BEITRÄGE ZUR SUDANFORSCHUNG. BEIHEFT 9

THE KUSHITE WORLD

PROCEEDINGS OF THE 11TH INTERNATIONAL CONFERENCE FOR MEROITIC STUDIES VIENNA, 1 – 4 SEPTEMBER 2008

THE KUSHITE WORLD

PROCEEDINGS OF THE 11TH INTERNATIONAL CONFERENCE FOR MEROITIC STUDIES

VIENNA, 1 – 4 SEPTEMBER 2008

Edited by Michael H. Zach

Vienna 2015

BEITRÄGE ZUR SUDANFORSCHUNG. BEIHEFT 9

Publisher: Verein der Förderer der Sudanforschung
c/o Department of African Studies
University of Vienna
Spitalgasse 2, Court 5.1
1090 Vienna
Austria

Printing House: Citypress
Neutorgasse 9
1010 Vienna
Austria

Front Cover: Northern Pylon of Naqa Apedemak Temple (© Department of African Studies, Inv. No. 810)

ISSN: 1015-4124

THE ECONOMIC BASIS OF THE QUSTUL SPLINTER STATE: CASH CROPS, SUBSISTENCE SHIFTS, AND LABOUR DEMANDS IN THE POST-MEROITIC TRANSITION

Dorian Q. Fuller

Abstract
This paper provides a synthetic review of archaeobotanical evidence and other sources of inference on past agricultural systems over the long-term in Nubia, with a focus on the transformations of the Late Meroitic period to the Post-Meroitic period. The adoption of double-cropping in the north, facilitated by *saqia* irrigation made new labour demands, creating a demographic vacuum, while agricultural innovation and intensification also allowed more effective cash-crop production in Nubia, including cotton and for a period grapes. The resulting increase in population and local wealth production provided the necessary economic foundation for an independent polity. The *saqia* effect combined with savanna crop effect created a population sink in northern Nubia, which allowed for the emergence of local peasantry on which a state system could be based. The foundation of the Qustul-Ballana state can be attributed at least in part to these economic developments.

Introduction

Within two centuries of the last royal pyramid of Meroe the region that had once been within the territory of a expansive pagan state was one of three distinct states—Nobatia, Makuria and Alwa—all embracing Christianity (Welsby 2002; Edwards 2004). The Meroitic civilization of the Sudan was an expansive and long-lived state which left its mark on the landscape but its transformation into three successor states remains a subject of scholarly speculation and debate. In the present contribution I would like explore some additional factors that contributed both to the transformation of social conditions in northern Nubia as well as the fragmentation of the Meroitic state. In essence I will argue that agricultural innovations in Lower Nubia, including some introduced from both north and south, contributed to the collapse of the Meroitic state in as much they established the economic and demographic basis for political and military power of a splinter polity. Aspects of these agricultural innovations can in turn be attributed to social motivations that had been created by the expansion of the Meroitic state and its successes in the trade of prestige goods in previous centuries.

Numerous hypotheses have been proposed for explaining the Meroitic collapse, but none of them provides an entirely convincing model, and many merely defer issues of causality. Invasions have often figured prominently in histories of the end of Meroe, including invading "Noba tribes" from the South or West (e.g. Kirwan 1957; 1958; 1960; Williams 1991b: 158-160; Török 1988: 219 ff.); including Blemmyes from the East into Lower Nubia (e.g. Williams 1991b: 157; cf. Christides 1980). The military conquest of Meroe by Axum seems well-established (Arkell 1955: 171-173; Kirwan 1957; 1960; Shinnie 1967: 52-55; Török 1988: 33), but begs the question as to why Meroe city after becoming a vassal of Axum should have been largely abandoned and splinter states in the North emerged. Increasing political independence of Northern Nubia from the Meroitic core has been proposed as a key factor (e.g. Adams 1976; Millet 1981; Fuller 1997) but also heavily criticized (e.g. Török 1984a; 1997). The importance of trade with the Roman empire for supporting the Meroitic economy and the collapse of this trade has also been proposed (e.g. Hintze 1978; Török 1988: 41; 1999: 151), although there is little doubt that Roman items still made their way to Nubia (in general, cf. Török 1989)—found in quantity in Qustul (Török 1988; Williams 1991b); Gemai (Bates and Dunham 1927; Török 1988), and to a lesser degree at Kalabsha (Strouhal 1984) and Qasr Ibrim (Mills 1982), and even El Hobagi (Lenoble and Sharif 1992; Lenoble 1999a). Thus, the question remains as to how changing patterns in their distribution in Nubia can be related to the causes and consequences of the collapse of the Meroitic kingdom and its urban

centre at Meroe. Other authors have proposed environmental factors, such as deforestation of the area around Meroe and its hinterland, which heavily used wood to produce iron (Hintze 1978; Katznelson 1973: 83). Nevertheless iron weapons continue to be found in Post-Meroitic graves, and are generally more widespread and arguably more numerous (cf. Williams 1991a; 1991; Lenoble 1997; 1999b). The possibility of climatic change towards drier conditions can also be suggested (see below). The purpose of this paper is to argue that many of these factors can be linked together and more adequately explained by considering the economic, and particularly agricultural basis, of the Meroitic kingdom and how it was transformed over the Late Meroitic and Post-Meroitic periods. The extent to which climatic changes took place, they need to be understood in terms of their impacts on local agricultural systems, and the patterns of trade and migration must be seen in terms of demographic trends linked to agricultural productivity and population sinks and surpluses.

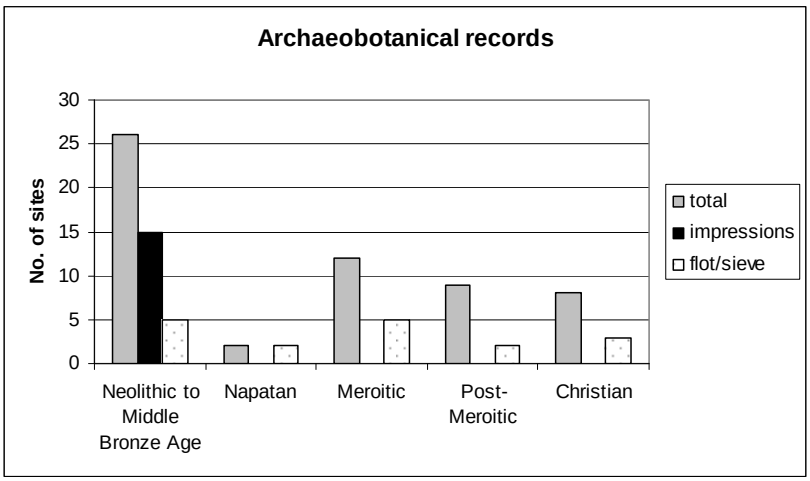

Fig. 1: The Nubian Archaeobotanical Record: A summary of coverage, or lack thereof. (Based on a database of 57 published archaeobotanical datasets from Sudan/Egyptian Nubia; see Tables 1-3, below; for references, see Appendix.)

The agricultural long-term of Nubia: The establishment of a Kushite pattern

Archaeobotanical evidence for agriculture in Northern Nubia is limited (Figure 1). Despite a wealth of settlement and cemetery evidence from Lower Nubia, most work was carried out before sieving was routine or field flotation had been developed, so archaeobotanical evidence for agriculture is rather patchy, with the notable exception of Qasr Ibrim (Rowley-Conwy 1989; Clapham and Rowley-Conwy 2006; 2007). Nevertheless, the overall picture appears to be one of continuity in the importance of barley and emmer wheat as cereal staples, which were established by the end of the Fourth Millennium B.C. (the A-Group period, cf. Lal 1967; Chowdhury and Ghosh 2005). The limited evidence from C-Group and Kerma finds indicates the presence of these Near Eastern cereals (Table 1), which were also the staples of Egypt (Murray 2000), and there is not evidence for any indigenous sub-Saharan cultivars in Nubia at this time.

Despite the evidence for morphologically wild sorghum and several other wild savanna millet grasses (*Panicum, Paspalum, Setaria, Pennisetum*) from impressions of temper in Neolithic ceramics from the Central Sudan (Magid 1989; Stemler 1990), there is no evidence that these were cultivated. The argument of Haaland (1995; 1999) for non-domestication cultivation relies on quantities of grindstones, but these are *post-harvest processing* tools that would have been equally necessary for the exploitation of collected wild grasses. The quantities suggest intensification of grass seed use, but not cultivation. Her suggestion, following Magid (1989), that cross-pollination in sorghum would have slowed down, or stopped, domestication by contrast to self-pollinating Near Eastern wheat and barley, can now be rejected by improved archaeobotanical evidence for self-pollinating species (wheat and barley) and cross-pollinating species (e.g. rice), since both kinds of cereals consistently show a protracted domestication process (Fuller 2007; Fuller *et al.* 2009; Purugganan and Fuller 2009), and if cultivation of sorghum had begun we would expect some evidence for shifts towards domesticated morphotypes.

Unfortunately, the archaeobotanical evidence is so limited at present that we are able to say little about the domestication process in sorghum. The wider archaeobotanical database for sorghum highlights major gaps in the evidence (Figure 2). In the Eastern Sahara and Sudan, there was Early and Mid Holocene use of wild *Sorghum arundinaceum*. Then finds of fully domesticated forms occur in the Meroitic period in the Nubian Nile and in parallel in the Fezzan of Southwest Libya. The latter evidence included, an advanced type of free-threshing sorghum, probably race *caudatum* (Pelling 2005), and as such indicated that sorghum had been evolving *as a domesticate* for some considerable period. Evidence that domesticated sorghum reached India by 2000-1700 B.C. (Fuller 2003a), implies that its cultivation, and probably domestication, had started prior to this somewhere in the savanna zones between Lake Chad and Ethiopia, but perhaps not in the Nile Valley.

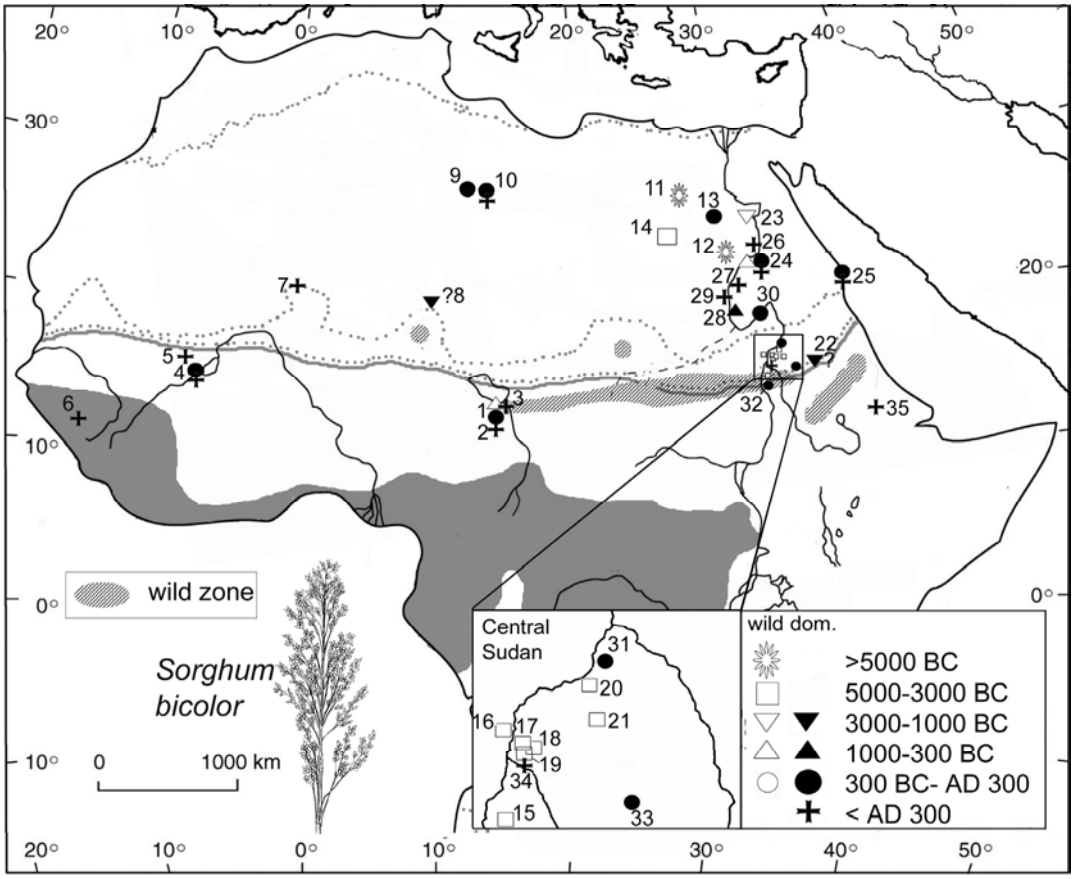

Fig. 2: A map of archaeobotanical sites with finds of sorghum, by broad time horizon. Domesticated finds indicated by black symbol; wild finds, by white symbol. Question marks indicate uncertain domestic identifications. General distribution of wild progenitors is based on Harlan (1971; 1992). 1. Kursakata (wild, ca. 1000 B.C.; dom., Iron Age); 2. Mege, Iron Age; 3. Daima (ca. A.D. 900); 4. Jenne-Jeno (Iron Age & Medieval); 5. Dia-Shoma (medieval); 6. Naini, (ca. A.D. 800); 7. Essouk (ca. A.D. 1000); 8. Adrar bous (wild?, c. 2000 B.C.); 9. Tinda (ca. 100 B.C.); 10. Jarma (ca. 100 B.C. onwards); 11. Farafra (wild, ca. 5900 B.C.); 12. Nabta Playa (wild, ca. 8000 B.C.); 13. Karga (ca. A.D. 300); 14. Abu Ballas (wild, ca. 4000 B.C.); 15. Rabak (wild, ca. 4300 B.C.); 16. Shaheinab (wild, ca. 3500 B.C.); 17. El Zakiab (wild, ca. 4000 B.C.); 18. Kadero (wild, ca. 3600 B.C.); 19. Um Direiwa (wild, ca. 4000 B.C.); 20. El Kadada (wild, ca. 3500 B.C.); 21. Shaqadud Cave (wild ca. 3000 B.C.); 22. Kasala JEG/SAG (ca. 1500 B.C.?); 23. Tutakhamun Tomb (wild, ca. 1300 B.C.); 24. Qasr Ibrim (wild, ca. 1000 B.C.; dom., ca. 100 B.C. onwards); 25. Berenike (ca. A.D. 100); 26. Wadi Qitna (ca. A.D. 300); 27. Faras East (ca. A.D. 400); 28. Kawa (ca. 500 B.C.); 29. Nauri (ca. A.D. 1000); 30. Umm Muri (ca. 100 B.C.); 31. Meroe (ca. A.D. 100); 32. Jebel Tomat (ca. A.D. 100); 33. Abu Geili (ca. A.D. 100); 34. Soba (ca. A.D. 700); 35. Axum (for references, see Appendix)

