Sonderdruck aus

Food, Fuel and Fields

Progress in African Archaeobotany

Edited by Katharina Neumann, Ann Butler and Stefanie Kahlheber

Offprint. R.M. Blench 2003. The movement of cultivated plants between Africa and India in prehistory. Pages 273-292.

AFRICA PRAEHISTORICA 15, Köln 2003

HEINRICH-BARTH-INSTITUT

Roger Blench

The movement of cultivated plants between Africa and India in prehistory

Abstract

Many cultivated plants are common to India and Africa and in particular plants of African origin seem to be well established in Indian agrarian systems, although their introduction and early use is nowhere documented. Although proposals for the prehistoric transmission of cultivated plants between Africa and India have a long history, there have also been claims that the archaeobotanical material from India does not stand up to scientific scrutiny and that only more recent dates should be accepted. New evaluations of the evidence has concluded that *some* early dates are justified, suggesting that similar dates may be appropriate for species so far not found in the archaeobotanical record. Proposals that Arabia represented a key staging post in this trade have been dropped in the absence of reliable archaeobotanical evidence. The paper enumerates all the crop species that may have been transmitted in both directions and suggests the possible route (either sea or land). Excluded are recent Indian Ocean introductions such as the sweet orange and the diploid bananas. It concludes with a number of 'mystery' species for which there is presently no evidence as to the time, place or direction of their spread.

Key words: Africa, India, crops, transmission routes, prehistory.

1. Introduction

1.1. Background

The transfer of cultivated plants between Africa and India in both prehistory and historic times has been mooted since DE CANDOLLE (1886), but the evidence is extremely scattered and much depends on the presumptions of botanists rather than on 'hard' archaeobotanical data. A conjunction of the much better-known flora of India and earlier compilations of data on its economic plants (e.g. WATT 1889-93) suggested to an earlier generation of scholars that cultivated plants found in both continents were transferred from India *to* Africa. Indeed, older botanical names often reflect this view, for example *Tamarindus indica* or *Sesamum indicum*. With apparently high levels of diversification on both sides of the Indian Ocean suggesting thousands of years of establishment, determining the region of domestication of these crops is not always easy, especially since early 'escapes' rapidly take on the appearance of 'wild' forebears. In more recent times this topic has been discussed by POSSEHL (1986. 1998), DOGGETT (1989), WIGBOLDUS (1996), ROWLEY-CONWY et al. (1997), WEBER (1998) and FULLER (2000a. This volume. In press a).

It may be that with modern laboratory-based techniques using mitochondrial DNA, as well as the study of co-associated pathogens and biotrophs, it will prove possible to resolve the present debates. However, this type of historical archaeobotany is a low priority in laboratories with these capabilities and, in the meantime, much can be deduced from existing archaeological and botanical data. KAJALE (1991) and FULLER (2000a. This volume) represent recent comprehensive reviews of Indian archaeobotanical data, but African material remains scattered.

2.1. The nature of the evidence

Assigning dates and routes for the transfer of cultigens faces a number of key problems:

a) Archaeobotanical evidence is very slight for many species, especially those that reproduce vegetatively.
b) Access to dates is difficult since many locally published reports, notably in India, are not easily available elsewhere. Dating is often not very secure and older dates and identifications are often criticised in more modern literature.
c) Research on modern-day plants, both phenotypic and genetic, is driven by their economic importance rather than their historical significance.
d) Historical documentation is lacking for 'minor' plants and synchronic descriptions are often inadequate.
e) Post-Columbian movements of plants cannot always be distinguished from earlier movements, especially in the case of 'tolerated weeds'.

The overland movement of crops, especially to and from India, cannot always be distinguished from sea-routes, and indeed some crops may have travelled both routes. In addition, the rapid movement of the Portuguese around the world in the sixteenth century was responsible for the introduction of what are now called 'pantropical species', particularly those which colonise wastelands and are occasionally cultivated. Some of these have adapted so rapidly to their new environments that their exact region of origin remains unknown. Further genetic work could probably resolve some of these problems, but for obvious reasons, plant geneticists do not see minor green vegetables as a priority.

An independent source of evidence that has barely been exploited is linguistic data. The use of names of cultivated plants to trace their likely routes of introduction has been employed successfully within West Africa (see COLOMBEL 1995. 1997. BLENCH 1997. 1998. BLENCH et al. 1997). For example, plants introduced by the Arabs into West Africa in the early Medieval period without exception still bear recognisable versions of their North African name. SOUTHWORTH (1976. 1988) has attempted to derive a chronology of Indian crops from linguistic reconstructions of plant names. Cultigens transmitted across the Indian Ocean in the Medieval period still bear recognisably Arabic or Hindi names on the East African coast. The analysis of cultigen names for crops transmitted at an earlier period is more complex and no work of this nature has yet been undertaken.

2.2. Historical stratification of routes to and from India

Historically, there seem to have been three important trade-routes between Africa and India:

a) From Egypt to the Near East, across Iran to Northwest India.
b) The 'Sabaean Lane', along the Red Sea, along the southern edge of the Arabian peninsula and then either coasting along the southern edge of Iran or perhaps crossing the open sea.
c) The open ocean crossing between the west coast of India and East Africa.

The first route was initially favoured by many historians and botanists, often because it involved known peoples with writing systems and substantial archaeological macro-remains, at least for Egypt and the Near East. Although some cultivated species were indeed transmitted along this route, the absence of many plants in the archaeological and epigraphic record show that it was only one avenue for the exchange of plants between continents. BLENCH (1991) considered the evidence for the Nile Valley route but omitted plants for which there was no evidence. The very full records of Ancient Egypt, textual, iconographic and archaeological, allow some weight to be assigned to negative evidence. In other words, if a major economic species is apparently absent from Egypt, then it is a reasonable assumption that it was *not* transmitted from Africa via the Nile Valley.

The Sabaean Lane is a name given to a shipping route that joined, Africa, Egypt, Oman and India. The name and the idea that it was a corridor for cultivated plants goes back at least to SCHWEIN-

FURTH (1872-73) who argued that the cow pea, *Vigna unguiculata*, must have been transmitted along this route while ANON (1894) speculated on the movement of the cultivated *Coleus* spp. from Africa to India. Although there is very little textual evidence for such a route, archaeological remains would appear to confirm its importance (e.g. BOWER & ALBRIGHT 1958). The earliest evidence for ships sailing down the Red Sea, along the southern coast of the Arabian peninsula and across to India, either coasting the Iranian coastline or perhaps sailing across open seas is ca. 4000 BC. POSSEHL (1996) describes the Akkadian literature on 'Meluhha', now generally identified with Harappa, and suggests that material culture is evidence for a 'Middle Asian interaction sphere' still to be recovered. Diodorus Siculus and Pseudo-Callisthenes refer to ships passing along this route (KOBISCHANOV 1965). Representations of reed boats appear on rock engravings and remains of such reed boats have been recovered from Oman (COSTANTINI 1990). As maritime technology improved, this route expanded and included excursions down the East African Coast, eventually to be recorded in the Periplus of the Erythraean Sea (HUNTINGFORD 1980).

Present knowledge of the evolution of maritime technology does not yet allow us to say precisely when it became possible to cross the open ocean from India to East Africa, but presumably the development of island settlements such as Shanga off the Kenyan coast reflect an intensive Arab and Persian trade (HORTON 1997). There is evidence for trade between the Aksumite kingdoms and India and possibly also China (MUNRO-HAY 1996). BLENCH (1996a) describes the ethnographic and textual evidence for Austronesian incursions on the East African coast.

In the complex history of cultigen exchange between Africa and India, plants exist which neither passed up the Nile Valley corridor, nor were carried by the dhow trade, but which were carried at times unknown along the Sabaean Lane. This paper examines the evidence for individual plants and suggests that the African cultigens reaching India may have played a role in the development of dryland agriculture.

3. Plants of African origin reaching India at an early period

3.1. General

The development of the trade to India in its initial phases seems to have been driven from the west, since the primary flow appears to be of significant economic plants *to* India. Many species are either not recorded at all from African archaeological sites or only with relatively recent dates. For major cereals such as sorghum and millet this has been seen as problematic and in need of explanation. **Table 1** shows the plants considered to be of African origin that have either been recorded archaeologically in India or are well established within its agricultural system. The order of presentation reflects the detailed discussion below.

There is an opposing view in the literature which essentially assumes that only written or ultra-secure archaeobotanical evidence can be accepted, and in their absence, only late dates can be adopted. The most extreme version of this is WIGBOLDUS (1996), who appears to think that the diffusion of millet, finger millet and sorghum is medieval and that all Indian archaeobotanical data which contradict this are to be discarded. The apparently similar views of ROWLEY-CONWY et al. (1997) on sorghum are given below in more detail. This paper takes the opposing view that if cultural, biological and linguistic forms of evidence are *not* given equal weight then an extremely Eurocentric view of prehistory must emerge. Reviews of the archaeobotany by WEBER (1998) and FULLER (2000a) support some of the early dates and thus reach conclusions similar to those set out here.

3.2. Cereals

Sorghum [guinea-corn, kaffir-corn[1]]
Sorghum bicolor (Linn.) Moench.

