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African crops in prehistoric South Asia: a critical review

Abstract

African archaeobotany has long faced a paradox: for a number of crops originating in Africa, the earliest archaeobotanical evidence yet discovered comes from India. This contribution will present a critical review of all the published finds of crops of African origin in South Asia, as well as new findings from the author's own research on the South Indian Neolithic Phases II-III (ca. 2200-1000 BC). This review will consider the South Asian evidence both in terms of our current understanding of the phylogenetics and biogeography of crop origins in Africa, and in terms of the cultural and economic contexts in which these crops came to be adopted in India. Although several authors have commented on African millets in South Asia in recent years, no systematic reconsideration of published finds has yet been undertaken by an archaeobotanist. While it is clear that a number of reports are dubious due to probable misidentifications, in particular for finger millet (*Eleusine coracana*), there are still numerous well-identified African crops in secure, dated archaeological contexts, most strikingly hyacinth bean (*Lablab purpureus*), as well as several finds of sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), and cow pea (*Vigna unguiculata*). While this evidence indicates that African species were becoming available in India by the first half of the second millennium BC, and perhaps already in the second half of the third millennium BC, this process appears to have been piecemeal rather than having occurred as a coherent package, as is the case with Near Eastern crops, for example. This piecemeal process argues for the need to consider the diffusion of African crops in terms of specific socio-economic contexts. From the perspective of Africa, these finds provide the broadest possible *terminus ante quem* for domestication and dispersal within Africa and challenge us to undertake further archaeobotanical research there.

Key words: Domestication, millets, pulses, India, archaeobotany.

Controversy abounds with regard to the presence of crops of African origin in prehistoric South Asia. On the one hand there are scholars who argue for trade contacts between South Asia and Africa in the third millennium BC (e.g. ALLCHIN & ALLCHIN 1968. VISHNU-MITTRE 1977. POSSEHL 1980. 1997. 1998. RAO 1986. TOSI 1986. WEBER 1993. 1998. SINGH 1996. HAALAND 1999). There is an extensive literature on the subsistence of the Harappan civilisation that cites the adoption of African millets and summer-cropping was important in the transformation of Indus agriculture in the Late Harappan period, i.e. late third to early second millennium BC (e.g. POSSEHL 1980: 54ff. COSTANTINI & BIASINI 1985. JARRIGE 1985. 1997. CLEUZIOU & TOSI 1989. MEADOW 1989. 1996. FRANKE-VOGT 1995), and perhaps also for the expansion of agriculture into peninsular India (HUTCHINSON 1976. POSSEHL 1980. 1986. HARLAN 1995). On the other hand there have been critics of the dating or identification of particular crops from this package, especially sorghum and sometimes pearl or finger millet (HILU et al. 1979. WIGBOLDUS 1991. 1996. WILLCOX 1992. ROWLEY-CONWY et al. 1997. 1999). The most extreme critic has been WIGBOLDUS (1991. 1996) who on the basis of historical records sees little evidence for the cultivation of any of the three main African millets before the Islamic Period. These controversies are critical to both African and South Asian archaeology as the presence of these crops is tied to issues surrounding the antiquity of Indian Ocean trade, the foundations of monsoonal agriculture in peninsular India, and the antiquity of these crops *in Africa*, as the dates claimed by some for the Indian evidence are often older than any equivalent evidence in Africa. Thus the status of the South Asian reports are important to our understanding of the antiquity of cultivation systems in parts of Africa.

In reconsidering this evidence, I will perform some much needed archaeobotanical "hygiene" to existing reports and discuss some new evidence. First, this review will be holistic, in that it will consider the whole gamut of crops of African origin reported from archaeological South Asia, in particular three millets and two pulses (with brief mention of castor), whereas previous reviews have focused on just sorghum (e.g. ROWLEY-CONWY et al. 1997. 1999), pearl millet (WIGBOLDUS 1991) or just millets (e.g. WEBER 1990. 1998. WIGBOLDUS 1995. 1996). Second, I consider the accuracy of identification through an examination of primary reports and their illustrations and descriptions. Having recently considered the problems of archaeobotanical millet identification in detail (FULLER 1999), I will show and articulate morphological features that make reported identifications plausible or unacceptable. While concerns over millet identification have been voiced in recent years (e.g. KAJALE 1996b), I will enlarge on these in the hope of drawing attention to specific difficulties. In doing this, I mean not to disparage the work of distinguished colleagues but only to highlight the need for further discussion and illustration of archaeobotanical specimens. One particular problem which has plagued South Asian archaeobotany has been a tendency to downplay or ignore the possibility of the presence of native millet cultivars or wild millet-grasses in favour of the big three African millets (see discussion in FULLER 2002). Despite the fact that there are some 12 cultivated species (in 10 genera) of so-called "millets" in modern India (RACHIE 1975. HULSE et al. 1980. DE WET 1992. FULLER 2002), most discussions of archaeobotanists seem to only consider the possible presence of 5 or 6 of these genera (e.g. VISHNU-MITTRE 1971. WEBER 1993. 1998). In addition, some approaches to identification in the past appear to have overlooked important preservational effects of charring (which I will discuss further below). In re-examining identifications, millet reports will be placed into four grades of reliability: (1) those which are illustrated and appear to have characteristic features, (2) those for which there is no reason to doubt but are either inadequately illustrated or not illustrated, (3) those which can not be definitely rejected but there is reason to believe that misidentification is likely, or (4) those which are illustrated and possess features which contradict the reported identification. Under each species below the reports will be listed in tables broken down into these four grades.

Another important problem regards the reliability of the dating of the millets. As others have noted (e.g. WIGBOLDUS 1996. ROWLEY-CONWY et al. 1997. 1999. HAALAND 1999), there is some apparent disagreement in the literature regarding the age of particular finds and there are often some concerns over the antiquity of particular sampled contexts. It must be noted that there are no direct AMS dates on millets or pulses from South Asian sites. As African archaeobotanists are well aware, later or modern contamination cannot be taken lightly, as Wadi Kubbaniya demonstrated (cf. HILLMAN 1989). This is certainly a problem that needs to be redressed. Nevertheless, in the absence of such dates, the integrity of particular archaeological contexts and the dating evidence for them can still be considered. Unlike the Sahara, where deflation and shallow burial are widespread taphonomic conditions, many, but not all, South Asian sites are more deeply and clearly stratified, similar to Near Eastern tells. Therefore the tables below also give some indication of the depositional context and the dating evidence for each find.

In reviewing the evidence I will consider in detail two pulses, cow pea (*Vigna unguiculata* [L.] Walp.) and hyacinth bean (*Lablab purpureus* [L.] Sweet.), and three millets, pearl millet (*Pennisetum glaucum* [L]. R. Br.), finger millet (*Eleusine coracana* [L.] Gaertn.), and the 'great millet' (*Sorghum bicolour* [L.] Moench.). I begin with the pulses in order to counterbalance the overemphasis on millets. Before reviewing the archaeobotanical finds from India, a brief synopsis of the current millets before the Islamic Period. These controversies are critical to both African and South Asian archaeology as the presence of these crops is tied to issues surrounding the antiquity of Indian Ocean trade, the foundations of monsoonal agriculture in peninsular India, and the antiquity of these crops *in Africa,* as the dates claimed by some for the Indian evidence are often older than any equivalent evidence in Africa. Thus the status of the South Asian reports are important to our understanding of the antiquity of cultivation systems in parts of Africa.

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Cow pea (*Vigna unguiculata*)

Cow pea (*Vigna unguiculata*), despite its pan-African wild distribution, appears to have been domesticated from a quite restricted geographical sample of the known genetic populations **[fig. 1]**, approximately restricted to modern Nigeria (STEELE & MEHRA 1980. HARLAN 1992b. VAILLANCOURT & WEEDEN 1992. NG 1995), with another possible centre of domestication in southern Africa, Botswana (PANELLA et al. 1993). The southeast Nigerian origin gains further support from historical linguistics as there is a proposed root for cow pea in Proto-East-Benue-Congo (BLENCH 1995). Today it is widely cultivated in Africa, South and Southeast Asia as well as parts of the New World (especially as 'black-eyed pea'). An unfortunate taxonomic confusion has entered the archaeobotanical literature in recent years as South Asian archaeobotanical reports of "*Dolichos biflorus*" have been converted to the nomenclature of *Vigna unguiculata* (e.g. WEBER 1991. REDDY

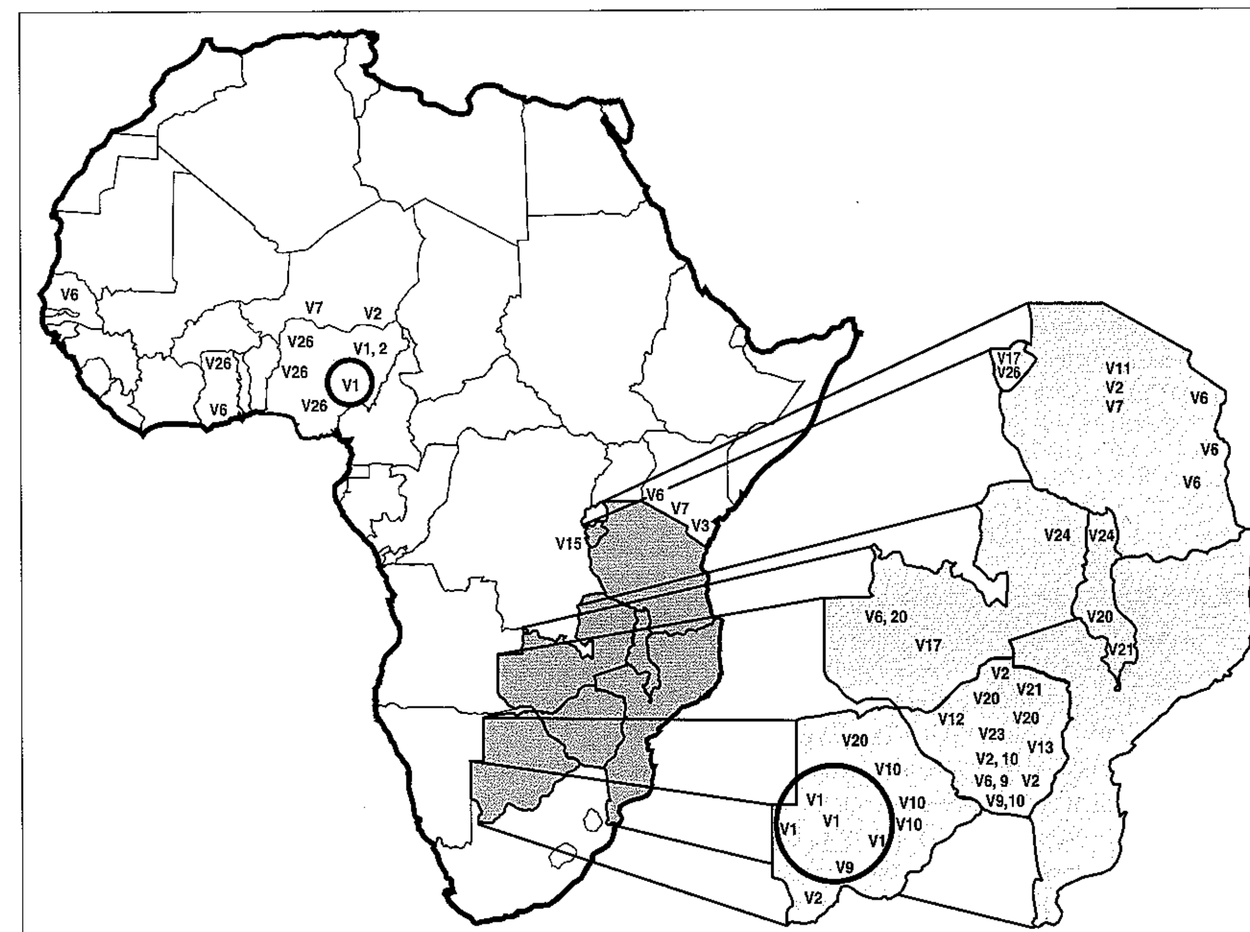


Fig. 1 Map of Africa indicating probable distribution of cow pea wild progenitors. The base map and enlarged area show the distribution of seed protein (Vignin) types in wild populations (after PANELLA et al. 1993). The dark circles indicate those wild populations that have exclusively types V1 or V9, the prevalent types amongst cultivars (other rare types amongst cultivars are likely to derive from introgression). The grey marked region in West Africa (Nigeria) represents the region in which the cultivar type cp-DNA polymorphism is found amongst wild populations (VAILLANCOURT & WEEDEN 1992). However, the populations of *Vigna unguiculata* ssp. *dekindtiana* var. *kgalagadiensis* of southern Africa (circled populations in Botswana) were not included in the cpDNA dataset, and could represent a centre for domestication of cow pea.

	Site (reference)	Nature of evidence	Assessment of identification	Depositional context of preservation	Dating evidence
1	Daimabad (VISHNU-MITTRE et al. 1986)	Numerous charred seeds	Also illustrated and reported. 'Phaesolus' spp. are probably *V. unguiculata* varieties	Two contexts, different levels in pit-fills with diverse seed assemablages	Malwa phase, 1500 - 1200 calBC (SHINDE 1994)
1	Sanghol (POKHARIA & SARASWAT 1999)	8 charred seeds. Resemble ssp. *sesquipedalis*	Photograph	Single context(?), no details	Early Historic/Kushana (200 BC - 250 AD)
2	Hulas (SARASWAT 1993a)	Charred seed fragments	Photograph	Shallow depth of burial, <60 cm below surface, single context	Mature to Late Harappan ceramic correlations, 2200 BC(?) - 1500 BC (DIKSHIT 1982). Two ^{14}C dates are even earlier (LAL 1997: 247)

Tab. 1 Reports of cow pea, *Vigna unguiculata* from Indian archaeological sites. Left hand column indicates reliability ranking (see text).

1994. KROLL 1996. 1997. 1998). While the synonymy of *D. biflorus* L. and *V. unguiculata* (L.) Walp. is correct, the conventional use of *D. biflorus* in the Indian botanical and agricultural literature is as a synonym for *D. uniflorus* Lam., the crop known as horsegram and thus these should be correctly converted to *Macrotyloma uniflorum* (Lam.) Verdc. (see PURSEGLOVE 1968. VERDCOURT 1970. SMARTT 1990. FULLER 2002).

True *Vigna unguiculata* has been reported from only three sites in India **[tab. 1; figs. 2; 3]**. The report from Malwa phase Daimabad (ca. 1700-

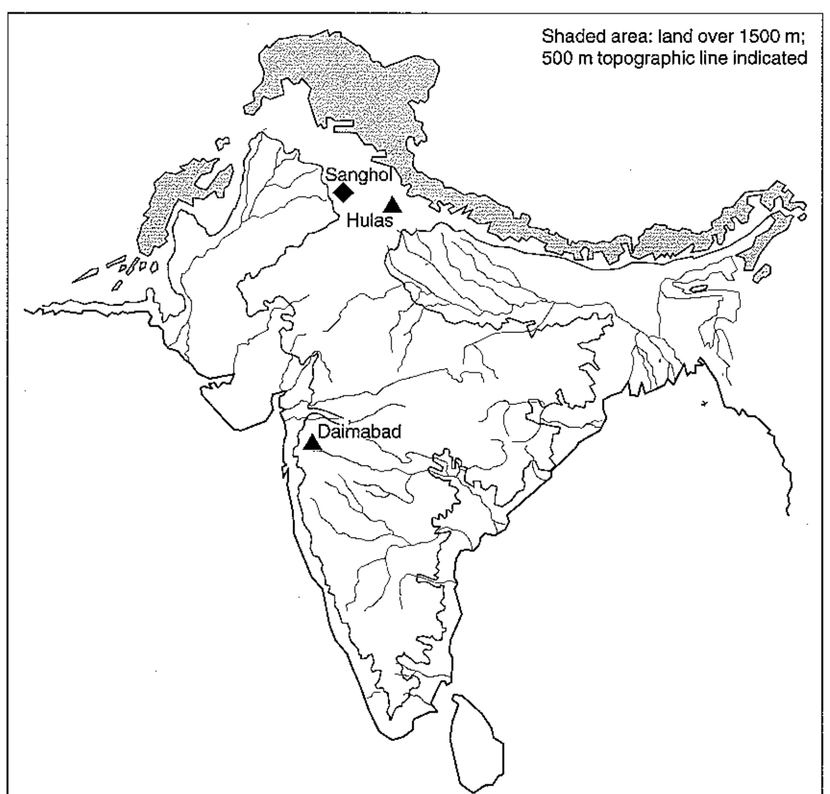
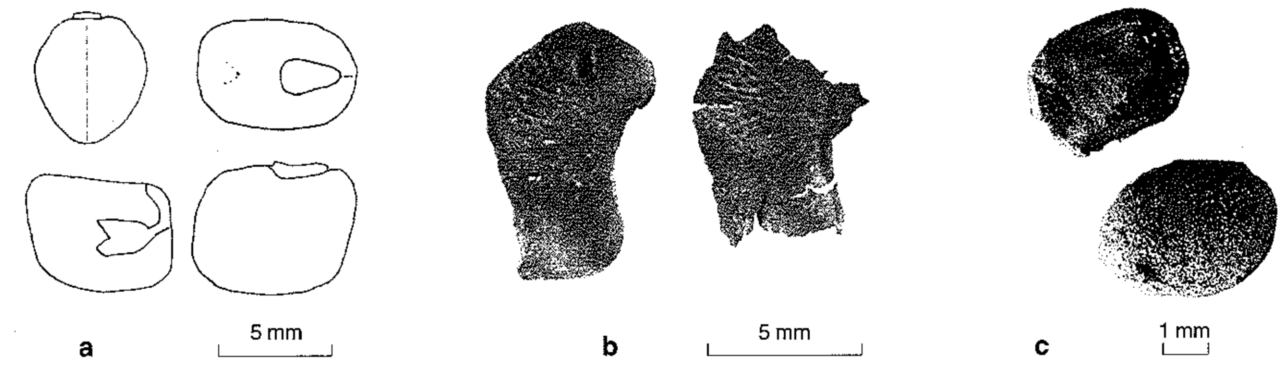
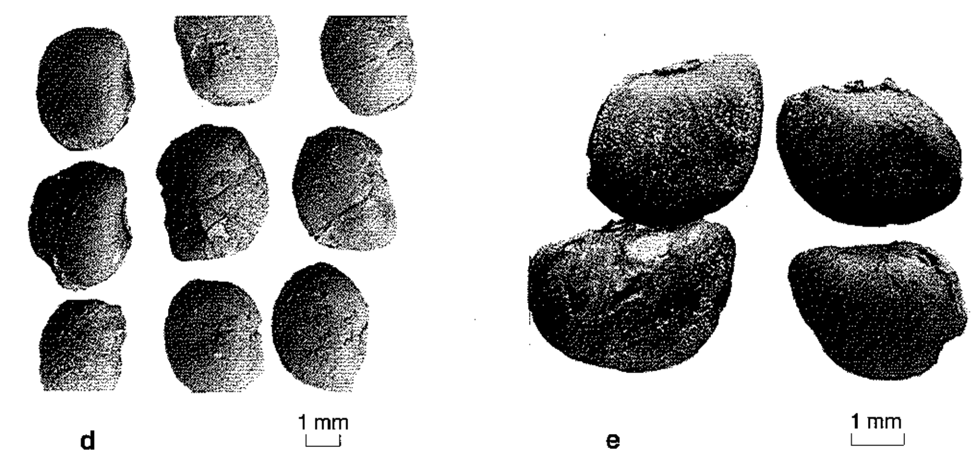


Fig. 2 Map of India showing distribution of archaeobotanical evidence for *Vigna unguiculata* in India, indicating approximate period.