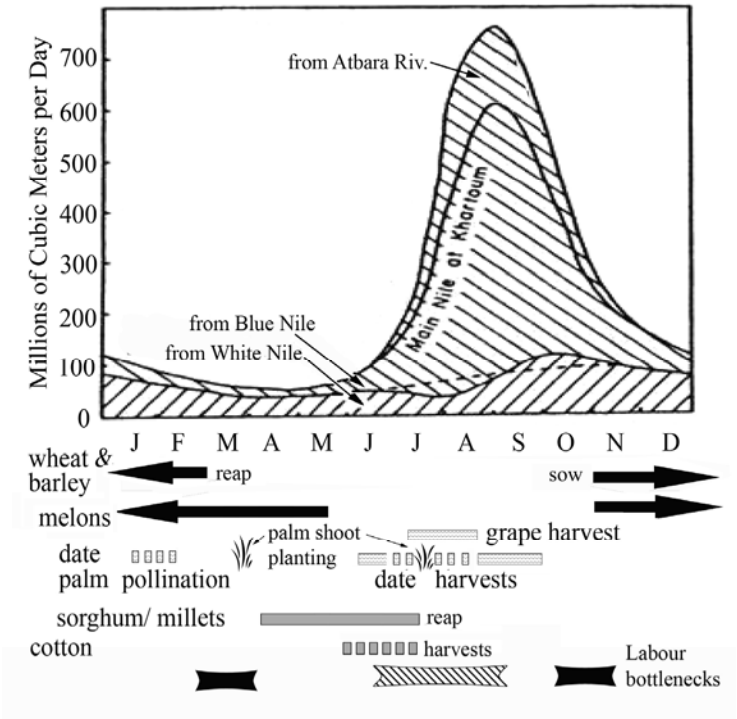

Fig. 3: Middle Nile seasonality and conventional cropping seasons of ancient Nubian crops.

The evidence of Nubia therefore suggests that the original agricultural cycle in Nubia was like that in Egypt, focused on winter cultivation based on receding Nile floods (Figure 3). The summer season of low Niles would not have been very conducive to cultivation without irrigation, except over very limited land areas or of very tolerant crops. Of interest in this regard is the report of broomcorn millet (*Panicum miliaceum*) from Kerma period Ukma (Van Zeist 1987). *Panicum miliaceum* is an early Neolithic domesticate of North China (Hunt *et al.* 2008; Barton *et al.* 2009; Lu *et al.* 2009), and it is the most arid tolerant crop of Asia, with a short growing season (~3 months) and minimal water requirements (the only cereal of comparable tolerance is pearl millet, *Pennisetum glaucum,* from West Africa). It should have been able to cope on the banks of the falling summer Nile without irrigation and to have provided some additional subsistence and risk-buffering to prehistoric Nubia. Its adoption in Kerma period Nubia, appears as the only clear example of an early South Asia to Africa crop-dispersal to balance the spread of African savannah crops (sorghum, pearl millet, hyacinth bean) to India by 2000-1700 B.C. (Boivin and Fuller 2009; see Fuller 2003a for the Indian evidence of African crops). Broomcorn millet has been reported from before 2000 B.C. in Yemen, and by 1900 B.C. in Pakistan, while it is unknown at this time in Egypt (cf. Murray 2000) nor in the Mesopotamia region until the end of the Second Millennium B.C. (Nesbitt and Summers 1988).

The other important addition to cultivation in Nubia during the Bronze Age was fruits (see Table 1). Watermelons and dates are both evident at Middle Kingdom Semna, and further reports of date remains (mainly wood charcoal) from Kerma period graves in the Kerma period. Date cultivation had its origins much earlier (5000-4000 B.C.) in Eastern Arabia and the Persian Gulf (Tengberg 2003; Boivin and Fuller 2009), and its spread was restricted probably in large part due to the labour demands of cultivation, requiring both watering and time-consuming hand-pollination. An increase in date palm cultivation, presumably with other trees, and grape vines, probably took place in the New Kingdom both in Egypt and Nubia aided by the adoption of labour-intensive *shaduf* irrigation, which provided some improvement to manual-watering (cf. Eyre 1994: 63-64, 79). The occurrence of some date palm evidence before the New Kingdom in Nubia may indicate that the spread of new cultivars (and perhaps *shaduf* irrigation) preceded rather than followed conquest.

By the time the Napatan state emerged, the basic agricultural patterns were well-established. This consisted of winter cereal crops, with very limited summer cropping (broomcorn millet), and labour-intensive fruit orchards and some vineyards. This is the dominant pattern documented from flotation samples from the Kawa town site (Fuller 2004b) and from Napatan levels at Qasr Ibrim (Clapham and Rowley-Conwy 2007), although there are no other good data points for comparison (Table 2). Of note, is that in addition to broomcorn millet there is evidence of a local kind of foxtail millet (probably *Setaria sphaceleata*) reported from Kawa, but

also known from Qasr Ibrim (A. Clapham, personal communication) and much later at Medieval Nauri (Fuller and Edwards 2001). The *Setaria* sp. reported from Early Meroitic Amir Abdallah is likely this species. This species is known to be gathered for food ethnographically in East Africa (Austin 2006), but it may have been an indigenous cultivar in Nubia on marginal summer plots with *Panicum miliaceum.* In addition the first possible evidence for cultivated sorghum occurs at this period. A direct AMS date of the Napatan period comes from a Kawa grain identified morphologically as sorghum (Fuller 2004b: 2450±40 BP [Beta-194234]/780–400 Cal B.C.). However, the C-13 fractionation on this date is rather high, more typical of a C-3 than C-4 grass, so this identification needs to be regarded with some caution. Nevertheless additional sorghum-type grains and unsorted samples remain to be studied from Kawa to test the presence of sorghum. If present, however, sorghum was rare by comparison to winter cereals or the *Panicum* and *Setaria* already discussed.

The Meroitic expansion and the significance of sorghum

The Meroitic period expansion of settlement implicates a role for sorghum, both economically and symbolically. Archaeobotanical finds from Meroe excavations, back to the last centuries B.C., indicate the cultivation of sorghum, while other finds include those from Gebel Tomat (associated with a C-14 date of A.D. 100-400: Clark & Stemler 1975), and the recently identified and directly dated Meroitic sorghum from the Wellcome expedition to Abu Geili (1790±40 BP [Beta-194245]/ cal. A.D. 100-350; material held in the UCL archaeobotanical laboratory). All of these finds indicate that primitive *bicolor* domesticates were widespread but also suggest that replacement by the advanced, free-threshing *durra* race was underway, and indeed this race may already have been present at Napatan Kawa (Fuller 2004b). Recent evidence from Dangeil indicates that sorghum was used there even as a substitute for filling traditional bread moulds, presumably designed for emmer/barley bread, as offerings to Amun (Anderson *et al.*

	Afyeh	Toshka West	Buhen	Semna West	Semna East	Ukma	Sai	NDRS: O16	NDRS: P1	NDRS: P37	Mahal Teglinos	JAG 1	SEG 9	Abu-Darbein	Shaqadud cave	Jebel Tomat Neolithic	El Zakiab	Um Direiwa	El Kadada	Nofalab	Shaheinab	Rabak	Kadero	Sheikh Mustafa	El Mahalab	Sheikh el-Amin	sum	%
Winter cereals/pulses (domesticated)																												
Hordeum vulgare	x	x	x			x	x	x	x	x	x																9	35%
Triticum sp.	x					x	x		x	x																	5	19%
Triticum diococcum							x																				1	4%
Summer cereals/pulses (domesticated)																												
Sorghum bicolor												x?	x?														0	0%
Panicum miliaceum						x																					1	4%
WILD Grasses																												
Sorghum bicolor arundinaceum															x	x	x	x	x		x	x	x	x	x	x	11	42%
Pennisetum															x		x										2	8%
Panicum														x	x	x				x							4	15%
Paspalum												x															1	4%
Setaria												x	x	x	x	x	x	x	x				x			x	10	38%
Fruits																												
Phoenix dactilifera				x	x				x	x																	4	15%
Hyphaene thebaica			x						x	x																	3	12%
Ficus sp./spp.					x																						1	4%
Vitis vinifera				x																							1	4%
Capparis/ C. decidua														x						x							2	8%
Ziziphus sp.				x	x				x		x			x	x												6	23%
Celtis integrifolia										x				x						x	x					x	5	19%
Citrullus lanatus				x	x																		?				2	8%

Table 1: An archaeobotanical summary of the Late Neolithic through Bronze Age; a register of the presence of a select roster of species across sites. Columns at the far right tally to total number of sites which have the crop and percentage of total sites for the time horizon (for references, see Appendix).

2007). Edwards (1996b) has suggested that sorghum was a socially important cereal during the Meroitic period and a base ingredient for making beers, which are inferred to be associated with distinctive necked jars. While this inference is thus far based on ethnographic parallel rather than hard scientific evidence for the identification of sorghum, it remains plausible, and a case can be made that sorghum was a central cereal of the Meroitic core.

The conventional division between the Napatan and Meroitic periods has been based on the location of royal pyramid burials, i.e. with the shift from Gebel Barkal to Meroe (Begrawiya South) at ca. 270 B.C., or an inferred shift in capital perhaps a century or so earlier under Harsiyotef (Shinnie 1967; Welsby 1996; Török 1997a). This change, however, seems to reflect a changing economic reality in which settlement, and inferred economic

	Karanog	Qasr Ibrim Napatan	Qasr Ibrim Meroitic	Qasr Ibrim Terminal/Post- Meroitic	Arminna West	Qustul Meroitic	Qustul/Ballana Post-Meroitic	Amir Abdallah	Kawa	Umm Muri	Dangeil	Meroe	Jebel Tomat Meroitic	Abu Geili		
Winter cereals/pulses																
Hordeum vulgare		x	x	x			x		x	?		x			6	43%
Triticum sp.		x	x	x			x		x	?		x			6	43%
Triticum diococcum		x	x	x					x						4	29%
Triticum durum				x											1	7%
Tritucum aestuvum				x											1	7%
Lens culinaris		x	x	x					x						4	29%
Pisum sativum				x											1	7%
Vicia faba									x						1	7%
Summer crops																
Sorghum bicolor				x					x	x	x	x	x	x	7	50%
Pennisetum glaucum				x								x?			1	7%
Panicum miliaceum		x							x						2	14%
Lablab purpureus				x						?					1	7%
Wild Grasses																
Sorghum arundinaceum		x	x						x						3	21%
Setaria cf. sphaceleata		x	x	x				x	x						5	36%
Oil/Fibre crops																
Linum usitatissimum		x													1	7%
Gossypium sp.			x	x											2	14%
Fruits																
Phoenix dactilifera	x	x	x	x		x		x	x			x			8	57%
Hyphaene thebaica		x	x	x				x	x						5	36%
Ficus sp./spp.		x						x	x				x		4	29%
Vitis vinifera				x	x	x									3	21%
Ziziphus sp.	x							x					x		3	21%
Citrullus lanatus		x							x						2	14%

Table 2: An archaeobotanical summary of the Napatan and Meroitic periods; a register of the presence of a select roster of species across sites. Columns at the far right tally to total number of sites which have the crop and percentage of total sites for the time horizon (for references, see Appendix).

production from the Butana hinterlands South and East of Meroe became increasingly important. As the settlement evidence, such as it is, from the Butana indicates, many sites can be attributed to the Meroitic period, from the Third Century B.C. or later (Edwards 1989; 1996a). The only clear exception to this is Meroe city itself which clearly has a long pre-Meroitic occupation back to early in the First Millennium B.C. (Bradley 1984; Shinnie and Anderson 2004). Despite the evidence from the deep soundings, most of the evidence for extensive urban occupation is from the Meroitic era, after 300 B.C. (Török 1997b; Shinnie and Anderson 2004), although this must represent the culmination of a gradual process as non-subsistence specialists, such as iron metallurgists, gathered here from 500-600 B.C. Indeed, a key transition may turn out to be during the 8th/7th century B.C. (25th Dynasty), from which some of the earliest burials in the non-royal West Cemetery date, and when a shift from huts to rectilinear mud-brick architecture is indicated by the excavations.

