J World Prehist (2006) 20:1–86
DOI 10.1007/s10963-006-9006-8

ORIGINAL PAPER

Agricultural Origins and Frontiers in South Asia: A Working Synthesis

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Published online: 1 December 2006

Abstract The accumulation of recent data from archaeobotany, archaeozoology and Neolithic excavations from across South Asia warrants a new overview of early agriculture in the subcontinent. This paper attempts a synthesis of these data while recommending further systematic work and methodological developments. The evidence for origins and dispersals of important crops and livestock from Southwest Asia into South Asia is reviewed. In addition evidence for indigenous plant and animal domestication in India is presented. Evidence for probable indigenous agricultural developments in Gujarat, the Middle Ganges, Eastern India, and Southern India are reviewed. An attempt is made to highlight regions of important frontiers of interaction between early farmers and hunter-gatherers. The current evidence suggests that the Neolithic trajectories in different parts of South Asia differ from each other. Indigenous centers of plant domestication in India also differ from the often discussed trajectory of Southwest Asia, while suggesting some similarities with agricultural origins in Africa and Eastern North America as well as secondary agricultural developments on the peripheries of Eurasia.

Keywords Neolithic · Domestication · India · Pakistan · Archaeobotany · Archaeozoology

Introduction

Fundamental changes in societies of modern humans occurred with the emergence of agriculture. Changes occurred in social organisation and cultural ecology, as well as in symbolic dimensions of culture, especially in the perception of the landscape and the human relationship to particular species of plants and animals. As agriculture involves relationships with animals and plants, the remains of these organisms provide our most direct evidence. There is a growing body of archaeobotanical and archaeozoological data from South Asian protohistory (or late prehistory) which calls for a new synthesis on agricultural origins

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and the Neolithic in South Asia. The present paper considers the state of the evidence, including its reliability and completeness, and summarises its broad contours. Details of the evidential basis can be found in reviews of archaeobotany (Fuller, 2002; Fuller & Madella, 2001; Kajale, 1991; Saraswat, 1992, 2005) and archaeozoology (Thomas & Joglekar, 1994; Thomas, 2001; Meadow, 1989a, 1996; Meadow & Patel, 2001, 2003; Chattopadyaya, 2002).

The synthesis presented in the present paper outlines basic geographical patterns in the emergence of agricultural economies. Certain regions are candidates for hearths of pristine origins through the domestication of native species while other regions must have received agriculture or pastoralism secondarily, either through migration (demic diffusion) or adoption (cultural diffusion). In distinguishing these possibilities, we must inevitably move beyond the archaeozoological or archaeobotanical evidence and place it in its wider archaeological context. For both pristine origins and secondary origins it is useful to consider how the Neolithic package, came together in terms of timing, ordering and association. As outlined by Childe (1936), we should consider food production, in terms of both animals and plants, ceramic production, and sedentism. Childe also regarded textile production to be part of the "Neolithic revolution," but this will not be given much space in the present paper due to limitations of the evidence, although the presence of some fibre crops and the introduction of woolly sheep breeds both have a place in the evidence considered.

A useful framework for thinking about these alternative processes of secondary origins is frontier theory (Alexander, 1977, 1978; Dennell, 1985; Zvelebil, 1986). Within this framework we can attempt to distinguish two alternative processes as dominating the establishment of agriculture in any region without local domestication of all its food species (Fig. 1). On the one hand we have moving frontiers when the prominent process is the movement and colonisation by agricultural populations although with at least some recruitment from pre-existing hunter-gatherer populations. This may have been driven in part by the higher population densities and population growth in agricultural societies (also called demic diffusion) and could have been allowed by their ability to exploit environments to which agriculture was already adapted. This process need not mean a spread wholesale of archaeological cultures, however, for as research the Eastern Mediterranean indicate, the cultural elements that accompany colonization may be selective (e.g. Perles, 2005). The alternative process may be termed a static frontier, in which stable agriculturalists interacted with hunter-gatherers and other neighbouring farmers. Such static frontiers would incorporate the "interactive trade" between hunter-gatherers and settled agriculturalists, a process which has been inferred for Gujarat and adjacent Rajasthan (Possehl, 1976; Possehl & Kennedy, 1979; Lukacs, 2002; Shinde, Deshpande, & Yasuda, 2004; cf. Morrison, 2002a). During this process some hunter-gatherers may have gradually taken up aspects of the Neolithic (i.e. cultural diffusion) and also new agricultural developments may have allowed the exploitation of new environments. Social interactions were doubtless also important such as inter-marriage, and new cultural traditions could have developed.

The present author suspects that across India much of the broad patterns of linguistic diversity and distribution became established in the Neolithic/Chalcolithic with the diffusion of agriculture and some dispersals of population (Fuller, 2003a). Evidence from historical linguistics indicates that there are multiple regional origins for core agricultural vocabulary (Southworth, 2005; Fuller, 2003a, 2006a, 2006b), which is congruent with the archaeological evidence reviewed below. Contrary to broad-brush generalizations about language family distributions and possible links to early agriculture (e.g. Renfrew, 1996; Bellwood, 1996, 2001, 2005; Diamond & Bellwood, 2003), there is neither archaeological nor etymological data to support the so-called Elamo-Dravdian Neolithic expansion from Iran to South India.

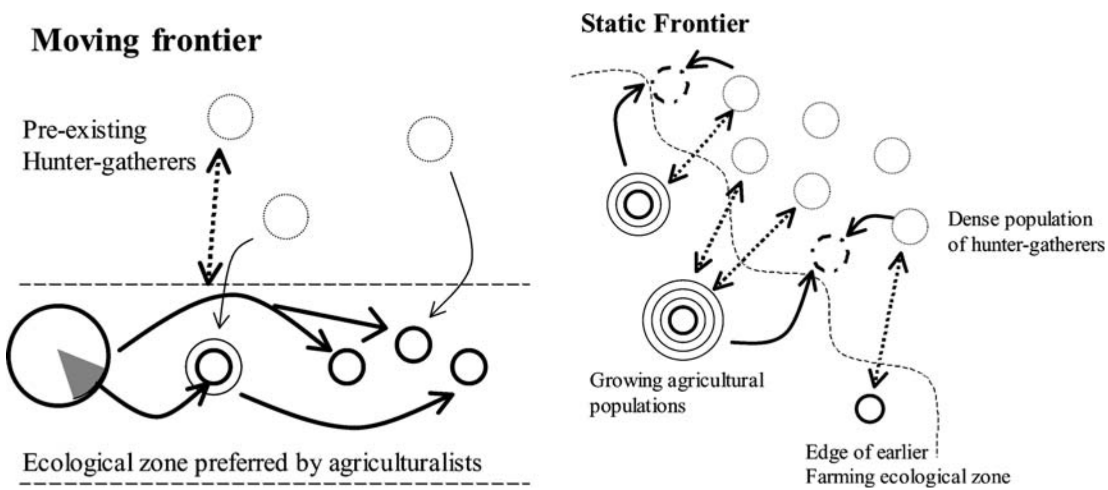

Fig. 1 A comparison of two general types of farmer-forager frontiers. *Left*: An agricultural moving frontier. From a large agricultural population a segment of that population migrates to establish new smaller agricultural settlements, seeking out space in a familiar ecological niche to which farming traditions are already suited. In surrounding environments hunter-gatherers persists which may interact with the pioneer agricultural settlements. This rapidly expanding settlements may include recruitment from hunter-gatherers populations who choose to settle and acculturate. (inspired by Alexander, 1977, 1978; Van Andel & Runnels, 1995). *Right*: A static frontier between growing agricultural populations and indigenous hunter-gatherer populations. Interaction between these groups, including trade and perhaps inter-marriage is indicated by *dashed arrows*. Population growth is indicated by concentric *circles* of agricultural populations. A new Neolithic cultural tradition may arise through the hybridisation of the previous Neolithic and hunter-gatherer traditions (inspired by Alexander, 1977, 1978; Zvelebil, 1996)

Rather the likelihood of independent trajectories towards agricultural economies within the floristic province of tropical India is suggested by Dravidian linguistic data (Fuller, 2003a, 2006a, 2006b; Southworth, 2005), including names for a range of key tree species of the tropical dry deciduous forests (Asouti & Fuller, 2006; Fuller, 2006b). In north and northwest India, loanwords into the intrusive Indo-Aryan languages strongly suggest one, or more, earlier 'substrate' languages of farmers in these regions (Fuller, 2003b, 2006a; Witzel, 1999, 2005; Southworth, 2005). The linguistic map of India, and the etymological evidence for loan words for crop names and other agricultural terms, highlights the need to think about the role of agricultural frontiers in the cultural history and geography of South Asia, and archaeological evidence helps to outline such frontiers of food production traditions.

One of the principal aims of the present paper is to highlight possible static and moving agricultural frontiers in South Asian prehistory. While the present evidence is far from adequate to delineate these in detail, the provisional suggestions offered below are aimed to help promote further systematic investigation of these issues. On the one hand it is possible to identify moving frontiers, i.e. regions in which agriculture became established rapidly and largely displaced hunting and gathering. In other cases the evidence suggests static frontiers, or regions in which a prolonged period of interaction between agriculturalists and hunter-gatherers took place but which ultimately tended towards the adoption of agriculture. In addition we can identify periods and regions in which crops, livestock, or practices were transferred between existing agricultural traditions. The identification of these frontier regions should provide a basis for the further investigation of the social and ecological processes involved in agricultural origins, and all that implies about social change. A full development, however, of the implications of understanding social change in particular Indian frontier situations is beyond the scope of the present paper, which highlights instead the current framework of subsistence evidence.

The regions discussed in this paper will differ somewhat from those recognized in previous research (Fig. 2). In general seven Neolithic cultural zones have been defined in India and Pakistan (Thapar, 1974; Saraswat, 1992; cf. Agrawal, 2002), although some of these archaeological cultures remain poorly represented in terms of bioarchaeological, especially archaeobotanical, evidence and will therefore not be considered in any detail in the present paper. Alternatively, Liversage (1989) provided a simpler breakdown of four cultural complexes which he suggested were broadly consistent through ecological conditions and cultural interaction. As the available evidence now shows, however, despite similar ecology or cultural interaction some adjacent regions differed in their early food production systems. These cases highlight the need to take an eclectic approach to understanding the causes and constraints of early agriculture including factors of environmental potentialities, species availability and cultural tradition. In addition it is clear that the beginnings of agriculture came at different times in different regions and thus drawn out over several millennia (Figs. 3 and 4).

Wild progenitors and the geography of domestication

Essential background for this paper is the modern botanical and biogeographical evidence for the regions of origin of particular crop species. Unlike the Near East and Mediterranean, for which Zohary and Hopf (2000) are an authoritative source, there is nothing equivalent for South Asia. Various botanical reference books contain information, but it is often of variable quality and reliability, and critical botanical reassessments are necessary for many species.

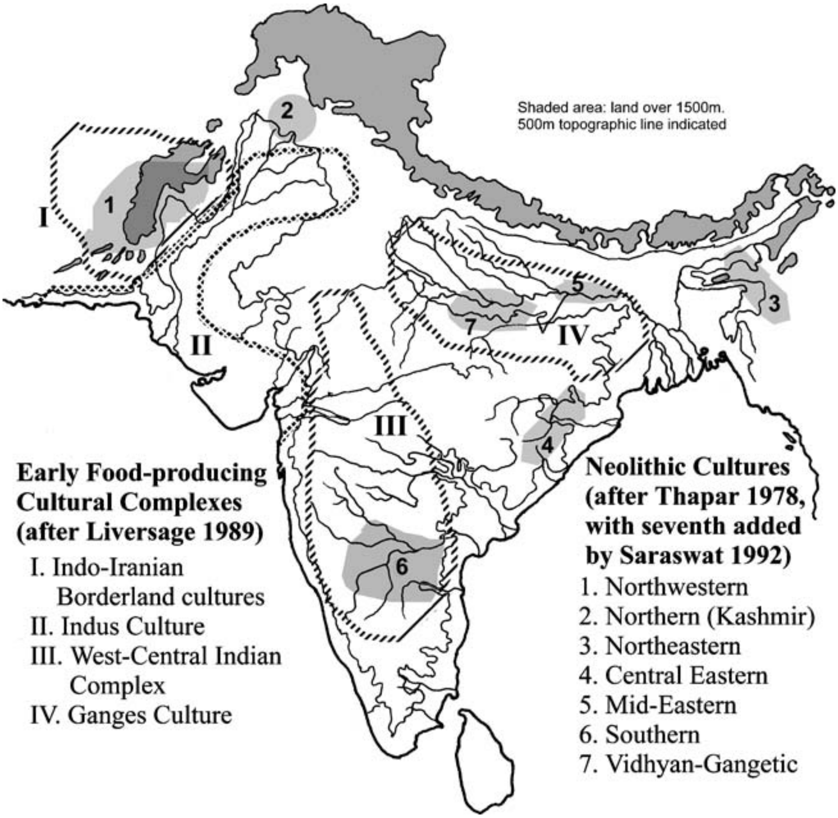

Fig. 2 Distribution of Neolithic or early food-producing cultures recognised in India, showing comparison of the broader complexes of Liversage (1989) and the Thapar-Saraswat scheme (Thapar, 1974; Saraswat, 1992). A revised scheme, indicating important zones of frontier dynamics, is suggested at the end of the present paper (see Fig. 13, below)

A recent tabulation of such evidence is provided by Fuller (2002) for major cereals, pulses and selected other crops in South Asia, although for many species renewed research is needed. Recently, the author has embarked on a reassessment through herbarium collections for some of the key South Asian native pulses, for which a provisional distribution map is provided here (Fig. 5), incorporating the important work by van der Maeson (1986). What this map suggests is plausible regions for horsegram domestication throughout the semi-arid savannah zone, mungbean origins in the western Himalayan foothills, or isolated hills of the eastern Ghats and urdbean origins in the northernmost Western Ghats or hills in Gujarat or Rajasthan. Much of the Western Ghats, which has received attention before (e.g. Fuller & Korisettar, 2004), should probably be ruled out because both wild mung and wild urd occur together here, but early archaeological finds suggest separate origins (see below; also Fuller & Harvey, 2006). Other useful sources are Simoons (1991) for Chinese and many Southeast Asian taxa, and the chapter on Africa in Harlan (1995), but see also the discussions in Fuller (2003b) and Neumann (2003), as well as discussions of individual crops included in Smartt and Simmonds (1995).

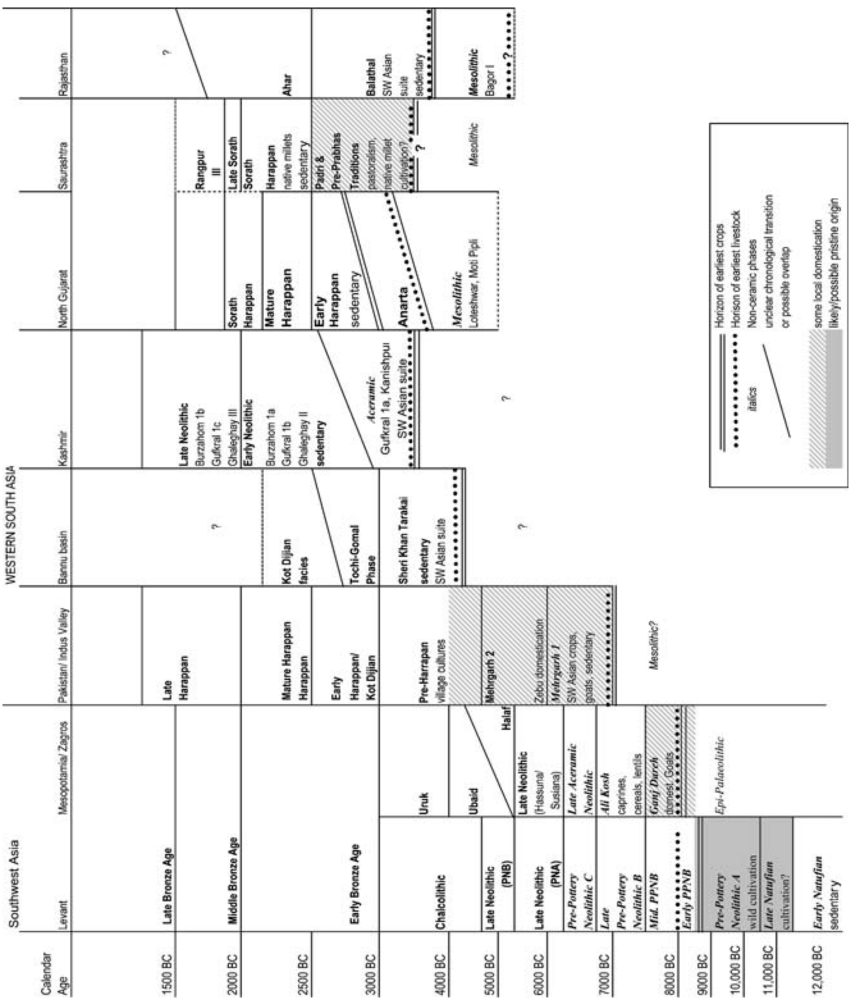

Fig. 3 A summary chronology Northwestern South Asia in the Holocene with comparison to the Near East, indicating key horizons in the development of agriculture

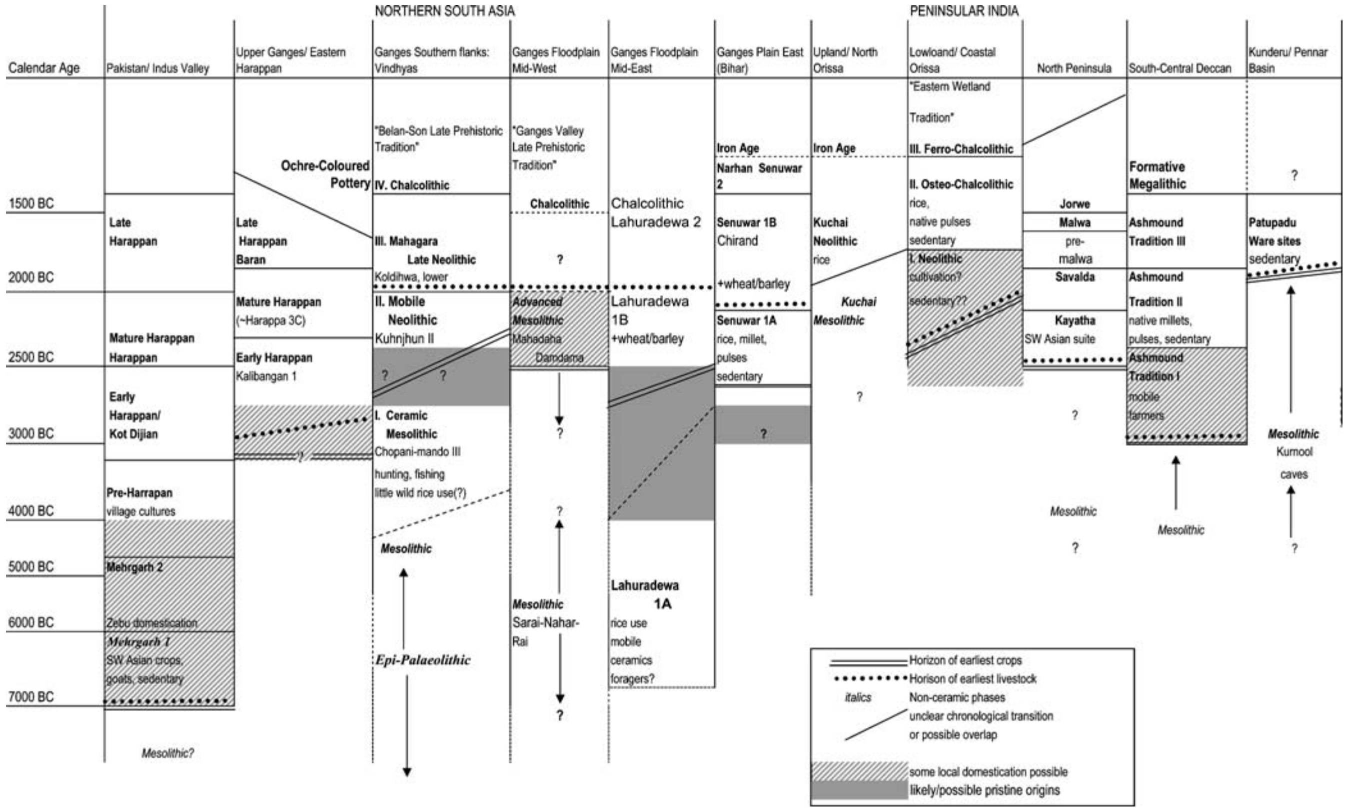

Fig. 4 A summary chronology Northern and Southern India in the Holocene with comparison to the Northwestern subcontinent, indicating key horizons in the development of agriculture

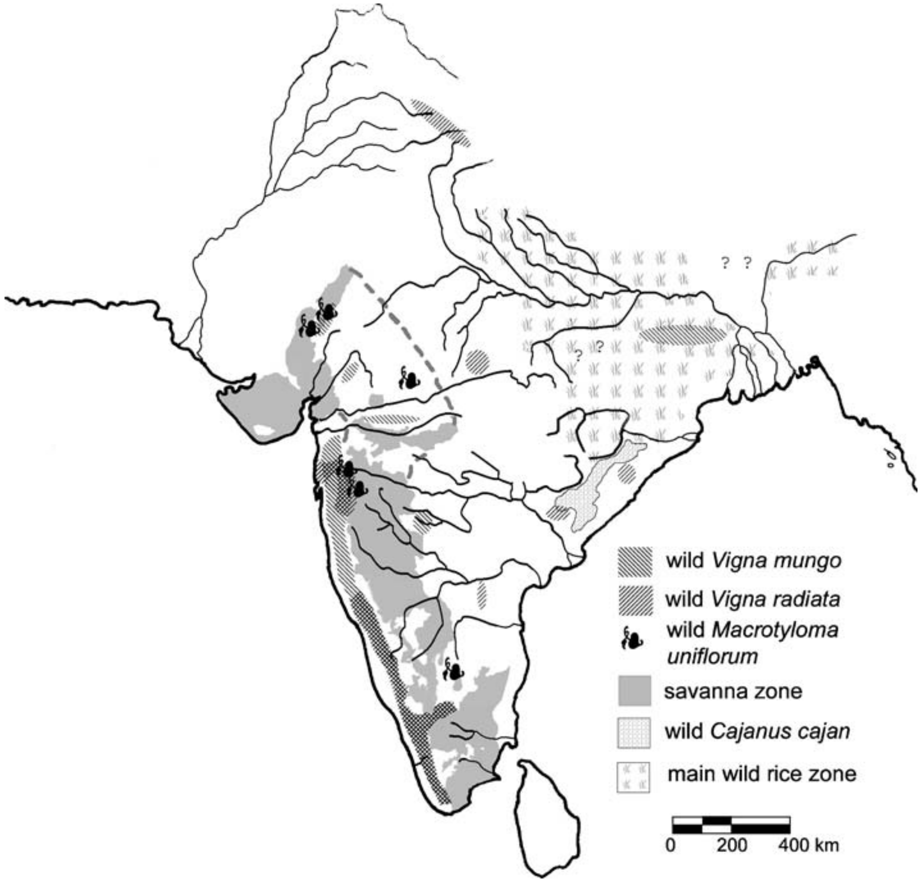

Fig. 5 A map of modern distributions of four pulse crop wild progenitors, with the semi-arid savannah zone shown in grey. Horsegram (*Macrotyloma uniflorum*), mungbean (*Vigna radiata*), and urdbean (*Vigna mungo*) based on the authors study of herbarium collections in Calcutta in Pune; wild pigeonpea (*Cajanus cajanifolia*) follows van der Maeson (1986). Questionmarks indicate areas with wild *Vigna* populations recorded in floras for which specific crop affinity is unclear

Paleoenvironmental context: Some generalizations

Important for any understanding of the beginnings of agriculture is a framework of how environments in the past differed and how this affected the distribution of wild progenitors and cultural adaptations. While a detailed review of the palaeoenvironmental record for South Asia will not be attempted here, a few hypotheses based on current quaternary science evidence are outlined to serve as a basis for discussions that follow (Fig. 6). A recent attempt to compile and discuss a wide range of quaternary sources can be found in Asouti and Fuller (2006) and Madella and Fuller (2006) (also, Fuller & Madella, 2001, pp. 355–366; Fuller & Korisettar, 2004; Schuldenrein, 2001; Meher-Homji, 2002; Shinde *et al.*, 2004). At the broadest temporal scale patterns of monsoon rainfall in India can be correlated with those documented in eastern Africa (Hassan, 1997; Gasse, 2000), the Arabian Peninsula (Lézine, Saliège, Robert, Wertz, & Inizian, 1998), and Tibet (Wei & Gasse, 1999). Similar patterns of

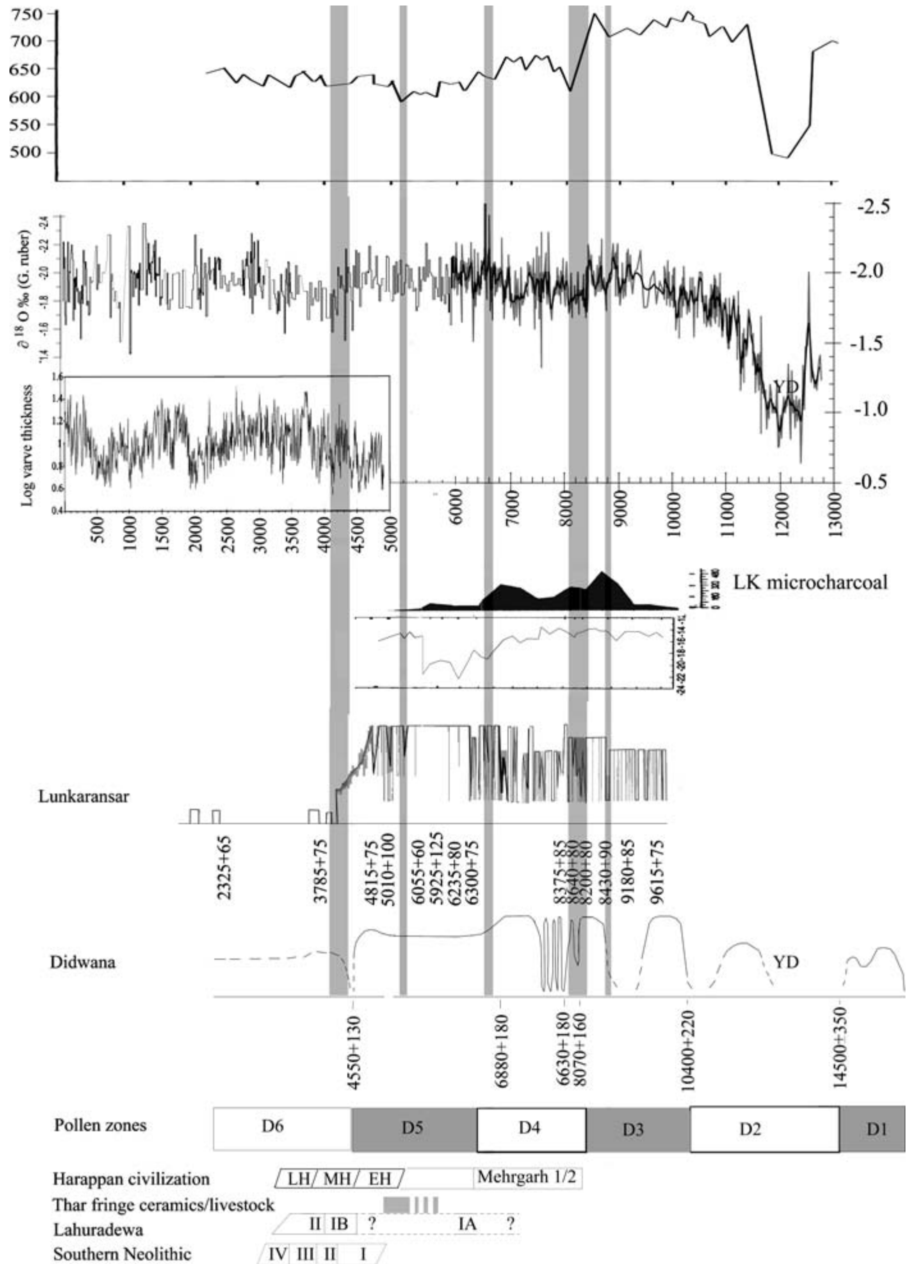

Fig. 6 Correlation between various paleoclimatic proxies from northwestern south Asia, and selected archaeological phases. From top to bottom: global atmospheric methane as measured in the Greenland GISP core (after Blunier *et al*., 1995), O-18 isotopic variation from Pakistan continental margin (after Staubwasser *et al*., 2002, 2003); 5000 years of Indus discharge inferred from Karachi delta varve thickness (after Von Rad *et al*., 1999), micro-charcoal from Lunkaransar (after Singh *et al*., 1974), lake level and C-13 data from Lunkaransar (after Enzel *et al*., 1999), lake levels and pollen zonation from the Didwana lake (after Wasson, Smith, & Agrawal, 1984; Singh *et al*., 1990), selected archaeological phases

much higher monsoon rainfall in the early Holocene, and to a lesser extent mid-Holocene can be inferred from pollen and sedimentary evidence in Rajasthan (Singh, Wasson, & Agrawal, 1990; Enzel *et al*., 1999), and the middle Ganges plain (Gupta, 1976; Chahuan, Pokharia, & Singh, 2005; Singh, 2005a, 2005b), as well as oxygen isotopes from varve-like sediments from sea floor near the Pakistani coast (Staubwasser, Sirocko, Grootes, & Erlenkeuser, 2002; Staubwasser, Sirocko, Grootes, & Segl, 2003). In South India an important sequence relates to aridification and agricultural impacts on vegetation from the later mid-Holocene (Caratini *et al*., 1994; discussion in Fuller & Korisettar, 2004; Meher-Homji, 2002). It is clear that there have been fluctuations in rainfall levels during the Holocene and connected shifts in vegetation, but it remains poorly understood how these may or may not relate the origins and spread of agriculture. Figure 6 summarizes the situation by correlating global atmospheric methane (Blunier, Chappellaz, Schwander, Stauffer, & Raynaud, 1995) with oxygen isotope and sediment data from the Pakistani margin of the Arabian sea (Staubwasser *et al*., 2002, 2003; with lake level data from two lakes in Rajasthan (Singh *et al*., 1990; Enzel *et al*., 1999) and the main pollen zones of Rajasthan as reflected at Didwana (Singh *et al*., 1990). There appears to be good correlation between the major long-term changes in lake level data, the Arabian sea data and the Greenland ice core. Significant aridification events are indicated in grey. The approximate temporal placement of the origination of various South Asian Neolithic traditions is indicated at the bottom of the chart based an updated calibration of all the dates, incorporating a stratigraphic ordering information into a Bayesian model.

Of significance is not just rainfall but the seasonality of rainfall. In northwestern South Asia, for example, the mid-Holocene wet period appears to have included higher winter precipitation which extended further east into central India than today (see Bryson & Swain, 1981, but these sequence needs to be re-dated along the lines indicated in Fig. 5). This situation may account for the some of the peculiar combinations of taxa noted from pollen cores in Madhya Pradesh (cf. Chahuan, 1996, 2000, 2002; further discussion below). Prior to the mid-Holocene wet period, a sharp dry event, that may have been global, occurred at ca. 6200 BC (Alley *et al*., 1997). While this event is not clearly identified in all Indian Quaternary sequences, it is apparent in Rajasthan and off-shore Pakistani data, although numerous other dry events can identified throughout the early to mid Holocene. The earliest evidence for rice use in the Gangetic plain and cultivation in Baluchistan dates to after this event, although the possibility of a correlation cannot be resolved on the basis of data currently available. Of interest is the clear evidence for persistently higher lake levels, and inferred rainfall in the Mid-Holocene after 5500 BC, which included both monsoonal and winter precipitation.

Also of interest is the evidence for clear anthropogenic manipulation of the landscape by the mid-Holocene. Although only a few pollen cores in South Asia have included quantification of micro-charcoal, that from the Thar Desert, including Lunkaransar, shows a clear increase and high levels of charcoal starting 7000–6000 BC and declining by ca. 4000 BC. This implies new anthropogenic burning regimes during this period, probably to be attributed to the substantial presence of Mesolithic hunter-gatherers inferred from microlithic sites, often found on stabilized dunes (Biagi & Kazi, 1995; Misra, 1989; Misra & Mohanty, 2001; Shinde *et al*., 2004; Ajithprasad, 2004). A peak in micro-charcoal is also evident in the Nilgiri hills of South India prior to 3500 BC (Sutra, Bonnefille, & Fontugne, 1997), and recent work near Lahuradewa indicates substantial landscape burning back to the Late Pleistocene/Early Holocene (Sharma *et al*., 2004; Singh, 2005a, 2005b). Such burning presumably played a role in promoting new plant growth and attracting wild game, as do modern tribal burning strategies do (Saha, 2002). Another anthropogenic signal is likely to be the emergence of modern 'climax'-type sal (*Shorea robusta*) forests in eastern Madhya Pradesh in the late

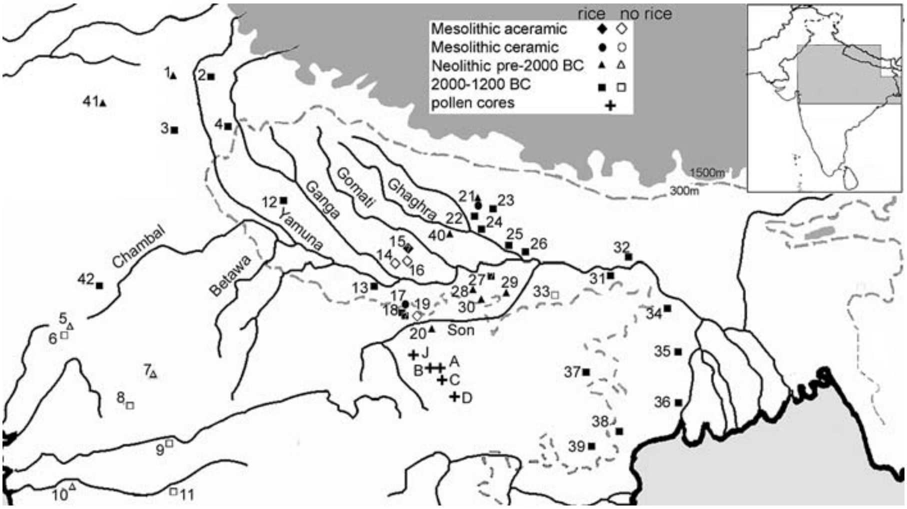

Fig. 7 Map of northern India with important Mesolithic and early agricultural sites indicated, by broad period. Solid shapes indicate presence of rice macro-remains, hollow symbols lack evidence for rice cultivation. White question-marks indicate sites with problematic earlier dates (early/mid Holocene). Note that dating evidence for eastern sites (nos. 31–39) is limited and problematic, and the period indicated is prone to revision. For most of these sites evidence consists only of reported rice/rice husk impressions in pottery. Important pollen core sites indicated by crosses: J. Jagmotha, B. Batsua, A. Amagaon, C. Chhui stream, D. Dongar-Sarbar swamp (after Chahuan, 1996, 2000, 2002); Sarai Nahar Rai pollen core site is adjacent to site no. 14; Lahuradewa pollen core is adjacent to site no. 21. Key to archaeological sites, indicating major data sources for plants (*P*) and animals (*A*): (1) Balu (Saraswat & Pokharia, 2002). (2) Hulas (*P*: Saraswat, 1993a, 1993b). (3) Mitathal (*P*: Willcox, 1992). (4) Lal Quila (*P*: Kajale, 1995; *A*: Shah, 1995). (5) Balathal (*P*: Kajale, 1996a; Misra & Mohanty, 2001; *A*: Thomas & Joglekar, 1996; Thomas, 2000). (6) Ahar (*P*: Vishnu-Mittre, 1969; *A*: Shah, 1969). (7) Kayatha (*P*: Vishnu-Mittre, 1977; *A*: Alur, 1975; Clason, 1979). (8) Dangwada (*P*: Vishnu-Mittre, Sharma, & Chanchala, 1984). (9) Navdatoli (*P*: Vishnu-Mittre, 1961; *A*: Clason, 1979). (10) Kaothe (*P*: Kajale, 1990b; *A*: Thomas & Joglekar, 1990). (11) Tuljapur Garhi (*P*: Kajale, 1988a; *A*: Thomas, 1992a). (12) Atranjikhera (*P*: Saraswat, Saini, Sharma, & Chanchala, 1990; Chowdhury, Saraswat, & Buth, 1977; *A*: Shah, 1983). (13) Sringeverapura (*P*: Saraswat, 1986a, 1986b). (14) Sarai Nahar Rai (*A*: Chattopadyaya, 1996, 2002). (15) Damdama (*P*: Kajale, 1990b; Saraswat, 2004b; *A*: Thomas, Joglekar, Matsushima, *et al.*, 1995; Chattopadyaya, 2002). (16) Mahadaha (*A*: Chattopadyaya, 1996). (17) Chopani-mando (*P*: Sharma *et al.*, 1980; *A*: Alur, 1980; Chattopadyaya, 2002). (18) Mahagara and Koldhiwa, the later with possible pre-third millennium occupation (Sharma *et al.*, 1980; *P*: Harvey *et al.*, 2005; *A*: Chattopadyaya, 2002). (19) Lekhahia (*P*: Kajale, 1991; *A*: Thomas, 1975; Thomas & Joglekar, 1994). (20) Kunjhun II (*P*: Clark & Khanna, 1989). (21) Lahuradewa (*P*: Tewari *et al.*, 2003; Saraswat & Pokhaira, 2004a; *A*: Joglekar, 2004). (22) Imlidh-Khurd (*P*: Saraswat, 1993b; *A*: Chattopadyaya, 2002). (23) Narhan (*P*: Saraswat, Sharma, & Saini, 1994). (24) Sohagaura (*P*: Vishnu-Mittre, 1989). (25) Manji (*P*: Chanchala, 2001; *A*: Thomas & Joglekar, 1994). (26) Chirand (*P*: Vishnu-Mittre, 1972; *A*: Nath & Biswas, 1980). (27) Malhar (*P*: Tewari *et al.*, 2000). (28) Baraunha (*P*: Kajale, 1991). (29) Senuwar (*P*: Saraswat & Chanchala, 1995; Saraswat, 2004a; *A*: Sathe & Badam, 2004). (30) Tokwa (*P*: Misra *et al.*, 2001). (31) Oriup (Kajale, 1991). (32) Sungbhum/Barudih (Kajale, 1991). (33) Taradih (*P*: Kajale, 1991). (34) Baidipur (*P*: Vishnu-Mittre, 1989). (35) Pandu Rajar Dhibi (*P*: Vishnu-Mittre, 1989). (36) Amri (*P*: Vishnu-Mittre, 1989). (37) Puri (*P*: cf. Glover & Higham, 1996a, 1996b). (38) Baidaypur (Kajale, 1991). (39) Kuchai (*P*: *Indian Archaeology—a Review 1961–1962*, p. 36; Thapar, 1978). (40) Khairadih (*P*: Bellwood *et al.*, 1992; Saraswat *et al.*, 1990; *A*: Thomas & Joglekar, 1994). (41) Kunal (*P*: Saraswat & Pokharia, 2003). (42) Ojiyana (*P*: Pokharia & Saraswat, 2004a, 2004b)

Third Millennium BC (Chahuan, 1996, 2000, 2002; sites shown in Fig. 7). The increase in *Madhuca indica*, with edible flowers, and *Shorea robusta*, which favours coppicing and establishment in previously burnt swidden fields (Sivaramakrishnan, 1999, pp. 211–235), suggests a response to changed human practices, such as the spread of agriculture.

Aridification at the end of the mid-Holocene appears to have occurred gradually beginning by the mid-Fourth millennium BC and levelling out at essentially modern conditions before 2000 BC (see review in Madella & Fuller, 2006). A more sudden increase in aridity at ca. 2200 BC has been suggested for some world regions, such as the Near East (e.g. Weiss *et al*., 1993; Hsu & Perry, 2002, Fig. 2, event K; De Menocal, 2001; Staubwasser *et al*., 2003) and must also be considered in the South Asian context, although the Rajasthan pollen sequences make it clear that this could only represent an acceleration of trends already underway in South Asia (discussion in Madella & Fuller, 2006). A number of cultural trends that may relate to this event may be of interest. In the northwest there is proliferation of Harappan-related sites in the Eastern Harappan zone towards the upper Ganges, which show a mixed cropping system of winter crops and summer crops, while in Gujarat there is general settlement continuity and in the Lower Indus region and adjacent Sindh there is a trend towards Mature Harappan site abandonment. Of more interest in the present context is the evidence from many regions of South Asia for the establishment of identifiable agricultural villages during and after this period of aridification.

The search for domesticates and evidence of management

Investigating where agriculture began and where it then spread largely relies on archaeological evidence either of the process of domestication or the local introduction of domesticates. No single definition of "domestication" can be considered to offer an overarching framework for all times, places and species (cf. Smith, 2001). Animal and plant domestication represent qualitatively different phenomena although they share a number of features. Concepts of domestication often incorporate aspects of the species' morphology and ecology as well as human behaviour and cognition. As an ecological relationship of inter-dependence domestication can be considered a form of symbiosis (Reed, 1977; Rindos, 1980, 1984; Uerpmann, 1996). While archaeologically it has tended to be examined in terms of morphological dichotomy, the underlying social and ecological causes need to be kept in mind. While domesticates differ from their wild progenitors morphologically, genetically and behaviourally today, this could not have been the case throughout prehistory since it represents the result of genetic selection under human influence (Higgs & Jarman, 1972). Thus the beginnings of herding or cultivation cannot be simplistically sought by finding the earliest "domestic" grain or bone remains. Nevertheless the presence of clearly morphological domesticates provides a minimum age for the processes of management that lead to those changes.

As a result of human herding practices and its impact on animal breeding, herded animals underwent morphological changes that have conventionally served as the basis for recognizing domestication. While biologically wild and domestic form a spectrum, socially and conceptually there is a clear dichotomy: While the hunter's focus is the dead animal as a commodity, the herder is concerned with the living animal, promoting reproduction and population survival (Meadow, 1984, 1993; Davis, 1987). Hunters interacted with populations of wild animals, whereas the herder began to interact with individuals (Ducos, 1978), recognising particular animals as property (Ingold, 1980, 1984). The changes these interactions brought about in animals may have been largely unintentional (unconscious) on the part of human societies with the nature of the interactions selecting for more juvenile traits such as docility and earlier maturation, as selection for defences against predators relaxed (Zohary, Tchernoc, & Horwitz, 1998). Some breeding experiments suggest that there may be genetic linkage between behavioral traits that people selected for and certain recurrent physical features of domestic animals, such as floppy ears and piebald coloration

(Trut, 1999). The beginnings of this process can be detected archaeologically in the demographic profiles of archaeological assemblages indicating herd management (Jarman & Wilkinson, 1972; Ducos, 1978; Zeder & Hesse, 2000). Nevertheless, most studies have relied on morphological change, in particular a gradual size decrease (e.g. Grigson, 1989; Legge & Harris, 1996; Legge & Rowley-Conwy, 2000; cf. Zeder & Hesse, 2000). As will become apparent, well-documented evidence of such processes in South Asia remains extremely rare.

