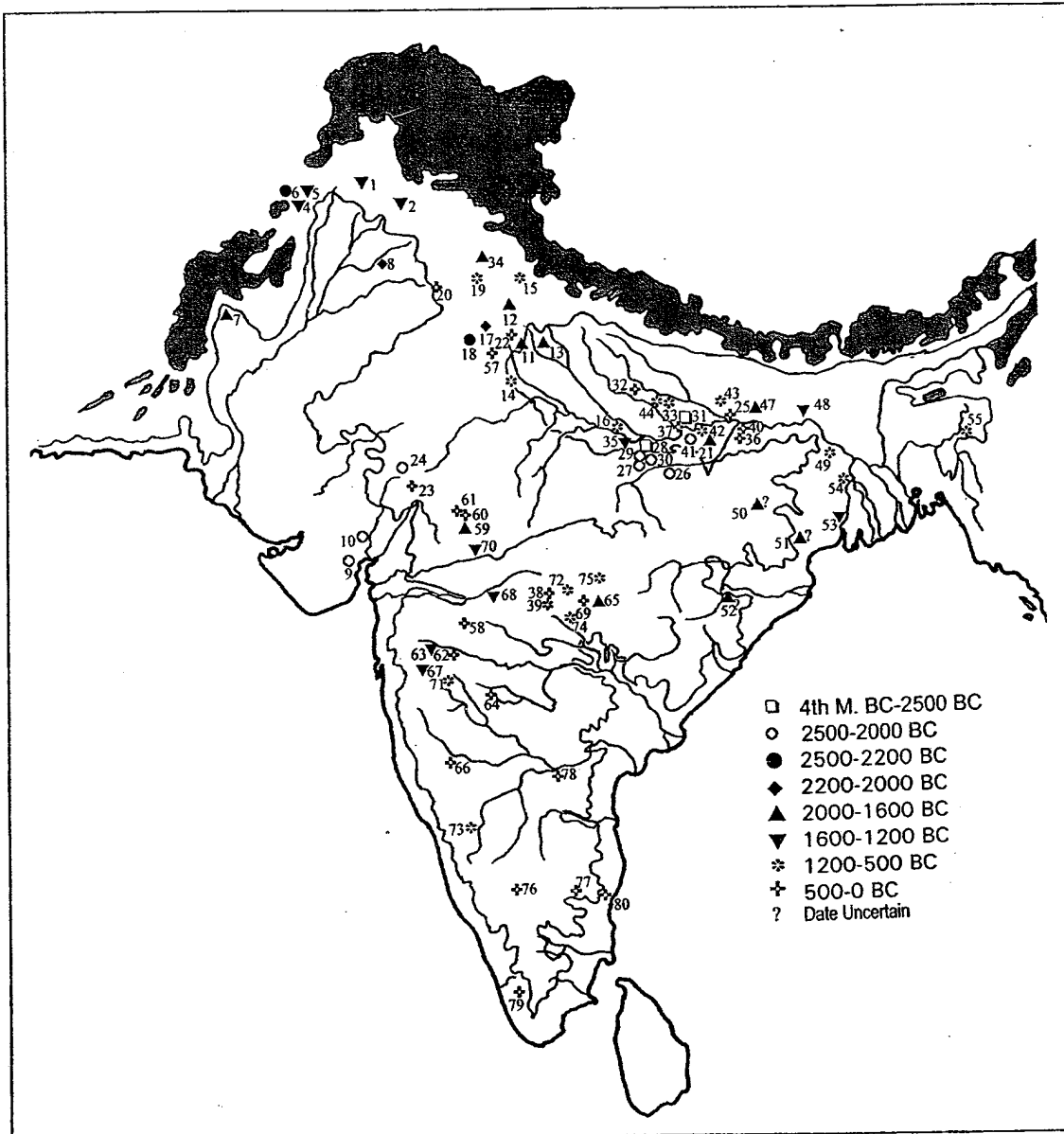


Fig. 7. Distribution of prehistoric archaeological evidence for rice, including sites of different periods. Sites numbered as per the following list. References for most sites given in Tables 2 and 3. Some additional sites, where rice only has been reported, are plotted on the basis of previous reviews (Vishnu-Mittre 1989; Kajale 1989c; 1991). Only sites not included in the above sources are followed by citations.

- | | | |
|---|---|-----------------------|
| 1. Semthan | 27. Lekhnia | 51. Baidaypur |
| 2. Gufkral | 28. Chopani-Mando III | 52. Pandu Rajar Dhibi |
| 3. Burzahom | 29. Koldihawa | 53. Ambri |
| 4. Loebanhr 3 | 30. Mahagara | 57. Kokhkrakot |
| 5. Bir-Kot-Ghwandai | 31. Damdama | 58. Bhokardan |
| 6. Ghaleghay | 32. Hulashkera | 59. Dangwada |
| 7. Pirak | 33. Khairadih | 60. Ujjain |
| 8. Harappa | 34. Un (Vishnu-Mittre
et al. 1986) | 61. Nagda |
| 9. Rangpur | 35. Kausambi | 62. Nevasa |
| 10. Lothal | 36. Sonapur | 63. Daimabad |
| 11. Lal Quila | 37. Patilaputra | 64. Ter |
| 12. Hulas | 38. Kaundinyapur | 65. Adam |
| 13. Atranjikhera | 39. Khairwada | 66. Kolhapur |
| 14. Noh | 40. Rajgir | 67. Walaki |
| 15. Hastinapura | 41. Baraunha | 68. Tuljapur Garhi |
| 16. Radhan | 42. Mahga | 69. Paunar |
| 17. Mitathal | 43. Sohgaora | 70. Navdatoli |
| 18. Burthana Trigrana | 44. Narhan | 71. Inamgaon |
| 19. Rupar | 45. Chirand | 72. Bhagimohari |
| 20. Sanghol | 46. Oriyup | 73. Hallur |
| 21. Senuwar | 47. Mahisadal | 74. Kairwada |
| 22. Daulatpur (Vishnu-
Mittre et al. 1985) | 48. Barudih/Singbhum
(date uncertain) | 75. Naikund |
| 23. Balathal | 49. Baidipur | 76. Koppa |
| 24. Ahar | 50. Puri (date uncertain,
plotted after Glover
and Higham 1996) | 77. Kunnatur |
| 25. Manji | | 78. Veerapuram |
| 26. Kunjhun (Clark &
Khanna 1989) | | 79. Adichanalur |
| | | 80. Arikamedu |