The expansion of Meroitic settlement into Lower Nubia can be seen as part of more widespread process that had already begun in the South. In addition to the establishment of settlements through the Butana, the same period witnessed the establishment of Faras and other communities in Lower Nubia (Williams 1985; Török 1984a), although population sizes are likely to have been low (Edwards 1996a; 1999). This same period saw at least some Meroitic settlement in the Fourth Cataract. Recent salvage archaeology in the Fourth cataract region has identified a Meroitic settlement on the island of Umm Muri (Fuller 2004a; Edwards and Fuller 2005; Payne 2005). Umm Muri indicates that some sedentary agricultural population was established in the Fourth Cataract during this period. The agricultural basis of this expansion can be expected to have been mainly that of the Napatan period, emmer and barley with limited cultivation of summer cereals. The constraints of limited arable land in both Lower Nubia and the Fourth Cataract helped to constrain population. Nevertheless there is clear evidence that domesticated sorghum was part of the small-scale summer repertoire in this period, with directly dated primitive *bicolor* race sorghums from both Umm Muri (Fuller 2004a: 2180±40 BP [Beta=194236] / 350-150 cal. B.C.) and Qasr Ibrim (Clapham and Rowley-Conwy 2007: various dates from ca. 100 ca. B.C. onwards). The presence of race *bicolor* in these areas, despite apparent free-threshing *durra* at Meroe (or perhaps durra-bicolor intermediates?) and *caudatum* in Libya, may indicate that *bicolor* varieties were less-demanding, and less thirsty, than more advanced large-grained sorghums.

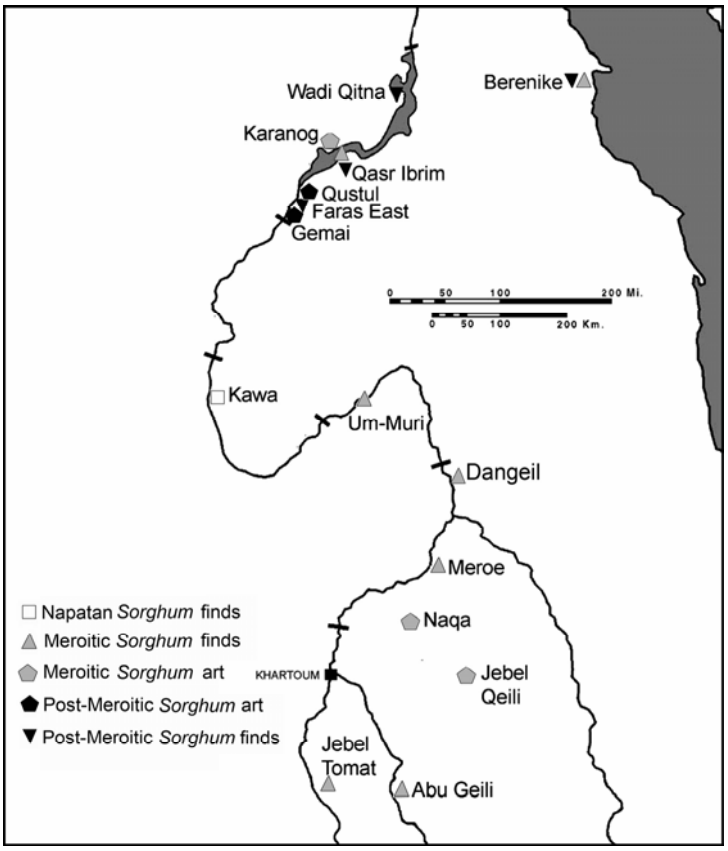

Figure 4: The distribution of archaeobotanical and art historical evidence for sorghum in Meroitic and Post-Meroitic Nubia

Sorghum would have been known, if only on a small scale, throughout the Meroitic kingdom (Figure 4). Archaeobotanical finds from Meroe excavations, back to the last centuries B.C. indicate the cultivation of sorghum, while other finds include Gebel Tomat, and recently identified and directly

dated Meroitic sorghum from the Wellcome expedition to Abu Geili (as noted above; in the UCL archaeobotany collections, studied by the author: cal. A.D. 100-350). All of these finds indicate that primitive *bicolor* domesticates were widespread but also suggest that replacement by the advanced, free-threshing durra race was underway, and indeed this race may already have be present at Napatan Kawa and at Meroe. What the Meroitic expansion into the Butana indicates therefore, is the expanding Nubian state taking advantage of this savannah production system, expanding beyond the surpluses that had long been provided by Nile flood winter farming.

Sorghum had a symbolic importance in the Meroitic kingdom, especially within the central region (Figures 4-5). While we might expect this crop to have been important in subsistence in this sahel/northern savannah zone, Meroitic art and material culture suggests a central symbolic role for this cereal within the Meroitic world. Notably a monumental rock engraving of the Meroitic king Shorakaror (later First Century A.D., Török 1997a: 205; Hintze 1959) shows the king offering bound captives to a deity shown emerging from the sun, who gives in exchange to the king a bouquet including a harvested sorghum ear (Figure 5B). This relief is located far to the Southeast of Meroe, some 92 miles East of Khartoum, and is interpreted as a monumental commemoration of Meroitic conquest or pacification of these southern lands (Török 1997a: 466-7). The prominent depiction of sorghum as one of the divine rewards might be taken to suggest that this region could provide important tribute/tax in terms of sorghum. Indeed, we would expect this more southern location towards to Blue Nile to have been wetter savannah, and able to support regular cultivation of rain fed savannah crops. Other depictions at Meroitic temples, however, suggest that sorghum was also an icon of offering born by royalty to deities, as at the Lion Temple at Naqa (Figure 5D).

Other parallel depictions of sorghum come from Northern Nubia from the mid-Third century A.D. and the Fourth Century, suggesting a diffusion of the cultural symbolism associated with this crop. The most clear is the depiction of a sorghum ear, with culm and leaves in the hand of a god from the Post-Meroitic period from a royal burial at Qustul. A silver plaque that had decorated a decayed wooden trunk from Qustul tumulus 17 (dated by to the 2nd generation of Qustul rulers towards the end of the Fourth Century; Török 1988; Williams 1991b: 10) depicts a composite sphinx deity with a Horus-falcon head and a crocodile tail (Figure 5C). The deity holds two things in its hands, a staff capped with an ankh and a plant sprig, which has been termed in the past "a flower" (Török 1988: 104). In fact, it appears to be a dense-eared (or, technically, dense-panicle) sorghum. This particular deity is known from other depictions, as at the Meroitic lion temple at Naqa in the central Sudan (Žabkar 1975: 106-116), and on signet rings of Meroitic elites at Karanog (Woolley and Randall-MacIver 1910: pl. 33, 8080-8085). It continues to be venerated at Philae, where it is apparently named Ptiris (Žabkar 1975). As noted by Žabkar held by this god on the Qustul plaques, the plant sprig that we have identified as a sorghum ear, finds parallels in objects held by Meroitic royalty at Naqa, which I have already suggested to be sorghum. A similar 'bouquet' is depicted in the hand of an elite ba-statue from the Late Meroitic cemetery at Karanog in Lower Nubia (Figure 5E) probably of Netewitar, viceroy of Lower Nubia towards the middle of the Third Century A.D. (cf. Eide *et al.* 1998: 1018). A similar interpretation can probably be assigned to more schematic depictions, such as the example from a Bronze bowl from Gemai (Figure 5F).

Current evidence indicates that the adoption of sorghum in the north was a protracted and gradual process. Nevertheless, an increased dietary and agricultural importance of sorghum in Lower Nubia can be attributed only to the very end of the Meroitic period and the subsequent Post-Meroitic period. Sorghum was one of several new crops, often with summer seasonality, that became prominent in the Post-Meroitic period. These adopted crops include sub-Saharan domesticates like pearl millet, cowpea and hyacinth bean, as well as sorghum (Rowley-Conwy 1989; Clapham and Rowley-Conwy 2007). This period also witnessed a new wheat variety, *Triticum durum,* which is part of a pattern of "culinary Hellenization" in Egypt (Bagnall 1993: 32). The summer crops are sown during a low season of the Nile, and thus would be confined either to just the lower

exposed banks, or require irrigation, especially for larger scale production (e.g. Omer 1985: 31). Thus we would expect these crops to increase in significance with the adoption of the *saqia*. Despite Adams' continued insistence, and evidence from Egypt back to the Second Century B.C. (Eyre 1994), a critical assessment of the archaeological evidence does not indicate the presence of *saqia* in Lower Nubia prior to the Terminal Meroitic period, when Meinarti was probably founded (Williams 1991b: 46; Rose 1992, Edwards 1996a; 1999; Fuller 1999). This indicates that the beginnings of summer crop cultivation came first, but subsequently increased evidence for their consumption comes from the Post-Meroitic period once *saqia* irrigation was well-established.

That these summer crops became particularly important in the Post-Meroitic diet is indicated by the isotopic evidence from Nubian burials in the Wadi Halfa region, which show a marked shift towards the consumption of more C-4 plants (which include sorghum and the millets) in the Post-Meroitic period (White and Schwarcz 1994). Isotopic evidence from mummified hair indicates the biseasonality of Post-Meroitic agriculture, and thus the importance of the summer-grown sorghum/ millets (White 1993; Schwarcz and White 2004). This evidence suggests that the presence of sorghum in Lower Nubia during Meroitic times was insignificant in terms of consumption and probably played a role as a risk-buffering catch crop, whereas in post-Meroitic times sorghum became an important element of consumption, along with other summer food crops. This expansion of summer-cropping would have been facilitated by the spread of the *saqia*.

The impact of the *saqia*: labour sinks; plagues and a demographic transition

With the introduction of the *saqia*, more crops could be produced, including staples, and industrial or luxury crops (e.g. cotton, dates, grapes), and more arable land would have been created out of old Pleistocene alluvium that was within the 15-meter elevation range of the *saqia* (On the height range of the *saqia*, Tothil 1952). This implies new land that may be valued and owned. This also implies the potential for conflict with pastoralists on what had previously been non-agricultural, grazing land, and may well be one of the contributing factors in the increased warfare from the mid-third century. These new crops also imply a second season of cultivation, as the *saqia* allows irrigation of summer crops when the river is low. This suggests that there was both an expansion of agriculture (more land under cultivation) and intensification (more labour invested in each bit of land), for example through two cropping seasons.

This has important implications for the potential density of population, since more crops can support more people. It also increased the potential productivity of wealth in terms of cash crops, like grapes or cotton, as well as in staple produce. But, more land will require more labour, and two seasons of cultivation will tie labourers to the land for a greater proportion of the year, thus potentially removing some of their potential to be part time specialists during the non-agricultural seasons (as potters, metallurgists, or part-time priests)—all of which are plausible summer pursuits during the Meroitic period. The requirement for more labour and labourers and increase in produce to support them means that there was a "population sink" in northern Nubia. This may have been a major "pull factor" that encouraged immigration and settlement in the region, and can be expected to contribute to increasing ethnic heterogeneity.

In the background of these events are additional demographic "events" that can be deduced from historical records and archaeological sources. Plagues and pestilences, for example, would have impacted the established Late Meroitic populations. External roman sources report a pestilence in Lower Nubia ca. 200 A.D.-- at least in the Dodekaschoinos, but hard to believe it didn't have some impact further south (FHN III: 241, Török 1984b: 52). The earlier plague of the Antonine Roman Empire is unrecorded from Nubian sources but should not be ruled out (McNeill 1976: 113; Boak 1955: 325). A 15-year plague in the Roman Empire, that had started in Nubia, ca. 250-265 A.D. (FHN III: 248; Török 1984b: 52), ravaged cities in the Mediterranean with reported death-tolls of 5,000 per day in Rome for some periods, and a major impact on Alexandria (Boak 1955: 418; McNeill 1976: 113-116).