● 2400 - 2000 BC
○ 2000 - 1700 BC
▲ **1700 - 1500 BC**
▼ 1500 - 1200 BC
■ 1200 - 300 BC
◆ **300 BC - 300 AD**





a Drawing of modern *V. unguiculata* (from Bellary, India)

b *V. unguiculata* fragments from Hulas (after SARASWAT 1993a: Pl. 2.13)

c *V. unguiculata*, identified as *Vigna sinensis* from Daimabad (after VISHNU-MITTRE et al. 1986: Pl. 115.C)

d *V. unguiculata* from Daimabad, reported as "Phaseolus lathyroides" (after VISHNU-MITTRE et al. 1996: Pl. 115.F)

e *V. unguiculata*, reported as "Phaseolus lunatus" (after VISHNU-MITTRE et al. 1996: Pl. 115.E)

Fig. 3 Archaeological evidence for *Vigna unguiculata* in India.

1500 calBC) is illustrated with a photograph that gives us no reason to doubt the identification (VISHNU-MITTRE et al. 1986), although a cross-section would have been useful. In addition at this site some of the reported *Phaeseolus* spp., of the subsequent Jorwe Phase, could be variant forms of cow pea. These specimens were found in multiple contexts and layers through the site, and thus more likely to be the result of past recurrence than of contamination. At the site of Hulas, from the Harappan/Late Harappan (which could be as early as 2200 calBC), the two fragmentary finds are less convincing but still a good match for *V. unguiculata* fragments, although in this case the depth of burial, of a single context, was between 50-60 cm leaving open some possibility of downward contamination (SARASWAT 1993a). Additional evidence comes from Sanghol from the end of the first millennium BC (POKHARIA & SARASWAT 1999).

Despite the limited evidence, the Daimabad and Hulas finds suggest that cow pea must have been domesticated well before 1500 BC to allow for it to have diffused from West (or South) Africa. The reported evidence from West Africa is still too young to shed light on the earliest dispsersal of cow peas. It has been suggested that cow peas were present during the Kintampo culture of Ghana, perhaps ca. 1500 BC (FLIGHT 1976. ANQUANDAH 1993), and there is subsequent evidence for the incorporation of cow peas into subsistence based on pearl millet (*Pennisetum glaucum*) from the late first millennium BC of Sahelian Burkino Faso (VOGELSANG et al. 1999), and the first half of the first millennium AD in Cameroon (OTTO & DELNEUF 1998)

Hyacinth bean (*Lablab purpureus*)

Lablab purpureus (L.) Sweet (hyacinth bean) subspecies *uncinatus* Verdc. is cultivated and wild in East Africa where it probably originated (VERDCOURT 1970. 1971. SMARTT 1990). The presence of wild populations, indicated by ROXBURGH (1832: III, 305ff.) has not been confirmed by subsequent work (HOOKER 1872-1897. HAINES 1922. VERDCOURT 1971. SMARTT 1990). Subspecies *uncinatus* is distributed throughout much of Tropical Africa including Sudan republic, Ethiopia, Uganda, Kenya, Tanganyika, Zanzibar and eastern Cape province (VERDCOURT 1970. 1971). Further genetic and botanical studies are needed to establish more definitively the region of origin of this crop, and current genetic investigations are promising (PENGELLY & MAASS 2001. B. Maass, pers. comm.). The high genetic diversity of this crop in India (VAVILOV 1992. LIU 1996) should therefore be seen as the result of either an early and extensive radiation in South Asia or multiple introductions from Africa.

Of all the African crops hyacinth bean is the most widely encountered archaeologically in South Asia **[tab. 2; fig. 4]**. It is also highly distinctive morphologically and would be difficult to mistake for anything else that is native **[fig. 5a]**. The illustrated report from Inamgaon leaves little doubt about its identity **[fig. 5d]**. It has also been recovered in large quantities from the Neolithic site of Sanganakallu where I have worked **[fig. 5b.c]**. On this site it occurs in large quantities, often the most prevalent find in a given sample. All finds comes from the upper 5 strata at this site which can be dated to Neolithic Phase III (from ca. 1800 calBC). Neolithic Sanganakallu is located on a hilltop which has not been occupied since this site was abandoned in prehistory and it is therefore unlikely to have contamination from later periods. It is, however, largely absent from contemporary sites in the region sampled by the same methods, although it had been earlier reported from Tekkalakota (KAJALE 1991); none was found by me in samples thus far sorted from this site and I have one clear specimen

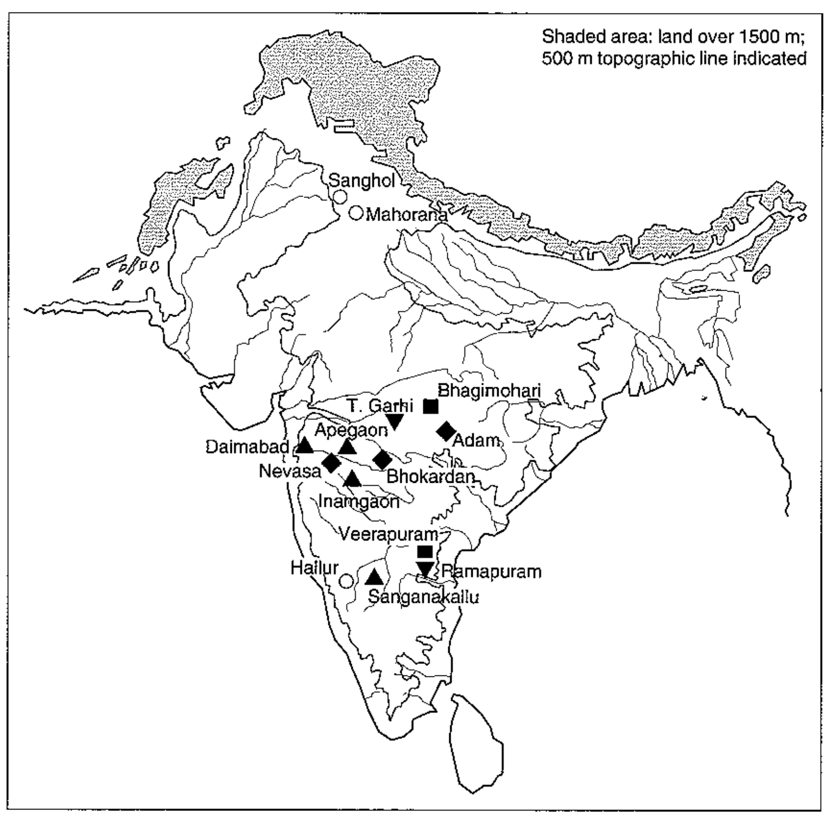


Fig. 4 Map of India showing reports of *Lablab purpureus* in India.

- ● 2400 - 2000 BC
- ○ 2000 - 1700 BC
- ▲ 1700 - 1500 BC
- ▼ 1500 - 1200 BC
- ■ 1200 - 300 BC
- ◆ 300 BC - 300 AD

	Site (reference)	Nature of evidence	Assessment if identification	Context(s) of preservation	Dating evidence
1	Inamgaon (VISHNU-MITTRE & SAVITHRI 1976. KAJALE 1988b)	Charred seeds	Illustrated and characteristic	Numerous throughout sequence	Malwa lvs - Jorwe lvs. (i.e. 1700 - 900 BC)
1	Tuljapur Garhi (KAJALE 1988a. 1996a)	Charred seeds	Illustrated and characteristic	Numerous samples, included sealed pits	(Early) Jorwe, 1500 - 1200 BC
1	Apegaon (KAJALE 1979)	Charred seeds	Illustrated and characteristic	Single sample from final phase of site	End(?) of Early Jorwe, ca. 1200 BC
1*	Hallur (KAJALE 1989a. FULLER 1999)	Charred seeds	Illustrated and characteristic	Two samples from two different studies	Neolithic, sub-phase uncertain (perhaps as early as Phase II, i.e. pre 1800 BC(?)
1*	Sanganakallu (FULLER 1999)	Charred seeds	Illustrated and characteristic	Two well-stratified sequences. Numerous	Neolithic phase III (1800 - 1200/1000 BC)
1	Veerapuram (KAJALE 1984)	Charred seeds	Illustrated and characteristic	Numerous samples throughout site	Iron Age (1st millennium BC)
1	Mahorana (SARASWAT 1991. SARASWAT & CHANCHALA 1994)	Charred seeds	Illustrated	Single sample	Period IB = Pre-Harappan to Bara transition (=? 2200 - 1900 BC)
1	Nevasa (KAJALE 1977b)	Charred seeds	Illustrated and characteristic	?	Satavahana, 150 BC- 50 BC
1	Bhokardan (KAJALE 1974)	Charred seeds	Illustrated and characteristic	3 different trenchs and contexts	Early Historic, 300 BC - 300 AD
1	Daimabad (VISHNU-MITTRE et al. 1986)	Charred seeds	Reported as *Phaeseolus vulgaris* and illustrated, clearly a large reniform pulse, of which *Lablab* is the only one in prehistory	?	Jorwe (1500 - 1200 BC)
2	Ramapuram (VENKATA-SUBBAIAH & KAJALE 1991)	Charred seeds	Not illustrated	Uncertain	Neolithic, probably mid(?) - 2nd millennium BC (cf. ARCHAEOLOGICAL SURVEY OF INDIA 1983)
2	Adam (KAJALE 1994)	Charred seeds	Not illustrated	Present in several cultural phases	Pre-Mauryan to Bhadra phases (300 - 0 BC) and later
2	Bhagimohari (KAJALE 1989b)	Charred seeds	Not illustrated	Numerous samples throughout site	Iron Age, 800 - 400 BC
2	Sanghol (SARASWAT & CHANCHALA 1997)	Charred seeds	Not illustrated	?	Late Harappan/Bara
3	Tekkalakota(?) (VISHNU-MITTRE & SAVITHRI 1979b. KAJALE 1991)	Charred seeds	Not illustrated, some nomenclatural confusion (see NAGTARAJA RAO & MALHOTRA 1965). Not recovered in flotation by the present author	Uncertain	Neolithic from pre 1800 BC to ca. 1200/1000 BC

Tab. 2 Reports of *Lablab purpureus* from Indian archaeological sites. Left hand column indicates reliability ranking (see text); asterix indicates material examined by the author.

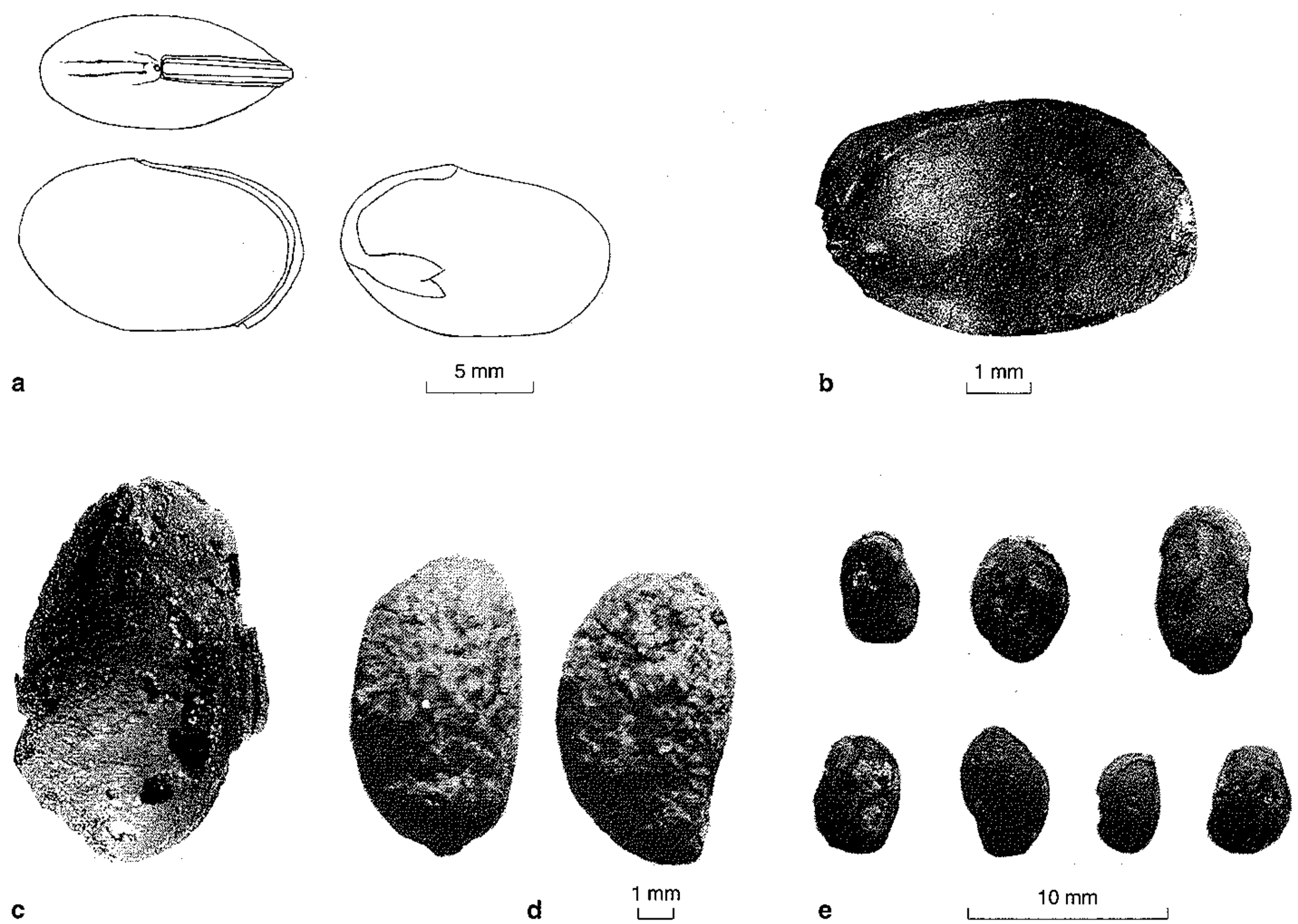


Fig. 5 Representative archaeobotanical evidence for *Lablab purpureus*.

a Drawing of modern comparative material (from Bellary, India); **b** Photograph of specimen from Sanganakallu, Karnataka, 1800-1500 BC (after FULLER 1999: Fig. 6.2C); **c** Photograph of specimen, showing cotyledon interior and plumule, specimen from Sanganakallu, Karnataka, 1800-1500 BC (after FULLER 1999: Fig. 6.2D); **d** Specimens from Inamgaon, 1700-1200 BC (after VISHNU-MITTRE et al. 1986: Pl. 115.B); **e** Probable *Lablab purpureus* from Daimabad, identified as 'large sized beans' (after KAJALE 1988b: fig. 14.34, 8).

from early in the sequence at Hallur sampled in 1998 (probably Neolithic Phase II, pending detailed study of the artefactual evidence and radiometric dates). This situation in South India implies that hyacinth bean was locally important for some select communities but not adopted by many others. As early as the Hallur find, and potentially earlier, is evidence from Mahorana, an eastern Harappan site, where it dates before 1900 BC and perhaps back to ca. 2200 BC (SARASWAT 1991). A great many other reports are not accompanied by illustration, but there seems no reason to doubt their identification, nor in most cases their antiquity.

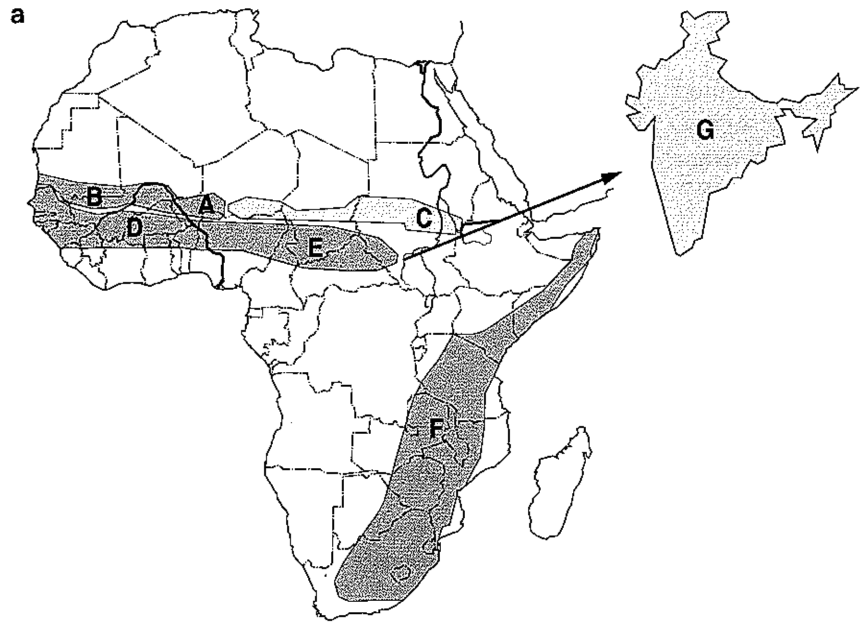
Finds from Africa are few. It is reported from one of the lower layers of the Geduld rock shelter, which also documents the advent of pastoralism in Namibia, at ca. 0-70 AD (SMITH & JACOBSEN 1995). It has also been recovered from Post-Meroitic contexts at Qasr Ibrim, ca. 4th/5th century AD (Alan Clapham, pers. comm.). Textual evidence from West Africa has been interpreted to indicate the cultivation of this crop in that region from at least ca. 850 AD (LEWICKI 1974).

