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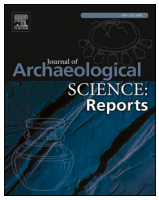

Cotton and post-Neolithic investment agriculture in tropical Asia and Africa, with two routes to West Africa

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ABSTRACT

This article provides an up-to-date review of the origins and spread of cottons in the Old World based on archaeobotanical evidence, and explores the routes and socioeconomic context through which cotton cultivation became established across the tropics and sub-tropics of Asia and Africa. Two cotton species were domesticated in the Old World, one of which was grown for millennia as a long-lived tree (*Gossypium arboreum*) and the other as a shrub over several years (*Gossypium herbaceum*). While *G. arboreum* began to be cultivated during the Middle Holocene (7000–4000 years ago) in Pakistan and Northwest India, *G. herbaceum* was likely domesticated in Africa, perhaps in Sudan. Evidence for cultivation of cotton in Sudan dates from around 2000 years ago, the same period that import of cotton from India into the Roman world was common. The spread of cotton through the African continent involved three trajectories. In southeast Africa, its near coastal islands and Madgascar, received cotton, inferred to be *G. arboreum* from India, around 1000 years ago in the context of increasing contact across the Indian ocean. As for western Africa, we postulate two dispersal routes: an oasis route through the Sahara and Sahel that focused on *G. herbaceum,* and a savanna route further south that brought *G. arboreum* to Cameroon, Benin and Ghana.

1. Introduction

Cotton clothes are ubiquitous today, but what many people may not realize is that this is largely the product of Post-Colombian globalization, especially the very high productivity of New World cottons in arable agriculture, particularly *Gossypium hirsutum.* The American cottons (*G. hirsutum* and *G. barbadense*) entered an Old World in which cotton production was already quite widespread in Africa and parts of Asia and began a process of displacing the Old World native cottons with those from the New World. This means that by the time of colonial era scientific botany, the distribution of native Old World cottons was already in retreat, but it is also the case that both *G. herbaceum,* regarded as African in origin and *G. arboreum,* of probable South Asian (Indus) origins (Hutchinson, 1954; Saunders, 1961; Viot, 2019; Vollesen, 1987; Zohary et al., 2012; Wendel, 1995), both already had transcontinental distributions. The purpose of this paper is to sketch a broad geographical and historical framework for the dispersal of these original cottons throughout the Old World, prior to AD 1492, and to suggest some recurrent patterns in terms of the social context of cotton adoption and spread in relation to both local social complexity and urbanization, on the one hand, and long-distance trade on the other. We explore these processes in some detail for western Africa, where the arrival of two cotton species by two routes is hypothesized and connected to local urbanization processes and wider agricultural transformations. This offers a comparable process to the initial spread of cotton into Southern India and Southeast Asia.

In terms of our methods, we draw upon a database of archaeological crop occurrences (Old World Crops Archaeobotanical Database), which is nearing completion and has focused on compiling records of crop occurrences throughout Asia and Africa (for previous uses, see, e.g. Stevens et al. 2016; Crowther et al. 2018; Champion and Fuller, 2018a). In this paper we provide an updated compilation of archaeobotanical cotton finds in Africa and Asia. We note at the outset that no attempt in the database has been made to differentiate between *G. herbaceum* and *G. arboreum,* which have traditionally proven difficult to separate on charred archaeological seed or seed fragment remains (Fig. 1). The only truly secure published species level identification is that based on ancient DNA from Qasr Ibrim that confirms the presence of *G. herbaceum*

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in post-Meroitic Nubia (Palmer et al. 2012). Efforts at geometric morphometrics have indicated substantial overlap between *G. arboreum* and *G. herbaceum* in linear measurements and two-dimensional shape index (Milon et al. 2023; Milon 2023), and poor correspondence between archaeological and modern seeds (Milon 2023). There are some suggestions that the fibers in textile may be differentiated, e.g. the identification of *G. arboreum* from burials at Meroe and Karanog (Griffith and Crowfoot 1934; Chowdhury and Buth 1971). However, it is unclear how reliable such criteria are or how consistently they have been deployed (see, e.g. Criticism by Chowdhury and Buth 1971 of the *G. arboreum* identification at Mohenjodaro by Gulati and Turner 1929). Until ancient DNA (aDNA) is more established or the promise of geometric morphometrics of seeds, discussed recently (e.g. Bouchaud et al. 2019; Milon et al. 2023), is realized fully, we are left to hypothesize about which cotton species or variety was cultivated on the basis of less ideal evidence, namely geographic location or written observations. Nevertheless, we have inferred ancient crops *arboreum* or *herbaceum* based on deductions from colonial era distributions and written sources. This means that the maps we provide charting these two species through time should be taken only as working hypotheses in need of further, focused testing.

2. Cotton: An original cash crop

One of the reasons cotton is of particular interest is that it is a "cash crop" par excellence. By *cash crop*, we follow the definition of Sherratt (1999), which does not require a monetary economy, but rather means that a crop is grown primarily for turning it into a trade commodity rather than for community subsistence. Unlike most annual seed crops, which are primarily caloric foods for people or livestock, cotton is mainly grown as raw material. It is a crop which requires careful attention to its environmental needs and beyond its cultivation requires a substantial labor investment for processing (ginning, combing, spinning, and weaving). Thus, investment in cotton implies both surplus land (removed from the needs for subsistence crops) and surplus labor. When cotton appears in the archaeological record it implies a certain

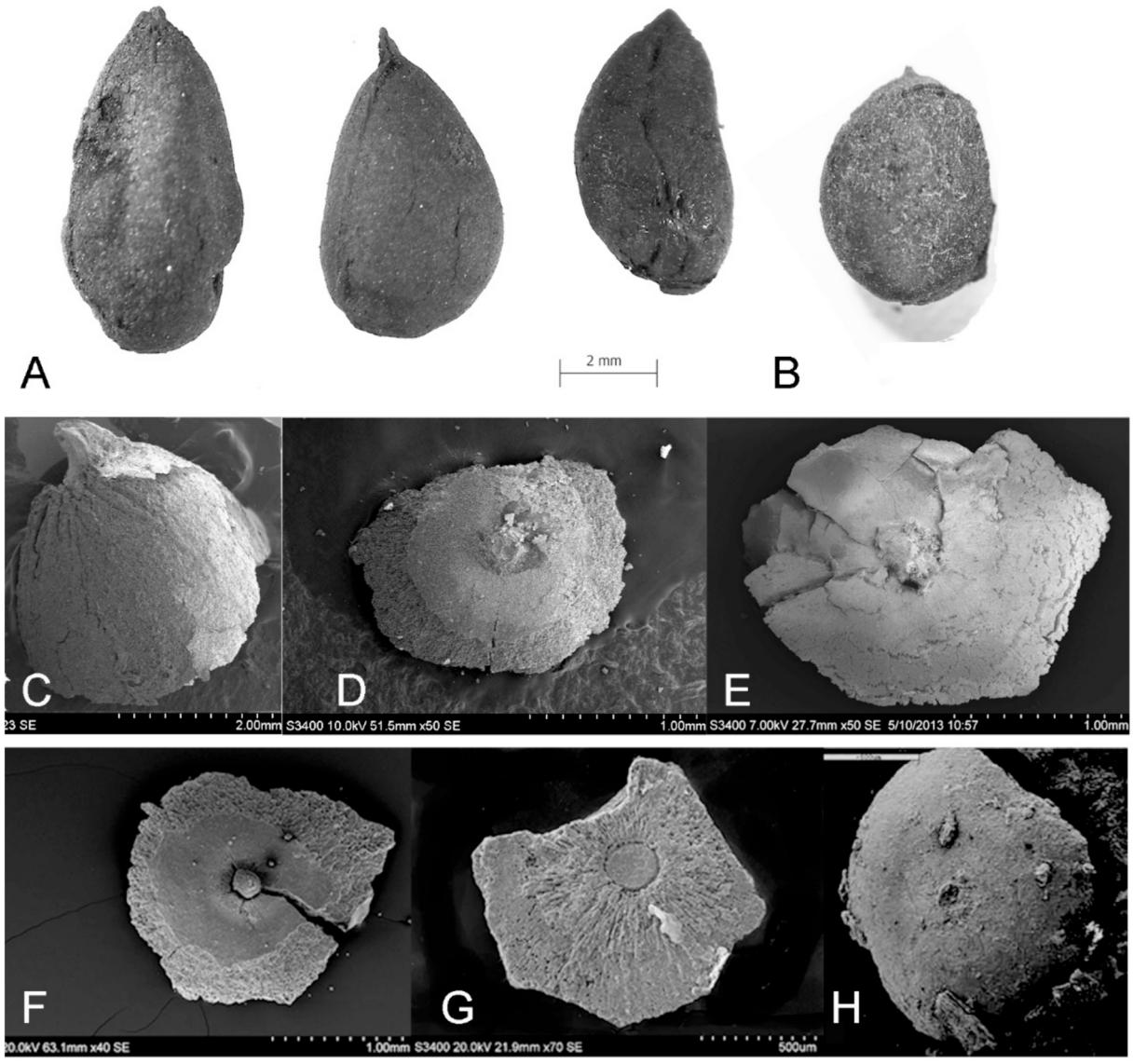

Fig. 1. Examples of archaeological cotton remains studied in the UCL archaeobotany laboratory. A. Three cotton seeds from Madikali, Benin (after Champion and Fuller 2018b). B. Cotton seed from Islamic Gao, Mali (after Fuller 2000; 1996). C. Fragment of cotton seed with hilum "beak" from Paithan, India (after Fuller 2020). D. Cotton funicular cap from Paithan, India (after Fuller 2020). E. Cotton funicular cap from Hamadab, Sudan. F. Cotton funicular cap from Gourouberi, Benin (after Champion and Fuller 2018b). G. Cotton funicular cap from Khao Sam Kaeo, Thailand (after Castillo et al. 2016). H. Cotton funicular cap from Ufalda, India (after Fuller 2008).

