THE LECH KRZYŻANIAK EXCAVATIONS IN THE SUDAN

KADERO

Botanical evidence

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To add to the well-known archaeological uniqueness of Kadero, we anticipated the eventual discovery of equally unique archaeobotanical evidence for the early use of domesticated cereals at this Neolithic site. The 1999 season at Kadero began in November in a highly optimistic Mood. Our goal was to systematically collect botanical samples from the settlement middens and the burial ground, and the entire team and especially Professor Krzyżaniak eagerly awaited the evidence, particularly for the early use of *Sorghum*. Our optimism was based on several considerations. We were at the right place in Africa to look for early evidence for domesticated African cereals; and we devoted meticulous care to the recovery of plant remains.

Unfortunately, our expectations were not fulfilled as, in spite of our best efforts, no cereal remains were found. Nonetheless, I still consider myself fortunate to have had the privilege to work at Kadero.

This contribution intends to present an overview of all archaeobotanical research carried out at the Neolithic site of Kadero in the Central Sudan, under the inspiring guidance of Professor Lech Krzyżaniak.

The site

The Neolithic site of Kadero lies ca. 20km north of Khartoum, on the eastern bank of the Nile (Krzyżaniak 1984). The site has been excavated by Professor Lech Krzyżaniak, together with a team of archaeologists, geologists, anthropologists and archaeobotanists, for nearly 20 seasons. According to recent geological studies the site, which is situated on a small hill, rests on the surface of the pediment, in a small valley which was once a tributary of the Nile (Stankowski, this volume). The site consists of two settlement middens and a burial ground. The middens are the result of accumulated settlement debris originally swept away from the surface of the occupation area by the inhabitants. Radiocarbon dates acquired from charcoal ranged from 5960 to 5030 BP (4850-4250 cal BC). The excavations in the middens yielded a rich assemblage of settlement remains including lithic artefacts, grindstones, potsherds and animal remains (Krzyżaniak 1991). The unique nature of the site is also apparent in the burial ground. Here, the contents of the graves document a local Neolithic community with a well-developed social structure and funerary customs (Krzyżaniak 1991). The assemblages of animal remains from the middens were particularly large and diverse, and provided evidence for an early pastoral economy in the Central Sudan based on cattle, sheep and goats (Gautier 2007). Finally, plant impressions preserved in the pottery (Klichowska 1984, Stemler 1990), and plant remains that were encountered during the 1999 and 2001 and earlier seasons (Krzyżaniak 1991) were studied.

Non-charcoal plant remains

In 1999 and 2001, botanical samples were taken from the settlement middens as well as from the individual graves within the cemetery. On the middens, samples were collected within a 1x1m grid which was vertically subdivided into 10cm-layers. From each layer within a sampling unit, botanical samples of ca. 10 litre each were taken. All samples were dry-sieved through 1.0 and 0.5mm sieves. A total of 61 samples from the middens was processed, and 15 from the graves. The 1999 and 2001 seasons produced very few plant remains (see Table 1). The botanical assemblages contained mainly small pieces of charcoal. The only types of plant remains other that charcoal were charred fragments of fruit stones of *Zizyphus* and hackberry (*Celtis*). There are several possible explanations for this limited preservation of plant remains. The degree of fragmentation of the charcoal suggests strong (wind-) erosion and exposure to alternating wet and dry conditions after the site was abandoned.

The charred fruit stones of *Zizyphus* recovered from Kadero indicate that this plant was being used, possibly as food. The fruits of most species

Table 1. Summary table of plant remains recovered from Kadero (field seasons 1999 and 2001)