The domestication of plants is a parallel case of human behaviour resulting in plant genetic change. Morphologically domestic seed crops should be clearly differentiated from their wild progenitors by the loss of natural seed dispersal mechanisms (Zohary & Hopf, 2000). Humans, as opposed to the brittle rachis of a cereal grass or the dehiscent pod of a pulse or legume, become the means of dispersal. In the case of wheat, experimental harvesting and planting as well as genetic work shows that the change to domestic morphology is due to one or a few genetic "switches" that under selection of planting and certain harvesting behaviours will occur extremely rapidly, perhaps in 20–100 years (Hillman & Davis, 1990; Zohary, 1996; Willcox, 1999). Genetic studies have found a very limited range of genes that control domestication characters (Paterson *et al.*, 1995; Peng *et al.*, 2003), and in Pearl Millet (*Pennisetum glaucum*), for example, several rather dramatic domestication changes are linked to one group of genes that can be changed together (Poncet, Lamy, Devos, Gale, Sarr, & Robert, 2000). Plant domestication needs to be distinguished from cultivation (Helbaek, 1960; Harlan, 1992, 1995; Harris, 1989, 1996; Ford, 1985; Smith, 2001), since we would expect cultivation to precede morphological change and because some methods of harvesting will not select for morphological domestication (Hillman & Davis, 1990; Willcox, 1999; Lu, 1999).

Indeed in Southwest Asia, there is now a growing database for pre-domestication cultivation and the phases evolution of different aspects of the domestication syndrome in cereals. Evidence from several sites in Syria suggests cultivation prior to domestication as indicated by the emergence of arable weed floras alongside morphologically wild cereals (Hillman, 2000; Hillman, Hedges, Moore, Colledge, & Pettitt, 2001; Willcox, 1999, 2002a, 2002b; Colledge, 1998, 2002). At Abu Hureyra this arable flora had been argued to emerge in response to the Younger Dryas, as these disturbance tolerant species (weeds) increase against the grain of climatic change, against the grain of steppic species (Hillman *et al.*, 2001). Also important is a growing morphomeric database from the Near East (Willcox, 2004; also, Colledge, 2001, 2004) which indicates that wheat and barley grains increased in size starting in the Pre-Pottery Neolithic A and earliest Pre-Pottery Neolithic B, prior to evidence for the emergence of domestic type seed dispersal indicated by charred wheat, barley or rye rachis remains (in the PPNB). This implies that grain size increased under the selection of early cultivation, prior to the evolution of the full domestication syndrome in Near Eastern cereals (Willcox, 2004; Tanno & Willcox, 2006a). In summary, Near Eastern archaeobotany now allows the outline of a phased evolutionary process over about two millennia, during which changes in human practices (cultivation) and changes in plant morphology (seed size increase and domestic-type seed dispersal).

In South Asia, clear archaeobotanical evidence for morphological domestication is largely unreported and undiscussed. For many taxa the establishment of reliable characters based on study of modern comparative material is lacking. For millets, spikelet bases should be informative about wild-type or domestic-type seed dispersal, although few studies have tried to document this, and the relevant spikelet parts are poorly represented archaeobotanically. Some brittle (wild-type) and non-brittle spikelet bases were identified amongst archaeobotanical material form South India in a preliminary study (Fuller, 1999), but further work along these lines is needed. Another potential approach is to consider the morphometric properties of grains in relation to patterns of grain maturation. This is because hunter-gatherers will be expected to target plants with immature grains as these will not yet have been shed. Thus, statistically, wild plant harvesting should include a high proportion of immature grains which in many cases will differ from proportions of mature grains targeted by farmers. This approach shows particular potential for tracking the transition from wild rice harvesting to exploitation of fully domesticated populations, and may also prove useful for other panicle cereals such as millets. Another approach that shows promise is the quantification of the presence of asymmetric millet grains, which are likely to be produced in higher frequency in denser domestic type ears, but the necessary documentation of this in modern material, let alone archaeobotanical application is needed. Reliance on morphological domestication indicators is further complicated by the fact that several crops retain wild-type seed dispersal even in modern cultivation, including a substantial proportion of the population amongst some small millets, pulses, and sesame (for the latter, see Fuller, 2003c). In addition the rachis remains of millets are much less common archaeologically than the more robust remains of wheat and barley.

Another important change with domestication in plants relates to germination mechanisms, with cultivation selecting for varieties that have lost natural inhibitors of germination. Such inhibitors are often contained in the seed coat, which is reduced with domestication through the selection for seeds which germinate rapidly after planting in a cultivated field. The reduction in seed coat thickness is potentially an important indicator in pulses and other starchy or oily seeds (but not cereals) (Butler, 1989; Smith, 1995). The situation differs with vegetatively propagated plants, such as most staple tubers, in which morphological or genetic change may be unnecessary or extremely cryptic archaeologically. Given that there is as yet no real archaeobotanical record for tuber crops from India, they will not be discussed in any depth below, although it must be noted that parenchyma tissues do preserve in South Asian contexts (Fuller, 1999; Fuller, Korisettar, Venkatasubbaiah, & Jones, 2004) and should be an important line of evidence in the future. Direct archaeobotanical documentation of domestication in South Asia is still largely lacking, and other approaches such as identifying weed assemblages suggestive of domestication are yet to be investigated. The need for such background studies is highlighted by the important new evidence from Lahuradewa in the Ganges Plain (see below).

Beyond domestication and the initial origins of agriculture are important secondary developments in plant cultivation and animal management. For animals, consideration should be given to the complex of secondary products, especially milk (and sometimes blood), wool and traction (Sherrat, 1981). For plants, the development of aboriculture, for example of fruit trees, may represent a similar "revolution" to early farming economies (Sherrat, 1999; cf. Zohary & Spiegel-Roy, 1975; Fuller & Madella, 2001, p. 339). While these are important developments that require investigation through the archaeozoological and archaeobotanical database, the synthesis of current evidence lies beyond the scope of the present paper, although in some cases unquestioned assumptions about secondary products enter the discussion of early agricultural production in South Asia. For example, it is often assumed that the presence of domestic cattle was due to the use of milk as an important resource (e.g. Dhavalikar & Possehl, 1974; Sahu, 1988, pp. 188, 280). However, cattle or other domesticates are not universally milked, and there remain groups in India today who abstain completely from such activities (Simoons, 1970). Thus dairying is a product of particular cultural historical trajectories (Simoons, 1978; Sherrat, 1981, 1983; Davis, 1987, pp. 155ff.; Durham, 1991, pp. 226–285; Voight *et al.*, 2006) and its adoption, perpetuation and spread in South Asia remains to be elucidated (Dhavalikar, 1988:1004; Meadow, 1991, 1996; Meadow

& Patel, 2001, p. 400; Korisettar, Venkatasubbaiah, & Fuller, 2001; Korisettar, Joglekar, Fuller, & Venkatasubbaiah, 2001, p. 205). Age profile data may be used to suggest herd management for secondary products (Payne, 1973; Davis, 1984, 1987, p. 155ff.), although this approach is not without its problems. Nevertheless, such data are still rarely reported from South Asian archaeozoological assemblages. Plausible sequences for the emergence of such forms of pastoral management, as inferred from a change in age profiles, have been reported from the Bannu basin of northwest Pakistan from the pre-Harappan Kot Diji phase (Thomas, 2003, p. 423). The data from Miri Qalat (a Harappan age site in Baluchistan) might also suggest management of sheep and goat for secondary products (Desse, 1997). Another important assemblage comes from Harappan Dholavira in the Kutch region where kill-off patterns inferred from dental ware for bovines (*Bos* and *Bubalis*) differ markedly from those for caprines and and pigs, suggesting differing management of cattle (and buffalos) for older individuals which could indicate the use for milk and/or traction (Patel, 1997, pp. 108–109). Milk-use in the Harappan context has also been argued on the basis of functional inferences from ceramic vessel forms, especially perforated pots (Gouin, 1990, 2003).

Elsewhere in South Asia, there is little in the way of reliable age structure data, although an intriguing pattern of change was reported from Chalcolithic Inamgaon on the northern Peninsula (cf. Thomas, 1988). The majority of "caprine" bones (although these include some wild small bovids, cf. Naik & Mishra, 1997; Pawankar & Thomas, 1997) consistently represent ages between two and three years. While there is a trend amongst these small bovids towards less mature animals, amongst large bovines kill-off patterns change dramatically towards older animals (Thomas, 1988). In the Malwa period, the kill-off pattern is not significantly different from caprines, with the majority of cattle slaughtered between two and three years (64.5%) and fully mature animals representing less than 20%. In the succeeding Early Jorwe, mature animals climb to nearly 45% of the assemblage with a corresponding decrease in immatures. In the Late Jorwe this trend is exaggerated further with over 65% of bones coming from mature animals. The data suggests that more of the herd was reaching reproductive maturity. This could represent a transformation in how animals within a herd were valued, such for increasing emphasis on milking. More data of this sort are needed from South Asian sites, together with clear presentation of the methods for determining age classes.

The use of animals as sources of traction, and the contribution of this to crop production, also requires systematic consideration. In the case of the Harappan (and pre-Harappan) northwestern subcontinent, clear evidence for use of cattle for traction is available from the third millennium BC based on study of bone pathologies as well as model ploughs (Miller, 2003). The spread of these practices into peninsular India remains problematic, although it is sometimes suggested to be coincident with the adoption of agriculture (e.g. Chakrabarti, 1995, p. 166, 1999, p. 209). In many parts of the Deccan ploughing seems to have been adopted in recent centuries (Furer-Haimendorf, 1963), although arguments have been advanced for ploughing in the Chalcolithic Deccan in the second millennium BC (Shinde, 1987). Of interest in this regard is historical linguistic analysis for widespread cognate terms for plough in Indo-Aryan, Dravidian and Munda languages which may derive from early borrowing between these groups or from a common substrate, perhaps from the Harappan zone (Southworth, 2005, p. 80; Witzel, 1999, pp. 29–30). While an assessment of such practices would be important for characterizing the nature of early agricultural economies in different parts of South Asia, the nature of current evidence limits the present paper to discussing the presence or absence of herding animals and cultivating particular crops.

Assessing data quality

Although efforts at systematic recovery of plant and animal remains are becoming more widespread in South Asia, much data comes from haphazard samples or is reported without information of sampling strategy or samples sizes. Amongst archaeobotanical evidence, quantities of soil floated, volumes of charcoal recovered and sorted, and quantities of seeds identified are rarely reported. This makes it difficult to assess the significance of apparent absences in the evidence. While the presence of a taxon, assuming secure context and valid identification, is clear, the absence of a taxon is not (Jones, 1991). It could mean three things: (1) the absence of the species from the site in prehistory; (2) the taphonomic masking of the evidence for the presence of the species; or (3) the failure to recover the evidence through excavation/sampling methods. Given inconsistencies in sampling, recovery and reporting of South Asian bioarchaeological data, absence of evidence may be very misleading and needs to be assessed in its own right.

The presence of a given taxon can be misleading without the context of systematic sampling and quantitative reporting. This should involve both quantitative reporting and description of archaeological context. The early identification of a single rice grain at Inamgaon (Vishnu-Mittre & Savithri, 1976) had led to the assumption that rice was an important crop in Chalcolithic Maharsahtra (Dhavalikar & Possehl, 1974; Achaya, 1994, p. 43). Systematic flotation, however, has only yielded 3 grains of rice out of several thousand seeds (Kajale, 1988b). This suggests that rice was imported to the site and thus could not have been one of the major staples locally. Also the possibility of a wild forest rice, *Oryza granulata*, needs to be considered. Similarly, the report of barley at Rojdi, if taken only on presence, could easily be misinterpreted to suggest that Rojdi followed the agricultural practices typical of core Harappan sites. However, quantified data show that there were only 13 grains of barley in comparison to more than 3000 grains of small millets, reported as *Setaria* spp., *Panicum sumatrense* (syn. *P. miliare*) and *Eleusine coracana* (Weber, 1991). Given that barley grains are frequently found at sites throughout India (Kajale, 1991; Saraswat, 1992; Fuller, 2002) and were found in high proportions in many Harappan period sites of Baluchistan and Bannu as well as Harappa (Costantini & Biasini, 1985; Thomas, 1999a,b; Tengberg, 1999; Weber, 1999, 2003), the assessment of a low presence seems even more significant. To these observations must be added the absence of barley from large flotation programs at Oriyo Timbo and Babar Kot (Reddy, 1994), as well as available samples from Surkotada and Shirkapur (Chanchala, 1994). Barley, together with Wheat, was also reported in a "very insignificant proportion" at the Harappan site of Kuntasi in western Saurashtra (Kajale, 1996b). The (near) absence of wheat and barley, in these contexts of systematic sampling is in stark contrast to sites from the Indus Valley through the Near East and Europe, and must indicate a significant agricultural pattern. On the balance therefore, the winter cereals (wheat and barley) appear to have been marginal in Saurashtra during the Harappan period, and may only have been imported to certain townsites within the Harappan trading sphere. Although wheat is a significant crop in the region today, this must have developed in post-Harappan times based on current archaeobotanical data.

Another problem obstructing the interpretation of bio-archaeological data is identification. Often it is not possible to make a reliable assignment to taxon below the level of family or genus. Difficulties surround separation of sheep, goat and Blackbuck, as well as cattle and buffalo, as well as between South Asian deer species (Meadow, 1996; Meadow & Patel, 2001, 2003; Joglekar, 2006). The ability of distinguish these species depends in part on the availability of extensive reference material. Published examples of mis-attributions are known, including sites from the peninsular region and the Gangetic region. In the case of the initial reports from Vindhyan and Gangetic Mesolithic and Neolithic sites (Alur, 1980), bone were referred to domestic categories, although re-examination of this material (discussed below, following Chattopadyaya, 2002), indicates misattributions of bones from wild taxa, including deer and antelopes referred to sheep/goat (see also, Joglekar, 2006, p. 40). In addition, it is clear that at Inamgaon (Thomas, 1988) there were initially misattributions of blackbuck antelopes to sheep or goat (see Meadow, 1996; Pawankar & Thomas, 1997). Such instances indicate the need for systematic assessment of published reports, re-assessment of bone assemblages using revised criteria and further publication and specialist discussion of the identification challenges. The different standards of reporting, and limited clarification of identification criteria used by different labs and workers, require improvement. At the Deccan College archaeozoology lab, improved reporting and criteria have been formulated in recent years, especially for large bovids since about 1990 and smaller bovids more recently. Recent publications have suggested criteria for distinguishing these taxa (e.g. Joglekar, Thomas, Matsushima, & Pawankar, 1994; Pawankar & Thomas, 2001), although there remains some concerns about reliability of some of these criteria (see Meadow & Patel, 2003), highlighting the need for further specialist debate and discussion on these problems.

Another problem is identifying animal domestication. For some taxa, including both zebu cattle and water buffalos, assignment to domestic status is not always clearly supported. While both of these bovines are likely to have one or more domestications within South Asia, adequate documentation of such processes has been limited. Good metrical studies that indicate change through time or contrasts between presumed hunted and herded assemblages have been limited, with important studies on water buffalos from Western India (Patel & Meadow, 2003), and Zebu cattle from Baluchistan (Meadow, 1984, 1993). The situation with Mesolithic and Neolithic bovines in the Ganges valley by contrast remains obscure and problematic (see below), and the only unambiguous evidence is not from bones but from a penning structure with cattle hoofprints at Mahagara (Sharma, Misra, Mandal, Misra, & Pal, 1980). The present review attempts to be circumspect in the use of faunal data, but there is much that needs to be done by active archaeozoological workers to standardize reporting methods and identification criteria.

In the case of plants, there are a similar range of problems, with those relating to wheat variety and millet species being prominent. Older archaeobotanical literature includes attributions of wheat grain to *Titicum compactum*, *T. aestivum*, and *T. sphaerococcum* (e.g. Vishnu-Mittre & Savithri, 1982), when modern comparative studies highlight the overlaps in the grains of free-threshing wheats (Hillman, Mason, de Moulins, & Nesbitt, 1996; Maier, 1996; Zohary & Hopf, 2000; Fuller, 2002), including *Triticum durum*, an important wheat through much of central and western India today which has been largely ignored in considerations of South Asian archaeological wheats. In the case of plants there have been mis-identifications by non-specialists in preliminary reports, such as the oft-cited rice from Kalibangan, which is in fact impressions of wheat (Vishnu-Mittre & Savithri, 1975). Specialists and non-specialists alike have made mistakes with bones and seeds, and thus critical assessment of identification criteria is necessary, and identifications need to be supported by illustration until criteria are clear.

More vexing are difficulties with the specific identification of small millets and in some cases sorghum. India today is home to the cultivation of a dozen “millet” species, of various geographical origins (Table 1), many of which are today highly restricted in extent of cultivation and poorly researched by agronomists or ethnobotanists. Unfortunately, as a review of the archaeobotanical literature of India make clears (Fuller, 2002), a comprehensive consideration of these species as potential crops in the past has been lacking, and as a result the identification of archaeological millets in South Asia is plagued with probable inaccuracies

Table 1 Millet species cultivated in South Asia, their taxonomy and regions of origin[a]

Species	Common name	Region of origin and Cultivation (reference)	Remarks
Brachiaria ramosa (L.) Stapf.	Browntop millet, pedda-sama	South India (1, 2)	Overlooked in early archaeobotanical research, now appears widespread in Indian prehistory
Digitaria cruciata (Ness) A. Camus var. *esculenta* Bor	Raishan	Khasi Hills, Assam; Hill tribes of Vietnam (3, 4)	
Digitaria sangiuinalis (L.) Scop	Harry crabgrass	Eurasian origin; cultivated in Kashmir, formerly in Europe (1)	
Echinochloa colona ssp. frumentacea (Link) De Wet, Prasada Rao, Mengesha and Brink (= *E. frumentacea* Link)	Sawa Millet	Peninsular India(?), also cultivated in Himalayas (5, 6)	Distinct species and domestication from Japanese barnyard millet, *E. crus-galli* (6; 7)
Eleusine coaracana (L.) Gaertn.	Finger Millet, ragi	East African highlands (8, 9, 10)	Widely reported but widely based on misidentified material of other species (10)
Panicum miliaceum (L.) ssp. *Miliaceum*	Proso millet	China, and SE Europe(?)/Caucasus; cultivated throught South Asia (1)	
Panicum sumatrense Roth. ex Roem. & Schult. subsp. *sumatrense*	Little millet, samai	India, especially peninsula (11)	Often called *P. miliare*, an illegitimate taxonomic name
Paspalum scrobiculatum (L.)	Kodo millet	India, especially peninsula (12)	
Pennisetum glaucum (L.) R. Br (= *P. americium* (L) Leeke)	Pearl Millet	West African Savannah, cultivated throughout India (10, 13)	
Setaria italica (L.) P. Beauv ssp. *italica*	Foxtail millets	China, and SE Europe(?)/Caucasus, cultivated throughout South Asia (14, 15)	Identification complicated by presence of *Brachiaria ramosa* and other *Setaria* spp
Setaria pumila (Poir.) Roem & Schult	Yellow foxtail millet, korali	India (1, 2)	Often called *S. glauca*, an illegitimate taxonomic name
S. verticillata (L.) P. Beauv	Bristley foxtail millet	South India	Existence of modern domesticated populations problematic; poorly documented

[a]Sorghum is not included in this table. References: 1. De Wet (1995a); 2. Kimata *et al.* (2000); 3. Bor (1955); 4. Singh and Arora (1972); 5. De Wet, Prasada Rao, Mengesha, and Brink (1983c); 6. Hilu (1994); 7. Yabuno (1987); 8. Hilu and De Wet (1976); 9. Hilu and Johnson (1992); 10. Fuller (2003b); 11. De Wet *et al.* (1983a); 12. De Wet, Prasada Rao, Mengesha, and Brink (1983b); 13. Tostain (1998); 14. De Wet, Oestry-Stidd, and Cunero (1979); 15. Prasada Rao,De Wet, Brink, and Mengesha (1987).

and uncertainties. A number of published overviews of millets in South Asian prehistory must be taken with a grain of salt. Problems with archaeological mis-identification of finger millet were first raised by leading millet taxonomists (Hilu, De Wet, & Harlan, 1979). This problem has been taken up over the full range of published archaeobotanical reports and millets by the present author (Fuller, 2003b). The author (in continuing collaboration with Mukund Kajale) has been refining millet grain identification criteria on the basis of an extensive comparative study and has found numerous probable mis-identifications in the literature. Most commonly small-grained millets in *native* genera have been mistakenly attributed to "ragi," the finger millet of *African* origin (*Eleusine coracana*) (Fuller, 1999, 2002, 2003b, 2003d). Unsubstantiated reports of this species should be rejected until claims are supported by illustrated specimens. The present review is based on a critical assessment of all crop identifications.

The most common form of archaeological plant preservation is charring, due to (partial) burning. Thus assemblages of plant remains will be biased by differential destruction (or distortion) of taxa during charring, as well as by the absence of taxa that did not regularly come into contact with fire. Amongst those seeds which were regularly charred, we might expect seeds in dung fuel and seeds in the waste of crop-processing (Hillman, 1981, 1984; Bottema, 1984; Miller & Smart, 1984; Reddy, 1994, 1997, 2003a, 2003b; Charles, 1998; Fuller, 2002, 2003d; Weber, 2003). Thus we are reminded that not all seeds present in the archaeological record were necessarily food plants. Indeed there is a danger of a "utilization fallacy" in which every recovered plant is interpreted into terms of some ethnographically documented use or another. What must be accounted for is how seeds (or other parts) of a particular species were *repeatedly* exposed to accidents involving fire. While the presence of these plants in an ancient landscape opens the possibility of multifarious uses, few of these uses are likely to lead to archaeological preservation on any appreciable scale, with the exception of routine waste disposal in fire, either through dung-burning or the burning of routine crop-processing waste.

Taking stock of the concerns of preservation, recovery and identification, we are left with a highly patchy and incomplete dataset for South Asia as a whole. Nevertheless this dataset covers much of the subcontinent and is beginning to suggest a pattern of origins and dispersals that differs from the views expressed in previous general syntheses. While Vavilov (1992 [orig. 1950]) had identified the Indian subcontinent as a 'Centre of Origin' his broad geographical conception ignored variability within the region (for a useful revised assessment of Vavilov's centres, see Zeven & De Wet, 1982). Subsequent authors have tended to emphasize the secondary nature of Indian origins, with the important origins of agriculture derived by spread from Southwest Asia and/or Southeast Asia, with domestication of local crops occurring secondarily and inspired by the introduction of crops from the West or perhaps Southeast Asia (Hutchinson, 1976; MacNeish, 1992; Harlan, 1995). Nevertheless, it has long been clear that the domestication of zebu cattle and water buffalo were indigenous to northern South Asia (Meadow, 1984; Grigson, 1985; Zeuner, 1963; Patel & Meadow, 1998). For the semi-arid monsoonal environments of much of India, especially Gujarat and the Peninsula, many non-native crop species have been very important in South Asian subsistence systems since prehistory, along with the clear significance of introduced animal domesticates, the available evidence now argues for the existence of local cultivation systems based on native species prior to the influx of introduced crops. Crops introduced from Africa, including millets and pulses, have gradually been inserted into indigenous monsoonal cropping systems (Weber, 1998; Fuller, 2003b, 2005). This process began certainly by Late Harappan times, and more recently in many regions African millets have come to dominate cultivation at the expense of native species.

Northwestern background: From Southwest Asia to the indus valley

In northwestern South Asia the dominant crops from the time of earliest evidence derived from the Southwest Asian Neolithic Founder crops (sensu Zohary, 1996; Zohary & Hopf, 2000). The beginnings of the cultivation of these crops, especially wheats and barley can now be placed in the Late Pleistocene, when the cultivation of morphologically wild forms of these plants is evident from Late Natufian sites of the northern Levant (Fig. 8), i.e. Middle Euphrates River Valley, Syria, after ca. 11,000 BC and certainly prior to ca. 9000 BC (Willcox, 1999, 2002a, 2004, 2005; Moore, Hillman, & Legge, 2000; Hillman *et al*., 2001; Garrard, 2000). This appears well correlated with the Younger Dryas climatic event which led to rapid declines in rainfall and contraction of wetter ecological zones including the distribution of wild cereals. Current debates and research highlight the need for further sophistication in interpreting the impact of environmental changes and subsistence changes on a local rather than macro-regional level, as different communities continued or adjusted their exploitation of wild cereals and other resources (see Willcox, 2005). Cultivation developed long after hunter-gatherers in the region had begun utilizing wild cereals, indeed as early as 22,000 BC wild emmer wheat and wild barley were being gathered, ground and consumed at Ohalo II in Israel (Kislev, Nadel, & Carmi, 1992; Piperno, Wiess, Holst, & Nadel, 2004; Weiss, Wetterstrom, Nadel, & Bar-Yosef, 2004). The first possible domesticated forms of these cereals date from the Pre-Pottery Neolithic A (ca. 9500 BC) in adjacent regions of Southwest Asia (e.g. Tell Aswad, Iraq ed-Dubb; with cereal finds of uncertain status from Cayonu, Qermez Dere and M'lefaat), although their domestication statuis or dating remains problematic (Colledge, 2001, p. 150 2004; Willcox, 2005). What seems to be indicated by recent studies is that by the end of the PPNA larger-grained cereals were present (Colledge, 2001, p. 143; Willcox, 2004), arguing for selection for size increase under cultivation during this period. This may have preceded full domestication, defined on the basis of seed dispersal criteria, as tough rachis remains of fully domeaticated ears are only clearly documented, and quite widespread in the Pre-Pottery Neolithic B and may only dominate assemblages later (from ca. 8800 BC) (Garrard, 2000; Colledge, 2001, p. 150, 2004; Colledge & Conolly, 2002; Willcox, 2002b, 2004, 2005; Tanno & Willcox, 2006a). For the pulses of Southwest Asian origin, such as lentils, peas, chickpeas, grasspea and vetches clear morphological changes are significantly later, although it is generally assumed that their cultivation begins along with the cereals (cf. Zohary & Hopf, 2000; Tanno & Willcox, 2006b).

A Southwest Asian agricultural package was well-established and presumably widespread by the time of Harappan urbanism (Costantini, 1990; Meadow, 1989a, 1996, 1998; Weber, 1997, 1999, 2003; Fuller & Madella, 2001), including wheats (*Triticum* spp.), barley (*Horduem vulgare* L. *sensu lato*), lentils (*Lens culinaris* Med.), chickpeas/gram (*Cicer arietinum* L.), peas (*Pisum sativum* L), grass pea (*Lathyrus sativus* L.), and flax/linseed (*Linum usitatissimum* L.). The only early Southwest Asian domesticates notably absent are the vetches and broad bean (*Vicia* spp.), although some vetches turn up on Gangetic sites, e.g. Senuwar (Saraswat, 2004a), presumably as a weeds of winter cereals. It remains to be clarified whether or not the Near Eastern crops came to South Asia together at the period of agricultural beginnings, represented by the site of Mehrgarh (starting perhaps ca. 7000 BC), where the lack of systematic flotation samples (Costantini, 1983) may bias against recovery of pulses and linseed/flax, or whether the pulses and linseed/flax diffused separately over a much longer period, as might be suggested by the evidence from Miri Qalat (Tengberg, 1999; cf. Costantini & Biasini, 1985). As yet there is no site in Baluchistan that provides the transitional stages that must have preceded the establishment of Mehrgarh, but the clear antiquity agriculture based on the same crops in the Near East suggests that when found this transition

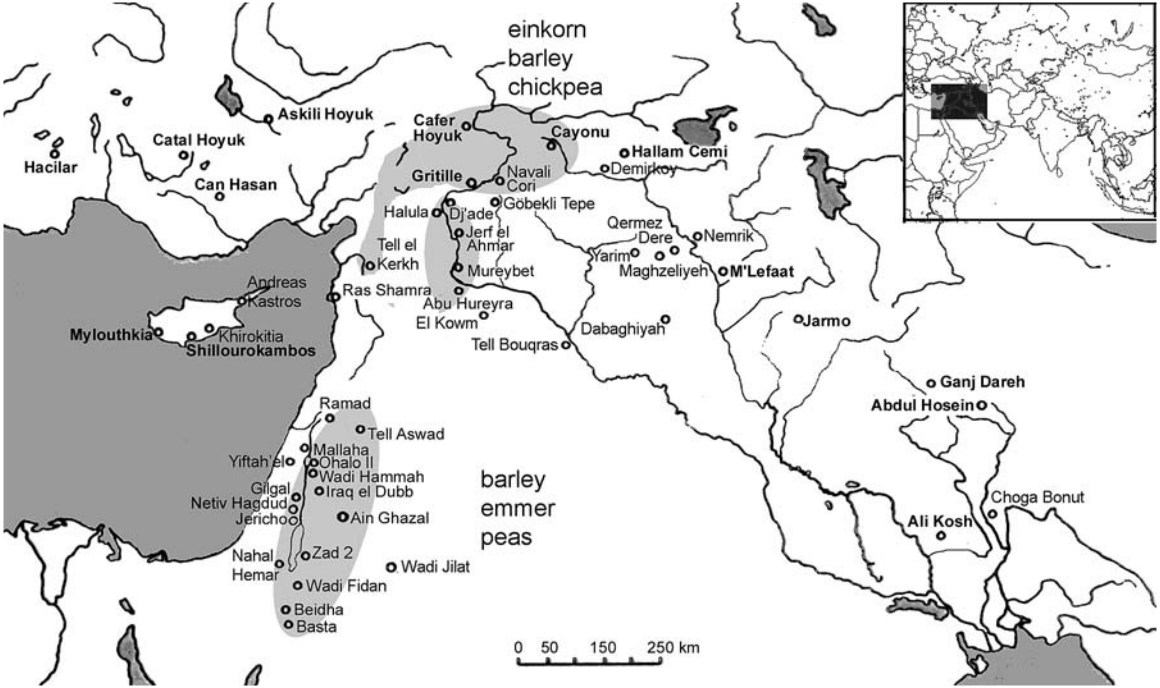

Fig. 8 Map of Southwest Asia, indicating selected sites with pre-ceramic archaeobotanical evidence. Regions indicated in grey are probable distinct plant domestication centres based in part on different species or lineages of the Southwest Asian cereals. These zones provide some evidence for pre-domestication cultivation and the earliest domesticates

will include the introduction of crop already domesticated elsewhere. While the evidence from Mehrgarh for locally domesticated animals in quite strong (discussed below), claims for locally domesticated cereals are unsubstantiated.

The situation with cereals recovered from Mehrgarh, as well as the pulses and oilseeds known only from subsequent periods, strongly argues for the introduction of cultivation to this region from the West at some period prior to the founding of Mehrgarh, although whether this process should be seen as cultural diffusion (adoption by local foragers) or demic diffusion (immigration of farmers) is unclear. From the earliest levels at Mehrgarh (the chronology of which is discussed below), ca. 6000 plant impressions in mud-brick were examined (Costantini, 1983; Possehl, 1999, p. 459). They contained 95% barley and a small amount of wheat, with the latter attributed to both hulled (or glume) and naked (or free-threshing) varieties. The barley is largely naked, six-row barley, which thus shows some evolutionary advance over its wild ancestors (wild forms are two-rowed and hulled). Some wild barley is also reported. Co-occurrence of wild and domesticated forms of a plant, however, is insufficient to establish a local transition/transformation from one to the other. Although wild Barley is found in this region, it may have dispersed as an early weed of cultivation from the west, since it is known largely from secondary habitats (Zohary, 1969; Zohary & Hopf, 2000). As emphasised by Possehl (1999, pp. 404–414, 459–461), however, botanical research on wild relatives of crops and archaeological research into agricultural origins has been minimal in Baluchitsan and Afghanistan, so that separate domestications in these regions cannot be ruled out; Possehl (ibid.) regards these areas as part of an "Expanded Nuclear Zone" of Southwest Asian agricultural origins (also Possehl, 2002a, 2002b). Wild wheats, for example, have a much more limited known distribution today, in the northern Levant and southern turkey, (Zohary & Hopf, 2000; Hillman, 2000), which argues against a domestication of these cereals in Northwestern South Asia, unless we assume a massive level of vegetation rearrangements between Iran and India during the Holocene. For the beginnings of plant cultivation based on Eurasian winter cereals, current evidence favours a restricted nuclear zone, within which there were probably a few local centres of domestication (Willcox, 2002a, 2002b, 2005), as indicated in Fig. 7. Within this Near Eastern zone wild wheats and barley form extensive stands, the likes of which are not known from Northwestern South Asia, even for wild barley . Furthermore, the Southwest Asian zone of domestications included a wide range of winter pulses and flax as companion crops for the wheats, barley and rye (see Zohary & Hopf, 2000).

Excursus: Problems and significance of wheat species identifications

Important issues surround the history of different varieties of wheat in South Asia, which represent potentially separate introductions in addition to having different ecological and culinary potentials. The reported hulled wheats at Mehrgarh includes diploid einkorn and tetraploid emmer, both of which persist in Baluchistan at least until the time of Miri Qalat (Tengberg, 1999), although einkorn is no longer known from India (Pal, 1966). Each of these represents one or more separate domestications in Southwest Asia. There are a few other finds of emmer-type grains or spikelets, including some of those from the Southern Neolithic (Fuller, 1999; Fuller, Korisettar, & Venkatasubbaiah, 2001; Fuller *et al.*, 2004), Harappan Kalibangan (Fuller & Madella, 2001, based on illustration in Vishnu-Mittre & Savithri, 1975), Late Harappan Rohira (Saraswat, 1986a, 1986b), and in the Kashmir Neolithic (Pokharia & Saraswat, 2004a, 2004b; Mani, 2004). Emmer type grains are also present in the South Indian Neolithic (Fuller *et al.*, 2004). The likelihood is that additional finds of emmer are to be found amongst the wheat grain assemblages in South Asia, as most identifications have been based on preserved grains and not chaff or spikelets (for an exception, Tengberg, 1999). The possibility of the early dispersal of emmer in South Asia contrasts with the Neolithic of central Asia in which hulled wheats appear to be largely einkorn (see Harris, 1998b; Charles & Bogaard, 2007), although another form of glume wheat, presumably an extinct cultivar that has received increased attention (Jones *et al.*, 2000), is also found at Djeitun (Charles & Bogaard, 2007). The predominance of emmer on the southern route is also suggested by evidence from Sialk in Iran, where Fifth Millennium BC samples are dominated by emmer wheat, to the exclusion to definite einkorn, as well as some bread wheat (Tengberg & Thiebault, 2003; Tengberg, 2004).

Free-threshing wheats at Mehrgarh were reported as hexaploid bread-wheat (*T. aestivum*), with a local evolution over time towards Indian shot wheat (*Triticum sphaerococcum* Perc.). This is in line with most other South Asian reports that list *T. aestivum* along with *T. sphaerococcum* (e.g. Vishnu-Mittre & Savithri, 1982; Kajale, 1991; Weber, 1999). It is now recognized by archaeobotanists, however, that on the basis of grains alone it is not possible to assign free-threshing wheats to species, or ploidy level with certainty (Miller, 1992; Willcox, 1992; Hillman *et al.*, 1996; Zohary & Hopf, 2000; Fuller, 2002), and the Mehrgarh or Harappan grains could therefore be tetraploid *T. durum*/*T. turgidum*, which can also bee found in compact forms.

Given the lack of detailed morphometric studies of the grain shape of supposed sphaerococcoid wheat, there is room for some scepticism about the existence of this variety in prehistory (Fuller, 2002; Fuller & Madella, 2001), although some studies of large bodies of material maintain that it is a distinct form (e.g. Saraswat, 1986a, 1986b, 1992; Weber, 1999; Miller, 1988; Thomas, 2003).The possible existence in the past of other compact/sphaerococcoid wheat types also needs to be kept in mind. For example, if confirmed morphometrically, the sphaerococcoid wheat types reported from prehistoric Kashmir (Lone *et al.*, 1993), do not make sense as varieties adapted to high aridity, as is generally suggested for the historical *T. sphaerococcum* of Pakistan (Ellerton, 1939). Recently the author has measured some notably short wheat grains from a high elevation site in Nepal (Kohla, ca. 12th century AD, above 3000 m elevation), which also suggests a Himalayan adapted compact-grained wheat, but which need not have any direct relationship with *T. sphaerococcum*. Further work on this problem is clearly needed. A sphaerococcoid form of barley has also been reported but not documented in detail (Costantini, 1983; Miller, 1988; Weber, 1999; Thomas, 2003). Morphometric studies and future identification of rachis remains are needed.

Where chaff remains have been reported, at Miri Qalat (Tengberg, 1999), Shortugai, Afghanistan (Willcox, 1991), and Sialk, Iran (Tengberg, 2004), hexaploid wheats are present to the exclusion of tetraploids, in line with the modern situation in these areas. This, however, raises the question of when and where *T. durum* entered the Indian subcontinent. Hexaploid wheats are derived from crossing of tetraploid wheats (e.g. *T. diococcum* or *T. durum*) with the goat-face grass *Aegilops squarrosa* which grows today in northern Iran, Transcaucasia and Afghanistan (Zohary & Hopf, 2000), and we might therefore expect this to have occurred prior to the introduction of wheat at the earliest period of Mehrgarh. Finds of free-threshing wheat grains occur in the early Neolithic of Syria and Turkey (Middle PPNB, 8000–7300 BC), prior to their hypothesized spread to Mehrgarh, and rare rachis finds indicate that both tetraploid and hexaploids were established at early dates in the Near East, e.g. hexaploids at Abu Hureyra, Cafer Hoyuk, Catal Hoyuk, Hacilar, El Kowm II, and tetraploids at Abu Hureyra, Catal Hoyuk and El Kowm II (De Moulins, 1997, 2000; Helbaek, 1970; Fairbairn, Asouti, Near, & Martinoli, 2002), with a few examples known from Djeitun in Central Asia (Charles & Bogaard, in press; Charles, 2006).

While the minutiae of identification of specific wheat types may seem inconsequential botanical detail, it is in fact potentially of great significance to cultural history. Different species of wheat not only represent separate origins and dispersals but also present different potentials in terms of ecological constraints and possibilities in cooking and consumption. Amongst the free-threshing wheats, Macaroni wheat (*Triticum durum*) is genetically tetraploid and distinct from soft, more glutinous, hexaploid bread wheats (*T. aestivum* and *T. sphaerococcum*). *T. aestivum* has superior bread-making qualities, i.e. lighter and spongier breads (such as for *naan* or *paratha* style breads), and has traditionally dominated the cultivation for bread-making of the northwestern continent and the Ganges valley. *T. durum* is hardier, more drought resistant and generally provides a grittier flour less conducive to soft or leavened breads and often traditionally used in grits (*suji* or *rava*)and many sweets (see Ambasta *et al*., 1986; Achaya, 1998).

Although the genetic differences between these wheats were not understood in the 19th century, and thus older taxonomic nomenclature is unreliable, a perusal of Watt's (1889–1893) *Dictionary of the Economic Products of India* provides much information on traditional wheat varieties in different parts of India in the 19th century, and his descriptions often imply different regional preferences and treatments of *durum* and *aestivum* wheat types. *T. durum* has been the dominant wheat of central India in modern times (Pal, 1966), and the dominant wheat forms with their traditional cultivation techniques noted by Watt reflect this, e.g. *kathia* and *hansia* (in Madhya Pradesh and Maharashtra), *jamali* (in Bengal), and formerly dominant "hard" wheat varieties in Bihar (no local name provided by Watt). Meanwhile, in many of these regions bread wheats were less common and often poorly regarded until they received increased demand from English colonizers (e.g. varieties referred to by Watt as *pissi* in central India). In addition Peninsular India has retained varieties of hulled wheats, probably all emmer (which persists in cultivation in the Nilgiri Hills, see Pal, 1966), and is probably represented by Watt's references to "spelt" such as the variety called *khaple* in the Bombay Presidency, *pumban* in Sindh, and an unnamed variety of the Madras Presidency. The earlier history of these wheat forms requires renewed archaeobotanical investigation focusing on the small and often overlooked (or unpreserved) rachis and chaff remains, rather than the less diagnostic grains.

Animal domestications in Southwest Asia and Northwestern South Asia

The evidence for local animal domestication contrasts with the crop evidence. While cereal agriculture appears to have been part of the repertoire introduced by the first settlers at Mehrgarh, at least some animal-herding appears to have developed locally. This is supported by archaezoological data for sheep and cattle, and implied by recent genetic data for sheep, goats, and cattle. The accumulation of phylogenetic research in livestock genetic sequences has called into doubt hypotheses of single origins in the Near East for any domestic animal (e.g. MacHugh & Bradley, 2001; Bruford, Bradley & Luikart, 2003; Larson *et al*., 2005). At present archaezoological data is still insufficient from many regions, including much of South Asia, for locating in time and space the several domestications postulated from genetics. One notable exception to this is the archaezoological record from Northwestern South Asia where archaeological evidence for animal domestication is quite strong.

Goats appear to have already been herded and domesticated animals in Baluchistan at earliest known Neolithic period, although this is only documented in any detail from the site of Mehrgarh. The earliest levels at Mehrgarh include some very small goats, in addition to young goats buried with people, both of which suggest that goats were introduced locally as domesticates (Meadow, 1984, 1987, 907, 1993). The short-eared goat breeds of India probably represent descendants of the original domestic stock, while lop-eared, screw horned varieties of Pakistan and northern India represent a later introduction (Mason, 1984). Despite the lack of archaeological evidence, recent genetic studies on modern goats indeed suggest multiple domestications of this species, probably three, with one these genetic lineages restricted to central, south and eastern Asia (Luikart, Gielly, Excoffier, Vigne, Bouvet, & Taberlet, 2001; Mannen, Nagata, & Sowers, 2001; Joshi *et al*., 2004). This would suggest that there remains a domestication to be discovered archaeologically, perhaps in Afghanistan or even Baluchistan. This implies that the geography of different wild goat species has been transformed during the Holocene (as wild species in these areas today include those not related to domesticated goats, cf. Manceau, Després, Bouvet, & Taberlet, 1999).

Archaeological evidence for the gradual development of morphologically domestic characters is thus far only known from the Near East. Domesticated goats are well known from the Levant by 7500–7000 BC (Legge & Harris, 1996; Legge & Rowley-Conwy, 2000). A detailed consideration of size and age of archaeological goats from Ganj Dareh in the Zagros Mountains of Iran indicates that they were being herded before morphological change, and numerous direct AMS collagen dates place this back to ca. 8000 BC (Zeder & Hesse, 2000). A parallel domestication of goats may have occurred in the central Levant/Lebanon (Wasse, 2001). Goats dispersed west, along with sheep, pigs and cattle, to Cyprus by ca. 8400 cal. BC, where wheat and barley were also introduced along with apparently Levantine Pre-Pottery Neolithic B immigrants (Vigne *et al*., 2000; Peltenberg, Croft, Jackson, McCartney, & Murray, 2000). The evidence from Cyprus indicates at the very least the translocation of wild animals by people, especially as they include evidence of mainland deer, if not the beginnings of herding. The evidence from Mehrgarh then suggests that the dispersal of goats and cereals to Pakistan considerably after morphological domestication had occurred in Southwest Asia, but it is possible that some or all of these initial goats came from a domestication distinct from West Asia (e.g. in Afghanistan), with later introductions of goats providing the background for screw-horned and lop-eared forms.

The evidence for sheep and cattle both suggest local sequences of domestication but later than goats. While it is conceivable that this derives from morphologically wild herded animals that had been introduced, as was the case in parts of Southwest Asia such as Cyprus, the evidence for cattle clearly indicates domestication of local wild stock, which could also be the case with sheep. Local domestications of both these species is supported by genetic evidence. In general terms both sheep and cattle have distinct eastern and western phylogenetic groups of domesticated populations in Eurasia (MacHugh & Bradley 2001; Bruford *et al*., 2003), with additional less common third and fourth lineages indicated in recent genetic studies in cattle.