The primary studies of the evolution of sorghum are SNOWDEN (1936), DOGGETT (1988), HARLAN

1 A pejorative term found in earlier literature and regrettably enshrined in some varietal terminology.

English name	Scientific name
Cereals	
finger millet	*Eleusine coracana* (Linn.) Gaertn.
ditch millet	*Paspalum scrobiculatum* L. var. *frumentaceum*
sorghum	*Sorghum bicolor* (Linn.) Moench. (bicolor, caudatum and guinea races)
bulrush millet	*Pennisetum glaucum* (L.) R. Br.
Tubers	
dazo	*Plectranthus esculentus* NE Br.
Hausa potato	*Solenostemon rotundifolius* (Poir.) JK Morton
Vegetables	
okra	*Abelmoschus esculentus* L. Moench.
spider-flower	*Celosia argentea* L. var. *cristata*
Indian mustard	*Brassica juncea* (Linn.) Coss
Pulses	
cow pea	*Vigna unguiculata* (L.) Walp. (1842)
hyacinth bean	*Lablab purpureus* (L.) Sweet (1827)
Bambara groundnut	*Vigna subterranea* (L.) Verdc. (1980)
velvet bean	*Mucuna pruriens* (L.) DC. var. *utilis* (Wall ex Wight) Bak. ex Burck
cluster bean [guar]	*Cyamopsis tetragonoloba* (L.) Taub. (1894)
Oilcrops	
castor bean	*Ricinus communis* Linn.
niger seed	*Guizotia abyssinica* Cass.
Fibres	
kenaf	*Hibiscus cannabinus* Linn.
jute	*Corchorus olitorius* Linn.
Managed trees	
tamarind	*Tamarindus indica* Linn. (1753)
silk-cotton	*Ceiba pentandra* (L.) Gaertn. var. *pentandra*

Tab. 1 Plants of African origin reaching India in prehistory.

& STEMLER (1976), OLLITRAULT et al. (1989) and DOGGETT & PRASADA RAO (1995). All these studies concur that sorghum indeed originated in Africa and identify the original region of domestication of sorghum as a band stretching from SW Ethiopia to Lake Chad. Hypotheses about the domestication and diffusion of sorghum in Africa are based almost exclusively on the distribution of modern races, since the evidence from archaeology remains so exiguous.

Sorghum certainly has a history of early dates within Africa that have been discounted following more detailed examination. WASYLIKOWA & DAHLBERG (1999) show that the carbonized sorghum grains found at Nabta Playa in southern Egypt at ca. 8000 bp are exclusively wild. Archaeological evidence for sorghum in West Africa is relatively late. KLEE & ZACH (1999: 87ff.) report domestic sorghum only appearing very late in the mound at Mege in NE Nigeria. It is not recorded at Dhar Tichitt, Kursakata and Gajiganna although it appears at Niani, in Guinea in the 8th century and at Daima in Northeastern Nigeria in the 9-10th centuries (CONNAH 1981). This must almost certainly be an artefact of excavation, since the complexity and diversity of sorghum phenotypes in West Africa argues for a more ancient establishment. At Inyanga in Zimbabwe, and in Zambia there are records of sorghum, at roughly the same period (SHAW 1976).

Cultivated sorghum presents one of the more perplexing problems in African agrarian history. It is found in archaeological sites in Korea and India millennia before confirmed archaeological

Tab. 2 The earliest archaeological records of domesticated sorghum.

Region	Country	Site	Date(s)	Reference
Africa	Sudan	Jebel Tomat	245 ± 69 AD	CLARK & STEMLER (1975)
	Sudan	Meroe	20 ± 127 BC	ROWLY-CONWY (1991)
	Nigeria	Daima	800 AD	CONNAH (1981)
India	India	Hulas	2200 -1500 BC	SARASWAT (1993)
	India	Tuljapur Garhi	1200 - 900 BC	KAJALE (1988)
East Asia	Korea	Hunamni	3000 bp	CHOE (1982) [doubtful]

finds in Africa. **Table 2** presents selected African and Eurasian records for archaeological sorghum; Fuller (this volume) presents data and evaluations of the Indian material in much greater detail.

BURKILL (1937: 118) may have been the first author to clearly state that African sorghum reached India in prehistory. Sorghum is widely grown in India today and races bicolor, guinea and caudatum are all present, suggesting strongly both early and repeated introductions. Reports of sorghum in Oman with dates of 3500 calBC (POTTS 1993) and Yemen at 2000 calBC (COSTANTINI 1990) were originally taken as evidence of the 'Sabaean Lane' transmission via Arabia. However, Tengberg (pers. comm.) notes that all the Arabian finds depend on dubious identifications none of which have been subsequently validated and that if a sea-route was used it did not include stops on the Arabian peninsula. ROWLEY-CONWY et al. (1997. 1999) have reviewed all the African and some of the extra-African evidence, taking a robustly positivist approach and casting doubt on the dates of all early finds outside Africa. Nonetheless, the re-evaluations of FULLER (2000a. This volume. In press a) suggest that some sorghum was reaching India as early as 4000 bp and that this cannot be the case unless comparably early sorghum is present in Africa. So the question becomes, where is the missing African evidence?

YOUNG & THOMPSON (1999) explore this question from the geochemical perspective and suggest that the paucity of macro-botanical remains can no longer be attributed to an absence of research and that poor preservation may reflect wet tropical soils. HAALAND (1996. 1999) invokes a 'cultivation without domestication' scenario to explain these lacunae. Cultivation, the resowing of wild seed in convenient locations, is contrasted with 'domestication' where selection induces morphological change in the seed. She argues that wild sorghum would have been cultivated in the Chad-Ethiopia belt from 6000 bp onwards, but that domestication took place outside Africa, perhaps in Arabia, but most likely in India.

The following rather speculative historical scenario is synthesized from HARLAN & STEMLER (1976), MANN et al. (1983), DE WET (1983), DEU et al. (1994) and DOGGETT & PRASADA RAO (1995) to account for the synchronic distribution of sorghum races:

a) *Sorghum bicolor* is the least specialised race of sorghum, and the source of the other cultivated races, deriving from *Sorghum* sect. *Sorghum* ssp. *verticilliflorum*. This evolved through disruptive selection in the semi-arid zone between the Nile tributaries and Lake Chad before 5-6000 bp This conclusion was in part anticipated by CHEVALIER (1932: 884ff.) who pointed to the diversity of wild sorghums in this region.
b) *S. bicolor*, developed into the 'guinea' races, in turn divide into subraces Roxburghii and guineense. Roxburghii has been retained in Ethiopia, but also spread southwards and was carried to South Asia, SE Asia and the south coast of China. Roxburghii also spread southwards, and through back-crossing with *S. verticilliflorum* produced the 'kafir' sorghums typical of Southern Africa.
c) the *durra* sorghums evolved in Ethiopia, perhaps as a result of introgression of weedy *Sorghum* spp. The former idea that these developed outside Africa and were re-introduced has now been generally rejected. DOGGETT (1988) noted that sorghums reached Iran and

south-western Asia from further east and that they only arrived in Egypt in the Ptolemaic period (see also GERMER 1985:227f.). PLINY (Nat.Hist. XVIII,10), writing in the 1st century AD, noted that a new 'black' millet had been introduced during the previous decade. The Chinese *kaoliang* sorghums appear to arise from a crossing of the wild *S. propinquum* and *durra* sorghums. CHEVALIER (1932: 85ff.) points out that sorghum in northern Saharan oases is usually of the *durra* type.

d) The *caudatum* sorghums, with their resistance to flooding, drought and parasites, may have been the last to evolve, probably in Ethiopia. Their dark grains contain polyphenols that make the flour bitter and thus resistant to birds. The *caudatum* sorghums spread both to West Africa and into East Africa. They have freely crossed with other races and stable durra and guinea 'half-caudatums' are found across Africa. Caudatums have largely replaced the original *bicolor* in many places because they are adapted to the same climatic regime.

HARLAN & STEMLER (1976: 475ff.) argued for the sea transport of the guinea sorghums to India on the grounds that there are no residual landraces in the intervening territories. However, the traffic to India was by no means all in one direction; in the case of the hyacinth bean (see below), there is evidence for reverse traffic. By the early tenth century, travellers such as Abu Zaid and al-Mas'udi were reporting that 'black' sorghum was an important food on the East African coast. WATSON (1983: 14ff.) points out that Indian varieties were re-imported, perhaps through Pemba, as these 'new' cultivars are known as 'Pemba rice' in some languages.

Pearl millet [bulrush millet, cumboo millet]
Pennisetum glaucum (L.) R. Br.

The wild relatives of pearl millet are found on the southern edge of the Sahara (CHEVALIER 1932: 888ff. BRUNKEN et al. 1977) and it is usually considered that this was its locale of domestication (DE WET 1995a. TOSTAIN 1989. 1994. 1998). GILL et al. (1997) have recently summarised the modern-day distributional evidence and provide an up-to-date bibliography on pearl millet. The levels of Dhar Tichitt in Mauritania provide the most detailed sequence of wild and cultivated *Pennisetums*. Re-examination of the ceramics from Dhar Tichitt and Oualata revealed that domesticated *Pennisetum* was grown at least as early as 3500 bp (AMBLARD & PERNÈS 1989. AMBLARD 1996). A sherd with impressions of *Pennisetum* has been directly dated to 3500 ± 100 bp (1936-1683 calBC, Pa-1157) and thus provides the oldest evidence for pearl millet (AMBLARD 1996). Agriculture was practised from the beginning of the occupation, correlated with well developed settlement structures including granaries (AMBLARD-PISON 1996). A find of comparable age (3460 ± 200 bp (1980-1520 calBC, TO-8172) has been reported from the site of Birimi in NE Ghana (D'ANDREA et al. 2001. D'ANDREA & CASEY in press). Slightly later is the dune site Tin Akof in Burkina Faso where grains of domesticated *Pennisetum* have been found, directly dated to 2840 ± 49 bp. In Gajiganna in Nigeria, domesticated *Pennisetum* occurs used as pottery temper in Phase IIb dated to 2930 ± 60 bp (1261-1034 calBC, UtC-2329) (NEUMANN 1999). In the earliest phase, there is only a single grain of *Pennisetum*, but more occur in Phase IV. Although it is recognisably cultivated in subsequent phases, its role cannot be easily deduced in the early period. There is no certain evidence for pearl millet in Ancient Egypt and earlier identifications of millet in intestines were probably sorghum (DARBY et al. 1977: 494ff. GERMER 1985: 224ff.).