level of social complexity and trade, and thus a more diversified agricultural system, as argued for the spread of cotton in the Indian subcontinent (Fuller 2008) and implied by recent syntheses on Meroitic Nubian cotton (Yvanez et al., 2019) and the Niger river basin (Champion and Fuller, 2018a, 2018b; Champion, 2019). During the Middle Ages, at least in the Khmer Empire in Cambodia, cotton takes on the role of currency and paid in as tax and for ritual (Castillo et al. 2020; Castillo 2023).

Cash crops, as a broader category, represent an important set of related agricultural innovations that took place between the Neolithic, in a world of small village communities that were largely self-sufficient, and early urbanization. In these scenarios, large population centers drew upon a wide agricultural hinterland and acted as hubs in the long-distance trade in commodities, including various artefactual materials (beads, metals, etc.), but also transformed foodstuffs (like wine) and textiles. Among the first cash crops in Mesopotamia, prior to Bronze Age urbanization, were species like olive (*Olea europaea* L.), grape (*Vitis vinifera* L.), date (*Phoenix dactylifera* L.) and fig (*Ficus carica* L.) (Sherratt 1999; Fuller and Stevens 2019; Langgut and Garfinkel 2022). Similarly, it has been argued that Late Neolithic China, prior to Bronze Age state formation saw the establishment of cultivated trees like peach (*Prunus persica* (L.) Batsch), apricot (*Prunus armeniaca* L.), jujube (*Ziziphus jujuba* Mill.) and probably mulberry (*Morus alba* L.) for sericulture (Fuller and Stevens 2019; Shen and Li 2021). Parts of late Chalcolithic India also saw the emergence of fruit orchard cultivation, including mango (*Mangifera indica* L.), jackfruit (*Artocarpus heterophyllus* Lam.) and citrus (Kingwell-Banham and Fuller 2012), while pomelo (*Citrus maxima* (Burm.) Merr.) cultivation was established in parts of mainland Southeast Asia certainly by the time of the earliest Iron Age cities (Castillo et al. 2016; Fuller et al. 2018). What these fruit domesticates have in common is that they are long-lived perennials, requiring years of investment in cultivation before providing produce, and many years more before they can be regarded as representing a good return on investment. Fuller and Stevens (2019) suggest that this can be characterized as *investment agriculture* in contrast to an emphasis on *sustainability agriculture* that characterized Neolithic food production systems, with a focus on shorter term (usually annual) returns of calories and nutrition, mostly destined for the households and communities that produced them. One of the key implications of this shift to investment agriculture based on long-lived perennials is reliable land tenure systems, so that investment in establishing seedlings or saplings of long-lived plants can be seen through to productive adult years (McCorriston 2009). Early civilizations appear to have had routinely specialized production of textile fibers, as the weaving of textile fits into urban trade economies, while clothes helped to define social identity and status in complex societies (e.g. Barber 1990). For Mesopotamia, flax and sheep wool were a low cost alternative that really took off in production in the 5th millennium BCE in the lead up to urbanization in the 4th millennium BCE (McCorrsiton, 1997). In China, silk as well as plant fibers like ramie (*Boehmeria nivea*) presumably took that role. Meanwhile in much of the Old World tropics, from sub-Saharan Africa through to India and Southeast Asia it was cottons that took this role, being both a perennial, woody tree crop and a specialized textile commodity.

Old world cottons divide into two taxa, which are both perennial but nevertheless have differing characteristics (Stanton et al. 1994; Viot 2019). *Gossypium arboreum* is a large shrub or tree, upto 3 m tall (Fig. 2a), with typical lifespans reported from 5 to 20 years. Medieval Arabic sources suggest a peak in productivity occurred only once plants were 9 years old or more (Watt 1907: 85, 135–136). Traditional management might have involved coppicing, as described from 19th century Ethiopia (Nicholson 1960), or pollarding, cutting back branches to the main trunk (Brink 2011); such practices are described in records of cotton plantations from Gujarat in the 1780s (Watt 1907: 94). While quasi-annual, shorter varieties did eventually evolve, this was much

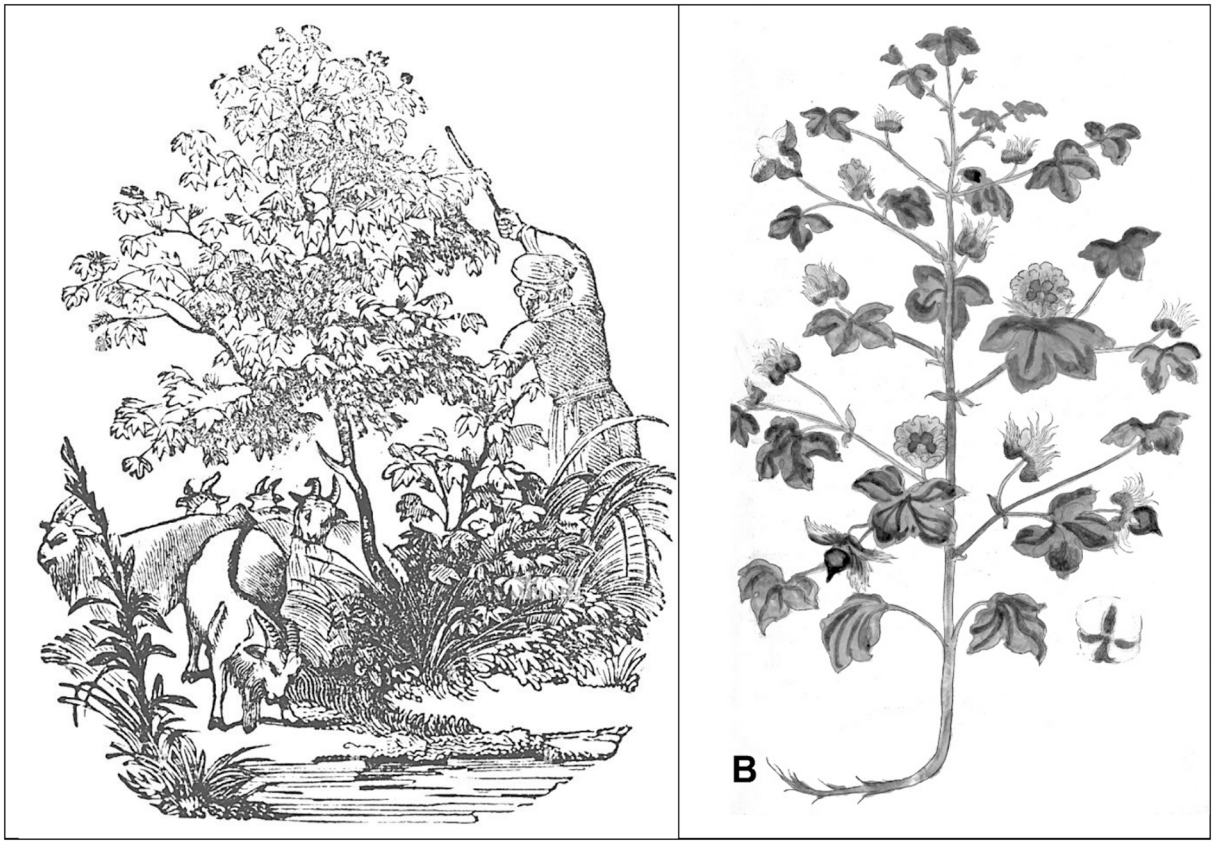

Fig. 2. Illustrations contrasting Gossypium arboreum (A) and G. herbaceum (B). (A) after Anonymous 1833 (B) after Fuch 1543.

later (Bouchaud et al. 2019): annual varieties appear from the 13th century AD in China, based on written sources, and annual forms only became established in parts of India around the 18th century (Watt 1907; Hutchinson, 1959; Zeven and De Wet 1982). *G. arboreum* is often grown in dedicated orchards, which, in drier areas, may be irrigated in order to provide adequate water for the flowering period. Decades old orchards were described as still present along parts of the Sudanese Nile valley in the early 20th century (Bond 1925). It is possible, therefore, that tree cotton was initially grown alongside other perennial tree and vine crops, such as grape, dates or jujube, which also need permanent orchards and benefit from irrigation. The cultivation of perennial and tree crops signifies a switch from annual rewards (such as those gained from grain or tuber crops) to more long-term investment. Many of these crops only produce a first harvest after 3–5 years, with trees in particular requiring several years growth before yielding significant quantities of fruit, as has been indicated for tree cotton. With cotton, this investment was not for subsistence, but instead for the production of cloth and a tradable product (a cash crop).