samples of charcoal were examined for taxonomic identification by Chowdhury, Ghosh and colleagues at the Dehra Dun forestry institute (Table 10). Starting from about 1975, Vishnu-Mittre and colleagues began reporting species identified from charcoal samples submitted for radiocarbon dating; this has produced a large number of reports of one or a few species from a site (e.g. Vishnu-Mittre and Savithri 1979c). In most cases only a very few species were identified and rarely were they at all surprising or indicative of significant vegetational differences from the present. A detailed discussion of the vegetational grouping represented in the material from Lothal in Gujarat, concluded that some of the forest communities may have been more widespread in the state in prehistory (Ramesh Rao and Lal 1985). In a few instances, however, charcoal analyses reveal the presence of species which are known to be cultivated or utilized for food; while the use of the wood of these species certainly does not indicate other uses of other plant parts, it at least raises the possibility. For example, sites in Baluchistan, Iran, Kashmir and Punjab have produced *Vitis* (grape) charcoal, which supports the contention that grapes were

TABLE 10. SITES WITH IDENTIFIED WOOD CHARCOAL IN INDIA/PAKISTAN

Site	Period	Sampling notes	Taxa qty.	Reference
Arikamedu	Early Historic	hand	3	Chowdhury and Ghosh 1946
Hastinapura	1000-500 BC	hand	3	Chowdhury and Ghosh 1955
Maski	Neolithic	hand	2	Chowdhury and Ghosh 1957
Kalsi	Early Historic	hand	4	Ghosh and Lal 1961
Rangpur	2500-1000 BC	hand	6	Lal 1962-3
Kandiyapura	Early Historic	hand	1	Vishnu-Mittre 1966
Prakash	1700 BC-600 AD	hand	7	Rao and Sahi 1967
Ter	200 BC-400 AD	hand	6	Vishnu-Mittre et al. 1971
Rojdi	c. 2000 BC (?)	hand	1	Vishnu-Mittre and Savithri 1979c
Hallur	1800-1000 BC	hand	5	Vishnu-Mittre and Savithri 1979c
Tekkalakota	2000-1500 BC	hand	1	Vishnu-Mittre and Savithri 1979c
Inamgaon	1800-1000 BC	hand	3	Vishnu-Mittre and Savithri 1979c
Kalibangan	2600-1500 BC	hand	12	Vishnu-Mittre and Savithri 1979c
Ahar	?(2500-1500 BC)	hand	2	Vishnu-Mittre and Savithri 1979c
Rupar	c. 500 BC	hand	2	Vishnu-Mittre and Savithri 1979c
Chirand	c. 1700 BC	hand	1	Vishnu-Mittre and Savithri 1979c
Lothal	c. 1700 BC	hand	4	Chowdhury 1974
		43 samples, by hand	7	Ramesh Rao and Lal 1985
Inamgaon (1971)	1700 BC- c. 1000 BC	6 samples, hand collected	8	U. Prakash, in Vishnu-Mittre and Savithri 1975
Atranjikhera	2000-50 BC	hand	10	Chowdhury et al. 1977
Ramapuram	c. 1000 BC	hand	1 (+1 later contaminant)	Vishnu-Mittre et al. 1985
Veerapuram	c. 0 AD	hand	1	Vishnu-Mittre et al. 1985
Kayatha, Madhya Pradesh	(2500-1400 BC)	hand	2	Vishnu-Mittre et al. 1985
Singh- Bhagwantpur, Dt. Kurukshetra, Harayana	?	hand	3	Vishnu-Mittre et al. 1985
Nagara, Dt. Kaira, Gujarat	(c. 1500-500 BC)	hand	1	Vishnu-Mittre et al. 1985
Sonegan, Dt. Pune	c. 1500-1000 BC	hand	2	Vishnu-Mittre et al. 1985
Besnagar, Dt. Vidisha Madhya Pradesh	Early Historic	hand	2	Vishnu-Mittre et al. 1985
Sringaverapura, Dt. Allahabad, U.P.	c. 1000 BC	hand	6	Vishnu-Mittre et al. 1986
Lekhahia, Dt. Mirzapur U.P.	Mesolithis	hand	3	Vishnu-Mittre et al. 1986
Rajgir, Bihar	Iron Age	hand	1	Vishnu-Mittre et al. 1985
Gufkral	2300-1500 BC	hand	2	Vishnu-Mittre et al. 1984
		hand	4	Vishnu-Mittre et al. 1985
		hand	7	Vishnu-Mittre et al. 1986b
Semthan	c. 1500 BC	flot	1	Buth and Bisht 1981 (blue pine)
Burzahom	2325-1500 BC	hand?	3	Vishnu-Mittre and Savithri 1979c
	2325-1500 BC	flot	4	Buth and Kaw 1984
	2325-1500 BC	flot		Lone et al. 1993

(contd.)

Site	Period	Sampling notes	Taxa qty.	Reference
Mehrgarh-Nausharo	c. 6000- c. 2000 BC	sampling hearths, sieving	14	Theibault 1988, 1989, 1991, 1992
Rohira	2500-1700 BC	?	13	Saraswat et al. 1990; Saraswat and Chanchala 1994
Ahichchhatra, Dist. Bareilly, U.P.	?	hand?	5	Saraswat et al. 1990
Kausambi, Dt. Allahabad, U.P.	Early Historic	hand?	8	Saraswat et al. 1992
Burzhom, Kashmir	2400 BC-200 AD	flot, 4 phases	27	Lone et al. 1993
Semthan, Kashmir	1500 BC-1000 AD	flot, 5 phases	27	Lone et al. 1993
Hulaskhera, Dt. Lucknow U.P.	(800 BC-500 AD)	hand?	6	Saraswat and Chanchala 1994
Narhan	1000-200 BC	flot.	25	Saraswat et al. 1993, 1994
Shikarpur, Kutch	2500-2200 BC	hand(?)	9	Saraswat et al. 1995
Mahorana, Punjab	2300-1900 BC	hand(?)	3	Saraswat and Chanchala 1996
	800-400 BC	hand(?)	1	
	100-200 AD	hand(?)	5	
Senuwar, Bihar	2200-600 BC	hand(?)	20	Saraswat and Chanchala 1996
Sanghol, Punjab	(1900-1400 BC)	?	7	Saraswat and Chanchala 1997
Kot Diji	Harappan	from section scraping		Castelletti et al. 1994