PORTÈRES (1976: 433ff.) provides a detailed overview of the subtypes of pearl millet in Africa and argues that the morphological evidence strongly supports early transmission to India. The absence of finds in the Nile Valley and the Near East support a sea-route. Although the cultivation of *Pennisetum* millet is well-established in many parts of India (WATT 1889-93: P. 384[2]), the archaeological record is frankly weak, with grains dated by context rather than directly. However,

2 References to the Dictionary of the Economic Products of India give the entry number (preceded by P.) rather than the volume and page.

recent reviews of the evidence have confirmed that at least some records can be considered well-founded (FULLER 2000a. This volume). **Table 3** summarises the present evidence for archaeological millet in Africa and India.

Much work remains to be done on the historical and morphological relations between African and Asian pearl millet.

Kodo [birds' millet, ditch millet]
Paspalum scrobiculatum L. var. *polystachyum* Stapf.

Indian kodo, *Paspalum scrobiculatum* L. var. *frumentaceum*, remains a major staple for ordinary subsistence farmers in many parts of the subcontinent (WATT 1889-93: 332ff.). It is highly varietally diversified in different regions, suggesting considerable depth of establishment (DE WET et al. 1978). The outer husk or pericarp can be toxic and must be removed in the milling process (see PORTÈRES 1976: 432ff. for references on poisoning outbreaks). The principal archaeological record is in Kurnool district, Veerapuram, Andhra Pradesh where seeds dating to 5-300 BC have been recovered (KAJALE 1991: 168ff.).

A very similar cultivated cereal also exists in Africa, *Paspalum scrobiculatum* L. var. *polystachyum* Stapf. Wild forms of this plant are found in low-lying places across Africa and Asia giving rise to the name 'ditch millet'. The only source for the use of kodo as a crop is PORTÈRES (1976: 429ff.); no mention of its existence appeared before 1959. Although this cereal is also gathered, like many other *Paspalum* spp. among the Kissi and Kuranko of southern Guinea, it is transplanted into rice paddies or else encouraged to invade eroded upland rice patches (NATIONAL RESEARCH COUNCIL 1996: 339ff.).

The similarities between these two plants and existence of wild forms in Africa, led Portères to observe that they are indeed the same plant and that kodo millet must originally have been carried from Africa to India. Since there are no records of even pseudo-cultivation in the East African region, this may have been as a 'promising' wild plant.

Finger millet [ragi]
Eleusine coracana (Linn.) Gaertn.

The exact area of domestication of finger millet has remained controversial. Because it shows the greatest varietal diversity in India, earlier sources suggested a homeland there and VAVILOV (1951)

Region	Country	Site	Date(s) BP	Date(s) calBC/BC	Reference
Africa	Mauritania	Dhar Tichitt		1936 - 1683 calBC 1881 - 1527 calBC	AMBLARD (1996)
	Burkina Faso	Tin Akof	2840 ± 49 BP (UtC-4906)	1035 - 916 calBC	NEUMANN (1999: 77)
	Nigeria	Kursakata	Directly dated to 2430 ± 70 BP (UtC-5452) 2290 ± 70 BP		NEUMANN et al. (1996), KLEE et al. (2000)
		Birimi	3460 ± 200 BP (TO-8172)	1980 - 1520 calBC	D'ANDREA et al. (2001)
	Mali	Gao	?	?	FULLER (2000b: 32)
Asia	India	Rangpur Narhan Hallur		ca. 1800 - 1200 BC ca. 1200 - 1000 BC ? 2200 - 1800 BC	HERMAN (1997) SARASWAT et al. (1994) FULLER (1999. This volume)

Tab. 3 The earliest archaeological records of domesticated pearl millet.

proposed in 1926 the grassy uplands as its true source. PORTÈRES (1951) inclined to an African origin on the basis of a study of terms in African languages, a view supported by MEHRA (1962. 1963) on botanical grounds. Portères later changed his mind and reverted to the hypothesis of Indian origin (PORTÈRES 1976: 417ff.). However, HARLAN et al. (1976: footnote, 417ff.) point out that this was to ignore the existence of *Eleusine africana*, a wild tetraploid that crosses freely with cultivated finger millet. This assertion of an African origin for *Eleusine* appears to have been generally accepted (HILU & DE WET 1976. 1977. HILU et al. 1979. DE WET 1995b. HILU 1995). In south-eastern Africa, there is a record of cultivated *Eleusine* at Inyanga, in modern-day Zimbabwe, where carbonised seeds are associated with late Iron Age pottery (SUMMERS 1958).

Finger millet has been recorded from numerous Indian sites but it appears that many reports are misidentifications of foxtail millet (*Setaria*) caryopses or even *Echinochloa* (FULLER 2000a. This volume). Only one site, Hallur (? 1000 BC) appears to have a single trustworthy caryopsis and even the dating of this is still uncertain. Despite this, finger millet is both extremely widespread and diverse in India today. If other finds confirm the apparent indication of Hallur, then finger millet probably travelled in the same ships as sorghum and pearl millet.

3.3. Tubers

Hausa potato [Frafra potato, tumuku]
Solenostemon rotundifolius (Poir.) JK Morton

This is the most widespread of the cultivated Labiatae, found throughout Africa, on Madagascar and in Java and Sri Lanka CHEVALIER 1953). According to CHEVALIER & PERROT (1905) was first noted by Rumphius in Volume 5 (p. 372) of *Herbarium Amboinense* (published in 1750 but apparently compiled in 1695). A specimen collected in the Transvaal in 1884 was successfully grown in Paris and then redistributed by Thollon in the Western parts of Equatorial Africa in the 1880s, leading to some confusion about the 'real' distribution of the various races (CODD 1975). The first proposal that the Indian *Coleus* species were related to those in Africa appears to date back to ANON (1894). Its cultivation is not recorded in any intervening locations between East Africa and India.

3.4. Vegetables

Okra [gumbo, ladies' fingers]
Abelmoschus esculentus L. Moench. (formerly *Hibiscus esculentus*)

Although okra was previously considered to have been domesticated in South or SE Asia (CHEVALIER 1940. BUSSON 1965: 294ff.), FRANKE (1976: 232ff.) took the alternative view, now generally accepted, that its origin was in West Africa, confirmed by research on the germplasm (HAMON & VAN SLOTEN 1989. BURKILL 1997: 5ff.). The 'wild' okra in India is generally thought to be subspontaneous. Although okra only occurs in North Africa in a cultivated state and is grown in all the oases of the Sahara (CHEVALIER 1932: 834ff.) there is no incontrovertible evidence for its presence in Ancient Egypt (DARBY et al. 1977: 695ff. GERMER 1985: 122ff.), as the first reference to it in Cairo is as late as 1216 (MAUNY 1953: 702ff.). These late dates suggest that it was carried to India at an early period along the sea-lanes.

Spider-flower [lizard bean, Lagos spinach, quail-grass]
Celosia argentea L. var. *cristata*

Spider-flower is both cultivated and found as a weed of cultivation throughout the Old World. The exact region of domestication of spider-flower is disputed. BURKILL (1985: 53ff.) argues that it must be an Asian domesticate on the shaky grounds of its early appearance in Chinese medical texts. However, other authors describe it as native to a broad area of humid tropical Africa (RAPONDA-WALKER & SILLANS 1961: 49ff. EPENHUISJEN 1978: 45ff.). It appears in Egyptian grave-garlands of the Graeco-Roman period from the Necropolis at Hawara and was presumably brought into Egypt from the upper reaches of the Nile (GERMER 1985: 33ff.).

Indian mustard [leaf-mustard]
Brassica juncea (Linn.) Coss

Despite its vernacular name, this plant appears to be indigenous to Africa (EPENHUISJEN 1978: 40f. BURKILL 1985: 560ff.). The main centres of diversification are India and China, suggesting that the plant must have spread to India at an early date (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 163ff.). Mustard-seed has been recovered from Chanhu-daro, a Harappan site in Sind (RANDHAWA 1980: 179ff.). In the East Asian literature, *B. juncea* is known as *B. campestris* ssp. *nipposinica*, and there is some evidence for its early cultivation in China (CRAWFORD 1992: 28ff.).

Roselle [sorrel]
Hibiscus sabdariffa L.

The original place of domestication of roselle is disputed. Curiously, it was thought to be an American plant earlier in the twentieth century and is known in Dutch as *Amerikaansch Zuur* (OCHSE & BAKHUIZEN VAN DEN BRINK 1980:475-477ff.). BUSSON (1965: 299ff.) claims that *H. sabdariffa* was domesticated in India and spread to Africa; but this is probably only true of the *karkarde* forms, those with calices that are deep red when dried and are used to make a drink. Generally speaking, roselle has green calices and is used as a potherb, leaves and all, and in that form is most likely to be indigenous to West-Central Africa (RAPONDA-WALKER & SILLANS 1961: 274f.). The principal agents of dispersal of the red-caliced form were the trans-Saharan traders, as it is still found mainly in Islamised regions of Sahelian West Africa (CHEVALIER 1932: 834ff.).