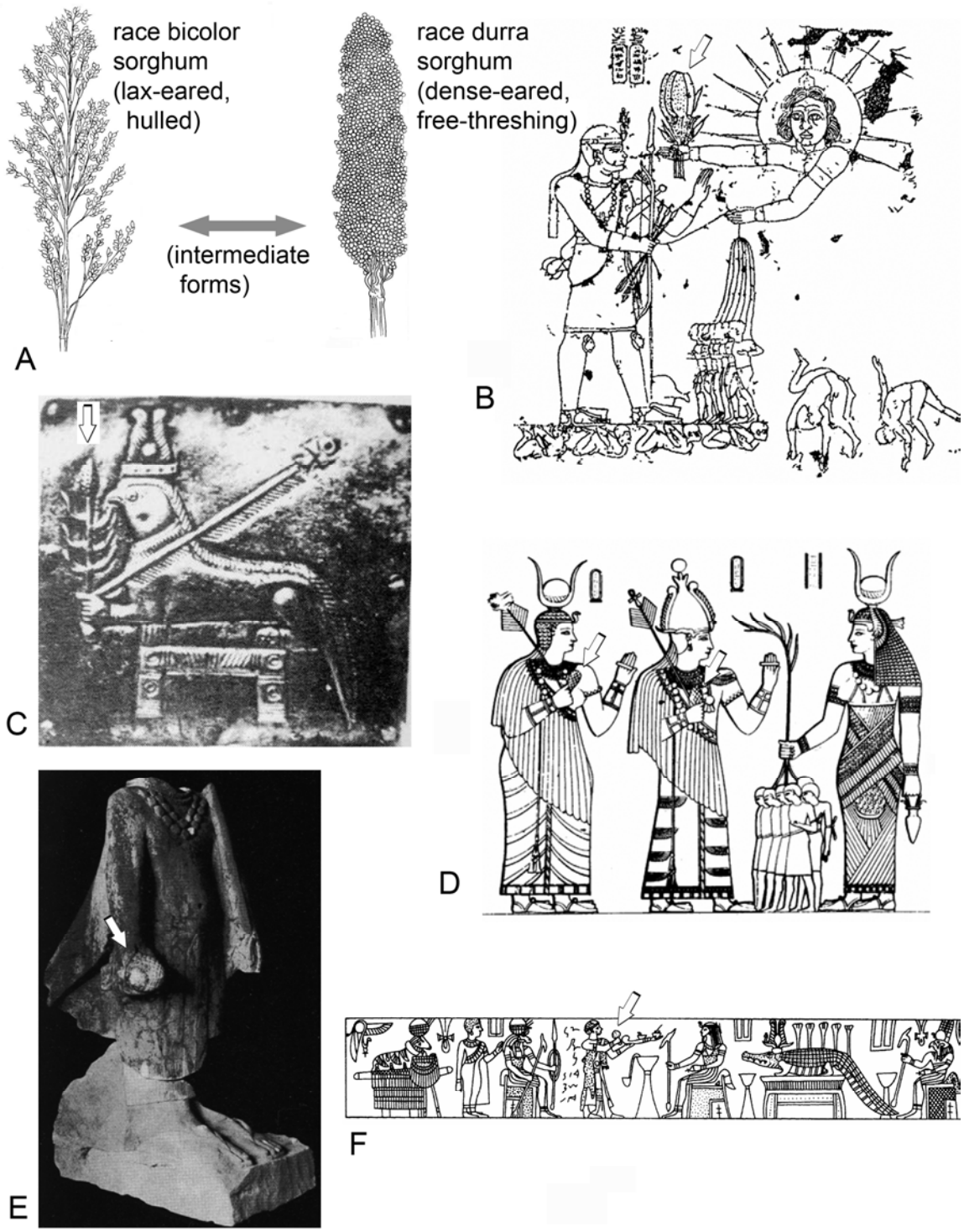

Figure 5: Art historical evidence with depictions identifiable as sorghum, with arrows indicating sorghum depictions: A. sketches of typical race bicolour lax-panicle and race durra dense-panicle sorghums for comparison (note intermediate forms exist). B. The Jebel Qeili rock carving of King Shorakaror (after Hintze 1959); C. Silver plaque from Qustul 17, with composite deity holding dense-eared sorghum on culm, with leaves (after Emery and Kirwan 1938); D. Scene from the Naqa Lion Temple showing probably dense-eared sorghum in the hands of kings and queens (after Žabkar 1975); E. Ba-statue from Karanog grave 203, attributed to viceroy Netewitar, mid 3rd c. A.D. (after Woolley & Randall-MacIver 1910); F. Scene from bronze bowl from Gemai, early-mid Fourth century (after Bates and Dunham 1927).

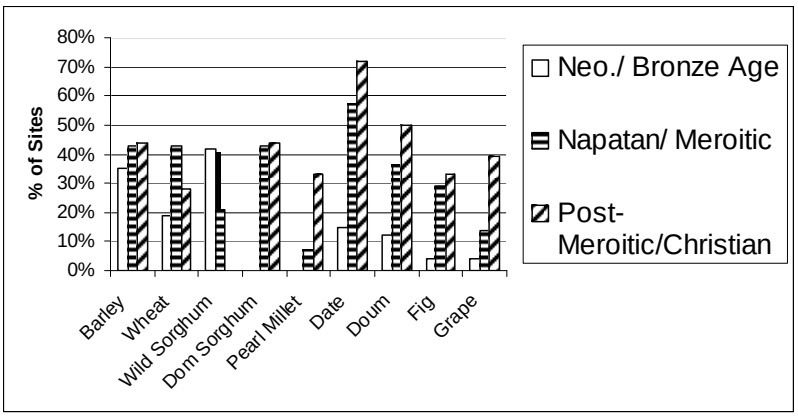

Figure 6: The regional presence of a select roster of crops, from Prehistory, Kushite and Post-Meroitic/Christian evidence. Notice, the rise in prominence of sorghum, pearl millet and summer harvested fruits.

Both of these events could have potentially had major impacts on established communities in Lower Nubia, changing demographic profiles, changing the land-labour relationship towards a shortage of labour, and randomly disrupting previous regimes of knowledge and power transmission through the generations (see, for example, discussions of the impact of disease on social structure of societies of the Mississippi basin after the onslaught of European microbes: Crosby 1986: 209-212; Fagan 1995: 474-476; McNeill 1976: 185ff.). It is during and after this period that some existing temples are likely to have been abandoned, even if they were later re-established. For example, by 250 A.D. the temple of Kalabsha had been overrun by pigs, but became an important sanctuary through the Post-Meroitic period (FHN III: 248; see also, Török 1999: 140). But also it is during this same period (The first half of the Third Century), when communities were established (like Arminna West, cf. Fuller 1997; 1999), and established lineages asserted their authority in new ways, such as the Wayekiye family of Gebel Adda and Kalabsha (see various discussions, e.g., Millet 1968: 44-49; 1981; Török 1980; 1987: 172-174; 1997a: 471-475; Fuller 1997; 2003b). By the end of the third century or the start of Fourth Century other new communities were being founded, such as at Kalabsha/Wadi Qitna, presumably "Blemmyes" from the Red Sea Hills (as per Williams 1991b; Rose 1992; cf. Barnard 2002).

With the founding of these new communities, and with the opening of new land to agriculture made possible with the *saqia*, we would expect there to be a labour vacuum, creating a situation typical of "internal frontiers," in which new settlers are encouraged and welcomed. This may have contributed to creating communities including groups of people of rather more diverse backgrounds (see Kopytoff 1987). In addition, human reproductive strategies are often adjusted to perceived conditions (Voland 1998; Shennan 2002: 109-110). Perceived resource surplus and colonization opportunities should have encouraged increased reproductive rates, while increased child mortality (due to diseases) also encourages increased reproduction. Immigration might have also been influenced by "push" factors. The settling of populations with ancestry in the Red Sea Hills (Blemmyes) in part of Lower Nubia, especially around Kalabsha must also be considered in relation to a probable decline in average rainfall.

There is a clear case to be made for declines in rainfall on northeastern Africa, which should have impacted the Central Sudan and Red Sea Hills, in the early to mid first millennium A.D. Various paleoclimatic datasets suggest a decline in rainfall in Ethiopia over the course of the first few centuries A.D., perhaps focused on the third-fourth century, in contrast to the wetter conditions of later first millennium B.C. (Machado *et al.* 1998; Gasse 2000: fig. 9: Lake Abhe; Chalié and Gasse 2002). This decline in Ethiopia is likely to be connected to less extensive rains in the Sudan, penetrating less far northward into the Sahel and desert, and may correlate with more global phenomena (cf. Lamb *et al.* 1995), and various indications of climatic decline in Europe (Randsborg 1991: 23-29). Thus in thinking through the social changes of the Late to Post-Meroitic periods we need to seriously consider demographic factors, which are likely to have contributed to increased population, punctuated by disease and by war related kill-offs, and increased heterogeneity in terms of cultural backgrounds.

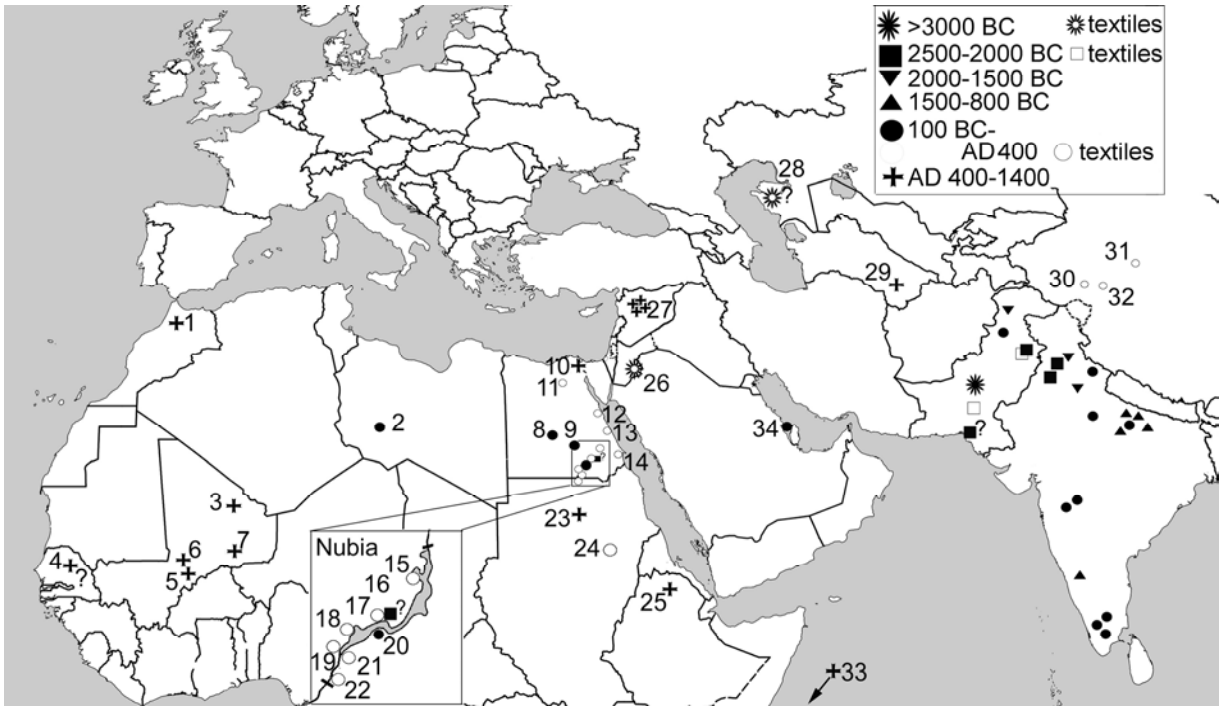

Figure 7: The archaeobotanical distribution of cotton finds in the Old World, highlighting the wide dispersal during the Meroitic/Roman horizon. For details of the finds from India and Pakistan, see Fuller 2008. Other sites: 1. Volubilis; 2. Jarma; 3. Essouk; 4. Ogo; 5. Tellem burial caves; 6. Dia; 7. Gao; 8. Dakhleh Oasis; 9. Khargeh Oasis; 10. Tinnis; 11.Karanis; 12. Abu Sha'ar; 13. Quesir al-Qadim; 14. Berenike; 15. Wadi Qitna; 16. Afyeh; 17. Karanog; 18. Arminna West; 19. Ballana; 20. Qasr Ibrim; 21. Qustul; 22. Second cataract cemeteries; 23. Nauri; 24. Meroe West cemetery; 25. Axum; 26. Dhuweila; 27. Sheheil, Guftan, Medād, Hrim; 28. Maykop kurgan, "cotton-like" textiles, 3700-3200 B.C.; 29. Merv, seeds, A.D. 300-500; 30. Sampul; 31. Ordek; 32. Niya; 33. Arrow pointing in direction of Pemba island sites, Tumbe A.D. 600-1000 and Chwaka A.D. 1100-1600; 34. Qalat al Bahrain, 500-300 B.C.

Taken together, demographic expansion with the agricultural expansion and intensification, the basis for a local peasantry emerges. Importantly, this growth of a peasantry provided the basis for the emergence of a local state. There was increased population to be ordered hierarchically, and there was increased productivity providing the surplus. Local elites could sequester this surplus to support local power based on stored and redistributed staples (i.e. "staple finance"), which in turn could support more specialists (of craft / ritual / war / politics) who engaged in production, exchange and consumption of luxury goods which constituted a "wealth finance" (on the general distinction between staple and wealth finance, see D'Altroy and Earle 1985). While "wealth finance" has been a significant part of the Meroitic socio-economic system, as discussed by Edwards (1996a; 2004) in relation to prestige-goods trade, local elites in lightly populated areas, such as Lower Nubia or the Fourth Cataract, and perhaps the Dongola reach as well, were dependent on the redistribution from the recognized royalty at Meroe, with its superior economic productivity (based in its expansive savannah hinterland as well as the Nile). The increases in population in the North, which may well have included more ethnic heterogeneity and therefore less ethnic loyalty to Meroe, a decreasing practical need to be reliant on Meroe, even if its ritual/symbolic importance, suzerainty persisted (Fuller 2003b). Initially we expect there to have been elites competing for power, influence and surplus—reflected in the multiple Terminal Meroitic/early Post-Meroitic centres of wealth and grandiose burials in the Fourth Century (Kalabsha, Qasr Ibrim, Qustul, Gemai), it was ultimately the elites of Qustul (and Ballana), who succeeded. In part, this must have been through military success, reflected historically in the Phonen-Abourni letter from Qasr Ibrim

(Hägg 1986; FHN III: 319) and the Silko Inscription (FHN III: 317) Thus the linked agricultural and demographic changes of the Post-Meroitic transition which developed out a distinctively Meroitic and savannah cultural background (in terms of a range of summer crops) and in part from imported innovations (especially the *saqia*), were a key factor that conditioned the end of the Meroitic kingdom and paved the way for the three successor states of early Christian Nubia.