Phylogenetic evidence from bones and fossils have long suggested separate South Asian and West Asian origins for cattle, and these have now been confirmed and augmented through a range of genetic and phylogenetic studies. Morphological comparisons by Grigson (1980, 1985) revealed allometric relationships between the bones of Pleistocene fossil *Bos namadicus* and *Bos indicus* (modern zebu) on the one hand and *B. taurus* (taurine domestic cattle of Southwest Asia and Europe) and West Eurasia fossil *B. primigenius* on the other hand, suggesting that the two domestic cattle types derive from two distinct species of wild cattle. This work augmented the earlier arguments of Zeuner (1963). Although many have argued for lumping all the cattle into a single species since hybrids are known today (Joglekar & Thomas, 1990; Corbet & Hill, 1992), such a taxonomic move does little to clarify evolutionary history as revealed by recent genetic work. Mitochondrial DNA, and nuclear microsatellites have clearly indicated a deep pre-domestication time divergence (ca. 200,000 years) between humpless taurine cattle and humped zebu cattle and separate radiations since domestication (Loftus, MacHugh, Bailey, Sharp, & Cunningham, 1994; MacHugh, Shriver, Loftus, Cunningham, & Bradley, 1997; Bradley, Loftus, Cunningham, & MacHugh, 1998; Bruford *et al*., 2003). An additional separate center of domestication is suggested from the genetics for African 'taurine' cattle, although suggested archaeological support (e.g. from Nabta Playa) remains controversial (for counterpoints see, Wendorf & Schild, 1994; Grigson, 2000; for reviews, MacDonald, 2000; Marshall & Hildebrand, 2002). Subsequent to the initial establishment of taurine and zebu domestic populations there has been interbreeding and gene-flow, which appears to have occurred from zebu into African cattle through male translocations across the Indian ocean (MacHugh *et al*., 1997; Bradley *et al*., 1998), and between taurines and zebus across the region from Mesopotamia to the Indus (Kumar *et al*., 2003). Recently an additional domestication of zebu domestication has been suggested on the basis of further phylogenetic analysis and increased sampling (Magee & Bradley, 2006), which suggests that more easterly cattle in India derive from a distinct origin to those in the northwestern subcontinent.

Archaeological evidence for the transformational process leading from animal husbandry to morphological domesticates is well illustrated by Mehrgarh's cattle evidence. The earliest levels (Period I), despite inconsistent radiocarbon dates, date to before 6200–6000 BC, and may start ca. 7000 BC or earlier (Jarrige, 1984; Meadow, 1993; Jarrige, Jarrige, & Quivron, 2006). The subsequent Period II is well dated as starting from 6000 BC. In the earliest level, true wild taxa (i.e. taxa which were never domesticated) made up about 55% of the assemblage (Meadow, 1984, 1989a, 1993). This declines in succeeding levels, where prodomesticates, primarily sheep and cattle, increase in importance to ca. 80% of the assemblage. *Bos* alone changes from 4 to 38% to 65% by ca. 5000 BC (Meadow, 1987). This dramatic rise in the importance of certain species suggests the gradual emergence of specialised predation, like that of herding. This trend is accompanied by a size trend in which the average size and size range of *Bos* and *Ovis* decreases through the sequence (Meadow, 1984, 1987, 1993). There is no sudden shift, but rather the suggestion of a statistical trend of change in these two species, while wild taxa such as gazelle do not undergo any change. This is the same kind of data available from domestication in the Near East (Grigson, 1989; Legge & Harris, 1996).

Mehrgarh therefore provides evidence to situate in time and space an origin for humped zebu cattle, distinct from those indicated for taurine cattle in the Near East. On the basis of a few distinctive thoracic vertebrae and artistic representations from Mehrgarh, Meadow (1984, 1987) attributes the cattle to *Bos indicus* Archaeological evidence suggests that *B. indicus* spread west across the Iranian plateau to sites like Tepe Yahya and Shahr-i-Sokhta (Meadow, 1987, p. 898) and even Mesopotamia (Bökönyi, 1990, 1997) and east into India. Depictions on Harappan seals indicate that some humpless taurine cattle had spread into South Asia from the west by this time (Zeuner, 1963). Thus, sometime between the period of zebu domestication in Pakistan and the urban Harappan civilization (from the mid Third Millennium BC), the introgression between West Asian and South Asian cattle had begun, a process that remains detectable in the genes of modern cattle populations (Kumar *et al*., 2003).

The dynamic history of sheep, and the shifting frontier of ancient hair sheep and woolly varieties, remains to be written. The original domestic sheep like their wild ancestors would have had long kemp hair and relatively little wool (Ryder, 1984; Sherrat, 1981; Davis, 1987). Hair sheep are still the predominate breeds in southern India (Ryder, 1984) and South and Central coastal Orissa (author's observation). Hair sheep(?) with cork-screw horns occur in Harappan depictions (Ryder, 1984). Central and northern India today have long-tailed fleece sheep, which represent a selectively bred domesticate, presumably introduced in Harappan or post-Harappan times. Baluchistan today is inhabited by fat-tailed sheep, possibly a later evolved breed, which are known from Mesopotamia by the second millennium BC. Thus while some sheep may have been domesticated in South Asia there were at least two later waves of new breeds. Gene flow between these introduced breeds and the hair sheep already present may account for the chromosome count of modern domesticates. Significant usage of wool would not have been likely until the first of these breed introductions. This must have occurred by the time of the *Rig Veda* since shearing is mentioned. The date of epic is unfortunately not clear, and hotly debated (cf. Bryant, 2002), but can be argued to have accrued over several centuries in Late and Post-Harappan times (Parpola, 1988, 1994; Southworth, 2005; Witzel, 1999, 2005). Evidence from sheep/goat age profiles from Miri Qalat suggests that these animals could have been managed for secondary products (such as wool or also milk) already by the Mature Hatappan period (Desse, 1997), while the earlier assemblage from Sohr Damb suggests meat-focused management (Benecke & Neef, 2005).

It should be noted that there is no evidence for pig domestication at Mehrgarh or indeed is there clear evidence anywhere else at any other period in South Asian archaeology. Pigs are generally a negligible proportion of mammalian bone assemblages in South Asia, and no concentrated study has examined morphometric evidence for their domestication in South Asia. Nevertheless, modern genetic data from Indian pigs and wild boars suggests a separate domestication in this area, one of many (perhaps 6) spread across Eurasia (Larson *et al.*, 2005).

Mehrgarh in chronological and regional context

The evidence from Mehrgarh represents the earliest phase yet documented of a punctuated process of the introduction of subsistence species and practices from the west as well as the earliest evidence for local domestication processes in South Asia. Although goats, 2 or 3 varieties of wheat and barley were introduced in the beginning these were subsequently augmented by local cattle and perhaps sheep domestications and at some later date by the introduction of other sheep, goat and cattle varieties. It remains unclear if winter pulse crops and flax were also later additions or part of the initial package. In addition cotton appears to have been cultivated by the later Neolithic, before ca. 5000 BC (Costantini, 1983; Moulherat, Tengberg, Haquet, & Mille, 2002), presumably from a domestication in the region (Fuller & Madella, 2001, p. 337). Mehrgarh also provides evidence for grapes and jujube that might have been cultivated or managed for fruit. The status of the large true date seeds from Mehrgarh is problematic as they are uncharred and undated, but at the Harappan Miri Qalat in Makran wild type date stones (probably *Phoenix sylvestris*) occur confirming date consumption (and probably cultivation) in this region (Tengberg, 1999). *Phoenix sylvestris* continues to be cultivated and managed from Sindh through southern India, and is a candidate for Harappan era dates. True dates (*Phoenix dactylifera*), which have longer seeds, were present in Iran before this time (Tengberg & Thiebault, 2003; Tengberg, 2004).

The chronology of Mehrgarh has been problematic. The second ceramic phase at Mehrgarh seems well-dated, beginning ca. 6000 BC, as recent stratigraphic reassessment indicates (Jarrige *et al.*, 2006). The earlier aceramic period at the site is estimated to have begun by ca. 7000 BC, or even earlier (Jarrige, 1984; Meadow, 1993; Possehl, 1999; Jarrige *et al.*, 2006), although radiocarbon dates are inconsistent, including many dates that are millennia too young, as well as a few old dates. Despite some arguments in favour of cereal domestication in Pakistan (e.g. Possehl, 1999), the lack of wild progenitors (for wheats, all the pulses, flax and safflower), and the available dates that are late by comparison to Southwest Asia, point towards the spread of crops, and this could have involved the spread of farmers, although diffusion of just the crops is possible too.

Whatever the case, the date of Mehrgarh is in line with a dispersal/diffusion from Southwest Asia, but is rather late to see Baluchistan as part of a parallel trajectory (as suggested by Possehl, 1999, 2002a, 2002b). In Southwest Asia of the Middle Pre-Pottery Neolithic B (ca. 8100 BC) the domesticated crops and animals (at least sheep and goat) are well-established and this subsistence package dispersed in all directions during the eighth and seventh millennia BC (Fig. 9). Dispersal westwards, for example, is dated by the Aceramic Neolithic horizons of Greece and the island of Crete going back to ca. 7000 BC (Halstead, 1996; Tringham, 2000). In Iran, pre-pottery Neolithic sites with evidence for these crops and sheep and goat include Ganj Dareh (8000–7400 BC) and Ali Kosh (7400–6800 BC) (Helbaek, 1969; dates after Zeder & Hesse, 2000). Evidence further east from the Iranian plateau, however, is later, with aceramic Tepe Zaghe dated to ca. 6250 BC, and ceramic Neolithic sites such as Tepe Sialk and Tepe Yahya VII starting from the mid-sixth millennium. In the dispersal towards Turkmenistan and Central Asia, foundation dates for the Neolithic, which has ceramics, are towards the end of the seventh millennium, such as Sang-I-Chakmuk (ca. 6300 BC) and the well-known Djeitun Culture at ca. 6000 BC (Harris, 1998b; Brunet, 1999). In other parts of Central Asia, Neolithic cultures begin ca. 6000 BC or up to half a millennium later, represented for example by the Kel'teminar complex of Kazakhstan, the Hissar culture of Tadjikistan, the Central Ferghana of Uzbekistan, the Neolithic levels of the Oshkona site in Tadjikistan (Brunet, 1999). While most of these cultures are lacking in archaeobotanical evidence, the evidence from the site of Djietun is clear for wheat (especially einkorn, but also a "new" extinct glume wheat) and barley cultivation (Harris, 1998b; Charles & Bogaard, in press). Some of these other regional "Neolithic" cultures may have been focused on fishing, hunting or just herding but targeted archaeobotanical analyses are needed.

While the evidence discussed above can form a coherent narrative, questions are raised by the two Ak-Kupraq cave sites in Afghanistan (see review in Possehl, 1999, pp. 433–438; Brunet, 1999; Harris, 1998b). Although these sites have yielded few radiocarbon dates and have not had their faunal and floral remains collected and analysed to modern standards (see Meadow, 1989b), as initially reported they may contain domesticated sheep and goats in aceramic levels that could date between 8500 and 7000 BC, or even earlier if one focuses on the tails of radiocarbon probabilities. Ceramic levels begin ca. 6000 BC, in line with other parts of Central Asia. These suggestive, but problematic sites, taken together with problems surrounding the beginnings of Mehrgarh, both in terms of dating and in terms of precursor sites in the region, highlight the need for more directed research to resolve the beginnings of agriculture. Nevertheless, a parsimonious explanation for origins would posit the dispersal of goats (and sheep?), wheat and barley (and perhaps pulses and linseed), to Baluchistan in the seventh millennium, which set off the food-producing revolution in this region where additional animals (especially zebu cattle) and crops (notably cotton and eventually sesame) were domesticated. It was this package, with a largely Southwest Asian origin, that formed the subsistence base of Harappan urbanism.

From the Northwest to inner India: Evidence from Fauna

From Baluchistan and the Indus valley the Mehrgarh crop and livestock package dispersed further eastwards, although they may not have spread at the same time. Despite some

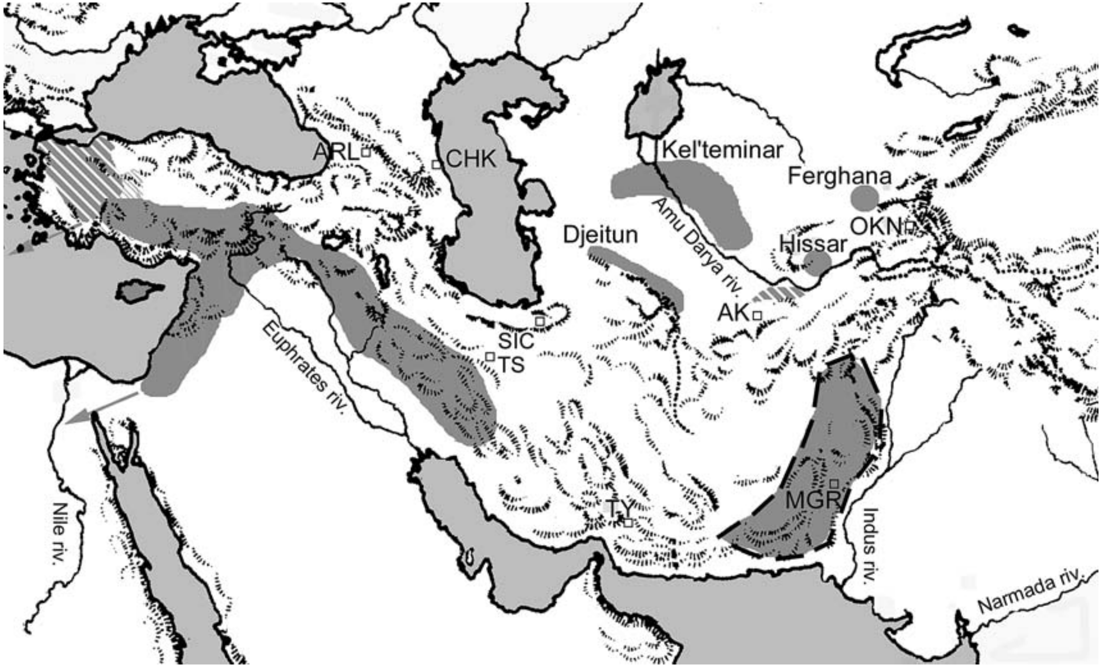

Fig. 9 Map of the Neolithic of West and Central Asia in relation to Northwestern South Asia. Important Neolithic cultural zones, discussed in the text, are *shaded*. The greater fertile crescent area is indicated (for details, see Fig. 3), with arrows indicating the direction of westward dispersal of wheat/barley agropastoralism. Other documented early Neolithic cultural zones discussed in the text are indicated. Probable late preceramic/early ceramic Neolithic cultural extensions are indicated by hatching in northwest Turkey (after Özdogan, 1997) and in northern Afghanistan (based on surveys of Vinogradov, see Sarianidi, 1992; Possehl, 1999, p. 437). Other important Neolithic sites are indicated by squares, with the abbreviations: CHK: Chokh, ARL: Arukhlo, SIC: Sang-I-Chakmuk, AK: Ak-Kupraq, TY: Tepe Yahya, TZ: Tepe Zaghe, TS: Tepe Sialk, MGR: Mehrgarh, OKN: Oshkona. The probable wider cultural zone of the Baluchistan Neolithic or Khili Ghul Mohammad Tradition is indicated by dashed line (based on Possehl, 1999, fig. 4.14)

claims for additional Zebu domestications (e.g. Allchin & Allchin, 1974; Alur, 1990), and some suggestive proxy genetic indicators (Naik, 1978; Magee & Bradley, 2006) there is as yet no clear archaeozoological evidence to locate the second domestication. Nevertheless the presence of large *Bos* bones, which suggest the existence of wild cattle populations into the Neolithic/Chalcolithic period in both Gujarat and South India (Thomas, Joglekar, Matsushima, Pawankar, & Deshpande, 1997; Joglekar, in press; cf. Korisettar, Joglekar, *et al*., 2001), as well as possibly the Vindhyas (see Chattopadyaya, 2002) makes additional zebu domestication(s) plausible. In some regions, such as the middle Ganges, cultivation is likely to have begun prior to animal domestication (see below). In other regions, however, livestock may have spread without crop plants, or even preceded cultivation.

In regions around the Southern and Eastern Thar Desert a case can be made for the spread of livestock amongst hunter-gatherers, although the associarion with the first ceramics requires clarification. The earliest established dates for the presence of cattle beyond Baluchistan and east of the Indus valley are ca. 3500 BC from northern Gujarat, where recent AMS dates on the organic fraction of cattle bones, are reported from collagen dates from the early Chalcolithic (ceramic phase) at Loteshwar (Patel, 1999; Meadow & Patel, 2003, pp. 73–74; Ajithprasad, 2004, pp. 119–123). Earlier non-ceramic Mesolithic deposits at the site indicate pure hunting.

In Rajasthan, on the east side of the Thar the situation remains unclear. Older excavations at the Mesolithic site of Bagor, were thought to include evidence for some sheep and goats in aceramic Mesolithic levels, perhaps in the Fourth or Third Millennium BC (Misra, 1973; Possehl, 1999, pp. 474–481; 2002a, 2002b, pp. 32–34). Later levels have ceramics of the Banas/Ahar tradition, better known from Chalcolithic settlement sites in the region, such as recently investigated Balathal, which was settled before 3000 BC (Misra, Shinde, Mohanty, Pandey, & Kharakwal, 1997; Misra & Mohanty, 2001; Shinde, 2002; Misra, 2005). Recently, new AMS dates on charcoal have suggested that ceramics might be as early as 4500 BC at Bagor (Shinde *et al*., 2004, p. 395). It remains to be clarified as to whether these new dates actually date the beginnings of ceramic production, and still whether sheep and goat have been adequately distinguished from wild blackbuck. Elsewhere hunter-gatherer communities persisted until the end of the Third Millennium. For example, further south in Rajashtan, the site of Langhnaj has a well-documented assemblage of wild hunted fauna form the mid to late Third millennium associated with ceramics of the Ahar Tradition (Clutton-Brock, 1965; Kennedy, 2000, pp. 208–210). Similarity in skeletal morhpohology between Langhnaj human remains and the Harappan site of Lothal, somewhat further south, suggest some biological similarity perhaps due to gene flow (Kennedy & Possehl, 1979; Kennedy, 2000), or shared genetic background. As was explored by Hooja (1988) this whole broader region represents a static frontier of interaction between hunter-gatherers and food producers, over a period of one to two millennia.

There are a number of other suggested "Mesolithic" (aceramic) sites with reported bone remains that include some probable domesticates. This includes, for example, sheep, goat and cattle reported from Kanewal, goats and cattle from Tilwara, sheep/goat and cattle from Bagor (reviewed in Chattopadyaya, 2002, see also Possehl, 1999, pp. 474–481). Reservations over identifications need to be resolved (Meadow & Patel, 2001, pp. 397; 2003, pp. 72), but these finds could provide a link between Fourth Millennium BC Loteshwar and the diffusion of livestock to South India by the start of the Neolithic in the early Third Millennium BC (see below). The dating of the evidence from the other sites remains rather less secure, but those available would place these sites broadly between 4000 and 2500 BC (cf. Possehl, 1999, p. 481, for dates from Bagor). Further east in Central India (Madhya Pradesh), the possibility of domestic cattle from Mesolithic contexts at a Bhimbetka rock shelter (Misra, 1989), and sheep/goat and cattle from Adamgarh (Chattopadyaya, 2002) suggests that the dispersal of livestock may have progressed far and relatively fast amongst many Indian mid-Holocene hunter-gatherers.

During the third millennium BC domestic fauna became widely established, often alongside agriculture. A domestic fauna economy is well-established in Saurashtra by ca. 3000 BC with the Padri culture (Joglekar, 1997), and it is likely that this culture also included cultivation, although this is not yet confirmed through flotation for plant remains. Further east, across the Aravalli hills the beginnings of the Ahar culture of Rajasthan can now be pushed back into the fourth millennium BC, which included cattle and sheep/goat pastoralism (Thomas & Joglekar, 1996) and presumably winter crop cultivation (cf. Kajale, 1996a; Misra & Mohanty, 2001). The earliest evidence from the Peninsula remains that of the ashmounds of Karnataka from ca. 2800 BC, with a noticeable gap in contemporary or earlier evidence in the intervening region of Maharashtra (Thomas & Joglekar, 1994; Joglekar, 1999; Korisettar, Venkatasubbaiah *et al*., 2001; Korisettar, Joglekar *et al*., 2001). In the Ganges valley, current evidence indicates the absence of domestic fauna at sampled Mesolithic sites, but confirms cattle but not sheep or goat at Neolithic Mahagara and Koldihwa (Chattopadyaya, 2002). Unfortunately, it is unclear whether any of these faunal remains date to earlier than the mid-third millennium BC to which the bulk of the deposits from these sites probably date. Evidence for occupation on some Neolithic sites going back to the sixth millennium BC (see below) remains to be clearly linked with faunal data. Further east at Chirand in Bihar sheep, goat and cattle were herded by early agriculturalists by the start of the second millennium BC. Further work is needed to more clearly outline the dispersal of the different livestock in the Gangetic region and the extent to which their dispersals differed from each other and from that of crop plants.

Additional Livestock: Water buffalo and chicken

Other animal domesticates that remain more problematic in terms of their origins in South Asia are water buffalo, chickens and pigs. In all of these taxa serious identification challenges exist, especially in distinguishing indigenous wild populations from domesticated forms.

Water buffalo were probably wild throughout most of South Asia, although today wild populations remains relictual (Grove, 1985; Hoffpauir, 2000). The limited data available from modern genetics suggests two phylogenetic radiations of domesticated water buffalo, which can be suggested to relate to China and South Asia (cf. Lau & Alii, 1998; reviewed in MacHugh & Bradley, 2001; Bruford *et al*., 2003). Finds of probable wild water buffalo are widespread, from early Mehrgarh and in quantity from the Mesolithic site of Santhli in Gujarat (Meadow & Patel, 2001, p. 399, 2003), as well as some South Indian Neolithic sites (Korisettar, Joglekar *et al*., 2001). Water buffalo hunting is likely to have continued into the Harappan era in the Indus valley, although a few finds from Harappan sites also suggest herding especially on southern Harappan sites (Meadow & Patel, 2001, 2003): a domestic-type horn-core from Balakot, and quantities of measured specimens from Dholavira that imply a smaller domestic form had evolved prior to the period of this site, i.e. in pre-Harappan times. The addition of water buffalo to the faunal spectrum from sites in the Bannu basin (northwestern frontier Pakistan) only from the Kot Diji phase (pre-Harappan), after their absence earlier, suggests the introduction of these as herd animals (Thomas, 2003, p. 423). By contrast, at Balathal the quantities of buffalo remains decrease through time (Thomas, 2000) which might suggest that these represent wild population in decline due to hunting and climatic change. While pigs have been widely reported on prehistoric/protohistoric sites, they are consistently in low quantities and no plausible criteria for distinguishing domesticated from wild forms have been offered. Despite claims for the presence of both wild and domestic types (cf. Thomas, 2000, 2001, p. 413; Chattopadyaya, 2002), such reports need systematic verification.

Nowhere yet investigated does the pig seem to have played a significant subsistence role in early farming systems, a contrast with the situation in Neolithic China (Yuan & Flad, 2002) and parts of Southwest Asia (Bökönyi, 1993; Smith, 1995, pp. 62–65; Hongo & Meadow, 1998; Hongo *et al*., 2001). The general absence of pigs from Iran, Baluchistan and Central Asia has been suggested to be absence from the early livestock package of this zone (Bökönyi, 1993; Desse, 1997), which could imply a separate pig domestication in South Asia someplace further east. Indeed, recent genetic evidence from pigs and wild boars suggests six separate pig domestications across Eurasia, including a distinctive Indian lineage (Larson *et al*., 2005).

The wild progenitor of the domestic chicken occurs in India as the green junglefowl, distributed across north India and Gujarat. Morphological bone evidence is lacking for a domestication process. Wild *Gallus* spp. are well-known in South Asia, such as *G. sonnerati* of the peninsula, while the wild progenitors of domestic chickens are distributed across north India and northeast India in addition to Southeast Asia (Zeuner, 1963; Crawford, 1984). Unfortunately, recent genetic studies on chickens and junglefowl have neglected to sample South Asian wild populations (e.g. Fumihito *et al*., 1994, 1996; Niu *et al*., 2002), and thus claims for monophyletic origin can only be taken to suggest a single origin for Chinese/Southeast Asia chickens, with the possibility of a separate Indian domestication still open. In addition there are several other gallinaceous birds native to South Asia, and as detailed comparative studies in an African context indicate (MacDonald, 1992), distinguishing chickens from these others may prove complicated, and has not yet been seriously tackled in South Asian, or indeed East Asian, publications. While modern domestic chickens on average are much larger and heavier than wild junglefowl (Crawford, 1984), measured ancient specimens from Africa and Europe show no significant distinction (MacDonald and Edwards, 1993). Size alone is thus not a reliable criterion. *Gallus* bones are also surely to be under-represented due to the destructive forces of dogs and deposition. While similar concerns may be warranted in the case of Chinese Neolithic chickens, the widespread occurrence of *Gallus*-type bones on north Chinese Neolithic sites by the sixth-fifth millennium BC would seem to argue for husbandry/domestication (West & Zhou, 1988), associated with early Chinese millet cultivators. If we are allowed to take a similar view of the numerous *Gallus* reports from South Asia, which are by and large restricted to agricultural periods (Table 2), we can suggest the pattern of chicken dispersal. In western regions (Gujarat and the Indus Valley), where the wild progenitor is absent today (although this need not have been in the case in prehistory) several finds point to chicken-keeping by the Mature Harappan phase. Similarly, most finds from north India within the wild progenitor's range also come from the second half of the third millennium BC. An intriguing exception is the earlier(?) evidence of Mesolithic Damdama where chickens occur in reasonably large quantities during the later levels (Thomas, Joglekar, Mishra, Pandey, & Pal, 1995): could this indicate emerging chicken husbandry amongst semi-sedentary hunter-gatherers or hunter-cultivators? The dating of this site, and its chickens becomes crucial in order for the likelihood that Fourth Millennnium BC chickens in Iran (from the site of Tepe Yahya, Meadow, 1986b, but based on a single bone not directly dated) represent dispersal from South Asia or from the north via Central Asia (cf. West & Zhou, 1988). In Peninsular India, despite the poor dating of some sites, most *Gallus* finds date from the mid to late second millennium BC and are often absent

Table 2 Finds of *Gallus* bones in South Asian archaeological sites, with probable dates cal. BC. Those at right occur within the native range of *Gallus spp*. those at the top (*shaded*) are within the range of Red Junglefowl, ancestor of domestic chicken. Those at left occur outside modern natural range and are likely domestic chickens. Peninsular finds, at lower right, within the wild range of Green Junglefowl, show general consistency suggesting introduction of chickens in the mid-second millennium BC. Data from Rao (1973); Shah (1983, 1988); Venkatasubbaiah *et al*. (1992); Joglekar and Thomas (1993); Thomas and Joglekar (1994); Thomas and colleagues (Thomas, Joglekar, Deshpande-Mukherjee *et al*., 1995, Thomas, Joglekar, Matsushima *et al*., 1995, Thomas *et al*., 1997); Thomas (2000). A find from Tepe Yahya in Iran could be from fourth millennium BC (Meadow, 1986a)

		Areas with wild **Gallus**	
	Areas with wild *Gallus gallus*	**Kashmir** Gufkral I (ca.2300 BC)	**Ganges** Damdama (4000-2000 BC) Mahadaha (5500-2500 BC) Bharatapur (2nd mill. BC?) Atranjikhera (1200-600 BC) Narhan (ca. 1400-800 BC)
Areas without wild *Gallus*			
Indus (2500-2000 BC) Harappa Mohenjodaro Kalibagan II Rupar	**Rajasthan** Ahar IC (2100-2000 BC) Balathal (2600-1500 BC) **Gujarat** Lothal (2500-2000 BC) Rojdi (2500-2000 BC) Surkotada (2400-2000 BC) Shikarpur (2500-2000 BC) Khanpur Babor Kot (2000-1700 BC)	**Northern Deccan** Daimabad V (1500-1100 BC) Nevasa (1500-1200 BC) Inamgaon (1700-1000 BC) Walki (1500-1000 BC) Thuljapur Garhi (1500-1000 BC)	**Southern Neolithic** Kodekal (1600-900? BC) Paiyampalli (1700-900 BC) Hallur (1400-1100? BC) Hanumantaraopeta (1500-1000?) Peddamudiyam (1500-1000?)

from earlier levels of the same sites. This would seem to indicate that chickens dispersed Southwards as domesticates in the early to mid-Second millennium.

Southwest Asian crops beyond the Indus

The Southwest Asian crops may have lagged behind the livestock in their dispersal eastwards and southwards in India. They had probably reached Rajasthan before the end of the fourth millennium BC, as suggested by the emerging evidence from Ahar culture sites such as Balathal (cf. Kajale, 1996a; Misra & Mohanty, 2001; Shinde, 2002; Misra, 2005). There may be a correlation here with the mid-Holocene wet Phase which appears to have led to increased winter rainfall in Rajasthan (see Madella & Fuller, 2006; cf. Bryson & Swain, 1981; Singh, Joshi, Chopra, & Singh, 1974; Enzel *et al*., 1999), perhaps facilitating the initial cultivation of these species without artificial irrigation. Recent palynological data from eastern Madhya Pradesh (Chahuan, 1996, 2000, 2002; sites indicated on Fig. 10) may indicate that in the mid-Holocene winter rainfall was also important this far east, as there is pollen of *Artemisia* and high grass levels reminiscent of the Iranian Steppe and western India (Rajasthan), which decline only as monsoon deciduous forests become established in the second half of the third millennium BC. Interestingly large grass pollen (which could include cereals) and plausible winter crop weeds (e.g. *Justicia, Polygonum*) appear in these sequences shortly before ca. 2500 BC. Hard evidence for the further diffusion of these crops

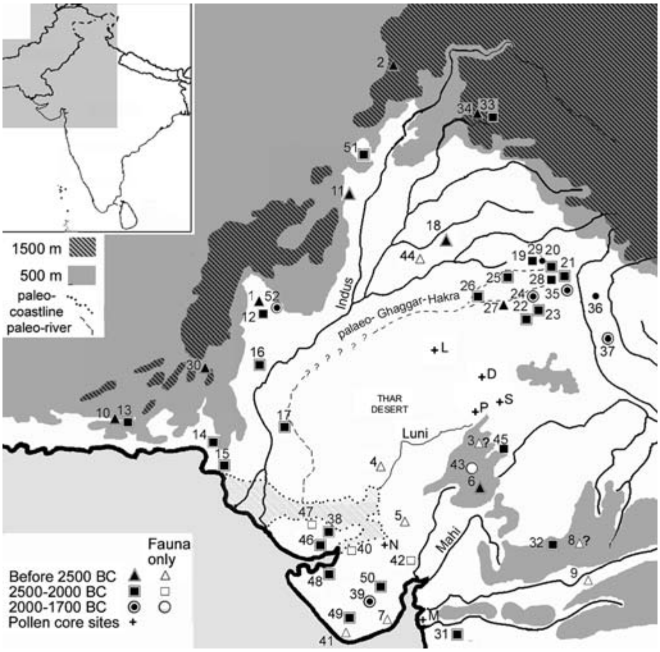

Fig. 10 Sites in Northwestern South Asia with early evidence for domesticates. Sites are divided into three broad temporal horizons, prior to the emergence of Harappan Civilization, more or less contemporary with Mature Harappan Civilization, and the Late Harappan phase. Note that sites on the northern peninsula dating to after 2000 BC have been excluded from this map. Important pollen core sites of the Thar Desert (Singh *et al.*, 1974) indicated by crosses with letters: L. Lunkaransar; D: Didwana; P: Pushkar; S: Sambhar; M: Malvan (Vishnu-Mittre & Sharma, 1973); N. Nal Sarovar (Vishnu-Mittre & Sharma, 1978). Key to archaeological sites with citations of data sources, indicating *P*: plants, *A*: animals: (1) Mehrgarh (*P*: Costantini, 1983; *A*: Meadow, 1993). (2) Ghalegay, Swat (*P*: Costantini, 1987; *A*: Campagnoni, 1979). (3) Bagor (*A*: Thomas, 1975). (4) Tilwara (*A*: Thomas, 1975). (5) Loteshwar (*A*: Meadow & Patel, 2003). (6) Balathal (*P*: Kajale, 1996a; Misra & Mohanty, 2001; *A*: Thomas & Joglekar, 1996; Thomas, 2000). (7) Padri (*A*: Joglekar, 1997). (8) Bhimbetka (*A*: Misra, 1989). (9) Adamgarh (*A*: Nath, 1967). (10) Miri Qalat (*P*: Tengberg, 1999; *A*: Desse, 1997). (11) Rehman Dheri (*P*: Duranni, 1988; Thomas, 1999). (12) Nausharo (*P*: Costantini, 1990; *A*: Meadow, 1987). (13) Shahi Tump (*P*: Tengberg, 1998). (14) Balakot (*P*: McKean, 1983; *A*: Meadow, 1979a, 1987). (15) Allahdino (*P*: Fairservis, 1982; McKean, 1983). (16) Mohenjodaro (*P*: Vishnu-Mittre & Savithri, 1982; *A*: Meadow, 1989a; Sewell & Guha, 1931). (17) Chanudaro (*P*: Vishnu-Mittre & Savithri, 1982). (18) Harappa (*P*: Weber, 1997, 1999, 2003 *A*: Meadow, 1991). (19) Rohira (*P*: Saraswat, 1986a, 1986b). (20) Rupar (*P*: Vishnu-Mittre & Savithri, 1979a, 1979b; *A*: Nath, 1968). (21) Mahorana (*P*: Vishnu-Mittre, Sharma, & Chanchala, 1986b; Saraswat & Chanchala, 1994; Chanchala, 2005). (22) Burthana Tigrana (*P*: Willcox, 1992). (23) Laduwala (*P*: Willcox, 1992). (24) Mitathal (*P*: Willcox, 1992). (25) Banawali (*P*: Lone, Khan, & Buth, 1987; Saraswat, 2002b). (26) Kalibangan (*P*: Vishnu-Mittre & Savithri, 1982; *A*: Nath, 1969). (27) Kunal (*P*: Saraswat & Pokharia, 2003). (28) Balu (*P*: Saraswat, 2002a). (29) Sanghol (*P*: Saraswat, 1997). (30) Sohr Damb/Nal (*P* & *A*: Benecke & Neef, 2005). (31) Kaothe (*P*: Kajale, 1990b; *A*: Thomas & Joglekar, 1990). (32) Kayatha (*P*: Vishnu-Mittre, 1977; *A*: Alur, 1975; Clason, 1979). (33) Burzahom I (*P*: Lone *et al.*, 1993; *A*: Nath, 1969). (34) Kanishpur (*P*: Saraswat & Pokharia, 2004a). (35) Daulatpur (*P*: Vishnu-Mittre & Savithri, 1982; Vishnu-Mittre *et al.*, 1985). (36) Hulas (*P*: Saraswat, 1993a). (37) Lal Quila (*P*: Kajale, 1995; *A*: Shah, 1995). (38) Surkotada (*P*: Vishnu-Mittre, 1990; Chanchala, 1995; *A*: Sharma, 1990). (39) Babor kot (*P*: Reddy, 1994, 2003a; *A*: Thomas *et al.*, 1997). (40) Khanpur (*A*: Thomas, 1984a). (41) Prabas Patan (*A*: Thomas, 1984a, 2000). (42) Lothal (*A*: Nath & Rao, 1985). (43) Ahar (*P*: Vishnu-Mittre, 1969; *A*: Shah, 1969). (44) Jalilpur (*A*: Meadow, 1988). (45) Ojiyana (*P*: Pokharia & Saraswat, 2004a, 2004b). (46) Shirkapur (*P*: Chanchala, 1994; *A*: Thomas, Joglekar, Deshpande-Mukherjee, *et al.*, 1995). (47) Dholavira (*A*: Patel, 1997). (48) Kuntasi (*P*: Kajale, 1996b; *A*: Thomas, Matsushima, & Deshpande, 1996). (49) Rojdi (*P*: Weber, 1991; *A*: Kane, 1989). (50) Rangpur (*P*: Ghosh & Lal, 1963; *A*: Nath, 1963). (51) Tarakai Qila (*A* & *P*: Thomas, 1999, 2003). (52) Pirak (*P*: Costantini, 1979; *A*: Meadow, 1979b, 1987

into central or peninsular India is limited, but stray finds of wheat from the site of Kayatha (Vishnu-Mittre, Sharma, & Chanchala, 1985), ca. 2500–2000 BC, are indicative. Traditional cultivation on the black soils of Central Madhya Pradesh focuses on wheat, and it maybe that this tradition was established in prehistory as distinct from rice and millet cultivators of other contemporary regions. In the northern Deccan (Mahrashtra) Chalcolithic of the first half of the second millennium wheats, barley and southwest Asian pulses were important crops (Kajale, 1988b, 1991), while only wheats and barley made a limited impact on the Neolithic of the Southern Deccan, from ca. 2000 BC (Fuller, 2003d, 2005).

One the eastern margins of the Harappan zone, the cultivation of these Near Eastern winter crops was constrained by climatic conditions, in particular the predominance of summer rainfall. Within such monsoon zones we might expect summer crops to dominate, as was the case in Gujarat and South India. The perennial rivers of the Ganges, the upper Ravi and others, however, offered a means to grow winter crops as well as monsoon crops. Indeed Early Harappan and Mature Harappan archaeobotanical evidence from this region consistently shows the presence of native Indian monsoon crops alongside the Harappan (Near Eastern) winter crops (e.g. Willcox, 1992; Saraswat, 1991, 1993a, 2002a, 2002b; Saraswat & Pokharia, 2002, 2003). The earliest known agricultural settlements in the Upper Ganges plain date to the Early Harappan period, starting by ca. 2800 BC, and the available evidence suggests that winter and summer crops were already both part of the agricultural system at such sites (e.g, Kunal). These crops included native Indian pulses such as horsegram (*Macrotyloma uniflorum*), which might be from domestication in Rajasthan, Gujarat or the Peninsula, and the mungbean (*Vigna radiata*) which could have a western Himilayan origin as well as one on the peninsula. Of particular interest in this regard is the presence of small, Indian millets from Early Harappan levels at Harappa (back to the Ravi Phase, ca. 3200 BC), especially *Panicum sumatrense* (Weber, 2003). This implies that the monsoon crops were already available as cultivars, perhaps from this region in an as yet undocumented pre-sedentary period or else from areas to the east, such as the middle Ganges. This hints at domestication of monsoonal millet crops that is earlier than and perhaps independent of those further South on the Peninsula or in Gujarat (see below). Further archaeoogical evidence is needed to document the emergence of agricultural villages and pre-Harappan sites in this eastern Harappan zone and the upper Ganges as well as their cultural relations to developments in the middle Ganges.

The winter crops subsequently spread further east into the Ganges valley and south into Peninsular India. Direct AMS dates document these in the Ganges valley in the later third millennium BC, such as barley at Damdama by 2400–2200 BC and at Senuwar and Lahuradewa before 2000 BC (Saraswat, 2005). These crops had reached the southern Neolithic zone by 1900 BC (Fuller, Boivin, & Korisettar, in press-a). In both South India and the Ganges valley, the early finds of the Southwest Asian (and Harappan) package of winter crops suggest that these species were added to existing agricultural systems based on other, monsoonal crops, and did not get agriculture started. As I argue below, current evidence points to separate origins of distinct agricultural systems in both of these regions before the diffusion of winter crops from the west.

The Northern Neolithic

It was during broadly the same Middle Holocene period that agriculture became established in the Kashmir valley and other northern valleys, like Swat in northern Pakistan. Here sites occupy the milder valley bottoms and begin to be occupied between 3000 and 2500 BC, represented by the sites of Burzahom, Gufkral, Ghaleghay, and Bir-Kot-Ghwandai, but with more evidence and sites dating closer to 2500–2000 BC (e.g. Sharma, 1982, 1986; Allchin & Allchin, 1982, pp. 111–116). The earliest phases are characterized by broad deep pits, with bell-shaped profiles. While these have conventionally been interpreted as pit houses, recent debates have raised the likelihood that they were large storage features (Conningham & Sutherland, 1998). Archaeobotanical evidence indicates the presence of the Southwest Asian cereal and pulse package from the earliest samples at Kashmir Neolithic sites (Buth, Khan, & Lone, 1986; Lone *et al*., 1993; Kajale, 1991; Saraswat & Pokharia, 2004b) and those in Swat (Costantini, 1987), which are roughly contemporary with the Harappan civilization (including the Early Harappan period). Faunal evidence includes sheep, goat, and cattle, while the status of buffalos and pigs requires confirmation (Sharma, 1982, 1986). The winter crops of Near Eastern origin, together with sheep, goat and cattle argue for derivation of agriculture from either the Indus region or central Asia. The biotic evidence is therefore opposed to the idea that the Kashmir Neolithic can be related to a westward dispersal of millet-growing Sino-Tibetan speakers, derived from Yangshao China, as some have argued (Parpola, 1994, p. 142; Van Driem, 1998, pp. 76–84; Possehl, 2002a, 2002b, p. 39). Parallels with China seem to have been argued largely on the basis of similar stone harvest tool typology (see below), but the absence of pigs and East Asian millets is surely against derivation from the east. The agricultural situation might therefore be congruent with the suggestion of a distinct, extinct linguistic substrate in Kashmir (Witzel, 1999, pp. 6–7). As discussed by Agrawal (1992, p. 211, 2002), the establishment of agriculture in this region may have only become possible in the warmer conditions of the mid-Holocene. Another key factor may have been adaptations in the crops themselves, since winter-tolerant vernalizing varieties of wheat and barley are grown here unlike the plains to the south and west. Others have noted that there is no clear evidence for intensive Mesolithic occupation in the region (Ray & Ghosh, 1986). The existence of aceramic occupation at the earliest levels of Neolithic sites (as at Gufkral), in the third millennium BC when adjacent regions (e.g. within the Harappan orbit) are ceramic using, could suggest that this culture represents the adoption of crops by hunter-gatherers, perhaps in an adjacent region to the west or northwest, who then settled in Kashmir.

The presence of Chinese like stone harvesting knives in Kashmir remains curious but must be regarded as a technological diffusion given the subsistence data. This diffusion seems to have occur during the later Harappan horizon, after 2000 BC. These forms only occur in later Neolithic phases such as Burzahom II and Gufkral 1C (Allchin & Allchin, 1982, fig. 5.9; Sharma, 1982). These harvesters also appear around this time further south in Baluchistan in the Late Harappan era, as at Pirak (Jarrige, 1985, 1997). As discussed by Jarrige (1985, 1997) this period sees important changes in cooking techniques as well. Impressions in pottery from Ghalegay, together with grains from Bir-Kot-Gwandhai, suggest some localized *indica* rice cultivation by 2500 BC (Costantini, 1987), which must have diffused from the Gangetic region to the Southeast. By contrast later Harappan rice from Pirak (after 1900 BC), has notably shorter, plumper grains, suggesting *japonica* type (Costantini, 1979), which is also supported by the form of bulliform phytoliths from the site (Sato, 2005). Thus by early in the Second Millennium BC, we can infer that the northern Pakistan/Kashmir region had developed contact with cultural groups to the north/east in the Chinese cultural sphere, indicating either long-distance trade or immigration into adjacent Himilayan zones of Sino-Tibetan speaking groups.