Melon
Cucumis melo L. var. *chate* (L.) Naud. ex Boiss.

The wild ancestor of the Mediterranean sweet melon grows along the southern margins of the Sahara, in Sudan and the Nile Valley and may stretch to the Near East (CHEVALIER 1932: 859ff. BATES & ROBINSON 1995: 67ff.). Distinguishing between feral and truly wild specimens is highly problematic, hence the uncertainty about the natural range of *C. melo*. However, the greatest phenotypic diversity is in Southern and Eastern Africa. The earliest evidence for its use in Ancient Egypt is considered to be pictorial representations in the Old Kingdom, although the identification of these has been questioned (GERMER 1985: 128f.). It must have been developed into a desirable fruit in the Near East at an early date, to judge by the longings of the Israelites leaving Egypt (BIBLE, Numbers, Book 11, verse 5). The first uncontroversial find of seeds of *C. melo* is in Egyptian tombs from the Graeco-Roman period. India and China both represent secondary centres of diversity, supported by abundant archaeobotanical remains. VATS (1940) reports melon seeds at Harappa and KAJALE (1988) observes that melon was probably present from the Malwa period (1700-1500 BC). CRAWFORD (1992: 27ff.) notes that over 5000 seeds have been recovered from Japanese sites, in one case final Jomon or 2500 calBP.

3.5. Pulses

Cow pea [black-eyed bean]
Vigna unguiculata (L.) Walp. (1842)

The cow pea is indigenous to West-Central Africa (CHEVALIER 1932: 855ff. BUSSON 1965: 249f. FARIS 1965. RAWAL 1975. PANELLA et al. 1993. NG 1995), although its long-established presence in India was until recently considered as evidence for an Asian domestication. PANELLA et al. (1993) proposed another locus of domestication in Botswana but the late inception of agriculture in this region makes this unlikely. The wild *Vigna* subsp. *dekindtiana* var. *dekindtiana* is generally considered to be the progenitor of the domestic cow pea. The cow pea must have been transmitted to Egypt from Sub-Saharan Africa early, for specimens were identified by Schweinfurth among offerings in Fifth Dynasty tombs, and Keimer noted small faenza models of the plant (DARBY et al. 1977: 692ff. GERMER 1985: 87f.). Finds of cow peas are reported at Kintampo in south-central Ghana dated to 3500 bp but their domestic status remains debatable (STAHL 1985). ALBERT et al. (2000: 343ff.) record cow pea from the site of Oursi in Burkina Faso as *Age de Fer ancien* for which they give a date of 1869-1807 calBP. In south-central Africa, the first record of cultivated cow peas is in Central Zambia where seeds have been recorded from the 2nd century AD (PHILLIPSON 1993: 192ff.). Carbonised seeds have been recorded in a late Iron Age context at Inyanga, in modern-day Zimbabwe (SUMMERS 1958). They are widely cultivated in Ethiopia (WESTPHAL 1974: 213ff. HEDBERG & EDWARDS 1989: 174ff.). BLENCH (1996b) notes that a root for 'cow pea' can be reconstructed to Proto-East Benue-Congo, supporting the idea of domestication in the Nigeria-Cameroon borderland. Long-podded varieties were developed for grain and carried further east to SE Asia where the very long *sesquipedalis* cultivars evolved (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 435ff.).

Although NG (1995: 330ff.) states that cow peas were carried to India by sea at 2200 bp, he presents no evidence for this. Nomenclatural confusion has not been helpful in clarifying Indian archaeological material but it is now generally accepted that at least two early records are genuine (Daimabad ca. 1700-1500 calBC and Hulas 2200-1500 BC) (see FULLER 2000a: fn. 2. This volume). The lack of any convincing records of cow peas in intermediate sites strongly supports the sea-route but at a date far earlier than that proposed by Ng. Hulas is a remote site almost in the foothills of the Himalayas and it is difficult to imagine the cow pea left East Africa later than 4000 bp.

Hyacinth bean [dolique de Chine]
Lablab purpureus (L.) subsp. *unicinctus* Sweet (1827)

The hyacinth bean is now thought to have originated in East Africa (SMARTT 1990. LIU 1996) although its cultivation is known principally from India, where it has developed considerable agrobiodiversity (FOOD AND AGRICULTURE ORGANISATION 1988: 337ff.). It was carried to Melanesia at an early but unknown date (SILLITOE 1983: 89f.). Hyacinth bean has been reported from many sites in India with reliable illustrated finds from as early as 1800 BC (Fuller, this volume). As with the cow pea, a lack of Arabian sites suggests a sea-route, with rather similar dates. Unlike cow peas, there are no archaeological reports of *Lablab* in Sub-Saharan Africa. Although conventional wisdom is that it is a widespread early cultigen in West-Central Africa (BUSSON 1965: 239f.), the lack of vernacular names (or in the case of Hausa, names suggesting it was brought from Egypt, or even by 'white men' may imply it is quite a recent introduction (BURKILL 1995). Hyacinth bean has been reported sporadically throughout Eritrea and Ethiopia, especially in Gamu Gofa (WESTPHAL 1974: 92ff. HEDBERG & EDWARDS 1989: 179ff.) and it is known but not widely cultivated in Eastern and Southern Africa. Indian cultivation systems have been introduced back into Africa and are contributing to its spread in traditional farming systems (FOOD AND AGRICULTURE ORGANISATION 1988: 337ff.).

Bambara groundnut
Vigna subterranea (L.) Verdc. (1980) (formerly *Voandzeia subterranea*)

Bambara groundnut is an annual prostrate herb grown for its edible seeds throughout most of sub-Saharan Africa and on Madagascar (BUSSON 1965: 250f.). It is native to West Africa and was presumably domesticated in the region of the Benue near the present-day Nigeria/Cameroon border (HARMS 1912. HEPPER 1963). ALBERT et al. (2000: 343ff.) record the Bambara nut from the site of Oursi in Burkina Faso as *Age de Fer ancien (Couche IIa)* dated to ca. 1800 bp. In south-eastern Africa, the first record of cultivated Bambara groundnuts is at Inyanga, in modern-day Zimbabwe where carbonised seeds have been recorded in a late Iron Age context (SUMMERS 1958). The Bambara groundnut is widely cultivated in India and Java, although the date and route by which it reached Asia is unknown (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 439ff.). However, its undoubted domestication in Africa and its absence in the Near East strongly suggest the sea-lanes.

Velvet bean [cow-itch < Hindi kiwach]
Mucuna pruriens (L.) DC. var. *utilis* (Wall ex Wight) Bak. ex Burck

A climbing herb with pods to 9 cm found wild in many parts of Africa, although cultivated in the Wellega region of Ethiopia (HEDBERG & EDWARDS 1989: 164ff.). The pods are covered in hairs that give a painful sting, but a variety without stinging hairs, var. *utilis*, is widespread in India and may well have evolved there (BURKILL 1995: 406ff.). *Mucuna* is widely used for cover-crops, fodder-crops and vegetables and in this form has been widely re-introduced back to Africa in recent times.

Cluster bean [guar]
Cyamopsis tetragonoloba (L.) Taub. (1894)

Guar is a bushy annual grown for its edible young pods and seeds, cultivated in Keren in Eritrea which appears to be a native of Africa (HEDBERG & EDWARDS 1989: 138ff.). Although widely grown throughout India, it has no *in situ* wild relatives, although there are no archaeological finds to indicate the antiquity of its introduction (KAJALE 1991: 174ff.).

3.6. Oil seeds

Castor bean
Ricinus communis Linn.

The original region of domestication of the castor bean appears to have been West-Central Africa but it must have spread early to Egypt, for seeds are found in pre-dynastic sites (GERMER 1985: 104ff.). LORET (1902) reviewed all the records of castor oil in Egypt. Castor is both wild and cultivated in Egypt today, and the seeds of the earliest finds are so reduced in size that they may well be subspontaneous. The earliest reference to castor oil in Egypt is in Herodotos, fifth century BC (DARBY et al. 1977: 782f.). In south-eastern Africa, the first record of castor beans is at Inyanga, in modern-day Zimbabwe where carbonised seeds have been recorded from the eighth century. The earliest archaeobotanical castor in India is at the Harappan site of Hulas, dated at between 1800-1300 BC (SARASWAT 1993).

Niger seed [noug]
Guizotia abyssinica Cass.

Niger seed is an erect leafy herb cultivated as an oil seed both in Eastern Africa and throughout India (WATT 1889-93: G. 358. BURKILL 1985: 474ff.). It is found throughout much of Africa as a plant of waste lands and as a casual in Europe. It appears to have been domesticated in the highlands of Ethiopia (BAAGOE 1974) but to have been carried early to India. RILEY & BELAYNEH (1989: 399ff.) note that 'Niger gene pools in Ethiopia and India have been separated for several thousand years'. A closely related plant, *Guizotia scabra* (Vis.) Chiov. is cultivated in Nigeria, Ethiopia and Sudan but there are no reports of its presence in India.

3.7. Fibre plants

Kenaf
Hibiscus cannabinus Linn.

Kenaf is cultivated principally for its fibres, but the young leaves, as with most of the *Hibiscus* spp., can be used as a potherb (CHEVALIER 1932: 834ff.). Apparently domesticated in West Africa, it spread to India at an early period, where there has been a considerable development of cultivars (BUSSON 1965: 294ff.).

Jute [Jews' mallow]
Corchorus olitorius Linn.