Pearl millet (*Pennisetum glaucum*)

Wild *P. glaucum* (L.) R. Br. is widely distributed in the northern semi-arid savanna zone of Africa, and is generally more drought tolerant than other savanna millets like sorghum (BRUNKEN 1977. HARLAN 1992a. 1995. DE WET 1995a). Contrary to previous opinions, however, domestication is not equally likely throughout this northern savanna belt. Recent isozyme surveys of wild populations and domesticated varieties has identified only a limited number of modern wild populations that are close to the domesticated crop (TOSTAIN 1992. 1998), notably two foci, one in the far west of Africa (Mauritania) and the other in the region west of Lake Chad **[fig. 6b]**. Indeed introgression between wild populations in other areas and the crop is quite limited. Isozyme variation amongst cultivars indicates that Indian pearl millet is closest to, and presumably derives

	Site (reference)	Nature of evidence	Assessment of identification	Depositional context of preservation	Dating evidence
1	Hulaskhera (CHANCHALA 1992)	Charred caryopses	Photograph, not entirely clear	Missing from individual context tabulation. Period therefore unclear.	Unclear from report. Sunga?, 200 BC - 0 AD. Earliest levels reported plants remains, ca. 700 BC.
1	Kaothe (KAJALE 1990)	Sevaral caryopses	Photographs	Several samples. But entire site consisted on 60-70 cm of deposit below modern surface, thus high potential of intrusive charred seeds	Single ^{14}C date for site: 2400 - 2000 calBC (SHINDE 1994)
1	Narhan (SARASWAT et al. 1994)	Five charred caryopses	Photograph	Single context, pit-fill, deeply buried level	Red and Black Ware Phase, ca. 1200 - 1000 BC
1*	Daimabad (unpublished)	Several charred caryopses, well-preserved. Note: not in samples of VISHNU-MITTRE et al. 1986.	Examine by author with M. Kajale. Not listed in the published note (KAJALE 1977a)	?	Jorwe Phase (1500 - 1200 BC)
1	Rangpur (GHOSH & LAL 1963)	Clump of charred grains	Photograph	Single context	Phase III, 1800 - 1200 BC (HERMAN 1997)
1*	Hallur (FULLER 1999)	One clear caryopsis, three probable fragments	see **fig. 8d.e** this chapter	Three different strata, in well-stratified sequence	Still poorly dated. Southern Neolithic, could be Phase II, 2200-1800 BC
2	Surkotada (CHANCHALA 1991)	Several grains, including oblong and obovate	Two photographed grains but of limited definition	From large pot of charred seeds	Third phase (Period IC), 2000 - 1700 BC (for period of context see VISHNU-MITTRE & SAVITHRI (1982); for dating SHAFFER (1992)
2	Imlidh-Kurdh (SARASWAT 1993b)	Single grain	Not-illustrated. Preliminary report	?	Period I, Cord-impressed ware (before 1300 BC)
2	Babor Kot (REDDY 1994: 276)	One caryopsis reported	No illustration; reservation expressed	Feature fill in unit excavated under site slope	Occupation III, 2000 - 1700 BC. But single ^{14}C date calibrates to 2500 - 2200 BC (HERMAN 1997)

Tab. 3 Reports of *Pennisetum glaucum* from Indian archaeological sites. Left hand column indicates reliability ranking (see text); asterix indicates material examined by the author.



a The distribution of isozyme groups A - G amongst cultivated populations of pearl millet. Arrow indicates the probable direction of spread to India based on the close affinity of group G with C and E.

b Map of wild populations of pearl millet broken into the isozyme groups I - V. Multivariate statistical analysis suggests that groups I and IV are most likely to have contributed to the domesticated gene-pool.

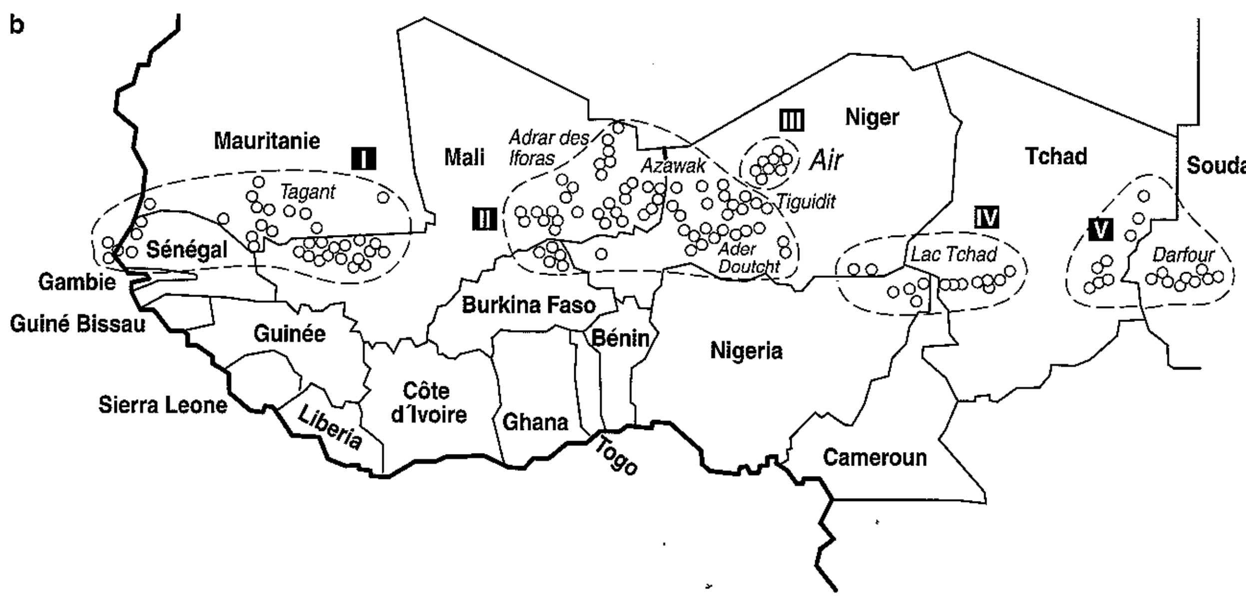
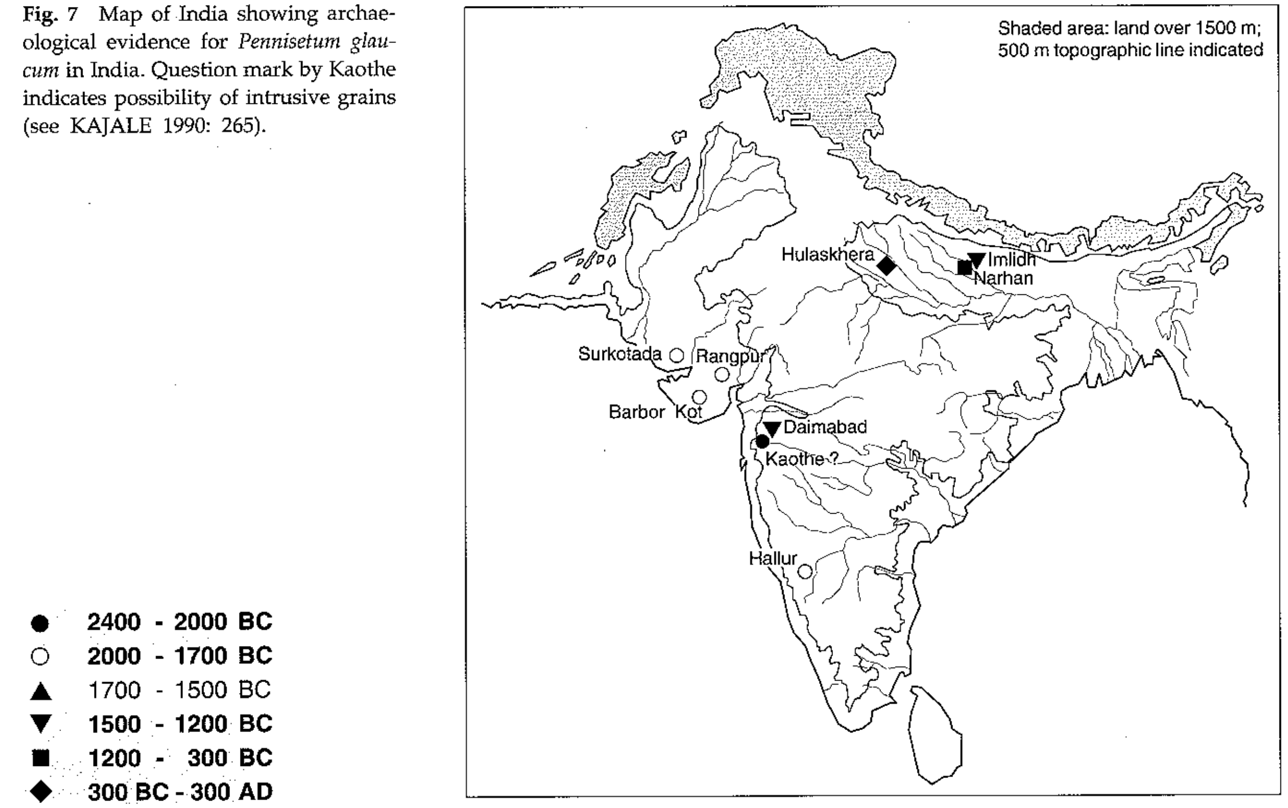


Fig. 6 Maps of Africa and India showing the distribution of wild and cultivated populations of *Pennisetum glaucum* characterised through enzymatic studies (after TOSTAIN 1998).

from, populations from the eastern African savanna (TOSTAIN 1989. 1998), i.e. from Chad through Sudan **[fig. 6a]**, thus providing some indication of the route by which this species spread.

All the illustrated reports of pearl millet in India appear legitimate **[fig. 7; 8; tab. 3]**. This is one of the most distinctive millets, especially the typical elongate-conical grains typical of two-grained spikelets, as illustrated from Narhan and Kaothe. A sizeable minority of spikelets are single-grained (GODBOLE 1925), producing much more widely ovate grains that could conceivably

Fig. 7 Map of India showing archaeological evidence for *Pennisetum glaucum* in India. Question mark by Kaothe indicates possibility of intrusive grains (see KAJALE 1990: 265).



be confused with some sorghum varieties, although the scutellum in *Pennisetum* is normally both deeper and the grain base more narrowly acure rather than broadly acute or acuminate. A clear specimen from a single-grain spikelet was found by the author in material from the Southern Neolithic site of Hallur, which despite being an inadequately dated sequence could date back to ca. 2000 BC; a few additional fragmentary grains were also identified at this site (FULLER 1999). Potentially the earliest finds are those from Kaothe (2400-2200 BC), although this site was shallowly buried and included at least some intrusive plant material (KAJALE 1990). This site is dated on the basis of one radiocarbon date, which is supported by ceramic comparison with Harappan material. The finds from Gujarat, at Babor Kot and Surkotada, could also be late third millennium BC.

Although limited, the Indian evidence does suggest that early domestic pearl millet is still awaiting discovery in Africa. Taking into account the Indian evidence, TOSTAIN (1998) has argued that pearl millet may have been domesticated as early as 6000 BC, although this appears to be only a wild guess. The earliest African archaeobotanical evidence is not quite early enough. It comes from the mid-second millennium BC in Ghana (D'ANDREA et al. 2001) and the end of the second millennium BC from eastern Nigeria (KLEE & ZACH 1999), both adjacent to but outside the proposed Lake Chad centre of domestication, with evidence closer to Tostain's proposed Western centre of domestication only from ca. 1900 calBC in Mauritania (AMBLARD & PERNES 1989). The route of dispersal of this crop to India may have been roughly the same as that of *Vigna unguiculata*, as suggested by STEELE & MEHRA (1980), although the two taxa have not been found together in India arguing against seeing them as a west African crop package.

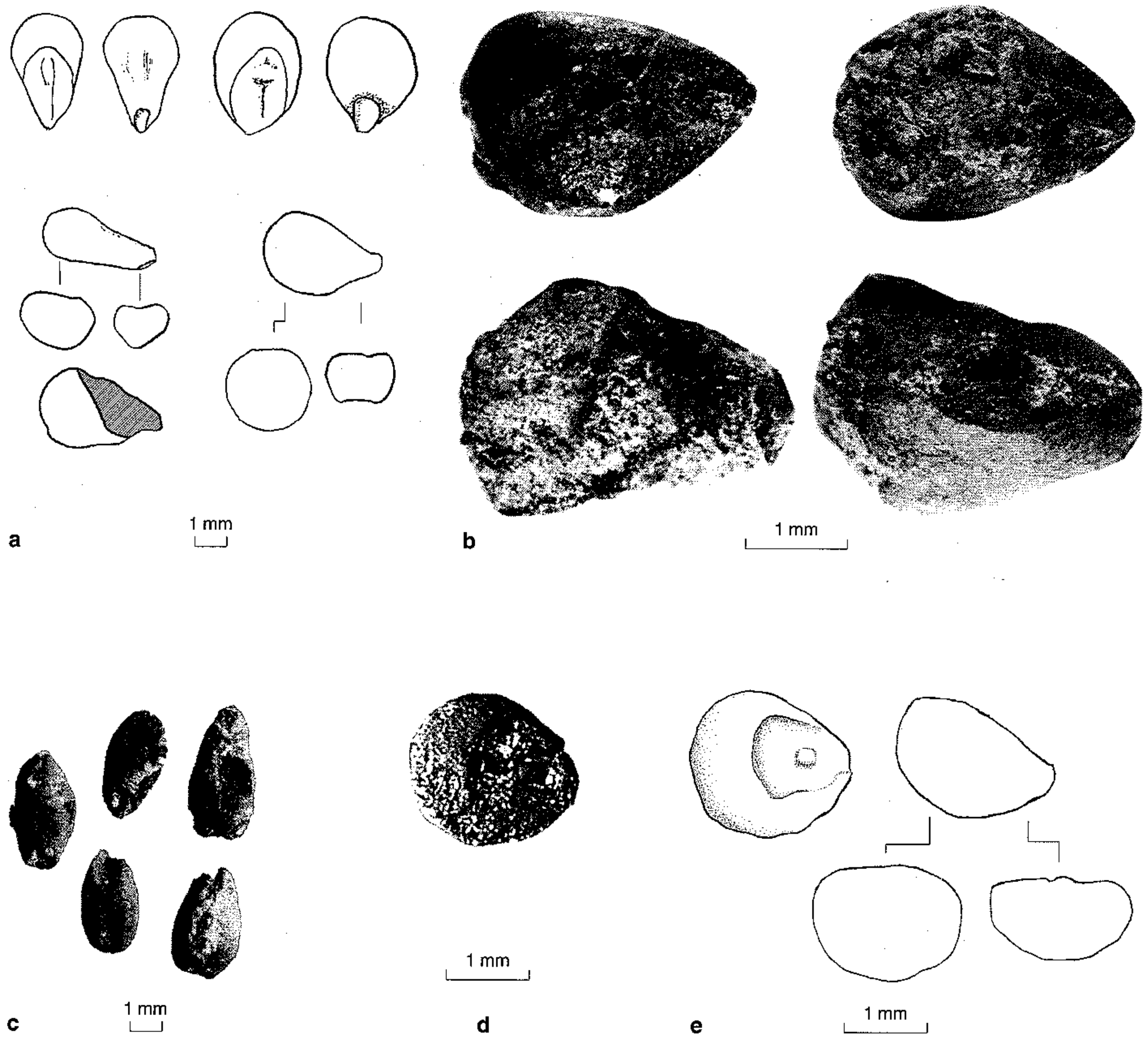


Fig. 8 Representative archaeobotanical evidence for *Pennisetum glaucum* in India.

a Drawings of modern *Pennisetum glaucum* for comparison (reference material from Dharward, India), showing more narrow grain form typical of two-seeded spikelets (left) and broadly ovate grain form typical of one-seeded spikelets (right); **b** Four representative charred grains from Kaothe (after KAJALE 1990: Fig. 11.2); **c** Illustrated grains from Narhan (after SARASWAT et al. 1994: Pl. 2.2); **d** Well-preserved specimen from Hallur, HLR.98A.7, digital photograph (after FULLER 1999: Fig. 6.9b); **e** Drawing of Hallur specimen (after FULLER 1999: Fig. 6.9b).

Sorghum (*Sorghum bicolor*)

The origins of crop sorghums, in the form of the primitive race bicolor, have generally been assigned to the sub-Saharan thorn savanna belt, from Nigeria to the Sudan, from *arundinaceum* race verticilliflorum (DE WET & HUCKABAY 1967. HARLAN 1971. 1992a. 1995. HARLAN & STEMLER 1976. STEMLER 1980), although an Ethiopian origin has also been suggested (VAVILOV 1992 [1935]. DOGGETT & PRASADA RAO 1995). Isozyme studies of wild and domesticated races in Africa suggest that kafir type sorghums of Southern Africa are closer to wild *arundinaceum* race verticilliflorum populations that are local in South Africa, suggesting that race kafir may represent a distinct domestication from the main domesticated lineage (SCHECHTER & DE WET 1975. DE WET 1978). Races bicolor and kafir represent hulled cereals while the other more derived races are more or less free-threshing. In India at least four of the races are clearly represented **[fig. 9]** (DE WET & HUCKABAY 1967. APPA RAO et al. 1996. Cf. SNOWDEN 1938. BOR 1960). Assuming that the cultivated races are monophyletic, we must assume at least three introductions into India to account for the presence of races bicolor, caudatum, and guinea. While HARLAN & STEMLER (1976) infer that durra evolved in India, alternatively it represents a fourth introduction if we accept evolution within Africa (e.g. ROWLEY-CONWY 1991. DOGGETT & PRASADA RAO 1995). The presence of race guinea, especially in 'tribal' areas of Andhra Pradesh, Madhya Pradesh, Orissa and Bihar (BOR 1960. APPA RAO et al. 1996), which is important in West Africa and southeast Africa (HARLAN & STEMLER 1976) suggests that it spread by sea from southeastern Africa, which could also have been the general region from which *Lablab*, possibly some cow peas, and finger millet (below) reached India.