Shifting patterns in cotton production and consumption

New irrigated lands and additional labour allowed another key revolution in northern Nubia, the emergence of a local cotton textile industry. Cotton is a thirsty crop but should not be waterlogged or get wet as fruits form, and early varieties were likely to have been grown as shrubby perennials with life spans of several years (Fuller 2008; cf. Nicholson 1960). This means it needed to be grown well above potential Nile flood levels, but needed to be irrigated by lifting water to it. While this might of have been possible on a small scale with the *shaduf*, the *saqia* made this much easier on a much larger scale. That cotton production was taking place locally in Nubia is implied by the evidence from Qasr Ibrim (25B.C.-A.D. 100) for both seeds and capsules, with the latter less likely to be transported with raw cotton (Clapham and Rowley-Conwy 2007; 2009). This needs to be seen in the context of wider patterns of cotton production around the southern fringes of the Roman world (Figure 8), both within the empire and beyond starting perhaps from the Third Century A.D., indicated by production in the Fezzan Libya, Dakleh and Kargeh oases, and Nubia (Pelling 2005; Wild *et al.* 2007; Fuller 2008). This suggests a growth in cultivation in response to Roman demand, but also probably made possible by agricultural innovations, especially in irrigation. In Nubia this probably involved the *saqia*, while in Libya this would have involved the *qanat* (see Pelling 2005; Drake *et al.* 2004).

An open question remains as to whether cotton cultivation was already established further south in the Meroitic heartland, but the balance of evidence suggests that it was. In the Old World, the earliest cultivated cotton comes from Pakistan, where it is inferred that the tree cotton (*Gossypium arboreum*), was domesticated from now extinct wild progenitor before 4000 B.C. (see Moulherat *et al.* 2004; Fuller 2008). Cloth may have occasionally been exported westwards (e.g. Betts *et al.* 1994), but was not a regular cloth in either Mesopotamia or the Nile where flax predominated. In the Indus valley spinning and weaving was established before the Harappan civilization (2600-1900 B.C.), based on both the indigenous cotton and introduced flax (Fuller and Madella 2001; Fuller 2008). In subsequent periods, both textile crops and textile production dispersed east and south into 'inner' India to become established by ca. 1400-1000 B.C. (Fuller 2008).

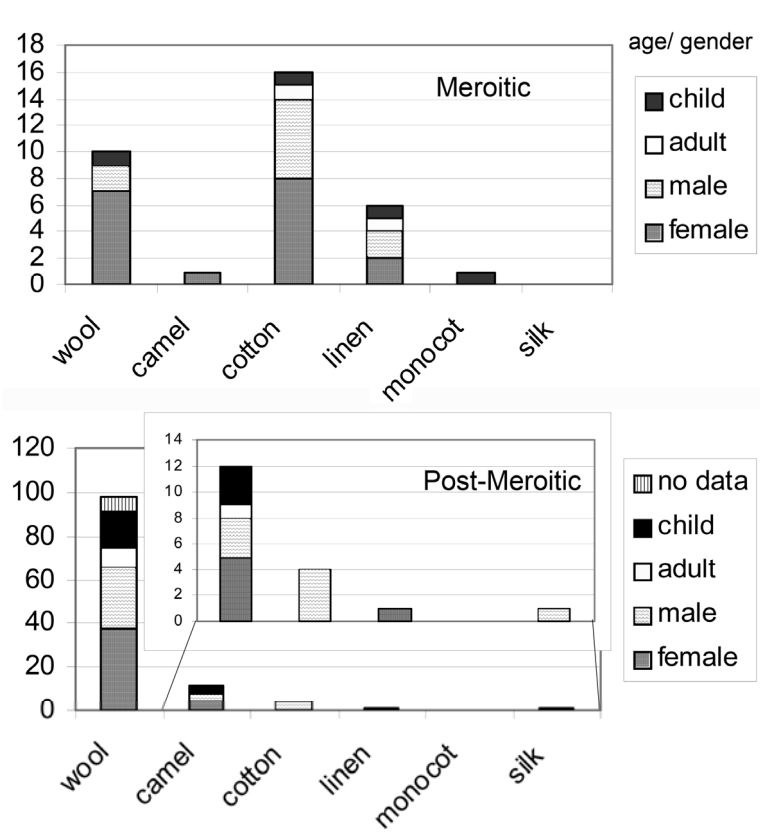

Figure 8: A comparison of the representation of textile materials in the Qustul and Ballana cemeteries between the Meroitic and Post-Meroitic periods (data from Mayer Thurman and Williams 1979; with dating following Williams 1991a; 1991b).

After this period, during the Iron Age, cotton become even more widespread, especially in the far south of India, whence it was a major item of export by Roman times as indicated in the *Periplus* (Casson 1989). It is also during the Iron Age that cotton cultivation came to parts of Western Asia, including Bahrain and parts of Assyria, also probably aided by the expansion of *qanat* (or locally, *falaj*) irrigation (Potts 1994; Boivin and Fuller 2009). The evidence from Berenike on the Red Sea coast indicates that cloth with z-spun threads arrived in large quantities, and this is interpreted as imports from India (Wild 1997; Wild and Wild 2005). The few finds of s-spun textiles are suggested to be more 'local' imports, e.g. from Nubia, which is supported by their dominance of Meroitic textile assemblages (Clapham and Rowley-Conwy 2009). The evidence of Roman coin finds in southern India suggests the period of the largest influx of Roman money was at the end of the First Century B.C. and the First Century A.D. (Turner 1989), focused broadly around the Augustan period, and it may be that the decline in Roman coinage in India reflects the rise of other competitors in cotton production – initially perhaps Meroe, and then in short order the Garamantes (in the Fezzan, Libya), the Axumites, and the southern Egyptian oases and eventually Lower Nubia.

It is possible that the Meroitic or Post-Meroitic cotton production was based on a different species, the short-staple cotton *(G. herbaceum*) (cf. Nicholson 1960: 7), which is indigenous to Africa (on cotton taxonomy, see Wendel 1995). Initial assessment of the Qasr Ibrim macro-remains material suggested the latter species (cf. Rowley-Conwy 1989), although distinguishing these taxa reliably based on seed morphology seems impossible (personal observations), and even capsule remains may prove recalcitrant. By contrast measurements on cotton fibres from Meroitic textiles at Karanog suggested identification as *G. arboreum* (Griffith and Crowfoot 1934). Further research is needed to determine whether there was indeed cultivation of both the introduced Indian *arboreum* and African *herbaceum* in Meroitic/ Post-Meroitic Nubia. Despite the claim for cotton *herbaceum* (?) seeds associated with goat dung in A-Group Afyeh (Chowdhury and Ghosh 1971; Chodwhury and Ghosh 2005), there is no reason to believe either that the cotton was spun or cultivated. One might also express concerns over the reliability of its dating, as it may be later intrusive material into a shallowly buried A-Group site. It may nevertheless attest to formerly more northern wild populations of *G. herbaceum* subsp. *africanum,* which is today restricted to southeast Africa, extending north into Ethiopia (cf. Nicholson 1960). It is also possible that tree cotton was introduced from India to the Persian Gulf and then to Nubia in the First Century B.C./A.D., and that cultivation of both species was taking place.

An interesting pattern with the adoption of cotton in Lower Nubia, however, is that as local cultivation *increased* local consumption of cotton, indicated by finds in burials *decreased.* The textile data from Ballana and Qustul represents this pattern (Figure 8), since this site provides details of fibre identifications (Mayer-Thurman and Williams 1979) and details of finds contexts which allow for reliable dating and assessment of social status and skeletal sex (Williams 1991a; 1991b). In the Meroitic textile corpus, although the quantity is lower overall cotton is the most common. Also its frequency with adult male and female skeletons is more or less the same. This is consistent with redistribution from the central Meroitic Kingdom and with the relatively elevated status of women in Meroitic society. The importance of cotton production in the central Meroitic economy is implied by the Ezana inscription, as argued by Crowfoot (1911: 37) many years ago (see also, Griffith and Crowfoot 1934: 7; Nicholson 1960). Flax by contrast is presumably rare as it would likely be imported from Roman Egypt. By contrast in the Post-Meroitic period wool textiles predominate and cotton is quite rare. When cotton occurs it is almost always in male graves, and a perusal of the finds register suggest these are all relatively wealthy burials, i.e. cotton seems to be restricted to high status males. At first glance this might seem inconsistent with the archaeobotanical argument that local cotton took off in the Post-Meroitic period, but this distinction is, in fact, crucial as it indicates a shift in values. In the Post-Meroitic period locally produced cotton textiles were presumably made for export, and they were a controlled commodity of wealth, and the cheaper and readily available wool had to suffice for normal local consumption. By contrast in the

Meroitic period cotton was non-local and arrived locally as regular gifts that trickled down from the Meroitic state. Part of the economic basis of the Qustul/Ballana splinter state was in taking control of increased local production for export commodities. In addition to the growing of cotton, its preparation (ginning, carding, washing, spinning, weaving) also require large amounts of labour, often dispersed across households and across the calendar (see, e.g. Nicholson 1960), and as such would constitute an additional labour sink for a growing peasantry.

Final discussion: agricultural innovation as catalyst for "collapse"

Previous discussion of links between Lower Nubian change and the demise of the central Meroitic power have not clearly outlined linkages between population density, agricultural production, political power and ethnogenesis. As outlined above, increased labour needs and increased population through higher reproduction rates, through population influx and through the settling of more mobile population elements is all likely to have contributed to a transformed demographic

	Wadi Qitna	Sayala	Qasr Ibrim Terminal/Post- Meroitic	Qasr Ibrim Christian	Arminna West Christian	Qustul/Ballana Post-Meroitic	Abdallah Nirqi	Faras East	Serra East	Debeira West	Amir Abdallah	Nauri	Hambukol	Old Dongola	Gabati	Sobar East: Post Meroitic/early	Soba East: early Medieval	Soba East: later Medieval		
Winter cereals/pulses																				
Hordeum vulgare	x		x	x		x						x				x	x	x	8	44%
Triticum sp.	x		x	x		x						x							5	28%
Triticum diococcum			x																1	6%
Triticum durum			x	x															2	11%
Tritucum aestuvum	x		x	x								x							4	22%
Lens culinaris			x	x								x							3	17%
Pisum sativum			x	x				x				x							4	22%
Vicia faba								x											1	6%
Summer crops																				
Sorghum bicolor	x		x	x				x				x				x	x	x	8	44%
Pennisetum glaucum			x	x								x				x	x	x	6	33%
Setaria italica												x	x						2	11%
Vigna unguiculata				x								x				x	?	?	3	17%
Lablab purpureus			x	x															2	11%
wild(?) grasses																				
Setaria											x	x				x	x	x	5	28%
Oil/Fibre crops																				
Carthamus tinctorius												x							1	6%
Gossypium sp.			x	x								x							3	17%
Sesamum indicum			x	x			x												3	17%
Fruits																				
Phoenix dactilifera	x	x	x	x			x	x	x	x	x	x				x	x	x	13	72%
Hyphaene thebaica			x	x	x		x	x		x	x						x	x	9	50%
Ficus sp./spp.									x		x	x				x	x	x	6	33%
Vitis vinifera			x	x								x	x			x	x	x	7	39%
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18	

Table 3: An archaeobotanical summary of the Post-Meroitic and Christian periods; a register of the presence of a select roster of species across sites.

context and one that probably had pluri-ethnic origins. New productivities, made possible by improved irrigation and expanded arable land (the *saqia* effect) and by more effective double-cropping (the savanna crop effect), undermined the economic superiority of the Meroitic savanna core. At the same time, growing aridity over northeast Africa, indicated for example in the decline of Lake Abhe water-levels (e.g. Gasse 2000), would have put added stress on the productivity of the Meroitic heartland. It may have favoured a shift towards more pastoral mobility and less sedentism. If Meroitic (or Kushite) ethnicity was intimately tied to operation of the state apparatus and its Meroitic symbols, as the operation of its prestige goods system suggests (e.g. Edwards 1996a; Fuller 2003b), then the collapse of this state system necessarily implies a dilution, or transformation of ethnicity. The dissolution of the Meroitic state can thus be seen as an inevitable and unintended result of the expansion and agricultural innovation of the Meroitic period. This innovation includes both the spread and more common cultivation of savannah crops and the incorporation of the *saqia* irrigation derived from Roman Egypt. This allowed for a shift in agricultural production in Northern Nubia (to double-cropping and *saqia*-lands) away from what it had been for nearly three millennia since the establishment of cultivation at the end of the Neolithic. The next great shifts in agriculture would not occur until the spread of American crops in the Ottoman period, and new industrial irrigation methods of the Twentieth Century.