cultivated in these regions in prehistory (Costantini 1979c; Thiebault 1988, 1989; Saraswat et al. 1990; Lone et al. 1993: 180). Similarly, the presence of *Mangifera indica* (mango) wood from Narhan in the early first millennium BC (Period II) raises the possibility that mangoes were cultivated or at least husbanded (Saraswat et al. 1994). Mangoe wood charcoal together with that of the jackfruit tree (*Artocarpus heterophyllus*) were also found from Senuwar, Phase II, c. 1200 BC- 600 BC (Saraswat et al. 1996). While charcoal, and in one case fibre impressions, have been identified to the genus *Saccharum*, there remains no evidence for *S. officinarum* L., the cultivated sugarcane (Chowdhury and Ghosh 1955; Vishnu-Mittre 1971, 1974: 26). In addition, wood charcoal can provide evidence for the expansion or contraction of woody species ranges in the past, whether through climatic influence or human action. For example, in Kashmir a number of taxa represented in wood charcoal are not considered native to the Himalaya and must have been adopted through some sort of interaction/contact with cultures to the north in more temperate Asia, including *Platanus orientalis*, *Morus* and *Buxus* (Buth and Bisht 1981; Buth and Kaw 1985; Buth et al. 1987; Lone et al. 1993).

In addition to charcoal, wood is on occasion preserved without charring (see Table 11), often due to waterlogging. The finds in this category are very heterogenous with regard to cultural associations. Nevertheless, these data have provided some important

information on long-distance trade either in special woods or wooden products themselves. For example, a wooden coffin excavated from Harappa was found to contain two woods from the Himalayan forests, Elm (*Ulmus* sp.⁷) and cedar (*Cedrus deodara*), the latter known today for its fine scent (Chowdhury and Ghosh 1951). The Indian rosewood (*Dalbergia latifolia*) is restricted today to inner India and may also have been transported some distance to Harappa. However, the reports of *Dalbergia* charcoal from Baluchistan and Iran (Thiebault 1988; Costantini 1979c) in antiquity raises the possibility that this species may have had a broader distribution. This suggests the transport of particular wood types for the production of special objects from regions on periphery of, or indeed beyond, the Harappan Civilization area. In addition, wood represented in preserved furniture fragments, are often from species valued for the hardwoods today and generally rare or absent from studied charcoal assemblages, such as the *Diospyros* from Arikamedu (although there are admittedly few charcoal assemblages published from south India). This does hint at the selection against certain useful species as fuel. More work on reconstructing the distributions of vegetational groups in the past, through systematic charcoal studies and other lines of evidence such as pollen, are needed in South Asia to better understand the distribution and utilization of forest materials. In some coastal areas of the country, notably in the region of Calcutta, waterlogged wood remains (submerged forests) are sometimes preserved which if studied offer detailed information on local natural vegetational communities in the past (e.g. A. Ghosh 1941; for an example of the kinds of analysis that can be made with submerged forests, see Clapham et al. 1997).

6.2 Potential of Parenchyma

Fragments of charred parenchyma, the starchy storage tissue of plants which often comes from tubers (or other storage structures), are a common component of archaeobotanical assemblages. Parenchyma fragments, however, have gone largely unnoticed by archaeobotanists and unstudied until quite recently, especially in the Old World (Pearsall 1989: 165-73; Hather 1992, 1994a, 1996; Hather and Kirch 1991). Two likely sources of these are: firstly, the tubers of weeds used as fuel, which enter the site as crop by-products when harvesting is done by uprooting (as is often the case with south Indian legumes). The second possibility is root foods. Parenchyma can be easily separated during initial sorting of samples, but identification requires high magnification, probably SEM, and may not always provide diagnostic characters. There are no comparative collections, nor to my knowledge literature, on the identification of Indian tubers. Nevertheless, work on European tubers provides useful guides to identification at the family level (Hather 1994b), and some archaeobotanical studies of tubers are available from Island South-East Asia which discuss the major root crop groups of the Old World tropics such as Dioscoreaceae, Araceae and Zingiberaceae (Hather and Kirch 1991; Hather 1994c; cf. Hather 1996). *Dioscorea* spp. have also been identified in samples from West Africa (Paz 1997).

When and where the various root crops or gathered tubers were used remains a large lacuna in our understanding of the past subsistence. In exploring these lines of evidence,

TABLE 11. UNCHARRED WOOD FINDS

Site (Period)	Find type/Context	Taxa	Reference
Añikamedu (Early Historic)	tools, furniture, or timbers	<i>Heritiera</i> sp. <i>Mimusops</i> sp. <i>Diospyros</i> sp.	Chowdhury and Ghosh 1946
Kirari Harappa (Harappan)	post coffin	<i>Casearia</i> sp. <i>Cedrus deodara</i> <i>Dalbergia latifolia</i> <i>Ulmus</i> sp.	Ghosh 1950 Chowdhury and Ghosh 1951
Sisulpurgarh (Early Historic)	mortar waterlogged	<i>Zizyphus</i> sp. <i>Acacia</i> sp. <i>Casearia</i> sp. (?) <i>Holharrhena</i> sp. <i>Boswellia serrata</i> Bambusaceae	Chowdhury and Ghosh 1952
Pataliputra (Early Historic)	palisade	<i>Shorea robusta</i>	Ghosh and Lal 1958
Mula-Dam	fragments from sediments	<i>Terminalia</i> sp.	Rajaguru 1970
Chirand	fibre impressions	<i>Saccharum</i> cf. <i>spontaneum</i>	Vishnu-Mittre 1971
Nirgudsar	from buried channel		Kajale and Rajaguru 1989
Betamcherla (Mesolithic)	fragments from cave sediments	<i>Cassia</i> cf. <i>fistula</i> L. <i>Acacia</i> cf. <i>chudra</i> Willd.	Kajale et al. 1991