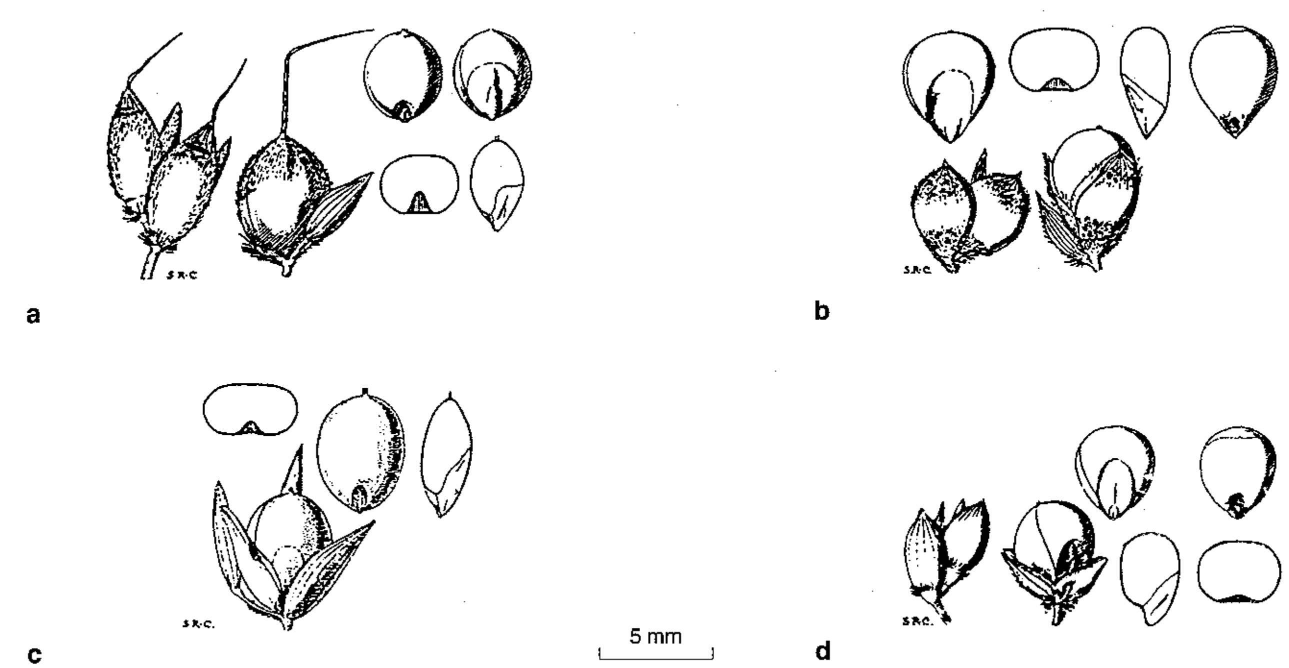


Fig. 9 Representatives of the main cultivated races of *Sorghum bicolor* in India (sensu HARLAN & DE WET 1972; illustrations after SNOWDEN 1936: fig. 18; 29; 7; 26).

a Race bicolor (*Sorghum bicolor* [L.] Moench. var. *bicolor*); **b** Race durra (*Sorghum durra* [Forsk.] Stapf. var. *aegyptiacum* [Koern.] Snowden); **c** Race guinea (*Sorghum conspicuum* Snowden); **d** Race caudatum (*Sorghum caudatum* Stapf. var. *caudatum*).

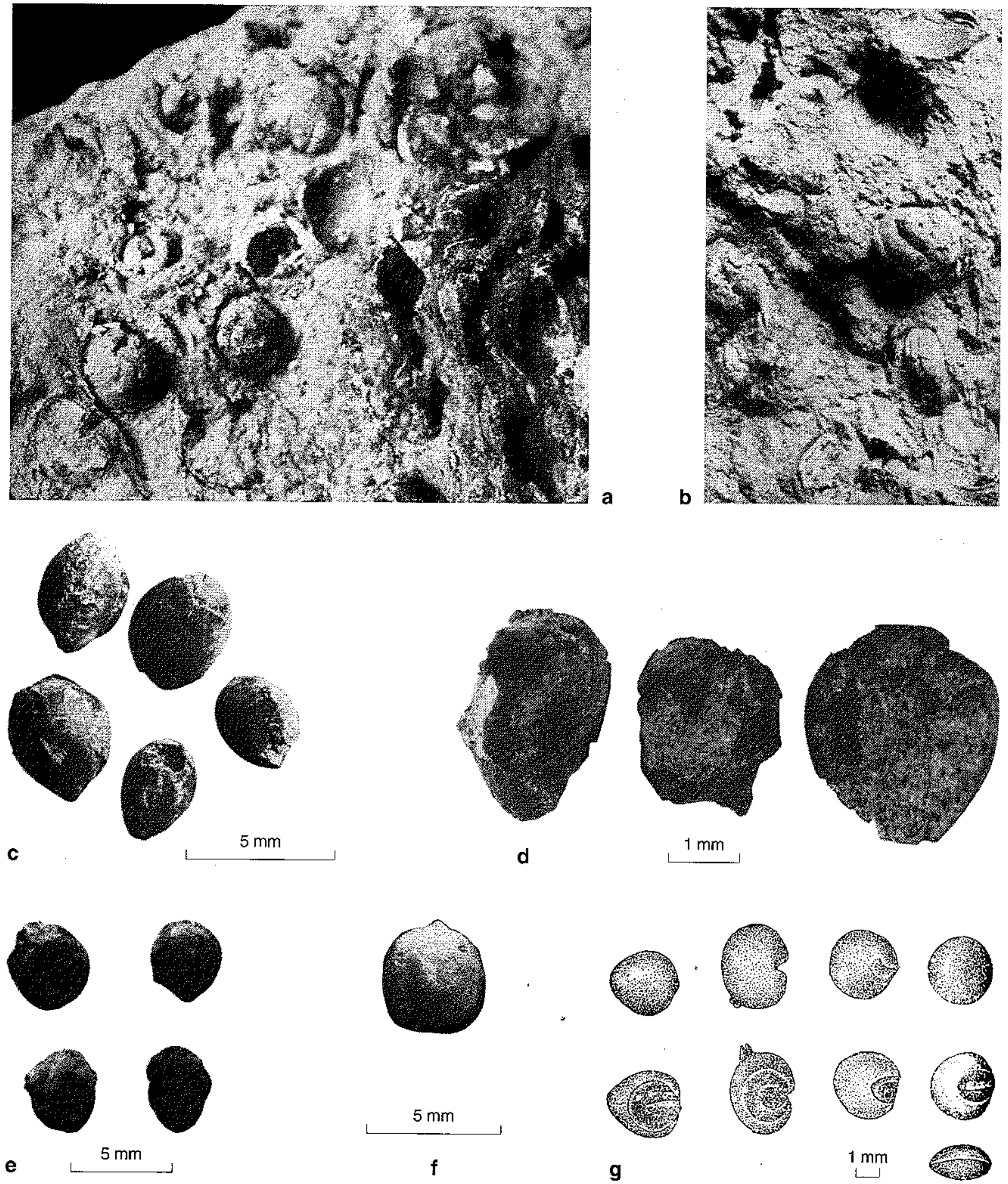


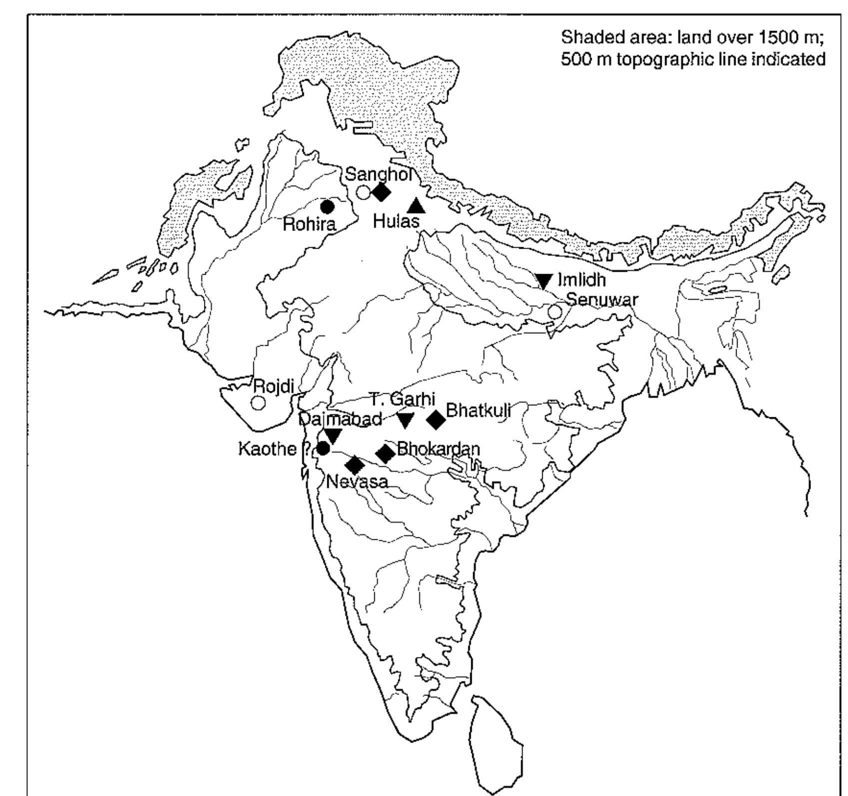
Fig. 10 Examples of archaeobotanical evidence reported for *Sorghum bicolor* in India.

a.b Impression from Ahar (after VISHNU-MITTRE 1969: Pl. XXX.3-4), considered dubious in the present review. Arrow in (a) indicates a grain that shows a long, wide scutellum and overall shape reminiscent of *Echinochloa* spp. Spikelet(?) in (b) does resemble *Sorghum*, but detail is insufficient; acuminate glumes also occur in *Echinochloa*; **c** *Sorghum* from Hulas (after SARASWAT 1993a: Pl. I.6); **d** Selected grains from Kaothe (after KAJALE 1990: Fig. II.1), with some resemblance to race caudatum; **e** *Sorghum* from Nevasa (after KAJALE 1977b: Pl. 2.2); **f** *Sorghum* grain from Bhokardan (after KAJALE 1974: Pl. LVIII.5); **g** Drawings of *Sorghum* from Bhatkuli (after VISHNU-MITTRE & GUPTA 1968b: fig. 1).

In recent years there has been controversy surrounding the antiquity of sorghum domestication. The standard interpretation sees the domestication of sorghum between ca. 5000 BC and 3000 BC (CLARK & STEMLER 1975. STEMLER et al. 1975. DOGGETT & PRASADA RAO 1995. HARLAN 1992b. 1995), reaching India just after 2000 BC (POSSEHL 1986. 1997. 1998. WEBER 1990. 1991. 1998. KAJALE 1991). After identifying apparently wild type sorghum spikelets at Qasr Ibrim in Nubia from the Napatan-Meroitic period (700 BC-0 BC), with clear domesticated types only in the late Meroitic/post-Meroitic period (0-500 AD) and later, ROWLEY-CONWY (1991) suggested a late domestication of sorghum. Recent DNA sequence data from modern sorghum and archaeological specimens from Qasr Ibrim has been used to argue that domestication was quite late, perhaps as late as ca. 0 AD (ROWLEY-CONWY et al. 1997. 1999. DEAKIN et al. 1998. MARSHALL 1998. WETTERSTROM 1998). The genetic data, however, are at best ambiguous. The genetic locus utilised showed so little variation between modern domesticated and wild varieties (i.e. lacking polymorphism) that the sequences are unlikely to be informative when it comes to assessing phylogenetic divergence between sorghum lineages and timescale: there are at most only four (usually one or two) base pairs different between any two samples (as recognised by DEAKIN et al. 1998: 37f.). Nevertheless, the late domestication hypothesis has led to two approaches to the reports of prehistoric sorghum outside Africa (from India/Pakistan and Arabia), either questioning the reports and arguing for a late domestication within Africa (ROWLEY-CONWY et al. 1997. 1999. MARSHALL 1998. WETTERSTROM 1998) or accepting the South Asian reports and arguing for an extra-African domestication (HAALAND 1995. 1999).

The large number of sorghum reports from South Asia represent varying degrees of reliability. Several of the best known and most often quoted examples are based on impressions in pottery, none of which has been convincingly demonstrated to be *Sorghum* **[fig. 10a.b]**. In the case of Ahar in Rajasthan, *Sorghum* was identified

Fig. 11 Map of India showing the distribution of archaeological *Sorghum bicolor* in India after questionable identifications have been discarded. Question mark by Kaothe indicates possibility of intrusive grains (see KAJALE 1990: 265).



- ● **2400 - 2000 BC**
- ○ **2000 - 1700 BC**
- ▲ **1700 - 1500 BC**
- ▼ **1500 - 1200 BC**
- ■ 1200 - 300 BC
- ◆ **300 BC - 300 AD**

	Site (reference)	Nature of evidence	Assessment of identification	Depositional context of preservation	Dating evidence
1*	Daimabad (KAJALE 1977a)	Several well-preserved caryopses. Note: Not in samplesof VISHNU-MITTRE et al. (1986)	Not illustrated in publication, but examined by the author	?	Early Jorwe (1500 - 1200 BC)
1	Bhatkuli (VISHNU-MITTRE & GUPTA 1968b)	Several charred grains, lengths 2.2-4mm	Illustrated by drawings	Context not reported; single samples(?)	Early Historic (300 BC - 300 AD)
1	Hulas (SARASWAT 1993)	Five charred caryopses	Illustrated with clear photograph.	Deeply buried in lower stratum with range of crop taxa.	Mature to Late Harappan ceramic correlations, 2200BC(?) - 1500BC (DIKSHIT 1982). Two ^{14}C dates are even earlier (LAL 1997: 247).
1	Kaothe (KAJALE 1990)	Charred seeds. Ancient status queried in report.	Illustrated with photograph	Context/samples number not reported. The entire site consisted on 60-70 cm of deposit below modern surface, thus high potential of intrusive charred seeds	single ^{14}C date for site: 2400 - 2000 calBC
1	Nevasa (KAJALE 1977b)	Charred grains	Photograph	?	Indo-Roman 50BC - 200 AD
1	Rohira (SARASWAT 1988), referred to var. *bicolor*	Three charred grains	Photograph	Lower excavated layers at depth of nearly 3 m	Phase I, Sothi-Siswal phase, probably equivalent to Mature Harappan (2500?) - 2300-2000 BC
1	Sanghol (SARASWAT & CHANCHALA 1997; POKHARIA & SARASWAT 1999; SARASWAT 1997)	Charred grain(s)	Illustrated in POKHARIA & SARASWAT 1999	?	POKHARIA & SARASWAT (1999) report from Kushana period, 200 BC - 250 AD. Late Harappan / Bara (SARASWAT 1997)
1	Tuljapur Garhi (KAJALE 1988a. 1996a)	Charred lumps of seeds, and individual grains	Illustrated by photographs	Found in 3 pit contexts sealed only by topsoil	Late Jorwe, 1200 - 900 BC

Tab. 4 (continued next page)

on the basis of impressions in pottery which were interspersed with those of rice, rice chaff and straw (VISHNU-MITTRE 1969). However, the published photographs (VISHNU-MITTRE 1969: pl. 30) seem to show a long parallel-sided, round-ended scutellum on one of the grains, which might suggest *Echinochloa*. Such an attribution may be more logical as *E. colona* and *E. crus-galli* are well known weeds of rice (MOODY 1989). The reported size of these impressions, including lengths between 1.5 and 2.5 mm fits well with the size range of *Echinochloa* spp. especially *E. crus*-galli var. *oryzoides*, a large-seeded rice mimic (cf. CRAWFORD 1983. 1997). The find from Paunar derived from the same sort of evidence. The oft-cited material from Pirak (from the post-Harappan period) was reported with reservations and was not illustrated (COSTANTINI 1979). In some cases finds in preliminary reports have not been confirmed, nor even discussed or illustrated, in subsequent final archaeobotanical reports as at Inamgaon (VISHNU-MITTRE & SAVITHRI 1976. KAJALE 1988b) and Daimabad (KAJALE 1977a. VISHNU-MITTRE et al. 1986). Moving beyond India, there are no convincing illustrated characters on which to accept the identified sorghum impressions from Oman or

	Site (reference)	Nature of evidence	Assessment of identification	Depositional context of preservation	Dating evidence
2	Bhokardan (KAJALE 1974)	Single charred grain	Poor photograph, but plausible	In single sample	Early Historic, phase 1B, 100 BC - 200 AD
2	Mangali & Luduwala (WILLCOX 1992)	Charred caryopses(?)	Not illustrated. No reason to doubt.	?	1500 - 1900 AD
2	Rojdi (WEBER 1991)	113 charred seeds	Not illustrated	From three trenches, depths upto 175 cm	Phase C, i.e. 2000 - 1700 BC and Period D, Medieval
2	Senuwar (SARASWAT & CHANCHALA 1995)	Charred grain(s)	Not illustrated	?	Phases IA, IB, II
3	Inamgaon (VISHNU-MITTRE & SAVITHRI 1976)	Not in samples of final report of KAJALE 1988b	Not illustrated	?	Jorwe (1500 - 900 BC)
3	Pirak (COSTANTINI 1979)	Three charred grains	Not Illustrated	In fill context	2nd millennium BC, i.e. anytime between 1900 - 1000 BC (for chronology see SHAFFER 1992)
4	Ahar (VISHNU-MITTRE 1969)	Circular impressions in potsherds along with rice husk (i.e. processing waste)	Size at small end of *Sorghum* range. Illustration shows no distinctive *Sorghum* shape/ scutellum features. Could be *Echinochloa*, which is more probable as contaminant of rice-processing waste used as temper.	In mixed fill context	Reported as before 1500 BC, but excavator (SANKALIA et al. 1969: 217) indicates concerns about integrity of context which could be Early Historic (i.e. 1500 - 2000 years later)
4	Paunar (VISHNU-MITTRE & GUPTA 1968a)	Circular impressions in potsherds along with rice husk (i.e. processing waste)	Criteria refer to those of Ahar (see above)	?	Early Historic (300 BC - 300 AD)

Tab. 4 Archaeological reports of *Sorghum* in India and Pakistan. Left hand column indicates reliability ranking (see text); asterix indicates material examined by the author.

Yemen (see Tengberg, this volume. De Moulins, this volume. FULLER 2002. Reported by COSTANTINI 1979. 1990. CLEUZIOU & COSTANTINI 1980. 1982).

Despite these concerns, there are several cases of illustrated charred grains from Indian archaeological sites that can be accepted as *Sorghum* **[fig. 10,c-g]**. The total number of finds is still quite small, and in most cases they are restricted to individual groups of charred grains preserved in individual contexts. If we accept the unillustrated finds from India (Rohira, Senuwar, Malhar, Imlidh-Kurd and Rojdi), for which I see no reason to doubt, then we have a wide geographical distribution of evidence from the first half of the second millennium BC **[fig. 11; tab. 4]**. If more cautiously we hold the former to one side, and exclude Kaothe on the possibility that the grains are intrusive due to the shallow stratigraphy of the site, we are still left with the find from Hulas which is likely to have been in a secure context (2.2 m below the surface in stratum 8, part of the Late Harappan levels that underlie Northern Black Polished Ware levels i.e first millennium BC ceramics). The reports from Daimabad and Tuljapur Garhi, of the Jorwe period, are also fairly early, i.e. 1500-1200 BC. Similarly from the second half of the second millennium BC come finds from the middle Ganges region at Imlidh-Kurd and Malhar. The general distribution then indicates the earliest Indian sorghums in the Northwest, along with Kaothe on the peninsula, with subsequent dispersal eastward. Most of the reports appear to be good candidates for the primitive race bicolor which we would expect to have reached India first. The specimens from Kaothe, however, with thick protruding scutellum and a widely obovate shape, might be comparable to race caudatum, although as noted these could be modern intrusives.