APPENDIX: SOURCES FOR ARCHAEOBOTANICAL DATA

This list includes all sites with archaeobotanical data which are referred in the tables and maps of this paper, indicating primary source(s). Superscript [2, 7] indicate those sites which are plotted in figures 2 and 7.

Abdallah Nirqi	Sudan	Skoflek and Arendas 1981
[2] Abu Ballas	Egypt	Barakat & Fahmy 1999
Abu Darbein	Sudan	Magid 1989
[2] Abu Geili	Sudan	Fuller, unpublished observations (collection at UCL)
[7] Abu Sha'ar	Egypt	Bender-Jorgensen & Vogelsang-Eastwood 1991
Abydos	Egypt	Murray 2000
[2] Adrar Bous	Niger	Shaw 1976
[7] Afyeh	Egypt	Chowdhury & Buth 2005
Amir Abdallah	Sudan	Fernandez 1983
[7] Arminna West	Egypt	Examined by the author and L. McWeeney: Fuller 1999: 208.; textiles: unpublished
[2 7] Axum	Ethiopia	Boardman 1999
[7] Ballana	Egypt	Mayer-Thurman and Williams 1979 (textiles)
[2 7] Berenike	Egypt	Cappers 1999; 2006; Textiles: Wild & Wild 2005
Buhen	Egypt	Fuller, unpublished observations (collection at UCL Petrie Museum)
[2] Daima	Nigeria	Connah 1981: 188-189
Dangeil	Sudan	Anderson *et al.* 2007
Debeira West	Sudan	Shinnnie and Shinnie 1978: 107
[7] Dhuweila	Jordan	Betts *et al.* 1994
Dia - Mara	Mali	Murray, S. 2005a; 2005b
[2 7] Dia - Shoma	Mali	Murray, S. 2005a; 2005b; 2007
[7] Dakleh Oasis	Egypt	Thanheiser 2002
[2] El-Kadada	Sudan	Stemler 1990
Elephantine	Egypt	Willerding & Wolf 1991
[2] El Zakiab	Sudan	Stemler 1990; also Magid 1989
El Kadada	Sudan	Stemler 1990
El Mahalab	Sudan	Magid 2003
[2 7] Essouk	Mali	Unpublished, UCL: Nixon, Murray, & Fuller
[2] Farafra, Hidden Valley	Egypt	Barakat & Fahmy 1999
[2] Faras East	Sudan	Säve-Söderbergh *et al.* 1981: 64
Gabati	Sudan	In Edwards 1998 [identified by A. Clapham]
[7] Gao	Mali	Fuller 2000
[7] Guftan	Syria	Samuel 2001
Hambukol	Sudan	Welsby 2002, p. 270, n. 35 (after Grzymski)
[7] Hrim	Syria	Samuel 2001
[2 7] Jarma (Germa)	Libya	Pelling 2005; 2007
[2] Jebel Tomat	Sudan	Clark & Stemler 1975; Magid 1989
[2] Jenne-Jenno 1981	Mali	McIntosh 1995
[2] Kadero	Sudan	Stemler 1990
[2 7] Khargeh [Karga] Oasis, north	Egypt	Clapham and el Dorri, unpublished (personal communication); cotton: Clapham and Rowley-Conwy 2009
[7] Karanis	Egypt	Leighty 1933; Bartlett 1933; Wilson 1933 (cotton thread)
Karanog	Egypt	Woolley and Randall-MacIver 1910; textiles: Griffith and Crowfoot 1934
[2] Kasala: JAG9 & SEG 1	Sudan	Costatini *et al.* 1982; 1983
[2] Kawa	Sudan	Fuller 2004b
[2] Kursakata	Nigeria	Klee, Zach and Neumann 2000
Mahal Teglinos	Sudan	Constatini *et al.* 1982; 1983
[7] Maykop	Russia	Shishlina *et al.* 2003

[7] Medād	Syria	Samuel 2001
[2] Mege	Nigeria	Klee and Zach 1999
[2] Meroe	Sudan	Shinnie & Anderson 2004: 366
[7] Meroe West Cemetery	Sudan	Textiles: Griffiths and Crowfoot 1934
[7] Merv	Turkmenistan	Nesbitt 1993; 1994
[2] Nabta Playa	Egypt	Wasylikowa *et al.* 1993; 1995; 1997; 2002; Wasylikow and Dahlberg 1999
Nafolab	Sudan	Magid 1989
[2] Naini	Rep. of Guinea	Shaw 1976
[2 7] Nauri	Sudan	Fuller and Edwards 2001
*NDRS: Northern Dongola Reach Survey	Sudan	Cartwright 2001
[7] Niya	China	Textiles: Mallory and Mair 2000: 165
[7] Ogo	Senegal	Chavane 1985
Old Dongola	Sudan	Cited in Welsby 2002
[7] Ordek	China	Textiles: Mallory and Mair 2000: 152
[7] Pemba Island sites: Tumbe A.D. 600-1000 and Chwaka A.D. 1100-1600	Tanzania	Walshaw 2005
[2 7] Qasr Ibrim	Egypt	Rowley-Conwy 1989; Clapham & Rowley-Conwy 2006; 2007; 2009; Steele and Bunting 1982
[7] Quesir al-Qadim	Egypt	Whitcomb and Johnson 1982 (textile)
[7] Qustul	Egypt	Batrawi 1935: 149; Williams 1991a: 162; textiles: Mayer-Thurman and Williams 1979
[2] Rabak	Sudan	Magid 1989
Sai	Sudan	Geus 2004; Hildebrand 2007
[7] Sampul	China	Textiles: Mallory and Mair 2000: 155
Sayala, Cem 132	Egypt	Firth 1927: 190
Serra East	Sudan	Save-Söderbergh *et al.* 1981: 64
[7] Sheheil	Syria	Samuel 2001
[7] Second Cataract cemeteries (various)	Sudan	Bergmann 1975 (textiles)
*Semna	Sudan	van Ziest 1983
[2] Shaheinab	Sudan	Magid 1989
[2] Shaqadud Cave	Sudan	Magid 1989
Sheikh al-Amin	Sudan	Magid 2003
Sheikh Mustafa	Sudan	Magid 2003
Shenshef	Egypt	Cappers 2006
[2] Soba East 1	Sudan	Van der Veen 1991; Cartwright 1998
[7] Tellem burial caves, Bandiagara escarpment	Mali	Marr 1978; Boland *et al.* 1991
*Timna	Egypt	Kislev 1988a
[2] Tinda	Libya	Pelling 2005; 2007
[7] Tinnis	Egypt	Clapham and Rowley-Conwy 2009
*Toshka West	Egypt	Fuller, unpublished (collection at Yale)
[2] Tutankhamun's Tomb	Egypt	De Vartavan 1990
Umm Muri	Sudan	Fuller 2004a
Ukma	Sudan	Van Zeist 1987
[2] Umm Direiwa	Sudan	Magid 1989; Stemler 1990
[2] Umm Muri	Sudan	Fuller 2004b
[2 7] Wadi Qitna	Egypt	Strouhal 1984: 262-263 (seeds)
[7] Volubilis	Morocco	Unpublished, UCL: Fuller & Pelling

BIBLIOGRAPHY

Adams, W.Y.
1976 *Meroitic North and South. A Study in Cultural Contrasts*, Meroitica 2, Berlin, 1-26, 119-175

Anderson, J.R., A.C. D'Andrea, A. Logan and Salah Mohamed Ahmed
2007 Bread Moulds from the Amun Temple at Dangeil, Nile State – an Addendum, *Sudan & Nubia* 11, 89-93

Arkell, A.J.
1955 *A History of the Sudan to AD 1821*, London

Austin, D.F.
2006 Fox-tail millets (*Setaria : Poaceae*) – abandoned food in two hemispheres, *Economic Botany* 60 (2), 143-158

Bagnall, R.S.
1993 *Egypt in Late Antiquity*, Princeton

Barakat, H.N. and A.G. Fahmy
1999 Wild grasses as 'Neolithic' food resources in the Eastern Sahara: A Review of the Evidence, in: M. Van der Veen (ed.), *The Exploitation of Plant Resources in Ancient Africa*, New York, 33-46

Barnard, H.
2002 Eastern Desert Ware, a first introduction, *Sudan & Nubia* 6, 53-57

Bartlett, H.H.
1933 Fruits and Other Plants, in: A.E.R. Boak (ed.), *Karanis: The Temples, Coin Hoards, Botanical and Zoological Reports, Seasons 1924-31*, Ann Arbor, 88

Barton, L., S.D. Newsome, F.-H. Chen, H. Wang, T.P. Guilderson and R.L. Bettinger
2009 Agricultural origins and the isotopic identity of domestication in northern China, *Proceedings of the National Academy of Sciences* (USA) 106 (14), 5523-5528

Bates O. and D. Dunham
1927 *Excavations at Gammai*, Harvard African Studies 8, Cambridge, Mass.

Batrawi, A.A.
1935 *Report on the Human Remains*, Service des Antiquités de l'Égypte. Mission Archeologique de Nubie 1929-34, Cairo

Bender-Jorgensen, L. and G.M. Vogelsang-Eastwood
1991 The 'Abu Sha'ar Textiles 1991, *Archaeological Textiles Newsletter* 13, 3-4

Bergman, I.
1975 *Late Nubian Textiles*, The Scandinavian Joint Expedition to Nubia vol. 8, Copenhagen-Oslo-Stockholm

Betts, A., K. van der Borg, A. de Jong, C. McClintock, and M. van Stryndonck
1994 Early Cotton in North Arabia, *Journal of Archaeological Science* 21, 489-499

Boak, A.E.R.
1955 *A History of Rome to 565 A.D.*, Fourth edition, New York

Boardman, S.
1999 The agricultural foundation of the Aksumite Empire, Ethiopia, in: M. van der Veen (ed.), *The exploitation of plant resources in ancient Africa*, London, 137-148

Boivin, N. and D.Q. Fuller
2009 Shell middens, ships and seeds: Exploring coastal subsistence, maritime trade and the dispersal of domesticates in and around the ancient Arabian peninsula, *Journal of World Prehistory* 22 (2) [in press]

Bradley, R.J.
1984 Meroitic Chronology, in: F. Hintze (ed.), *Meroitistische Forschungen 1980. Akten der 4. Internationalen Tagung für meroitistische Forschungen vom 24. bis 29. November 1980 in Berlin*, Meroitica 7, Berlin, 195-211

Cappers, R.
1999 Trade and Subsistence at the Roman Port of Berenike, Red Sea Coast, Egypt, in: M. Van der Veen (ed.), *The Exploitation of Plant Resources in Ancient Africa*, London, 185-197
2006 *Roman Foodprints at Berenike: Archaeobotanical Evidence of Subsistence and Trade in the Eastern Desert of Egypt*, Costen Institute of Archaeology, UCLA, Los Angeles

Cartwright, C.
1998 The wood, charcoal, plant remains and other organic material, in: D. Welsby (ed.), *Soba II. Renewed excavations within the metropolis of the Kingdom of Alwa in Central Sudan*, British Institute of East Africa Memoir 15, London, 255-268
2001 The plant remains, in: D. Welsby (ed.), *Life on the Desert Edge. Seven thousand years of settlement in the Northern Dongola Reach, Sudan* II, Oxford, 556-567.