it will be necessary to consider a large range of indigenous, edible wild tubers, in India. In addition, it has been suggested on modern ethnographic parallels in north-eastern India, that these wild tubers would have served as important food resources of Palaeolithic/Mesolithic hunter-gatherers (Chatterjee and Ghosh 1990; Chatterjee 1991). Many of these species are known as 'famine foods' in floristic or ethnobotanical literature (Gamble and Fischer 1921-35; Vishnu-Mittre 1981, 1985; Mehra and Arora 1985; Maheshwari and Singh 1965). There is textual evidence for the use of root foods in the first millennium BC in northern India from the Yajurveda and Brahmanas (Achaya 1994), including *aluka* yams (probably *Dioscorea alata* or *D. esculenta*), originally from northern South-East Asia or Burma(?) (Alexander and Coursey 1969; Hahn 1995); *visa* lotus stem, *shaluka* lotus roots (*Nymphaea* sp. ?); radishes (*Raphanus sativus* L.) originally from South-West Asia (Crisp 1995); ginger (*Zingiber officinale* Rosc.) which could be native to India, as several wild *Zingiber* species are known and utilized as seasoning (cf. Maheshwari and Singh 1965), although South-East Asia and Pacific Islands are also possibilities from initial domestication and wild *Z. officinale* has not yet been identified (Nayar and Ravindran 1995); garlic/onions (*Allium* spp.) from Iran/Afghanistan? (Zohary and Hopf 1993). Identifying archaeological evidence for these and other species remains a challenge for future archaeobotany.

Archaeobotanical evidence of tubers in South Asia has yet to be fully explored. Small

rhizomes have been reported from two sites in Haryana, protohistoric and late historic, although these small tuber types were not necessarily food plants (Willcox 1992). Also, ongoing work on assemblages from Southern Neolithic site by the author (unpublished; see Fuller et al. n.d.) indicates the presence of probable charred parenchyma fragments on most Southern Neolithic sites, especially on the earliest levels. SEM examination of these specimens should allow to assess whether these represent the utilization of edible tuber types such as yams.

6.3 *Pollen from Archaeological Sites: Problems of Preservation and Interpretation*

The study of pollen from archaeological sediments has received less attention than macroremains. A few studies have highlighted its potential to fill-out reconstructions of past vegetation and plant use and potential contributions of this dataset have been reviewed by Dimbleby (1985) and Pearsall (1989). But soil pollen and that from archaeological sediments presents serious problems of taphonomy and preservation. Several of difficulties of interpreting archaeological pollen assemblages were outlined by Bottema (1975), including a careful consideration of the representation of insect-pollinated taxa (mostly asteraceae) which have been reported in large quantities from archaeological sites. Pollen rain, in general, consists of wind-pollinated species, but burrowing bees and other insects can lead to the accumulation of other taxa. In addition, bioturbation of this kind and others will lead to the contamination of ancient layers by more modern pollen. Pollen may even be moved downwards by water percolation. In addition, some soil environments, especially with extremes in pH, pollen is chemically destroyed or damaged, in particular pollen taxa with thinner exines. On the whole these and other factors indicate the need for extreme caution when interpreting archaeological pollen.

The first attempt to extract pollen from archaeological sediments in South Asia was the work on material from Maski (Vishnu-Mittre 1957d). From six soil samples spanning Periods I and II at that site, 10 pollen morphotypes were distinguished, seven of which could be assigned to at least a family level taxon but only a few with certainty to genus. This state of identification resulted both from the early state affairs with regards to the comparative study of the Indian pollen flora as well as the more general difficulties with specific level identification from pollen of several families. Little interpretation is offered for the pollen; while most of the taxa could be readily referred to tree and grassland flora of southern India as it is known today, the presence of pine was noted with interest. Pine pollen, however, is always problematic due to its form which allows dispersal over particularly vast distances. Vishnu-Mittre subsequently became less enthusiastic about pollen analysis from archaeological sediments since many of the sites he sampled over the years yielded very little (Vishnu-Mittre 1989). There has been some renewed interest for testing some archaeological sediments for the presence of pollen apparently preserved due to proximity of copper artefacts (e.g. Kajale and Deotare 1990, 1993, 1996), although the analytical contribution of such pollen is unclear.

Nevertheless, archaeological pollen analysis made some significant contributions to the archaeobotany of the Harappan Civilization through two studies. In conjunction with their study of natural pollen sequences from salt lakes in Rajasthan, Gurdip Singh and his colleagues also examined two sediment samples from the excavations at Kalibangan (Singh 1971; Singh et al. 1974). They compared the pollen constituents with the pollen subzone SM-3a, defined on the basis of the pollen sequence of Sambhar Lake, which corresponded to the Mature Harappan period. Cereal sized grass pollen was recovered from both archaeological samples, with an extremely large presence in one of them (58 per cent of the pollen). This, they suggest must indicate 'very local' occurrence. Indeed, on analogy with a crop processing in which pollen was collected (Vuorela 1973; Richardson and Hubbard 1977; Bower 1992), it can be suggested that the processing of cereal crops is likely to have been carried in the vicinity of the archaeological context sampled. (This assumes that the large grass pollen is correctly identified as that of a cereal; for discussion of some of the difficulties see Section 5.6, above.)

A more extensive study of pollen from the Harappan site of Balakot (in Sindh) was undertaken for a doctoral thesis by McKean (1983; unfortunately unpublished but summarized in Dales 1986). As excavation and flotation had yielded little in the way of macro-remains, although barley was present, pollen provided another means of investigating local environment and agriculture. On the whole, McKean found that the pollen flora represented the local vegetational groups that remain present in the region of the site today, and she concluded that there was therefore no evidence for climatic change in this area since the Harappan period, calling into question the argument by Singh et al. (1974) that Post-Harappan cultural changes were brought about by a rapid climatic change at the end of the Harappan period that was indicated in the Rajasthan lake profiles (for further discussion of this topic see Fuller and Madella in Vol. IV of this series). In addition, she obtained pollen evidence for the presence of crop plants in addition to cereals, including cotton. On the whole, pollen from archaeological sediments has made only minor contributions to the larger archaeobotanical record of South Asia, and, as Vishnu-Mittre (1989) asserted, it seems unlikely to do so in the near future due to the difficulties with predicting which sites will preserve pollen and when they do, interpreting the formation processes of archaeological pollen assemblages.

6.4 Potential of Phytoliths

Phytoliths (called spodograms when cuticle is preserved) are microscopic silica bodies produced by plants. Since opaline silica is a glass it does not usually bio-degrade, although it can be destroyed by physical abrasion and in some soil environments chemical dissolution. The extraction of phytoliths from archaeological sediments is increasingly being used to examine ancient human plant use (Piperno 1988; Pearsall 1989; Kajale et al. 1995). Phytoliths are also deposited in natural environments. After plants decay, phytoliths are deposited in the soil or they can be transported by wind, water, or animals. In principle then they are deposited constantly and should be preserved in palaeosols.