Gossypium herbaceum is a small shrub and is productive mainly from three to five years in age (Fig. 2b). Management traditionally involved ratooning (or coppicing), i.e. cutting it back to the roots (after about 5 years) and allowing new shrubs to grow from the roots (Jimu 2011). Annual forms also evolve later, and are those traditionally cultivated in the Middle East (e.g. Iran) and Central Asia. The earliest annual forms may be represented by 4th-5th century cultivation in the Nabatean region (around modern Jordan) (Bouchaud et al. 2019), and by archaeological finds of similar age in southern Central Asia at Kara-Tepe, Uzbekistan (Brite and Marston 2013), and at Merv in Turkmenistan (Nesbitt and O'Hara 2000). Cultivation seems to have been established in Chinese Turkestan (Xinjiang) by the 7th century (Shafer 1963: 205). *G. herbaceum* became increasingly widespread during the Early Islamic era where it spread around the Eastern Mediterranean, Iran and North Africa (Samuel 2001; Ducène 2019; Fuller and Pelling 2018).

Apart from differences in life cycle, these two cottons also differ in systems of management. The differences in growth habit and life cycle lend themselves to differing cultivation systems, with *G. arboreum* suited to being grown as part of mixed gardens or orchards, whereas *G. herbaceum,* with regular coppicing is suited to be grown in more traditional agricultural fields. Viot (2019) reports that they have very similar yield characteristics and fiber quality, with generally greater variability within *G. arboreum,* including some with finer fiber characteristics. With the dominance of annual cottons in more recent centuries, tree cotton has tended to become relegated to hedge rows or similar settings; for example, Watt (1890:6) noted the perennial tree cotton was often planted in temple groves, and was used for string in temple lamps (Watt 1907: 85). Similarly, perennial cottons persist in hedge and garden contexts in Africa (Chevalier 1924).

3. South Asian origins and dispersal of tree cotton

The diploid cottons *G. herbaceum* and *G. arboreum* originated in the Old World and the phylogeny of *Gossypium* suggests that *G. herbaceum* and *G. arboreum* diverged at least 400,000 years ago, undergoing separate domestication events (Renny-Byfield et al. 2016). *G. herbaceum* appears to have been largely restricted to Africa, and possibly the Arabian Peninsula during the wetter periods of the Early Holocene (Betts et al. 1994; Fuller 2008; Viot 2019). In contrast, *G. arboreum* is generally thought to be native to South Asia. Feral plants are suggested to occur in dry land areas of the Sindh and Deccan today (Hutchinson and Ghose 1937; Santhanam and Hutchinson 1974), but a true wild progenitor appears to be extinct. Early finds of cotton seeds in South Asia are therefore presumed to be *G. arboreum*.

The earliest finds of cotton in South Asia come from Mehrgarh, Baluchistan. Several seeds, as well as twisted cotton fibers preserved on the interior of a corroded copper bead were recovered from deposits from the late 6th millennium or 5th millennium BCE onwards (Costantini 1984, Moulherat et al. 2002). The conventional chronology for Mehrgarh found in much of the literature suggesting the site may start from ca. 7000 BCE onwards (e.g. Possehl 1999; Fuller 2006; Jarrige 2008; Petrie 2015) is problematic as most radiocarbon dates fall in the 6th millennium BCE region and the stratigraphically lowest dates reported in Jarrige and Lechavallier (1980) are calibrated to between 6000 and 5600 BCE. The transition to ceramic levels occurs after 5000 BCE (cf. Jarrige and Lechavallier 1980; Petrie 2015), but a thorough reassessment of the chronometrics of Mehrgarh is beyond the scope of the present paper. Finds from this site indicate that textile production and use of cotton had been established within the area of Baluchistan by 5000–4300 BCE, but whether this was wild cotton use or represents early cultivation is unknown. It is not until c.2500 BCE in the Harappan period that cotton, as seeds, begins to be found with any regularity on archaeological sites within the Indus region, and we can infer that cultivation was well-established (Fuller 2008; Pokharia and Srivastava 2013; see Fig. 3). The earliest preserved fragments of woven cotton are also from the Harappan period (Gulati and Turner, 1929; Hawkes, 2021; Kenoyer, 2004). There is not yet any clear evidence for morphological domestication, but we would assume this was established, or well under way, at this time.

The presence of cotton at such a wide range of sites by 2000 BCE, both in terms of geographical range and settlement size/function, shows that cotton production was a significant economic activity by the Mature Harappan urban period. As such, it can be seen as a key cash crop which played a role in the development of regional economies and economic links, goods production and exchange. It is also indicative of specialized craft production, as the process of spinning and weaving cotton fabrics requires both specific technologies (spindles, looms etc.) and skilled labor, comparable to evidence of wool and linen textile production by the time of early urban Mesopotamia (McCorriston 1997).

It is not until c.1000 BCE, however, that cotton seeds begin to appear at sites in other regions of India, with one of the earliest secure finds of cotton seed from outside the Indus region recovered at Hallur, Karnataka, c.1000 BCE (Fuller et al. 2007). At Neolithic/Chalcolithic sites in the Indian peninsula, spindle whorls start to become frequent finds only after 1500 BCE (Fuller 2008). But it is particularly during the Iron Age, after 1000 BCE, that cotton is likely to have become a more widespread crop (Cooke and Fuller 2015; Fuller 2020), with finds in the Arabian peninsula attributed to an Indian origin based on strontium isotope analysis (Ryan et al. 2021). By early historic times, in the late centuries BCE, cotton was widespread across India and as far east as Bangladesh from the 1st century BCE (Rahman et al. 2020), it is known from the far south of Sri Lanka by ca. 400 AD (Murphy et al. 2018). Fig. 3 maps current archaeological evidence for cotton in South Asia.

There is an increase in spindle whorls from c.1800–1500 BCE in the Gangetic Plains which has been attributed to an increase in cotton production (Fuller 2008). We note that this could also relate to the spinning of wool, but these require heavier spindle whorls than for cotton (Kossowska-Janik, 2016), which seems not to be the case, although detailed studies are needed. Hawkes (2021) has drawn particular attention to the importance of spindle whorl studies, including statistics of size and weight, as a key element in textile production studies in South Asia; he also highlights that many spindle whorls have likely been reported as large beads in many excavation reports, especially "Areca-nut" shaped beads that appear in the Iron age from ca. 500 BCE.

Cotton was a major export from ancient India, both as a commodity of trade and as a crop adopted elsewhere. It is clear that cotton cloth was widely exported from South India, as indicated by Roman written sources (e.g. Casson 1989; Table 1), as well as finds of textiles in the dry conditions of Roman Egypt, that include Z-spun thread that are thought to derive mainly from Indian manufacturing style (Crowfoot 1931; Wild and Wild 2001; 2005; cf. Bouchaud et al. 2019). The widespread importance of the cotton textile industry in many parts of India is supported by historical linguistic data, terminologies relating to cotton, its