Casson, L.
1989 *The Periplus Maris Erythraei. Text with Introduction, Translation, and Commentary*, Princeton

Chalié, F. and F. Gasse
2002 Late Glacial-Holocene diatom record of water chemistry and lake level change from the tropical East African Rift Lake Abiyata (Ethiopia), *Palaeogeography, Palaeoclimatology and Palaeoecology* 187, 259-283

Chavane, B.
1985 *Villages de l'ancien Tekrour. Recherches archéologiques dans la moyenne vallée du fleuve Sénégal*, Paris

Chowdhury, K.A. and G.M. Buth
1971 Cotton seeds from the Neolithic in Egyptian Nubia and the origin of Old World Cotton, *Biological Journal of the Linnean Society* 3, 303-312
2005 Plant remains from excavation of terraces of the Nile at Afyeh, Nubia and Egypt, *Puratattva* [Journal of the Indian Archaeological Society] 35, 154-159

Christides, V.
1980 Ethnic Movements in Southern Egypt and Northern Sudan: Blemmyes-Beja in Late Antique and Early Arab Egypt until 707 A.D., *Listy filologicke* 103, 129-143

Clapham, A. and P. Rowley-Conwy
2006 Rewriting the History of African Agriculture, *Planet Earth* Summer 2006, 24-26
2007 New Discoveries at Qasr Ibrim, Lower Nubia, in: R. Cappers (ed.), *Fields of Change. Proceedings of the 4th International Workshop for African Archaeobotany*, Groningen, 157-164
2009 The archaeobotany of cotton (Gossypium sp. L) in Egypt and Nubia with special reference to Qasr Ibrim, Egyptian Nubia, in: A. Fairbairn and E. Weiss (eds.), *From Foragers to Farmers: papers in honour of Gordon C. Hillman*, Oxford, Chapter 26

Clark, J.D. and A.B. Stemler
1975 Early domesticated sorghum from Central Sudan, *Nature* 25, 588-591

Connah, G.
1981 *Three thousand years in Africa: Man and his environment in the Lake Chad region of Nigeria*, Cambridge

Constatini, L., R. Fattovich, E. Pardini and M. Piperno
1982 Preliminary Report of Archaeological Investigations at the Site of Mahal Teglinos (Kassala). November 1981, *Nyame Akuma* 21, 30-33

Costantini, L., R. Fattovich, M. Piperno and K. Sadr
1983 Gash Delta Archaeological Project: 1982 Field Season, *Nyame Akuma* 23, 17-19

Crosby, A.W.
1986 *Ecological Imperialism. The Biological Expansion of Europe, 900-1900*, Cambridge

Crowfoot, J.W.
1911 *The Island of Meroe. Part I. Sôba to Dangêl*, Archaeological Survey of Egypt 19th Memoir, London

D'Altroy, T. and T. Earle
1985 Staple finance, wealth finance, and storage in the Inca political economy, *Current Anthropology* 26, 187-206

Drake, N., A. Wilson, R. Pelling, K. White, D. Mattingly and S. Black
2004 Water table decline, springline desiccation and the early development of irrigated agriculture in the Wadi al-Ajal, Libyan Fazzan', *Libyan Studies* 35, 95-112

Edwards, D.N.
1989 *Archaeology and Settlement in Upper Nubia in the 1st Millennium A.D.*, Cambridge Monographs in African Archaeology 36. BAR International Series 537, Oxford
1996a *The Archaeology of the Meroitic State: New perspectives on its social and political organization*, Cambridge Monographs in African Archaeology 38. BAR International Series 640, Oxford
1996b Sorghum, Beer and Kushite Society, *Norwegian Archaeological Review* 29, 65-77
1998 *Gabati. A Meroitic, Post-Meroitic and Medieval Cemetery in Central Sudan,* Volume 1, London
1999 Meroitic Settlement Archaeology, in: D.A. Welsby (ed.), *Recent Research in Kushite History and Archaeology. Proceedings of the 8th International Conference for Meroitic Studies*, British Museum Occasional Paper 131, London, 65-110
2004 *The Nubian Past. An Archaeology of Sudan*, London

Edwards, D.N. and D.Q. Fuller
2005 Excavations and survey in the Central Amri-Kirbekan Area, Fourth Cataract, 2003-2004, *Gdańsk Archaeological Museum African Reports* 4, 21-29

Emery, W.B. and L.P. Kirwan
1938 *The royal tombs of Ballana and Qustul*, Cairo

Eyre, C.J.
1994 The Water Regime for Orchards and Plantations in Pharaonic Egypt, *Journal of Egyptian Archaeology* 80, 57-80

Fagan, B.M.
1995 *Ancient North America. The Archaeology of a Continent. Second Edition*, London

Fernández, V.M.
1983 *La cultura alto-meroítica del norte de Nubia. La necrópolis de Amir-Abdallah*, 2 vols., PhD Dissertation, Universidad de Madrid, Madrid

FHN III = Eide, T., T. Hägg, R.H. Pierce and L. Török
1998 *Fontes historiae Nubiorum: textual sources for the history of the Middle Nile region between the eighth century BC and the sixth century AD. Vol. III: From the first to the sixth century AD*, Bergen

Firth, C.M.
1927 *The Archaeological Survey of Nubia. Report for 1910-1911*, Cairo

Fuller, D.Q.
1997 The Confluence of History and Archaeology in Lower Nubia: Scales of Continuity and Change, *Archaeological Review from Cambridge* 14 (1), 105-128
1999 A Parochial Perspective on the End of Meroe: Changes in Cemetery and Settlement at Arminna West, in: D.A. Welsby (ed.), *Recent Research in Kushite History and Archaeology. Proceedings of the 8th International Conference for Meroitic Studies*, British Museum Occasional Paper 131, London, 203-217
2000 The Botanical Remains, in: T. Insoll (ed.), *Urbanism, Archaeology and Trade, Further Observations on the Gao Region (Mali). The 1996 Field season Results*, British Archaeological Reports International Series 829, Oxford, 28-35
2003a African crops in prehistoric South Asia: a critical review, in: K. Neumann, A. Butler and S. Kahlheber (eds.), *Food, Fuel and Fields. Progress in Africa Archaeobotany*, Africa Praehistorica 15, Cologne, 239-271

2003b Pharaonic or Sudanic? Models for Meroitic Society and Change, in: D. O'Connor and A. Reid (eds.), *Ancient Egypt and Africa (Encounters with Ancient Egypt series, edited by Peter Ucko)*, London, 169-184

2004a The Central Amri to Kirbekan Survey. A Preliminary Report on Excavations and Survey 2003-04, *Sudan & Nubia* 8, 4-16

2004b Early Kushite Agriculture: Archaeobotanical Evidence from Kawa, *Sudan & Nubia* 8, 70-74

2007 Contrasting Patterns in Crop Domestication and Domestication Rates: Recent Archaeobotanical Insights from the Old World, *Annals of Botany* 100 (5), 903-924

2008 The spread of textile production and textile crops in India beyond the Harappan zone: an aspect of the emergence of craft specialization and systematic trade, in: T. Osada and A. Uesugi (eds.), *Linguistics, Archaeology and the Human Past Occasional Paper 3: Indus Project. Research Institute for Humanity and Nature*, Kyoto, 1-26

Fuller, D.Q. and D.N. Edwards

2001 Medieval Plant Economy in Middle Nubia: Preliminary Archaeobotanical Evidence from Nauri, *Sudan & Nubia* 5, 97-103

Fuller, D.Q. and M. Madella

2001 Issues in Harappan archaeobotany: Retrospect and prospect, in: S. Settar and R. Korisettar (eds.), *Indian Archaeology in Retrospect. Vol. II. Protohistory*, New Delhi, 317-390

Fuller, D.Q., Ling Qin, Yunfei Zheng, Zhijun Zhao, Xugao Chen, Leo Aoi Hosoya and Guo-ping Sun

2009 The Domestication Process and Domestication Rate in Rice: Spikelet bases from the Lower Yangtze, *Science* 323, 1607-1610

Gasse, F.

2000 Hydrological changes in the African tropics since the Last Glacial Maximum, *Quaternary Science Reviews* 19, 189-211

Geus, F.

2004 Pre-Kerma Storage Pits on Sai Island, in: T. Kendall (ed.), *Nubian Studies 1998. Proceedings of the Ninth Conference of the International Society of Nubian Studies, August 21-26, 1998. Boston, Massachusetts*, Boston, 46-51

Griffith, F.Ll. and G.M. Crowfoot

1934 On the Early Use of Cotton in the Nile Valley, *Journal of Egyptian Archaeology* 20, 5-12

Grove, A.T.

1978 *Africa*, 3rd Edition, Oxford

Hägg, T.

1986 'Blemmyan Greek' and the Letter of Phonen, in: M. Krause (ed.), *Nubische Studien. Tagungsakten der 5. Internationalen Konferenz der International Society for Nubian Studies, Heidelberg, 22.-25. September 1982*, Mainz am Rhein, 281-286

Haaland, R.

1995 Sedentism, Cultivation, and Plant Domestication in the Holocene Middle Nile Region, *Journal of Field Archaeology* 22, 157-174

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

Harlan, J.R.

1971 Agricultural Origins: Centers and Noncenters, *Science* 174, 468-474

1992 Indigenous African Agriculture, in: C.W. Cowan and P.J. Watson (eds.), *The Origins of Agriculture: An International Perspective*, Washington, D.C., 59-70

Hildebrand, E.

2007 The significance of Sai Island for early plant food production in Sudan, in: B. Gratien (ed.), *Mélanges offerts à Francis Geus*, Cahiers de Recherches de l'Institut de Papyrologie et d'Égyptologie de Lille 26, Lille, 173-181

Hintze, F.
1959 Preliminary report on the Butana expedition, *Kush* 7, 171–196
1978 The Meroitic Period, in: *Africa in Antiquity. The Arts of Ancient Nubia and the Sudan I. The Essays*, Brooklyn/New York, 89-105

Hunt, H.V., M.V. Linden, X. Liu, G. Motuzaite-Matuzeviciute, S. Colledge and M.K. Jones
2008 Millets across Eurasia: chronology and context of early records of the genera Panicum and Setaria from archaeological sites in the Old World, *Vegetation History and Archaeobotany* 17 supplement, 5-18

Katznelson, I.S.
1973 The Study of the History of the Napatan and Meroitic Kingdom: Present State and Tasks, in: F. Hintze (ed.), *Sudan im Altertum. 1. Internationale Tagung für meroitistische Forschungen in Berlin 1971*, Meroitica 1, Berlin, 67-96

Kirwan, L.P.
1957 Tanqasi and the Noba, *Kush* 5, 37-41
1958 Comments on the Origins and History of the Nobatae of Procopius, *Kush* 6, 69-73
1960 The Decline and Fall of Meroe, *Kush* 8, 163-173

Klee, M. and B. Zach
1999 The Exploitation of Wild and Domestic Food Plants at Settlement Mounds in North-East Nigeria (1800 cal BC to Today), in: M. Van der Veen (ed.), *The Exploitation of Plant Resources in Ancient Africa*, London, 81-88

Klee, M., B. Zach and 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, 223-237

Kopytoff, I.
1987 The Internal African Frontier: The Making of African Political Culture, in: I. Kopytoff (ed.), *The African Frontier. The Reproduction of Traditional African Societies*, Bloomington and Indianapolis, 3-84

Lal, B.B.
1967 Indian Archaeological Expedition to Nubia 1962. A preliminary report, in: *Fouilles en Nubie (1961-1963). Campagne internationale de l'Unesco pour la sauvegarde des monuments de la Nubie*, Cairo, 97-118

Lamb, H.F., F. Gasse, A. Benkaddour, N. El Hamouti, S. van der Kaars, W.T. Perkins, N.J. Pearce and C.N. Roberts
1995 Relation between century scale Holocene arid intervals in tropical and temperate zones, *Science* 373, 134-137

Leighty, C.E.
1933 Cereals, in: A.E.R. Boak (ed.), *Karanis: The Temples, Coin Hoards, Botanical and Zoological Reports, Seasons 1924-31*, Ann Arbor, 87-88

Lenoble, P.
1997 Enterrer les flèches, enterrer l'empire I: Carqouis et flèches des tombes imperials à el-Hobagi, in: *Actes de la VIIIe conférence internationale des études nubiennes. Lille 11-17 septembre 1994. II – Découvertes archéologiques*, Cahiers de Recherches de l'Institut de Papyrologie et d'Égyptologie de Lille 17/2, Lille, 137-152
1999a The Division of the Meroitic Empire and the End of Pyramid Building in the 4th Century AD: an introduction to further excavations of imperial mounds in the Sudan, in: D.A. Welsby (ed.), *Recent Research in Kushite History and Archaeology. Proceedings of the 8th International Conference for Meroitic Studies*, British Museum Occasional Paper 131, London, 157-197
1999b Enterrer les fleches, enterer l'empire II: Les archers d'El-Kadada et l'administration de l'imperium méroïtique, *Cahiers de Recherches de l'Institut de Papyrologie et d'Égyptologie de Lille* 20, 125-144

Lenoble, P. and Nigm ed Din Mohammed Sharif
1992 Barbarians at the gates? The royal mounds of El Hobagi and the end of Meroe, *Antiquity* 66, 626-635

Lu, H., J. Zhang, K.-B. Liu, N. Wu, Y. Li, L. Zhou, M. Ye, T. Zhang, H. Zhang, X. Yang, L. Shen, D. Xu, and Q. Li
2009 Earliest domestication of common millet (*Panicum miliaceum*) East Asia extended to 10,000 years ago, *Proceedings of the National Academy of Sciences* (USA) [Published online before print April 21, 2009, doi:10.1073/pnas.0900158106]

Machado, M.J., A. Pérez-González and G. Benito
1998 Paleoenvironmental Changes during the Last 4000 yr in the Tigray, Northern Ethiopia, *Quaternary Research* 49, 312-321

Magid, A.A.
1989 *Plant Domestication in the Middle Nile Basin – an archaeobotanical case study*, BAR International Series 523, Oxford
2003 Exploitation of food-plants in the Early and Middle Holocene Blue Nile area, Sudan and neighbouring areas, in: V.M. Fernández (ed.), *The Blue Nile Project. Holocene Archaeology in Central Sudan (Four thousand years in the Blue Nile: Paths to inequality and ways of resistance)*, Complutum 14, Madrid, 345-372

Mallory, J.P. and V.H. Mair, H. Victor
2000 *The Tarim Mummies: Ancient China and the Mystery of the Earliest Peoples from the West*, London

Mayer-Thurman, C.C. and B.B. Williams
1979 *Ancient Textiles from Nubia, Meroitic, X-Group and Christian Fabrics from Ballana and Qustul*, Chicago

McNeill, W.H.
1976 *Plagues and Peoples*, London

Mills, A.J.
1982 *The Cemeteries of Qasr Ibrim*, Egypt Exploration Society. Fifty-First Excavation Memoir, London

Millet, N.B.
1968 *Meroitic Nubia*, unpublished dissertation, Yale University. University Microfilms, Ann Arbor, Michigan
1981 Social and Political Organization in Meroe, *Zeitschrift für Ägyptische Sprache und Altertumskunde* 108, 124-141