Small samples of soil/sediment can be collected like those for archaeological pollen study (Section 12, above): collection from freshly exposed sediments should be immediately bagged and sealed so as to avoid contamination by modern airborne phytoliths. One important advantage of these over other kinds of samples is that they can be collected from the cleaning of old stratigraphic sections, thus allowing the re-sampling of previously excavated sites, such as a study of Pre-Harappan/Harappan Kot Diji (Madella 1995, 1997). In addition, because samples are very small, they provide the opportunity for comparing discrete archaeological contexts/locales on a single site in order to study spatial variation in past activities which involved plant use (e.g. Madella 1998). The collection and laboratory processing for phytolith extraction must be done to insure against cross-contamination between the sediments of different samples. Numerous extraction techniques have been described, with the important steps being the removal of organics and carbonates in the sediments, usually followed by the separation of the silica fraction from the denser mineral fraction (Powers and Gilbertson 1987; Piperno 1988; Pearsall 1989; Madella et al. 1998; Lentfer and Boyd 1998). Since most processing techniques have the potential to sometimes damage multi-cellular ('articulated') phytoliths, additional slide mountings of sediment without chemical treatment have sometimes been used to scan for multi-cellular preservation (Madella 1995, 1997).

Phytolith studies can trace their roots to the 1830s when 'phytolitharia' were identified amongst other *infusoria*, microscopic organisms or their remains, discovered in wind-carried dust and sediments by the physician/naturalist Christian Ehrenberg (Powers 1992). Nineteenth and early twentieth century German research focused on the morphology of silica bodies produced by different plants while the systematic study of silica from soils was pursued from the late 1930s in Russia and subsequently in the 1950s in Wales, U.K. (Powers 1992). The first palaeobotanical and archaeological applications began in the late 1960s and 1970s, in Japan and America, notable among them are the studies of Watanbe (1968, 1970) to identify prehistoric phytoliths of rice and millets, and the methodological review by Rovner (1971). Archaeological phytolith analysis has yet to be conducted on any appreciable scale in India, although its potential has recently been outlined (Kajale et al. 1995). Phytoliths (although not referred to as such) have already played a part in understanding archaeological site formation. The presence of silicified grass cells was an important factor in arguments in favour of a dung origin for the Neolithic ashmounds of south India made by Zeuner (1959), whose results were repeated at the Kupgal ashmound (Mujumdar and Rajaguru 1966). Both groups of researchers found groups of articulated, silicified long cells, which in light of phytolith studies can be classed as spiny rods, a cell type common in the epidermis of grass, particularly on the glumes, lemma and palea of grass florets. Systematic phytolith studies may have much to contribute to understanding the Neolithic ashmounds or similar dung deposits (as suggested by Kajale et al. 1995), since dung usually incorporates large amounts of well preserved plant silica bodies. Such information may provide evidence relating to layer formation, seasonality and palaeoecology. The phytoliths should reflect the fodder of Neolithic cattle herds, and thus provide insight into the kinds of environments visited by Neolithic herders.

Some phytolith study has been carried on sites in Pakistan of the Harappan period. Fujiwara et al. (1992) reported a preliminary analysis of phytolith samples collected from old exposures at Harappa which included rice forms and possible *Eleusine*. However, the sampling conditions are not clear and the possibility of modern wind-borne contamination must be considered. Nevertheless, additional samples from recently excavated contexts being studied by Marco Madella also contain rive phytoliths (M. Madella: personal communication). It is not as yet clear whether domesticated finger millet, *Eleusine coracana* produces silica bodies which are clearly distinct from wild South Asian relatives, such as *E. indica* or *Dactyloctenium aegyptiacum* (tribe Eragrostideae), both widespread weeds and colonizers of disturbed habitats. Phytolith analysis is now a part of the Italian Archaeological Mission to the Rohri Hills, Pakistan and the Excavations at Harappa (Madella 1995, 1997, 1998: personal communication).

Phytolith identification is complicated by the fact that any given plant produces numerous different forms of phytoliths and similar phytolith forms may be produced by unrelated species. This has led to two different directions of research on phytoliths: one focuses on finding particular phytolith forms specific to a given species or taxonomic group while the alternative approach classifies phytoliths into form categories and uses these morphological types to compare assemblages and therefore highlight changes in the nature of vegetation input to sediments, such as differences in anatomical parts (e.g. leaves, stems, roots, spikelets), or differences in terms of source plant community. There are disagreements amongst specialists about the degree to which the identification of individual plant species is possible. Numerous food plant genera have been sampled for distinctive forms (e.g. Cummings 1992), although there is need for caution until a wider range of non-crop relatives have been sampled. The rice genus (*Oryza*) can be identified by a distinctive bulliform phytolith (Fujiwara 1993; Pearsall et al. 1995), and domesticated rice can be reliably distinguished from wild species through examination of the 'double-peaked glume cell', allowing for a degree of overlap which produces some indeterminate examples in most samples (Pearsall et al. 1995; Zhao et al. 1998). Bananas (*Musa acuminata*) and related plantains produce recognizable 'volcano' forms (Tomlinson 1969; Wilson 1985). In cases where specific identification is not yet possible, it is often possible to assign phytoliths to larger taxonomic groupings on the basis of certain general forms, such as the wavy rods of grasses or the 'cones' of sedges (Piperno 1988; Pearsall 1989; Ollendorf 1992). It has been suggested that multi-cellular phytoliths from grasses (or cereals) allow specific identification (Rosen 1992), an approach which is akin to more traditional studies of cuticle morphology, such as that used to distinguish wheat chaff temper from that of rice (e.g. Vishnu-Mittre and Savithri 1975). Statistical image-analysis of SEM images of inflorescence phytoliths shows promise for different ploidy levels in wheat (Ball et al. 1996). In general articulated phytoliths (preserved multicellular silica skeletons) offer potentially more taxonomic resolution, although individual phytoliths are far more often preserved. In addition, it is possible to compare ancient phytolith assemblages with those from modern top soils collected in environments or those from modern ungulate faeces (Powers et al. 1989; Powers 1992). Then even if the taxonomic

sources of individual phytoliths are unknown they can be compared in terms of ecological suites.