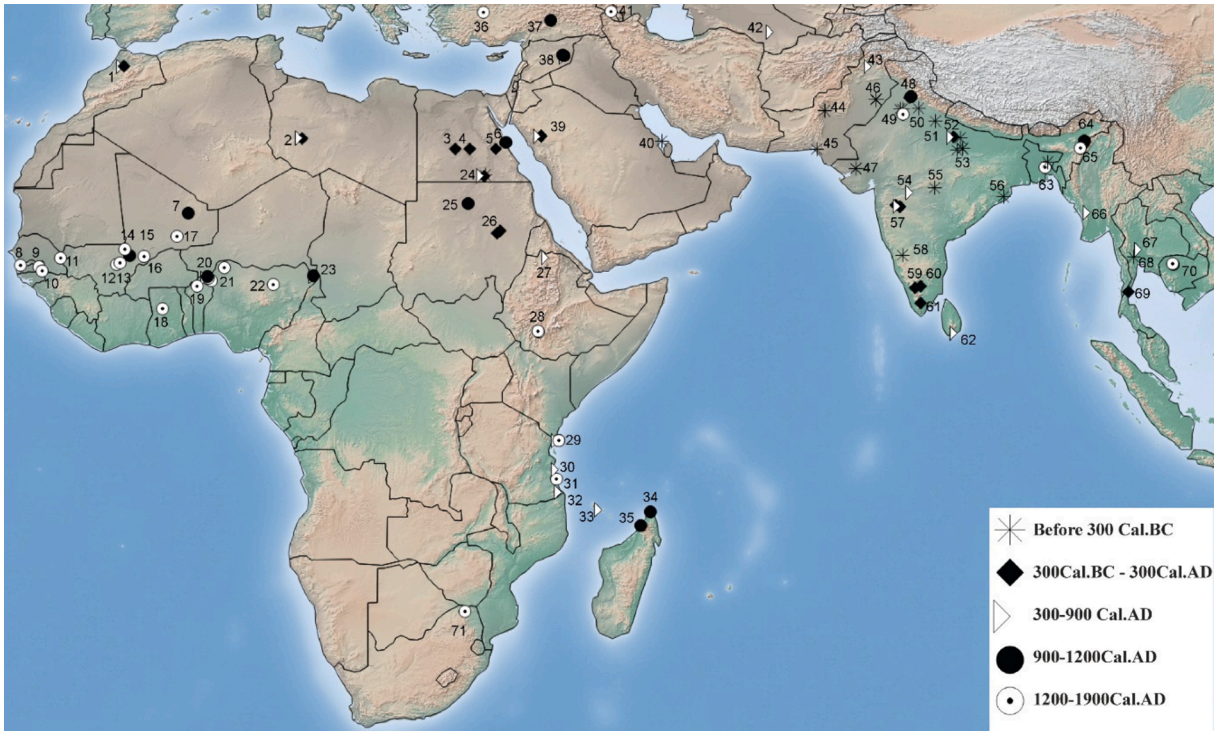

Fig. 3. Map of archaeobotanical cotton seed evidence in across Africa and Asia, indicating inferred distribution of major cotton varieties. Note that Kara-Tepe, Uzbekistan (Brite and Martson 2013) is not shown and falls beyond the northern edge of the map. Ages based on median estimates. Sites numbered: 1. Volubilis (Fuller and Pelling 2018); 2. Old Jarma; 3. Dakhleh oasis sites; 4. Kharga oasis sites; 5. Al-Zarqa; 6. Quesir al-Qadim; 7. Essouk; 8. Luffure; 9. Korop; 10. Payoungou; 11. Djoutoubaya; 12. Sorotomo; 13. Togu; 14. Akumbu; 15. Dia; 16. Tellem; 17. Gao; 18. Old Buipe; 19. Niyanpangu-bansu; 20. Benin Niger valley sites (Birnin Lafiya, Tintin, Bogo-Bogo, Gorouberi, Madekali,); 21. Surame; 22. Shira; 23. Mege and Daima; 24. Qasr Ibrim; 25. Nauri; 26. Muweis and Hamadab; 27. Axum; 28. Tuwatey Zonga Cave and Garu Songalay (Arthur et al. 2019); 29. Chwaka abd Tumbe, Pemba Island; 30. Unkuju Cave, Mafia Island; 31. Mikindani; 32. Kilwa; 33. Old Sima, Comores; 34. Lakato'ni Anja; 35. Mahilaka; 36. Gordion (Marston 2017); 37. Asvan Kale (Nesbitt et al. 2017); 38. Middle Euphrates sites (Diban, Qaryat Medad, Tell Guftan, Tell Hrim) (Samuel 2001); 39. Mada'in Salih (Bouchaud et al. 2011); 40. Qalat Bahrain (Tenberg and Lombard, 2001); 41. Areni-1 (Wilkinson et al. 2012); 42. Merv (Nesbitt and O'Hara, 2000); 43. Hund; 44. Mehrgarh; 45. Balakot; 46. Harappa; 47. Kanmer; 48. Sanghol and Singh-Bhagwantpur; 49. Banawali, Kunal and Ludwala; 50. Hulas; 51. Ahichchhatra; 52. Hulaskhera and Sringaverapura; 53. Kausambi and Hetapatti (Pokharia et al. 2017); 54. Paturda; 55. Rithi Rajana (Nihildas et al. 2018); 56. Ostapur (unpublished data); 57. Paithan and Nevasa; 58. Hallur; 59. Perur; 60. Kodumanal; 61. Mangudi; 62. Kirinda (Murphy et al., 2018); 63. Wari-Bateshwar and Vikrampura (Rahman et al. 2020); 64. 65. 66. Sri Ksetra (unpublished data); 67. Prominthen Tai (D'Alpoim Guedes et al. 2019); 68. Ban Don Ta Phet 69. Khak Sam Kaeo; 70. Preah Khan of Kompong Svay, Angkor Wat, Ta Prohm and Angkor Thom (Castillo et al. 2018; Castillo et al. 2020). Sources for African sites, unless indicated above: this paper (Table 2) for western Africa, Bouchaud et al. (2018) for northeastern Africa, Crowther et al. (2018) for southeastern Africa. Sources for sites in India and Pakistan, unless indicated above (Fuller 2008).

processing, spinning, and weaving, and specialist weaver occupations found in Sanskrit and Prakrit (i.e. Indo-European Indic languages), and reconstructed for Proto-South Dravidian, the ancestor of Old Tamil (Southworth 2005; Fuller 2008). The Sanskrit term *karpā'sa*, "cotton," is of presumed non-Indo-European origin, and thus plausibly from an extinct language family formerly spoken in the Indus and/or upper Gangetic region (Masica 1979; Fuller 2003: Table 16.8; Fuller 2007). It is also clear that Southeast Asian languages, such as Old Khmer, have borrowed from Indian (Sanskrit) terminologies relating to cotton (Fuller 2008).

4. Northeast African cotton and the origins of *G. herbaceum*

There is a strong case to be made that *G. herbaceum* was domesticated in northeast Africa, perhaps in Sudan, although we lack any evidence for a domestication process or its clear association with a Neolithic/Bronze Age/Iron Age prehistoric culture in the region (Bouchaud et al. 2018; 2019). Ancient sources describe the import of Indian cotton to the main ports of Africa and Arabia, from where it was circulated throughout Egypt and perhaps the Mediterranean world (Table 1; Bouchaud et al. 2018). However, cotton imported from India was circulated through the area alongside locally produced fabrics (Livingstone 2009; Bouchaud et al. 2018). It is clear that cotton was favoured by the Meroitic elites during the first four centuries AD (Griffith and Crowfoot 1934; Adams 2010; Mayer-Thurman and Williams 1979; Clapham and Rowley-Conwy 2009; Yvanez 2016; Yvanez et al. 2019), and archaeobotanical evidence for cotton production and processing comes from central Sudanese Meroitic sites, such as Muweis and Hamadad (Fuller 2014; Bouchaud et al. 2018; Milon 2023), as well as northern Nubian Qasr Ibrim in Egypt (Clapham and Rowley-Conwy 2009). The exceptional preservation of a capsule, as well as ancient DNA, allowed for the Qasr Ibrim cotton to be positively identified as *G. herbaceum* (Palmer et al. 2012). Around the same time, new centres of cotton production seem to have emerged: the Kharga and Dakhleh oases, from where trade networks of cotton textiles had reached the Nile valley by the 2nd century AD (Table 1). The quantity of cotton described in these sources has given rise to the hypothesis that the volume of exported cotton was substantial, and that some of it was used as payment in kind (Bouchaud et al. 2018). It is plausible that at least some, if not much, of this new, Late Roman and Late Meroitic era cotton production, was based on the newly domesticated *G. herbaceum* of indigenous African origin, but it is also plausible that *G. arboreum* of South Asian origin had been introduced, which the Meroitic cloth identifications of Crowfoot and Griffith (1934) would imply.

G. herbaceum var. *africanum* (Watt) Vollesen is generally understood as "a reasonable model of the ancestor" (Hutchinson 1954), but the existing populations are unlikely to represent the actual progenitor populations. Existing variants of *G. herbaceum* var. *africanum* in southern

Table 1
Textual sources (Greek and Latin) during final centuries BCE/early centuries AD mentioning cotton, (after Bouchaud et al. 2018).