The case for a Gujarati center of origin

While hard evidence for origins is lacking, it can be suggested that Gujarat may have been a centre for the domestication of local, monsoon-adapted crops, such as the little millet (*Panicum sumatrense*) and a species (or two) of *Setaria*. Although the earliest archaeobotanical samples date back only to ca. 2600 BC, sedentary sites with ceramics such as Padri suggest that cultivation was established by the end of the fourth millennium BC (Shinde, 1998a, 1988b, 2002; Ajithprasad, 2001). Despite being a region generally included in the Harappan civilisation (see, e.g. Possehl, 1980; 1997; Kenoyer, 1998; Chakrabarti, 1999), Saurashtra shows a very different agricultural system from the Indus valley (Weber, 1991; Fuller & Madella, 2001). In part this can be attributed to local ecology since Gujarat lacks the perennial irrigation of a major river and instead must rely on monsoon rains—to which the summer-cultivated millets are better suited. Although sites such as Rojdi and Kuntasi which date to the Mature Harappan phase have extremely limited evidence for wheat and barley in a few samples, the ubiquitous and dominant species are tropical millets. In addition pulses from the earliest phase at Rojdi include urd (*Vigna mungo*), which could be native here, or the adjacent zone from the northern Western Ghats to the Southern Aravalli Hills. By contrast mungbean (*Vigna radiata*) must have diffused from either the peninsula (Southern Neolithic) or from the north (the Eastern Harappan zone), after 2000 BC. Horsegram also occurs first in this later time horizon.

It is in this region where issues of taxonomic identification of archaeological millet remains are really crucial. Many of the published reports suggest presence of *Eleusine coracana*, of East African origin. There are grounds, however, from those reports with published illustrations to doubt that these remains have been correctly identified (as first noted by Hilu *et al*., 1979). Elsewhere (Fuller, 2003b; Fuller *et al*., 2004) I have considered at some length how the charred de-husked grains of various native millet species, including *Setaria* spp. and *Brachiaria ramosa*, have been systematically misidentified since the pioneering work of Vishnu-Mittre and Savithri (1978, 1979b). If the reported *Eleusine coracana* identifications are all accepted then this species was a widespread agricultural dominant by ca. 2500 BC, and strong case could be made for the importance of African contact in allowing agricultural settlement of this region (Possehl, 1986; Hutchinson, 1976). I believe, however, that these identifications are in error and we are thus left with an agriculture based largely on taxa native to South Asia and potentially domesticated in this region.

Gujarat is one of the regions in which native small millets were important. Amongst the most ubiquitous millets across sampled sites and numerically the most numerous at Rojdi is the little millet, *Panicum sumatrense* (e.g Weber, 1991), the identification of which is not in doubt, in addition to foxtail millets, *Setaria* spp. (the specific-level identification of which can be problematic). There are several native *Setaria* spp., including *S. verticillata* and *S. pumila* (= *S. glauca* in many reports and floras), both of which are known to be cultivated in parts of South India today. These latter two species are also reported from Rojdi (Weber, 1991). I believe that reported *E. coracana* will turn out to be largely the de-husked grains of a *Setaria* sp., or perhaps *Brachiaria ramosa* or *Echinochloa colona* (these latter two species are both native species cultivated in India). One of these native *Setaria* species has been recovered in substantial quantities in Early Harappan Baluchitsan at Sohr Damb (Benecke & Neef, 2005). *Setaria verticillata* was also utilized in South India and the Ganges region in preshistory (discussed below), and thus these native foxtails were important, still poorly documented, subsistence resources in several parts of early South Asia.

The other identification issue which is significant is the presence of *Setaria italica*, as this is not a native species, but was domesticated in Neolithic northern China, in addition perhaps to somewhere in Central Asia or the Caucasus (see Marnival, 1992; Lu, 1999; Zohary & Hopf, 2000; Jones, 2004). Given that identifications have been based in the rugose husk patterns (e.g. Vishnu-Mittre & Savithri, 1978; Weber, 1991), they are more likely to be reliable although confusion with *Brachiaria ramosa* is still a possibility. If we assume they are correct, it would indicate that this species had diffused through northwestern South Asia to reach Gujarat by the beginning of the Mature Harappan phase, whereas I would take the earliest well-illustrated specimen of *Setaria italica* to be that from Late Harappan Surkotada (Fuller, 2003b, fig. 13a-b).

The cultural history of this species, together with *Panicum miliaceum*, remains poorly known. Early finds of both species date back to the Sixth and Fififth Millennium BC from both ends of temperate Eurasia (Europe and China) (Jones, 2004), which may well indicate multiple domestications. Towards the central Asian region there are possible finds from the the 5th millennium BC in the Caucasus at Arukhlo (Litsina, 1984) and at Tepe Yahya in Iran (Costantini & Biasini, 1985; Lamberg-Karlovsky & Tosi, 1989), although caution is warranted about both sites either in terms of dating or identification. Clear finds of *Panicum miliaceum* occur in the northwestern region in Late Harappan times, at Pirak (Costantini, 1979) and Shortughai in Afghanstian (Willcox, 1991). It is plausible that *S. italica* and *P. miliaceum* came along with several other new technologies and species from Central Asia or the West at the end of the Harappan period, such as horses, donkeys and camels (Meadow, 1989a; Meadow & Patel, 2003, pp. 400–401), and central Asian fruits like apricots, peaches, almonds and walnuts (Fuller & Madella, 2001, pp. 340–341), and possibly a field crop variety of *Cannabis sativa* (Fuller & Madella, 2001, p. 338). This is also the period that sees cultural diffusion from central China, suggested by harvest knives found in Kashmir and at Pirak (Jarrige, 1997).

Old reports of rice husk impressions in pottery or mud clods, as at Rangpur and Lothal (Ghosh & Lal, 1963; Rao & Lal, 1985), and Ahar in Rajasthan (Vishnu-Mittre, 1969), are problematic as they have not been corroborated by macro-remains from systematically sampled sites. While the identity of the *Oryza* genus is not in doubt, evidence does not clearly indicate the cultivar *Oryza sativa*. Evidence of Oryzoid phytoliths from Balathal (Kajale & Eksambekar, 2001) raises a similar problem, and could be explained by the assumption of a formerly extensive wild rice distribution in these regions, which contracted as the wetter Mid-Holocene came to an end. Wild rice could have served as fodder or a thatching material. This problem requires renewed investigation, together with further informed debate over whether rice in some contexts may be invisible in the charred archaeobotanical record but present as phytoliths (cf Madella, 2003, pp. 222–225), or ceramic impressions. Both the presence in ceramics and phytolith evidence relates to the distribution of crop-processing by-products, but we would expect charred macro-remains in most cases if crop-processing were part of domestic routine, as is clearly the case in the Neolithic Ganges (Harvey & Fuller, 2005). The absence of rice macro-remains from flotation samples argues against rice cultivation, although a recent preliminary report from Ojiyana in Rajasthan indicates the presence of rice, suggesting that there may have been some localized cultivation in Western India by 1500 BC (Pokharia & Saraswat, 2004a). Further work needs to integrate ceramic provenience studies with archaeobotanical documentation of ceramic impressions, to determine whether rice-tempered pottery might have been part of regional ceramic exchange, which has been documented for this period (Gogte, 1996).

In my view the crop package of Saurashtra differs from the native crop packages from other regions of South Asia (see below) enough so as to raise the likelihood of local plant domestication processes in this region, perhaps to be dated back to the fourth or early third millennium BC. This region clearly received livestock from the Indus valley and Baluchistan, but the crops from the northwest made little impact in this region. This suggests that we probably need to envision a local trajectory of plant cultivation beginning amongst local hunter-gatherers who presumably adopted livestock from their neighbours to the west, and thus one can suggest a stationary frontier between the pre-Harappan agriculturalists of the Indus valley in Sindh and the pre-Padri hunter-gatherers or proto-cultivators of Gujarat. These early cultivators in Saurashtra presumably represent a different tradition from the Mesolithic and Chalcolithic of the Luni river valley to their north and adjacent Rajasthan, where there is evidence for herder-hunters, presumably without agriculture from perhaps 4000 BC to 2000 BC. In addition, it is notable that the Mesolithic site of Langnaj in Gujarat, with a date from the second half of the third millennium, had an apparently entirely wild fauna (Clutton-Brock, 1965), which would indicate the persistence of pure hunter-gatherers long after the selective uptake of herd animals by some groups and the establishment of plant cultivation in adjacent regions. Nevertheless these hunter-gatherers (or hunter-traders) were interacting with settled agricultural populations (Possehl & Kennedy, 1979; Possehl, 2002a, 2002b). Taken as a whole then the evidence from Mid-Holocene Gujarat indicates the existence of a long-standing static frontier, in which local hunter-gather groups in interaction with agricultural and herding groups further west selectively took up livestock, while some of them also began cultivation based on local wild millets.

A gangetic center of origin?

The case for a center of agricultural origins in the Ganges basin can be drawn from botanical, archaeological and linguistic evidence (Fig. 5). On biogeographic grounds there are numerous crops that have wild progeniors in the region, including rice (Table 3). A small, but growing body of archaeobotanical evidence indicates that the earliest crop assemblages were composed only of potentially native species, with non-native species, such as wheat, barley, and peninsular pulses being added later. It must be noted that current evidence indicates that livestock are also adopted at around this time. In addition, evidence for substrate languages in Northern and Northwest India, which provided extensive agricultural and botanical vocabulary to Sansktit and other Indo-Aryan languages, might be related to separate agricultural origins in this region (Fuller, 2003a, 2006a, 2006b; cf. Witzel, 1999; Southworth, 2005).

An important set of crops which is native to northern India, but still poorly documented are cucurbitaceous vegetables (Decker-Walters, 1999), including cucumbers (*Cucumis sativus*), snake gourd (*Trichosanthes cucumerina*), bitter cucumbers (*Momordica* spp.) and ivy gourd (*Coccinia grandis*) (Table 3). Linguistic evidence for these species may be indicative of borrowing from an extinct agricultural language of northern/Gangetic India (Fuller, 2003a, 2006b). Although *Cucumis* sp. seeds have been reported fairly widely, specific identity remains elusive, and several wild species are possible. *Coccinia grandis* has been recovered from Hulas in the upper Ganges basin from 1800–1300 BC, and from Senuwar IB, ca. 1750–1300 BC. Evidence from the upper Ganges valley and the middle Ganges, as at Senuwar, indicates that by the early second millennium BC some crops of African origin had been adopted in the region, including hyacinth bean, cowpea and sorghum, while evidence for pearl millet and finger millet is absent before the late second millennium BC (Fuller, 2003a; cf. Saraswat, 2004a).

The origins of Indian rice remain problematic, but a domestication event in north India is certainly possible. Rice was domesticated at least once in Yangtze basin of southern China (Lu, 1999; Pei, 1998; Zhao, 1998; Cohen, 1998, 2002; Yasuda, 2002; Toyama, 2002), although clear archaeobotanical evidence for when this occurred remains elusive. Some

Table 3 List of field crop species that are candidates for domestication in Gangetic India and/or Orissa

Crop	Common name	Region of origin
Oryza sativa L.	Rice, vrihi	Tract from Central Uttar Pradesh, through Chattisgarh, Bihar, west and south Orissa
Paspalum scrobiculatum L.	Kodo millet, Varagu (Tamil), arikelu (Telegu)	Secondary domestication of Gangetic rice weed(?)
Brachiaria ramosa (L.) Stapf.	Browntop millet, pedda-sama (Telegu), kadu-baragu (Kananda)	Dry deciduous forest clearings, savanna zone streams, north-facing slopes. Southern Neolithic Zone
Seteria vertcillata (L.) P. Beauv.	Bristley foxtail millet	Dry deciduous forest clearings, savanna zone streams, north-facing slopes. Southern Neolithic Zone
Setaria pumila (Poir.) Roem. & Schult	Yellow foxtail millet, korali (Tel./Kan.)	Dry deciduous forest clearings, savanna zone streams, north-facing slopes
Echinochloa colonum (L.) Link	Sawa Millet, bonta chamalu (Telegu)	Secondary domestication of rice/millet weed(?)
Pulses		
Vigna mungo (L.) Hepper	Black Gram, Urd	South Asia–northern extent of wild progenitor at Mt. Abu (Rajasthan), but could include South Vindhyas(?) and Bihar hills (?)
Vigna radiata (L.)	Green Gram, Mung	South Asia–northern extent of wild progenitor could include Vindhyas and Orissan hills (?)
Macrotyloma uniflorum (Lam.) Verdcourt	Horsegram, Kulthi	South Asia: savannahs or dry deciduous woodlands (more towards Western India?)
Cajanus cajan (L.) Millsp.	Pigeonpea, Red Gram, Tuvar	South Orissa, Bastar, Northern Andhra Pradesh
Cucurbits		
(*Cucurbitaceae*)	"Gourds" (including melons and cucmbers)	Wild and/or feral in Northern and Eastern India
Cucumis sativus L.	Cucumber, khira	Wild in the Himalayan foothills, possibly also the high hills of Orissa
Coccinia grandis (L.) Voigt	Ivy gourd, kunduri	Wild in Himalayan foothills, hills on central and eastern India
Trichosanthes cucumerina L	Snake gourd, chachinga	"
Praecitrullus fistulosus (Sticks) Pang	Tinda, Indian squash melon	"
Momordica charantia L	Bitter gourd, karela	Wild in Himalayan foothills, hills on central and eastern India through Yunnan, China: 2 origins (Marr *et al*., 2004)
Momordica dioeca Roxb. Ex Willd	Small bitter gourd, murela, jangli karela	"
M. balsamina L	Balsam apple, mokha	"
Luffa cylindrica (L.) M. J. Roem	Sponge gourd, loofah	Wild in Himalayan foothills and Yunnan, China: 2 origins (Marr *et al*., 2005a)

Table 3 Continued

Crop	Common name	Region of origin
Luffa acutangula (L.) Roxb.	Ridged gourd, angled loofah	Wild in Himalayan foothills, hills on central and eastern India (Marr *et al*., 2005b)
Tubers		
Colocasia esculenta	Taro	Eastern India and/or SE Asia
Dioscorea spp.	Yams	Eastern India and/or SE Asia
Other		
Abelmoschus. tuberculatus Pal and Singh	Wild okra	One of the likely genome donors of domestic okra. Wild in Uttar Pradesh
Abelmoschus ficulneus (L.) Wight & Arnot	Wild okra	One of the likely genome donors of domestic okra. Wild in northwest through Deccan
Abelmoschus moschatus Moench	Musk mallow	Eastern India through Burma

would tie early South Chinese rice to a hypothetical 'Austric' package (Blust, 1996) that dispersed by migration into northeastern India with the Austro-Asiatic (Munda) languages (e.g. Higham, 1995; Glover & Higham, 1996a, 1996b; Bellwood, 1996, 2005; Diamond & Bellwood, 2003), but for a critique of this see Fuller (2003a, 2003d, 2006a, 2006b; Blench, 2005). The rice dispersal hypothesis is contradicted by evidence for multiple rice origins. The current genetic evidence, however, is clear in indicating a minimum of two domestications for *Oryza sativa* (Sato *et al*., 1990; Sano & Morishima, 1992; Chen, Nakamura, Sato, & Nakai, 1993a; Chen, Nakamura, Sato, & Nakai, 1993b; Wan & Ikehashi, 1997; Sato, 2002; Vaughan, 2002; Cheng *et al*., 2003; Li, Zhang, Ying, Liang, & Han, 2001; Zhu & Ge, 2005; Londo, Chiang, Hung, Chiang, & Schaal, 2006), with the second domestication of *indica* cultivars conceivably in the Gangetic basin, or eastern India (Western Orissa, Chattisgarh, Jharkhand, Bihar). The latest genetic data and "phylo-geography" (Londo *et al*., 2006) indicates two or even three distinct clades of *indica* rices, suggesting multiple domestications across South (and Southeast) Asia (also, cf. Cheng *et al*., 2003).

At present there are three sites where archaeobotanical data from flotation samples suggests earlier indigenous cultivation than evidence for adopted crops. Recent sampling at Senuwar (Saraswat, 2004a, figs. 93–94; see also, Saraswat, 1992; Saraswat & Chanchala, 1995; Singh, 2001) indicates that during the first phase of this Neolithic site wheat, barley, lentils, grasspea and peas arrive but are absent from the beginning of the site, when rice (*Oryza sativa*) and small millet(s) are present. This implies that a rice-millet cultivation system was already established before other crops were introduced from the west. A similar absence of introduced species occurs at Mahagara in the early Second Millennium BC, although the sample size is too small to inspire confidence (Harvey, Fuller, Pal, & Gupta, 2005). Important evidence comes from recent excavations at Lahuradewa (Tewari, Srivastava, Singh, Saraswat, & Singh, 2003, 2005; Saraswat & Pokharia, 2004a; Saraswat, 2005), which indicate early ceramics and rice millennia earlier.

At present we might discern at least three contemporary cultural/economic traditions in the region. The first of these, and most recently discovered, is located towards the eastern part of Uttar Predesh, north of the Ganges valley and in the lower Son river basin (e.g. Lahuradewa, Senuwar). A second is in the northern Vindhyas focused on the Belan river valley and the upper Son (including Koldihwa. Mahagara and Kunjhun). A third relates to the Mesolithic tradition of central Gangetic plain, which was focused on oxbow ponds and former (Early Holocene) meander channels.

At present the earliest evidence for precursors to the well-developed Neolithic comes from the site of Lahuradewa. This site provides evidence for occupation on a lake edge back to the seventh millennium BC (Tewari *et al*., 2003, 2005; Saraswat & Pokharia, 2004a, 2005; Singh, 2005a, 2005b). Already in this period, or certainly by sometime in the end of the fifth millennium, ceramics had begun to be produced, and rice was part of the diet, and may even have been cultivated, although the very limited evidence available to date is inconclusive and is more suggestive of wild rice collecting. All the fauna thus far studied from that period were wild (Joglekar, 2004), and it is likely that occupation was intermittent (with hiatuses), or else highly seasonal to account long a timespan of 3000–3500 years for this lowest layer (less than 50 cm thick). Intriguingly, the ceramic assemblage does not yet suggest much perceptible change during the period, although the third millennium levels include several new forms including some that suggest influence from the Harappan zone to the west. In the third millennium and certainly during the period 2500–2000 BC, settlement probably became more regular. Evidence for cultivation is then less ambiguous, as species from external sources were adopted, in particular barley (Saraswat, 2004c, 2005), as well as pulse species that may also be non-local. In this period at least some domesticated sheep/goats are present (also adopted from the west). At this period agricultural village settlements are being founded over a wider region, such as Senuwar (Saraswat and Pokharia, 2004b, 2005), suggesting the filling in of the landscape with agriculturalists and the emergence of sedentary settlements. After 2000 BC a wider crop repertoire is present, including summer and winter pulses and the faunal assemblage is predominantly domesticated including cattle, sheep and goats. Clay lined storage bins suggest more investment in permanent facilities at the site. Intriguing is the evidence from Senuwar that crops of African origin, in particular sorghum with more problematic '*Eleusine coracana*,' which are adopted before the end of the first cultural phase, perhaps by ca. 1700 BC. This is generally the period when Afircan crops turn up on sites in several parts of India (Fuller, 2003b). It must be noted, however, that this phase could run until later, ca. 1400 BC.

Caution is warranted in considering early/mid-Holocene radiocarbon dates reported from this region. A few sites have reported dates in the 6th millennium BC, such as Koldihwa and Malhar (Sharma *et al*., 1980; Tewari, Srivastava, Saraswat, & Singh, 2000, 2003; Saraswat, 2004a, pp. 533–535). Both these sites have dates mainly of much later period (i.e. from the Second Millennium BC), and artifact assemblages consistent with the younger dates. At Malhar there is no associated cultural assemblage that is pre-Chalcolithic (Tewari *et al*., 2000; Saraswat, 2004a, p. 533), while at Koldihwa material is Neolithic, comparable to Mahagara and subsequent Chalcolithic, with some early Iron Age. Thus both dates would appear to be residual within their archaeological contexts, or represent very old wood. Field observations at Koldihwa and Mahagara, and direct AMS dates on grains from recent flotation, indicate that these sites have clear stratified occupation from the later Neolithic, starting after ca. 1900 BC (Harvey *et al*., 2005; and unpublished data). The more extensive deposits at these sites can be linked by ceramic styles and other dating evidence to a number of other sites in the region (Pal, 1986; Singh, 1997, 2001; Kumar, 2001).

The unambiguous evidence for sedentary, agricultural villages after mid-third millennium and mainly after 2000 BC, as well as ceramic links, suggests that the Neolithic mainly of the later third millennium/early second millennium with possible origins in the earlier fourth millennium suggested from the radiocarbon evidence from the sites of Chopani-mando and Khunjun II with mid-fourth millennium dates and rice-tempered pottery (e.g. Pal, 1986; Sharma & Sharma, 1987; Clark & Khanna, 1989; Possehl & Rissman, 1992;

Bellwood *et al*., 1992; Glover & Higham, 1996a, 1996b; Singh, 1997; Fuller, 2002; Baker 2005). What the archaeology of these sites with fourth millennium BC dates suggests, however, is rather less extensive deposits and less intensive occupation than is found from the later third millennium BC, and thus we may be dealing with seasonally occupied sites of transhumant/semi-sedentary communities. If this is the case, then the even earlier dates of the 5th and 6th millennium BC are also most likely to be from seasonally occupied sites, and it is therefore not surprising that such occupations have been to some extent obscured by subsequent sedentary occupation over the top of them.

While Lahuradewa has an earlier sequence with ceramics, and may have a more continuous sequence through the mid-Holocene, this does not justify old sequences at the other sites. There is still much that needs to be clarified about the nature of human occupation and subsistence, and the actual status of rice from these early periods, whether gathered, cultivated or domesticated, and how much diversity (in terms of species) are represented by the rice finds and other associated plants. More archaeobotanical sampling, systematic documentation and direct AMS-dating are needed.

Several issues require clarification before the emergence of agriculture in the Gangetic basin can be understood or even accurately outlined. Sedentary agriculture is indisputable from at least the mid/late third millennium BC, but what is at issue is the beginnings of sedentism, the beginnings of ceramic production, and the transition from foraging of wild rice to cultivation and appearance of morphologically domesticated of rice. Systematic sampling and direct AMS dates are needed, to clarify the antiquity of rice and pottery, and further botanical research is needed to produce replicable criteria for determining wild vs. domestic status. While Tewari *et al*. (2003) suggested that many sites may show a hiatus between the sixth/fifth millennium and the third millennium BC, this only begs the questions of the nature of human subsistence and occupation in the region through the mid-Holocene. The apparent continuity in basic ceramic types, cord-impressed and rusticated wares, for three or more millennia requires some explanation as well, although it may not be unprecedented, like in the wide date range for early Eastern Saharan pottery (Saharan Neolithic/Khartoum Mesolithic dotted wavy-line and rocker-stamp impressed wares: cf. Close, 1995; Mohammed-Ali & Khabir, 2003). Available illustrations of the rice material and criteria, whether qualitative morphological or metrical, are not yet adequately reported, and thus not replicable amongst different workers.

The critical review of rice grain measurements by Thompson (1996) raises serious doubts about the utility of grain morphometrics alone as a discriminant tool, although these should still be useful for documenting population level change through time which may help to track domestication. In this regard, a particularly important distinction may in changes in grain maturity. As foragers harvesting wild rice would have had to target somewhat unripe plant and thus more immature grains, as opposed to the fully mature grains that can be harvested from domesticated plants. Rice grain proportions would therefore be expected to change through time as an outcome of changing grain maturity brought about through domestication. In addition, while promising criteria have been reported from the form of lemma and palea (husk) cells, both on carbonized material (e.g. Sharma, 1983; Pei, 1998; Zhang, 2002) and phytoliths (e.g. Zhao, Pearsall, Benfer, & Piperno, 1998; Zhang, 2002), further refinement and testing of these approaches on modern material is needed.

Work in progress should add clarification in the next few years. The excavations and sampling at Lahuradewa by Tewari, Saraswat and colleagues is significant in this regard (Tewari *et al*., 2003, 2005; Saraswat & Pokharia, 2004a). Recent re-sampling initiated at Koldihwa, Mahagara and Chopani-mando also contributes to characterizing early agriculture in the region once it was fully established (Harvey *et al*., 2005; Harvey & Fuller, 2005; Harvey, 2006). Current research on these samples indicates by-products from the full crop-processing sequence of rice (Harvey & Fuller, 2005). Subsistence was not based on rice alone, however, for the macro-remains also include small native millets (notably *Brachiaria ramosa*), mungbean, and some evidence for winter cereals, i.e. barley and wheat, later in the sequence (Harvey *et al*., 2005). This evidence therefore parallels that at Senuwar (Saraswat, 2004a) and other sites indicating that by the time wheat and barley were introduced cultivation based on native species was already established, and this may point towards earlier local cultivation practices, prior to the mid-Third Millennium BC. Preliminary observations on Neolithic plant remains from the site of Tokwa suggest a similar mixed cultivation system was well established before the end of the Neolithic (Misra, Pal, & Gupta, 2001). The subcontinental record for rice indicates the diffusion of this species from the Ganges region starting in the early third millennium (e.g. Early Harappan Kunal). Evidence for the presence of rice cultivation on the peninsula is only in the first millennium BC (Fuller, 2002).

What is clearest from the evidence at present is the *end of the process* of agricultural origins in this region, as rice/millet/pulse- cultivating sedentary villages with domestic livestock become widely established in the early Second Millenium BC. Many of these sites consistently show later continuity into the Chalcolithic assemblage in the mid second millennium BC (also congruent with accumulating evidence from other sites, see Kumar, 2001; Singh, 2001).

Also intriguing about this region, and requiring further research as well as theorization is the possible persistence of hunter-gatherer-fisher communities alongside agriculture. Numerous Mesolithic sites are known in the region, especially in the region north of the Ganges river (see Lukacs & Pal, 1993; Pandey, 1990; Misra, 1999; Kennedy, 2000, pp. 200–205; Lukacs, 2002). The first of these sites to be reported in any detail was Mahadaha (Sharma *et al*., 1980), where Alur had reported an entirely domesticated fauna and where radiocarbon dates suggested later third to early second millennium BC age. It was on the basis of this apparent overlap with Neolithic sites south of the Ganges in the Vindhyan zone that Possehl and Rissman (1992: 473) suggested an interaction zone between farmers and hunter-gatherers. Subsequent consideration of the fauna strongly suggests mis-identification of entirely (or mainly) wild fauna (Thomas, Joglekar, Deshpande-Mukherjee, & Pawankar, 1995; Chattopadyaya, 1996, 2002). Here wild fauna suggested in particular an importance of small game, birds and aquatic resources (Thomas, Joglekar, Deshpande-Mukherjee *et al*., 1995). Intriguing amongst the fauna is the significant presence of *Gallus* bones (see Table 2), which could relate to the origins of chicken keeping, as early chicken remains have also been reported from Mesolithic Mahadaha (Alur, 1980). In addition to the faunal data, analysis of human skeletal remains point to a broad-based hunter-gatherer adaptation (Lukacs & Pal, 1993; Lukacs, 2002). The Mesolithic sites of Damdama and Sarai Nahar Rai, where further Mesolithic deposits and burials were excavated, yielded some similarly "late" dates pointing to the later third millennium BC. Subsequently some dates have suggested mid-Holocene, while dates on human skeletons have consistently been earlier Holocene. Direct AMS dates on human burials, two each from Damdama and the site of Lekhahia, a Mesolithic site of the Vindhyas, point to dates from ca. 8000–7000 BC (Lukacs & Pal, 1993; Kennedy, 2000: 202; Lukacs, 2002: 53). Additional recent dates from Damdama date some burials to the sixth millennium BC (see Tewari *et al*., 2003). It is unclear how these dated burials relate stratigraphically and chronologically to the plant remains reported by Kajale (1990a, 1990b) and Saraswat (2004b). These sites either saw episodic use over a very long period, of five or six millennia, or else some of the available dates, such as those on skeletons, are in error.

Archaeobotanical evidence supports a late chronology, or at least a late phase of use of these sites by populations that were consuming agricultural products, if not cultivating. Initial archaeobotanical results from Damdama (Kajale, 1990a, 1990b) indicated the presence of rice use as well as wild grasses (but species that are known to be or have become rice weeds: *Eleusine indica* and *Dactyloctinum* sp.), although the aceramic, 'Mesolithic' context led many to assume this represents wild rice collecting (e.g. Fuller, 2003b). More recent analysis of flotation samples indicates the consumption of rice as well as non-native barley (Saraswat, 2004b). Direct AMS dates on each of these taxa place the consumption of these grains into the second half of the third Millennium BC, indicating that the aceramic cultural tradition of this region persisted alongside the development of villages of ceramic-making peoples in other parts of the greater middle Ganges region.

An attempt to assess seasonality of fauna, and the orientation of burials in relation to sunset/sunrise alignment, led Chattopadyaya (1996) to suggest year-round use of the site. If a short time span for these sites were acceptable then sedentism might be a likelihood, but the divergent dating evidence of the burials and the grains suggests that these sites were used periodically over several millennia.

Further work is needed on pinning down the stratigraphy, dating and biology, of early rice use at sites like Damdama and Lahuradewa. It is crucial to determine whether we are dealing with a mid-Holocene transition from foraging to rice farming, under climatic conditions wetter than today, or a late Holocene transition when aridification in the 4th to 3rd millennium BC might have decreased the availability of wild rice and locally available aquatic resources. It is perhaps during this period when we should seek evidence for pre-domesctication cultivation. The mid-Holocene also witnessed a decrease in the number of river tributary channels, as many meanders were changed into oxbow ponds, which were themselves subsequently infilled (Singh, 2002). The impact of such hydrological changes on the distribution of perennial *Oryza rufipogon sensu stricto*, which is not involved in Indian rice domestication, versus annual *O. nivara*, the probable progenitor of *indica* rice cultivars requires careful consideration.

The potential for sorting out the process seems high since this is one of the few regions in India in which Mesolithic sites have been widely identified and in some cases have good archaeological integrity. Efforts to clarify the geomorphological and environmental context of these sites (e.g. Singh, 2002, 2005a, 2005b) and to provide alternative models for how Mesolithic hunter-gatherer societies were organized on the landscape (e.g. Lukacs, 2002) represent important directions for research, in addition to ongoing archaeobotanical and archaeozoological laboratory research. Ongoing archaeological excavation has much to contribute, especially as the newer techniques of phytolith analysis, geoarchaeology and AMS-dating are incorporated. Archaeobotanical research also needs the development of systematic models of different potential subsistence systems and quantitative expectations against which floated assemblages can be compared including the morphometric properties of ancient rice assemblages.

Although there is much to be resolved in terms of dating and domestication status of remains from the middle Ganges, I am prone to regard this region as a possible center of domestication, because the earliest well-sampled levels contain potentially native crops. Although it is possible that these species had diffused from elsewhere in India, such as Orissa. The evidence for cultivation is at least as old, if not older, than that in Gujarat and South India, and although some species such as pulses are shared between these regions, the cereals (small millets or rice) vary between these regions, thus suggesting separate histories. This local agriculture had begun by the earlier third millennium into which other crops and livestock diffused from the west during the Harappan period.

If this is indeed the case we would expect evidence for cultural diffusion to be evident in the periods of the earliest evidence for Southwest Asian crops and sheep, goat or cattle. This might be hypothesized to be represented by the appearance of footed plates, as at Lahuradewa 1B. This should be contrasted with a migrationist model which would see the earliest agriculture in the region introduced as part of a immigrant cultural package, presumably including pottery and other artefact types (e.g. Glover & Higham, 1996a, 1996b; Kharakwal, Yano Yasuda, Shinde, & Osada, 2004). As reviews of the material culture indicate much of it shows local trajectories of evolution, although ceramic innovations of the Chalcolithic period (from the early/mid second millennium) might derive from Central Indian traditions to the South (Singh, 1997). This southwards contact indicated by ceramics is later than the period when Southwest Asian/Harappan winter crops are adopted (in the later Neolithic). Thus a consideration of other indications for cultural contact in the late third millennium needs to be considered. Did the winter crops diffuse northwards across the Vindhyas from Madhya Pradesh, or did they come east down the Ganges from the Harappan region?

Further research is needed to understand the upper Ganges plain. While it is possible that this was within an independent 'Eastern Harappan' domestication zone (see above), it is also possible that hunter-gatherer groups settled into agriculture (perhaps as the proto-Baran culture?) under the influence of Early Harappan societies further west and/or proto-agriculturalists further east in the middle Ganges region.

Eastern India: Problems and prospects

Many regions of India remain poorly studied in regards to these issues and the necessary bioarchaeological datasets, and notable in this regard is Orissa and other parts of Eastern India. The limited number of excavated sites, radiocarbon-dated sequences, and almost complete absence of flotation samples or faunal reports of current standards forces question marks to follow any claims about the early agricultural societies in this part of the subcontinent.

Nevertheless the topographical and ecological diversity of Orissa and adjacent regions, especially the tribal zone of Western Orissa, Chattisgarh (formerly eastern Madhya Pradesh) and Jharkhand (formerly southern Bihar), as well as well documented wild progenitors of some crops, such as pigeonpea, rice and cucurbits, highlights the need to investigate possible agricultural origins processes in these regions. The evidence of wild progenitors is largely linked to that of Northern India discussed above (Table 3), with annual wild rice (*Oryza nivara*) extensively distributed throughout this zone, as well as probably truly wild forms of the various gourds (cucurbitaceae) discussed above, as well as wild chickens, and potentially millets. The Northeastern limits of the wild form of mung and/or urd (*Vigna sublobata sensu lato*) probably extends to this area but requires botanical field investigations. One species which is clearly of eastern Indian origins is red gram/pigeon pea (*Cajanus cajan*), the wild form of which (*Cajanus cajanifolia*) is distributed in the Bastar region of Chattisgarh and in Southern Orissa (van der Maeson, 1986). The case of tuber crops, such as taro (*Colocasia esculenta*) and various yams (*Dioscorea* spp.), which remain important in parts of Orissa, requires further research. For it is conceivable that the wild forms of such species could well be native to Orissan forests, although dispersal from Southeast Asia is also plausible.

As a working hypothesis, one can suggest two Neolithic traditions from the archaeology of Orissa, one associated with the coastal plain and major river valleys and another in the foothills and uplands, often in what are traditionally considered tribal areas. The Neolithic of coastal Orissa (which we might call the Eastern Wetland Tradition) is represented by some impressive mound sites, with well-stratified and substantial sequences that begin sometime in the (early?) third millennium BC and continue into the Iron Age (early first Millennium BC), as at Golabai Sassan (Sinha, 2000), Gopalpur (Kar *et al*., 1998), and Khameswaripalli (Behera, 2001). These sites have produced extensive ceramic assemblages, animal bones and when excavated bone tool assemblages (Sinha, 2000; Behera, 2001), including projectile and harpoon points. The harpoon points as well as environmental context of these sites (on perennial streams and rivers in the wet lowlands), suggests the likelihood that fishing was a significant part of the economy, in addition to animal husbandry (Kar *et al*., 2001), and cultivation. Whether the full complement of sheep, goat, cattle and water buffalos were present from the beginning of this tradition requires clarification from systematic faunal sampling and reporting, although the apparent absence of sheep and goat from the surface bone assemblage of Golpalpur could hint at a more interesting process of gradual livestock adoption (cf. Kar *et al*., 2001). Charcoal recovered from excavations at Golabai provides the preliminary basis of a chronology, suggesting the earliest foundations of the site at the end of the third Millennium BC. In addition preliminary identification of rice and horsegram were reported (Sinha, 2000). Recent Golabai and Gopalpur field sampling indicates that substantial archaeobotanical evidence is available from these sites to clarify the nature of seed crop agriculture within which rice and Indian pulses (*Macrotyloma*, *Vigna radiata*, *Cajanus*) were prominent (Harvey, Fuller, Basa, Mohany, & Mohanta, in press). New AMS dates indicate, however, that most of the mound was formed during occupation during the second half of the second millennium BC, and similar dates have come from Gopalpur (unpublished data). As discussions of the artefacts have indicated there is a general affinity between the ceramic and bone tool assemblage of these Orissan sites and those of Chirand in the Ganges valley of Bihar (Sinha, 2000; Dash, 2000). It is indeed conceivable that these sites are all connected as part of a rapidly dispersing subsistence culture, based on fishing, domestic fauna and rice-pulse agriculture. Chirand, however, contrasts with Orissa in having evidence for wheat and barley throughout its stratigraphic sequence, which did not diffuse to Orissa. Like Chirand, the main phase of occupation, at these coastal sites appears to have begun towards the middle Second Millennium BC, with sedentary occupation continuing until the Iron Age, mid-First Millennium BC).

Broadly contemporary with these sites is a quite distinct Neolithic that has come to light in inland, upland areas, such as Northern and Central Orissa (Angul, Keonjar, and Mayurbanj districts). Neolithic sites in these areas are mostly known from surface collections, dominated by ground stone axe, and axe-manufacturing assemblages, and often little or no pottery (Mohanta, 2003; Dash, 2000). These sites appear to be largely superficial with little depth of deposit, nor clear archaeological strata and sparse find densities. Attempts to excavate some of these sites and sample for plant remains suggests that charcoal densities are low in the extreme or absent (Harvey *et al*., in press). What this pattern suggests is a very different nature of site occupation, of shorter longevity and/or longer lapses between occupation episodes. Either we are dealing with seasonally occupied sites, perhaps for special activities such as lithic/celt manufacture, or the loci of settlements of shifting cultivators, or both. The ethnoarchaeological and archaeological research in the Rajmahal Hills by Pratap (2001) suggests an essentially similar pattern, which he attributes to shifting cultivation. The absence of any more substantial sites and pottery points indeed to a much less sedentary tradition, and one wonders whether the absence of pottery might also suggest an emphasis on crops like tubers, which can be readily pit-roasted, rather than seed crops.

It is unclear whether there was some input into the subsistence systems from further east (Southeast Asia). Conventionally, the presence of Munda-speaking groups, who linguistically are related to the diverse Austro-Asiatic language family, in Orissa and adjancent states is attirbutred to Neolithic immigration from the Northeast (Higham, 1998, 2003; Fuller, 2003b). Recent linguistic findings, however, might suggest that proto-Munda and earlier Austroasiatic speakers were already present in parts of South Asia, including the Indus region (Witzel, 1999, 2005), with subsequent eastward dispersal and diversification (Donegan & Stampe, 2004; Fuller, 2006a). This scenario fits better with linguistic inferences about early agricultural vocabulary which includes a number of pulse crops indigenous to South Asia, as well as millets, rice and livestock, including sheep and goat which must have spread from the west (Zide & Zide, 1976; Fuller, 2003b). The historical linguistic data suggests an earlier shifting-cultivation tradition, perhaps focused on hilly areas, with a subsequent more settled agriculture associated with the South Munda subfamily, perhaps to be identified with the Neolithic of the Mahanadi and coastal plains (Fuller, 2006a). The epicentre for this agricultural evolution might be suggested to be in Southern Orissa (the Koraput region *sensu lato*), with subsequent dispersal of Northern and Southern Munda groups northwards and westwards, perhaps with an even earlier pre-Munda Austroasiatic spread. This region is the centre of gravity of the two Munda language sub-groups as well as a region of overlap or proximity to South-Central Dravidian groups, with whom there are some shared vocabulary (Fuller, 2003b). Clearly problem-oriented research into the archaeology and palaeoecology of the Orissan hills is needed to test such a hypothesis and fill a major lacuna in agricultural prehistory.

The Southern Deccan: Indigenous millets and pulses

The Southern Neolithic, of northern Karnataka and southwest Andhra Pradesh, has long provided evidence for the earliest pastoralism in Peninsular India (Korisettar, Venkatasubbaiah *et al.*, 2001; Korisettar, Joglekar *et al.*, 2001). A well-known site category of the Southern Neolithic is the ashmound, which has been shown to be an accumulation of animal dung at ancient penning sites that have been episodically burnt, sometimes to an ashy consistency, and sometimes to a scoriaceous state (Allchin, 1963; Paddayya, 1998). Preserved hoof-prints (at Utnur) and animal bones (at all sampled sites) indicate the dominance of cattle in the animal economy with a smaller presence of sheep and goat (Korisettar, Venkatasubbaiah *et al.*, 2001, Korisettar, Joglekar *et al.*, 2001). Local savannah and woodland fauna were also hunted. Although Allchin and Allchin (1974, 1997) have made a case for local domestication of zebu varieties in the South, this suggestion is not yet corroborated by archaeological bone evidence. Their argument is based on the morphology of rock art depictions which contrast with contemporary Harappan depictions and suggest varietal differentiation between southern and northwestern zebus was already established. Since this issue remains unresolved, I will opt for a more minimalist assumption that cattle were introduced from the north, since sheep and goats certainly were.