In addition to the South Asian evidence, reports from East Asia must also be considered. The modern racial distribution (DE WET & HUCKABAY 1967) suggests that race bicolor sorghums reached East Asia, presumably via India, to exclusion of other races, perhaps before the other races had been introduced into South Asia or intervening regions. Reports from Korea and Japan date back to the later first millennium BC. At the Korean site of Hunamni, sorghum was reported along with rice, barley and *Setaria italica*, from a phase placed at ca. 1400 BC (NELSON 1999: 153). In Japan, from the early Yayoi Period, ca. 300-100 BC, from *Morooka* (Kukuoka prefecture) in a jar accompanying a burial, sorghum was found along with barley, rice and adzuki bean (*Vigna angularis*) (TERASAWA & TERASAWA 1981). The other find is from the *Ayaragi-go Daichi* site (Yamaguchi prefecture) where it was found in a pit (interpreted as a storage pit) with small millets, wheat and nuts (TERASAWA & TERASAWA 1981). Although it has not been possible to examine illustrations in primary reports, the relatively late date of the Japanese finds in relation to those in India makes them acceptable. The Korean evidence would support the contention that sorghum must have reached South Asia in the first half of the second millennium BC if it were to have spread to Korea in the second half. The South Asian evidence, together with the few reports from East Asia, argues strongly that the currently available African evidence is still limited to finds that are too late to provide information on early cultivation.

Finger millet (*Eleusine coracana*)

Finger millet was domesticated from the wild taxon *Eleusine africana* Kennedy-O'Bryne of East African highlands (MEHRA 1962. 1963. PHILLIPS 1972. HILU & DE WET 1976. HIREMATH & CHENNAVEERAIAH 1982). Despite some earlier claims for an Indian origin (DE CANDOLLE 1886. VAVILOV 1992 [1935]: 331f. VISHNU-MITTRE 1971. PORTERES 1976. VISHNU-MITTRE et al. 1984), several genetic proxy studies leave no doubt as to its wild progenitor (HILU & JOHNSON 1992. WERTH et al. 1994. DE WET 1995b. HILU 1995). Genetic data indicates highly restricted variation in the crop by comparison to its wild progenitor and other wild species, suggesting very few domestications. The region of wild populations today suggests this crop's origins took place in an environment other than the lowland savannahs where it is well established today in both India and Africa **[fig. 12]**. The racial differentiation of *Eleusine* within India suggests that it was first introduced to the plains of the peninsula and subsequently spread to the northern and northwestern part of the subcontinent (HILU & DE WET 1976. HILU 1995). The genetic evidence of HILU (1995), although of limited sample size, could indicate that some of the most "primitive" genotypes of the crop come from Tanzania. Linguistic evidence may provide additional support: the root **-dègi* for finger millet in a number of bantu languages from Southern Tanzania and Northern Malawi may be the source for *ragi* and its variants in the Indian subcontinent (PHILLIPPSON & BAHUCHET 1996). The Dravidian linguist SOUTHWORTH (1988) suggested an alternative derivation from the reconstructed proto-Dravidian etymon **iraki*, meaning food. It is worth noting that a range of other millet-grasses (e.g. *Brachiaria ramosa, Paspalum scrobiculatam*, as well as *Setaria italica* and *Panicum miliaceum*) also have colloquial names including the element *-ragu* (as recorded in FISCHER 1928).

Eleusine coracana has been widely reported from Chalcolithic/Neolithic sites all over India (see POSSEHL 1986. 1997. 1998. VISHNU-MITTRE 1989. KAJALE 1991. WEBER 1998), but it has been widely mis-identified and *none* of the published reports is yet supported by illustration of unambiguous specimens (see FULLER 2002) **[tab. 5; fig. 13]**. That at least some finger millet reports are mis-identifications was clarified by re-examination of material in India during the author's visit in August-September 2000. It appears that these attributions of finds to finger millet occurred through comparative study that failed to take into account the difference between hulled and de-hulled specimens of the same species. The first report of *Eleusine* that was illustrated and described was that from Hallur (VISHNU-MITTRE 1971) in which some six modern species of millets were described as comparative material. Other species, such as *Brachiaria ramosa* or *Echinochloa colona* ssp. *frumentacea*, known to be cultivated in the region today (DE WET 1995c. GRUBBEN & PARTOHARDJONO 1996) do not even appear to have been considered. The emphasis on other species of millets, especially introduced species that are of wide importance in Indian agriculture today, indeed represents a "modernist anachronism" (WIGBOLDUS 1996: 79f.), but the real mistake lies in failing to take into account the potential effects of charring, especially in terms of differentially destroying lemmas and paleas. It is clear that material from *Panicum* spp., *Setaria* spp., and *Paspalum scrobiculatum* were all examined as hulled spikelets with lemmas and paleas adhering (which is also the state in which they are usually illustrated in standard seed atlases), whereas *Pennisetum, Sorghum*, and *Eleusine* were described as de-hulled caryopses, as these taxa tend to be free-threshing. As the hulled-millets tend to be biconvex with pointed apices, they differed from the round-ovate archaeological millets, and the closest comparison by default was therefore *E. coracana*, despite the fact that the archaeological millets were clearly longer than

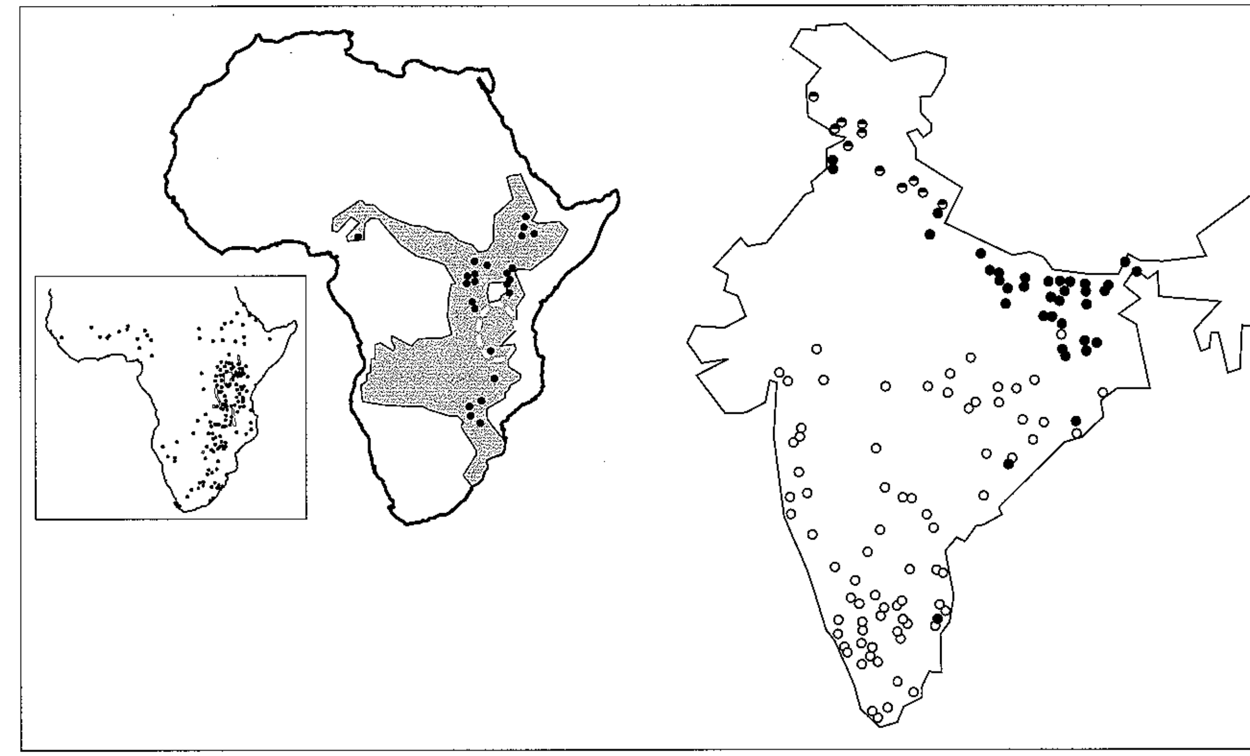


Fig. 12 Maps of Africa and India showing modern distribution of races of *Eleusine coracana* (after HILU & DE WET 1976), with inset showing the distribution of the wild progenitor *Eleusine africana* (after PHILLIPS 1972).

In Africa: African highland race (black circles) and African lowland race (grey area). The distribution of the Bantu linguistic root *dègi* is indicated by a dashed white oval (based on PHILIPSON & BAHUCHET 1996).
In India: the lowland race, which is closest to the African lowland type, is indicated by open circles; the Indian race is indicated by black circles, and the Indian highland race is indicated by half-solid circles.

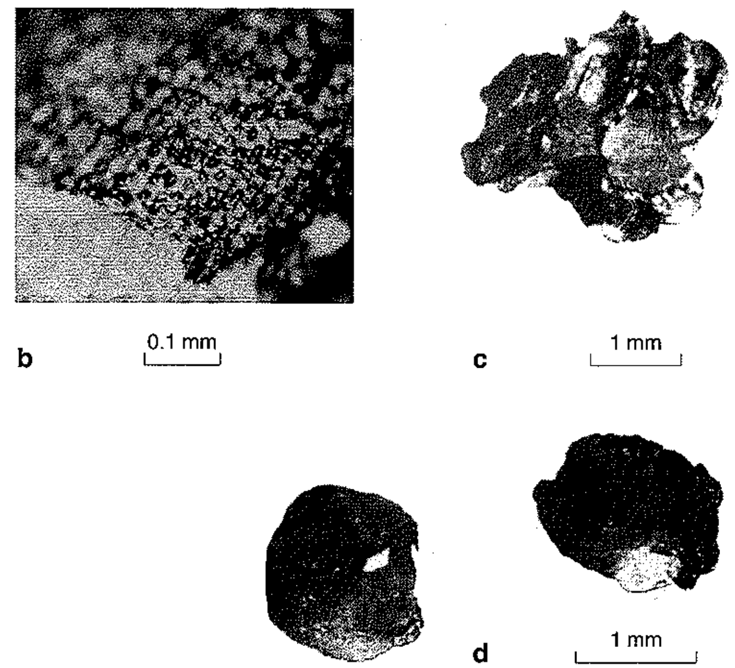
	Site (reference)	Nature of evidence	Assessment of identification	Depositional context of preservation	Dating evidence
1*	Hallur (FULLER 1999)	Single charred caryopsis, fragmented	Internal anatomy clear, some apparent preservation of pericarp	Charcoal lens rich in small seeds, collected in bulk. No reason to believe this seed intrusive.	Near top of sequence samples in 1998. Probably late Neolithic, perhaps towards 1000 BC(?).
4*	Hallur (VISHNU-MITTRE 1971)	Charred lumps of caryopses	Mis-recognised long-scutellum millet caryopsis (*Setaria* sp./ *Brachiaria ramosa*)	Single sample	Neolithic, 2200-1200 BC
1*	Malhar (TEWARI et al. 2000)	Charred caryopses	Well preserved morphology and pusticulate pericarp	?	Early Iron Age level with ^{14}C dates before ca. 800 BC; one date as early as 1600 BC (old wood?).
3	Bhokardan (KAJALE 1974)	Charred caryopses	Illustration indistinct	Single sample	Early Historic, 300 BC - 300AD
3	Kuntasi (DHAVALIKAR 1995, quoting Kajale pers. comm., but NOT included in finale report by KAJALE 1996b)	Charred caryopses(?)	KAJALE (1996) has changed this identification, apparently grouping most small millets as *Panicum* sp.	?	Mature Harappan, 2500 - 2000 BC
3	Manji (SARASWAT & CHANCHALA 1997)	Charred caryopses	No illustration	?	Early Historic
3	Senuwar (SARASWAT et al. 1995. In press)	Charred caryopses	Illustration and description in forthcoming report suggest a long-scutellum millet caryopsis	Various flotation samples, from lower . levels	Phase IA, 2500(?) BC - 1700 BC
3	Rojdi (WEBER 1991)	Charred caryopses. Same samples include *Setaria* identified only from preserved spikelets.	No illustration. Criterion follows that of VISHNU-MITTRE & SAVITHRI (1978). Dimensions too ovate for *E. coracana*.	Numerous contexts and levels	Phases I-III, Harappan to Late Harappan, 2600 - 1700 BC
3	Babor Kot (REDDY 1994)	Charred caryopses. Same samples include *Setaria* identified only from preserved spikelets.	No illustration. Criterion follows that of VISHNU-MITTRE & SAVITHRI (1978). Dimensions too ovate for *E. coracana*.	Numerous contexts and levels	2000-1700 BC
3	Oriyo Timbo (REDDY 1994)	Charred caryopses. Same samples include *Setaria* identified only from preserved spikelets.	No illustration. Criterai follows that of VISHNU-MITTRE & SAVITHRI (1978). Dimensions too ovate for *E. coracana*.	Numerous contexts and levels	1700 - 1400 BC
3	Paiyampalli (cited in KAJALE 1991)	Charred caryopses	No illustration	?	Late(?) Neolithic, 1800 - 1000 BC
3	Watgal (DEVARAJ et al. 1995)	Charred caryopses	No illustration. Not a specialist report. Not mentioned in abstract of KAJALE (1998). Likely to be *Brachiaria/Setaria* ubiquitous of contemporary sites in the region (FULLER 1999)	?	Southern Neolithic II-III (i.e. from 2200 BC through 2nd millennium)
3	Paiyampalli (cited in KAJALE 1991)	Charred caryopses	No illustration	?	Late(?) Neolithic, 1800 - 1000 BC
4	Hulaskhera (CHANCHALA 1992)	Charred caryopses	Photograph, suggests *Paspalum scrobiculatum* caryopses.	From several contexts and layers	Early Historic, Sunga Period, 200 BC - 0 AD, and Kushana period 0 - 300 AD, and early Gupta, 300 - 500 AD
4	Surkotada (VISHNU-MITTRE 1990. VISHNU-MITTRE & SAVITHRI 1978. 1979a. CHANCHALA 1991)	Mass of charred caryopses together with charred spikelets of *Setaria* cf. *italica* type	Illustrations. Mis-recognised long-scutellum millet caryopsis. Probably de-hulled form of accompanying (*Setaria* cf. *italica*). Other *Setaria* sp(p). Also present.	Charred storage jar, from depth 1.6 m	Period III, Late Harappan, 2000 - 1700 BC
4	Shikarpur (CHANCHALA 1991)	Charred caryopses	Illustration. Mis-recognised long-scutellum millet caryopsis. Probably de-hulled form of accompanying *Setaria* sp.	From flotation samples. Context not stated.	Mature Harappan, 2500 - 2000 BC
4	Hulas (SARASWAT 1993a)	Charred caryopses and charred lump	Illustrated with photographs. Appears to be long-scutellum millet with fragments of adhering lemma/palea of *Setaria* type.	Single sample, well-sealed context	Late Harappan, 2000 - 1700 BC
4	Inamgaon (KAJALE 1988b)	Charred caryopses	Illustration not entirely distinct, but appears to show long-scutellum, ovate millet. Some examples could be shorter scutellum like *Eleusine*. Note that *Setaria* illustrated in hulled form (spikelets) only.	Small numbers of grains in 5 samples, through the sequence	Malwa to Late Jorwe, 1700 - 900 BC
4	Daimabad (VISHNU-MITTRE et al. 1986;	Charred caryopses. (Also reported by KAJALE (1977a) without illustration)	Illustrations. Mis-recognised long-scutellum millet caryopsis (*Setaria* sp./*Brachiaria ramosa*)	Numerous contexts and levels	Malwa-Jorwe, 1700 - 1200 BC
4	Nevasa (KAJALE 1977b)	Charred caryopses	Long scutellum millets(?)	?	Early Historic, 300 BC - 300 AD

Tab. 5 Archaeological reports of *Eleusine coracana* from India. Left hand column indicates reliability ranking. An asterix indicates that the author has examined the material.

they were wide or thick and had very long-scutellums. None of these are traits characteristic of *Eleusine* **[fig. 14]**. Occasional adhering fragments of charred lemma/palea, especially of the rugose types found in *Setaria* spp. or *Brachiaria ramosa*, were then interpreted as preservation of the pusticulate pericarp of the caryopsis surface in *Eleusine*. This misunderstanding of the state of preservation of archaeological millets and the anatomical parts to be compared with modern

a

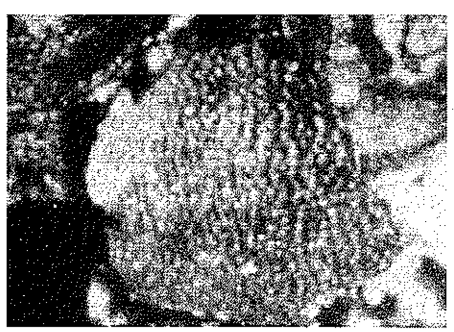
1 mm



b 0.1 mm

c 1 mm

d 1 mm



e

1 mm

Fig. 13 Examples of small, long-scutellum millets reported as '*Eleusine coracana*' or 'ragi' in the Indian archaeobotanical literature.

a Charred caryopsis from Surkotada considered a typical archaeological *Eleusine coracana* (after VISHNU-MITTRE & SAVITHRI 1979a: Pl. 1.5), but note ovate shape, long scutellum and adhering lemma fragment; **b** Close-up of surface of supposed 'seed coat' (after VISHNU-MITTRE & SAVITHRI 1979a: Pl. 1.1) but probably lemma; **c** Clump of charred 'ragi' from Hulas (after SARASWAT 1993a: Pl. 2.11), note long scutellum; **d** Examples of 'ragi' from Hulas (after SARASWAT 1993a: Pl. 2.10); **e** Close up of surface of alleged 'ragi' from Hulas (after SARASWAT 1993a: Pl. 2.12), note rugose rows of pusticulae.

material was canonized in definitive articles on the identification of *Setaria* and *Eleusine* published in *Palaeobotanist* (VISHNU-MITTRE & SAVITHRI 1978. 1979a). Both of these articles were based on modern comparative material and archaeological material from the charred contents of a single jar. It contained both *Setaria* cf. *italica*, identified only when preserved as hulled spikelets with lemma and palea intact, and '*Eleusine coracana*' identified from de-hulled caryopses, which the illustrations strongly suggest to be the de-hulled *Setaria* grains one would expect to accompany the hulled examples (since we would expect charring to tend to de-hull at least some of the spikelets). A re-examination of Vishnu-Mittre's sample from Hallur together with Dr. Saraswat in September 2000, confirms that it consists of long-scutellum millet caryopses of *Brachiaria ramosa* type. Similarly, material examined with Dr. Kajale from Songaon that had been provisionally been referred to *Eleusine* turned out to be *Brachiaria ramosa* type. Many subsequent studies by other archaeobotanists must be suspect by having relied upon the published criteria of the Hallur and Surkotada studies.