Author	Date	Description	Source	Refs*
Herodotus	445 BCE	"[In India] grows on wild trees wool more beautiful and excellent than the wool of sheep."	The Persian Wars, book III, c. 106.	10
Pliny the Elder	1st cent. AD	*Gossypinus/xylon* "wool-bearing tree" which grows on the Arabian side of Upper Egypt and Sudan	Natural History, 19.14	5
Arrian	1st – 2nd cent. AD	"The Indians wear linen garments according to Nearchus, the linen coming from the trees of which I have already made mention. This linen is brighter in colour than any other."	Indica, 16.1	10
Julius Pollux	2nd cent. AD	*Gossypinus/xylon* "wool-bearing tree" having as habitat the Arabian side of Upper Egypt and Sudan	Onomasticon 6.75	5
Unknown	2nd cent. AD	Indian cotton cloth and garments of different qualities were exported to the main ports of Arabia and Africa	Periplus Maris Erythraei (PME)	5, 6
Unknown	164–165 AD	Lands around Kysis bears cotton "wool-tree" among a list of economic trees (olive, date, fruit trees)	P. land. 7. 142	5
Unknown	4th cent. AD	Clothes-weaving shop, weaving workshop Rent-payment to landowner in cotton or in other commodities One *lithos* of cotton assigned to a woman for weaving	[Kellis Agricultural Account Book (KAB)] *KAB* 547, 556, 720: 1484 KAB 558	1, 5, 8
Unknown	237 CE 257 CE	Receipts for six years of harvests mentioning "substantial quantities of cotton"	[Ostraca] O. Kellis 68 O. Kellis 69	2, 5, 13
Unknown	4th cent. AD	List names of five women associated with cotton Mention of quantities of cotton Order to deliver cotton as a payment of *Annona militaris*	*O.Douch* 1.51 [temple of Kysis] O.Douch 5.537 & O. Douch 5.634 *O.Douch* 4.381 [Kysis military area]	5, 7 12 11
Unknown	4th cent. AD	Mention of quantities of cotton	*O.Trim* 38 & *O.Trim* 44 [Amheida, Dakhleh Oasis]	2, 4, 5
Unknown	2nd – 3rd cent. AD	Sending of a cotton garment from Psobthis to Oxyrhynchus in the Nile Valley	*SB.* 6.9025	5
Unknown	2nd – 3rd cent. AD	Making of garments from cotton thread	*SB* 6.9326	2, 5
Unknown	2nd – 3rd cent. AD	List of taxed goods in which cotton appears	P. Land 3.928	2, 5
Unknown	2nd – 3rd cent. AD	Mention of cotton garment	*P. Oxy.* 59.3991 [Oxyrhynchus]	3, 5
Unknown	2nd cent. AD	Mention of cotton goods having been sent from Rome	*P. Mich* 8.500.7 [private letter found at Karanis]	5
Unknown	mid 4th cent. AD	Destruction of the provisions of grain and cotton	Epigraphic record of the raid of the Aksumite king Ezana against the Meroitic kingdom	5, 9

* 1) Bagnall 1997, 2) Bagnall 2008, 3) Bagnall and Cribiore 2006, 4) Bagnall and Ruffini 2012, 5) Bouchaud et al. 2018, 6) Casson 1989, 7) Cuvigny and Wagner 1986, 8) Gardner et al. 1999, 9) Littmann, 1913, 10) Gulati and Turner, 1929, 11) Wagner 1999, 12) Wagner 2001, 13) Worp and Hope 2004.

Africa have not been observed to be used by the local population for its lint (Vollesen, 1987), and its southerly distribution of this species is distant from the most ancient archaeological evidence of the use of cotton in Africa (Clapham and Rowley-Conwy 2009). *G. herbaceum* var. *africanum* as wild progenitor of *G. herbaceum* either disappeared from Nubia, where *G. herbaceum* is considered to have been domesticated (Bouchaud et al. 2018; Moulherat et al. 2002), or it derived from a third, unknown and now extinct *G. herbaceum* subspecies (Viot 2019). *G. herbaceum* is understood to have been domesticated somewhere between 2500 BCE and the first half of the 1st millennium BCE (Bouchaud et al. 2019), prior to it becoming a significant cultivar during the Meroitic period (350 BCE-AD 350). Cotton cultivation and the production of textiles, widely attested by whorls and loom weights throughout the Meroitic world, can be seen as part of broader economy of craft specialization that included iron-working, ceramic fineware production and extensive long-distance trade (see Edwards 1996; Fuller 2014; Yvanez et al. 2019). The broader spread of cotton, from Libya through the Egyptian oases, Nubia and parts of the Arabian peninsula during the early centuries AD (Bouchaud et al. 2018) can be seen in many ways to parallel the growth of imported textile from India into the Roman world, implying increased consumption of cotton cloth by urbanized and cosmopolitan populations well beyond their zones of production. The growth in consumption encouraged both an increase in the trade and cultivation of cloth where that was possible, including oases in the Sahara and Arabia and in savanna-lands south of the Sahara and in South India.

5. Southeast Asian cottons

A parallel process of cotton spread can be traced around this same period, and possibly slightly earlier, into Southeast Asia. Traditional cotton production in Southeast Asia is patchier than that in the Indian subcontinent due to generally higher rainfall levels in many regions and two rainy seasons in the wettest parts of mainland Southeast Asia. Today, although there is some cotton production in the north and northeast of Thailand, it is not considered a favourable area to grow cotton, even if Thailand is a tropical country (Nuttonson 1963). Production is more widespread in Myanmar. Although cotton requires an abundance of water at the beginning of the season, it is sensitive to heavy rains and requires dry conditions when the fruit and seed develop (Fuller 2008; Brink 2011; Bouchaud et al. 2019). The difficulties of growing cotton in Thailand arise from the unpredictability of rainfall and the lack of cold weather that reduces the impact of pests (Nuttonson 1963). In the early part of the twentieth century, the Europeans made several attempts to introduce various cotton species from both the New World and Old World to Southeast Asia including the Malay Peninsula with no success (Burkill 1935). Failure was attributed to high humidity.

It therefore follows that if cultivated in Late Prehistory, farmers may have encountered similar problems. Nevertheless, it seems likely that the long-lived *G. arboreum* cotton trees were likely to have been more tolerant even if productivity was lower and highly variable. Lower productivity and reliability would have only served to increase the value of cotton products. Certainly during the 19th century, the naturalist Thorel (1873) reported that *G. arboreum* was common in hedges around fields in the Mekong Basin.

That cotton came to Southeast Asia from India is clearly indicated in linguistic data as Southeast Asian terms for cotton derive from those in India, in particular Sanskrit *karpā'sa* is the apparent source Old Khmer *krəpa:s*, Proto-Viet-Muong **k-pa:lh*, Proto-Katuic, Proto-Banharic and Proto-Pearic **kə-pa:jh* (Peiros and Starostin 2003; Fuller 2008).The earliest indigenous written sources in Southeast Asia are those in Old Khmer (9th century AD onwards) associated with the Angkorian empire, with its many famous monumental temples, and in these *karpas* [*krəpa:s*], occurs often, as do references to 'cloth' (Pou and Martin 1981; Pou, 2004). A recent review of some of the major Angkorian textual corpora indicates that references to cotton/cloth are frequent, surpassed only by references of rice (*Oryza sativa*) amongst mentioned plants in 12th century inscriptions, but is mentioned even more frequently than rice in a 10th century inscription (Castillo et al. 2020); mungbean (*Vigna radiata*) is the only other frequently mentioned crop, with other plant commodities such as peppers or fruits being rare.

Another early historical source on Southeast Asia is the Chinese written sources. Zhou Daguan was a Chinese ambassador who visited Angkor in 1296 CE; he described people wearing both silks and cottons (Harris 2007; Gunn 2011: 141–142). He records that "wild" people (ethnic minorities), living near Angkor cultivated the cotton tree, and weaved products that he deemed to be "coarse". Zhou also writes that textiles were also used as a currency, of higher value than cereals such as rice, but of less value than silver and gold (Harris 2007; Pelliot 1951). Garments are important items mentioned in the inscriptions as donations to temples, a practice also linked to Indian temple traditions (Castillo et al. 2020). However, activities related to cotton processing are not represented in any Angkorian reliefs (Green 2000; Green 2003). The inscriptions at both Preah Khan and Ta Prohm mention six hundred and forty-five and six hundred and forty sets of garments respectively in white and red for the gods (Maxwell 2008). Silk or silk cloths are specifically mentioned in the inscriptions (Coedès 1906; Maxwell 2008), we therefore propose that these pieces of clothing and garments are different from the 'silk' mentioned in the inscriptions and are most probably cotton garments.

Even earlier Chinese sources refer to cotton cloth and weaving in northern Vietnam and adjacent Guangdong, China, i.e. ancient Champa (*Chan-po*), during the Tang Dynasty sources (8th-9th century) (Shafer 1963: 205-206; Shafer 1967: 180-181). The earliest Chinese imports of cotton date back the end the Han Dynasty (3rd century), apparently including both "silk road" sources via central Asia and southern sources via Southeast Asia (Shafer 1963: 205). By the later Tang Dynasty (8th century), Chinese sources indicate that household cotton weaving was commonplace among the "Southern Yueh" or "Nam-Viet" people (modern Guangdong/northern Vietnam). Chinese terms for cotton in that period included **kuo-puâi* derived from Sanskrit *karpāsa* (via Southeast Asia languages) and *b'nk-d'iep* (or *pai-tieh*) related to Persian *bagtak*, Indian Pali *patāka* (Shafer 1963: 327, n. 92–93; Dale 2009). The import of Indian cottons via Central Asia to China was such a consistent pattern that Dale (2009) suggests that from the Chinese perspective this was as much a "cotton road" as it was a "silk road" from the western perspective. In addition, cotton was known among the Chams, people who lived south of the Red River (presumably Austronesian speakers), and whose king was described as dressed in cotton with golden beads as ornaments (Shafer 1967: 72). Colored cotton cloth (*Varnakā,* Middle Chinese **jiwat-nâk*) was also imported to Tang China from Pyu Burma (Shafer 1963: 201).