The original homeland of jute is debated. Jute was used in India very early as a fibre plant, but it appears to grow wild in West Africa (FRANKE 1976: 398ff. BURKILL 1985: 96ff.). Whether this plant was cultivated in ancient Egypt remains disputed but seeds of the cultivated plant have been found in tombs of the Graeco-Roman period at Kom Ouchin (DARBY et al. 1977: 671. GERMER 1985: 118f.). Al-'Umari mentions that Jews' mallow as growing wild in West Africa (LEVTZION & HOPKINS 1981: 263ff.).

3.8. Managed trees

Tamarind [Indian date, sour tumbler]
Tamarindus indica Linn. (1753)

The tamarind is now generally considered to be of West African origin, despite its scientific name (< *tamr hindi* = 'date of India' in Arabic) but to have spread to India at an early date (MORTON 1958. BUSSON 1965: 262ff. LEFEVRE 1971. BURKILL 1997: 169ff.). Charcoal from a tamarind tree has been identified from Narhan site in the middle Ganges at some 1300 BC (SARASWAT et al. 1994). SALIM et al. (1998) note that it is referred to in the Brahmasamhita scriptures (1200-200 BC) and in Buddhist sources from around 650 AD. Indian Ocean traders are considered to have carried the tree from India to SE Asia in the medieval period (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 431ff. COATES-PALGRAVE 1988. GUNASENA & HUGHES 2000). An absence of Egyptian finds suggests that the tamarind may have travelled along the Sabaean Lane.

Silk-cotton [kapok]
Ceiba pentandra (L.) Gaertn. var. *pentandra*

BAKER (1965) argues that the cultivated kapok was introduced from West Africa to south-western Asia by the Arabs. However, kapok is very widely spread through insular SE Asia and is found through much of Africa as an anthropic species, so it may also have been carried directly across the Indian Ocean (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 79ff.).

English name	Scientific name
aerial yam	*Dioscorea bulbifera* Linn.
musk mallow	*Abelmoschus moschatus* Medik.
pigeon pea	*Cajanus cajan* (L.) Millsp. (1900)
sesame	*Sesamum orientale* Linn.
jujube	*Ziziphus mauritiana* Lam.
?	*Corchorus urticifolius* Wight & Arn.
horse-radish tree	*Moringa oleifera* Lam.

Tab. 4 Plants of South Asian origin apparently reaching Africa at an early date.

4. Plants of South Asian origin reaching Africa at an early date

A suite of cultivated plants of South Asian origin apparently reaches Africa at an early date to judge by their establishment within African farming systems. A summary of these is given in **table 4.**

Aerial yam
Dioscorea bulbifera Linn.

Aerial yams are cultivated widely through the Pacific (BARRAU 1956), SE Asia (OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 248ff.) and India as well in much of Africa. In Africa, aerial yams are spread from Senegambia to Kefa in SW Ethiopia (MARTIN 1974. WESTPHAL 1975: 161. BURKILL 1985: 657ff. HAMON et al. 1995: 46f.). There appear to be wild forms in both Africa and India, and both BURKILL (1911) and CHEVALIER (1936: 524ff.) argued that it was domesticated independently in both continents. CHEVALIER (1936. 1952) claims that the Indian types, *D. bulbifera* var. *birmanica*, were brought to the East African coast by the Arabs and to the West African coast by the Portuguese and would presumably have crossed with or supplanted the indigenous African aerial yam.

Pigeon pea
Cajanus cajan (L.) Millsp. (1900)

The pigeon pea is a shrub cultivated for its edible seeds and for the browse provided by the leaves now cultivated throughout the tropics (BUSSON 1965: 236ff. OCHSE & BAKHUIZEN VAN DEN BRINK 1980: 370ff. HEDBERG & EDWARDS 1989: 181ff.). Although originally thought to be indigenous to Africa (PURSEGLOVE 1974. FRANKE 1976: 138ff.), it is now generally considered to be South Asian in origin and to derive from *Cajanus cajanifolia* (formerly *Atylosia*) (VAN DER MAESEN 1986. 1995). Indian finds are scarce but the pigeon pea seems to have begun to spread in the mid-2nd millennium BC (FULLER in press a). Pigeon peas were in the Near East at a very early date, as Schweinfurth recorded them in a 12th Dynasty grave at Dra Abu el-Nega, although GERMER

(1985: 94ff.) does not accept this as proof that the pigeon pea was cultivated. No archaeobotanical evidence from Africa is available, but the relatively high level of embedding in agriculture in East Africa suggest an early date (FOOD AND AGRICULTURE ORGANISATION 1988: 130ff.) in contrast to the virtual absence of pigeon pea throughout much of West Africa (BURKILL 1997: 296ff.).

Sesame [beniseed, gingelly, sesame, simsim]
Sesamum orientale Linn. (formerly *Sesamum indicum*)

The original homeland of *S. orientale* is the subject of some debate. Earlier authors saw West Africa as its homeland since a preponderance of wild relatives of sesame are found there (e.g. NAYAR & MEHRA 1970). However, during the 1980s, Bedigian proposed that its progenitor was the Indian *Sesamum orientale* var. *malabaricum* which today grows wild on granitic outcrops and is found in a weedy form all over the subcontinent (BEDIGIAN & HARLAN 1985. BEDIGIAN et al. 1985). More recently, HIREMATH & PATIL (1999) have advanced a strong case for *S. mulayanum* also occurring in India, vindicating the argument of IHLENFELDT & GRABOW-SEIDENSTICKER (1979).

Archaeological evidence for sesame in ancient India is sparse; *Sesamum* is present during the Mature Harappan period at Mohenjo-Daro, 2600/2500-2000 calBC (FULLER & MADELLA 2001). Sesame in China is exceptionally early; HO (1977) reports seeds from a site at Chien-shan-yang dated to 4567 ± 100 bp. Although most authors identify the *še-giš-ì* of the Sumerians as sesame, there is no archaeobotanical proof for this; it is at least possible it referred to another oil seed (BEDIGIAN & HARLAN 1986). Evidence for sesame in Egypt places it earlier than the generally accepted 18th Dynasty date (DARBY et al. 1977: 497f.; 785f. GERMER 1985: 171ff.). PLINY (Nat.Hist. 18.22.96) also refers to sesame as an import from India, a trade confirmed by the 'Periplus of the Erythraean Sea'.

If *S. mulayanum* is indeed the ancestor of *S. orientale* then it was probably carried to Africa perhaps both via the Nile Valley and the Sabaean Lane. However, West Africa has at least two other domesticated sesames not found outside the region, *S. alatum* and *s. radiatum*. The common use of domesticated sesames in West Africa is as mucilagineous potherbs, not oil seeds. It may therefore be that the white-seeded types domesticated in India later outcrossed with indigenous West African sesames to produce the mucilagineous and oil seed varieties grown there today.

Jujube
Ziziphus mauritiana Lam.

The jujube was apparently domesticated at an early period in India (FULLER 2000b) and brought to sub-Saharan Africa via the Near East at an unknown period (ZOHARY & HOPF 1993).

Musk mallow
Abelmoschus moschatus Medik. (formerly *Hibiscus abelmoschus*)

The exact origin of this plant remains disputed, although CHEVALIER (1940) argued that it was domesticated in the Pacific region, spreading early to India and thence to Egypt and Sub-Saharan Africa. It is widespread in Africa and shows no sign, culturally and linguistically, of not being anciently established (BUSSON 1965: 293f. BURKILL 1997: 11f.). It may thus have reached sub-Saharan Africa both via the sea-lanes and down the Nile corridor.

Corchorus urticifolius Wight & Arn.

A relative of jute, domesticated in India but also widely cultivated in Ethiopia and East Africa, and recorded in gardens in the Gambia (BURKILL 1985: 97ff.). Nothing is known about the date or route by which it reached Africa.

Horse-radish tree [ben-oil tree, drumstick tree]
Moringa oleifera Lam.

The origin of the horse-radish tree is disputed: either it is indigenous to West Africa, but reached

India at an early date, or the reverse (BUSSON 1965: 204ff. BURKILL 1997: 221ff.). Although recorded in Egyptian tombs, no early record has been published and GERMER (1985: 59ff.) notes that botanical remains are not easy to distinguish from those of *Moringa peregrina*. COLOMBEL (1997: 307ff.) sets out the vernacular terms for *Moringa oleifera* in Central Chadic languages, many of which seem to have been borrowed from Arabic *halim* suggesting the tree was brought across the desert to sub-Saharan Africa in the medieval period.

Appendix: Some queries

The plants listed in this section are of Asian origin but have been recorded in cultivation in Africa. Nothing is known of the dates and routes by which they arrived.

Moth bean
Vigna aconitifolia (Jacq.) Maréchal (1969)

A hairy annual with trailing branches from an erect stem, cultivated for its edible pods and seeds. Domesticated in Asia, it is recorded from Eritrea, although its period of introduction is unknown (HEDBERG & EDWARDS 1989: 177ff.).

Asystasia gangetica (Linn.) T. Anders with *Asystasia mysorensis*

An annual or perennial semi-woody herb found throughout tropical Africa and also in India and SE Asia (BURKILL 1985: 3f.). Occasionally cultivated but more often the leaves are collected from wasteland (SCHIPPERS & BUDD 1997: 137ff.).

Oasis carrot
Daucus carota L. var. *sahariensis* A. Chev.

An unusual type of carrot is cultivated in the oases of the Central Sahara with long, thin white roots. CHEVALIER (1932: 864ff.) notes that it resembles the carrot types cultivated at the oases of Turkestan, described by Vavilov.