As with other botanical data types phytoliths need to be analysed taphonomically. In addition to potential contamination by extraneous phytoliths analysis may be complicated by problems such as low concentrations of phytoliths or heavily damaged assemblages due to the abrasion or wind transport (for example, in ancient sands from Egypt, Kaplan 1989). Understanding phytolith taphonomy presents important challenges that should direct future research.

Although phytoliths are taphonomically complex, they may also yield insight into numerous categories of sites (Madella 1998). Ultimately suites of phytoliths will represent source plant communities and the particular morphological parts of plants. Thus differences between sites or through time might indicate changes in vegetation or behaviours which bring vegetation onto a site. Madella (1998) has suggested that there will be fundamental differences between the phytolith assemblages on hunter-gatherer sites as opposed to agricultural sites which have much higher frequency of grass lemma, palea, and glume phytoliths (i.e. from chaff). Another important direction for study, being pursued by Madella at Harappa, compares the assemblages of different functional contexts on the site, such as hearths, kilns, pits and domestic floor sediments. The utility of this data set should be assessed in relation to macrobotanical remains from the same contexts.

6.5 *The Potential of Molecular Techniques*

A new technique which has promise for addressing certain archaeological questions, relating to crop evolution and diversification, is the extraction of ancient genetic material (DNA) from archaeobotanical remains. Over the past decade, since the advent for the laboratory technique of PCR amplification (polymerase chain reaction) it has become possible to work with small quantities of DNA, including that sometimes preserved in carbonized plant remains (Brown and Brown 1992; Brown et al. 1993). The study of ancient DNA poses methodological difficulties, including generally low rates of preservation of DNA in ancient material. A few studies have estimated the rate of recovery of ancient DNA from plant remains at something approaching 5 per cent, i.e. 1 out of every 20 specimens yields positive results (Allaby et al. 1994, 1997; Schulbaum et al. 1998a). While this is likely to preclude DNA analysis from becoming a standard archaeobotanical technique, it remains a powerful tool for large assemblages and can be used to target particular questions, especially of a phylogenetic nature. The first successful extractions of ancient DNA from archaeobotanical material came from desiccated maize remains from prehistoric America (Rollo et al. 1991). Since then there have been studies on rice from China (Nakamura and Sato 1991); desiccated *Sorghum* from Egypt (Rowley-Conwy et al. 1997; Deakin et al. 1998), a radish seed from the same site (O'Donoghue et al. 1996), as well as wheat from a few prehistoric sites in Europe (Allaby et al. 1994; 1997; Blatter et al. 1998; Schlumbaum et al. 1998b). The first studies of ancient wheats were targeted at distinguishing ploidy level, as it is often impossible to do this from charred grains themselves (Brown et al. 1993; Allaby et al. 1994; Sallares et al. 1995; Schlumbaum

et al. 1998b). Experimental work is also underway to develop reliable methods for DNA preserved in ancient pollen from sediments in order to trace cereals in the pollen record (Bower 1997).

The most intriguing information to come from ancient DNA relates to phylogenetic questions through the identification of different evolutionary lineages in ancient material. The necessary baseline for such studies comes from gene sequencing of modern plant populations. Studies based on modern plants can be used to produce phylogenetic trees and identify distinct lineages. The historical and geographical spread of different lineages could potentially be traced and correlated with the archaeological sequences and cultural change (M. Jones et al. 1996). In addition, extinct genetic diversity can potentially be identified. This could allow a more detailed understanding of evolution within crops, as pointed out by Allaby et al. (1994: 127-8):

... it could also liberate our thinking from the gross 'genetic events' of 'domestication' to the perspective of a continuous evolutionary dynamic, in which the constant restructuring in human society through space and time is reflected in an equally continuous process of phylogenetic response, sometimes miniscule, sometimes substantial, in the plants and animals with which humans have been most closely associated.

Such detailed information is not yet available, however, for example, two distinct lineages of Asian rice have been identified on the basis of a cpDNA deletion implying separate domestications of *indica* and *japonica* types (Chen et al. 1993). As these are difficult to distinguish on the basis of charred grains alone, screening of ancient DNA may be useful for tracing these lineages in the past. For example, Nakamura and Sato (1991) successfully extracted *japonica* type DNA fragments from rice from China that dates to the first millennium AD. A phylogeny has recently been developed on the basis of modern landraces of emmer (*Triticum diococcum*) which suggests two separate domestications of *Triticum diococcum* (Allaby et al., forthcoming). These different lineages could now be traced in the archaeobotanical record and they have been identified in archaeological material in Switzerland (Blatter et al. 1998). Similar kinds of study on other crop plants are yet to be carried out in the Old World, but they have much to contribute to our future understanding of the agricultural history of South Asia.

7. DISCUSSION: THEORETICAL ISSUES IN ARCHAEOBOTANY

The history of archaeobotany has been largely the story of improved methods and increasing data, but there is now increasingly an interest in theoretical issues. In general, theoretical questions which can and are grappled with through archaeobotany can be divided into two groups. First, there are those which relate more closely to the kinds of issues explored by botanists, namely questions relating to plant ecology and plant evolution. Second, there are questions which are of archaeological (or anthropological origin), which take an interest in social systems and social change, in this case in terms of plant exploitation and use. Much theoretical consideration has been given to the origins and spread of agriculture, although other issues, such as intensification and hunter-gatherer

subsistence modes can also be addressed. While detailed exploration of these issues will not be pursued here, a few general observations may be worthwhile.