Archaeological evidence, although limited, indicates that cotton, presumably under cultivation was established in parts of Southeast Asia prior to these written sources (Fig. 4). Given the inference that all early Indian cotton was tree cotton, and the later Chinese description of Angkorian use of cotton, we infer that all of these finds are probably *G. arboreum.* Cotton is first identified in Southeast Asia during the late prehistoric period. Early archaeobotanical remains include charred seed fragments from Khao Sam Kaeo (400–100 BCE) in southern Thailand (Castillo et al. 2016). A cotton thread found preserved adhering to human bones from a grave at Ban Don Ta Phet was dated to ca. 390–360 BCE (Cameron 2011). The material culture found in these sites shows the emergent trade links with India through the material culture, that eventually led to more sustained contacts which facilitated the transfer of the Indic religions, Hinduism and Buddhism, into Southeast Asia. Continued presence of cotton during the Dvaravati period is documented in the Central Thai site, Phromthin Tai (d'Alpoim Guedes et al. 2019). In central Thailand the site of Tha Kae produced a large assemblage of spindle whorls (300 BCE-AD 300), including a new spindle whorl form and iron spindles that appear to have derived from South Indian forms (Cameron 2011). Cameron (2011) infers that the adoption of cotton and cotton production from India took place in the context of Iron Age craft diversification dating to the first millennium AD. In Myanmar at the site of Sri Ksetra, AD 600–800 (Stargardt 2016; Stargardt et al. 2017), we have recently identified cotton seed fragments (Fuller/Castillo, unpublished data). In the case of seed remains and spinning evidence, it is always possible that they were processed but not grown locally, especially where a very wet climate and limited dry season might make cotton boll maturation difficult; this is unlikely the case for Sri Ksetra in the dry (teak forest) zone of central Myanmar. It might, however, have been the case at Khao Sam Kaeo, an urban site in the wet tropics of southern Thailand that would have provided ample labor for processing, as would have also been the case at Angkor Wat. Nevertheless, production of cotton in groves can still be inferred to have been taking place somewhere in the wider agricultural landscapes of these regions.

Cotton appears to have been a major product in ancient (Medieval) Cambodia associated with the Angkorian empire. Recent archaeobotanical research based on systematic flotation has been carried out at Preah Khan of Kompong Svay (10th-12th c AD), Angkor Wat (11th-13th c. AD), Ta Prohm (8th-14th c AD) and Angkor Thom (14th-15th C. AD) (Castillo et al. 2018; Castillo et al. 2020; Castillo 2023). Whole charred seeds are rare, but seed fragments of *Gossypium*, especially funicular caps have been found from all of these sites. Cotton had a quite high ubiquity in these sites (n refers to raw counts): 27 %, n = 3 (Preah Khan of Kompong Svay) 29 %, n = 41(Angkor Wat), 50 %, n = 155 (Ta Prohm) and 50 %, n = 5 (Angkor Thom). It therefore is likely that fiber processing, including deseeding, was carried in or around these temple cities on a household level. At Ta Prohm, cotton finds accounted for 74 % of economic plants in pre-temple levels (8th-10th c AD), even outnumbering rice, the presumed staple grain; this suggests that inhabitants of this site were heavily engaged in cotton processing. There was a high demand for cotton which meant the capital of Angkor engaged in cotton processing, but also in peripheral sites such as Preah Khan of Kompong Svay 100 kms away from the capital. Thus, in mainland Southeast Asia, the evidence for increased social differentiation, associated with an urbanized state, taxation and the requirements for rituals and the temple offerings, correlates with increased production of textiles and increased cotton cultivation.

The beginnings of cotton cultivation in Southeast Africa is connected to trade contacts and crop introductions from Southeast Asia and India to East African islands (Boivin et al. 2013). The traditional pre-modern cottons in these areas are likely to have been *G. arboreum,* and colonial era botanists compared them taxonomically with the "rozi" tree cottons from Gujarat (race *indicum* Silow) (Hutchinson and Ghose 1937; Hutchinson 1954). Archaeobotanically, cotton occurs on sites that also have evidence for rice (*Oryza sativa*) and usually mungbean (*Vigna radiata*), pointing to an association with tropical Asian crop

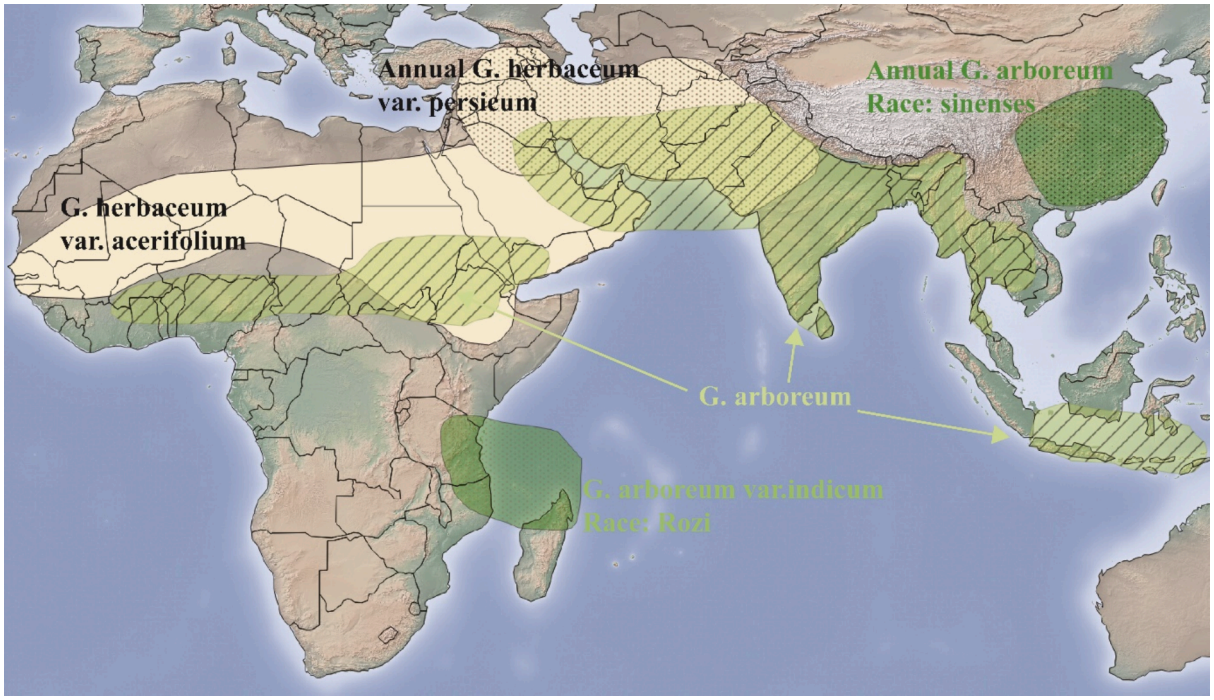

Fig. 4. Map of inferred distribution of major cotton varieties by early Medieval/Islamic times (ca. AD 700); based on discussion in this text; also see Brite and Marston 2013; Viot 2019.

introductions, and the beginnings of Austroasiatic movements across the Indian ocean (Crowther et al. 2016). This period is also associated with urbanization and agricultural innovation (Walshaw 2010; Fleisher and LaViolette 2013). Tree cotton was an important traditional crop in Madagascar, especially in the South and West, although there also was a local traditional variety of *G. herbaceum* that had presumably been introduced from Africa (Beaujard 2017: 253).

6. Western African cottons: Two routes for two species

Cotton is not native to western Africa, but both *arboreum* and *herbaceum* cottons, as well as New World species, are traditionally cultivated. We therefore can infer at least two introductions of cotton, starting in the later Iron Age, which also fits with differences in their traditional cultivation. It is notable that despite being established at Old Jarma in Southwest Libya by ca. AD 200, there are no secure finds in West Africa older than AD 500 and most date to after AD 1000 (Table 2). This suggests that local readiness to produce cotton had to await either changes in agricultural practice or urbanization, and associated craft specialization that accompanies it, or both. In terms of agriculture, most of the Neolithic through early Iron Age agriculture in western Africa was very focused on pearl millet (*Pennisetum glaucum*), with diversification into a wider range of crops beginning mainly in the early centuries AD (Champion and Fuller 2018a). Based on colonial records of the traditional distribution of the two Old World cotton species in western Africa, we suggest that these reached the west by two different routes, which we will refer to as the "savannah route" linked to *G. arboreum* race soudanense, and the "oasis route" linked to *G. herbaceum* (Fig. 5). Early finds

Table 2
West African Archaeological sites with cotton remains.