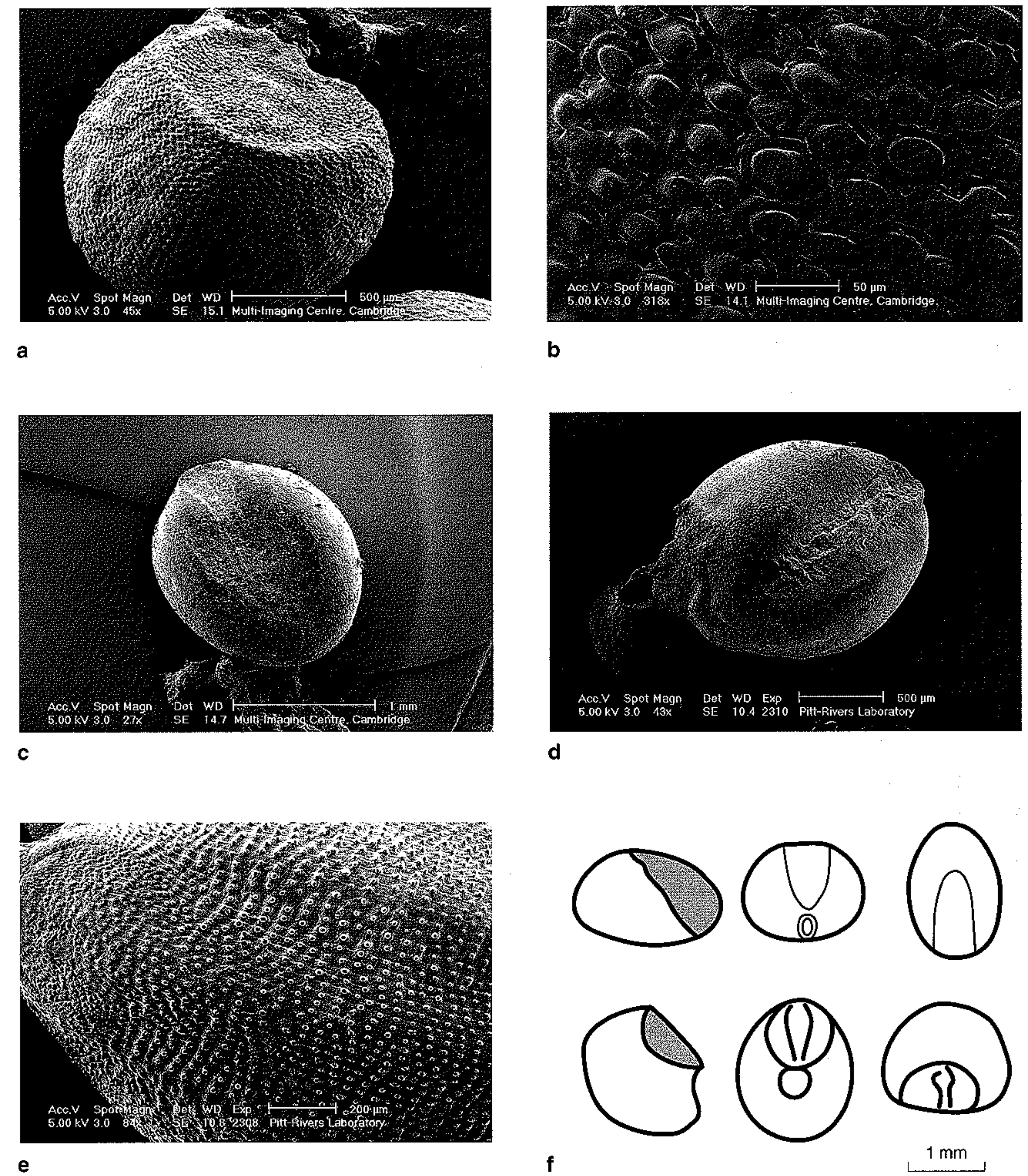


Fig. 14 Modern comparative material of *Eleusine coracana* and selected long-scutellum ovate millets.

a Modern caryopsis of *Eleusine coracana* (from Bellary, India); **b** Close up of pericarp surface of *Eleusine coracana* grain in (f), note nearly straight rows of well-spaced pusticulae; **c** Modern grain of *Brachiaria ramosa:* an ovate, long-scutellum millet; **d** Modern grain of *Setaria italica* race maxima: an ovate, long-scutellum millet; **e** Lemma surface of *Setaria italica* race maxima, note rugose rows of pusticulae (compare to **fig. 13,b.e**); **f** Schematic drawings comparing *Setaria italica*, top (which is generally similar to other *Setaria* spp., *Brachiaria ramosa*, and *Echinochloa* spp.) and *Eleusine coracana*, bottom. Shading shows scutellum area in longitudinal section.

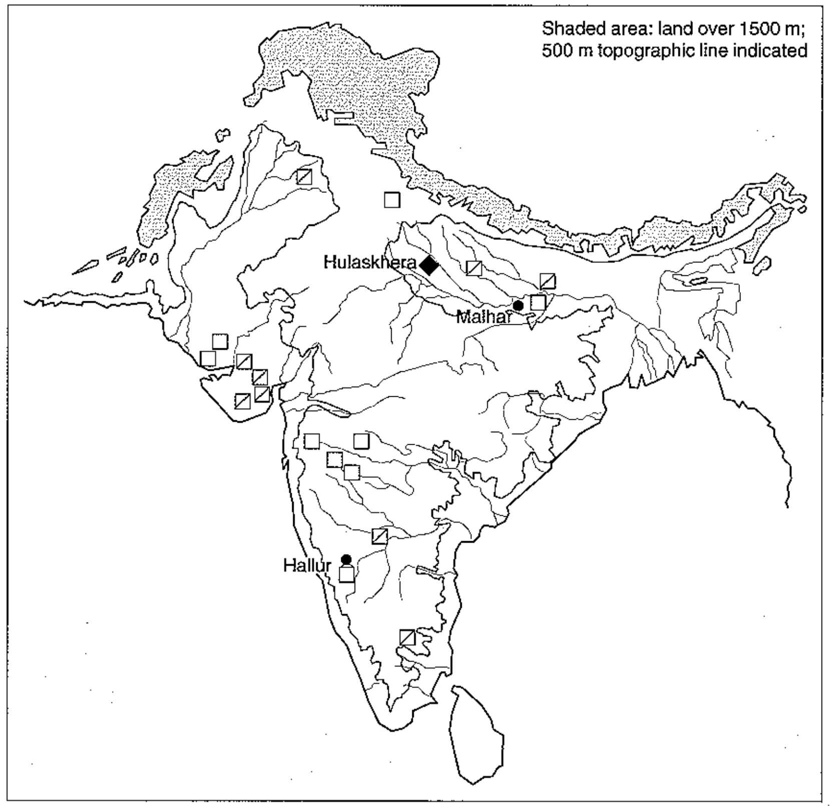


Fig. 15 Map of India showing distribution of dubious reports of *Eleusine coracana*, which probably represent mis-attributed long scutellum millets such as *Setaria* spp., *Brachiaria ramosa*, or *Echinochloa colona*, and unillustrated reports which the author would regard with scepticism at present. The author has reported a single find of *Eleusine coracana* from Hallur from a late Neolithic level, perhaps ca. 1000 BC at a guess. Recently, Dr. Saraswat has found *Eleusine coracana* from Early Iron Age Malhar, which is suggested to pre-date 800 BC (in TEWARI et al. 2000).

☐ Mis-identified
⊠ Not illustrated
● New evidence

The Indian evidence for this crop is thus completely unsatisfactory **[fig. 15]**. The lone Hallur specimen is probably late second millennium BC, although the dating of this context is at best only a guess at present **[fig. 16]**. Well preserved, and unambiguous specimens were seen by the author in material from Malhar under study by Dr. K.S. Saraswat, which pre-dates 800 BC and could be as old as ca. 1600 BC (preliminary report: TEWARI et al. 2000). Specimens illustrated from Hulskhera are convincing and date back to 700 BC (CHANCHALA 1992). SOUTHWORTH's (1988) imputed linguistic evidence puts it back to Proto-South Dravidian only (which is speculatively early first/ late second millennium BC). Archaeobotanical evidence from Aksum puts it back in Ethiopia only to ca. 500 AD (BOARDMAN 1999). What is clear, however, is that the recent orthodoxy in South Asian archaeology about the widespread importance of this species in prehistoric agriculture requires revision.

Castor

Although there is a range of other crops of African origin cultivated in South Asia today (see Blench, this volume), there has been less archaeobotanical evidence forthcoming. One species which has been identified from a context nearly as early as the African millets and pulses is the castor plant, *Ricinus communis* L. SARASWAT (1993a) reported this species from Hulas on the basis of a fragmentary exocarp, which appears convincing. An earlier report of *R. communis* from Early Historic Terr, however, may have been mis-identified (VISHNU-MITTRE et al. 1971: pl. 1.6. VISHNU-MITTRE 1977: pl. 5). While the seed appears to be elliptic in shape, as is the case in *Ricinus*, the two most distinctive traits of castor seeds appear absent on the illustrated specimen nor are they mentioned in the description. *Ricinus* has a distinctive longitudinal ridge along the length of the seed and a carbuncle at one end. Rather the

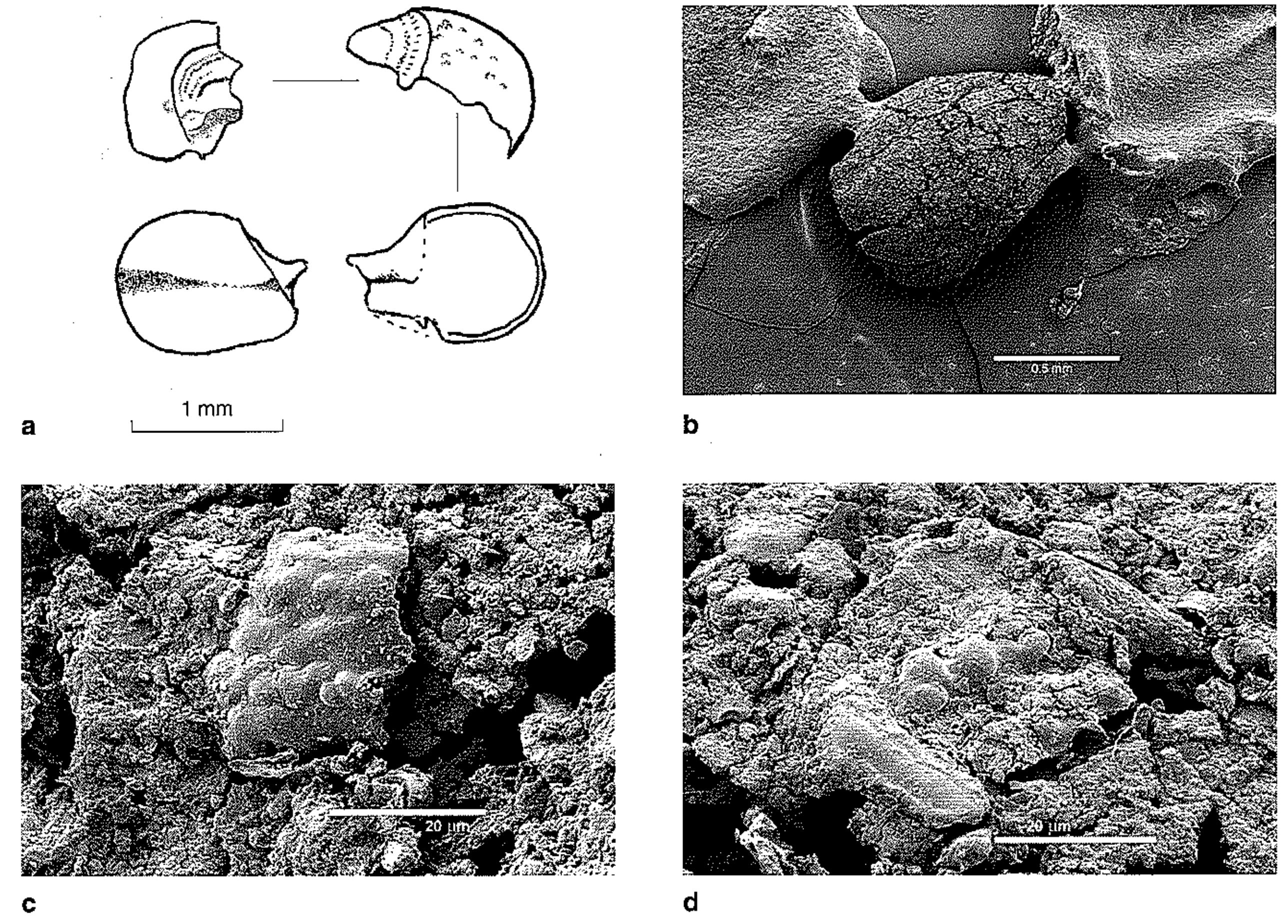


Fig. 16 **a** Drawing of specimen from HLR.98B identifiable as *Eleusine coracana*; **b** Fragment of archaeological specimen of *Eleusine coracana* from HLR.98B; **c** Close-up of surface of specimen in (d) showing preserved fragment of pusticulate pericarp; **d** Close-up of surface of specimen in (d) showing preserved fragment of pusticulate pericarp.

illustrated specimen resembles a mimusoid seed, although this could just be a case of a poor photograph.

Discussion

The Selective Uptake of African Crops

In summing up the available evidence, it can be seen that the adoption of crops of African origin into South Asia did not follow a simple, single trajectory. The cereals and pulses of Near Eastern origins appear to have diffused into northwestern South Asia at an early date and then further eastward and southward as a fairly coherent agricultural package. This formed a significant componenet of the subsistence economy in, for example, the Ganges valley or the northern Peninsula (FULLER 2002). In contrast, the spread of African crops was more piecemeal and selective.

While a number of authors have in the past suggested that the adoption of African millets may have been an agricultural 'revolution' of the Late Harappan period or a critical factor in the spread of agriculture into monsoonal environments of India (e.g. HUTCHINSON 1976. POSSEHL 1980. 1986. JARRIGE 1985. MEADOW 1989. 1996), the available evidence indicates that these taxa were not adopted on a large scale on individual sites nor are they consistently in evidence over particular regions (FULLER & MADELLA 2001). Rather each of the African species appears to be locally important, or supplemental, to agricultural economies based primarily on other species. As already noted by WEBER (1993. 1998) the African millets appear largely to have been adopted on sites where there was already ample evidence for the cultivation of other summer crops, including millets and pulses of South Asian origin, as well as perhaps introduced east Asian millets such as *Setaria italica*. The author's own data from South Indian Neolithic sites indicates this process, as *Pennisetum glaucum* occurs only in small quantities through part of the stratigraphic sequence at Hallur, where all samples are dominated by *Vigna radiata*, *Macrotyloma uniflorum*, *Brachiaria ramosa* type and *Setaria verticillata* type. At the site of Sanganakallu, *Lablab purpureus* occurs in large quantities, often dominating samples, but only in the second (later) half of the stratigraphic sequence, whereas the same four taxa at Hallur are found throughout the sequence.

The period at which these species were selectively taken up appears to be one in which agricultural experimentation and crop exchange generally was underway. The second millennium BC, especially after ca. 1700 BC, provides evidence for long-distance trade and influence in material culture styles between the northern and southern Peninsula, and further afield with northwestern India (cf. LAHIRI 1992. KORISETTAR et al. 2001). New crops were adopted in South India during this general period, beginning with wheats and barley from the north, some evidence for rice at a limited number of sites, and pigeon pea (*Cajanus cajan*) that had originated on the north eastern peninsula (FULLER 1999. 2002. FULLER et al. 2001). Although there is no clear evidence for trade with Africa, the wider economic context within South Asia indicates that such contact would not have been out of place. Archaeological evidence from this period from coastal regions of peninsular India is still largely lacking, so evidence for the first contact with African crops is not yet available. The nature of contact with Africa, however, remains wholly obscure. Archaeological evidence for contact is lacking, although it is notable that clay pedestal-headrests from a few South Indian Neolithic sites have been compared to traditional east African headrests (ALLCHIN 1966. NAGARAJA RAO 1970). A copal pendant from Mesopotamia attests to the movement of some tradegoods from southeast Africa during this period (MEYER et al. 1991. POSSEHL 1997). The lack of African crops in Oman and eastern Arabia (see Tengberg, this volume), a region clearly in regular trade with the Harappan northwest, argues against transit via the Arabian peninsula, although the situation with Yemen is not yet clear. The general distribution of *Lablab*, *Eleusine*, and caudatum *Sorghums* might all argue for dispersal from coastal regions south of the horn of Africa, although agriculture is not yet archaeologically established for this region in the third millennium BC.

Incidentally, the archaeobotanical evidence from India seems to fit that of historical linguistics. At least for the three African millets, SOUTHWORTH (1976. 1988) provides historical reconstructions for earlier Dravidian sub-groupings. He traces both sorghum and pearl millet back to Proto-South-Central Dravidian, which he would guess dates to the first half to mid second millennium BC. While we may doubt the linguistic dates, it fits rather well with the present archaeological picture. Interestingly, as already noted he traces *ragi* as finger millet (*E. coracana*) back to a more recent grouping, namely Proto-South Dravidian. This too fits with the archaeobotanical evidence in indicating that this species was not present as early as the others. Unfortunately he provides no evidence for the pulses. Sanskrit textual evidence tends to be much later than the earliest archaeological evidence, or the reconstructed proto-Dravidian. Sorghum and pearl millet, although not found in early Vedic texts, have a wide distribution in modern Indo-Aryan languages that might attest to fairly early adoption, perhaps before the end of the first millennium BC in northern India (SOUTHWORTH 1976. POSSEHL 1998). Early written references to cow peas come from the Mahabhashya of Patanjali dated to ca. 150 BC (STEELE & MEHRA 1980), in addition to *nishpava*, identified as *Lablab*, in Buddhist canoncial literature that dates back to perhaps ca. 400 BC (ACHAYA 1994: 188f.).

Implications for African agricultural origins

The evidence of at least four African crops in South Asia by the mid-second millennium BC, with *Eleusine* being adopted sometime later, clearly has implications for the antiquity of their cultivation and domestication in Africa. While it is conceivable, following the reasoning of HAALAND (1995. 1999), that some of these species had been cultivated without domestication in Africa, it seems more plausible that their introduction via long-distance trade attests to their cultivation as staples that might be stored for long voyages. Are such staples more likely to have already been morphologically domesticated? If we assume this to have been the case, then we must assume that sorghum, pearl millet, cow pea and hyacinth bean were domesticated by the end of the third millennium BC. While this need not imply early Holocene agricultural origins, i.e. as early as China or Southwest Asia, it does suggest earlier origins than some have suggested recently in particular for sorghum (e.g. ROWLEY-CONWY et al. 1997. 1999. MARSHALL 1998. WETTERSTROM 1998). Rather we must still be missing the evidence for the earliest cultivation and domestication of these taxa. Plausible candidates for complex societies, presumably with agriculture, in tropical Africa may be identified in the ancient lands known as *Yam* and *Punt* in Old Kingdom Egyptian records (at least as early as 5th dynsasty, ca. 2500 BC), with the latter generally placed somewhere between Port Sudan and the Horn of Africa (GRIMAL 1992: 76ff. KITCHEN 1993. O'CONNOR 1993. MARSHALL 1998. PHILLIPS 1998). The general regions in which we might look for the earlier origins of these crops might be suggested by the available botanical evidence for wild populations, but adjusted for wetter conditions of the mid-Holocene. As also suggested by the review above, we are not looking for a single centre from which all the African crops came but at least three, or perhaps more. The South Asian evidence challenges us to expand the quantity and geographical coverage of early archaeobotanical evidence in Africa.