5. Conclusion: the impact of African crops in India

This paper highlights the hypothesised major movements of cultivated and semi-cultivated plants between Africa and India, especially those that may have passed along the Sabaean Lane. The basis for the majority of these claims is neither archaeobotanical nor textual but the synchronic distribution and cultivar diversity of crops present in both locations, combined with botanical evidence on the original locus of domestication. In some cases, doubts remain about the identity of plants in different continents and whether apparent wild relatives are in fact escapes, as with sesame. India is rather better known than Africa archaeobotanically and plants such as the hyacinth bean are known from Indian archaeological contexts but so far remain unrecorded in Africa. Nonetheless there may be other reasons for the absence of specific cultigens from African sites, if Haaland's 'cultivation before domestication' hypothesis is adopted.

The evidence points to a considerable traffic in 'promising plants' from Africa to India and rather less in the opposite direction. The logic of this is simple; if the Indian dates of ca. 4000 bp attributed to cereals and pulses are correct, at that date much of the East African coast would have been populated only by pastoralists and foragers whose interest in new cultigens would have been rather limited. Only Ethiopia, and then only the highland populations, would have been the willing recipients of new crops. Once Bantu farmers began reaching the East coast around 0 AD, a population more receptive to both trade and agricultural exchange would have been present. From this perspective, Indian Ocean traders would have had several thousand more years to observe and transport potential cultigens from Africa to India, hence the greater numbers of plants travelling west to east in the later period.

There is a powerful tradition of scepticism about early dates for African cultigens in India. Nonetheless, recent re-evaluations of archaeobotanical claims of early dates for major grains and pulses in India of African origin have confirmed their presence, even after discarding doubtful finds and insecure dating. Both linguistic evidence and the degree of secondary diversity of many crops in India seem to confirm these claims. However, of all the plants that probably passed along this route, only a very few have yet made an appearance in the archaeobotanical record. Moreover, as the claims for finds in the Arabian peninsula have collapsed, it appears there was little interaction between the sea-traders and the coastal populations.

POSSEHL (1986) was one of the first writers to suggest that African cultigens played a role in the expansion of Indian agriculture into dryland areas. The argument is that Harappan agriculture was based primarily around winter crops familiar from Europe such as wheat, barley and peas. As a result, despite its early date in the northwest, agriculture did not spread into the monsoon-dominated regions of India for several thousand years after its establishment. With the advent of sorghum, millet, finger millet, pulses and oil seeds, it became possible to take advantage of arid regions with concentrated summer rains and thus agriculture took off in these regions. WEBER (1998), FULLER & MADELLA (2001) and FULLER (in press b) have recently questioned this, suggesting that summer cropping based on indigenous millets was already in place and that the introduced cereals and pulses gradually supplanted them because of yield advantages. Probably only a higher density of sites and dated material will be able to resolve this issue conclusively.

Nonetheless, it is surprising that a traffic on such a significant scale has left so little trace, both archaeologically and textually. This paper does not deal with domesticated animals but the principal gift of India to Africa was probably not a crop but zebu cattle, a species that came to dominate the pastoral economy of Africa. The prehistory of the Indian Ocean trade has tended to rely on text-based analysis and the archaeology of direct finds, but the botanical evidence suggests that 'invisible' voyages can have highly tangible effects.

Acknowledgments

This paper is extracted and expanded from a paper first given at the 16th Congress of the Indo-Pacific Prehistory Association, Melaka, 1-7 July 1998. Thanks to Katharina Neumann for inviting me to Frankfurt to participate in IWAA and prepare this revised version and for providing updated information on West African archaeobotanical finds. I am grateful to Mukund Kajale for both comments on the text and bringing a number of valuable references to my attention and to Dorian Fuller for correcting some more egregious errors as well as making available his recent offprints and pre-prints. At the IWAA meeting, Dorothea Bedigian and Margareta Tengberg were kind enough to give me some corrections and I learnt about the shaky nature of the evidence from the Arabian Peninsula. Kay Williamson and Colin Leakey and an anonymous referee read earlier versions and made valuable editorial comments.

6. References

ALBERT, K-D., M. HALLIER, S. KAHLHEBER & C. PELZER (2000) Montée et abandon des collines d'occupation de l'age de fer au nord du Burkina Faso. *Berichte des Sonderforschungsbereichs 268*, Band 14, 2000: 335-351.

AMBLARD, S. (1996) Agricultural Evidence and its Interpretation on the Dhars Tichitt and Oualata. In: Pwiti, G. & R. Soper (eds.), Aspects of African Archaeology, Papers from the 10th Congress of the Pan-African Association of Prehistory and Related Studies. Harare 1996: 421-427 (University of Zimbabwe Publications).

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

AMBLARD-PISON, S. (1996) Greniers néolithiques sur pilotis du Sahara méridional (Dhars Tichitt et Oualata, Mauritanie). *L'Anthropologie* 10,2-3, 1996: 356-365.

ANON (1894) CCCLVI: Tuberous Labiatae. *Kew Bulletin* 1894: 10-14.

BAAGOE, J. (1974) The genus *Guizotia* (Compositae). A taxonomic revision. *Botaniske Tidsskrift* 69, 1974: 1-39.

BAKER, H.G. (1965) The Evolution of the Cultivated Kapok Tree: a Probable West African Product. In: Brokensha, D. (ed.), Ecology and Economic Development in Tropical Africa. Berkeley 1965: 185-216 (University of California).

BARRAU, J. (1956) Les ignames alimentaires des îles pacifiques du Sud. *Journal d'Agriculture Traditionnelle et de Botanique Appliquée* III,7-8, 1956: 385-401.

BATES, D.M. & R.W. ROBINSON (1995) Cucumbers, Melons and Water-Melons (*Cucumis* and *Citrullus* (Cucurbitaceae). In: SMARTT & SIMMONDS, eds., 1995: 156-159.

BEDIGIAN, D. & J.R. HARLAN (1986) Evidence for the cultivation of sesame in the ancient world. *Economic Botany* 40, 1986: 137-154.

BEDIGIAN, D., D.S. SEIGLER & J.R. HARLAN (1985) Sesamin, sesamolin and the origin of sesame. *Biochemistry and Systematic Ecology* 13, 1985: 133-139.

BIBLE, THE

BLENCH, R.M. (1991) Contact between Ancient Egypt and sub-Saharan Africa: the Evidence of Cultivated Plants. In: Davies, W.V. (ed.), Egypt and Africa. London 1991: 54-56 (British Museum Press).

- (1996a) The Ethnographic Evidence for Long-Distance Contacts between Oceania and East Africa. In: Reade, J. (ed.), The Indian Ocean in Antiquity. London/New York 1996: 417-438 (Kegan Paul International/British Museum).

- (1996b) Evidence for the Inception of Agriculture in the Nigeria-Cameroun Borderland. In: Sutton, J.E.G. (ed.), The Growth of Farming Communities in Africa from the Equator Southwards. *Azania* Special Volume 19-20, Nairobi 1996: 83-102 (BIEA).

- (1997) A History of Agriculture in Northeastern Nigeria. In: Barreteau, D., R. Dognin & C. Von Graffenried (éds.), L'Homme et le Milieu Végétal dans le Bassin du Lac Tchad. Paris: 1997: 69-112 (ORSTOM).

- (1998) The Diffusion of New World Cultigens in Nigeria. In: Chastenet, M. (éd.), Plantes et Paysages d'Afrique. Paris 1998: 165-210 (Karthala).

BLENCH, R.M., K. WILLIAMSON & B. CONNELL (1997) The diffusion of maize in Nigeria: a historical and linguistic investigation. *Sprache und Geschichte in Afrika* XIV, Köln 1997: 19-46.

BOWER, R.L. & F.P. ALBRIGHT (1958) Archaeological Discoveries in South Arabia. Baltimore 1958 (John Hopkins Press).

BRUNKEN, J., J.M.J. DE WET & J.R. HARLAN (1977) The morphology and domestication of pearl millet. *Economic Botany* 31, 1977:163-174.

BURKILL, I.H. (1911) The polarity of the bulbils of *Dioscorea bulbifera*. *Linnaean Journal, Proceedings of the Asiatic Society of Bengal* n.s. 7, 1911: 467-469.

- (1937) XVI: The races of Sorghum. *Kew Bulletin* 1937: 112-119.

BURKILL, H.M. (1985) The Useful Plants of West Tropical Africa, Families A-D. Richmond 1985 (Royal Botanic Gardens Kew).

- (1994) The Useful Plants of West Tropical Africa, Families E-I. Richmond 1994 (Royal Botanic Gardens Kew).

- (1995) The Useful Plants of West Tropical Africa, Families J-L. Richmond 1995 (Royal Botanic Gardens Kew).

- (1997) The Useful Plants of West Tropical Africa, Families M-R. Richmond 1997 (Royal Botanic Gardens Kew).

BUSSON, F. (1965) Plantes Alimentaires de l'Ouest Africain. Paris 1965 (Ministère de la Coopération).

CHEVALIER, A. (1932) Les productions végétales du Sahara. *Revue de Botanique Appliquée et d'Agriculture Tropicale* 12, 1932: 669-924.

- (1936) Contribution à l'étude de quelques espèces africaines du genre Dioscorea. *Bulletin Musée nationale de l'Histoire naturelle de Paris*, 2ième Ser. 8,6, 1936: 520-551.

- (1940) L'origine, la culture et l'usage des cinq Hibiscus de la section Abelmoschus. *Revue Internationale d'Agriculture Tropicale et Botanique appliquée* 20, 1940: 319-328; 402-419.

- (1952) De quelques *Dioscorea* d'Afrique Équatoriale toxique dont plusieurs variétés sont alimentaires. *Revue Internationale d'Agriculture Tropicale et Botanique appliquée* 32, 1952: 14-19.