Site	Country	Date (cal. AD)	Putative species	Putative Route	Reference
Jarma	Libya	140–380	*G. herbaceum*	Oasis route	Pelling 2005
Essouk	Mali	950–1400	*G. herbaceum*	Oasis route	Nixon et al. 2011
Dia	Mali	1000–1400	*G. herbaceum*	Oasis route	Murray 2007
Gao	Mali	1400–1550	*G. herbaceum*	Oasis route	Fuller 2000
Togu Missiri	Mali	1200–1300	*G. herbaceum*	Oasis route	Champion 2019
Sorotomo	Mali	1200–1450	*G. herbaceum*	Oasis route	Champion 2019
Tellem	Mali	1000–1400	Textile	Oasis route	Bedaux 1972
Akumbu	Mali	1200–1400	*G. herbaceum*	Oasis route	Champion 2019
Birnin Lafiya	Benin	800–1000	*G. arboreum*	Savanna route	Champion and Fuller 2018b; Champion 2019
Birnin Lafiya	Benin	1200–1950	*G. herbaceum*	Oasis route	Champion and Fuller 2018b; Champion 2019
Bogo-Bogo	Benin	1400–1600	*G. herbaceum*	Oasis route	Champion and Fuller 2018b; Champion 2019
Tintin	Benin	1000–1400	*G. herbaceum*	Oasis route	Champion and Fuller 2018b; Champion 2019
Madekali	Benin	1400–1600	*G. herbaceum*	Oasis route	Champion and Fuller 2018b; Champion 2019
Niyanpangu-bansu	Benin	1400–1600	*G. herbaceum*	Oasis route	Champion and Fuller 2018b; Champion 2019
Korop	Senegal	1500–1800	*G. herbaceum*	Oasis route	Sticker 2016
Payoungou	Senegal	1800–1900	*G. herbaceum*	Oasis route	Sticker 2016
Juffure	Gambia	1700–1900	*G. herbaceum*	Oasis route	Gijanto and Walshaw 2014
Djoutoubaya	Senegal	950–1400	*G. herbaceum*	Oasis route	Mayor et al. 2019
Mege	Nigeria	700–1500	*G. arboreum*	Savanna route	Bigga and Kahlheber 2011
Old Buipe	Ghana	1300–1900	*G. herbaceum*	Oasis route	Genequand et al. 2020
Surame	Nigeria	1400–1650	Probably both	Probably both	Champion, this study
Shira	Nigeria	1350–1550	Probably both	Probably both	Champion, this study

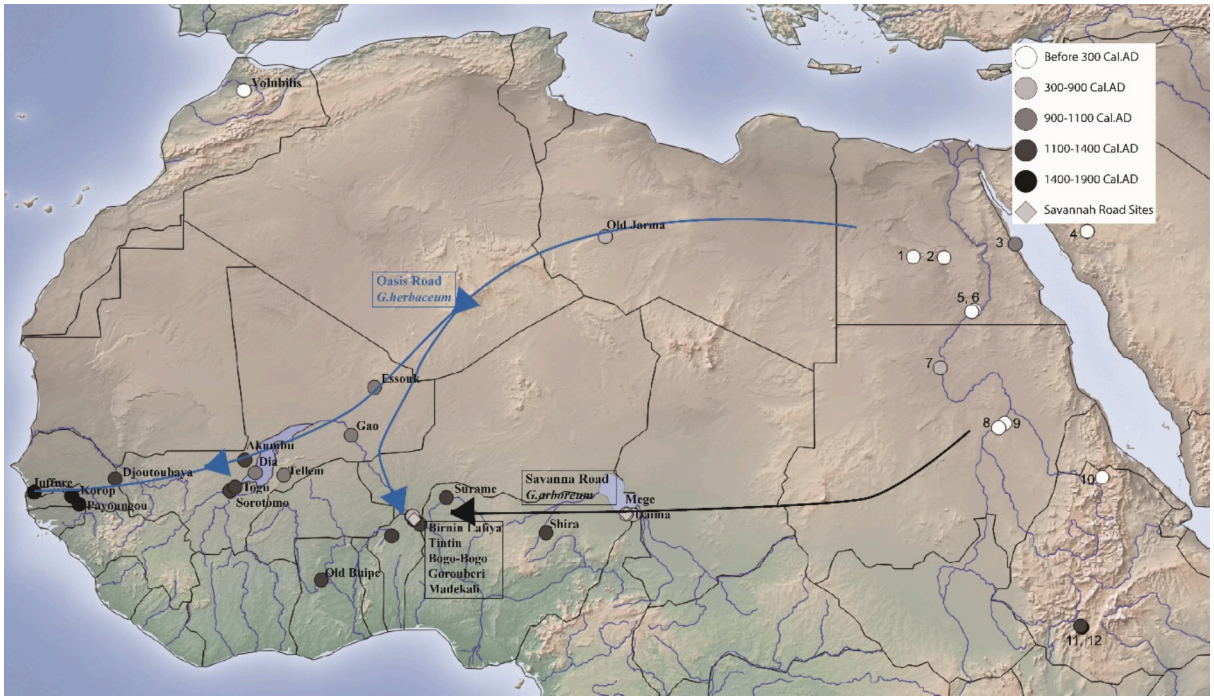

Fig. 5. Map of archaeobotanical cotton seed evidence in Africa, with inferred oasis and savanna routes for westward dispersal. West African sites labelled with names (see Table 2), other sites numbered: 1. Dakhleh oasis sites; 2. Kharga oasis sites; 3. Al-Zarqa; 4.. Mada'in Salih; 5. Quesir al-Qadim; 6. Qasr Ibrim; 7. Nauri; 8. Muweis; 9. Hamadab; 10. Axum; 11. Tuwatey Zonga Cave; 12. Garu Songalay (sources: see Table 2; 1–10 reviewed in Bouchaud et al. 2018; 11. Arthur et al. 2019; 12. Fuller, unpublished).

of clay spindle whorls suggest two zones for the development of textile production in western Africa, which we can suggest connect to these two cotton dispersal processes, one northeast of Lake Chad from the 8th century AD and the other in the middle and upper Niger valley from the 10th century (Kriger 2005). The distribution of west African archaeological cotton—seeds and textiles—is plotted in Fig. 6.

Historical sources suggest that clothing and the use of cloth, presumably much of it from cotton, became important during the Islamization of western Africa, and urban centres of the Islamic era (Kriger 2005; Candotti 2010). "Wearing clothes became an indication of the conversion to Islam and belonging to the Islamic *umma* (community)" (Candotti 2010, 189). This fits the archaeobotanical evidence for cotton from all Islamic era urban centres that have had archaeobotanical sampling (see Table 2; also, Nixon et al. 2011), from ca. AD 1000 onwards. The extent to which cotton was cultivated elsewhere in western Africa prior to this is unclear (cf. Kriger 2005). Sets of loan words in several language groups suggest borrowing from Arabic speakers (Kriger 2005). Linguistic evidence suggests that *shigge*, a term for cotton cloth, was used in West Africa (Mali) in the 11th century and since the 9th century there was a cotton market in Kano, Nigeria (Dalziel 1937). In the Dendi area, in the 1960s the French introduced a new cotton variety (*G. hirsutum*); before then the population cultivated "*indigenous cotton*" (Van Driel 2001). The presence of cotton and African rice fields is documented by the Portuguese on their arrival on the African coast in the 15th century: In 1446 the chronicler Gomes Eanes de Azurara states, *"They found the country covered by vast crops, with many cotton trees and large fields planted with rice…"* (Linares 2002:16360). But sources suggest that different parts of western Africa had a focus on different cotton species, and as we review below (also Table 2), this forms the basis of our hypothesis of two routes of cotton dispersal.

The oasis route, we propose represents the spread *G. herbaceum* from Nubia via oases in the Sahara and onwards to the Inland Niger region and more Sahelian areas, such as Senegal. As already noted, Qasr Ibrim in Egyptian Nubia provided the only unambiguous archaeological evidence, based on aDNA, for *G. herbaceum* in the early centuries AD (Palmer et al 2012). In this same period cotton arrived in the Fezzan region of Southern Libya, a Saharan oasis (Pelling 2005), alongside finds in various Egyptian oases (Clapham and Rowley-Conwy 2009; Bouchaud et al. 2018). Colonial era observations, such as those of Chevalier (1936; 1939) indicate that perennial *G. herbaceum* was common as a relict cultivar in much of the Saharan region. A study of traditional cotton cultivation in Senegal also notes that aside from new World taxa it is *G. herbaceum* that is encountered (Beye 1986). We associate this dispersal with irrigation systems, such as the qanats that emerged in the Saharan oases in the early centuries AD (Drake et al. 2004). In western Africa, cotton appears in the middle Niger region (modern Mali) around the 10th century. Its timing, and often urban contexts, suggest it is associated with the Islamic period, raising the likelihood that it is connected to new Islamic identities and *trans*-Saharan trade. It should be noted that this African oasis expansion of *G. herbaceum,* is probably parallel to its adoption in Arabian oases (e.g. Bouchaud et al. 2011) and its spread through the Middle East and Central Asia (see Brite and Marston 2013), although the latter involved the evolution of annual *G. herbaceum* var. *persicum.* Much of this temperate expansion in western and central Asia is associated with Islamisation (Watson 1983; Bulliet 2009), but it is likely to have started earlier. Cotton cloth was apparently found at Shahr-I Zohak fortress in Afghanistan from sometime in the Pre-Islamic First Millennium AD (Baker and Allchin 1991: 69). More reliable evidence comes from Kara-tepe in Uzbekistan before AD 500 (Brite and Marston 2013). Thus the oasis route by which *herbaceum* cotton spread west across the Sahara, and east through Arabia had a northerly side branch on which an annual form evolved and adapted to regions with a cold winter.