Domestication represents an evolutionary process of morphological and genetic change in a plant brought about by a new kind of environment created through human activity. As discussed by Reed (1977) and Rindos (1980, 1984), this can be seen as a form of symbiosis. The nature of this symbiosis depends on the kind of plant involved, which plant part(s) are utilized and ecology. A significant distinction can be made between vegeticulture, focused on root crops and seed culture, a distinction that generally correlates with global environmental zones, i.e. biomes (Harris 1972, 1973; Ellen 1994; Hather 1996). Interest has often turned to understanding the interaction of plant reproductive mode (whether self-pollinating, outcrossing, or predominantly vegetative reproduction), plant part utilized by humans, and the ecological setting created by humans (e.g. Harlan et al. 1973; Zohary 1984, 1997; Zohary and Hopf 1993; Rindos 1980, 1984; Ladazinsky 1989; Ellen 1994; Blumler and Byrne 1991; Blumler 1996). The symbiotic relationship, changes the plant morphologically, usually leading to the whole or partial dependence on humans for dispersal in seed crops, and loss of toxins or bitterness in root crops, fruits or vegetables. Whether the genetic changes in plants preceded or succeeded cultivation (harvesting, storage and planting) has been one important issue, with the majority of evidence now favouring the former situation in most instances (see Blumer and Byrne 1991, with commentaries). The factors leading to these changes result from the ecological circumstances created through human activity have been much debated, with controlled burning, the creation of refuse heaps and other kinds of disturbance being cited as possible causal settings (Blumler and Byrne 1991; Blumler 1996). There is unlikely to be one universal explanation, but rather a range of human-environment-plant interactions that led to domestication. This needs to be investigated through a combination of modern evidence from ecological and experimental studies (e.g. Hillman and Davies 1990), and available archaeobotanical and palynological evidence.

Taking an anthropological point of view, interest focuses on the nature of the transition in human cultural practices, its relationship to changes in social organization, and the causes of the change to agriculture. Other earlier generations of archaeologists considered the origins of agriculture as the gaining of progressive knowledge, such as Vishnu-Mittre (e.g. 1968c, 1970b, 1975), in his earlier papers, and Chowdhury (1969). However, it is now clear that it was not an obvious or inevitable change, but a contingent one. The change to agriculture can be considered a change from a largely extractive approach to subsistence towards a highly regulative one (Ellen 1994), or a switch from seeking stability in an 'information bank' (knowledge of a range available resources) to a 'labor bank' (the investment in farming for delayed returns) (Binford 1983: 208). However, agriculture was not a sudden revolution but a process that shifted the interaction between societies, plants and animals along a spectrum of possibilities (Rindos 1980, 1984; Harris 1989, 1996a). Early agriculture has often been linked to concepts of ownership and sedentary communities, although it is now clear that in some parts of the world sedentism preceded cultivation and domestication, while in other regions it followed from them (MacNeish

1992; Ellen 1994). It has been suggested that some of the necessary changes in social relationships were dependent on changes in societies already underway in the Upper Palaeolithic (Hodder 1990; cf. Hastorf 1998). Be that as it may there remains a vast literature on not just the pathways to agriculture but the numerous suggested causes, with the most common being some combination of climatic change and population pressure (Blumler and Byrne 1991; MacNeish 1992; Ellen 1994; Bar-Yosef and Meadow 1995; Harris 1996b) but with growing interest in possible social factors such as competition for prestige (Hayden 1990, 1995), social gift exchange between women (Hastorf 1998), or the emergence of a gendered division of labour with the development of pottery and grain-based cooking (Haaland 1995).

Beyond domestication there are additional theoretical problems of an ecological nature. For example there is no clear agreement about the process by which crops and agriculture spread, whether by colonization of agriculturalists or diffusion, and the motivating factors behind this (Rindos 1980, 1984; MacNeish 1992; Hayden 1995; M. Jones et al. 1996; Harris 1996b; Thomas 1996). Another set of theoretical issues revolves around agricultural intensification, how it is defined, detected and caused (Morrison 1994, 1996). Intensification in turn relates to the problem of the relationship between early agriculture and environmental change, e.g. of the sort registered in pollen diagrams, which at least in Europe appears to have occurred two to four millennia after the first agricultural communities occurred on the continent (Willis and Bennett 1994; M. Jones et al. 1996). The relationship between early Neolithic agriculture, later intensification and the formation of the Indian landscape, especially the vast peninsular grasslands, remains an important issue to explore which will require both more empirical data from archaeology and palaeoecology, as well as theoretical bridging arguments to relate this datasets and the processes they represent.

In part due to the development of post-processual and cognitive approaches to archaeology (Hodder 1992; Whitley 1998), there has been an increasing interest in the role of past human perception on behaviour. These theoretical perspectives highlight the need to take into account culturally specific values and frameworks of thought when interpreting past actions, for example the role of culinary preferences, status foods, or taboos on the social processes of the adoption and diffusion of certain crops (see Farb and Armelagos 1980; Weissner and Sciefenhovel 1996; Hosoya and Fuller, forthcoming; Hastorf 1998). This work exemplifies a point emphasized by the archaeologist Gordon Childe that human societies adapt the environment as they perceive it, not necessarily as it truly is (e.g. Childe 1951: 176-7; Trigger 1991). However, studies highlighting the historical constraints on 'adaptation' have yet to arise from South Asian archaeobotany. In addition, the spread of crops and agricultural practices by diffusion (as opposed to actual colonization) was more than just a matter of availability. As with other kinds of diffusion, crop diffusion requires compatibility with the existent cultural and economic system, i.e. social approval (Childe 1951: 172). It is as likely to have been cultural factors, rather than purely ecological factors, which delayed the spread of millets in the central Indus Valley during the Harappan period and perhaps also the lack of wheat/barley

cultivation in Gujarat. On the other hand, the rapid and wide distribution of some crops in prehistory, such as wheat and barley in the second millennium BC or *Lablab*, could have had to do with cultural or prestige associations. The difficulty lies in trying to establish such social factors, although they can be inferred in general by contrasts with other crops and ecological predictions.

8. THE FUTURE OF ARCHAEOBOTANY

The history of any discipline, particularly in its early years, is the story of a few enthusiastic and often visionary individuals. The foresters and wood anatomists at the Dehra Dun forestry institute, including K.A. Chowdhury and S.S. Ghosh might be singled out as the founders of archaeobotany in India. More than anything else they must be credited with bringing to the attention of practising archaeologists that plant remains from ancient sites could provide an additional line of evidence on the past. However, the mode of analysis during this period was still largely 'antiquarian' (sensu Trigger 1989) in that it consisted of collecting information, identification of species and compilations of lists, which were largely done for the sake of collecting. It was during the career of Vishnu-Mittre that archaeobotany emerged as a discipline in its own right, a specialization on the plant remains from the human past. As with many pioneers, Vishnu-Mittre's greatest contribution was his wide-ranging involvement and enthusiasm that helped to start research paths in numerous directions. He began to consider seriously the origins and spread of agriculture in South Asia and promoted a 'botanical perspective on the quaternary'. It now appears that in some cases he was somewhat overzealous in his identifications, and critical reassessments of some of his claims are in order. His discussions of early evidence for *ragi* (*Eleusine coracana*) in south India and rice in the Vindhya attracted interest to possible indigenous domestications of plants but in neither case were the data systematically enough collected or reported to substantiate his claims. The time is ripe for the systematic examination of these issues through the collection and careful documentation of new evidence.