The author's recent archaeobotanical research has provided a picture of staple and likely secondary crops of the Southern Neolithic (Fuller, 2001a, 2003c, 2006a; Fuller, Korisettar *et al.*, 2001; Fuller, Venkatasubbaiah, & Korisettar, 2001; Fuller *et al.*, 2004). This is based on flotation samples from 12 sites, with additional material under ongoing analysis, forming a roughly east-west transect across Karnataka and Southwestern Andhra (Fig. 11). All the samples came from archaeological levels that coincide with Phases II and III in the Southern Neolithic chronology of Allchin and Allchin (1982), equivalent to 2200–1800 cal. BC and

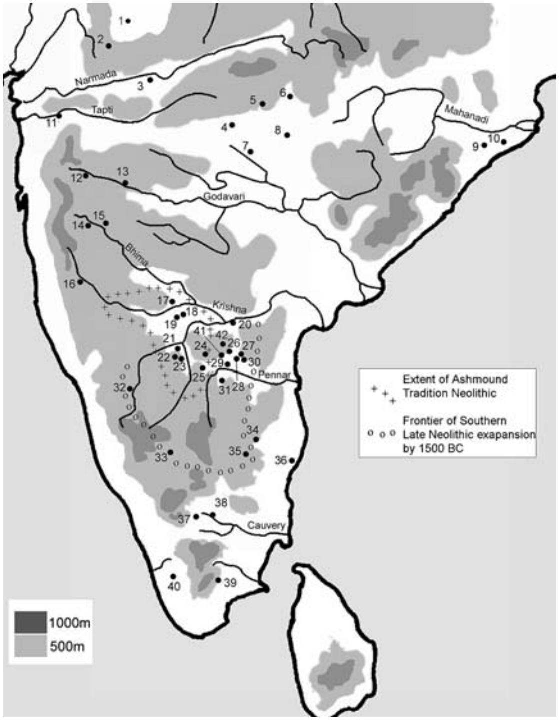

Fig. 11 Important sites for understanding the beginnings of agriculture in peninsular India, with archaeobotanical data. None of these sites begins before the mid-third millennium BC, and many are later. The Ashmound Tradition Neolithic zone and the frontier of later Neolithic expansion southwards are indicated. Sites labelled with numbers as per the following list, with sources for archaeobotanical and archaeozoological evidence. (1) Kayatha (*P*: Vishnu-Mittre *et al*., 1985; *A*: Alur, 1975). (2) Dangwada (*P*: Vishnu-Mittre *et al*., 1984). (3) Navdatoli (*P*: Vishnu-Mittre, 1961; *A*: Alur, 1973; Clason, 1979). (4) Tuljapur Garhi (*P*: Kajale, 1988a, 1996c; *A*: Thomas, 1992a). (5) Bhagimohari (*P*: Kajale, 1989a, 1989b; *A*: Thomas, 1993). (6) Naikund (*P*: Kajale, 1982). (7) Kharwada (*P*: Kajale, 1991; *A*: Thomas, 1992b). (8) Adam (*P*: Kajale, 1994a). (9) Golpapur (Harvey *et al*., in press; *A*: Kar, Basa, & Joglekar, 1998). (10) Golabai Sasan (*P*: Harvey *et al*., in press; *A*: Sinha, 2000). (11) Kaothe (*P*: Kajale, 1990a; *A*: Thomas & Joglekar, 1990). (12) Daimabad (*P*: Kajale, 1977; Vishnu-Mittre *et al*., 1986a, 1986b; *A*: Badam, 1986). (13) Apegaon (*P*: Kajale, 1979; *A*: Badam, 1979). (14) Walaki (*P*: Kajale, 1991; *A*: Joglekar & Thomas, 1993). (15) Inamgaon (*P*: Kajale, 1988b; *A*: Badam 1977; Thomas, 1988; Pawankar & Thomas, 1997). (16) Songaon (*P*: Kajale, 1991). (17) Budihal (*P*: Kajale & Eksambekar, 1997; *A*: Korisettar *et al*., 2001b). (18) Watgal (*P*: Kajale, personal communication; *A*: Korisettar *et al*., 2001b). (19) Piklihal (*P*: Fuller, under analysis; *A*: Allchin, 1960). (20) Veerapuram (*A*: Kajale, 1984; *A*: Thomas, 1984b). (21) Tekkalakota (*P*: Fuller, Korisettar, *et al*., 2001, 2004; *A*: Korisettar *et al*., 2001b). (22) Kurugodu (*P*: Fuller, Korisettar, *et al*., 2001a, 2004; *A*: Korisettar *et al*., 2001b). (23) Sanganakallu and Hiregudda (*P*: Fuller, Korisettar, *et al*., 2001, 2004; *A*: Korisettar *et al*., 2001b). (24) Hattibellagallu (*P*: Fuller, Korisettar, *et al*., 2001, 2004; *A*: Korisettar *et al*., 2001b). (25) Velpumudugu (*P*: Fuller, Korisettar, *et al*., 2001, 2004; *A*: Korisettar *et al*., 2001b). (26) Singanapalle (*P*: Fuller, Venkatasubbaiah, *et al*., 2001, 2004). (27) Rupanagudi (*P*: Fuller, Venkatasubbaiah, *et al*., 2001, 2004; *A*: Venkatasubbaiah, Pawankar, & Joglekar, 1992). (28) Injedu (*P*: Fuller, Venkatasubbaiah, *et al*., 2001, 2004; *A*: Venkatasubbaiah *et al*., 1992). (29) Hanumantaraopeta (*P*: Fuller, Venkatasubbaiah, *et al*., 2001, 2004; *A*: Venkatasubbaiah *et al*., 1992). (30) Peddamudiyam (*P*: Fuller, Venkatasubbaiah, *et al*., 2001, 2004; Venkatasubbaiah & Kajale, 1991; *A*: Venkatasubbaiah *et al*., 1992). (31) Bilijapalle (*P*: Venkatasubbaiah & Kajale, 1991; *A*: Venkatasubbaiah *et al*., 1992). (32) Hallur (*P*: Fuller, Korisettar, *et al*., 2001, 2004; Kajale, 1989a, 1989b; *A*: Korisettar *et al*., 2001b). (33) Koppa (*P*: Vishnu-Mittre, 1989). (34) Kunnatur (*P*: Vishnu-Mittre, 1989). (35) Paiyampalli (*P*: Kajale, 1991). (36) Arikamedu (*P*: Wheeler, Ghosh, & Deva, 1946; *A*: Chatterjee & Bose, 1946). (37) Perur (*P*: Cooke *et al*., 2005). (38) Kodumanal (*P*: Cooke *et al*., 2005; Kajale, 1994b). (39) Mangudi (*P*: Cooke *et al*., 2005). (40) Adichannalur (*P*: Vishnu-Mittre, 1989). (41) Ramapuram (*P*: Venkatasubbaiah & Kajale, 1991; *A*: Thomas & Joglekar, 1994). (42) Sanyasula Gavi (*P*: Fuller, under analysis)

1800–1200 cal. BC respectively (cf. Deveraj, Shaffer, Patil, & Balasubramanya, 1995). As of yet few non-ashmound occupation sites that can be clearly referred to Phase I are known from south of the Tungabhadra river, although such sites are known in the Raichur Doab, such as at Watgal (Deveraj *et al*., 1995) and Piklihal (Allchin, 1960), but archaeobotanical evidence is not yet available from these sites. Nevertheless, the consistency of the studied samples suggest a widespread Southern Neolithic crop suite that presumably was already established during Phase I.

This package includes 2 small millets and 2 pulses. The millets have been identified as being primarily from two species, *Brachiaria ramosa* and *Setaria verticillata*, species known to be utilised on only a small scale today (De Wet, Prasada Rao, & Brink, 1983a; De Wet, 1995; Pandey & Chanda, 1996, p. 26; Kimata, Ashok, & Seetharam, 2000). The consistently recovered pulses are two species native to the region, mungbean (*Vigna radiata*) and horsegram (*Macrotyloma uniflorum*) present from the earliest levels, while other pulses appear only in later levels. Other species are sporadic across the region or else present only in Phase III suggesting that these species were adopted by selected communities during the course of the Neolithic. These include non-native taxa, such as wheat and barley, possibly rice (found in small quantities only at Hallur), hyacinth bean (*Lablab purpureus*, probably a native of East Africa), African pearl millet (*Pennisetum glaucum*) and pigeonpea (*Cajanus cajan*, from Orissa or adjacent parts of eastern India, see Fig. 5). Thus the staple taxa of the Southern Neolithic, on which the earliest agriculture in this region is likely to have been based, are native species, presumably domesticated within South India independent of the introduction of agriculture from elsewhere (Fuller, 2001a, 2003c, 2006a, 2006b, 2006c; Fuller, Korisettar *et al*., 2001, 2004). In addition cotton and a single grain of African finger millet (*Eleusine coracana*) were identified from late Neolithic samples from Hallur, dating at the end of the second millennium BC. The latter sample also contained linseed, a Southwest Asian domesticate.

The basic Southern Neolithic crop package can be interpreted as a case of local domestication on account of the distribution of the wild forms of these species in the region. In addition the documented Southern Neolithic crops there are a number of other probable domesticates of the Indian peninsula (Table 4). The wild progenitor of mungbean is known to occur in the wet and dry deciduous forests on the eastern edge of the Western Ghats in clearings and forest edge habitats (Fuller & Korisettar, 2004), but also occurs sporadically in parts of the eastern ghats (author's recent data: Fig. 5). While recent hypotheses have suggested that the southern Neolithic mungbean was domesticated in the Western Ghats area (Korisettar, Venkatasubbaiah *et al*., 2001; Fuller & Korisettar, 2004; Fuller, 2006a, 2006b, 2006c), this area in fact provides both wild mung and urd and thus why only mung became a major crop of the Southern Neolithic seems curious. Thus it might be the case that isolated populations of hills east or northeast of the Southern Neolithic zone might have provided domestication zones where only wild mung occurred. Meanwhile horsegram is native to *Acacia* thickets ranging from the Aravalli hills in Rajasthan through the savannahs of the Southern Peninsula (author's recent data: Fig. 5). It is within the dry deciduous zone, and to some extent the thorn-scrub, where the wild millet-grasses would have been available as resources before they were cultivated. It can further be suggested that these wild progenitors may have been more widespread during the mid-Holocene climatic wet phase, and the reduction of their availability during aridification that began in the later fourth millennium BC may be connected to their domestication and the emergence of the Southern Neolithic (Fuller & Korisettar, 2004; Asouti *et al*., 2005; Fuller, 2006a, 2006b, 2006c).

The existence of an apparently native cultivation system together with introduced domestic animals (which sheep and goat certainly were) raises the question of how, when, and

Table 4 List of field crop species and selected fruits that are candidates for domestication in Peninsular India

Crop	Common name	Region of origin/comments
Millets		All widespread in peninsular India
Brachiaria ramosa (L.) Stapf.	Browntop millet, pedda-sama (Telegu), kadu-baragu (Kananda)	Dry deciduous forest clearings, savanna zone streams, north-facing slopes. Southern Neolithic Zone (also Vindhyas?)
Seteria vertcillata (L.) P. Beauv	Bristley foxtail millet	Dry deciduous forest clearings, savanna zone streams, north-facing slopes. Southern Neolithic Zone (also Vindhyas?)
Setaria pumila (Poir.) Roem. & Schult	Yellow foxtail millet, korali (Tel./Kan.)	Dry deciduous forest clearings, savanna zone streams, north-facing slopes
Panicum sumatrense Roth. ex Roem. & Schult	Little millet, samai (Tamil), nella-chamalu (Telegu)	At least one domestication in Gujarat (?)
Paspalum scrobiculatum L	Kodo millet, Varagu (Tamil), arikelu (Telegu)	Secondary domestication of Gangetic rice weed(?)
Echinochloa colonum (L.) Link	Sawa Millet, bonta chamalu (Telegu)	Secondary domestication of rice/ millet weed(?)
Pulses		
Vigna mungo (L.) Hepper	Black Gram, Urd	Wet-dry deciduous forests, especially northern Western Ghats
Vigna radiata (L.)	Green Gram, Mung	Wet-dry deciduous forests, especially southern Western Ghats, or Eastern Ghats
Macrotyloma uniflorum (Lam.) Verdcourt	Horsegram, Kulthi	South Asia: savannahs or dry deciduous woodlands. Wild in western India and Deccan
Abelmoschus ficulneus (L.) Wight & Arnot	Wild okra	One of the likely genome donors of domestic okra. Wild in northwest through Deccan
Tubers		
Dioscorea spp.	Yams	Wild species in forests, could include *D. bulbifera* (?)
Fruits		Available wild in region, but currently and traditionally cultivated
Ziziphus mauritania Lam	Ber, Indian jujube, regu (Telegu)	Throughout semi-arid zones, from Deccan through northwest India and Pakistan
Cordia dichotomoa Forst. (syn. *C. myxa* auct. Pl.)	Sebesten plum, nekkera (Telegu)	Wet/Dry deciduous forests
Phyllanthus emblica L.	Emblic myrobalan, nelli (Telegu)	Wet/Dry deciduous forests
Buchnania lanzan Spreng.	Cuddapah almond, morli (Telegu)	Dry deciduous forests
Syzigium cumini Skeels.	Indian jambos, neredu (Telegu)	Wet/Dry deciduous forests and riverine groves

Table 4 Continued

Crop	Common name	Region of origin/comments
Limonia acidissima L.	Elephant apple, wood apple, velãga (Telegu)	Deccan hills or Himalayan foothills
Aegle marmelos (L.) Corr.	Bael, Bengal quince, maredu (Telegu)	Himalayan foothills or Western Ghats
Mangifera indica L.	mango	Wild in Western Ghats rainforests. Large-fruited sweet varieties probably introduced from northeast Indian domestication

where an integrated agropastoral system developed in South India. The earliest evidence for this integration comes from the Ashmound Tradition, but the botanical ecology of the crops involved suggests that they are likely to have been cultivated first in an adjacent region, such as the eastern hils between the Krishna and Godavari rivers. This region is largely unexplored archaeologically. Work in this region should be a priority if we are to understand the beginnings of agriculture in South India. By this logic the Ashmound Tradition seems likely to represent the outcome of a process of cultural interaction and economic development of earlier cultivators, either through interaction with immigrant pastoralist-foragers or the adoption of livestock from such groups in the north central Deccan. Archaeological evidence for this process remains elusive and constitutes part of the wider problem of poor archaeological visibility of the early to mid-Holocene "Mesolithic" cultures of India.

As more sites of the Southern Neolithic have been investigated in recent years, it has become increasingly apparent that full sedentism develops and spreads during the course of the Neolithic and thus develops after the advent of pastoralism and presumably cultivation. In the three phase chronology of the Southern Neolithic (Allchin & Allchin, 1982, p. 287; Korisettar, Venkatasubbaiah *et al.*, 2001, pp. 181–185), sites attributable to the first phase (before 2300–2200 BC) consist almost exclusively of ashmound sites that represent cattle-penning and encampment sites (Fuller *et al.*, in press-a). While the recently excavated settlement site of Watgal dates back to this period, the reported deposits from the earliest levels suggest cycles of occupation and abandonment, the latter represented by probable natural water-laid layers of the rainy season (cf. Deveraj *et al.*, 1995). The later phases of this site (IIB onwards), which are suggestive of sedentary occupation, date from 2300/2200 BC. It remains unclear how sedentary the earliest occupation of Piklihal was, as it is represnted by thin stratigraphic deposits and burials in a single locality of what becomes a much more extensive complex of stratified sites (personal observations at the site; cf. Allchin, 1960). Recently published radiocarbon data from the excavation at Budihal (Paddayya, 2001), indicates a tight focus for ashmound deposits at ca. 2300–2200 cal.BC. By contrast, the other site areas, such as that with hut structures may begin during this period and continues into the second millennium BC, but provides no evidence for intensive, sedentary occupation at an earlier period. It is during this same period, beginning ca. 2300–2200 BC through ca. 1900 BC that numerous village sites, many located on granite hilltops, come into occupation indicating the widespread establishment of sedentary farming villages (Korisettar, Venkatasubbaiah *et al.*, 2001; Fuller, 2001a, 2001b, 2003d; Boivin, Korisettar, & Fuller, 2005; Fuller *et al.*, in press-a). What is striking about the sites from this period, is that all those which have been systematically sampled for plant remains have produced the same recurrent assemblage of millets and pulses, strongly suggesting that the beginnings of the cultivation of the species dates to an earlier period, when more mobile communities left few archaeological deposits that provide for archaeobotanical sampling. A challenge for future research is to find and better document sites relating to this pre-sedentary period, and to therefore investigate the advent of both livestock and crop cultivation.

Once established the millet-pulse-livestock agriculture of the Ashmound Tradition dispersed southwards and eastwards to adjacent regions. Evidence from the Kunderu river basin, just beyond the eastern distribution of the ashmounds indicates that the same subsistence package was established by sometime in the second millennium BC (Fuller, Venkatasubbaiah, *et al.*, 2001b). The cultural differences, in terms of the lack of ashmounds and some distinctive aspects of ceramic style, might suggest that this represents cultural diffusion, as hunter-gatherer groups of the Erramalai hills and adjacent valleys adopted agriculture from their Ashmound Tradition neighbors. While the presence of hunter-gatherers in the recent colonial past in some areas (such as the Nallamalai hills) could indicate the persistence of non-agricultural traditions. In some cases hunter-gatherers are specialist producers within a wider cultural network of exchange, as the example of pepper procuring forager-traders of the late Medieval/early colonial period indicates (Morrison, 2002b). Hard evidence in Southern Karnataka and Tamil Nadu is still lacking to understand the dynamic processes of foragers becoming farmers, generalized foragers becoming specialist foragers, or even farmers becoming foragers.

Despite the establishment of agriculture in the Southern Deccan of Karnataka in the third millennium BC, evidence further South in Tamil Nadu (and presumably Kerala) suggests a much later adoption of agriculture (Fig. 12). Hard evidence is extremely limited, although evidence for rice has been reported from sites of the Early Historic period (300 BC–AD 300), such as at Arikamedu, Kunnatur and Adichanalur (Kajale, 1991; Fuller, 2002). The emergence of early historic polities in South India at the end of the first millennium BC, the Cholas, Pandyas and the Cheras, necessarily implies an agricultural basis. At least for these coastal polities rice seems to have been important (indicated also by early Tamil Sangam literature, Zvelebil, 1975; Smith, 2006), and presumably this rice spread to south India during the Iron Age immediately prior to the emergence of urban/state centers (cf. Fuller, 2002). Also relevant is the report of colluvium of megalithic (Iron Age) date near Pondicherry, as this suggests forest clearance for agriculture (Achyuthan, Ghate, Deo, & Mishra, 2001). This agricultural spread probably represents the dispersal of a cultivation system from coastal Orissa, which probably included taro tubers (*Colocasia esculenta*) as well as rice. Today this same cultivation system, focused on rice but with field-edge and feral taro continues around the tip of the peninsula and up the Malabar-Konkan coast of western India but is absent from most of the Deccan interior.

In inland Tamil Nadu, early historic texts suggest pastoralism and millet cultivation (Zvelebil, 1975), and archaeological survey (cf. Selvakumar, 1996; Rajan, 1997) suggests the shift towards these forms of food production was during the Megalithic and Early Historic periods. Clearly sedentary village communities may become established only in the late Megalithic/early Historic period, ca. 300–100 BC. Recent systematic sampling on the early Historic sites of Perur, Kodumanal and Mangudi suggests that the Southern Neolithic crops were important in this region, in addition to other Indian millets, African millets (*Eleusine* and *Pennisetum*) and pulses and, for some sites, rice (Cooke, Fuller, & Rajan, 2005). While much more archaeobotanical sampling and analysis is necessary, the regions of inland Tamil Nadu and the far southern peninsula can be seen as a broad static frontier zone. Local hunter-gatherers during the first millennium BC began to adopt elements of pastoralism and cultivation and become incorporated into the trade-networks of early coastal polities. It is unclear the extent to which this was primarily an indigenous transformation of

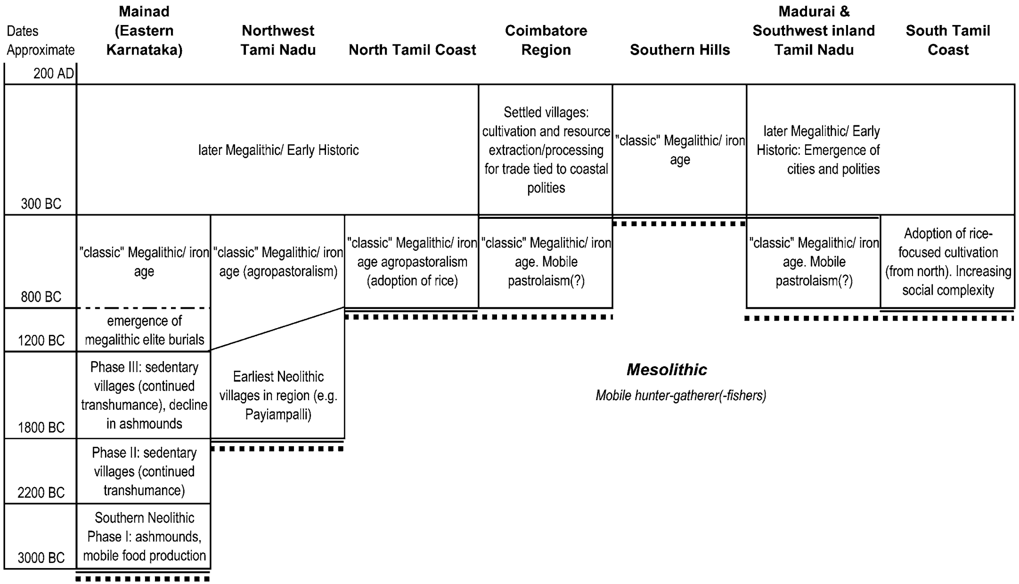

Fig. 12 Archaeological chronology of later prehistoric Tamil Nadu, indicating probable periods of agricultural beginnings as boxed phases. Shown in relation to the chronology the South-Central Deccan (Mainad) region where the Ashmound Tradition was located. The Southern Hills, refer to the Nilgiri and Anamalai Hills

foragers or whether coastal polities provided agricultural colonists in inland areas. It is within this context that southernmost India appears to have developed shared linguistic, literary, and cultural traditions, predominantly non-vedic and non-Sanskrit in origin.

One intriguing implication of the Southern Neolithic data is its difference from Chalcolithic societies of Maharashtra (Fuller, 2003d, 2005). While most of the sites with data are equivalent to Phase III of the Southern Neolithic, i.e. Malwa and Jorwe cultures, systematic studies by Kajale indicate the widespread dominance of the Southwest Asia/Harappan crop package, in addition to summer pulses such as horsegram, *Vigna* spp., and the African hyacinth bean (for sites see Fig. 11). Small millets are also present, although taxonomic identification requires clarification before it can be clearly established whether these are the same taxa as those of the Southern Neolithic, or of Gujarat, or include African finger millet. In any case, the implication of these data is that there must have been a significant agricultural frontier somewhere between the sampled Southern Neolithic sites and Maharashtra cultures at least from the later third millennium BC. This would imply that diffusion both northwards and southwards between these regions must have occurred in crops, and indeed is also indicated in ceramic types (see Korisettar, Venkatasubbaiah *et al*., 2001; Fuller, 2005). Whether in an earlier period, for which there is not good archaeological data in Maharashtra, there may have been a more purely South Indian agriculture, or a 'Harappan' style of agriculture is not clear. The only possible site from this period in Maharashtra with archaeobotanical data is Kaothe (Kajale, 1990b), although it is more likely to date to Late Harappan (early second millennium BC) times. Although connected to the Harappan tradition in terms of ceramic parallels (Dhavalikar, Shinde, & Atre, 1990), it has an atypical crop package, either for the Harappans or later sites in the region, with significant presence of African sorghum and pearl millet (although some concerns over contamination must be kept in mind). Nevertheless, it is notable that this site also has only native summer pulses, urd and horsegram, which might suggest that there is a pure monsoon-cropping system that precedes the adoption of winter crops from the northwest. These winter crops must have arrived via the Malwa plateau from Rajasthan given that they are largely absent from Gujarat. This would then suggest another agricultural frontier somewhere in the Malwa plateau or northern Mahrashtra.

Concluding discussion

Hard evidence for the early agriculture in South Asia, especially from well-dated crop remains, is scarce for a region so large. Nevertheless, the available evidence for both plants and animals suggests certain patterns, and the intention of the present synthesis is to suggest hypotheses that can be tested and revised through modern, problem-oriented fieldwork. South Asia appears to have been host to a mosaic of processes, including local domestication of plants and animals, the dispersal of pastoral and agro-pastoral peoples between regions, and the adoption of food production by indigenous hunter-gatherers from neighbouring cultures. In Fig. 13, the regional patterns discussed in this paper are summarized. In the latter, I have attempted to indicate possible centers of domestication, as well as important frontiers. These frontiers include the moving frontiers of spreading food-producing populations and the static frontiers of interactions across which local hunter-gatherers are likely to have acquired crops and animals. In Fig. 14, possible natural frontiers defined by climatic and other geographical factors are highlighted. These of course represent modern geography under modern climatic conditions, and what is needed in order to understand their possible contribution to structuring agricultural origins is targeted Quaternary research that attempts to understand these patterns in previous periods. In some regions frontiers may have been

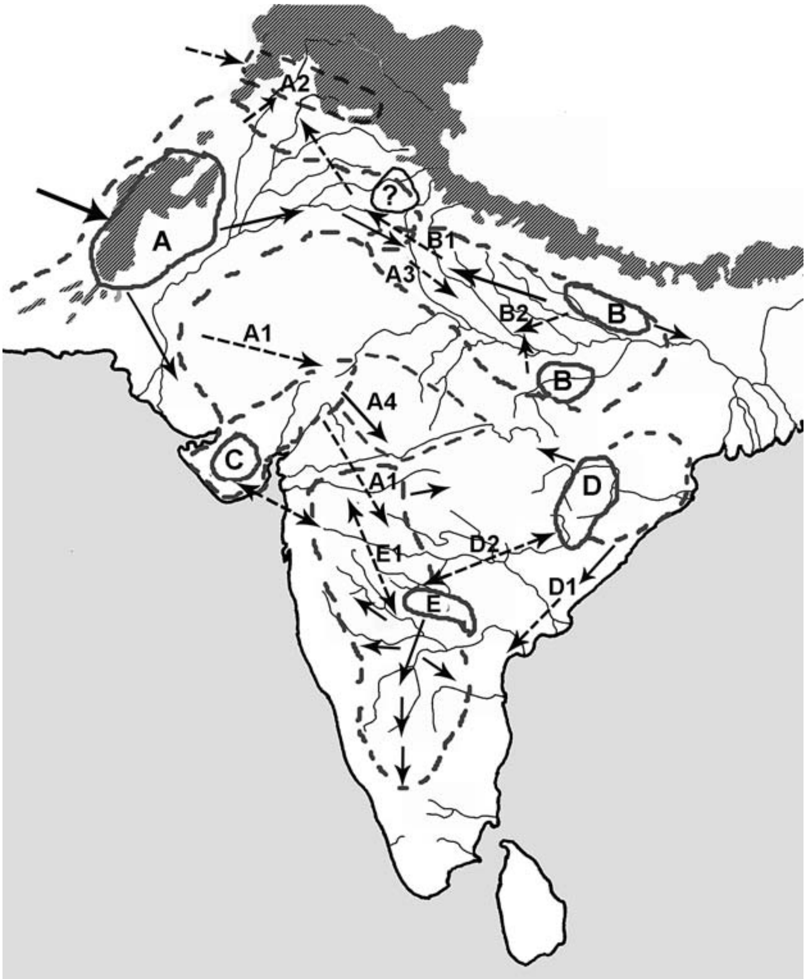

Fig. 13 A synthetic view of early agricultural origins and dispersals in South Asia. Regions of probable local domestications outlined in solid lines, adjacent early spread areas of the same agricultural package indicated by dashed lines. Agricultural package dispersals (probable moving frontiers) indicated by arrows, diffusion across likely static frontiers indicated by dashed arrows. Selected "events" labelled: A. Early zone of agro-pastoralism of Southwest Asian origin, with some local domestications (zebu cattle, cotton, sheep?). A1. possible dispersal of pastoralism without Southwest Asian cultivars, across the Thar and down the peninsula; A2. Diffusion of agricultural package into aceramic Kashmir/Swat; A3. Diffusion of crops and livestock into Gangetic agricultural zone. A4. Expansion of Ahar (and Kayatha?) winter agriculture; B. Middle Ganges centre(s) of domestication, with dispersal through the Gangetic plain. B1. Diffusion of rice into the Indus agricultural zone and beyond to Swat, B2. Diffusion of rice and millets into the aceramic Mesolithic of the central plains. C. Saurashtra zone of probable plant domestication. D. Probable zone of Eastern "Munda" domestication, D1. Dispersal and later diffusion rice along the coastal plain, D2. Two-way diffusion of pulses, and millets(?), between the Peninsular and Eastern zones, E. Southern domestication centre of small millets and pulses, with phased southward dispersal indicated, E1. Diffusion between Chalcolithic North Deccan and the Southern Neolithic. The likely zone of millet and pulse domestication in the upper Sutlej basin is indicated with a question mark, although these could represent secondary domestications by Near Eastern crop farmers

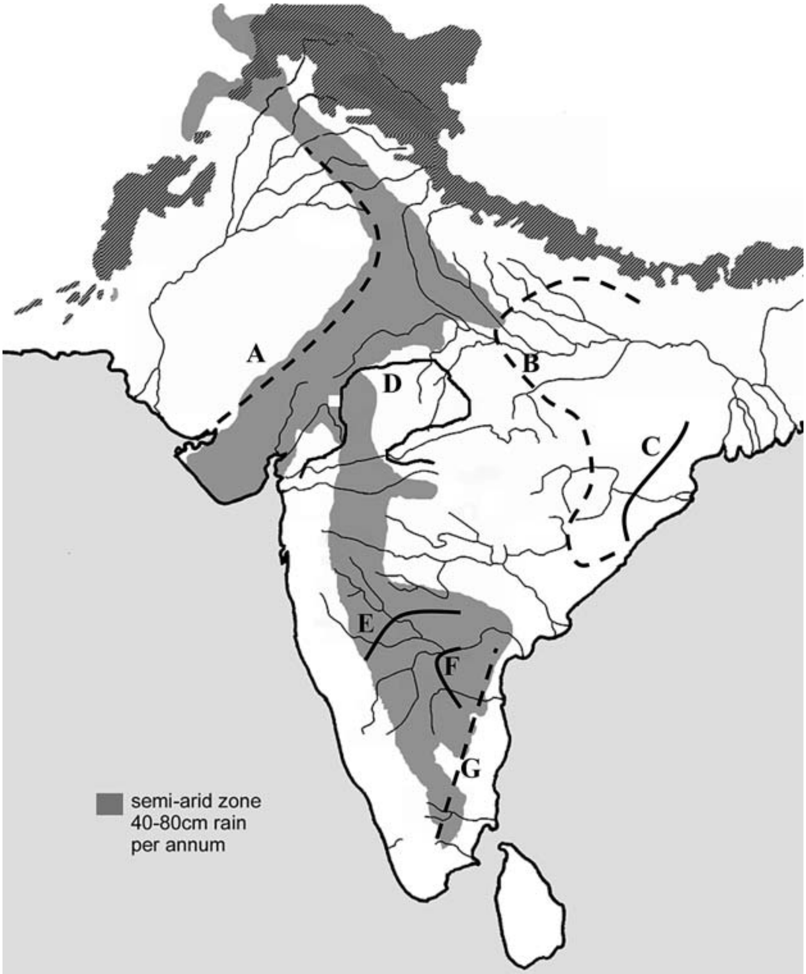

Fig. 14 Major natural frontiers that contributed to the geography of agricultural origins in India: solid lines, geological; dashed lines, climatically-controlled; A. The western boundary of sufficient monsoon rainfall for reliable dry-cropping; this boundary is likely to have shifted further eastwards during the mid-Holocene; B. The western margins of the distribution of annual wild rice, *Oryza nivara*; this frontier might have retreated eastward with aridification towards modern conditions; C. The frontiers between the Orissan uplands and the coastal plain; D. The northern frontier of the Deccan traps and water-retentive black cotton soils; E. The transition from the black clay soils of the Deccan Traps (north Deccan) and the sandy soils of the South Deccan Archaean rocks; F. Erramalai hill ranges which separate the granitic South Deccan from the quartzites, limestones, shales and dark soils of the Cuddapah-Kurnool region; G. the transition between predominantly summer monsoon and important input from northeast winter monsoon

multidimensional with interactions between two or more different food-producing cultural traditions as well as hunter-gatherers. The evidence from Orissa is suggestive of this, as are parts of the Southern Peninsula where hunter-gatherers could choose from coastal-focused rice-based agriculture and the Deccan millet-pulse package.

Important contrasts in settlement location, however, can be drawn between South India and other zones. Whereas the Ganges Neolithic, pre-Harappan cultures of the greater Indus, or the

Neolithic/Chalcolithic of Rajasthan and Gujarat had settlement patterns largely focused on perennial waterways, especially rivers, the Southern Neolithic sites are consistently located away from major rivers. The granitic hills of the Southern Neolithic zone had springs, but the landscape context of sites suggests that monsoon rainfall rather than river level fluctuations would have been primary to millet and pulse cultivation in South India. Maharashtra, with its winter (dry season) crops followed a riverine pattern.

The current evidence for agricultural origins in South Asia provides a new set of similarities and contrasts for comparative studies of agricultural origins. The South Asian trajectories towards agriculture can be compared to other regions in terms of the ordering of the trajectory, which I will consider under three headings: first, the relationship of early cultivation to animal herding, then the relationship with sedentism, and the origins pottery. Finally I will consider aspects of causation in comparative context.

Cultivation and pastoralism

Based on the intensively studied Southwest Asia record, the origins of agriculture is usually phrased in terms of two transitions, of the development of cultivation amongst foraging gatherer-hunters, and herding amongst hunting cultivators (Crabtree, 1993; Harris, 1996, 1998a; Bar-Yosef & Meadow, 1995; Bar-Yosef, 2000; Moore *et al*., 2000) as evidence for cultivation and crop domestication clearly precedes herding. Such evidence is thus congruent with arguments that there are few, if any, societies which have been purely based on domesticated animals, and self-sufficient without relying on support from agricultural produce (Wright, 1971, p. 112; Barth, 1973; Chang & Koster, 1986; Sadr, 1991, pp. 2–11; MacDonald, 1999, p. 336; Meadow & Patel, 2003, p. 75). Nevertheless, pastoralism seems to have existed in the absence of agriculture, as evident in the case of parts of Africa. In the early to mid-Holocene Sahara cattle herding may have begun before 7000 BC, at a time when no domesticated plants are known from the region, and sheep, goat and cattle become widespread amongst hunter-foragers across the Sahara and sub-Saharan zone during the mid-Holocene (Wendorf & Schild, 1994; Close, 1995; Bower, 1996; Wetterstrom, 1998; Marshall, 1998; Marshall & Hildebrand, 2002; Cremaschi & Di Lernia, 1999), and even later in Southern Africa (Sadr, 2003). Despite attempts, such as that by Wetterstrom (1998) to explain this away by positing ‘proto-cultivation’ of sorghum at Nabta Playa, most of the sites across the Sahara with archaeobotanical evidence indicate grass-seed foraging and limited herding of cattle together with hunting, with evidence of plant domesticates and more sedentary sites only from the third or early second millennium BC (Neumann, 2003, 2004). In the high Andes of Peru, available evidence suggest that hunter-gatherers gradually brought camelids (llama/alpaca) under control through an *in situ* domestication process in the mid Holocene, but they utilized entirely wild plants (Wing, 1977; discussed in Burger, 1992, pp. 43–44; Pearsall, 1992, p. 197). Subsequently sedentism emerged and camelid herds were integrated into economies of cultivators at lower elevations (cf. MacNeish, 1977). Although patchy, and limited by methodological problems of identification, the evidence from India suggests that pastoralism spread amongst hunter-foragers of the semi-arid scrub/savannah zones during the mid-Holocene prior to the emergence of agriculture.

Sedentism

Since Childe’s (1936) discussion of the Neolithic revolution, sedentism has been associated with the advent of farming. For example, in Smith’s (1995) worldwide survey of agricultural origins, he sees sedentism in resource rich environments, and near natural water sources as a regularity in the development of seed crop agriculture. While the Near Eastern evidence generally points towards sedentism before the beginnings of cultivation and subsequent plant domestication, this is not globally the case. Models of agricultural origins based on the Southwest Asian evidence generally agree that sedentism preceded agriculture. In that region, sedentism probably goes back to the late Pleistocene, Natufian period (Henry, 1989; Lieberman, 1993; Bar-Yosef & Meadow, 1995; Harris, 1998a; Willcox, 1999; Moore *et al*., 2000.).

In several other regions of the world, however, year-round sedentism and increasing occupational duration appears to be more a consequence of the beginnings of food production than part of the cause. In Saharan and sub-Saharan Africa, during the wetter early Holocene, groups are clearly seasonally mobile (Wendorf & Schild, 1994; Close, 1995; Bower, 1996; Wetterstrom, 1998; Marshall, 1998; Marshall & Hildebrand, 2002; Cremaschi & Di Lernia, 1999). In parts of northwestern Europe, such as England, where agriculture clearly derives from introduced domesticates much recent scholarship points towards seasonal mobility, and the strong possibility that crops may have been less important relative to livestock and wild plant resources than was the case in subsequent Bronze Age or Iron Age societies (Whittle, 1999; Thomas, 1999a, 1999b, pp. 7–33; Robinson, 2000; Stevens, 2006; but cf. Rowley-Conwy, 2004). Despite some uncritical claims for early sedentism in China, the earliest finds of ceramics in south China, as well as early finds of rice—not necessarily domesticated (Zhao, 1998; Cohen, 1998, 2002; Yasuda, 2002; Yuan, 2002; Toyama, 2002; Kuzmin, 2006), come from cave sites that are suggestive of seasonally mobile groups. Yasuda (2002, p. 124) makes the assumption that the presence of ceramics indicates sedentism. Indeed early ceramics and cave-dwelling generally are assumed to indicate sedentism in east Asian archaeology (also, Kobayashi, Kaner, & Nakamura, 2004, p. 100), although Kuzmin (2006) calls into doubt sedentism. What is striking is the contrast between the rarity of early Neolithic sites, with exception of a few caves, by contrast to the extensive and numerous Middle Neolithic sites (broadly 7000–5000 BC: Pengtoushan/Bashidang, Lower Zaoshi culture, Kuahuqiao Culture, Shangshan Culture) that represent clear villages with architecture and occupational longevity (Cohen, 1998; Lu, 1999; Pei, 1998, 2002; Jiang & Liu, 2006), but not necessarily with domesticated crops (Fuller *et al*., in press-b). Similarly, in Japan abundant Middle Jomon pit-houses indicate increased population, settlement size and sedentism (Imamura, 1996, pp. 93–99). Models of agricultural origins in Mesoamerica have long-posited that it was mobile hunter-gatherers who began to manipulate proto-domesticates (e.g. MacNeish, 1992; Flannery, 1973).

The current evidence from India suggests the beginnings of cultivation amongst non-sedentary societies in both South India and in the Gangetic basin. If there is indeed pre-cultivation pastoralism in parts of Gujarat and Rajasthan it is also unsettled. Similar pre-sedentary early agriculture might be the case for other regions as well, such as Orissa or the earliest (still undocumented) phase of the Eastern Harappan zone. Indeed, one of the serious challenges faced by archaeological investigation of early agriculture in India is that well-preserved plant and animal remains have tended to be recovered from the more archaeologically visible sites of sedentary villagers, i.e. sites that are occupied for most or all of the year and continuously for many generations, rather than shorter occupation seasonal sites or settlements that are shifted after a few years (as we would expect of shifting-cultivators). More archaeologically obvious, and more sedentary, sites only become evident from the mid or late third millennium BC to early second millennium across most of India. At all such sites investigated so far, we have evidence for a full complement of livestock and crops, implying that the origins of domesticates and the integration of cultivation and pastoralism must have occurred earlier amongst less archaeologically visible, mobile communities.

Pottery and the Neolithic

In other parts of the world cases can be found in which agriculture precedes pottery as well as cases when ceramics were developed by hunter-gatherers prior to food production (Rice, 1999). The pre-ceramic evidence for domesticated crops and livestock in the Levant is well known (e.g. Bar-Yosef & Meadow, 1995). In diverse regions the adoption of cultivation also preceded potting, as in the case of the American Southwest (Crown & Wills, 1995; Plog, 1997) and eastern North America (Smith, 1992, 1995). On the western desert coast of Peru, plant cultivation precedes ceramics by at least a millennium, while in the highlands probable animal domestication is similarly pre-ceramic (Burger, 1992, pp. 28–33, 42–45; Pearsall, 1992). Also the earliest agriculture in Pakistan at Mehrgarh, based on crops from Southwest Asia, was similarly carried out by a community without pottery, prior to 6000 BC. In most of India pre-ceramic cultures are too poorly understood to address whether they practiced any food production or not.The suggested early adoption of livestock of the Gujarat/Rajasthan margins of the Thar Desert might have occurred in pre-ceramic contexts, e.g. at Bagor, but this is unconfirmed, whereas at Loteshwar the earliest domesticated cattle are associated with pottery (cf. Ajithprasad, 2004).

On the other hand, there are well-documented instances of ceramics without food production. For example, the Jomon culture of Japan had pottery prior to evidence for clearly domesticated crops for at least 10,000 years (Imamura, 1996; Crawford, 1997; D'Andrea, Crawford, Yishizaki, & Kudo, 1995; Kobayashi *et al*., 2004), with even earlier pottery in the Russian Far East (Tsutsumi, 2002, pp. 247–249; Kuzmin, 2006), and of comparable dates in parts of South China (Yasuda, 2002; Yan, 2002; Kuzmin, 2006). Early pottery of the Sahara precedes domestic plants and animals in many regions, although it may have initially developed in the Eastern Sahara in the context of hunter-cattle herders gathering wild grasses (Close, 1995; Marshall & Hildebrand, 2002; Jesse, 2003; Neumann, 2004; Jousse, 2004). Cultivation then began in the southern Saharan fringes once ceramics and livestock diffused to the area, or entered with immigrant pot-making herders (MacDonald, 1999; Marshall & Hildebrand, 2002; Neumann, 2004). In the tropical lowlands of South America pottery begins in some local traditions ca. 4000–3500 BC, amongst forager-fishers (Roosevelt, 1995; Oyuela-Caycedo, 1995). Indeed, Rice (1999, pp. 34–36) argues that it is amongst storing hunter-gatherers that pottery may be expected to develop.

Thus there are numerous instances in which ceramics were in use by mobile societies, that were predominantly, if not entirely, hunter-gatherer. This comparative perspective counsels caution in jumping to the conclusion that 5000–7000 year old pottery in the middle Ganges region (Lahuradewa) is connected to rice agriculture. Rather this may represent the first steps of technological intensification of the exploitation of wild rices by hunter-gatherers. It seems clear that in the other traditions of the Gangetic region, represented by Chopani-Mando, ceramics were manufactured by hunter-gatherers.

Diverse trajectories to pottery are suggested by the South Asian record. In the northwest cultivation and herding are pre-ceramic. For some groups in the Ganges, represented by the Central Plains lakes Mesolithic (e.g. Damdama), crops are adopted amongst aceramic groups. A contrast to adjacent regions which have early forager ceramics. Interestingly, it is plausible that ceramics and livestock spread together through Gujarat, whereas in South India the early economic association of the first pottery is unclear.

Causal comparisons

Although the limitations of the evidence, especially for actual transitions from wild procurement to production based on domesticates, preclude a clear understanding of the causes of agricultural origins in South Asia, a few comparisons with other global regions can be suggested. Perhaps the most widespread explanatory paradigm for agricultural origins is a model of "food stress" in which an imbalance between population density and food resources resulted in intensified reliance on particular species that become domesticated. In the best-studied Near Eastern scenario, it is clear that climatic changes, the Younger Dryas, contributed to this by reducing wild food resources during a period when sedentary populations were at record highs (see Hillman *et al*., 1996; Bar-Yosef, 1998; Harris, 1998a; Moore *et al*., 2000; Hillman *et al*., 2001; Bar-Yosef & Belfer-Cohen, 2002). Although the timing was very different, it is plausible that similar processes were at work in the semi-arid tropical regions of South Asia as the mid-Holocene wet phase ended, forests retracted and drier environments became more widespread. For a model of this process in South India, see Fuller and Korisettar (2004). It is striking that the emergence of widespread sedentary farming villages across much of India occurs during the 2500–1800 BC window during which modern climatic conditions set in (Madella & Fuller, 2006). A parallel can be drawn to the situation in sub-Saharan Africa, where cultivation became established as the desert expanded (cf. Marshall & Hildebrand, 2002; Neumann, 2003). In addition, many early crops native to India, including its pulses and small millets, do not form dense and extensive stands in the same way as is reported for the wild cereals of the Near East, and thus rather different ecological parameters may be at work. Rice, on the other hand, may provide a better analogue to the wild wheat and barley stands, although its distribution was affected not just by changing rainfall patterns but by changes in the Gangetic river system as numerous palaeochannels became restricted to oxbow ponds (Singh, 2002, 2005a, 2005b). Of particular importance are shifts in the water systems, from more meandering channels to oxbow ponds, for their impact on the availability of different species of wild rice, and it can be suggested that the shift towards oxbows might have increased the distribution of monsoonal, rather than marshland, wild rices, including *Oryza nivara*, the progenitor of *indica* rice.

The patchy nature of many Indian wild progenitors, the fact that their cultivation may have begun during the mid-Holocene, and the subsequent rise to prominence of introduced crops over local domesticates suggests some parallel processes to those documented for North America. The similarities between the situation in India and the emergence of cultivation in Eastern North America during a similar period when woodland-prairie margins shifted and patterns of alluviation changed (cf. Smith, 1992), warrants further consideration. Nevertheless, as noted, the actual beginnings of cultivation in India precede this and might therefore have occurred during an era of relatively more congenial climatic conditions. As in eastern North America where unmistakable local domesticates are present from the second millennium BC (Smith, 1992, 1995), but for which earlier cultivation must be posited, many early Indian domesticates, notably small millets like *Brachiaria ramosa*, were marginalized in subsequent millennia as other crops were introduced, such as maize in Eastern North America and African millets in Peninsular India and Gujarat. In South Asia, by contrast, evidence indicates major dependence on the cultivation of native crops, whereas in North America several millennia of "low-level food production," in which wild foods remained predominant, is indicated (Smith, 2001).

Alternative visions of agricultural origins, that might be termed "food choice" (Fuller, 2003d, pp. 374–376) emphasizing social motivations might thus have some role to play. While the "competitive feasting" model (Hayden, 1990, 1997) has no clear evidence to support it in India, the emphasis on large cattle at early Mehrgarh (Meadow, 1996; Meadow & Patel, 2001, 2003), as also in other Neolithic contexts such as the Ashmound Tradition, presumably implies meat sharing amongst larger groups than would an emphasis on caprines, and therefore might be considered in light of such a model. The hypothesis of "scheduled consumption," proposed by Marshall and Hildebrandt (2002, pp. 101–102) to account for small scale beginnings of animal management or plant cultivation, of species that were not staples, in African prehistory might be fruitfully considered in relation to the Indian evidence, especially in relation to the probably localized nature of wild pulses and small millets in the clearings and margins of wet to dry deciduous woodlands. The emergence of significant quantities of chickens amongst hunter-gatherers of the middle Ganges, who were dependent, certainly in terms of quantity, on hunted large mammals might provide another example.