Moulherat, C., M. Tengberg, J.F. Haquet and B. Mille
2002 First evidence of cotton at Neolithic Mehrgarh, Pakistan: Analysis of mineralized fibres from a copper bead, *Journal of Archaeological Science* 29, 1393-1401

Murray, M.A.
2000 Fruits, vegetables, pulses and condiments, in: P. Nicholson and I. Shaw (eds.), *Ancient Egyptian Materials and Technology*, Cambridge, 609-655

Murray, S.S.
2005a Recherches archéobotaniques, in: R.M.A. Bedaux, J. Polet, K. Sanogo, and A. Schmidt (eds.), *Recherches archéologiques à Dia dans le Delta intérieur du Niger, Mali: bilan des saisons de fouilles 1998-2003*, Leiden, 386-400
2005b *The Rise of African Rice Farming and the Economic Use of Plants in the Upper Middle Niger Delta (Mali)*, PhD Dissertation, University of Wisconsin
2007 Medieval cotton and wheat finds in the middle Niger Delta (Mali), in: R. Cappers (ed.), *Field of Change. Proceedings of the 4th International Workshop for African Archaeobotany*, Groningen, 43-52

Nicholson, G.E.
1960 The production, history, uses and relationships of cotton (*Gossypium* spp.) in Ethiopia, *Economic Botany* 14 (1), 3-36

Nesbitt, M.
1993 Archaeobotanical remains [in: G. Herrmann *et al.*, The International Merv Project, preliminary report on the first season (1992), 39-62], *Iran* 31, 56-58
1994 Archaeobotanical research in the Merv Oasis, [in: G. Herrmann *et al.*, The International Merv Project. Preliminary report on the second season (1993), 53-75], *Iran* 32, 71-73

Nesbitt, M. and G.D. Summers
1988 Some recent discoveries of millet (*Panicum miliaceum* L. and *Setaria italica* (L.) P. Beauv.) at excavations in Turkey and Iran, *Anatolian Studies* 38, 85–97

Omer, El Haj Bilal
1985 *The Danagla Traders of Northern Sudan. Rural Capitalism and Agricultural Development*, London

Payne, J.
2005 Excavations of the Late Kushite and Medieval Settlement on Umm Muri, *Sudan & Nubia* 9, 9-13.

Pelling, R.
2005 Garamantean agriculture and its significance in a wider North Africa context: the evidence of plant remains from the Fazzan Project, *The Journal of North African Studies* 10, 397–411
2007 *Agriculture and trade amongst the Garamantes: 3000 years of archaeobotanical data from the Sahara and its margins*, PhD Dissertation, Institute of Archaeology, University College, London

Potts, D.
1994 Contributions to the agrarian history of Eastern Arabia II: The cultivars, *Arabian Archaeology and Epigraphy* 5, 236-275

Purugganan, M.D. and D.Q. Fuller
2009 The nature of selection during plant domestication, *Nature* 457, 843-848

Randsborg, K.
1991 *The First Millennium A.D. in Europe and the Mediterranean. An Archaeological Essay*, Cambridge

Rose, P.J.
1992 *The Aftermath of the Roman Frontier in Lower Nubia*, unpublished PhD dissertation, University of Cambridge

Rowley-Conwy, P.
1989 Nubia AD 0-550 and the "Islamic" Agricultural Revolution: Preliminary Botanical Evidence from Qasr Ibrim, Egyptian Nubia, *Archeologie du Nil Moyen* 3, 131-138

Ryder, M.L.
1984 Skin, hair and cloth remains from the ancient Kerma Civilization of northern Sudan, *Journal of Archaeological Science* 11, 477-482

Samuel, D.
2001 Archaeobotanical evidence and analysis, in: S. Berthier (ed.), *Peuplement rural et aménagements hydroagricoles dans la moyenne vallée de l'Euphrate fin VIIe-XIXe siècle*, Damascus, 343-481

Säve-Söderbergh, T., G. Englund and H.-A.Nordström
1981 *Late Nubian Cemeteries*, The Scandinavian Joint Expedition vol. 6, Copenhagen-Oslo-Stockholm

Schwarcz, H.P. and C.D. White
2004 The grasshopper or the ant?: cultigen-use strategies in ancient Nubia from C-13 analysis of human hair, *Journal of Archaeological Science* 31, 753-762

Shaw, T.
1976 Early crops in Africa: A review of the evidence, in: J.R. Harlan, J.M.J. De Wet and A.B. Stemler (eds.), *Origins of African Plant Domestication*, The Hague, 107-153

Shennan, S.
2002 *Genes, memes and human history: Darwinian archaeology and cultural evolution*, London
Shinnie, P.L.
1967 *Meroe. A Civilization of the Sudan*, New York-Washington
Shinnie, P.L. and J. Anderson
2004 *The capital of Kush 2: Meroe excavations, 1973-1984*, Meroitica 20, Wiesbaden
Shinnie, P.L. and M. Shinnie
1978 *Debeira West. A Mediaeval Nubian Town*, University of Ghana Expedition to Nubia, Warminster
Shishlina, N.I., O.V. Orfinskaya and V.P. Golikov
2003 Bronze Age textiles from the North Caucasus: new evidence of Fourth Millennium BC fibres and fabrics, *Oxford Journal of Archaeology* 22 (4), 331-344
Skoflek, I. and V. Arendas
1981 Abdallah Nirqi 1964. Plant remains from the Nubian excavation, *Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften* 10/11, 215-219
Steele, W.M. and A.H. Bunting
1982 Plant remains from the mortar 192.2.10 from Qasr Ibrim, in: A.J. Mills (ed.), *The Cemeteries of Qasr Ibrim*, London, 86-87
Stemler, A.B.
1990 A Scanning Electron Microscopic Analysis of Plant Impressions in Pottery from Sites of Kadero, El Zakiab, Um Direiwa and El Kadada, *Archeologie du Nil Moyen* 4, 87-106
Strouhal, E.
1984 *Wadi Qitna and Kalabsha-South. Late Roman – Early Byzantine Tumuli Cemeteries in Egyptian Nubia I: Archaeology*, Prague
Tengberg, M.
2003 Research into origins of date palm domestication, in: The Emirates Center for Strategic Studies and Research (ed.), *The Date Palm. From Traditional Resource to Green Weath*, Abu Dhabi, 51-62
Thanheiser, U.
2002 Plant Remains from Kellis: First Results, in: C.A. Hope and A.J. Mills (eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1992-1993 and 1993-1994 Field Seasons*, Oxford, 89-103
Török, L.
1980 To the History of the Dodekaschoenos between ca. 250 B.C. and 298 A.D., *Zeitschrift für Ägyptische Sprache und Altertumskunde* 107, 76-86
1984a The Historical Background: Meroe, North and South, in: F. Hintze (ed.), *Meroitistische Forschungen 1980. Akten der 4. Internationalen Tagung für meroitistische Forschungen vom 24. bis 29. November 1980 in Berlin*, Meroitica 7, Berlin, 139-229
1984b Economy in the Empire of Kush: A Review of the Written Evidence, *Zeitschrift für Ägyptische Sprache und Altertumskunde* 111, 45-69
1988 *Late Antique Nubia: History and Archaeology of the Southern Neighbor of Egypt in the 4th-6th Centuries A.D.*, Antaeus 16, Budapest
1989 Kush and the External World, in: S. Donadoni and S. Wenig (eds.), *Studia Meroitica 1984. Proceedings of the Fifth International Conference for Meroitic Studies. Rome 1984*, Meroitica 10, Berlin, 49-215
1997a *The Kingdom of Kush. Handbook of the Napatan-Meroitic Civilization*, Handbuch der Orientalistik 31, Leiden
1997b *Meroe City. An Ancient African Capital. John Garstang's Excavations in the Sudan*, The Egypt Exploration Society. Occasional Papers 12, London
1999 The End of Meroe, in: D.A. Welsby (ed.), *Recent Research in Kushite History and Archaeology. Proceedings of the 8th International Conference for Meroitic Studies*, British Museum Occasional Paper 131, London, 133-156

Tothill, J.D.
1952 *Agriculture in the Sudan: being a handbook of agriculture as practised in the Anglo-Egyptian Sudan*, London

Turner, P.K.
1989 *Roman Coins from India,* University College London Institute of Archaeology Publications, Occasional Publication. UCL Institute of Archaeology, London

Van Zeist, W.A.
1983 Fruits in Foundation Deposits of Two Temples, *Journal of Archaeological Science* 10, 351-354
1987 The plant remains, in: A. Vila (ed.), *Le Cimetière Kermaique d'Ukma Ouest*, Paris, 247-255

Voland, E.
1998 Evolutionary Ecology of Human Reproduction, *Annual Review of Anthropology* 27, 347-374

Walshaw, S.C.
2005 *Swahili urbanization, trade, and food production: botanical perspectives from Pemba Island, Tanzania, A.D. 600-1500*, PhD Dissertation, Department of Anthropology, Washington University, St. Louis

Wasylikowa, K. and J. Dahlberg
1999 Sorghum in the Economy of the Early Neolithic Nomadic Tribes at Nabta Playa, Southern Egypt, in: M. van der Veen (ed.), *The Exploitation of Plant Resources in Ancient Africa*, New York, 11-31

Wasylikowa, K., H.N. Barakat, L. Boulos, A. Butler, J.A. Dahlberg, J. Hather and J. Mitka
2001 Site E-75-6: Vegetation and Subsistence of the Early Neolithic at Nabta Playa, Egypt, reconstructed from charred plant remains, in: F. Wendorf and R. Schild (eds.), *Holocene Settlement of the Egyptian Sahara: Volume 1: The Archaeology of Nabta Playa*, New York, 544-591

Wasylikowa, K., J.R. Harlan, J. Evans, F. Wendorf, R. Schild and A.E. Close
1993 Examination of botanical remains from early Neolithic houses at Nabta Playa, Western Desert, Egypt, with special reference to sorghum grains, in: T. Shaw, P. Sinchalir, B. Andah and A. Okpoko (eds.), *The Archaeology of Africa. Food, Metals and Towns*, London, 154-164

Wasylikowa, K., J. Mitka, F. Wendorf and R. Schild
1997 Exploitation of wild plants by the Early Neolithic hunter-gatherers in the Western Desert of Egypt: Nabta Playa as a case-study, *Antiquity* 71, 932-941

Wasylikowa, K., R. Schild, F. Wendorf, H. Krolik, L. Kubiak-Martens and J.R. Harlan
1995 Archaeobotany of the Early Neolithic site E-75-6 at Nabta Playa, Western Desert, South Egypt (preliminary results), *Acta Palaeobotanica* 35, 133-155

Welsby, D.A.
1996 *The Kingdom of Kush. The Napatan and Meroitic Empires*, London
2002 *The Medieval Kingdoms of Nubia. Pagans, Christians and Muslims along the Middle Nile*, London

Wendel, J.F.
1995 Cotton, in: J. Smartt and N.W. Simmonds (eds.), *Evolution of Crop Plants*, second edition, London, 358-366

Whitcomb D. and J.H. Johnson
1982 *Quseir al-Qadim 1980. Preliminary Report*, Malibu

White, C.D.
1993 Isotopic determination of seasonality in diet and death from Nubian mummy hair, *Journal of Archaeological Science* 20, 657-666

White, C.D. and H.P. Schwarcz
1994 Temporal trends in stable isotopes for Nubian mummy tissues, *American Journal of Physical Anthropology* 93, 165-187

Wild, J.-P.
1997 Cotton in Roman Egypt: Some Problems of Origin, *Al-Rafidan* XVIII, 287-298
Wild, J.-P. and F.C. Wild
2005 Rome and India: early Indian cotton textiles from Berenike, Red Sea coast, Egypt, in: R. Barnes (ed.), *Textiles in Indian Ocean Studies*, London, 11-16
Wild, J.-P., F.C. Wild and A. Clapham,
2007 Irrigation and the spread of cotton growing in Roman times, *Archaeological Textiles Newsletter* 44, 16-18
Willerding, U. and G. Wolf
1991 Paläoethnobotanische Untersuchungen von Pflanzenresten aus dem 1. Jahrtausend v. Chr. von Elephantine, *Mitteilungen des Deutschen Archäologischen Instituts Kairo* 46, 263-267
Williams, B.B.
1985 A Chronology of Meroitic Occupation below the Fourth Cataract, *Journal of the American Research Center in Egypt* 22, 149-195
1991a *Meroitic Remains from Qustul Cemetery Q, Ballana Cemetery B and a Ballana Settlement*, University of Chicago Oriental Institute Nubian Expedition vol. VIII, Chicago
1991b *Noubadian X-Group Remains from Royal Complexes in Cemeteries Q and 219 and from private cemeteries Q, R, V, W, B, J, and M at Qustul and Ballana*, University of Chicago Oriental Institute Nubian Expedition vol. IX, Chicago
Wilson, L.M.
1933 *Ancient Textiles from Egypt in the University of Michigan Collection*, Ann Arbor
Woolley, C.L. and D. Randall-MacIver
1910 *Karanòg. The Romano-Nubian Cemetery*, University of Pennsylvania. Egyptian Department of the University Museum. Eckley B. Coxe Junior Expedition to Nubia: Vols. III und IV, Philadelphia
Žabkar, L.V.
1975 *Apedemak, Lion God of Meroe. A Study in Egyptian-Meroitic Syncretism*, Warminster