- (1953) Labiées du Genre *Coleus Loureiro* cultivées dans le pays tropicaux de l'Ancien Monde. *Revue Internationale d'Agriculture Tropicale et Botanique appliquée* 33, 1953: 334-341.

CHEVALIER, A. & E. PERROT (1905) Les Végétaux Utiles de l'Afrique Tropicale; I: *Coleus*. Paris 1905 (Dépôt des publications).

CHOE, C.-P. (1982) The diffusion route and chronology of Korean plant domestication. *Journal of Asian studies* 41,5, 1982: 19-29.

CLARK, J.D. & A. STEMLER (1975) Early domesticated sorghum from Central Africa. *Nature* 254, 1975: 588-591.

COATES-PALGRAVE, K. (1988) Trees of Southern Africa. Cape Town 1988 (Struik).

CODD, L.E. (1975) *Plectranthus* (Labiatae) and allied genera in Southern Africa. *Bothalia* 11,4, 1975: 371-422.

COLOMBEL, V. de (1995) Noms de Plantes: Classification, Reconstruction et Histoire à Partir des Noms de Six Cents Plantes en Dix Langues Tchadiques des Monts du Mandara. In: Ibriszimow, D. & R. Leger (eds.), Studia Chadica et Hamitosemitica. Köln 1995: 229-251 (Rüdiger Köppe).

- (1997) Noms et Usages des Plantes: Etude Comparative en Dix Langues Tchadiques du Groupe Central. Méthodologie pour une Remontée dans le Temps. In: Barreteau, D., R. Dognin & C. Von Graffenried (éds.), L'Homme et le Milieu Végétal dans le Bassin du Lac Tchad. Paris 1997: 289-310 (ORSTOM).

CONNAH G. (1981) Three Thousand Years in Africa. Cambridge 1981 (Cambridge University Press).

COSTANTINI, L. (1990) Ecology and Farming of the Protohistoric Communities in the Central Yemeni Highland. In: Maigret, A. de (ed.), The Bronze Age Cultures of Hawlan At-Tiyal and Al-Hada. Rome 1990: 187-204 (Ismeo).

CRAWFORD, G. (1992) Prehistoric Plant Domestication in East Asia. In: Cowan, C. & P.J. Watson (eds.), The Origins of Agriculture. Washington 1992: 7-38 (Smithsonian).

D'ANDREA, C. & J. CASEY (in press) Pearl millet and Kintampo subsistence. *African Archaeological Review* (in press).

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

DARBY, W.J., P. GHALIOUNGLI & L. GRIVETTI (1977) Food, the Gift of Osiris. 2 vols. London 1977 (Academic Press).

DE CANDOLLE, A. (1886) Origine des plantes cultivées. 2nd ed. Paris rééd. Marseille 1886 (Lafitte).

DE WET, J.M.J. (1983) Systematics and evolution of *Sorghum* sect. Sorghum (Gramineae). *American Journal of Botany* 65, 1983: 477-484.

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

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

DE WET, J.M.J., K.E. PRASADA RAO, M.H. MENGESHA & D.E. BRINK (1978) Diversity in kodo millet. *Economic Botany* 37,2, 1978: 159-163.

DEU, M., D. GONZALEZ-DE LEON, J.-C. GLASZMANN, I. DEGREMONT, J. CHANTEREUA & P. HAMON (1994) RFLP diversity in cultivated sorghum in relation to racial differentiation. *Theoretical Aspects of Genetics* 88, 1994: 838-844.

DOGGETT, H. (1988) *Sorghum*. London 1988 (Longmans).

– (1989) A Suggested History of the Crops Common to Ethiopia and India. In: Krzyzaniak, L. & M. Kobusiewicz (eds.), Late Prehistory of the Nile Basin and the Sahara. Poznan 1989: 27-47 (Poznan Archaeological Museum).

DOGGETT, H. & K.E. PRASADA RAO (1995) Sorghum (*Sorghum bicolor*). In: SMARTT & SIMMONDS, eds., 1995: 173-180.

EPENHUISJEN, C.W. van (1978) La Culture des Légumes Indigènes au Nigeria. Rome 1978 (Food and Agriculture Organisation).

FOOD AND AGRICULTURE ORGANISATION (1988) Traditional Food Plants. Rome 1988 (Food and Agriculture Organisation).

FARIS, D.G. (1965) The origin and evolution of the cultivated forms of *Vigna sinensis*. *Canadian Journal of Genetics and Cytology* 7, 1965 :433-452.

FRANKE, W. (1976) Nutzpflanzenkunde. Stuttgart 1976.

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

– (2000a) Fifty Years of Archaeobotanical Studies in India: Laying a Solid Foundation. In: Settar, S. & R. Korisettar (eds.), Indian Archaeology in Retrospect; III: Archaeology and Interactive Disciplines. New Delhi 2000: 317-390 (Oxford and IBH).

– (2000b) The Botanical Remains. In: Insoll, T. (ed.), Urbanism, Archaeology and Trade: Further Observations on the Gao Region (Mali). *British Archaeological Reports* Intern. Ser. 829, Oxford 2000: 28-35.

– (in press a) Indus and Non-Indus Agricultural Traditions: Local Developments and Crop Adoptions on the Indian Peninsula. In: Weber, S. & R. Belcher (eds.), Ethnobiology and the Indus Civilization. An Interdisciplinary Approach to Subsistence, Environment and Change.

– (in press b) Domestication, Diffusion and the Development of Agricultural Villages: a Study of the South Indian Neolithic. In: van Kooij, K.R. & E.M. Raven (eds.), South Asian Archaeology, 1999. Leiden 1999 (International Institute for Asian Studies).

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

GERMER, R. (1985) Flora des Pharaonischen Agypten. Mainz 1985 (von Zabern).

GILL, G., C.N. TURTON & R.M. BLENCH (1997) Pearl Millet in Developing Countries. Unpublished report to DFID 1997.

GUNASENA, H.P.M. & A. HUGHES (2000) Tamarind: *Tamarindus indica* L. Southampton 2000 (University of Southampton).

HAALAND, R. (1996) A Socio-Economic Perspective on the Transition from Gathering to Cultivation and Domestication: a Case Study of Sorghum in the Middle Nile Region. In: Pwiti, G. & R. Soper (eds.), Aspects of African Archaeology, Papers from the 10th Congress of the Pan-African Association of Prehistory and Related Studies. Harare 1996: 391-400 (University of Zimbabwe Publications).

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

HAMON, S. & D.H. VAN SLOTEN (1989) Characterisation and Evaluation of Okra. In: Brown, A.H.D., O.H. Frankel, D.R. Marshall & J.T. Williams (eds.), The Use of Plant Genetic Resources. Cambridge 1989: 173-196 (Cambridge University Press).

HAMON, P., R. DUMONT, J. ZOUNDJIHEKPON, B. TIO-TOURÉ & S. HAMON (1995) Les Ignames Sauvages d'Afrique de l'Ouest. Paris 1995 (ORSTOM).

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

HARMS, H. (1912) Über die Heimat der Erderbse *Voandzeia subterranea*. *Notizblatt Botanische Garten Berlin* 5, 1912: 253-258.

HEDBERG, I. & S. EDWARDS (eds.) (1989) Flora of Ethiopia, vol. 3. Addis Ababa 1989 (National Herbarium) (Uppsala University).

HEPPER, F.N. (1963) The bambara groundnut (*Voandzeia subterranea*) and Kersting's groundnut (*Kerstingiella geocarpa*) wild in West Africa. *Kew Bulletin* 16, 1963: 395-407.

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

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, 1976: 1131-1138.

– (1977) Domestication of *Eleusine coracana* (L.) Gaertner. *Economic Botany* 30, 1977: 199-208.

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. & C.G. PATIL (1999) Genome homology and putative progenitor of Sesame (*Sesamum indicum* L.). *Journal of Cytological Genetics* 34,1, 1999: 69-74.

HO, P.-T. (1977) The Indigenous Origins of Chinese Agriculture. In: Reed, C.A. (ed.), Origins of agriculture. The Hague 1977: 413-484 (Mouton).

HORTON, M.K. (1997) Shanga. Nairobi 1997 (BIEA).

HUNTINGFORD, G.W.B. (1980) The Periplus of the Erythraean Sea. London 1980.

IHLENFELDT, H.-D. & U. GRABOW-SEIDENSTICKER (1979) The Genus *Sesamum* L. and the Origin of Cultivated Sesame. In: Kunkel, G. (ed.), Taxonomic Aspects of African Economic Botany. Las Palmas 1979: 53-60 (AETFAT).

KAJALE, M. (1988) Plant Economy. In: Dhavalikar, M.K., H.D. Sankali & Z.D. Ansari (eds.), Excavations at Inamgaon; vol. I,ii. Pune 1988: 727-820 (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.M. (ed.), New Light on Early Farming. Edinburgh 1991: 155-189 (Edinburgh University Press).

KLEE, M. & B. ZACH (1999) The Exploitation of Wild and Domesticated Food Plants in North-East Nigeria (1800 calBC to today). In: VEEN, ed., 1999: 81-88.

KLEE, M., B. ZACH & K. NEUMANN (2000) Four thousand years of plant exploitation in the Chad Basin of northeast Nigeria I: the archaeobotany of Kursakata. *Vegetation History and Archaeobotany* 9, 2000: 223-237.

KOBISCHANOV, Y.M. (1965) On the problem of the sea voyages of Ancient Africans in the Indian Ocean. *Journal of African History* VI, 1965: 137-141.