The growing body of evidence for early agriculture in South Asia offers potentially exciting insights into this key economic transition in another world region, but has featured little in anthropological discussions of domestication. On present evidence there are probably several independent centres of plant domestication in South Asia, as well as local animal domestications. The dispersal of domesticates also played an important role, and thus South Asia offers another region in which to investigate the frontiers between food-producers and hunter-gatherers. Unfortunately, due to the rapid pace of economic development in India, Neolithic archaeological evidence is undergoing relentless and unchecked attrition. (With each visit in recent years the present author has observed more sites destroyed in full or in part; see also Paddayya, 1996.) It is therefore urgent that problem-oriented research aimed at understanding the beginnings of sedentism, animal domestication, and plant cultivation be carried out and expanded in South Asia so that this subcontinent can be better understood in its own archaeological terms and in comparison with other regional trajectories in world prehistory.

Acknowledgments I would like to thank several friends and colleagues, especially Ravi Korisettar, Pramod Joglekar and Rabi Mohanty, who encouraged me to produce a paper along these lines. The synthesis represented in this paper has benefited greatly from the opportunities to visit and work on several sites in various regions, for which I am grateful to Ravi Korisettar and P. C. Venkatasubbaiah (Karnataka and Andhra Pradesh), J. N. Pal and M. C. Gupta (Vindhyan sites), K. Rajan (southern Tamil Nadu), Rabi Mohanty, Kishor Basa and Basant Mohanta (Orissa) and Vinod Nautiyal (Garhwal). I have always benefited from discussions with such experienced scholars with detailed local knowledge. On issues of botanical origins and identification I have had fruitful discussions with Daniel Zohary and Mukund Kajale. I am grateful to Rakesh Tewari and K. S. Saraswat for the opportunity to visit recent Lahuradewa excavations and to discuss (and debate) the significance of the evidence there. I have also benefited from the new work and ideas of my research students and associates, Emma Harvey, Miriam Cooke, and Dr. Eleni Asouti. The author's most recent fieldwork in Southern India has been supported by a grant from the Leverhulme Trust (U.K.), with additional support for Indian field research from the British Academy, The Society for South Asian Studies, the Institute of Archaeology, and the University College London Dean's Travel Fund. Aspects of the history of archaezoology in South Asia have been revealed to me through conversations with Pramod Joglekar, Ajita Patel and Richard Meadow. This paper has benefited from critical readings while in draft form, in particular from David Harris, Emma Harvey, Eleni Asouti, Nicole Boivin, Robert Harding, and Marco Madella. Further improvements came from extensive and thought-revoking comments from two anonymous peer-reviewers and Angela E. Close.

References

Achaya, K. T. (1994). *Indian food. A historical companion*. Delhi: Oxford University Press.

Achaya, K. T. (1998). *A historical dictionary of Indian food*. New Delhi: Oxford University Press.

Achyuthan, H., Ghate, S., Deo, S. S., & Mishra, S. (2001). Holocene episodes of colluvial deposition at Kalapet near Pondicherry. *Man and Environment*, *26*(2), 43–46.

Agrawal, D. P. (1992). *Man and environment in India through ages*. New Delhi: Books and Books.

Agrawal, D. P. (2002). The earliest agriculture and pottery in South Asia. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 81–88). New Delhi: Lustre Press and Roli Books.
Ajithprasad, P. (2001). The pre-Harappan cultures of Gujarat. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Protohistory*, vol. II (pp. 129–158). New Delhi: Manohar.
Ajithprasad, P. (2004). Holocene adaptations of the Mesolithic and Chalcolithic settlements in north Gujarat. In Y. Yasuda & V. S. Shinde (Eds.), *Monsoon and civilization* (pp. 115–132). New Delhi: Lustre Press/Roli Books.
Alexander, J. A. (1977). The &frontier' concept in prehistory: The end of the moving frontier. In J. V. S. Megaw (Ed.), *Hunters, gatherers and first farmers beyond Europe* (pp. 25–40). Leicester: Leicester University Press.
Alexander, J. A. (1978). Frontier studies and the earliest farmers in Europe. In D. Green, C. Haselgrove, & M. Spriggs (Eds.), *Social organisation and settlement* (pp. 13–29). Oxford: BAR.
Allchin, F. R. (1960). *Piklihal excavations*. Hyderabad: Andhra Pradesh Government Publications.
Allchin, F. R. (1963). *Neolithic cattle keepers of South India. A case study of the Deccan ashmounds*. Cambridge: Cambridge University Press.
Allchin, F. R., & Allchin, B. (1974). Some new thoughts on Indian cattle. In J. E. van Lohuizen-de Leeuw & J. N. Ubaghs (Eds.), *South Asian archaeology 1973* (pp. 71–77). Leiden: E. J. Brill.
Allchin, B., & Allchin, F. R. (1982). *The rise of civilization in India and Pakistan*. Cambridge: Cambridge University Press.
Allchin, F. R., & Allchin, B. (1997). *Origins of a civilization. The prehistory and early archaeology of South Asia*. New Delhi: Penguin Books India.
Alley, R. B., Mayewski, P. A., Sowers, T., Stuvier, M., Taylor, K. C., & Clark, P. U. (1997). Holocene climatic instability: A prominent, widespread event 8200 yr ago. *Geology*, *25*(6), 483–486.
Alur, K. R. (1973). Animal remains from Navdatoli. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *31–32,* 337–345.
Alur, K. R. (1975). Animal remains from Kayatha. In Z. D. Ansari & M. K. Dhavalikar (Eds.), *Excavations at Kayatha* (pp. 29–38). Pune: Deccan College.
Alur, K. R. (1980). Faunal remains from the Vindhyas and the Ganga Valley. In G. R. Sharma, V. D. Misra, D. Mandal, B. B. Misra, & J. N. Pal (Eds.), *Beginnings of agriculture (Epi-Palaeolithic to Neolithic: Excavations at Chopani-Mando, Mahadaha, and Mahagara)* (pp. 201–227). Allahabad: Abinash Prakashan.
Alur, K. R. (1990). *Studies in Indian archaeology and palaeontology*. Dharwad: Shrihari Publications.
Ambasta, S. P., Ramachandran, K., Kashyapa, K., & Chand, R. (Eds.). (1986). *The useful plants of India*. New Delhi: Publications and Information Directorate.
Asouti, E., Fuller, D. Q., & Korisettar, R. (2005). Vegetation context and wood exploitation in the Southern Neolithic: preliminary evidence from wood charcoals. In U. Franke-Vogt & J. Weisshaar (Eds.), *South Asian Archaeology 2003. Proceedings of the European Association for South Asian Archaeology Conference, Bonn, Germany, 7th–11th July 2003* (pp. 336–340). Aachen: Linden Soft.
Asouti, E., & Fuller, D. Q. (2006). *Trees and woodland in South India: An archaeological approach*. Walnut Creek: Left Coast Press (in press).
Badam, G. L. (1977). Faunal remains from Chalcolithic Inamgan. *Man and Environment*, *1,* 58–60
Badam, G. L. (1979). Bone remains. In S. B. Deo, M. K. Dhavalikar, & Z. D. Ansari (Eds.), *Apegaon excavations 1976* (pp. 40–49). Pune: Deccan College
Badam, G. L. (1986). Preliminary report on the faunal remains from Chalcolithic Daimabad, Maharashtra. In Anonymous (Ed.), *Archaeological studies* (pp. 93–100). Varanasi: Bharat Kala Bhavan.
Baker, D. E. U. (2005). The human presence in Baghelkhand, Madya Pradesh, to 800 BC. *Pragdhara (Journal of the Uttar Pradesh State Department of Archaeology)*, *15,* 203–220.
Barth, F. (1973). A general perspective on nomad-sedentary relations in the Middle East. In C. M. Nelson (Ed.), *The desert and the sown* (pp. 11–21). Berkeley: University of California Press.
Bar-Yosef, O. (1998). The Natufian culture in the Levant. *Evolutionary Anthropology*, *6,* 159–177.
Bar-Yosef, O. (2000). The context of animal domestication in Southwestern Asia. In M. Mashkour, A. M. Choyke, H. Buitenhuis, & F. Poplin (Eds.), *Archaeozoology of the Near East IVA. Proceedings of the Fourth International Symposium on the Archaeozoology of southwestern Asia and adjacent Areas* (pp. 185–195). Groningen: ARC.
Bar-Yosef, O., & Belfer-Cohen, A. (2002). Facing environmental crisis. Societal and cultural changes at the transition from the Younger Dtyas to the Holocene in the Levant. In R. T. J. Cappers & S. Bottema (Eds.), *The dawn of farming in the near east* (pp. 55–66). Berlin: Ex Oriente.
Bar-Yosef, O., & Meadow, R. (1995). The origins of agriculture in the near east. In T. D. Price & A. B. Gebauer (Eds.), *Last hunters-first farmers. New Perspectives on the prehistoric transition to agriculture* (pp. 39–94). Santa Fe: School of American Research Press.

Behera, P. K. (2001). Excavations at Khameswaripali–A Proto Historic settlement in the middle Mahanadi valley, Orissa: A preliminary report. *Pragdhara*, *11,* 13–34.
Bellwood, P. (1996). The origins and spread of agriculture in the indo-pacific region: Gradualism, diffusion or revolution and colonization. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 465–498). London: UCL Press.
Bellwood, P. (2001). Early agriculturalist population diasporas? Farming, languages and genes. *Annual Review of Anthropology*, *30,* 181–207.
Bellwood, P. (2005). *First farmers. The origins of agricultural societies*. Oxford: Blackwell.
Bellwood, P., Gillespie, R., Thompson, G. B., Vogel, J. S., Ardika, I. W., & Datan, I. (1992). New dates for prehistoric Asian rice. *Asian Perspectives*, *31,* 161–170.
Benecke, N., & Neef, R. (2005). Faunal and plant remains from Sohr Damb/Nal: A Prehistoric site (c. 3500–200 BC) in Central Balochistan (Pakistan). In U. Franke-Vogt & J. Weisshaar (Eds.), *South Asian archaeology 2003. Proceedings of the European Association for South Asian Archaeology Conference* (pp. 81–91). Aachen: Linden Soft.
Biagi, P., & Kazi, M. (1995). A Mesolithic site near Thari in the Thar Desert (Sindh, Pakistan). *Ancient Sindh*, *2,* 7–12.
Blench, R. M. (2005). From the mountains to the valleys. Understanding ethnoliguistic geography in Southeast Asia. In R. M. Blench, L. Sagart, & A. Sanchez-Mazas (Eds.), *Perspectives in the phylogeny of east asian languages* (pp. 31–50). London: Curzon Press.
Blunier, T., Chappellaz, J., Schwander, J., Stauffer, B., & Raynaud, D. (1995). Variations in atmospheric methane concentration during the Holocene epoch. *Nature*, *374,* 46–49.
Blust, R. (1996). Austronesian culture history: the windows of language. In W. H. Goodenough (Ed.), *Prehistoric settlement of the pacific* (pp. 28–35). Philadelphia: American Philosophical Society.
Boivin, N. L., Korisettar, R., & Fuller, D. Q. (2005). Further research on the Southern Neolithic and the Ashmound Tradition: The Sanganakallu-Kupgal Archaeological Research Project. *Journal of Interdisciplinary Studies in History and Archaeology*, *2*(1), 59–86.
Bökönyi, S. (1990). *Kamid el-Loz. 12. Tierhaltung und Jagd*. Bonn: Dr. Rudolf Habelt GMBH.
Bökönyi, S. (1993). Domestication models: The Anatolian-Mesopotamian and others in Southwest Asia. In H. Buitenhuis & A. C. Clason (Eds.), *Archaeozoology if the Near East* (pp. 4–8). Leiden: Universal Book Service.
Bökönyi, S. (1997). Zebus and Indian wild cattle. *Anthropozoologica*, 25–26, 647–654.
Bor, N. L. (1955). The genus "Digitaria" Heist. in India and Burma. *Webbia*, *11,* 301–360.
Bottema, S. (1984). The composition of modern charred seed assemblages. In W. Van Zeist & W. A. Casparie (Eds.), *Plants and Ancient Man. Studies in Paleoethnobotany* (pp. 207–212). Rotterdam: A. A. Balkema.
Bower, J. (1996). Early food production in Africa. *Evolutionary Anthropology*, *4,* 130–139.
Bradley, D. G., Loftus, R., Cunningham, P., & MacHugh, D. E. (1998). Genetics and domestic cattle origins. *Evolutionary Anthropology*, *6*(3), 79–86.
Bruford, M. W., Bradley, D. G., & Luikart, G. (2003). DNA markers reveal the complexity of livestock domestication. *Nature Reviews: Genetics*, *4,* 900–910.
Brunet, F. (1999). La Néolithisation en Asie Centrale: Un État de La Question. *Paléorient*, *24*(2), 27–48.
Bryant, E. (2002). *The quest for the origins of vedic culture. The Indo-Aryan migration debate*. Oxford: Oxford University Press.
Bryson, R. A., & Swain, A. M. (1981). Holocene variations of the monsoon rainfall in Rajasthan. *Quaternary Research*, *16,* 135–145.
Burger, R. L. (1992). *Chavin and the origins of Andean civilization*. London: Thames and Hudson.
Buth, G. M., Khan, M., & Lone, F. A. (1986). Antiquity of rice and its introduction in Kashmir. In G. M. Buth (Ed.), *Central Asia and Western Himalaya–A Forgotten Link* (pp. 63–68). Jodhpur: Scientific Publishers.
Butler, A. (1989). Cryptic anatomical characters as evidence of early cultivation in the grain legumes (pulses). In D. R. Harris & G. C. Hillman (Eds.), *Foraging and farming* (pp. 390–407). London: Unwin and Hyman.
Campagnoni, B. (1979). Preliminary report on the faunal remains from protohistoric settlements of Swat. In M. Taddei (Ed.), *South Asian Archaeology 1977* (pp. 697–700). Naples: Instituto Universitario Orientale, Seminario di Studi Asiatici.
Caratini, C., Bentaleb, I., Fontugne, M., Morzadec-Kerfourn, M. T., Pascal, J. P., & Tissot, C. (1994). A less humid climate since ca. 3500 yr B.P. from marine cores off Karwar, western India. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *109,* 371–384.
Chahuan, M. S. (1996). Origin and history of tropical deciduous Sal (Shorea robusta Gaertn.) forests in Madhya Pradesh, India. *The Palaeobotanist*, *43,* 89–101.

Chahuan, M. S. (2000). Pollen evidence of late-Quaternary vegetation and climate change in Northeastern Madhya Pradesh, India. *Palaeobotanist*, *49,* 491–500.

Chahuan, M. S. (2002). Holocene vegetation and climatic changes in southeastern Madhya Pradesh, India. *Current Science*, *83*(12), 1444–1445.

Chahuan, M. S., Pokharia, A. K., & Singh, I. B. (2005). Preliminary results on the palaeovegetation during Holocene from Lahuradewa Lake, District Sant Kabir Nagar, Uttar Pradesh. *Pragdhara (Journal of the Uttar Pradesh State Department of Archaeology)*, *15,* 33–38.

Chakrabarti, D. K. (1995). *Ancient Indian cities*. New Delhi: Oxford University Press.

Chakrabarti, D. K. (1999). *India: an archaeological history*. New Delhi: Oxford University Press.

Chanchala, S. (1994). Harappan plant economy of Kutch, Gujarat. *Geophytology*, *23*(2), 227–233.

Chanchala, S. (1995). Some seed and fruit remains from Kausambi, District Allahabad, U. P. (ca 600 B.C.–450 B.C.). *Geophytology*, *24*(2), 169–172.

Chanchala, S. (2001). Seed and fruit remains from Manjhi. *Pragdhara*, *11,* 143–153.

Chanchala, S. (2002). Botanical remains. In D. P. Tewari (Ed.), *Excavations at Charda* (pp. 166–194). Lucknow: Jarun Prakashan.

Chanchala, S. (2005). Plant economy at Ancient Mahorana, Sangrur District, Punjab (c. 2300 B.C.–A.D. 200). *Man and Environment*, *30*(1), 94–102.

Chang, C., & Koster, H. A. (1986). Beyond Bones: Toward an Archaeology of Pastoralism. *Advances in Archaeological Method and Theory*, *9,* 97–148.

Charles, M. (1998). Fodder from Dung: The recognition and interpretation of dung-derived plant material from archaeological sites. *Environmental Archaeology*, *1,* 111–122.

Charles, M. (2006 [in press]). East of Eden? A consideration of the Neolithic crop spectra in the eatsren Fertile Crescent and beyond. In S. Colledge & J. Connolly (Eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*. Walnut Creek: Left Coast Press.

Charles, M., & Bogaard, A. (in press). Charred plant macro-remains from Jeitun: Implications for early cultivation and herding practices in western Central Asia. In D. R. Harris (Ed.), *Origins of agriculture in western Central Asia: archaeological and environmental investigations in southern Turkmenistan*.

Chatterjee, B. K., & Bose, H. K. (1946). Report on human and animal remains. *Ancient India*, *2,* 114–116.

Chattopadyaya, U. C. (1996). Settlement pattern and the spatial organization of subsistence and mortuary practices in the Mesolithic Ganges Valley, North-Central India. *World Archaeology*, *27*(3), 461–476.

Chattopadyaya, U. C. (2002). Researches in archaeozoology of the Holocene period (Including the Harappan tradition in India and Pakistan). In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Archaeology and interactive disciplines*, vol. III (pp. 365–422). New Delhi: Manohar.

Chen, W.-B., Nakamura, I., Sato, Y.-I., & Nakai, H. (1993a). Distribution of deletion type in cpDNA of cultivated and wild rice. *Japanese Journal of Genetics*, *68,* 597–603.

Chen, W.-B., Nakamura, I., Sato, Y.-I., & Nakai, H. (1993b). Indica and Japonica differentiation in Chinese landraces. *Euphytica*, *74*(3), 195–201.

Cheng, C., Motohashi, R., Tchuchimoto, S., Fukuta, Y., Ohtsubo, H., & Ohtsubo, E. (2003). Polyphyletic origin of cultivated rice: Based on the interspersion patterns of SINEs. *Molecular Biology and Evolution*, *20*(1), 67–75.

Childe, V. G. (1936). *Man makes himself*. London: Watts.

Chowdhury, K. A., Saraswat, K. S., & Buth, G. M. (1977). *Ancient agriculture and forestry in north India*. New Delhi: Asia Publishing House.

Clark, J. D., & Khanna, G. S. (1989). The site of Kuhjhun II, middle sone valley and its relevance. In J. M. Kenoyer (Ed.), *Old problems and new perspectives in the archaeology of South Asia* (pp. 29–58). Madison: University of Wisconsin.

Clarke, D. (1973). Archaeology: The loss of innocence. *Antiquity*, *47,* 6–18.

Clason, A. C. (1979). *Wild and domestic animals in prehistoric and early historic India*. Lucknow: Ethnographic and Folk Culture Society.

Close, A. E. (1995). Few and far between. Early ceramics in North Africa. In W. K. Barnet & J. W. Hopes (Eds.), *The emergence of pottery. Technology and innovation in ancient societies* (pp. 23–37). Washington, DC: Smithsonian Press.

Clutton-Brock, J. (1965). *Excavations at Langhnaj, 1944–1963. Part 2, The Fauna*. Pune: Deccan College Postgraduate and Research Institute.

Cohen, D. J. (1998). The origins of domesticated cereals and the Pleistocene-Holocene transition in East Asia. *The Review of Archaeology*, *19*(2), 22–29.

Cohen, D. J. (2002). New perspectives on the transition to agriculture in China. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 217–227). New Delhi: Lustre Press and Roli Books.
Colledge, S. (1998). Identifying pre-domestication culltivation using multivariate analysis. In A. B. Damania, J. Valkoun, G. Willcox, & C. O. Qualset (Eds.), *The origins of agriculture and crop domestication* (pp. 121–131). Aleppo, Syria: ICARDA.
Colledge, S. (2001). *Plant exploitation on epipalaeolithic and early neolithic sites in the Levant*. Oxford: British Archaeological Reports.
Colledge, S. (2002). Identifying pre-domestication cultivation in the archaeobotanical record using multivariate analysis: presenting the case for quantification. In R. T. J. Cappers & S. Bottema (Eds.), *The dawn of farming in the near east* (pp. 141–151). Berlin: ex Oriente.
Colledge, S. (2004). Reappraisal of the archaeobotanical evidence for the emergence and dispersal of the 'founder crops.' In E. Peltenberg & A. Wasse (Eds.), *Neolithic revolution. New perspectives on southwest Asia in light of recent discoveries on Cyprus* (pp. 49–60). Oxford: Oxbow Books.
Colledge, S., & Conolly, J. (2002). Early Neolithic agriculture in Southwest Asia and Europe: Re-examining the archaeobotanical evidence. *Archaeology International*, *5,* 44–46.
Conningham, R. A. E., & Sutherland, T. (1998). Dwellings or granaries? The pit phenomenon of Kashmir-Swat Neolithic. *Man and Environment*, *22,* 29–34.
Cooke, M., Fuller, D. Q., & Rajan, K. (2005). Early historic agriculture in Southern Tamil Nadu: Archaeobotanical research at Mangudi, Kodumanal and Perur. In U. Franke-Vogt & J. Weisshaar (Eds.), *South Asian Archaeology 2003. Proceedings of the European Association for South Asian Archaeology Conference, Bonn, Germany, 7th–11th July 2003* (pp. 329–334). Aachen: Linden Soft.
Corbet, G. E., & Hill, J. E. (1992). *The mammals of the Indomalayan region: A systematic review*. Oxford: Oxford University Press.
Costantini, L. (1979). Plant remains at Pirak. In J.-F. Jarrige & M. Santoni (Eds.), *Fouilles de Pirak* (pp. 326–333). Paris: Diffusion de Boccard.
Costantini, L. (1983). The beginning of agriculture in the Kachi Plain: The evidence of Mehrgarh. In B. Allchin (Ed.), *South Asian Archaeology 1981* (pp. 29–33). Cambridge: Cambridge University Press.
Costantini, L. (1987). Appendix B. Vegetal remains. In G. Stacul (Eds.), *Prehistoric and Protohistoric Swat, Pakistan* (pp. 155–165). Rome: Instituto Italiano per il Medio ed Estremo Orientale.
Costantini, L. (1990). Harrapan agriculture in Pakistan: The evidence of Nausharo. In M. Taddei (Ed.), *South Asian archaeology 1987* (pp. 321–332). Rome: Instituto Italiano per il Medio ed Estremo Oreintale.
Costantini, L., & Biasini, L. C. (1985). Agriculture in Baluchistan between the 7th and 3rd Millenium B.C. *Newsletter of Baluchistan Studies*, *2,* 16–37.
Crabtree, P. J. (1993). Early animal domestication in the Middle East and Europe. In M. Schiffer (Ed.), *Archaeological method and theory*, vol. 5 (pp. 201–245). Tucson: University of Arizona Press.
Crawford, G. W. (1997). Anthropogenesis in prehistoric northeastern Japan. In K. J. Gremillion (Ed.), *People, plants and landscapes. studies in paleoethnobotany* (pp. 86–103). Tuscaloosa: University of Alabama Press.
Crawford, R. D. (1984). Domestic Fowl. In I. L. Mason (Ed.), *Evolution of domesticated animals* (pp. 298–311). London: Longman.
Cremaschi, M., & Di Lernia, S. (1999). Holocene climatic changes and cultural dynamics in the Libyan Sahara. *African Archaeological Review*, *16*(4), 211–238.
Crown, P. L., & Wills, W. H. (1995). Economic intensification and the origins of ceramic containers in the American Southwest. In W. K. Barnett & J. W. Hoopes (Eds.), *The emergence of pottery: Technology and innovation in ancient societies* (pp. 241–256). Washington, DC: Smithsonian Institution Press.
D'Andrea, A. C., Crawford, G. W., Yishizaki, M., & Kudo, T. (1995). Late Jomon cultigens in northeastern Japan. *Antiquity*, *69*(262), 146–152.
Dash, R. N. (2000). The neolithic culture of Orissa: A typo-technological analysis. In K. K. Basa & P. Mohanty (Eds.), *Archaeology of Orissa* (pp. 201–221). Delhi: Pratibha Prakashan.
Davis, S. M. (1984). The advent of milk and wool production in western Iran: Some speculations. In J. Clutton-Brock & C. Grigson (Eds.), *Animals in archaeology 3. Early herders and their flocks* (pp. 265–278). Oxford: BAR.
Davis, S. M. (1987). *The archaeology of animals*. London: Batsford.
De Menocal, P. B. (2001). Cultural responses to climate change during the late Holocene. *Science*, *292*(5517), 667–673.
De Moulins, D. (1997). *Agricultural changes at euphrates and steppe sites in the Mid-8th to the 6th Millennium B.C*. Oxford: British Archaeological Reports.
De Moulins, D. (2000). Abu Hureyra 2: Plant Remains from the Neolithic, in Village on the Euphrates. In A. M. T. Moore, G. C. Hillman, & A. J. Legge (Eds.), *Village on the euphrates. From foraging to farming at Abu Hureyra* (pp. 399–416). New York: Oxford University Press.

De Wet, J. M. J. (1995). Minor cereals. In J. Smartt & N. W. Simmonds (Eds.), *Evolution of crop plants* (pp. 202–207), 2nd edn. Essex: Longman Scientific and Technical.

De Wet, J. M. J., Oestry-Stidd, J. L. L., & Cunero, J. I. (1979). Origins and evolution of foxtail millets. *Journal d'Agriculture Traditionelle et de Botanique Appliquée*, *26,* 54–64.

De Wet, J. M. J., Prasada Rao, K. E., & Brink, D. E. (1983a). Systematics and domestication of Panicum sumatrense (Graminae). *Journal d'Agriculture Traditionelle et de Botanique Appliquée*, *30*(2), 159–168.

De Wet, J. M. J., Prasada Rao, K. E., Mengesha, M. H., & Brink, D. E. (1983b). Diversity in Kodo Millet, Paspalum scrobiculatum. *Economic Botany*, *37*(2), 159–163.

De Wet, J. M. J., Prasada Rao, K. E., Mengesha, M. H., & Brink, D. E. (1983c). Domestication of Sawa Millet (Echinochloa colona). *Economic Botany*, *37*(3), 283–291.

Decker-Walters, D. S. (1999). Cucurbits, Sanskrit, and the Indo-Aryans. *Economic Botany*, *53*(1), 98–112.

Dennell, R. W. (1985). The Hunter-Gatherer/agricultural frontier in prehistoric temperate Europe. In S. W. Green & S. M. Perlman (Eds.), *The archaeology of frontiers and boundaries* (pp. 113–140). New York: Academic Press.

Desse, J. (1997). Archéozoologie aux marges occidentales di Bélouchistan. *Anthropozoologica*, 25–26, 671–676.

Deveraj, D. V., Shaffer, J. G., Patil, C. S., & Balasubramanya (1995). The Watgal Excavations: An interim report. *Man and Environment*, *20*(2), 57–74.

Dhavalikar, M. K. (1988). Inamgaon: A Chalcolithic Chiefdon. In M. K. Dhavalikar, H. D. Sankalia, & Z. D. Ansari (Eds.), *Excavations at inamgaon* (pp. 1001–1008). Pune: Deccan College Postgraduate and Research Institute.

Dhavalikar, M. K., & Possehl, G. L. (1974). Subsistence pattern of an early farming community of western India. *Puratattva*, *7,* 39–56.

Dhavalikar, M. K., Shinde, V. S., & Atre, S. M. (1990). *Excavations at Kaothe*. Pune: Deccan College.

Diamond, J., & Bellwood, P. (2003). Farmers and their languages: The first expansions. *Science*, *300,* 597–603.

Donegan, P., & Stampe, D. (2004). Rhythm and the synthetic drift of Munda. In R. Singh (Ed.), *The yearbook of South Asian languages and linguistics 2004* (pp. 3–36). Berlin: Mouton de Gruyter.

Ducos (1978). "Domestication" defined and methodological approaches to its recognition in faunal assemblages. In R. Meadow & M. A. Zeder (Eds.), *Approaches to faunal analysis in the middle East* (pp. 53–56). Boston: Peabody Museum, Harvard University.

Duranni, F. A. (1988). Excavations in the Gomal valley: Rehman Dheri excavation report. *Ancient Pakistan*, *6,* 1–204.

Durham, W. H. (1991). *Coevolution. genes, culture and human diversity*. Stanford: Stanford University Press.

Ellerton, S. (1939). The origin and geographical distribution of *Triticum sphaerococcum* Perc. and its cytogenetical behaviour in crosses with *T. vulgare* Vill. *Journal of Genetics*, *38,* 307–324.

Enzel, Y., Ely, L., Mishra, S., Ramesh, R., Amit, R., Lazar, B *et al.* (1999). High resolution Holocene environmental changes in the Thar Desert, northwestern India. *Science*, *284,* 125–127.

Fairbairn, A., Asouti, E., Near, J., & Martinoli, D. (2002). Macro-botanical evidence for plant use at Neolithic Catalhoyuk, southcentral Anatolia, Turkey. *Vegetation History and Archaeobotany*, *11*(1–2), 41–54.

Fairservis, W. A. (1982). Allahdino: an excavation of a small Harappan site. In G. L. Possehl (Ed.), *Harappan civilization: A contemporary perspective* (pp. 107–113). New Delhi: Oxford-IBH.

Flannery, K. V. (1973). The origins of agriculture. *Annual Review of Anthropology*, *2,* 271–310.

Ford, R. (1985). The process of plant food production in prehistoric North America. In R. Ford (Ed.), *Prehistoric food production in North America* (pp. 1–18). Ann Arbor: University of Michegan Museum of Anthropology.

Fuller, D. Q. (1999). *The emergence of agricultural societies in South India: Botanical and archaeological perspectives*. Cambridge: Cambridge University.

Fuller, D. Q. (2001a). Ashmounds and hilltop villages: The search for early agriculture in southern India. *Archaeology International*, *4*(2000/2001), 43–46.

Fuller, D. Q. (2001b). Harappan seeds and agriculture: Some considerations. *Antiquity*, *75,* 410–413.

Fuller, D. Q. (2002). Fifty years of archaeobotanical studies in India: Laying a solid foundation. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Archaeology and Interactive Disciplines*, vol. III (pp. 247–363). Delhi: Manohar.

Fuller, D. Q. (2003a). An agricultural perspective on dravidian historical linguistics: Archaeological crop packages, livestock and dravidian crop vocabulary. In P. Bellwood & C. Renfrew (Eds.), *Examining the farming/language dispersal hypothesis* (pp. 191–213). Cambridge: McDonald Institute for Archaeological Research.

Fuller, D. Q. (2003b). African crops in prehistoric South Asia: A critical review. In K. Neumann, A. Butler, & S. Kahlheber (Eds.), *Food, fuel and fields. Progress in African archaeobotany* (pp. 239–271). Köln: Heinrich-Barth Institut.

Fuller, D. Q. (2003c). Further evidence on the prehistory of sesame. *Asian Agri-History*, *7*(2), 127–137.

Fuller, D. Q. (2003d). Indus and Non-Indus agricultural traditions: Local developments and crop adoptions on the Indian Peninsula. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 343–396). Lanham: Lexington Books.

Fuller, D. Q. (2005). Ceramics, seeds and culinary change in prehistoric India. *Antiquity*, *79*(306), 761–777.

Fuller, D. Q. (2006a [in press]). Non-human genetics, agricultural origins and historical linguistics in South Asia. In M. D. Petraglia & B. Allchin (Eds.), *The evolution and history of human populations in South Asia: Inter-disciplinary studies in archaeology, biological anthropology, linguistics and genetics* Springer. Doetinchem, The Netherlands: Springer, [in press].

Fuller, D. Q. (2006b). Silence before sedentism and the advent of cash-crops: A status report on early agriculture in South Asia from plant domestication to the development of political economies (with an excursus on the problem of semantic shift among millets and rice). In T. Osada (Ed.), *Proceedings of the Pre-Symposium of RIHN and 7th ESCA Harvard- Kyoto Roundtable* (pp. 175–213). Kyoto: Research Institute for Humanity and Nature.

Fuller, D. Q. (2006c). Dung mounds and domesticators: Early cultivation and pastoralism in Karnataka. In C. Jarrige & V. Lefèvre (Eds.), *South Asian archaeology 2001. Prehistory*, vol. I (pp. 117–127). Paris: Éditions Recherche sur les Civilisations.

Fuller, D. Q., & Harvey, E. (2006). The archaeobotany of Indian pulses: Identification, processing and evidence for cultivation. *Environmental Archaeology*, *11*(2), 241–268.

Fuller, D. Q., & Korisettar, R. (2004). The Vegetaional context of early agriculture in South India. *Man and Environment*, *29*(1), 7–27.

Fuller, D. Q., & Madella, M. (2001). Issues in Harappan archaeobotany: retrospect and prospect. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Protohistory*, vol. II (pp. 317–390). New Delhi: Manohar.

Fuller, D. Q., Korisettar, R., & Venkatasubbaiah, P. C. (2001). Southern neolithic cultivation systems: A reconstruction based on archaeobotanical evidence. *South Asian Studies*, *17,* 171–187.

Fuller, D. Q., Venkatasubbaiah, P. C., & Korisettar, R. (2001). The beginnings of agriculture in the Kunderu River Basin: evidence from archaeological survey and archaeobotany. *Puratattva*, *31*(1–8).

Fuller, D. Q., Korisettar, R., Venkatasubbaiah, P. C., & Jones, M. K. (2004). Early plant domestications in southern India: some preliminary archaeobotanical results. *Vegetation History and Archaeobotany*, *13,* 115–129.

Fuller, D. Q., Boivin, N. L., & Korisettar, R. (in press-a). Dating the Neolithic of South India: New Radiometric evidence for key economic, social and ritual transformations. *Antiquity*.

Fuller, D. Q., Qin, L., & Harvey, E. L. (in press-b). Evidence for a late onset of agriculture in the Lower Yangtze region and challenges for an archaeobotany of rice. In A. Sanchez-Mazas, R. Blench, M. Ross, M. Lin, & I. Pejros (Eds.), *Human migrations in continental East Asia and Taiwan: genetic, linguistic and archaeological evidence*. London: Taylor and Francis.

Fumihito, A., Miyake, T., Sumi, S.-I., Takada, M., Ohno, S., and Kondo, N. (1994). One subspecies of red junglefowl (*Gallus gallus gallus*) suffices as the matriarchic ancestor of all domestic breeds. *Proceedings of the National Academy of Sciences (USA)*, *91,* 12505–12509.

Fumihito, A., Miyake, T., Takada, M., Shingu, R., Endo, T., Gojobori, T *et al.* (1996). Monophyletic origin and unique dispersal patterns of domestic fowls. *Proceedings of the National Academy of Sciences (USA)*, *93,* 6792–6795.

Furer-Haimendorf, C. V. (1963). The social background of cattle-domestication in India. In A. Mourant & F. E. Zeuner (Eds.), *Man and cattle* (pp. 144–148). Glasgow: Royal Anthropological Institute of Great Britain & Ireland.

Garrard, A. (2000). Charting the emergence of cereal and pulse domestication in South-West Asia. *Environmental Archaeology*, *4,* 67–86.

Gasse, F. (2000). Hydrological changes in the African tropics since the last glacial maximum. *Quaternary Science Review*, *19,* 189–211.

Ghosh, S. S., & Lal, K. (1963). Plant remains from Rangpur and Other Explorations in Gujarat. *Ancient India*, *18–19,* 161–175.

Glover, I. C., & Higham, C. F. W. (1996a). New evidence for early rice cultivation in South, Southeast and East Asia. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 413–441). London: UCL Press.

Glover, I. C., & Higham, C. F. W. (1996b). New evidence for early rice cultivation in South, Southeast and East Asia. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 413–441). London: UCL Press.

Gogte, V. D. (1996). Chalcolithic Balathal–A trading centre as revealed by XRD study of ancient pottery. *Man and Environment*, *21*(1), 103–110.

Gouin, P. (1990). Rapes, jarres et faisselles. La production et l'exportation des produits laitiers dans l'Indus du 3[e] millénaire. *Paleorient*, *16*(2), 37–54.
Gouin, P. (2003). Production, consumption and trade of dairy products in the arid regions of the Harappan world. In V. N. Misra & M. D. Kajale (Eds.), *Introduction of African Crops into South Asia* (pp. 128–143). Pune: Indian Society for Prehistoric and Quaternary Studies.
Grigson, C. (1980). The craniology and relationships of four species of Bos 5. Bos indicus L. *Journal of Archaeological Science*, *7,* 3–32.
Grigson, C. (1985). Bos indicus and Bos namadicus and the Problem of Autochthonous Domestication. In V. N. Misra & P. Bellwood (Eds.), *Recent advances in indo-pacific preshitory* (pp. 425–428). New Delhi: Oxford and IBH.
Grigson, C. (1989). Size and sex–Evidence for the domestication of cattle in the Near East. In A. Milles, D. Williams, & N. Gardner (Eds.), *The beginnings of agriculture* (pp. 77–112). Oxford: BAR.
Grigson, C. (2000). *Bos africanus* (Brehm)? Notes on the archaeozoology of the native cattle of Africa. In R. Blench & K. MacDonald (Eds.), *The origins and development of African livestock* (pp. 38–60). London: UCL Press.
Grove, C. P. (1985). On the agriotypes of domestic cattle and pigs in the Indo-Pacific region. In V. N. Misra & P. Bellwood (Eds.), *Recent advances in Indo-Pacific prehistory* (pp. 429–438). New Delhi: Oxford and IBH.
Guiffra, E., Kijas, J. M. H., Amarger, V., Carlborg, O., Jeon, J.-T., & Anderson, L. (2000). The origin of the domestic pig: Independent domestication and subsequent introgression. *Genetics*, *154*(1785–1791).
Gupta, H. P. (1976). Holocene plynology from meander lake in the Ganga valley, District Pratapgarh, U.P. *The Palaeobotanist*, *25,* 109–119.
Halstead, P. (1996). The development of agriculture and pastoralism in Greece: When, how, who and what? In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 296–309). London: UCL Press.
Harlan, J. R. (1992). *Crops and ancient man*. Madison: American Society for Agronomy.
Harlan, J. R. (1995). *The living fields*. Cambridge: Cambridge University Press.
Harris, D. R. (1989). An evolutionary continuum of people-plant interaction. In D. R. Harris & G. C. Hillman (Eds.), *Foraging and farming: The evolution of plant exploitation* (pp. 11–26). London: Routledge.
Harris, D. R. (1996). Introduction: Themes and concepts in the study of early agriculture. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 1–9). London: UCL Press.
Harris, D. R. (1998a). The origins of agriculture in Southwest Asia. *The Review of Archaeology*, *19*(2), 5–11.
Harris, D. R. (1998b). The spread of neolithic agriculture from the levant to western Central Asia. In A. D. Damania, J. Valkoun, G. Willcox, & C. O. Qualset (Eds.), *The origins of agriculture and crop domestication. Proceedings of the Harlan Symposium 10–14 May 1997, Aleppo, Syria* (pp. 65–82). Alllepo: International Center for Agricultural Research in the Dry Areas.
Harvey, E. L. (2002). *Investigating Neolithic agriculture using phytolith analysis on two Asian sites (Yiluo River Valley, Henan Province, China and Mahagara, Uttar Pradesh, India)*. M.Sc. Dissertation, Institute of Archaeology, University College London.
Harvey, E. L. (2006). *Early agricultural communities in Northern and Eastern India: An archaeobotanical investigation*. Ph.D. Dissertation, Institute of Archaeology, University College London.
Harvey, E. L., & Fuller, D. Q. (2005). Investigating crop processing through phytolith analysis: The case of rice and millets. *Journal of Archaeological Science*, *32,* 739–752.
Harvey, E. L., Fuller, D. Q., Basa, K. K., Mohany, R., & Mohanta, B. (in press). Early Agriculture in Orissa: some archaeobotanical results and field observations on the Neolithic. *Man and Environment*.
Harvey, E. L., Fuller, D. Q., Pal, J. N., & Gupta, M. C. (2005). Early agriculture of Neolithic Vindyhas (North-Central India). In U. Franke-Vogt & J. Weisshaar (Eds.), *South Asian Archaeology 2003. Proceedings of the European Association for South Asian Archaeology Conference, Bonn, Germany, 7th–11th July 2003* (pp. 329–334). Aachen: Linden Soft.
Hassan, F. A. (1997). Nile floods and political disorder in early Egypt. In H. N. Dalfes, G. Kukla, & H. Weiss (Eds.), *Third millennium BC climate change and old world collapse* (pp. 1–23). Heidelberg: Springer-Verlag.
Hayden, B. (1990). Nimrods, piscators, pluckers, and planters: The emergence of food production. *Journal of Anthropological Archaeology*, *9,* 31–69.
Hayden, B. (1997). Practical and prestige technologies: The evolution of material systems. *Journal of Archaeological Method and Theory*, *5*(1), 1–55.
Heindleder, S., Mainz, K., Plante, Y., & Lewalski, H. (1998). Analysis of mitochondrial DNA indicates that domestic sheep are derived from two different ancestral sources: No evidence for controbutions from urial and argali sheep. *The Journal of Heredity*, *89*(2), 113–120.

Helbaek, H. (1960). Domestication paleobotany of the Near East and Europe. In R. J. Braidwood & B. Howe (Eds.), *Prehistoric investigations in Iraqi Kurdistan* (pp. 99–118). Chicago: University of Chicago Press.

Helbaek, H. (1969). Plant collecting, dry-farming and irrigation agriculture in prehistoric Deh Luran. In F. Hole, K. V. Flannery, & J. A. Neely (Eds.), *Prehistory and human ecology of the Deh Luran Plain* (pp. 383–426). Ann Arbor: Musuem of Anthropology, University of Michegan.

Helbaek, H. (1970). The plant husbandry of Hacilar. In J. Mellaart (Ed.), *Excavations at Hacilar* (pp. 189–244). Edinburgh: Edinburgh University Press.

Henry, D. O. (1989). *From foraging to agriculture: The levant at the end of the ice age*. Philadelphia: University of Pennsylvania Press.

Higgs, E. S., & Jarman, M. R. (1972). The origins of animal and plant husbandry. In E. S. Higgs (Ed.), *Papers in economic prehistory* (pp. 3–13). Cambridge: Cambridge University Press.

Higham, C. (1995). The transition to rice cultivation in Southeast Asia. In T. D. Price & A. B. Gebauer (Eds.), *Last hunters-first farmers. New perspectives on the prehistoric transition to agriculture* (pp. 127–156). Santa Fe, New Mexico: School of American Research.

Hillman, G., & Davis, M. S. (1990). Measured domestication rates in wild wheats and barley under primitive cultivation. *Journal of World Prehistory*, *4,* 157–222.

Hillman, G. C. (1981). Reconstructing crop husbandry practices from charred remains of crops. In R. Mercer (Ed.), *Farming practice in British prehistory* (pp. 123–161). Edinburgh: University of Edinburgh Press.

Hillman, G. C. (1984). Interpretation of archaeological plant remains: The application of ethnographic models from Turkey. In W. Van Zeist & W. A. Casparie (Eds.), *Plants and ancient man. Studies in paleoethnobotany* (pp. 1–41). Rotterdam: A. A. Balkema.