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References

ACHAYA, K.T. (1994) Indian Food. A Historical Companion. Delhi 1994 (Oxford University Press).

ALLCHIN, F.R. (1966) Pottery Headrest from Narsipur Sangam. In: Sen, D. & A. Gosh (eds.), Studies in Prehistory (Bruce Foote Memorial Volume). Calcutta 1966: 58-63 (Firma K.L. Mukhopadhyay).

ALLCHIN, B. & R. ALLCHIN (1968) The Birth of Indian Civilization. London 1968 (Pelican Books).

AMBLARD, S. & J. PERNES (1989) The identification of cultivated pearl millet (*Pennisetum*) amongst plant impressions on pottery from Oued Chebbi (Dhar Oualata, Mauritania). *The African Archaeological Review* 7, 1989: 117-126.

ANQUANDAH, J. (1993) The Kintampo Complex: a Case Study of Early Sedentism and Food Production in Sub-Sahelian West Africa. In: Shaw, T., P. Sinclair, B. Andah & A. Okpoko (eds.), The Archaeology of Africa. Food, Metals and Towns. London 1993: 255-259 (Routledge).

APPA RAO, S., K.E. PRASADA RAO, M.H. MENGESHA & V. GOPAL REDDY (1996) Morphological diversity in sorghum germplasm from India. *Genetic Resources and Crop Evolution* 43, 1966: 559-567.

ARCHAEOLOGICAL SURVEY OF INDIA (1983) Excavations at Ramapuram, District Kurnool. *Indian Archaeology 1980-81 – A Review* 1983: 3-7.

BLENCH, R. (1995) Linguistic evidence for cultivated plants in the Bantu borderland. *Azania* 29/30, 1995: 83-102.

BOARDMAN, S. (1999) The Agricultural Foundation of the Aksumite Empire, Ethiopia: An Interim Report. In: Veen, M. van der (ed.), The Exploitation of Plant Resources in Ancient Africa. New York 1999: 137-148 (Kluwer/Plenum).

BOR, N.L. (1960) The Grasses of Burma, Ceylon, India and Pakistan (Excluding Bambuseae). London 1960 (Pergamon Press).

BRUNKEN, J.N. (1977) A systematic study of *Pennisetum* sect. Pennisetum (Gramineae). *American Journal of Botany* 64,2, 1977: 161-176.

CHANCHALA, S. (1991) Harappan plant economy in the Rann of Kutch. *Geophytology* 23,2, 1991: 227-233.

– (1992) The fruit and seed remains from ancient Hulaskhera, District Lucknow, U.P. (c. 700 B.C. – 500 A.D.). *Pragdhara (Journal of the Uttar Pradesh State Archaeological Organisation)* 2, 1992: 65-80.

CLARK, J.D. & A.B. STEMLER (1975) Early domesticated sorghum from Central Sudan. *Nature* 25, 1975: 588-591.

CLEUZIOU, S. & L. CONSTANTINI (1980) Premiers éléments sur l'agriculture protohistorique de l'Arabie orientale. *Paléorient* 6, 1980: 245-251.

– (1982) A l'origine des oasis. *La Recherche* 13,137, 1982: 1180-1182.

CLEUZIOU, S. & M. TOSI (1989) The Southeastern Frontier of the Ancient Near East. In: Frifelt, K. & P. Sorensen (eds.), South Asian Archaeology. London 1985: 15-47 (Curzon Press).

COSTANTINI, L. (1979) Plant Remains at Pirak. In: Jarrige, J-F. & M. Santoni (eds.), Fouilles de Pirak; vol. 1. Paris 1979: 326-333 (Diffusion de Boccard).

– (1990) Ecology and farming of the protohistoric communities in central Yemeni highlands. In: Maigret, A. de (ed.), The Bronze Age Culture of Halwan at-Tiyal and Al-Hada (Republic of Yemen). Rome 1990: 187-204. (ISMEO)

COSTANTINI, L. & L. COSTANTINI BAISINI (1985) Agriculture in Baluchistan between the 7th and 3rd Millennium B.C. *Newsletter of Baluchistan Studies* 2, 1985: 16-37.

CRAWFORD, G.W. (1983) Paleoethnobotany of the Kameda Peninsula Jomon. *Anthropological Papers* 73, Ann Arbor 1983 (Museum of Anthropology, University of Michigan).

– (1997) Anthropogenesis in Prehistoric Northeastern Japan. In: Gremillion, K.J. (ed.), People, Plants and Landscapes. Studies in Paleoethnobotany. Tuscaloosa 1997: 86-103 (University of Alabama Press).

D'ANDREA, A.C., M. KLEE & J. CASEY (2001) Archaeobotanical evidence for pearl millet (*Pennisetum glaucum*) in sub-Saharan West Africa. *Antiquity* 75, 2001: 341-348.

DE CANDOLLE, A. (1886) Origin of Cultivated Plants. London [2]1886 (Keegan Paul, Trench & Co).

DE WET, J.M.J. (1978) Systematics and evolution of *Sorghum* sect. Sorghum (Gramineae). *American Journal of Botany* 65, 1978: 477-484.

– (1992) The Three Phases of Cereal Domestication. In: Chapman, G.P. (ed.), Grass Evolution and Domestication. Cambridge 1992: 176-198 (Cambridge University Press).

– (1995a) Pearl Millet (*Pennisetum glaucum*). In: SMARTT & SIMMONDS, eds., 1995: 156-159.

– (1995b) Finger Millet (*Eleusine coracana*). In: SMARTT & SIMMONDS, eds., 1995: 137-140.

– (1995c) Minor Cereals. In: SMARTT & SIMMONDS, eds., 1995: 202-207.

DE WET, J.M.J. & J.P. HUCKABAY (1967) The origin of *Sorghum bicolor*; II: Distribution and Domestication. *Evolution* 21, 1967: 787-802.

DEAKIN, W.J., P. ROWLEY-CONWY & C.H. SHAW (1998) Amplification and sequencing of DNA from preserved *Sorghum* of up to 2800 years antiquity found at Qasr Ibrim. *Ancient Biomolecules* 2,1, 1998: 27-41.

DEVARAJ, D.V., SHAFFER, J.G., PATIL, C.S. & BALASUBRAMANYA (1995) The Watgal Excavations: an Interim Report. *Man and Environment* 20,2, 1995: 57-74.

DHAVALIKAR, M.K. (1995) Cultural Imperialism: Indus Civilization in Western India. New Delhi 1995 (Books and Books).

DIKSHIT, K.N. (1982) Hulas and the Late Harappan Complex in Western Uttar Pradesh. In: Possehl, G.L. (ed.), Harrapan Civilization. A Contemporary Perspective. Warminster, U.K. 1982: 339-352 (Aris and Phillips Ltd.).

DOGGETT, H. & K. PRASADA RAO (1995) Sorghum. In: SMARTT & SIMMONDS, eds., 1995: 173.

FISCHER, C.E.C. (1928) Flora of the Madras Presidency; vol. III. London 1928 (Adlard & Son).

FLIGHT, C. (1976) The Kintampo Culture and its Place in the Economic Prehistory of West Africa. In: Harlan, J., J.M.J. De Wet & A.B. Stemler (eds.), The Origins of African Plant Domestication. The Hague 1976: 211-222 (Mouton).

FRANKE-VOGT, U. (1995) Cultural ecology of the Greater Indus Valley and beyond. *The Archaeological Review* (Karachi) 4, 1995: 13-64.

FULLER, D.Q. (1999) The Emergence of Agricultural Societies in South India: Botanical and Archaeological Perspectives. (PhD Thesis submitted to University of Cambridge 1999)

– (2002) Fifty Years of Archaeobotanical Studies in India: Laying a Solid Foundation. In: Settar, S. & R. Korisettar (eds.), Indian Archaeology in Retrospect; vol. III: Archaeology and Interactive Disciplines. Delhi 2002: 247-363 (Manohar).

FULLER, D.Q., R. KORISETTAR & P.C. VENKATASUBBAIAH (2001) Southern Neolithic cultivation systems: a reconstruction based on archaeobotanical evidence. *South Asian Studies* 17, 2001: 171-187.

FULLER, D.Q. & M. MADELLA (2001) Issues in Harappan Archaeobotany: Retrospect and Prospect. In: Settar, S. & R. Korisettar (eds.), Indian Archaeology in Retrospect; vol. II: Protohistory. Dehli 2001: 317-390 (Manohar).

GHOSH, S.S. & K. LAL (1963) Plant remains from Rangpur and other explorations in Gujarat. *Ancient India* 18-19: 161-175.

GODBOLE, S.V. (1925) *Pennisetum typhoideum*. Studies on the Bajri crop; I: The morphology of *Pennisetum typhoideum*. *Memoirs of the Department of Agriculture in India (Agricultural Research Institute, Pusa)* 14,8, 1925: 247-268.

GRIMAL, N. (1992) A History of Egypt (translated by Ian Shaw). London 1992 (Routledge).

GRUBBEN, G.J.H. & Soetjipto PARTOHARDJONO (eds.) (1996) Plant Resources of South-East Asia; No. 10: Cereals. Bogor, Indonesia 1996 (PROSEA).

HAALAND, R. (1995) Sedentism, cultivation, and plant domestication in the Holocene Middle Nile region. *Journal of Field Archaeology* 22, 1995: 157-174.

– (1999) The Puzzle of the Late Emergence of Domesticated Sorghum in the Nile Valley. In: Gosden, C. & J. Hather (eds.), The Prehistory of Food. Appetites for Change. London 1999: 397-418 (Routledge).

HAINES, H.H. (1921-1925) Botany of Bihar and Orissa; 6 parts. London 1921-1925 (Adlard and Son and Newmand Ltd.).

HARLAN, J.R. (1971) Agricultural origins: centers and noncenters. *Science* 174, 1971: 468-474.

– (1992a) Crops and Man. Madison, Wisconsin [2]1992 (American Society of Agronomy).

– (1992b) Indigenous African Agriculture. In: Cowan, C.W. & P.J. Watson (eds.), The Origins of Agriculture. An International Perspective. Washington D.C. 1992: 59-70 (Smithsonian Institution Press).

– (1995) The Living Fields. Cambridge 1995 (Cambridge University Press).

HARLAN, J.R. & J.M.J. DE WET (1972) A Simplified Classification of Cultivated Sorghum. *Crop Science* 12, 1972: 172-176.

HARLAN, J.R. & A.B. STEMLER (1976) The Races of Sorghum in Africa. In: Harlan, J.R., J.M.J. De Wet & A.B Stemler (eds.), The Origins of African Plant Domestication. The Hague 1976: 465-478 (Mouton).

HERMAN, C.F. (1997) "Harappan" Gujarat: the archaeology-chronology connection. *Paléorient* 22,2, 1997: 77-112.

HILLMAN, G.C. (1989) Late Palaeolithic Plant Foods from Wadi Kubbaniya in Upper Egypt: Dietary Diversity, Infant Weaning, and Seasonality in a Riverine Environment. In: Harris, D.R.& G.C. Hillman (eds.), Foraging and Farming. London 1989: 207-233 (Unwin & Hyman).

HILU, K.W. (1995) Evolution of finger millet: evidence from random amplified polymorphic DNA. *Genome* 38, 1995: 232-238.

HILU, K.W. & J.M.J. DE WET (1976) Racial evolution in *Eleusine coracana* ssp. *coracana* (finger millet). *American Journal of Botany* 63,10, 1976: 1311-1318.

HILU, K.W. & J.L. JOHNSON (1992) Ribosomal DNA variation in finger millet and wild species of *Eleusine* (Poaceae). *Theoretical and Applied Genetics* 83, 1992: 895-902.

HILU K.W., J.M.J. DE WET & J.R. HARLAN (1979) Archaeobotanical studies of *Eleusine coracana* ssp. *coracana* (finger millet). *American Journal of Botany* 66, 1979: 330-333.

HIREMATH, S.C. & M.S. CHENNAVEERAIAH (1982) Cytological studies in wild and cultivated species of *Eleusine* (Gramineae). *Caryologia* 35,1, 1982: 57-69.

HOOKER, J.D. (1872-1897) Flora of British India; 7 vols. London 1872-1897 (Reeve & Co.).

HULSE, J.H., J.M. LAING & O.E. PEARSON (1980) Sorghum and the Millets: their Composition and Nutritive Value. New York 1980 (Academic Press).

HUTCHINSON, J.B. (1976) India: local and introduced crops. *Philosophical Transactions of the Royal Society, London B* 275, 1976: 129-141.

JARRIGE, J.F. (1985) Continuity and Change in the North Kachi Plain (Baluchistan, Pakistan) at the Beginning of the Second Millennium B.C. In: Schotmans, J. & M. Taddei (eds.), South Asian Archaeology 1983. Naples 1985: 35-68 (Instituto Universitario Orientale, Dipartmento di Studi Asiatici).

JARRIGE, J.F (1997) From Nausharo to Pirak: Continuity and Change in the Kachi/Bolan Region from the 3rd to the 2nd Millennium B.C. In: Allchin, R. & B. Allchin (eds.), South Asian Archaeology 1995; vol. 1. New Delhi 1997: 11-32 (Oxford and IBH).

KAJALE, M.D. (1974) Plant Economy at Bhokardan. In: Deo, S.B. & R.S. Gupta (eds.), Excavations at Bhokardan (Bhogavardhana). Aurangabad 1974: 217-224 (Nagpur University).

– (1977a) On the botanical findings from excavations at Daimabad, a chalcholithic site in Western Maharashtra, India. *Current Science* 46, 1977: 818-9.

– (1977b) Ancient plant economy at Nevasa during Satavahana and Indo-Roman Period. *Bulletin of the Deccan College Research Institute* 36, 1977: 48-61.

– (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: Deo, S.B., M.K. Dhavalikar & Z. D. Ansari (eds.), Apegaon Excavations. Pune 1979: 50-56 (Deccan College Postgraduate and Research Institute).

– (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: Sastri, T.V.G., M. Kasturibai & J. Vara Prasada Rao (eds.), Veerapuram: a Type Site for Cultural Study in the Krishna Valley. Hyderabad 1984: Appendix B, 1-15 (Birla Archaeological and Cultural Research Institute).

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

– (1988b) Plant Economy. In: Dhavalikar, M.K., H.D. Sankalia & Z.D. Ansari (eds.), Excavations at Inamgaon; vol. 1, Part ii. Pune 1988: 727-821 (Deccan College Postgraduate and Research Institute).

– (1989a) Palaeobotanical findings from excavations at Hallur (second season), District Darwar, Karnataka. *Bulletin of the Deccan College Research Institute* 47-8, 1989: 123-128.

– (1989b) Archaeobotanical investigation on megalithic Bhagimohari, and its significance for ancient Indian agricultural system. *Man and Environment* 13, 1989: 87-96.

– (1990) Observations on the Plant Remains from Excavation at Chalcolithic Kaothe, District Dhule, Mahrashtra with Cautionary Remarks on their Interpretations. In: Dhavalikar, M.K., V.S. Shinde & S.M. Atre (eds.), Excavations at Kaothe. Pune 1990: 265-280 (Deccan College Postgraduate and Research Institute).

– (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: Renfrew, J. (ed.), New Light on Early Farming – Recent Developments in Palaeoethnobotany. Edinburgh 1991: 155-189 (Edinburgh University Press).

– (1994) Archaeobotanical Investigations on a Multicultural Site at Adam, Mahrashtra, with Special Reference to the Development of Tropical Agriculture in Parts of India. In: Hather, J. (ed.), Tropical Archaeobotany: Applications and new Developments. London 1994: 34-50 (Routledge).

– (1996a) Palaeobotanical Investigations on Chalcolithic Tuljapur Garhi. In: Bopardikar, B.P. (ed.), Excavations at Tuljapur Garhi 1984-1985 (Vidarbha, Mahrashtra), *Memoirs of the Archaeological Survey of India* 95, New Dehli 1996: 47-61.

– (1996b) Plant Remains, in Kuntasi. A Harappan Emporium on the West Coast. Pune: 285-289 (Deccan College Post-Graduate and Research Institute).

– (1998) South India in relation to data from contemporary sites. Abstract submitted to the 11th International Workgroup for Palaeoethnobotany, Toulouse/France 18-23 May 1998.

KITCHEN, K. (1993) The Land of Punt. In: Shaw, T., P. Sinclair, B. Andah & A. Okpoko (eds.), The Archaeology of Africa. Food, Metals and Towns. London 1993: 587-608 (Routledge).

KLEE, M. & B. ZACH (1999) The Exploitation of Wild and Domesticated Food Plants at Settlement Mounds in North-East Nigeria (1800 calBC to Today). In: Veen, M. van der (ed.), The Exploitation of Plant Resources in Ancient Africa. New York 1999: 81-88 (Kluwer/Plenum).

KORISETTAR, R., P.C. VENKATASUBBAIAH & D.Q. FULLER (2001) Brahmagiri and Beyond: the Archaeology of the Southern Neolithic. In: Settar, S. & R. Korisettar (eds.), Indian Archaeology in Retrospect; vol. I: Prehistory. Delhi 2001: 151-356 (Manohar).

KROLL, H. (1996) Literature on archaeological remains of cultivated plants (1994/95). *Vegetation History and Archaeobotany* 5, 1996: 169-200.

– (1997) Literature on archaeological remains of cultivated plants (1995/96). *Vegetation History and Archaeobotany* 6, 1997: 25-67.

– (1998) Literature on archaeological remains of cultivated plants (1996/1997). *Vegetation History and Archaeobotany* 7, 1998: 23-56.

LAHIRI, N. (1992) The Archaeology of Indian Trade Routes (up to c. 200 BC). Delhi 1992 (Oxford University Press).

LAL, B.B. (1997) The Earliest Civilization of South Asia. New Delhi 1997 (Aryan Books International).

LEWICKI, T. (1974) West African Food in the Middle Ages. Cambridge 1974 (Cambridge University Press).

LIU, C.J. (1996) Genetic diversity and relationships among Lablab purpureus genotypes evaluated using RAPD as markers. *Euphytica* 90, 1996: 115-119.

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

MEADOW, R. (1989) Continuity and Change in the Agriculture of the Greater Indus Valley: The Palaeoethnobotanical and Zooarchaeological Evidence. In: Kenoye, J.M. (ed.), Old Problems and New Perspectives in the Archaeology of South Asia. *Wisconsin Archaeological Reports* 2, Madison 1989: 61-74 (University of Wisconsin).

– (1996) The Origins and Spread of Agriculture and Pastoralism in Northwestern South Asia. In: Harris, D. (ed.), The Origins and Spread of Agriculture and Pastoralism in Eurasia. London 1996: 390-412 (UCL Press).