The second trajectory of cotton to western Africa probably followed a more southerly, savanna route. The savanna belt extending from the central Sudan through the lake Chad region and westwards, remains poorly explored archaeobotanically. It is postulated that this same route transmitted *Sorghum* crops of race *bicolor* and ancestral to race *guinea*, in contrast to a Saharan oasis dispersal of race *caudatum* (Fuller and Stevens 2018). *Gossypium arboreum* was naturally well adapted to such

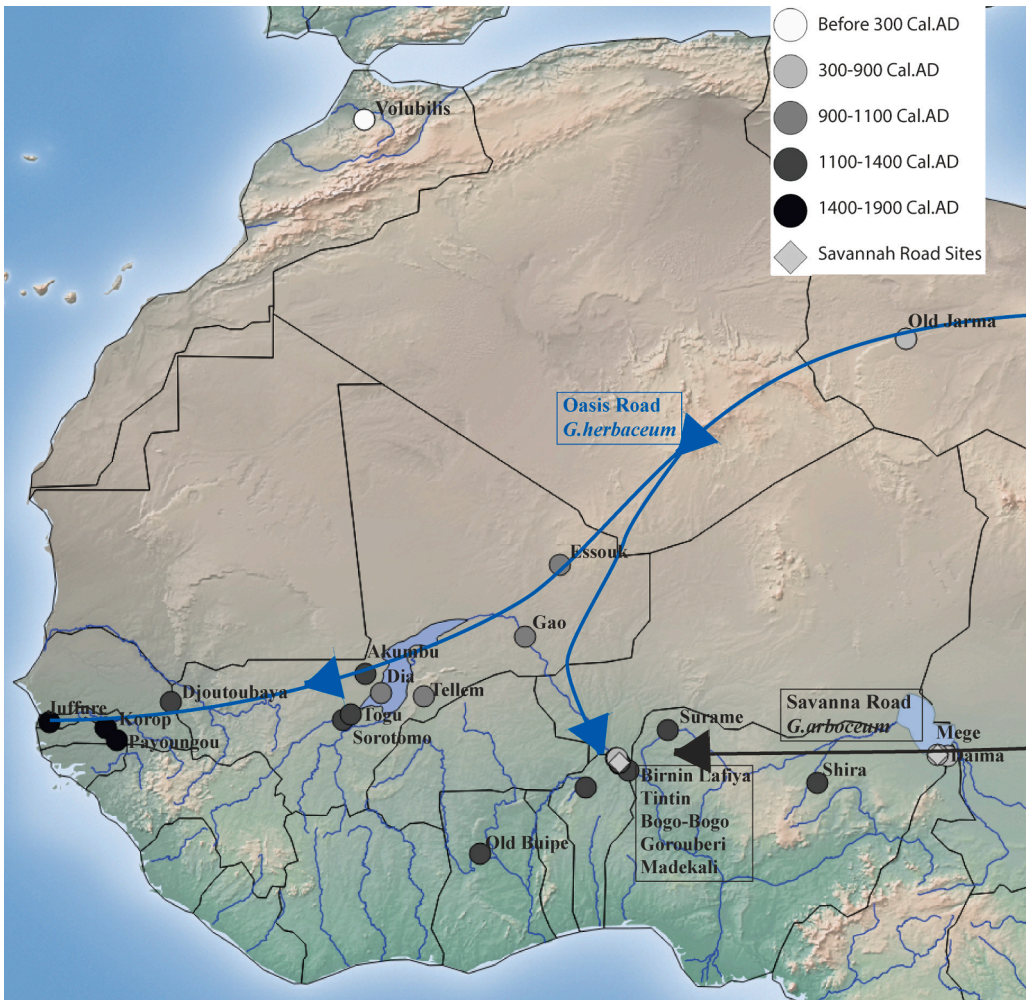

Fig. 6.

environments, from its South Asian ancestry, and it could be cultivated as a rainfed savanna tree crop. It seems likely that tree cotton was adopted into savanna agriculture in the southern Meroitic regions of central Sudan, as well as around the lower to middle elevations of the Ethiopian plateau, where it remains a persistent minor crop until recent times (Nicholson 1960). Tree cotton may lend itself to being grown on a small scale, with one or two trees in a household garden, but as with all textile crops the investment in its processing provided a potential link to trade networks and wealth generation.

Currently, the savanna route is represented by only two sites with archaeobotanical evidence, Birnin Lafiya in Benin (Champion and Fuller 2018a; 2018b) and Mege in Nigeria (Bigga and Kahlheber 2011) dated to 900–1000 CE. Based mainly on the distribution of relict populations recorded by Chevalier (1936; 1939), Hutchinson and Ghose (1937) and Hutchinson (1959), the cotton remains from both sites can be suggested to be *G. arboreum*. In the Lake Chad area, the archaeobotanical assemblage of Mege shows the appearance of a large number of cotton remains, *Gossypium* sp., around the late Iron Age, AD 700–1500 (Bigga and Kahlheber 2011). The presence of cotton coincided with the rise of the Kanem Kingdom that quickly controlled commercial routes in the area. Through these routes, slaves, ivory and goods like beads and salt from the North and East were traded (Insoll 1997). Cotton was probably a cash crop on these trade routes. The disappearance of cotton, during the Early Historic phase, 1450–1500 CE, corresponded to internal revolts that pushed the kings of Kanem to move to the Bornu region.

7. Conclusions

Unlike most annual seed crops, which are primarily caloric foods for people or livestock, cotton is primarily grown as raw material. Cotton requires surplus labor and land, but also specialised knowledge on growing requirements. Thus, the evidence so far, implies that cotton was cultivated when social complexity coupled with trade and agricultural diversification occurred. We see this correlated with the emergence of social hierarchy in South India and the Ganges basin in the era immediately preceded by urbanization. Elsewhere, cotton cultivation is closely associated with early urbanization in mainland Southeast Asia, Mali, Benin, Nigeria, Saharan oases (Essouk, Jarma), Axumite Ethiopia, and the middle Iron Age of the Swahili islands off the coast of southeastern Africa. In the case of Nubia, cotton production is closely associated with the Meroitic period, the period of most extensive imperial integration in the region. However, it is unclear, and currently there is no evidence, for cotton associated with either the initial experiment in Nubian urbanization at Kerma (3rd-2nd millennium BCE), nor with the emergence of the Kushite (Napatan) empire that conquered Egypt as Dynasty 25. Nevertheless, for the most part cotton is associated with societies that had investment agriculture (*sensu* Fuller and Stevens 2019), associated long-distance trade, intra-societal wealth, and status hierarchies. This raises the question as to whether the earliest cotton finds at Mehrgarh mark a transition from a simpler Neolithic village system to something more regional and hierarchical. Otherwise, Mehrgarh could be a Neolithic exception to a more general rule of the involvement of hierarchical societies in Old World cotton production.

While cotton generally falls into a secondary phase of agricultural diversification that included cash crops, the geographical zones occupied by the two Old World species only partly overlapped. It is certainly the case that both forms could be found in South Asia and in Africa (especially in Sudan), but in terms of their early dispersal trajectories we have identified alternative foci. For *G. herbaceum* there was a tendency for it to follow oases, the development of irrigation systems and eventually to spread north as annual forms developed. One might note that in most of these regions *G. herbaceum* spread readily into areas that had established textile traditions based on flax or wool. By contrast, *G. arboreum* remains more focused on savanna regions, and areas that tended to be beyond the range of flax production, and often occupied by hairsheep rather than woolly breed. In such areas, tree cotton was a main fine textile crop, competing perhaps with coarser bast fibers (such as various African Malvaceae). Such hypothetical patterns warrant further testing, as does a material and archaeological perspective on the transformational impact of higher yield annual cottons of American origin.

CRediT authorship contribution statement

Dorian Q Fuller: Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing. **Louis Champion:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – review & editing. **Cristina Cobo Castillo:** Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Anna den Hollander:** Data curation, Formal analysis, Investigation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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