Hillman, G. C. (2000). Abu Hireyra 1: The Epipalaeolithic. In A. M. T. Moore, G. C. Hillman, & A. J. Legge (Eds.), *Village on tyhe euphrates. From foraging to farming at Abu HUreyra* (pp. 327–398). New York: Oxford University Press.

Hillman, G. C., Hedges, R., Moore, A. M. T., Colledge, S., & Pettitt, P. (2001). New evidence of Late Glacial cereal cultivation at Abu Hureyra on the Euphrates. *The Holocene*, *11*(4), 383–393.

Hillman, G. C., Mason, S., de Moulins, D., & Nesbitt, M. (1996). Identification of archaeological reminas of wheat: The 1992 London Workshop. *Circaea*, *12*(2), 195–209.

Hilu, K. W. (1994). Evidence from RAPD markers in the evolution of *Echinochloa* millets (Poaceae). *Plant Systematics and Evolution*, *189,* 247–257.

Hilu, K. W., & De Wet, J. M. J. (1976). Racial evolution in *Eleusine coracana* ssp. *coracana* (Finger millet). *American Journal of Botany*, *63,* 1311–1318.

Hilu, K. W., De Wet, J. M. J., & Harlan, J. R. (1979). Archaeobotanical studies of *Eleusine coracana* ssp. *coracana* (Finger Millet). *American Journal of Botany*, *66,* 330–333.

Hoffpauir, R. (2000). Water Buffalo. In K. F. Kiple & K. C. Ornelas (Eds.), *The Cambridge world history of food* (pp. 583–606). Cambridge: Cambridge University Press.

Hongo, H., Ervynck, A., Dobney, K., & Meadow, R. (2001). Born Free? New evidence for the status of Sus scrofa at Neolithic Cayonü Tepesi (southeastern Anatolia. *Paléorient*, *27*(2), 47–73.

Hongo, H., & Meadow, R. (1998). Pig exploitation at Neolithic Cayonu Tepesi (Southeastern Anatolia). In S. M. Nelson (Ed.), *Ancestors for the Pigs: Pigs in prehistory* (pp. 77–98). Philadelphia: Museum Applied Science Center for Archaeology, University of Pennsylvania Museum of Archaeology and Anthropology.

Hooja, R. (1988). *The Ahar culture and beyond: Settlements and frontiers of "Mesolithic" and early agricultural sites in south-eastern Rajasthan, c. 3rd-2nd Millennia B.C*. Oxford: BAR.

Hsu, K. J., & Perry, C. A. (2002). Geophysical, archaeological, and historical evidence support a solar-output model for climate change. *Proceedings of the National Academy of Sciences USA*, *97*(23), 12433–12438.

Hutchinson, J. B. (1976). India: Local and introduced crops. *Philosophical Transactions of the Royal Society, London B*, *275,* 129–141.

Imamura, K. (1996). *Prehistoric Japan. New perspectives on insular East Asia*. London: UCL Press.

Ingold, T. (1980). *Hunters, pastoralists and ranchers*. Cambridge: Cambridge University Press.

Ingold, T. (1984). Time, social relationships and the exploitation of animals: Anthropological reflections on prehistory. In J. Clutton-Brock & C. Grigson (Eds.), *Animals in archaeology 3. Early herders and their flocks* (pp. 3–12). Oxford: BAR.

Jansen, P. C. M. (1989). Macrotyloma uniflorum (Lam.) Verdc. In L. J. G. van der Maeson & S. Somaatmadji (Eds.), *Plant resources of south-east Asia 1. Pulses* (pp. 53–54), Wageningen: Pudoc.

Jarman, M. R., & Wilkinson, P. F. (1972). Criteria of animal domestication. In E. Higgs (Ed.), *Papers in economic prehistory* (pp. 83–96). Cambridge: Cambridge University Press.

Jarrige, C. (1985). Continuity and change in the North Kachi Plain (Baluchistan, Pakistan) at the Beginning of the Second Millennium B.C. In J. Schotmans & M. Taddei (Eds.), *South Asian Archaeology 1983* (pp. 35–68). Naples: Instituto Universitario Orientale, Dipartimento di STudi Asiatici.

Jarrige, C. (1997). From Nausharo ti Pirak: Continuity and change in the Kachi/Bolan region from 3rd to 2nd Millennium BC. In B. Allchin & F. R. Allchin (Eds.), *South Asian archaeology 1995* (pp. 11–32). New Delhi: Oxford and IBH.

Jarrige, J.-F. (1984). Chronology of the earlier periods of the Greater Indus as seen from Mehrgarh, Pakistan. In B. Allchin (Ed.), *South Asian archaeology 1981* (pp. 21–28). Cambridge: Cambridge University Press.

Jarrige, J. F. (1987). Probléms de datation du site neolithique de Mehrgarh, Baluchistan, Pakistan. In O. Aurenche, J. Evens, & F. Hours (Eds.), *Chronologies du Proche Orient/Chronologies in the Near East: Relative Chronologies and Absolute Chronology 16,000–4,000 B.P.* (pp. 381–386). Oxford: British Archaeological Reports.

Jarrige, J.-F., Jarrige, C., & Quivron, G. (2006). Mehrgarh Neolithic: the updated sequence. In C. Jarrige & V. Lefevre (Eds.), *South Asian Archaeology 2001* (pp. 129–141). Paris: Editions Recherche sur les Civilisations.

Jesse, F. (2003). Early Ceramics in the Sahara and the Nile Valley. In L. Krzyzankiak, K. Kroeper, & M. Kobusiewicz (Eds.), *Cultural markers in the later prehistory of Northeastern Africa and recent research* (pp. 35–50). Poznan: Polish Academy of Sciences, Poznan Archaeological Museum.

Jiang, L., & Liu, L. (2006). New evidence for the origins of sedentism and rice domestication in the Lower Yangzi River, China. *Antiquity*, *80,* 355–361.

Joglekar, P. (2006). Faunal studies in India: Methodological issues and prospects. In T. Osada (Ed.), *Proceedings of the Pre-Symposium of RIHN and 7th ESCA Harvard-Kyoto Roundtable* (pp. 32–52). Kyoto: Research Institute for Humanity and Nature.

Joglekar, P. P. (1997). Faunal remains from Padri: Second preliminary report. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *56–57,* 55–68.

Joglekar, P. P. (1999). Re-examination of faunal remains from Piklihal, Karnataka. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *58–59,* 69–76.

Joglekar, P. P. (2004). *Fauna from Lahuradewa: Preliminary report*. National Seminar on the Archaeology of the Gange Plain, Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society, December 2004, Lucknow.

Joglekar, P. P. (in press). Faunal remains from Banahalli, Karnataka. In *Banahalli Excavations Report*. Delhi: Archaeological Survey of India.

Joglekar, P. P., & Thomas, P. K. (1990). Ancestry of Bos species: Myth and Reality I. Genetic evidence. *Man and Environment*, *15*(1), 49–56.

Joglekar, P. P., & Thomas, P. K. (1993). Faunal diversity at Walki–A small Chalcolithic settlement in western Maharashtra. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *53,* 75–94.

Joglekar, P. P., Thomas, P. K., Matsushima, Y., & Pawankar, S. J. (1994). Osteological differences between the forelimb bones of Ox (*Bos indicus*), Buffalo (*Bubalus bubalis*) and Nilgai (*Boselaphus tragocamelus*). *Journal of the Bombay Veterinary College*, *5,* 17–30.

Jones, M. K. (1991). Sampling in palaeoethnobotany. In W. Van Zeist, W. Wasylikowa, & K.-H. Behre (Eds.), *Progress in old world palaeoethnobotany* (pp. 53–61). Rotterdam: Balkema.

Jones, M. K. (2004). Between fertile crescents: Minor grain crops and agricultural origins. In M. K. Jones (Ed.), *Traces of ancestry: studies in honour of Colin Renfrew* (pp. 127–136). Cambridge: McDonald Institute for Archaeological Research.

Joshi, M. B., Rout, P. K., Mandal, A. K., Tyler-Smith, C., Singh, L., & Thangaraj, K. (2004). Phylogeography and origin of Indian domestic goats. *Molecular Biology and Evolution*, *21*(3), 454–462.

Jousse, H. (2004). A New contribution to the History of Pastoralismj in West Afroca. *Journal of African Archaeology*, *2*(2), 187–201.

Kajale, M. D. (1974a). Ancient grains from India. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *34*(1), 55–74.

Kajale, M. D. (1974b). Plant economy at Bhokardan. In S. B. Deo & R. S. Gupte (Eds.), *Excavations at Bhokardan (Bhogacardhana)* (pp. 217–224). Aurangabad: Nagpur University.

Kajale, M. D. (1977a). Plant economy at Inamgaon. *Man and Environment*, *1,* 64–66.

Kajale, M. D. (1977b). Ancient plant economy at Nevasa during Satavahana and Indo-Roman period. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *36,* 48–61.

Kajale, M. D. (1977c). On the botanical findings from excavations at Daimabad, a CHalcolithic site in Western Maharashtra, India. *Current Science*, *46,* 818–819.

Kajale, M. D. (1979). On the occurrence of ancient agricultural patterns during the Chalcolithic periods (*c.* 1600–1000 BC) at Apegaon, District Aurangabad in central Godavari valley, Maharashtra. In S. B. Deo, M. K. Dhavalikar, & Z. D. Ansari (Eds.), pp. 50–56.

Kajale, M. D. (1982). First record of ancient grains at Naikund. In S. B. Deo & A. P. Jamkhedkar (Eds.), *Excavations at Naikund 1978–1980* (pp. 60–63). Bombay: Department of Archaeology and Museums.

Kajale, M. D. (1984). New light on agricultural plant economy during 1st millennium BC: Palaeobotanical study of plant remains from excavations at Veerapuram, District Kurnool, Andhra Pradesh. In T. V. G. Sastri, M. Kasturibai, & J. V. Prasada Rao (Eds.), *Veerapuram: a type site for cultural study in the Krishna valley*, Appendix B (p. 15). Hyderabad: Birla Archaeological and Cultural Research Institute.

Kajale, M. D. (1988a). Ancient plant economy at Chalcolithic Tuljapur Garhi. District Amraoti, Maharashtra. *Current Science*, *57,* 377–379.

Kajale, M. D. (1988b). Plant economy. In M. K. Dhavalikar, H. D. Sankalia, & Z. D. Ansari (Eds.), *Excavations at inamgaon* (pp. 727–821). Pune: Deccan College Postgraduate and Research Institute.

Kajale, M. D. (1989a). Palaeobotanical findings from excavations at Hallur (second season), District Dharwar, Karnataka. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *47–48,* 123–128.

Kajale, M. D. (1989b). Archaeobotanical investigation on Megalithic Bhagimohari, and its significance. *Man and Environment*, *13,* 87–96.

Kajale, M. D. (1990a). Some initial observations on plaeobotanical evidence for Mesolithic plant economy from excavations at Damdama, Pratapgarh, Uttar Pradesh. In N. C. Ghosh & S. Chakrabarti (Eds.), *Adaptation and other essays* (pp. 98–102). Santiniketan: Visva Bharati Research Publications.

Kajale, M. D. (1990b). Observations on the plant remains from excavation at Chalcolithic Kaothe, District Dhule, Maharashtra with cautionary remarks on their interpretations. In M. K. Dhavalikar, V. S. Shinde, & S. M. Atre (Eds.), *Excavations at Kaothe* (pp. 265–280). Pune: Deccan College.

Kajale, M. D. (1991). Current status of Indian palaeoethnobotany: Introduced and indigenous food plants with a discussion of the historical and evolutionary development of Indian agriculture and agricultural systems in general. In J. M. Renfrew (Ed.), *New light on early farming–Recent developments in palaeoethnobotany* (pp. 155–189). Edinburgh: Edinburgh University Press.

Kajale, M. D. (1994a). Archaeobotanical investigations on a multicultural site at Adam, Maharashtra, with special reference to the development of tropical agriculture in arts of India. In J. Hather (Ed.), *Tropical archaeobotany: Applications and new developments* (pp. 34–50). London: Routledge.

Kajale, M. D. (1994b). Plant remains from Kodumanal excavations. *Avanam*, *4,* 132–134.

Kajale, M. D. (1995). Plant remains from Lal Qila. In R. C. Gaur (Ed.), *Excavations at Lal Qila. A Habitaional OCP site and unique copper hoard from Kiratpur* (pp. 189–193). Jaipur: Publication Scheme.

Kajale, M. D. (1996a). Palaeobotanical Investigations at Balathal: Preliminary Results. *Man and Environment*, *21*(1), 98–102.

Kajale, M. D. (1996b). Plant remains. In M. K. Dhavalikar, M. R. Raval, & Y. M. Chitalwala (Eds.), *Kuntasi. A Harappan emporium on the west coast* (pp. 285–289). Pune: Deccan College Post-Graduate and Research Institute.

Kajale, M. D. (1998). *Initial palaeoethnobotanical results from Neolithic Watgal, South India in relation to data from contemporary sites [unpublished abstract]*. 11th International Work Group for Palaeoethnobotany, Toulouse, France, 18–23 May, 1998.

Kajale, M. D. (2003). Antiquity of Native African Millets and associated plants with some observations on Prehistoric plant introductions into the Indian subcontinent. In V. N. Misra & M. D. Kajale (Eds.), *Introductions of African crops into South Asia* (pp. 23–48). Pune: Indian Society for Prehistoric and Quaternary Studies.

Kajale, M. D., & Eksambekar, S. P. (2001). Phytolith approach for investigating ancient occupations at Balathal, Rajasthan, India. In J. D. Maunier & F. Colin (Eds.), *Phytoliths: Application in earth sciences and human history* (pp. 199–212). Lisse: A. A. Balkema.

Kajale, M. D., & Eksamberkar (1997). Application of phytolith analyses to a Neolithic site at Budihal, Distirct Gulbarga, South India. In A. Pinilla, J. Juan-Tresserras, & M. J. Machado (Eds.), *Estado Actual de Los Etudios de Fitolitos en Suelos y Plantas (The State of the Art of Phjytoliths in Soils and Plants)* (pp. 219–229). Madrid: Centro Ciencial Medioambientales, Consejo Superior de Investigaciones Cientificas.

Kajale, M. D., & Lal, M. (1989). On the botanical findings from a multicultural site at Radhan, District Kanpur, Uttar Pradesh. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *47–48,* 109–111.

Kane, V. S. (1989). Animal remains from rojdi. In G. L. Possehl & M. R. Raval (Eds.), *Harappan civilization and rojdi* (pp. 182–184). New Delhi: Oxford-IBH.

Kar, S. K., Basa, K. K., & Joglekar, P. P. (1998). Explorations at Gopalpur, District Nayagarh, Coastal Orissa. *Man and Environment*, *23*(1), 107–114.

Kennedy, K. A. R. (2000). *God-Apes and fossil men. Paleoanthropology in South Asia*. Ann Arbor: University of Michigan Press.

Kennedy, K. A. R., & Possehl, G. L. (1979). Hunter-Gatherer/Agriculturalist Exchange in Prehistory: An Indian Example. *Current Anthropology*, *20*(3), 592–593.

Kenoyer, J. M. (1998). *Ancient cities of the Indus Valley civilization*. Karachi: Oxford University Press.

Kharakwal, J. S., Yano, A., Yasuda, Y., Shinde, V. S., & Osada, T. (2004). Cord impressed ware and rice cultivation in South Asia, China and Japan: possibilities of inter-links. *Quaternary International*, *123–125,* 105–115.

Kimata, M., Ashok, E. G., & Seetharam, A. (2000). Domestication, cultivation and utilization of two small millets, Brachiaria ramosa and Setaria glauca, Poaceae in South India. *Economic Botany*, *54,* 217–227.

Kislev, M. E., Nadel, D., & Carmi, I. (1992). Epipalaeolithic (19,000 bp) cereal and fruit diet at Ohalu II, Sea of Galilee, Israel. *Review of Palaeobotany and Palynology*, *73,* 161–166.

Kobayashi, T., Kaner, S., & Nakamura, O. (2004). *Jomon Reflections. Forager life and culture in the prehistoric Japanese archipelago*. Oxford: Oxbow Books.

Korisettar, R., Joglekar, P. P., Fuller, D. Q., & Venkatasubbaiah, P. C. (2001). Archaeological re-investigation and archaeozoology of seven southern Neolithic sites in Karnataka and Andhra Pradesh. *Man and Environment*, *26*(2), 47–66.

Korisettar, R., & Ramesh, R. (2002). Ihe Indian Monsoon: roots, relations and relevance. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Archaeology and Interactive Dsciplines*, vol. III (pp. 23–60). New Delhi: Manohar.

Korisettar, R., Venkatasubbaiah, P. C., & Fuller, D. Q. (2001). Brahmagiri and beyond: The archaeology of the southern Neolithic. In R. Korisettar & S. Settar (Eds.), *Indian archaeology in retrospect. Prehistory*, vol. I. New Delhi: Manohar.

Kumar, A. (2001). Origin, development and growth of the Mahagara Neolithic culture. *Pragdhara*, *11,* 119–124.

Kumar, P., Freeman, A. R., Loftus, R. T., Gaillard, C., Fuller, D. Q., & Bradley, D. G. (2003). Admixture analysis of South Asian cattle. *Heredity*, *91,* 43–50.

Kuzmin, Y. V. (2006). Chronology of the earliest pottery in East Asia: Progress and pitfalls. *Antiquity*, *80,* 362–371.

Lamberg-Karlovsky, C. C., & Tosi, M. (1989). The Proto-Elamite community at Tepe Yahya: Tools of administration and social order. In K. Frifelt & P. Sorensen (Eds.), *South Asian archaeology 1985* (pp. 104–113). London: Curzon Press.

Larson, G. K., Dobney, K., Albarella, U., Fang, M., Matisoo-Smith, E., Robins, J *et al*. (2005). Worldwide phylogeography of Wild Boar reveals multiple centers of pig domestication. *Science*, *307,* 1618–1621.

Lau, C. H., & Alii, E. (1998). Genetic diversity of Asian water bufalo (*Bubalus bubalis*): Mitrochondrial D-loop and cytochrome *b* sequence variation. *Animal Genetics*, *29,* 253–264.

Legge, A. J. (1996). The beginning of caprine domestication in Southwest Asia. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 238–262). London: UCL Press.

Legge, A. J., & Rowley-Conwy, P. A. (2000). The exploitation of animals. In A. M. T. Moore, G. C. Hillman, & A. J. Legge (Eds.), *Village on tyhe Euphrates. From Foraging to Farming at Abu Hureyra* (pp. 425–471). New York: Oxford University Press.

Lézine, A.-M., Saliège, J.-F., Robert, C., Wertz, F., & Inizian, M.-L. (1998). Holocene lakes from Ramlat as-Sab'atayn (Yemen) illustrate the impact of monsoon activity in southern Arabia. *Quaternary Research*, *50,* 290–299.

Li, C., Zhang, Y., Ying, K., Liang, X., & Han, B. (2004). Sequence variation of simple sequence repeats on chromosome-4 in two subspecies of Asian cultivated rice. *Theoretical and Applied Genetics*, *108,* 392–400.

Lieberman, D. E. (1993). The rise and fall of seasonal mobility among hunter-gatherers: The case of the Southern Levant. *Current Anthropology*, *34*(5), 599–631.

Litsina, G. N. (1984). The Caucasus–A centre of ancient farming in Eurasia. In W. Van Zeist & W. A. Casparie (Eds.), *Plants and ancient man. Studies in palaeoethnobotany* (pp. 285–292). Rotterdam: A. A. Balkema.

Liversage, D. (1989). The spread of food production into India–Some questions of interpretation. In K. Frifelt & P. Sorensen (Eds.), *South Asian archaeology 1985* (pp. 292–295). London: Curzon Press.

Loftus, R. F., MacHugh, D. E., Bailey, D. G., Sharp, P. M., & Cunningham, P. (1994). Evidence for two independent domestications of cattle. *Proceedings of the National Academy of Sciences (USA)*, *91,* 2757–2761.

Londo, J. P., Chiang, Y.-C., Hung, K.-H., Chiang, T.-Y., & Schaal, B. A. (2006). Phylogeography of Asian wild rice, Oryza rufipogon, reveals multiple independent domestications of cultivated rice, Oryza sativa. *Proceedings of the National Academy of Sciences (USA)*, *103,* 9578–9583.

Lone, F. A., Khan, M., & Buth, G. M. (1987). Plant remains from Banawali, Harayana. *Current Science*, *56*(16), 837–838.

Lone, F. A., Khan, M., & Buth, G. M. (1993). *Palaeoethnobotany–Plants and Ancient Man in Kashmir*. Rotterdam: A. A. Balkema.

Lu, T. L. D. (1999). *The transition from foraging to farming and the origin of agriculture in China*. Oxford: BAR.

Luikart, G., Gielly, L., Excoffier, L., Vigne, J.-D., Bouvet, J., & Taberlet, P. (2001). Multiple maternal origins and weak phylogeographic structure in domestic goats. *Proceedings of the National Academy of Sciences (USA)*, *98*(10), 5927–5932.

Lukacs, J. R. (2002). Hunting and gathering strategies in prehistoric India: a biocultural perspective on trade and subsistence. In K. D. Morrison & L. L. Junker (Eds.), *Forager-traders in south and southeast Asia* (pp. 41–61). Cambridge: Cambridge University Press.

Lukacs, J. R., & Pal, J. N. (1993). Mesolithic subsistence in north India: Inferences from dental attributes. *Current Anthropology*, *34*(5), 745–765.

Lyman, R. L. (1994). *Vertebrate taphonomy*. Cambridge: Cambridge University Press.

MacDonald, K. (1999). Invisible pastoralists: An inquiry into the origins of nomadic pastoralism in the West African Sahel. In C. Gosden & J. Hather (Eds.), *The prehistory of food. Appetites for Change* (pp. 333–349). London: Routledge.

MacDonald, K. (2000). The origins of Africna livestock: Indigenous or imported? In R. Blench & K. MacDonald (Eds.), *The origins and development of Africna livestock: Archaeology, genetics, linguistics and ethnography* (pp. 2–17). London: UCL Press.

MacDonald, K., & Edwards, D. N. (1993). Chickens in Africa: The importance of Qasr Ibrim. *Antiquity*, *67*(256), 584–590.

MacDonald, K. C. (1992). The domestic Chicken (Gallus gallus) in Sub-Saharan Africa: A background to its introduction and its osteological differentiation from indigenous fowls (Numidina and Francolinus sp.). *Journal of Archaeological Science*, *19,* 303–318.

MacHugh, D. E., & Bradley, D. G. (2001). Livestock genetic origins: Goats buck the trend. *Proceedings of the National Academy of Sciences (USA)*, *98*(10), 5382–5384.

MacHugh, D. E., Shriver, M. D., Loftus, R. T., Cunningham, P., & Bradley, D. G. (1997). Microsatellite DNA variation and the evolution, domestication and phylogeography of Taurine and Zebu Cattle (Bos taurus and Bos indicus). *Genetics*, *146,* 1071–1086.

MacNeish, R. S. (1992). *The origins of agriculture*. Norman, Oklahoma: University of Oklahoma.

Madella, M. (2003). Investigating agriculture and environment in South Asia: Present and future considerations of opal phytoliths. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 199–250). Lanham: Lexington Books.

Madella, M., & Fuller, D. Q. (2006). Paleoecology and the Harappan Civilisation of South Asia: A Reconsideration. *Quaternary Science Reviews*, *25,* 1283–1301.

Magee, & Bradley (2006 [in press]). Duality in Bos indicus mtDNA diversity–support for geographical complexity in zebu domestication. In M. D. Petraglia & B. Allchin (Eds.), *The evolution and history of human populations in South Asia: Inter-disciplinary studies in archaeology, biological anthropology, linguistics and genetics*. Doetinchem, The Netherlands: Springer.

Maier, U. (1996). Morphological studies of free-threshing wheat ears from a Neolithic site in southwest Germany, and the history of naked wheats. *Vegetation History and Archaeobotany*, *5,* 39–55.

Manceau, V., Després, L., Bouvet, J., & Taberlet, P. (1999). Systematics of the Genus *Capra* Inferred from mitochondrial DNA sequence data. *Molecular Phylogenetics and Evolution*, *13*(3), 504–510.

Mani, B. R. (2004). Further evidence on Kashmir Neolithic in light of recent excavations at Kanishkapura. *Journal of Interdisciplinary Studies in History and Archaeology*, *1*(1), 137–142.

Mannen, H., Nagata, Y., & Sowers, T. (2001). Mitochondrial DNA reveal that dmoestic goat (*Capra hircus*) are genetically affected by two subspecies of bezoar (*Capra aegragus*). *Biochecmical Genetics*, *39*(5/6), 145–154.

Marnival, P. (1992). Archaeobotanical data on millets (*Panicum miliaceum* and *Setaria italica*) in France. *Review of Palaeobotany and Palynology*, *73,* 259–270.

Marr, K. L., Bhattarai, N., & Xia, Y.-M. (2005b). Allozymic, morphological, and phenological diversity of cultivated *Luffa acutangula* (Cucurbitaceae) from China, Laos, and Nepal, and Allozyme divergence detween *L. acutangula* and *L. aegyptiaca*. *Economic Botany*, *59*(2), 154–165.

Marr, K. L., Mei, X. Y., & Bhattarai, N. (2004). Allozyme, morphological and nutritional analysis bearing on the domestication of *Momordica charantia* L. (Cucurbitaceae) from China, Laos, and Nepal. *Economic Botany*, *58*(3), 435–455.

Marr, K. L., Xia, Y.-M., & Bhattarai, N. (2005a). Allozymic, morphological, phenological, linguistic, plant use, and nutritional data on wild and cultivated collections of *Luffa aegyptiaca* Mill. (Cucurbitaceae) from Nepal, Southern China, and Northern Laos. *Economic Botany*, *59*(2), 137–153.

Marshall, F. (1998). Early food production in Africa. *The Review of Archaeology*, *19*(2), 47–57.

Marshall, F., & Hildebrand, E. (2002). Cattle before crops: The beginnings of food production in Africa. *Journal of World Prehistory*, *16,* 99–143.

Mason, I. L. (1984). Goat. In I. L. Mason (Ed.), *Evolution of domesticated animals* (pp. 85–106). London: Longman.

McKean, M. B. (1983). *The palynology of Balakot, a pre-Harappan and Harappan age site in Las Bela, Pakistan*. Ph.D Dissertation, Southern Methodist University, Dallas. University Microfilms, Ann Arbor

Meadow, R. (1979a). Prehistoric subsistence at Balakot: Initial consideration of the faunal remains. In M. Taddei (Ed.), *South Asian Archaeology 1977* (pp. 275–315). Naples: Instituto Universitario Orientale, Seminario di Studi Asiatici.

Meadow, R. (1979b). A preliminary note on the faunal remains from pirak. In J. F. Jarrige, M. Santoni, & J.-F. Enault (Eds.), *Fouilles de Pirak* (p. 334). Paris: Diffusion de Boccard.

Meadow, R. (1984). Animal domestication in the Middle East: A view from the Eastern margin. In J. Clutton-Brock & C. Grigson (Eds.), *Animals in Archaeology 3. Early Herders and their Flocks* (pp. 309–337). Oxford: BAR.

Meadow, R. (1986a). Faunal exploitation in the greater Indus valley: A review of recent work to 1980. In J. Jacobsen (Ed.), *Studies in the archaeology of India and Pakistan* (pp. 43–64). New Delhi: Oxford and IBH.

Meadow, R. (1986b). The geographical and palaeoenvironmental setting of Tepe Yahya. In C. C. Lamberg-Karlovsky & T. W. Beak (Eds.), *Tepe Yahya, Iran 1967–1975: The early periods* (pp. 21–38). Cambridge, Massachusetts: American School of Prehistoric Research Bulletin 38, Peabody Museum, Harvard University

Meadow, R. (1987). Faunal exploitation patterns in Eastern Iran and Baluchistan: A review of recent investigations. In G. Gnoli & L. Lanciotti (Eds.), *Oreintalia Iosephi Tucci Memoriae Dicata* (pp. 881–916). Rome: Istituto Italiano per il Medio ed Estermo Oreinte.

Meadow, R. (1988). The faunal remains from Jalilpur 1971. *Pakistan Archaeology*, *23,* 204–220.

Meadow, R. (1989a). Continuity and change in the agriculture of the greater Indus Valley: The palaeoethnobotanical and zooarchaeological evidence. In J. M. Kenoyer (Ed.), *Old problems and new perspectives in the archaeolohy of South Asia* (pp. 61–74). Madison: University of Wisconsin, Department of Anthropology.

Meadow, R. (1989b). Prehistoric wild sheep and sheep domestication on the eastern margin of the Middle East. In P. J. Crabtree, D. Campana, & K. Ryan (Eds.), *Early animal domestication and its cultural context*. Philadelphia: MASCA, The University Museum of Archaeology and Anthropology.

Meadow, R. (1991). Faunal remains and urbanism at Harappa. In R. Meadow (Ed.), *Harappan excavations 1986–1990* (pp. 89–106). Madison: Prehistory Press.

Meadow, R. (1993). Animal domestication in the Middle East: A revised view from the eastern Margin. In G. L. Possehl (Ed.), *Harappan civilization: A recent perspective* (pp. 295–320). New Delhi: Oxford and IBH.

Meadow, R. (1996). The origins and spread of agriculture and pastoralism in northwestern South Asia. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 390–412). London: UCL Press.

Meadow, R. (1998). Pre- and proto-historic agricultural and pastoral transformations in northwestern south asia. *The Review of Archaeology*, *19*(2), 12–21.

Meadow, R., & Patel, A. K. (2001). From Mehrgarh to Harappa and Dholavira: Prehistoric Pastoralism in North-Western South Asia through the Harappan Period. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Protohistory*, vol. II (pp. 391–408). New Delhi: Manohar.

Meadow, R., & Patel, A. K. (2003). Prehistoric pastoralism in Northwestern South Asia from the Neolithic through the Harappan period. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 65–94). Lanham: Lexington Books.

Meher-Homji, V. M. (2002). Biocliamtology and quaternary palynology in India. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Archaeology and interactive dsciplines*, vol. III (pp. 61–86). New Delhi: Manohar.

Miller, H. (1988). *Preliminary analysis of the plant remains from Tarakai Qila: Confessions of a law consumer*. London: University of London.

Miller, L. J. (2003). Secondary products and Urbanism in South Asia: The evidence for traction at Harappa. In S. A. Weber & W. R. Belcher (Eds.), *Indus Ethnobiology. New perspectives from the field* (pp. 251–326). Lanham: Lexington Books.

Miller, N., & Smart, T. L. (1984). Intentional burning of dung as fuel: A mechanism for the incorporation of charred seeds into the archaeological record. *Journal of Ethnobiology*, *4,* 15–28.

Miller, T. E. (1992). A cautionary note on the use of morphological characters for recognising taxa in wheat (genus Triticum). In P. C. Anderson (Ed.), *Prehistoire de l'Agriculture: nouvelles appreoaches experimentales et ethnographiques* (pp. 249–253). Paris: Editions CNRS.

Misra, V. D. (1999). Agriculture, domestication of animals and ceramic and other industries in prehistoric India: Mesolithic and Neolithic. In G. C. Pande (Ed.), *The dawn of civilization upto 600 BC* (pp. 233–266). Delhi: Centre for Studies in Civilization.

Misra, V. D., Pal, J. N., & Gupta, M. C. (2001). Exavation at Tokwa: A Neolithic-Chalcolithic settlement. *Pragdhara*, *11,* 59–72.

Misra, V. D., Pal, J. N., & Gupta, M. C. (2004). Significance of recent excavations at Tokwa in the Vindhyas and Jhusi in the Gangetic Plains. *Journal of Interdisciplinary Studies in History and Archaeology*, *1*(1), 120–126.

Misra, V. N. (1973). Bagor: A late Mesolithic settlement in north-west India. *World Archaeology*, *5*(1), 92–100.

Misra, V. N. (1989). Human adaptations to the changing landscape of the Indian Arid Zone during the Quaternary Period. In J. M. Kenoyer (Ed.), *Old problems and new perspectives in the archaeology of South Asia* (pp. 3–20). Madison: Wisconsin Archaeological Reports, Department of Anthropology, University of Wisconsin.

Misra, V. N. (2005). Radiocarbon chronology of Balathal, District Udaipur, Rajasthan. *Man and Environment*, *30*(1), 54–60.

Misra, V. N., & Mohanty, R. K. (2001). A rare Chalcolithic pottery cache from Balathal, Rajasthan. *Man and Environment*, *26*(2), 67–74.

Misra, V. N., Shinde, V., Mohanty, R. K., Pandey, L., & Kharakwal, J. (1997). Excavations at Balathal, Udaipur District, Rajasthan (1995-97), with special refernce to Chalcolithic architecture. *Man and Environment*, *22*(2), 35–59.

Mohammed-Ali, A. S., & Khabir, A.-R. M. (2003). The wavy line and dotted wavy line pottery in the prehistory of the central Nile and the Sahara-Sahel belt. *African Archaeological Review*, *20*(1), 25–58.

Mohanta, B. K. (2003). *Neolithic and Post-Neolithic cultures of Northern Orissa (with special reference to Mayurbhanj and Keonjhar Districts)*. Ph.D. Dissertation, Department of Anthropology, Utkal University, Bhubaneswar, Orissa.

Moore, A. M. T., Hillman, G. C., & Legge, A. T. (2000). *Village on the Euphrates. From foraging to farming at Abu Hureyra*. New York: Oxford University Press.

Morrison, K. D. (2002a). Introduction. In K. D. Morrison & L. L. Junker (Eds.), *Forager-traders in South and Southeast Asia* (pp. 21–40). Cambridge: Cambridge University Press.

Morrison, K. D. (2002b). Pepper in the hills: upland-lowland exchange and the intensification of the spice trade. In K. D. Morrison & L. L. Junker (Eds.), *Forager-traders in South and Southeast Asia* (pp. 105–128). Cambridge: Cambridge University Press.

Moulherat, C., Tengberg, M., Haquet, J.-F., & Mille, B. (2002). First Evidence of Cotton at Neolithic Mehrgarh, Pakistan: Analysis of Mineralized Fibres from a Copper Bead. *Journal of Archaeological Science*, *29,* 1393–1401.

Naik, S., & Mishra, S. (1997). The Chalcolithic phase in the Bhima Basin, Maharashtra: A review. *Man and Environment*, *22*(1), 45–58.

Naik, S. N. (1978). Origin and domestication of Zebu cattle (Bos indicus). *Journal of Human Evolution*, *7,* 23–30.

Nath, B. (1963). Animal remains from Rangpur. *Ancient India*, *18–19,* 153–160.

Nath, B. (1967). Animal remains from Adamgarh Rock Shelters. *Indian Museum Bulletin*, *2,* 28–38.

Nath, B. (1968). Animal remains from Rupar and Bara sites, Ambala District of East Punjab. *Bulletin of the Indian Museum*, *3*(1–2), 69–116.

Nath, B. (1969). The role of animal remains in the early and prehistoric culture of India. *Bulletin of the Indian Museum*, *4*(2), 102–110.

Nath, B., & Biswas, M. K. (1980). Animal remains from Chirand, Saran District, Bihar. *Records of the Zoological Survey of India*, *76,* 115–124.

Nath, B., & Rao, G. V. S. (1985). Animal remains from Lothal excavations. In S. R. Rao (Ed.), *Lothal: a Harappan port town 1955–1962* (pp. 636–650). New Delhi: Archaeological Survey of India.

Neumann, K. (2003). The late emergence of of agriculture in sub-Saharan Africa: Archaeobotanical evidence and ecological considerations. In K. Neumann, A. Butler, & S. Kahlheber (Eds.), *Food, fuel and fields. Progress in African archaeobotany* (pp. 71–92). Köln: Heinrich-Barth-Institute.

Neumann, K. (2004). The romance of Farming. Plant cultivation and domestication in Africa. In A. B. Stahl (Ed.), *African archaeology: A critical introduction* (pp. 249–275). Oxford: Blackwell.

Niu, D., Fu, Y., Luo, J., Ruan, H., Yu, X.-P., Chen, G *et al.* (2002). The origin and genetic diversity of Chinese native chicken breeds. *Biochemical Genetics*, *40*(5/6), 163–174.

O'Connor, T. P. (1996). A critical overview of archaeological animal bone studies. *World Archaeology*, *28,* 5–19.

Oyuela-Caycedo, A. (1995). Rock versus clay: the evolution of pottery technology in the case of San Jacinto 1, Colombia. In W. K. Barnett & J. W. Hoopes (Eds.), *The emergence of pottery. Technology and innovation in ancient societies* (pp. 133–144). Washington, DC: Smithsonian.

Özdogan, M. (1997). The beginning of Neolithic economies in Southeastern Europe: An Anatolian perspective. *Journal of European Archaeology*, *5*(2), 1–33.

Paddayya, K. (1996). Modern impacts on archaeological sites in India: A case study from the Shorapur Doab, Karnataka. *Man and Environment*, *21*(2), 75–88.

Paddayya, K. (1998). Evidence of Neolithic Cattle-Penning at Budihal, Gulbarga District, Karnataka. *South Asian Studies*, *14,* 141–153.

Paddayya, K. (2001). The problem of ashmounds of Southern Deccan in the light of the Budihal excavations, Karnataka. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *60–61,* 189–225.

Pal, B. P. (1966). *Wheat*. New Delhi: Indian Council for Agricultural Research.

Pal, J. N. (1986). *Archaeology of southern Uttar Pradesh. Ceramic industries of northern Vindhyas*. Allahabad: Swabha Prakashan.

Pandey, & Chanda (1996). *Economic botany*. New Delhi: Vikas Publishing House.

Pandey, J. N. (1990). Mesolithic in the Middle Ganga Valley. *Bulletin of the Deccan College Post-Graduate and Research Institute*, *49,* 311–316.

Pandey, J. N., Goel, A., Gautam, S. K., Pooja, P., & Pandey, A. K. (2005). Settlement pattern in the Mesolithic and Neolithic of the Ganga Valley. *Pragdhara (Journal of the Uttar Pradesh State Department of Archaeology)*, *15,* 71–90.

Parpola, A. (1988). The coming of the Aryans to Iran and India and the cultural and ethnic identity of the Dasas. *Studia Orientialia*, *64,* 195–302.

Parpola, A. (1994). *Deciphering the indus script*. Cambridge: Cambridge University Press.

Parpola, A. (1999). The formation of the Aryan branch of Indo-European. In R. Blench & M. Spriggs (Eds.), *Archaeology and Language III. Artefacts, languages amd texts* (pp. 180–207). London: Routledge.

Patel, A. K. (1997). The pastoral economy of Dholavira: A first look at animals and urban life in third millennium Kutch. In R. Allchin & B. Allchin (Eds.), *South Asian Archaeology 1995* (pp. 101–113). New Delhi: Oxford-IBH.

Patel, A. K. (1999). New radiocarbon determinations from Loteshwar and their implications for understanding settlement and subsistence in North Gujarat and adjoining areas. Paper presented by the Fifteenth International Conference on South Asian Archaeology, Leiden University, July 5–9, 1999.

Patel, A. K., & Meadow, R. (1998). The exploitation of wild and domestic water buffalo in prehistoric northwestern South Asia. In H. Buitenhuis, L. Bartosiewicz, & A. M. Choyke (Eds.), *Archaeozoology of the Near East III* (pp. 180–199). Rijksuniversiteit Groningen, Groningen: Centre for Archaeological Research and Consultancy.

Paterson, A. H., Lin, Y.-R., Li, Z., Schertz, K. F., Doebly, J. F., Pinson, S. R. M., *et al.* (1995). Convergent domestication of cereal crops by independent mutations at corresponding genetic loci. *Science*, *269,* 1714–1718.

Pawankar, S. J., & Thomas, P. K. (1997). Fauna and subsistence pattern in the Chalcolithic culture of Western India, with special reference to Inamgaon. *Anthropozoologica*, *25–26,* 737–746.

Pawankar, S. J., & Thomas, P. K. (2001). Osteological Differences between Blackbuck (Antilope cervicarpa), Goat (Caspra hircus) and Sheep (Ovis aries). *Man and Environment*, *26*(1), 109–126.

Payne, S. (1973). Kill-off patterns in sheep and goats: the mandibles from Asvan Kale. *Anatolian Studies*, *23,* 281–303.

Pearsall, D. M. (1992). The origins of plant cultivation in South America. In C. W. Cowan & P. J. Watson (Eds.), *The origins of agriculture. An international perspective* (pp. 173–205). Washington, DC: Smithsonian.

Pei, A. (1998). Notes on new advancements and revelations in the agricultural archaeology of early rice domestication in the Dongting Lake region. *Antiquity*, *72,* 878–885.

Pei, A. (2002). Rice paddy agriculture and pottery from the Middle reaches of the Yangtze River. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 167–181). New Delhi: Lustre Press and Roli Books.

Peltenberg, E., Croft, P., Jackson, A., McCartney, C., & Murray, M. A. (2000). Well-established colonists: *Mylouthkia* 1 and the Cypro-Pre-Pottery Neolithic B. In S. Swiny (Ed.), *The earliest prehistory of Cyprus. From colonization to exploitation* (pp. 61–108). Boston: American Schools of Oriental Research.

Peng, J., Ronin, Y., Fahima, T., Roder, M. S., Li, Y., Nevo, E., *et al.* (2003). Domestication quantitative trait loci in *Triticum dicoccoides,* the progenitor of wheat. *Proceedings of the National Academy of Sciences (USA)*, *100*(5), 2489–2494.

Perles, C. (2005). From the near east to Greece: Let's reverse hte focus. Cultural elements that didn't transfer. In C. Lichter (Ed.), *How did farming reach Europe?: Anatolian-European relations from the second half of the 7th through the first half of the 6th millennium cal BC: proceedings of the international workshop, Istanbul, 20–22 May 2004* (pp. 275–290). Istanbul, Turkey: Ege Yayinlar.

Petraglia, M. D. (2002). Pursuing site formation research in India. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect. Archaeology and Historiography*, vol. 4 (pp. 217–242). Delhi: Manohar.