MEHRA, K.L. (1962) Study of 35 herbarium specimens of African *Eleusine*. *Journal of Indian Botanical Society* 41, 1962: 531.

– (1963) Considerations on the African origin of *Eleusine coracana* (L.) Gaertn. *Current Science* 32, 1963: 300-301.

MEYER, C., J.M. TODD & C.W. BECK (1991) From Zanzibar to Zagros: a copal pendant from Eshnunna. *Journal of Near Eastern Studies* 50,4, 1991: 289-298.

MOODY, K. (1989) Weeds reported in rice in South and Southeast Asia. Manila 1989 (International Rice Research Institute).

NAGARAJA RAO, M.S. (1970) Significance of Pottery Headrests from Neolithic Sites of Karnataka. In: Deo, S.B. & M.K. Dhavalikar (eds.), Indian Antiquary 4. Professor H.D. Sankalia Felicitation Volume. Bombay 1970: 141-148 (Popular Prakashan).

NAGARAJA RAO, M.S. & K.C. MALHOTRA (1965) The Stone Age Hill Dwellers of Tekkalakota. Poona 1965 (Deccan College).

NELSON, S.M. (1999) Megalithic Monuments and the Introduction of Rice into Korea. In: Gosden, C.V. & J. Hather (eds.), The Prehistory of Food. Appetites for Change. London: 147-165 (Routledge).

NG, N.Q. (1995) Cowpea. *Vigna unguiculata* (Leguminosae-Papilionideae). In: SMARTT & SIMMONDS, eds., 1995: 326-332.

O'CONNOR, D. (1993) Urbanism in Bronze Age Egypt and Northeast Africa. In: Shaw, T., P. Sinclair, B. Andah, & A. Okpoko (eds.), The Archaeology of Africa. Food, Metals and Towns. London 1993: 570-586 (Routledge).

OTTO, T. & M. DELNEUF (1998) Evolution des Ressources Alimentaires et des Paysages au Nord du Cameroun: Apport de l'Archéologie. In: Chastanet, M. (éd.), Plantes et Paysages d'Afrique – Une Histoire à Explorer. Paris 1998: 491-514 (Editions Karthala and Centre de Recherches Africaines).

PANELLA, L., KAMI, J. & P. GEPTS (1993) Vignin diversity in wild and cultivated taxa of *Vigna unguiculata* (L.) Walp. (Fabaceae). *Economic Botany* 47, 1993: 371-386.

PENGELLY, B.C. & B.L. MAASS (2001) *Lablab purpureus* (L.) Sweet – diversity, potential use and determination of a core distribution of this multi-purpose tropical legume. *Genetic Resources and Crop Evolution* 48, 2001: 261-272.

PHILIPSON, G. & S. BAHUCHET (1996) Cultivated Crops and Bantu Migrations in Central and Eastern Africa: a Linguistic Approach. In: Sutton, J.E.G. (ed.), The Growth of Farming Communities in Africa from the Equator Southwards. *Azania* 29, 1996: 103-120 (British Institute of East Africa, Nairobi).

PHILLIPS, J. (1998) Punt and Aksum: Egypt and the Horn of Africa. *Journal of African History* 38, 1998: 423-457.

PHILLIPS, S.M. (1972) A survey of the genus *Eleusine* Gaertn. (Gramineae) in Africa. *Kew Bulletin* 27,2, 1972: 251-270.

POKHARIA, A.K. & K.S. SARASWAT (1999) Plant economy during Kushana period (100 - 300 A.D.) at ancient Sanghol, Punjab. *Pragdhara (Journal of the Upper Pradesh State Archaeological Organisation)* 9, 1999: 75-121.

PORTERES, R. (1976) African Cereals: *Eleusine*, Fonio, Black Fonio, Teff, *Brachiaria*, *Paspalum*, *Pennisetum*, and African Rice. In: Harlan, J.R., J.M.J. De Wet & A.B.L. Stemler (eds.), Origins of Africa Plant Domestication. The Hague 1976: 409-452 (Mouton Publishers).

POSSEHL, G.L. (1980) Indus Civilisation in Saurasashtra. Delhi 1980 (B.R. Publishing Corporation).

POSSEHL, G.L. (1986) African Millets in South Asian Prehistory. In: Jacobsen, J. (ed.), Studies in the Archaeology of India and Pakistan. New Dehli 1986: 237-256 (Oxford and IBH).

– (1997) The Seafaring Merchants of Meluhha. In: Allchin R. & B. Allchin (eds.), South Asian Archaeology 1995. New Delhi 1997: 87-100 (Oxford and IBH).

– (1998) The Introduction of African Millets to the Indian Subcontinent. In: Prendergast, H.D.V., N.L. Etkin, D.R. Harris & P.J. Houghton (eds.), Plants for Food and Medicine. Richmond 1998: 107-121 (Royal Botanic Gardens Kew).

PURSEGLOVE, J.W. (1968) Tropical Crops – Dicotyledons. London 1968 (Longmans).

RACHIE, K.O. (1975) The Millets. Importance, Utilization and Outlook. Hyderabad 1975 (International Crops Research Institute for the Semi-Arid Tropics).

RAO, S.R. (1986) Trade and Cultural Contacts between Bahrain and India in the Third and Second Millennia B.C. In: Al Khalifa S.H.A. & M. Rice (eds.), Bahrain through the Ages. New York 1986: 376-382 (KPI Ltd.).

REDDY, S.N. (1994) Plant Usage and Subsistence Modeling: An Ethnoarchaeological Approach to the Late Harappan of Northwest India. Ann Arbor, Michigan 1994, University Microfilms (PhD Dissertation, University of Wiscosin 1994)

ROXBURGH, W. (1832) Flora Indica; 3 vols. Calcutta 1832 (W. Thackery and Co.).

ROWLEY-CONWY, P. (1991) The Sorghum from Qasr Ibrim, Egyptian Nubia, c. 800 BC – AD 1811: a Preliminary View. In: Renfrew, J. (ed.), New Light on Early Farming. Edinburgh 1991: 191-212 (Edinburgh University Press).

ROWLEY-CONWY, P. , W. DEAKIN & C.H. SHAW (1997) Ancient DNA from archaeological sorghum (*Sorghum bicolor*) from Qasr Ibrim, Nubia: implications for domestication and evolution and a review of the archaeological evidence. *Sahara* 9, 1997: 23-34.

– (1999) Ancient DNA from Sorghum: The Evidence from Qasr Ibrim, Egyptian Nubia. In: Veen, M. van der (ed.), The Exploitation of Plant Resources in Ancient Africa. New York 1999: 55-62 (Kluwer/Plenum).

SANKALIA, H.D., S.B. DEO & Z.D. ANZARI (1969) Excavations at Ahar (Tambavati). Poona 1969 (Deccan College).

SARASWAT, K.S. (1988) Pre-Harappan Crop Economy at Ancient Rohira, Punjab (c. 2300 - 2000 B.C.). In: Ramachandran, K.S. (ed.), Studies in Indian History and Culture. New Delhi 1988: 221-239 (The Indian History and Culture Society).

– (1991) Crop Economy at Ancient Mahorana, Punjab (c. 2100 - 1900 B.C.). *Pragdhara (Journal of the Uttar Pradesh State Archaeological Organisation)* 1, 1991: 83-88.

– (1993a) Plant Economy of Late Harappan at Hulas. *Puratattva* 23, 1993: 1-12.

– (1993b) Seed and Fruit Remains at Ancient Imlidih-Khurd, Gorakhpur: A Preliminary Report. *Pragdhara (Journal of the Uttar Pradesh State Archaeological Organisation)* 3, 1993: 37-41.

– (1997) Plant Economy of Barans at Ancient Sanghol (ca. 1900 - 1400 B.C.), Punjab. *Pragdhara (Journal of the Uttar Pradesh State Archaeology Department)* 7, 1997: 97-114.

SARASWAT, K.S. & S. CHANCHALA (1994) Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1989-90 – A Review*. 1994: 132-133.

– (1995) Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1990-91 – A Review*. 1995: 103-104.

– (1997) Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1992-93 –A Review*. 1997:123-124.

SARASWAT, K.S., N.K. SHARMA & D.C. SAINI (1994) Plant Economy at Ancient Narhan (ca. 1,300 B.C. - 300/400 A.D.). In: Purushottam Singh (ed.), Excavations at Narhan (1984-1989). Varanasi 1994: 255-346 (Banaras Hindu University).

SCHECHTER, Y. & J.M.J. DE WET (1975) Comparative electrophoresis and isozyme analysis of seed proteins from cultivated races of sorghum. *American Journal of Botany* 62,3, 1975: 254-261.

SHAFFER, J.G. (1992) Indus Valley, Baluchistan, and the Helmand Drainage (Afghanistan). In: Ehrich, R.W. (ed.), Chronologies in Old World Archaeology. Chicago 1992: vol. 1, 441-464; vol. 2, 425-446 (University of Chicago Press).

SHINDE, V. (1994) The Deccan Chalcolithic: a recent perspective. *Man and Environment* 19,1-2, 1994: 169-178.

SINGH, P. (1996) The Origin and Dispersal of Millet Cultivation in India. In: Krzyzaniak, L. (ed.), Interregional Contacts in the Later Prehistory of Northern Africa. Poznan 1996: 471-474 (Polish Archaeological Museum).

SMARTT, J. (1990) Grain Legumes: Evolution and Genetic Resources. Cambridge 1990 (Cambridge University Press).

SMARTT, J. & N.W SIMMONDS (eds.) (1995) Evolution of Crop Plants. Harlow, Essex ²1995 (Longman Scientific and Technical).

SMITH, A.B. & L. JACOBSON (1995) Excavations at Geduld and the appearance of early domestic stock in Namibia. *South African Archaeological Bulletin* 50, 1995: 3-14.

SNOWDEN, J.D. (1936) The Cultivated Races of Sorghum. London 1936 (Adlard and Son, Ltd.).

SOUTHWORTH, F.C. (1976) Cereals in South Asian Prehistory: The Linguistic Evidence. In: Kennedy, K.A.R. & G.L. Possehl (eds.), Ecological Backgrounds of South Asian Prehistory. *South Asian Occasional Papers and Theses* 4, Ithaca 1976: 52-75 (Cornell University).

– (1988) Ancient Economic Plants of South Asia: Linguistic Archaeology and Early Agriculture. In: Jazayery, M.S. & W. Winter (eds.), Languages and Cultures. Studies in Honor of Edgar C. Polomé. Berlin 1988: 649-668 (Mouton de Gruyter).

STEELE, W.M. & K.L. MEHRA (1980) Structure, Evolution and Adaptation to Farming Systems and Environments in *Vigna*. In: Summerfield, R.J. & A.H. Bunting (eds.), Advances in Legume Science. Richmond, Surrey 1980: 393-404 (Royal Botanic Gardens, Kew & MAFF).

STEMLER, A.B. (1980) Origins of Plant Domestication in the Sahara and the Nile Valley. In: Williams, M.A.J. & A. H. Faure (eds.), The Sahara and the Nile. Rotterdam 1980: 503-526.

STEMLER, A.B., J.R. HARLAN & J.M.J. DE WET (1975) Evolutionary history of cultivated sorghums (*Sorghum bicolor* [Lin.] Moench) of Ethiopia. *Bulletin of the Torrey Botanical Club* 102,6, 1975: 325-333.

TERASAWA, K. & T. TERASAWA (1981) The basic study of the Yayoi plant food – For the research on the early agricultural society. *Kohkogaku Ronkoh (The Kashihara Institute for Archaeological Research)* 5, 1981: 1-129 [in Japanese].

TEWARI, R., R.K. SRIVASTAVA, K.S. SARASWAT & K.K. SINGH (2000) Excavations at Malhar, District Chandauli (U.P.) 1999: A preliminary report. *Pragdhara (Journal of the Uttar Pradesh State Archaeology Department)* 10, 2000: 69-98.

TOSI, M. (1986) Early Maritime Cultures of the Arabian Gulf and the Indian Ocean. In: Al Khalifa, S.H.A. & M. Rice (eds.), Bahrain through the Ages. New York 1986: 94-107 (KPI Ltd.).

TOSTAIN, S. (1989) Enzyme diversity in pearl millet (*Pennisetum glaucum* L.); 2: Africa and India. *Theoretical and Applied Genetics* 77, 1989: 634-640.

– (1992) Enzyme diversity in pearl millet (*Pennisetum glaucum* L.); 3: Wild millet. *Theoretical and Applied Genetics* 83, 1992: 733-742.

– (1998) Le Mil, une Longue Histoire: Hypotheses sur sa Domestication et ses Migrations. In: Chastanet, M. (éd.), Plantes et Paysages d'Afrique – Une Histoire à Explorer. Paris 1998: 461-490 (Editions Karthala and Centre de Recherches Africaines).

VAILLANCOURT, R.E. & WEEDEN N.F. (1992) Chloroplast DNA polymorphism suggests Nigerian center of domestication for the cowpea, *Vigna unguiculata*, Leguminosae. *American Journal of Botany* 79, 1992: 1194-1199.

VAVILOV, N.I. (1992) [orig. 1935] The Phyto-Geographical Basis for Plant Breeding. In: Vavilov, N.I., Origin and Geography of Cultivated Plants (translated by D. Love). Cambridge1992: 316-366 (Cambridge University Press).

VENKATASUBBAIAH, P.C. & M.D. KAJALE (1991) Biological remains from Neolithic and early historic sites in Cuddapah District, Andhra Pradesh. *Man and Environment* 16, 1991: 85-97.

VERDCOURT, B. (1970) Studies in the Leguminosae-Papilionoideae for the 'Flora of Tropical East Africa'; III. *Kew Bulletin* 24,3, 1970: 379-443.

– (1971) Phaseoleae. In: Milne-Redhead, E. & R.M. Polhill (eds.), Flora of Tropical East Africa; part 4: Leguminosae, part 2: Papilionidae. London 1971 (Crown Agents for Overseas Governments and Administrations).

VISHNU-MITTRE (1969) Remains of Rice and Millet. In: Sankalia, H.D., S.B. Deo & Z.D. Ansari (eds.), Excavations at Ahar (Tambavati). Pune 1969: 229-235 (Deccan College Postgraduate and Research Institute).

– (1971) Ancient Plant Economy at Hallur. In: Nagaraja Rao, M.S. (ed.), Protohistoric Cultures of the Tungabhadra Valley (Hallur Excavations). Dharwar 1971:1-9.

– (1977) Changing Economy in Ancient India. In: Reed, C. (ed.), Origins of Agriculture. Paris 1977: 569-588 (Mouton).

– (1989) Forty years of archaeobotanical research in South Asia. *Man and Environment* 14, 1989: 1-16.

– (1990) Plant Remains. In: Joshi, J.P.(ed.), Excavations at Surkotada. *Memoirs of the Archaeological Survey of India* 87, New Dehli 1990: 388-392 (ASI).

VISHNU-MITTRE & H.P. GUPTA (1968a) Ancient Plant Economy at Paunar, Maharashtra. In: Deo, S.B. & M.K. Dhavalikar (eds.), Paunar Excavations 1967. Nagpur 1968: 128-134 (University Press).

– (1968b) Plant remains from ancient Bhatkuli, District Amraoti, Maharashtra. *Puratattva* 2, 1968: 21-22.

VISHNU-MITTRE & R. SAVITHRI (1976) Ancient plant economy at Inamgaon. *Puratattva* 8, 1976: 55-63.

– (1978) *Setaria* in ancient plant economy of India. *The Palaeobotanist* 25, 1978: 559-564Fig. 3.

– (1979a) Further contribution on protohistoric Ragi – *Eleusine coracana* Gaertn. *The Palaeobotanist* 26, 1979: 10-15.

– (1979b) Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1975-76 – A Review* 1979: 86-88.

– (1982) Food Economy of the Harappans. In: Possehl, G.L. (ed.), Harappan Civilisation. New Delhi 1982: 205-221 (Oxford and IBH).

VISHNU-MITTRE, U. PRAKASH & N. AWASTHI (1971) Ancient plant economy at Ter, Maharashtra. *Geophytology* 1,2, 1971: 170-177.

VISHNU-MITTRE, A. SHARMA & S. CHANCHALA (1984) Palaeobotanical and pollen analytical investigations. *Indian Archaeology 1981-82 – A Review* 1984: 105-106.

– (1986) Ancient Plant Economy at Daimabad. In: Sali, S.A. (ed.), Daimabad 1976-1979. New Dehli 1986: 588-626 (Archaeological Survey of India).

VOGELSANG, R., K.-D. ALBERT & S. KAHLHEBER (1999) Le sable savant: les cordon dunaires sahéliens au Burkina Faso comme archive archéologique et paléoécologique du Holocène. *Sahara* 11, 1999: 51-68.

WEBER, S.A. (1990) Millets in South Asia: Rojdi as a Case Study. In: Taddei, M. (ed.), South Asian Archaeology 1987. Rome 1990: 333-348 (Instituto Italiano per il Medio ed Estremo Orientale).

– Plants and Harappan Subsistence – An Example of Stability and Change from Rojdi. New Dehli 1991 (Oxford and IBH).

– (1993) Changes in Plant Use at Rojdi: Implications for Early South Asian Subsistence Systems. In: Possehl, G.L. (ed.), Harrapan Civilization – A Recent Perspective. New Dehli (2nd revised edition) 1993: 287-293 (Oxford and IBH Publishing).

– (1998) Out of Africa: the initial impact of millets in South Asia. *Current Anthropology* 39,2, 1998: 267-274.

WERTH, C.R., K.W. HILU & C.L. LANGNER (1994) Isozymes of *Eleusine* (Gramineae) and the origin of finger millet. *American Journal of Botany* 81,8, 1994: 1186-1197.

WETTERSTROM, W. (1998) The origins of agriculture in Africa: with particular reference to sorghum and pearl millet. *The Review of Archaeology* 19,2, 1998: 30-46.

WIGBOLDUS, J.S. (1991) Pearl Millet outside Northeast Africa, Particularly in Northern West Africa: Continuously Cultivated from c. 1350 A.D. only? In: Leakey, R.E. & L.J. Slikkerveer (eds.), Origins and Development of Agriculture in East Africa: The Ethnosystems Approach to the Study of Early Food Production in Kenya. Ames, Iowa 1991: 161-181 (Iowa State University Research Foundation).

WIGBOLDUS, J.S. (1995) The spread of crops into sub-equatorial Africa during the Early Iron Age: a 'minimalist' view based primarily on documentary evidence from the Indian Ocean side. *Azania* 29-30, 1995: 121-129.

– (1996) Early Presence of African Millets near the Indian Ocean, In the Indian Ocean. In: Reade, J. (ed.), Antiquity. London 1996: 75-86 (Keegan Paul International).

WILLCOX, G. (1992) Some Differences between Crops of Near Eastern Origin and Those from the Tropics. In: Jarrige, C. (ed.), South Asian Archaeology 1989. *Monographs in World Archaeology* 14, Madison 1992: 291-299 (Prehistory Press).