LEFEVRE, J.-C. (1971) Revue de la littérature sur le tamarinier. *Fruits* 26,10, 1971: 687-695.

LEVTZION, N. & J.F.P. HOPKINS (1981) Corpus of Arabic sources for West African History. Cambridge 1981 (Cambridge University Press).

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

LORET, V. (1902) Le ricin et ses emplois médicaux. *Revue de Médecine* 22, 1902: 696.

MANN, K.A., C.T. KIMBER & F.R. MILLER (1983) The Origin and Early Cultivation of Sorghums in Africa. Bulletin 1454, College Station. Texas 1983 (Texas A & M University).

MARTIN, F.W. (1974) Tropical yams and their potential; part 2: *Dioscorea bulbifera*. USDA, Handbook 466. Washington, D.C. 1974.

MAUNY, R. (1953) Notes historiques autour des principales plantes cultivées d'Afrique Occidentale. *Bulletin IFAN* 15, 1953: 684-730.

MEHRA, K.L. (1962) Natural hybridization between *Eleusine coracana* and *E. africana* in Uganda. *Journal of the Indian Botanical Society* 41, 1962: 531-539.

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

MORTON, J.F. (1958) The tamarind *Tamarindus indica* (L.) its food, medicinal and industrial uses. *Proceedings of the Florida State Horticultural Society* 71, 1958: 288-294.

MUNRO-HAY, S.C.H. (1996) Aksumite Overseas Interests. In: Reade, J. (ed.), The Indian Ocean in Antiquity. London/New York 1996: 403-416 (Kegan Paul International/British Museum).

NAYAR, M.N. & K.L. MEHRA (1970) Sesame: its uses, botany, cytogenetics and origin. *Economic Botany* 24,1, 1970: 20-31.

NEUMANN, K. (1999) Early Plant Food Production in the West African Sahel. In: VEEN, ed., 1999: 73-80.

NEUMANN, K., A. BALLOUCHE & M. KLEE (1996) The Emergence of Plant Food Production in the West African Sahel: New Evidence from Northeast Nigeria and Northern Burkina Faso. In: Pwiti, G. & R. Soper (eds.), Aspects of African Archaeology. Papers from the 10th Congress of the Pan-African Association of Prehistory and Related Studies. Harare 1996: 441-448 (University of Zimbabwe Publications).

NG, N.Q. (1995) Cowpea. In: SMARTT & SIMMONDS, eds., 1995: 326-332.

NATIONAL RESEARCH COUNCIL (1996) Lost Crops of Africa; vol. I: Grains. Washington 1996 (National Academy Press).

OCHSE, J.J. & R.C. BAKHUIZEN VAN DEN BRINK (1980) Vegetables of the Dutch East Indies. Amsterdam 1980 (A. Asher) [Translation of Indische Groeten first published 1931].

OLLITRAULT, P., M. ARNAUD & J. CHANTEREAU (1989) Polymorphisme enzymatique des sorghos, II. *L'Agronomie tropicale* 44,3, 1989: 211-222.

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.

PHILLIPSON, D.W. (1993) African Archaeology. Cambridge 1993 (Cambridge University Press).

PLINY Natural History. 10 volumes. Loeb classical Library. H. Rackham ed. London Cambridge, Mass. 1938-1952 (Heineman & Harvard University Press).

PORTÈRES, R. (1951) *Eleusine coracana* Gaertn. Céréale des humanités pauvres des pays tropicaux. *Bulletin de l'Institut Français de l'Afrique Noire* 13, 1951: 1-78.

– (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 African Plant Domestication. The Hague 1976: 409-452 (Mouton).

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

– (1996) Meluhha. In: Reade, J. (ed.), The Indian Ocean in Antiquity. London/New York 1996: 133-208 (Kegan Paul International/British Museum).

– (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).

POTTS, D.T. (1993) The late prehistoric, protohistoric and early historic periods in Eastern Arabia (ca. 5000-1200 BC). *Journal of World Prehistory* 7, 1993: 163-212.

PURSEGLOVE, J.W. (1974) Tropical Crops. Dicotyledons. London 1974 (Longman).

RANDHAWA, M.S. (1980) A History of Agriculture in India; vol. I. New Delhi 1980 (Indian Council of Agricultural Research).

RAPONDA-WALKER A. & R. SILLANS (1961) Les Plantes Utiles du Gabon. Paris 1961 (Le Chevalier).

RAWAL, K.M. (1975) Natural hybridization among wild, weedy and cultivated *Vigna unguiculata* (L.). *Euphytica* 24, 1975: 699-707.

RILEY, K.W. & H.C. BELAYNEH (1989) Niger. In: Röbbeln, G., R.K. Downey & A. Ashri (eds.), Oil Crops of the World. New York 1989: 394-403 (McGraw Hill).

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

ROWLEY-CONWY, P.A., W.J. DEAKIN & Ch.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, ed., 1999: 55-61.

SALIM, A., A. SIMONS, A. WARUHIN & C. ORWA (1998) Agroforestry Tree Database: a Tree Species Reference and Selection Guide and Tree Seed Suppliers Directory. Nairobi 1998 (ICRAF).

SARASWAT, K.S. (1993) Plant economy of late Harappan at Hulas. *Puratattva* 23, 1993: 1-12.

SARASWAT, K.S., N.K. SHARMA & D.C. SAINI (1994) Plant Economy at Ancient Narhan (ca. 1300 BC – 300/400 AD). In: Singh, P. (ed.), Excavations at Narhan. Varanasi 1994: 255-346 (Banaras Hindu University).

SCHIPPERS, R. & L. BUDD (eds.) (1997) African Indigenous Vegetables. Nairobi/Greenwich 1997 (IPGRI: NRI).

SCHWEINFURTH, G. (1872-1873) Sur l'origine africaine des plantes cultivés en Égypte. *Bulletin de l'Institut Égyptien* 12, 1872-1873: 200-206.

SHAW, T. (1976) Early food crops in Africa: a review of the evidence. In: Harlan, J.R., J.M.J. De Wet & A.B.L. Stemler (eds.), Origins of African Plant Domestication. The Hague 1976: 107-154 (Mouton).

SILLITOE, P. (1983) Roots of the Earth. Manchester 1983 (Manchester University Press).

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. Essex ²1995 (Longman Scientific & Technical).

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

SOUTHWORTH, F.C. (1976) Cereals in South Asian Prehistory: the Linguistic Evidence. In: Kennedy, K.A.K. & G. Possehl (eds.), Ecological Backgrounds of South Asian Prehistory. Ithaca 1976: 52-75 (Cornell University).

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

STAHL, A.B. (1985) Re-investigation of Kintampo 6 rock shelter, Ghana: implications for the nature of culture change. *African Archaeological Review* 3, 1985: 117-150.

SUMMERS, R. (1958) *Inyanga*. Cambridge 1958 (Cambridge University Press).

TOSTAIN, S. (1989) Enzyme diversity in pearl millet (*Pennisetum glaucum*); 2: Africa and India. *Theoretical and applied genetics* 77, 1989: 81-93.

– (1994) Isozymic classification of pearl millet (*Pennisteum glaucum*, Poaceae) landraces from Niger (West Africa). *Plant Systematics and Evolution* 193, 1994: 81-93.

– (1998) Le Mil, une Longue Histoire: Hypothèses sur sa Domestication et ses Migrations. In: Chastenet, M. (ed.), Plantes et Paysages d'Afrique. Paris 1998: 461-490 (Karthala).

VAN DER MAESEN, L.J.G. (1986) *Cajanus DC.* and *Atylosia W & A. (Leguminosae)*. Agricultural University Papers Wageningen 1986: 84-85 (Wageningen Agricultural University).

– (1995) Pigeon-pea *Cajanus cajan*. In: SMARTT & SIMMONDS, eds., 1995: 251-255.

VATS, M.S. (1940) Excavations at Harappa. Delhi 1940 (Manager of Publications).

VAVILOV, N.I. (1951) The origin, variation immunity and breeding of cultivated plants. *Chronica Botanica* 13, 1951: 1-366.

VEEN, M. van der (ed.) (1999) The Exploitation of Plant Resources in Ancient Africa. New York 1999 (Kluwer/Plenum).

WASYLIKOWA, K. & J. DAHLBERG (1999) Sorghum in the Economy of the Early Neolithic Nomadic Tribes at Nabta Playa, Southern Egypt. In: VEEN, ed., 1999: 11-32.

WATSON, A.M. (1983) Agricultural Innovation in the early Islamic World. Cambridge 1983 (Cambridge University Press).

WATT, G. (1889-93) (ed.) A Dictionary of the Economic Products of India. 6 vols. Calcutta 1889-93 (Government of India).

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

WESTPHAL, E. (1974) Pulses in Ethiopia, their Taxonomy and Agricultural Significance. Wageningen 1974 (Centre for Agricultural Publishing and Documentation).

– (1975) Agricultural Systems in Ethiopia. Wageningen 1975 (Centre for Agricultural Publishing and Documentation).

WIGBOLDUS, J. (1996) Early Presence of African Millets near the Indian Ocean. In: Reade, J. (ed.), The Indian Ocean in Antiquity. London/New York 1996: 75-86 (Kegan Paul International/British Museum).

YOUNG, R. & G. THOMPSON (1999) Sorghum in the Economy of the Early Neolithic Nomadic tribes at Nabta Playa, Southern Egypt. In: VEEN, ed., 1999: 63-72.

ZOHARY, D. & M. HOPF (1993) Domestication of Plants in the Old World. Cambridge ²1993 (Cambridge University Press).