Piperno, D. R., Wiess, E., Holst, I., & Nadel, D. (2004). Processing of wild cereal grains in the Upper Palaeolithic revealed by starch grain analysis. *Nature*, *430,* 670–673.
Plog, S. (1997). *Ancient peoples of the American Southwest*. New York: Thames and Hudson.
Pokharia, A. K., & Saraswat, K. S. (2004a). *Plant resources at Ojiyana, Rajasthan*. Lucknow: National Seminar on the Archaeology of the Gange Plain, Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society.
Pokharia, A. K., & Saraswat, K. S. (2004b). *Plant resources in the Neolithic Economy at Kanishpur, Kashmir*. Lucknow: National Seminar on the Archaeology of the Gange Plain, Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society.
Poncet, V., Lamy, F., Devos, K., Gale, M., Sarr, A., & Robert, T. (2000). Genetic control of domestication traits in pearl millet (Pennisetum glaucum L., Poaceae). *Theoretical and Applied Genetics*, *100,* 147–159.
Possehl, G. (2002a). *The indus civilization. A contemporary perspective*. California: Alta Mira, Walnut Creek.
Possehl, G. L. (1976). Lothal: A gateway settlement of the Harappan Civilization. In G. L. Possehl & K. A. R. Kennedy (Eds.), *Ecological background of South Asian prehistory* (pp. 118–134). Ithaca: South Asia Program, Cornell University.
Possehl, G. L. (1980). *Indus civilization in Saurashtra*. Delhi: B. R. Publishing Corp..
Possehl, G. L. (1986). African Millets in South Asian Prehistory. In J. Jacobsen (Ed.), *Studies in the archaeology of India and Pakistan* (pp. 237–256). New Delhi: Oxford and IBH.
Possehl, G. L. (1997). The transformation of the Indus civilisation. *Journal of World Prehistory*, *11*(4), 425–472.
Possehl, G. L. (1999). *Indus age. The beginnings*. Philadephia: University of Pennsylvania Press.
Possehl, G. L. (2002b). Harappans and hunters: Economic interaction and specialization in prehistoric India. In K. D. Morrison & L. J. Junker (Eds.), *Forager-traders in South and Southeast Asia. Long term histories* (pp. 62–76). Cambridge: Cambridge University Press.
Possehl, G. L., & Kennedy, K. A. R. (1979). The hunter-gatherer/agricultural exchange in prehistory: An example from India. *Current Anthropology*, *20*(3), 592–593.
Possehl, G. L., & Rissman, P. (1992). The chronology of prehistoric India from earliest times to the Iron Age. In R. W. Ehrich (Ed.), *Chronologies in old world archaeology* (pp. 1, 465–490; 462, 447–474). Chicago: University of Chicago Press.
Prasada Rao, K. E., De Wet, J. M. J., Brink, D. E., & Mengesha, M. H. (1987). Infraspecific variation and systematics of cultivated Setaria italica, Foxtail Millet (Poaceae). *Economic Botany*, *41*(1), 108–116.
Pratap, A. (2001). *The Hoe and the axe. An ethnohistory of shiftinbg cultivation in Eastern India*. New Delhi: Oxford University Press.
Rajan, K. (1997). *Archaeological Gazetteer of Tamil Nadu*. Thanjuvar: Manoa Pathipakam.
Rao, R., & Lal, K. (1985). Plant remains. In S. R. Rao (Ed.), *Lothal* (pp. 667–684). Delhi: Archaeological Survey of India.
Rao, V. V. (1973). Ornithology in Protohistoric Archaeology of India. *Puratatta*, *6,* 56–59.
Ray, R., & Ghosh, A. K. (1986). An enquiry into the absence of any mesolithic site in Kashmir. In G. M. Buth (Ed.), *Central Asia and Western Himalaya–A Forgotten Link* (pp. 27–34). Jodhpur: Scientific Publishers.
Reddy, S. N. (1994). *Plant Usage and Subsistence Modeling: An Ethnoarchaeological Approach to the Late Harappan of Northwest India*. Ph.D. Dissertation, University of Wisconsin, University Microfilms, Ann Arbor.
Reddy, S. N. (1997). If the threshing floor could talk: Integration of agriculture and pastoralism during the Late Harappan in Gujarat, India. *Journal of Anthropological Archaeology*, *16,* 162–187.
Reddy, S. N. (2003a). *Discerning Palates of the Past: An ethnoarchaeological study of crop cultivation and plant usage in India*. Ann Arbor: Prehistory Press.
Reddy, S. N. (2003b). Food and fodder: Plant usage and changing socio-cultural landscapes during the Harappan phase in Gujarat, India. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 327–342). Lanham: Lexington Books.
Reed, C. A. (1977). Introduction: prologue. In C. A. Reed (Ed.), *Origins of agriculture* (pp. 1–21). The Hague: Mouton.
Renfrew, C. (1996). Language families and the spread of farming. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 70–92). London: UCL Press.
Rice, P. (1999). On the origins of pottery. *Journal of Archaeological Method and Theory*, *6*(1), 1–54.
Rindos, D. (1980). Symbiosis, instability, and the origins and spread of agriculture: A new model. *Current Anthropology*, *21,* 751–772.

Rindos, D. (1984). *The origins of agriculture. An evolutionary perspective*. New York: Academic Press.
Robinson, M. (2000). Further considerations of Neolithic charred cereals, fruit, and nuts. In A. Fairbairn (Ed.), *Plants in Neolithic Britain and beyond* (pp. 85–90). Oxford: Oxbow Books.
Roosevelt, A. C. (1995). Early pottery in the Amazon. Twenty years of scholarly obscurity. In W. K. Barnett & J. W. Hoopes (Eds.), *The emergence of pottery. Technology and innovation in ancient societies* (pp. 115–131). Washington, DC: Smithsonian.
Rowley-Conwy, P. A. (2004). How the West Was Lost: A Reconsideration of Agricultural Origins in Britain, Ireland, and Southern Scandinavia. *Current Anthropology*, *45*(S4), S83–S113.
Ryder, M. L. (1984). Sheep. In I. L. Mason (Ed.), *Evolution of domesticated animals* (pp. 63–86). London: Longman.
Sadr, K. (1991). *The development of nomadism in ancient northeast Africa*. Philadelphia: University of Pennsylvania Press.
Sadr, K. (2003). The Neolithic of Southern Africa. *Journal of African History*, *44,* 195–209.
Saha, S. (2002). Anthropogenic fire regimes in the deciduous forests of central India. *Current Science*, *82*(9), 1144–1147.
Sahu, B. P. (1988). *From Hunters to Breeders (Faunal Background of Early India)*. Delhi: Anamika Prakashan.
Saldanha, C. J. (1984). *Flora of Karnataka*, vol. I. New Delhi: Oxford and IBH.
Sankalia, H. D., Deo, S. B., Ansari, Z. D., & Ehrhardt, S. (1960). *From History to Prehistory at Nevasa (1954–1956)*. Pune: Deccan College.
Sano, R., & Morishima, H. (1992). Indica-Japonica differentiation of rice cultivars viewed from variations in key characters of isozyme, with species reference to Himilayan hilly areas. *Theoretical and Applied Genetics*, *84,* 266–274.
Saraswat, K. S. (1980). The ancient remains of the crop plants at Atranjikhera (c. 2000–1500 B.C.). *Journal of the Indian Botanical Society*, *59,* 306–319.
Saraswat, K. S. (1986a). Ancient Crop-economy of Harappans from Rohira, Punjab (c. 2000–1700 B.C.). *The Palaeobotanist*, *35,* 32–38.
Saraswat, K. S. (1986b). Ancient crop plant remains from Sringaverapura, Allahabad, U. P. (ca. 1,050–700 B.C.). *Geophytology*, *16*(1), 97–106.
Saraswat, K. S. (1991). Crop Economy at Ancient Mahorana, Punjab (C. 2100–1900 B.C.). *Pragdhara*, *1,* 83–88.
Saraswat, K. S. (1992). Archaeobotanical remains in ancient cultural and socio-economical dynamics of the Indian subcontinent. *Palaeobotanist*, *40,* 514–545.
Saraswat, K. S. (1993a). Plant economy of Late Harappans at Hulas. *Purattatva*, *23,* 1–12.
Saraswat, K. S. (1993b). Seed and fruit remains at ancient Imlidh-Khurd, Gorakhpur: A preliminary report. *Pragdhara*, *3,* 37–41.
Saraswat, K. S. (1997). Plant Economy of Barans at Ancient Sanghol (Ca. 1900–1400 B.C.), Punjab. *Pragdhara (Journal of the U. P. State Archaeology Department)*, *7,* 97–114.
Saraswat, K. S. (2002a). Balu (29°40′N; 76°22′E), District Kaithal. *Indian Archaeology 1996–1997–A Review*, 198–203.
Saraswat, K. S. (2002b). Banawali (29′37′5″N; 75′23′6″E), District Hissar. *Indian Archaeology 1996–1997–A Review*, 203.
Saraswat, K. S. (2004a). Plant economy of early farming communities. In B. P. Singh (Ed.), *Early farming communities of the Kaimur (Excavations at Senuwar)* (pp. 416–535). Jaipur: Publication Scheme.
Saraswat, K. S. (2004b). *Plant economy at Mesolithic Damdama, Pratapgarh Distirct, U.P.* National Seminar on the Archaeology of the Gange Plain, Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society, December 2004, Lucknow.
Saraswat, K. S. (2005). Agricultural background of the early farming communities in the Middle Ganga Plain. *Pragdhara (Journal of the Uttar Pradesh State Department of Archaeology)*, *15,* 145–177.
Saraswat, K. S., & Chanchala, S. (1994). Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1989–1990–A Review*, 132–133.
Saraswat, K. S. & Chanchala, S. (1995). Palaeobotanical and Pollen Analytical Investigations. *Indian Archaeology 1990–1991–A Review*, 103–104.
Saraswat, K. S., & Pokharia, A. K. (1998). On the remains of Botanical Material used in Fire-Sacrifice Ritualized during Kushana Period at Sanghol (Punjab). *Pragdhara*, *8,* 149–181.
Saraswat, K. S., & Pokharia, A. K. (2002). Harappan plant economy at ancient Balu, Haryana. *Pragdhara*, *12,* 153–172.

Saraswat, K. S., & Pokharia, A. K. (2003). Palaeoethnobotanical investigations at Early Harappan Kunal. *Pragdhara*, *13,* 105–140.
Saraswat, K. S., & Pokharia, A. K. (2004a). *Plant resources in the Neolithic Economy at Kanishpur, Kashmir*. Lucknow: Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society.
Saraswat, K. S., & Pokharia, A. S. (2004b). *Archaeological studies in the Lahuradewa Area, 2. Plant Economy at Lahuradewa: A Preliminary contemplation*. Lucknow: National Seminar on the Archaeology of the Gange Plain, Joint Annual Conference of the Indian Archaeological Society, Indian Society of Prehistoric and Quaternary Studies, Indian History and Culture Society, December 2004.
Saraswat, K. S., Saini, D. C., Sharma, M. K., & Chanchala, S. (1990). Palaeobotanical and pollen analytical investigation. *Indian Archaeology 1985-86–A Review*, 122–125.
Saraswat, K. S., Sharma, N. K., & Saini, D. C. (1994). Plant Economy ay Ancient Narhan (Ca. 1,300 B.C.–300/400 A.D.). In P. Singh (Ed.), *Excavations at Narhan (1984–1989)* (pp. 255–346). Varanasi: Banaras Hindu University.
Sarianidi, V. (1992). Food-producing and other Neolithic communities in Khorasan and Transoxania: eastern Iran, Soviet Central Asia and Afghanistan. In A. H. Dani & V. M. Masson (Eds.), *History of civilizations of central Asia. The Dawn of Civilization: Earliest Times to 700 B.C.*, vol. I (pp. 109–126). New Delhi: Motilal Banarsidass.
Sathe, V., & Badam, G. L. (2004). Faunal remains. In B. P. Singh (Ed.), *Early farming communities of the Kaimur (Excavations at Senuwar)* (pp. 585–590). Jaipur: Publication Scheme.
Sato, Y.-I. (2002). Origin of rice cultivation in the Yangtze River Basin. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 143–150). New Delhi: Lustre Press and Roli Books.
Sato, Y.-I. (2005). Rice and Indus Civilization. In T. Osada (Ed.), *Linguistics, archaeology and human past* (pp. 213–214). Kyoto: Research Institute for Humanity and Nature.
Sato, Y.-I., Ishikawa, R., & Morishima, H. (1990). Nonrandom association of genes and characters found in indica x japonica hybrids of rice. *Heredity*, *65,* 75–79.
Schiffer, M. (1972). Archaeological and systemic context. *American Antiquity*, *37,* 156–165.
Schiffer, M. (1987). *Formation processes of the archaeological record*. Albuquerque: University of New Mexico Press.
Schuldenrein, B. (2001). Geoarchaeological perspectives on the Harappan sites of South Asia. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in retrospect II. Protohistory* (pp. 47–80). New Delhi: Manohar.
Selvakumar, V. (1996). Archaeological Investigations in the Upper Gundar Basin, Madurai District, Tamil Nadu. *Man and Environment*, *21*(2), 27–42.
Sewell, R. B. S., & Guha, B. S. (1931). Zoological remains. In J. Marshall (Ed.), *Mohenjodaro and the Indus civilization* (pp. 649–673). London: Arthur Probsthain.
Shaffer, J. G. (1992). Indus Valley, Baluchistan, and the Helmand Drainage (Afghanistan). In R. W. Ehrich (Ed.), *Chronologies in old world archaeology* (vol. 1, pp. 441–464; vol. 442, 425–446). Chicago: University of Chicago Press.
Shah, D. R. (1969). Animal remains. In H. D. Sankalia, S. B. Deo, & Z. D. Ansari (Eds.), *Excavations at Ahar (Tambavati)* (pp. 237–245). Pune: Deccan College.
Shah, D. R. (1983). Appendix B. The animal remains. In R. C. Gaur (Ed.), *Excavations at Atranjikhera. Early Civilization of the Upper Ganga Basin* (pp. 461–471). Delhi: Motilal Banarsidass.
Shah, D. R. (1995). The animal remains. In R. C. Gaur (Ed.), *Excavations at Lal Qila. A Habitaional OCP site and unique copper hoard from Kiratpur* (pp. 193–198). Jaipur: Publication Scheme.
Sharma, A. (1983). *Further contributions to the palaeobotanical history of the crops*. Ph.D. Dissertation, Lucknow: University of Lucknow.
Sharma, A. K. (1982). Excavations at Gufkral, 1981. *Puratattva*, *11,* 19–25.
Sharma, A. K. (1986). Neolithic Gufkral. In G. M. Buth (Ed.), *Central Asia and Western Himalaya–A forgotten link* (pp. 13–18). Jodhpur: Scientific Publishers.
Sharma, A. K. (1990). Animal bone remains. In J. P. Joshi (Ed.), *Excavations at Surkotada* (pp. 372–383). New Delhi: Archaeological Survey of India.
Sharma, D. P., & Sharma, M. (1987). A reappraisal of the chronology of Mesolithic and Neolthic cultures of the Vindhyas and middle Ganga Valley. In Chattopadhyaya, B. M. Pande, & B. D. Chattopadhyaya (Eds.), *Archaeology and History–essays in memory of Shri A. Ghosh* (pp. 57–66). Delhi: Agam Kal Prakashan.
Sharma, G. R., Misra, V. D., Mandal, D., Misra, B. B., & Pal, J. N. (1980). *Beginnings of Agriculture (Epi-Palaeolithic to Neolithic: Excavations at Chopani-Mando, Mahadaha, and Mahagara)*. Allahabad: Abinash Prakashan.
Sherrat, A. (1981). Plough and pastorlism: aspects of the secondary products revolution. In I. Hodder, G. Isaac, & N. Hammond (Eds.), *Pattern of the past: Studies in honour of David Clarke* (pp. 261–305). Cambridge: Cambridge University Press.

Sherrat, A. (1983). The secondary exploitation of animals in the Old World. *World Archaeology*, *15,* 90–104.
Sherrat, A. (1999). Cash-crops before cash: organic consumables and trade. In C. Gosden & J. Hather (Eds.), *The prehistory of food. Appetites for change* (pp. 13–34). London: Routledge.
Shinde, V. (1987). Farming in the Chalcolithic Deccan, India c. 2000–1000 B.C. *Tools and Tillage*, *5*(4), 215–227.
Shinde, V. (1998a). Pre-Harappan Padri Culture in Saurashtra: The Recent Discovery. *South Asian Studies*, *14,* 173–182.
Shinde, V. S., Deshpande, S. S., & Yasuda, Y. (2004). Human reposnses to Holocene climate changes–A case study of Western India between 5th and 3rd Millennia BC. In Y. Yasua & V. S. Shinde (Eds.), *Monsoon and civilization* (pp. 383–406). New Delhi: Lustre Press/Roli Books.
Shinde, V. S. (1998b). *Early Settlements in the Central Tapi Basin*. New Delhi: Munshiram Manoharlal.
Shinde, V. S. (2002). The emergence, development and spread of agricultural communities in South Asia. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 89–115). New Delhi: Lustre Press and Roli Books.
Simoons, F. J. (1970). The traditional limits of milking and milk use in southern Asia. *Anthropos*, *65,* 547–593.
Simoons, F. J. (1978). The geographic hypothesis and lactose malabsorption. *American Journal of Digestive Diseases*, *23,* 963–980.
Simoons, F. J. (1991). *Food in China. A cultural and historical inquiry*. Boca Raton: CRC Press.
Singh, H. B., & Arora, R. K. (1972). Raishan (*Digitaria* sp.)–A minor millet of the lhasi hills, India. *Economic Botany*, *26,* 376–380.
Singh, B. P. (1997). Neolithic and Chalcolithic pottery of the MIddle Ganga Plains: A case study of Senuwar. In P. C. Pant & V. Jayaswal (Eds.), *Ancient Ceramics. Historical enquiries and scientific approaches* (pp. 3–33). Delhi: Agam Kala Prakashan.
Singh, B. P. (2001). Stages of culture development in the Middle Ganga Plains—A case study of Senuwar. *Pragdhara*, *11,* 109–118.
Singh, G., Joshi, R. D., Chopra, S., & Singh, A. B. (1974). Late Quaternary history of vegetation and climate in Rajasthan Desert, India. *Philosophical Transactions of the Royal Society, London B*, *267,* 467–501.
Singh, G., Wasson, R. J., & Agrawal, D. P. (1990). Vegetational and seasonal climatic changes since the last full glacial in the Thar Desert, northwestern India. *Review of Palaeobotany and Palynology*, *64,* 351–358.
Singh, I. B. (2002). Late Quaternary evolution of the Ganga Plan and proxy records of climate change, Neotectonics and anthropogenic activity. *Pragdhara*, *12,* 1–25.
Singh, I. B. (2005a). Quaternary Palaeoenvironments of the Ganga Plain and Anthropogenic activity. *Man and Environment*, *30*(1), 1–35.
Singh, I. B. (2005b). Landform development and palaeovegetation in Late Quaternary of the Ganga Plain: implicatrions for anthropogenic activity. *Pragdhara (Journal of the Uttar Pradesh State Department of Archaeology)*, *15,* 5–31.
Sinha, B. K. (2000). Golbai: A protohistoric site on the coast of Orissa. In K. K. Basa & P. Mohanty (Eds.), *Archaeology of Orissa* (pp. 322–355). Delhi: Pratibha Prakashan.
Sivaramakrishnan, K. (1999). *Modern forests. Statemaking and environmental change in colonial eastern India*. New Delhi: Oxford University Press.
Smartt, J., & Simmonds, N. W. (Eds.). (1995). *Evolution of crop plants* (2nd edn.). Harlow, Essex: Longman.
Smith, B. D. (1992). *Rivers of change. Essays on early agriculture in Eastern North America*. Washington, DC: Smithsonian.
Smith, B. D. (1995). *The emergence of agriculture*. New York: Scientific American Library.
Smith, B. D. (2001). Low-level food production. *Journal of Archaeological Research*, *9*(1), 1–43.
Smith, M. (2006). The archaeology of food preference. *American Anthropologist*, *108*(3), 480–493.
Southworth, F. (2005). *The linguistic archaeology of South Asia*. London: Routledge.
Staubwasser, M., Sirocko, F., Grootes, P. M., & Erlenkeuser, H. (2002). South Asian monsoon climate change and radiocarbon in the Arabian Sea during the early and middle Holocene. *Paleoceanography*, *17*(4), 1–12.
Staubwasser, M., Sirocko, F., Grootes, P. M., & Segl, M. (2003). Climate change at the 4.2 ka BP termination of the Indus Valley Civilization and Holocene south Asian monsoon variability. *Geophysical Research Letters*, *30*(8), 1425.
Stevens, C. J. (2006 [in press]). Reconsidering the evidence: towards an understanding of the social contexts of subsistence production in Neolithic Britian. In S. Colledge & J. Conolly (Eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*. Walnut Creek: Left Coast Press.
Stuiver, M., Reimer, P. J., Bard, E., Beck, J. W., Burr, G. S., Hughen, K. A., *et al.* (1998). INTCAL98 Radiocarbon age calibration 24,000–0 cal BP. *Radiocarbon*, *40,* 1041–1083.

Sutra, J.-P., Bonnefille, R., & Fontugne, M. (1997). Étude palynologiue d'un nouveau sondage dans les marais de Sandynalah (massif des Nilgiris, sud-ouest de l'Inde). *Géographie physique et Quaternaire*, *51*(3), 425–437.

Tanno, K.-I., & Willcox, G. (2006a). How fast was wild wheat domesticated? *Science*, *311,* 1886.

Tanno, K.-I., & Willcox, G. (2006b). The origins of cultivation of *Cicer arietinum* L. and *Vicia faba* L.: early finds from Tell el-Kerkh, north-west Syrua, late 10th millennium B.P. *Vegetation History and Archaeobotany*, *15,* 197–204.

Tengberg, M. (1998). *Paleoenvironnements et économie végétale en milieu aride: Recherches archébotaniques dans la région du Golfe arabo-persique et dans le Makran pakistanais: (4ème millénaire av. notre ère—1er millénaire de notre ère).* Unpublished PhD Dissertation, University of Montpellier, Languedoc.

Tengberg, M. (1999). Crop husbandry at Miri Qalat, Makran, SW Pakistan (4000–2000 B.C.). *Vegetation History and Archaeobotany*, *8,* 3–12.

Tengberg, M. (2004). Archaeobotanical analysis at Tepe Sialk. Results from the 2003/04 season. In S. M. Shahmirzadi (Ed.), *The potters of Sialk. Sialk Reconsideration Project Report No. 3* (pp. 25–32). Tehran: Iranian Center for Archaeolgical Research.

Tengberg, M., & Thiebault, S. (2003). Vegetation history and wood exploitation in Pakistani Baluchistan from the Neolithic to the Harappan Period: The evidence of charcoal analysis. In S. A. Weber & W. R. Belcher (Eds.), *Indus Ethnobiology. New Perspectives from the field* (pp. 21–64). Lanham: Lexington Books.

Tewari, R., Srivastava, R. K., Saraswat, K. S., & Singh, K. K. (2000). Excavations at Malhar, District Chandauli (U.P.) 1999: A Preliminary Report. *Pragdhara (Journal of the U. P. State Archaeology Department)*, *10,* 69–98.

Tewari, R., Srivastava, R. K., Singh, K. K., Saraswat, K. S., & Singh, I. B. (2003). Preliminary report of the excavation at Lahuradewa, District Sant Kabir Nagar, U.P. 2001–2002: Wider archaeological implications. *Pragdhara*, *13,* 37–68.

Tewari, R., Srivastava, R. K., Singh, K. K., Vinay, R., Trivedi, R. K., & Singh, G. C. (2005). Recently excavated sites in the Ganga Plain and North Vindhyas: some observations regarding the pre-urban context. *Pragdhara*, *15,* 39–49.

Thapar, B. K. (1974). Problems of the Neolithic Cultures in India: A retrospect. *Purratattava*, *7,* 61–65.

Thapar, B. K. (1978). Early agricultural communities in India. *Journal of Human Evolution*, *7,* 11–22.

Thomas, J. (1999a). *Understanding the Neolithic (A revised second edition of Rethinking the Neolithic).* London: Routledge.

Thomas, K. (1999b). Getting a life: stability and change in social and subsistence systems on the North-West Frontier, Pakistan, in later prehistory. In C. Gosden & J. Hather (Eds.), *The prehistory of food. appetities for change* (pp. 306–321). London: Routledge.

Thomas, K. (2003). Minimizing risk? Approaches to Pre-Harappan Human Ecology on the Northwest Margin of the Greater Indus system. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 397–430). Lanham: Lexington Books.

Thomas, P. K. (1975). Role of animals in the food economy of the Mesolithic culture of Western and Central India. In A. T. Clason (Ed.), *Archaeozoological studies* (pp. 322–328). Amsterdam: North Holland Publishing.

Thomas, P. K. (1984a). The faunal background of the Chalcolithi culture of Western India. In J. Clutton-Brock & C. Grigson (Eds.), *Animals in archaeology III* (pp. 355–361). Oxford: British Archaeological Reports.

Thomas, P. K. (1984b). Faunal assemblage of Veerapuram. In T. V. G. Sastri, M. Kasturibai, & J. V. Prasada Rao (Eds.), *Veerapuram: A type site for cultural study in the Krishna valley* (pp. i–xi). Hyderabad: Birla Archaeological and Cultural Research Institute.

Thomas, P. K. (1988). Faunal assemblage. In M. K. Dhavalikar, H. D. Sankalia, & Z. D. Ansari (Eds.), *Excavations at Inamgaon* (pp. 823–961). Pune: Deccan College Post-Graduate and Research Institute.

Thomas, P. K. (1992a). Faunal assemblage and subsistence strategies at Tuljapur Garhi. *Man and Environment*, *17*(2), 71–74.

Thomas, P. K. (1992b). Faunal background of the Iron Age culture of Maharashtra. *Man and Environment, 17*(2), 75–78.

Thomas, P. K. (1993). Faunal remains from Megalithic Bhagimohari, Maharashtra. *Man and Environment*, *17*(2), 105–118.

Thomas, P. K. (2000). Animal subsistence in the Chalcolithic culture of western India (with special reference to Balathal). *Bulletin of the Indo-Pacific Prehistory Association*, *19,* 147–151.

Thomas, P. K. (2001). Investigations in the archaeofauna of Harappan sites in Western India. In S. Settar & R. Korisettar (Eds.), *Indian archaeology in Retrospect. Protohistory* (vol. II, pp. 409–420). New Delhi: Manohar.

Thomas, P. K., & Joglekar, P. P. (1990). Faunal remains. In M. K. Dhavalikar, V. S. Shinde, & S. M. Atre (Eds.), *Excavations at Kaothe* (pp. 233–264). Pune: Deccan College.

Thomas, P. K., & Joglekar, P. P. (1994). Holocene faunal studies. *Man and Environment*, *19*(1–2), 179–203.

Thomas, P. K., & Joglekar, P. P. (1996). Faunal remains from Balathal, Rajasthan: A preliminary report. *Man and Environment*, *21*(1), 91–97.

Thomas, P. K., Joglekar, P. P., Deshpande-Mukherjee, A., & Pawankar, S. J. (1995). Harappan subsistence patterns with special reference to Shikarpur, a Harappan site in Gujarat. *Man and Environment*, *20*(2), 34–41.

Thomas, P. K., Joglekar, P. P., Matsushima, Y., Pawankar, S. J., & Deshpande, A. (1997). Subsistence based on animals in the Harappan culture of Gujarat, India. *Anthropozoologica*, *25–26,* 767–776.

Thomas, P. K., Joglekar, P. P., Mishra, V. D., Pandey, J. N., & Pal, J. N. (1995). A preliminary report of the faunal remains from Damdama. *Man and Environment*, *20*(1), 29–36.

Thomas, P. K., Matsushima, Y., & Deshpande, A. (1996). Faunal remains. In M. K. Dhavalikar, M. R. Raval, & Y. M. Chitalwala (Eds.), *Kuntasi: A Harappan Emporium on the West Coast* (pp. 297–330). Pune: Deccan College.

Thompson, G. B. (1996). *The Excavations of Khok Phanom Di, a prehistoric site in Central Thailand. Subsistence and environment: the botanical evidence. The Biological Remains Part III*, vol. IV. London: The Society of Antiquaries of London.

Thompson, G. B. (1997). Archaeobotanical indicators of rice domestication-a critical evaluation of diagnostic criteria. In *South-East Asian Archaeology 1992* (pp. 159–174). Rome: Instituto Italiano per L'Africa e L'Orient.

Tostain, S. (1998). Le mil, une longue histoire: Hypotheses sur domestication et ses migrations. In M. Chastenet (Ed.), *Plantes et Paysages d'Afrique. Une Histoire a explorer* (pp. 461–490). Paris: Editions Karthala.

Toyama, S. (2002). The origin and spread of rice cultivation as seen from rice remains. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 263–272). New Delhi: Lustre Press and Roli Books.

Tringham, R. (2000). Southeastern Europe in the transition to agriculture in Europe: Bridge, buffer, or mosaic. In T. D. Price (Ed.), *Europe's first farmers* (pp. 19–56). Cambridge: Cambridge University Press.

Trut, L. N. (1999). Early Canid Domestication: The Fox Farm Experiment. *American Scientist*, *87*(2), 160–169.

Tsutsumi, T. (2002). Origins of pottery and human subsistence strategioes for adaptation during the termination of the last0glacial period in the Japanese archipelago. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 241–262). New Delhi: Lustre Press/Roli Books.

Uerpmann, H.-P. (1996). Animal domestication-accident or intention? In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 227–237). London: UCL Press.

Van Andel, T. H., & Runnels, C. N. (1995). The earliest farmers in Europe. *Antiquity*, *69,* 481–500.

van der Maeson, L. J. G. (1986). *Cajanus DC. and Atylosia W & A. (Leguminosae)*. Wageningen: Agricultural University.

Van Driem, G. (1998). Neolithic correlates of ancient Tibeto-Burman migrations. In R. Blench & M. Spriggs (Eds.), *Archaeology and language II: Archaeological data and linguistic hypotheses* (pp. 67–102). London: Routledge.

Vavilov, N. (1950). *The origin, variation, immunity, and breeding of cultivated plants*. Cambridge: Cambridge University Press.

Venkatasubbaiah, P. C., & Kajale, M. D. (1991). Biological remains from Neolithic and Early Historic Sites in Cuddapah District, Andhra Pradesh. *Man and Environment*, *16*(1), 85–97.

Venkatasubbaiah, P. C., Pawankar, S. J., & Joglekar, P. P. (1992). Neolithic faunal remains from the Central Pennar Basin, Cuddapah District, Andhra Pradesh. *Man and Environment*, *17*(1), 55–59.

Vigne, J.-D., Carrer, I., Saliege, J.-F., Person, A., Bocherons, H., Guilane, J., *et al.* (2000). Predomestic cattle, sheep, goat and pig during the late 9th and the 8th millennium cal.BC on Cyprus: preliminary results of Shillourokambos (Parekklisha, Limassol). In M. Mashkour, A. Choyke, H. Buitenhuis, & F. Poplin (Eds.), *Archaeozoology of the near East IVA* (pp. 83–106). Groningen: ARC Publicatie.

Vishnu-Mittre (1961). Plant economy in ancient Navdatoli-Maheshwar. In *Technical report on archaeological remains* (pp. 13–52). Pune: Department of Archaeology and Ancient Indian History, Deccan College.

Vishnu-Mittre (1968a). Inter-relationship between archaeology and plant sciences. *Puratattva*, *1,* 4–15.

Vishnu-Mittre (1968b). Kaundinyapura plant economy in Pre-Historic and Historic times. In M. G. Dikshit (Ed.), *Excavations at Kaundinyapura* (pp. 140–147). Bombay: Government Central Press.

Vishnu-Mittre (1969). Remains of Rice and Millet. In H. D. Sankalia, S. B. Deo, & Z. D. Ansari (Eds.), *Excavations at Ahar (Tambavati)* (pp. 229–235). Pune: Deccan College.

Vishnu-Mittre (1972). The Neolithic Plant Economy of Chirand, Bihar. *The Palaeobotanist*, *21,* 18–22.

Vishnu-Mittre (1977). Changing economy in ancient India. In C. A. Reed (Ed.), *Origins of agriculture* (pp. 569–588). Paris: Mounton.
Vishnu-Mittre (1989). Forty years of archaeobotanical research in South Asia. *Man and Environment*, *14*(1), 1–16.
Vishnu-Mittre (1990). Plant remains. In J. P. Joshi (Ed.), *Excavations at Surkotada* (pp. 388–392). New Delhi: Archaeological Survey of India.
Vishnu-Mittre, & Gupta, H. P. (1968a). Ancient plant economy at Paunar, Maharashtra. In S. B. Deo & M. K. Dhavalikar (Eds.), *Paunar Excavations 1967* (pp. 128–134). Nagpur: University Press.
Vishnu-Mittre, & Gupta, H. P. (1968b). Plant remains from ancient Bhatkuli, District Amraoti, Maharashtra. *Puratattva*, *2,* 21–22.
Vishnu-Mittre, Prakash, U., & Awasthi, N. (1971). Ancient plant economy at Ter, Maharashtra. *Geophytology*, *1*(2), 170–177.
Vishnu-Mittre, & Savithri, R. (1974). Ancient plant economy of Noh, Rajasthan. *Puratattva*, *8,* 55–63.
Vishnu-Mittre, & Savithri, R. (1975). Supposed remains of Rice (Oryza sp.) in the terracotta cakes and pai at Kalibangan, Rajasthan. *The Palaeobotanist*, *22,* 124–126.
Vishnu-Mittre, & Savithri, R. (1976). Ancient plant economy at Inamgaon. *Puratattva*, *8,* 55–63.
Vishnu-Mittre, & Savithri, R. (1978). Setaria in ancient plant economy of India. *The Palaeobotanist*, *25,* 559–564.
Vishnu-Mittre, & Savithri, R. (1979a). Palaeobotanical and Pollen Analytical Investigations. *Indian Archaeology 1974–1975—A Review*, 78–81.
Vishnu-Mittre, & Savithri, R. (1979b). Further contribution on Protohistoric Ragi—*Eleusine coracana* Gaertn. *The Palaeobotanist*, *26,* 10–15.
Vishnu-Mittre, & Savithri, R. (1982). Food economy of the Harappans. In G. L. Possehl (Ed.), *Harrapan civilization. A contemporary perspective* (pp. 205–221). New Delhi: Oxford and IBH.
Vishnu-Mittre, Sharma, A., & Chanchala, S. (1984). Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1981–082–A Review*, 105–106.
Vishnu-Mittre, Sharma, A., & Chanchala, S. (1986a). Ancient plant economy at Daimabad. In S. A. Sali (Ed.), *Daimabad 1976–1979* (pp. 588–626). New Delhi: Archaeological Surey of India.
Vishnu-Mittre, Sharma, A., & Chanchala, S. (1986b). Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1983–984—A Review*, 174–178.
Vishnu-Mittre, & Sharma, C. (1973). Pollen analysis of the salt flat at Malwan, Gujarat. *The Palaeobotanist*, *22*(2), 118–123.
Vishnu-Mittre, & Sharma, C. (1978). Pollen analysis of Nal Lake, Gujarat. *The Palaeobotanist*, *26,* 96–104.
Vishnu-Mittre, K. S. S., Sharma, A., & Chanchala, S. (1985). Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1982–83—A Review*, 146–150.
Voight, B. F., Kudaravalli, S., Wen, X., & Pritchard, J. K. (2006). A map of recent positive selection in the human genome. *PLoS Biology*, *4*(3), e72.
Von Rad, U. M., Schaaf, M., Michels, K. M., Schulz, H., Berger, W. H., & Sirocko, F. (1999). A 5000-yr record of climate change in varved sediment from the Oxygen Mimimum Zone off Pakistan, Northeastern Arabian Sea. *Quaternary Research*, *52,* 39–53.
Wan, J., & Ikehashi, H. (1997). Identification of two types of differentiation in cultivated rice (Oryza sativa L.) detected by polymorphism of isozymes and hybrid sterility. *Euphytica*, *94,* 151–161.
Wandsnider, L. (1995). The results of education: Natural formation research and scalar analysis of archaeological deposits. In S. Wadia, R. Korisettar, & V. S. Kalthe (Eds.), *Quaternary environments and geoarchaeology of India* (pp. 435–445). Bangalore: Geological Society of India.
Wasse, A. (2001). The wild goats of Lebanon: Evidence for Early Domestication? *Levant*, *33,* 21–33.
Wasson, R. J., Smith, G. I., & Agrawal, D. P. (1984). Late Quaternary sediments, minerals and inferred geochemical history of Didwana Lake, Thar Desert, India. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *46,* 345–372.
Watt, G. (1889–1893). *A dictionary of the economic products of India*. London: W. H. Allen and Co.
Weber, S. A. (1991). *Plants and Harappan Subsistence. An example of stability and change from Rojd*. New Delhi: Oxford and IBH.
Weber, S. A. (1997). Harappa archaeobotany: a model for subsistence. In R. Allchin & B. Allchin (Eds.), *South Asian archaeology 1995* (pp. 115–117). New Delhi: Oxford and IBH.
Weber, S. A. (1998). Out of Africa: The impact of millets in South Asia. *Current Anthropology*, *39,* 267–274.
Weber, S. A. (1999). Seeds of urbanism: Paleoethnobotany and the Indus civilization. *Antiquity*, *73,* 813–826.
Weber, S. A. (2003). Archaeobotany at Harappa: Indications for change. In S. A. Weber & W. R. Belcher (Eds.), *Indus ethnobiology. New perspectives from the field* (pp. 175–198). Lanham: Lexington Books.

Wei, K., & Gasse, F. (1999). Oxygen isotopes in lacustrine carbonates of West China revisited: implications for the post glacial changes in summer monsoon circulation. *Quaternary Science Review*, *18*(12), 1315–1334.
Weiss, E., Wetterstrom, W., Nadel, D., & Bar-Yosef, O. (2004). The broad spectrum revisited: Evidence from plant remains. *Proceedings of the National Academy of Sciences (USA)*, *101*(26), 9551–9555.
Weiss, H., Courty, M. A., Wetterstrom, W., Guichard, F., Senior, L., Meadow, R., *et al*. (1993). The genesis and collapse of Third Millennium north Mesopotamian Civilization. *Science*, *261,* 995–1004.
Wendorf, F., & Schild, R. (1994). Are the Early Holocene Cattle in the Eastern Sahara Domestic or Wild? *Evolutionary Anthropology*, *3,* 118–128.
West, B., & Zhou, B.-X. (1988). Did chickens go North? New evidence for domestication. *Journal of Archaeological Science*, *15,* 515–533.
Wetterstrom, W. (1998). The origins of agriculture in Africa: With particular reference to Sorghum and Pearl Millet. *The Review of Archaeology*, *19*(2), 30–46.
Wheeler, R. E. M., Ghosh, A., & Deva, K. (1946). Arikamedu: An Indo-Roman Trading station on the east coast of India. *Ancient India*, *2,* 17–124.
Whittle, A. (1999). The Neolithic Period, c. 4000–2500/2200 BC. Changing the World. In J. Hunter & I. Ralston (Eds.), *The archaeology of Britain. An introduction from the upper Palaeolithic to the industrial revolution* (pp. 58–76). London: Routledge.
Willcox, G. (1991). Carbonised plant remains from Shortugai, Afghanistan. In J. M. Renfrew (Ed.), *New light on early farming. Recent developments in palaeoethnobotany* (pp. 139–153). Edinburgh: Edinburgh University Press.
Willcox, G. (1992). Some differences between crops of Near Eastern origin and those from the tropics. In C. Jarrige (Ed.), *South Asian archaeology 1989* (pp. 291–299). Madison: Prehistory Press.
Willcox, G. (1999). Agrarian change and the beginnings of cultivation in the Near East: evidence from wild progenitors, experimental cultivation and archaeobotanical data. In C. Gosden & J. Hather (Eds.), *The prehistory of food. Appetites for change* (pp. 478–500). London: Routeledge.
Willcox, G. (2002a). Charred plant remains from a 10th millennium B.P. kitchen at Jerf el Ahmar (Syria). *Vegetation History and Archaeobotany*, *11,* 55–60.
Willcox, G. (2002b). Geographical variation in major cereal components and evidence for independent domestication events in Western Asia. In R. T. J. Cappers & S. Bottema (Eds.), *The dawn of farming in the Near East* (pp. 133–140). Berlin: ex Oriente.
Willcox, G. (2004). Measuring grain size and identifying Near Eastern cereal domestication: evidence from the Euphrates valley. *Journal of Archaeological Science*, *31,* 145–150.
Willcox, G. (2005). The distribution, natural habitats and availability of wild cereals in relation to their domestication in the Near East: multiple events, multiple centres. *Vegetation History and Archaeobotany*, *14,* 534–541.
Wing, E. S. (1977). Animal domestication in the Andes. In C. A. Reed (Ed.), *Origins of agriculture* (pp. 837–859). The Hague: Mouton Publishers.
Witzel, M. (1999). Early sources for South Asian substrate languages. *Mother Tongue*, (Special Issue), 1–76.
Witzel, M. (2005). Central Asian roots and acculturation in South Asia: Liguistic and archaeological evidence from Western Central Asia, the Hindukush and Northwestern South Asia for Early Indo-Aryan language and religion. In T. Osada (Ed.), *Liguistics, archaeology and the human past* (pp. 87–211). Kyoto: Research Institute for Humanity and Nature.
Wright, G. A. (1971). Origins of food production in Southwetsern Asia: A survey of ideas. *Current Anthropology*, *12*(4–5), 447–478.
Yabuno, T. (1987). Japanese barnyard millet (*Echinochloa utilis*, Poaceae) in Japan. *Economic Botany*, *41*(4), 484–493.
Yan, W. (2002). The origins of rice agriculture, pottery and cities. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 151–156). New Delhi: Lustre Press and Roli Books.
Yasuda, Y. (2002). Origins of pottery and agriculture in East Asia. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 119–142). New Delhi: Lustre Press and Roli Books.
Yuan, J. (2002). Rice and pottery 10,000 yrs. BP at Yuchanyan, Dao County, Hunan Province. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 157–166). New Delhi: Lustre Press and Roli Books.
Yuan, J., & Flad, R. (2002). Pig domestication in ancient China. *Antiquity*, *76,* 724–732.
Zeder, M. A., & Hesse, B. (2000). The initial domestication of goats (*Capra hircus*) in the Zagros Mountains 10,000 years ago. *Science*, *287,* 2254–2257.
Zeuner, F. E. (1963). *A history of domesticated animals*. London: Hutchinson.
Zeven, A. C., & De Wet, J. M. J. (1982). *Dictionary of cultivated plants and their regions of diversity*. Wageningen: Centre for Agricultural Publishing and Documentation.

Zhang, W. (2002). The bi-peak tubercle of rice, the character of ancient rice and the origin of cultivated rice. In Y. Yasuda (Ed.), *The origins of pottery and agriculture* (pp. 205–216). New Delhi: Lustre Press and Roli Books.

Zhao, Z. (1998). The Middle Yangtze region in China is one place where rice was domesticated: phytolith evidence from the Diaotonghuan Cave, Northern Jaingxi. *Antiquity*, *72,* 885–897.

Zhao, Z., Pearsall, D. M., Benfer, R. A. J., & Piperno, D. R. (1998). Distinguishing rice (*Oryza sativa* Poaceae) from wild *Oryza* species through phytolith analysis II: finalised method. *Economic Botany*, *52*(2), 134–145.

Zhu, Q., & Ge, S. (2005). Phylogenetics relationships among A-genome species of the genus *Oryza* revealed by intron sequences of four nuclear genes. *New Phytologist*, *167,* 249–265.

Zide, A. R. K., & Zide, N. H. (1976). Proto-Munda cultural vocabulary: Evidence for early agriculture. In P. N. Jenner, L. C. Thompson, & S. Starosta (Eds.), *Austroasiatic studies, Part II* (pp. 1295–1334). Honolulu: University of Hawaii Press.

Zohary, D. (1969). The progenitors of wheat and barley in relation to domestication and agriculture dispersal in the Old World. In P. J. Ucko & G. W. Dimbleby (Eds.), *The domestication and exploitation of animals and plants* (pp. 47–66). London: Duckworth.

Zohary, D. (1996). The mode of domestication of the founder crops of Southwest Asian agriculture. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 142–158). London: UCL Press.

Zohary, D., & Hopf, M. (2000). *Domestication of plants in the old world*. Oxford: Oxford University Press.

Zohary, D., & Spiegel-Roy, P. (1975). Beginnings of fruit frowing in the Old World. *Science*, *187,* 319–327.

Zohary, D., Tchernoc, T., & Horwitz, L. K. (1998). The role of unconscious selection in the domestication of sheep and goats. *Journal of the Zoological Society of London*, *245,* 129–135.

Zvelebil, K. V. (1975). Pastoralism as reflected in the classical Tamil theory of landscapes. In L. S. Leshnik & G.-D. Sontheimer (Eds.), *Pastoralists and Nomads in South Asia* (pp. 30–39). Wiesbaden: Otto Harrassowitz.

Zvelebil, K. V. (1996). The agricultural frontier and the transition to farming in the circum-Baltic region. In D. R. Harris (Ed.), *The origins and spread of agriculture and pastoralism in Eurasia* (pp. 323–345). London: UCL Press.

Zvelebil, M. (1986). Mesolithic prelude and Neolithic revolution. In M. Zvelebil (Ed.), *Hunters in transition* (pp. 5–16). Cambridge: Cambridge University Press.