In the following decades, from the mid-1970s to more or less the present-day, a larger number of professional archaeobotanists became involved in research. With systematic collection through flotation and routine publication of results as parts of site reports, the amount of data has grown exponentially. This work has brought us to the stage of greater 'maturity' in which, through a greater awareness of the biases inherent in the archaeobotanical data, a more self-critical and theoretical discipline has emerged. Foreign archaeobotanists only entered the Indian scene in the recent past. For the most part their work has been concentrated in the north-western portion of the subcontinent, in particular on Harappan sites. They have brought with them a number of broader theoretical questions relating to cultural ecology and the rise, maintenance and fall of complex, urban societies. These perspectives have contributed a somewhat larger purview to archaeobotany. It is no longer sufficient to merely record species, but it is now necessary for archaeobotanists, alone or in collaboration, to interpret and explain their data in terms of both ecological understanding and past social activities, such as crop processing, storage, exchange and

cooking. International cross-fertilization has contributed to the development of a more reflective, taphonomically-orientated archaeobotany. In time, it is likely that Indian archaeobotany will make important contributions to theoretical problems and thinking abroad. Agriculture on the Indian subcontinent may have included the indigenous development of some small scale cultivation systems based around small, indigenous millets, pulses, and possibly wild root crops which were subsequently transformed by introduction of higher yielding crops such as wheat, barley and *Sorghum*. This may provide an important comparative case for understanding the early agriculture of North America where a number of small-yield, local crops, few of which are of any agricultural significance today, provided the foundations of village life which was subsequently transformed by the adoption of maize (Smith 1989; Fritz 1991). Other indigenous crops in India may turn out to be secondary domesticates whose domestication followed from the establishment of introduced cultivars. By understanding the ecological and social context, these secondary domestications can also be compared with cases elsewhere in the world.

Indian archaeobotany has a bright future but is still quantitatively disadvantaged by comparison to the discipline in some other parts of the world. Archaeobotanists are few and far between, and given the sheer size of India, its diversity in terms of natural environments and subsistence strategies (past and present), Indian archaeobotanists have their hands very full indeed. By comparison with the trajectory of the discipline in other parts of the world, we are on brink of increase. In Near Eastern archaeology of the sixties there were only a handful of archaeobotanists, but after the development of flotation there (Hole et al. 1969) there was a proliferation of workers, in the seventies and since. A similar increase can be seen to have occurred in eastern North America in the early 1980s (Watson 1997). Now both of these regions have vast datasets, allowing constant reanalysis and encouraging intricate discussion of ecological, political and social aspects of human-plant relationships. This is marked in particular by the involvement of general archaeologists in debates surrounding archaeobotanical evidence: archaeobotany is no longer peripheral but paramount to many questions of the human past. Food and the plant world are inextricably part of human existence, and something about which archaeobotany has much to say. The opening of the next century may, hopefully, see a similar development in India. The metaphorical tree that is archaeobotany may soon set fruit.

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NOTES

- 1 In grasses the outer coat of the grain is a pericarp, usually ornamented or haired, while the testa (true seedcoat), is in a second layer of cells fused with this (Hickey and King 1991; Pandey 1995). The lemma and palea enclose the grain (caryopsis).
- 2 Reports of *Vigna unguiculata* as the scientific name for horsegram, as at Rojdi (Weber 1991), Babar Kot (Reddy 1994), Watgal (Devaraj et al. 1995), are misnomers. The species usually known as *Dolichos biflorus* in archaeological literature is correctly known as *Macrotyloma uniflorum* (see references in Section 5.3).
- 3 Although often referred to in Indian floristics and agronomic literature as *Dolichos biflorus* Linn., this species of Linnaeus actually refers to a type specimen of catjang type cowpea (Hindi *chowli*, *lobia*), now placed in the polytypic species *Vigna unguiculata* (L.) Walp. Thus *D. biflorus* Linn. is a synonym for *V. unguiculata*. This equation has, however, been wrongly used by Weber (1991), Reddy (1994), Devaraj et al. (1995) and Kroll (1996; 1997; 1998), since the archaeological finds traditionally described as *D. biflorus* are not cowpeas (Hindi *chowli*)! *D. biflorus* is an invalid name for the horsegram (Hindi *kulthi*), which was first properly described by Lamarck as *Dolichos uniflorum*. It has now been transferred to the genus *Macrotyloma* (Verdcourt 1970; 1971; Smartt 1985a; 1990). The recent suggestion that '*Dolichos uniflorus*' is the wild form of '*Dolichos biflorus*' and localized in the southern and eastern peninsula (Mehra 1997), requires botanical clarification and substantiation.
- 4 *Vigna umbellata* (Thunb.) Ohwi & Ohashi, rice bean, is cultivated in parts of South-East Asia, while *V. angularis* (Willd.) Ohwi & Ohashi, the adzuki bean, originated in China or Japan where it is cultivated today. This name was mistakenly applied by Weber (1991) to the Black Gram, *V. mungo* (L.) Hepper!
- 5 It is indeed unfortunate that Linnaeus mixed-up the common names and therefore assigned the scientific *mungo* to black gram rather than to green gram, known colloquially as 'mung'. But the correct botanical nomenclature can not be helped, even if somewhat confusing to the uninitiated.
- 6 *Phaseolus aureus* and *P. radiatus* are not domesticated and wild forms, respectively, as suggested by Lone et al. (1993: 135), but older synonyms for the domesticated mung/green gram crop, the wild form of which is *Phaseolus sublobatus* Roxb. As they have all been transferred to *Vigna* and the wild progenitor has been demoted to subspecies following the nomenclatural system of Harlan and De Wet (1971), the wild progenitor is now known as *Vigna radiata* subsp. *sublobata* (Smartt 1985b, 1990). As black gram has a distinct progenitor, it has been removed from *sublobata* to become known as *V. mungo* subsp. *silvestris* (Smartt, *ibid.*).
- 7 *Ulmus wallichiana* is also known from Baluchistan as well as from the Himalaya, where *U. villosa* is restricted.

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