Sample	Charcoal	Plant remains other than charcoal	
Square A1/3	(+)	-	-
Square A1/4	(+)	-	-
Square A1/5	++	Zizyphus	fruit stone - 3 frg
Square A1/6	+		
Square A2/2	(+)	Zizyphus	fruit stone - 2 frg
Square A2/3	+	Zizyphus	fruit stone - 21 frg
Square A2/4	(+)	Zizyphus	fruit stone - 11 frg
Square A2/5	(+)	Zizyphus	fruit stone - 12 frg
Square A2/6	-	-	-
Square A3/1	-	-	-
Square A3/2	(+)	-	-
Square A3/3	(+)	-	indet. fruit stone - 1 frg
Square A3/4	(+)	-	-
Square A3/5	(+)	-	-
Square A3/6	-	-	-
Square A4/3	(+)	-	-
Square A4/4	-	-	-
Square A4/5	+	-	-
Square A4/6	+	Zizyphus	fruit stone - 4 frg
		Celtis	fruit stone - 2 frg
Square A5/2	-	-	-
Square A6/1	(+)	-	-
Square A6/2	(+)	-	-
Square A6/3	++	Zizyphus	fruit stone - 8 frg
Square A6/4	+	Zizyphus	fruit stone - 6 frg
Square A6/5	+	-	-
Square A6/6	(+)	-	-
Square A7/1	+	Zizyphus	fruit stone - 7 frg
Square A7/2	+	Zizyphus	fruit stone - 10 frg
Square A7/3	(+)	Zizyphus	fruit stone - 5 frg
Square A7/4	-	-	-
Square A7/5	-	-	-

Sample	Charcoal	Plant remains other than charcoal	
Square A7/6	(+)	-	-
Square A8/1	-	-	-
Square A8/4	(+)	-	-
Square A8/5	-	-	-
Square A9/1	-	-	-
Square A9/2	-	-	-
Square A9/3	(+)	-	-
Square A9/4	(+)	-	-
Square A9/5	(+)	Zizyphus	fruit stone - 1 frg
Square A10/1	-	-	-
Square A10/2	(+)	-	-
Square A10/3	(+)	-	-
Square A10/4	-	-	-
Square B1/2	-	-	-
Square B2/2	-	-	-
Square B3/2	-	-	-
Square B4/2	(+)	-	-
Square B5/2	-	-	-
Square B5/3	-	-	-
Square B6/3	++	-	-
Square B6/4	-	-	-
Square B6/5	(+)	-	-
Square B6/6	-	-	-
Square B7/3	-	-	-
Square B7/4	-	-	-
Square B8/2	-	-	-
Square B8/3	-	-	-
Square B9/2	-	-	-
Square B10/2	-	-	-
Square 681, under grinstone	(+)	-	-
Grave 226	(+)	Celtis	Fruit stone with fruit flesh - 1 frg
Grave 226, pit fill	(+)	-	pottery - 1 frg. (impression)
Grave 228	(+)	-	-
Grave 229 (infant)	++	indet.	parenchyma - 1 frg
Grave 232	+	Zizyphus	fruit stone - 2 frg
Grave 233	(+)	indet.	seed -1
Grave 237, pit fill	-	-	fish bone (+)
Grave 239, pit fill	(+)	-	-
Grave 239, pot	-	-	-
Grave 240, pit fill	-	-	-
Grave 241, pit fill	(+)	-	-
Grave 242, pit fill	-	-	fish bone (+)
Grave 243, pit fill	(+)	Zizyphus	fruit stone - 1 frg
Grave 244, pit fill	(+)	-	-
Grave 245, pit fill	-	-	-

Frequency scale: - = no plant remains, (+) = few fragments, + = frequent, ++ = numerous of *Zizyphus* are edible, and they can be eaten fresh or processed, as a mush or as cakes. The fruits are also easily dried and stored and acquire a soft date-like quality after only a short storage period (Dagher 1991). The Zagawa people in Sudan still make a type of meal from dried *Zizyphus* fruits but also extract the seeds from the crushed stones and grind these (Tubiana and Tubiana 1977). The seeds are likely to be rich in proteins and fat, although no data on the subject has been published yet. Interestingly, all *Zizyphus* remains from Kadero are actually crushed stones, which suggests extraction and use of the seed (Fig. 1). *Zizyphus* stones are hard and rather thick-walled, and their fragmented state therefore suggests that they were being crushed intentionally. This pattern of preservation – i.e. as crushed charred stones – is also known from other early sites such as the Early Neolithic Nabta Playa in southern Egypt (Wasylikowa and Kubiak-Martens (1995).

The presence of small and deeply concave lower grindstones, or mortars, in Kadero's stone tools assemblage may be associated with the exploitation of *Zizyphus* seeds. The working surface of the grindstones tends to be very coarse and uneven, with numerous traces of chipping. These 'mortars' were probably used in combination with club-shaped pestles, the working surfaces of which display almost identical use wear (Jórdeczka, this volume).

A few charred specimens of *Celtis* fruit stones were also recovered from the Kadero middens and graves. One fragment recovered from grave 226 had some fruit flesh still attached to the stone (Fig.

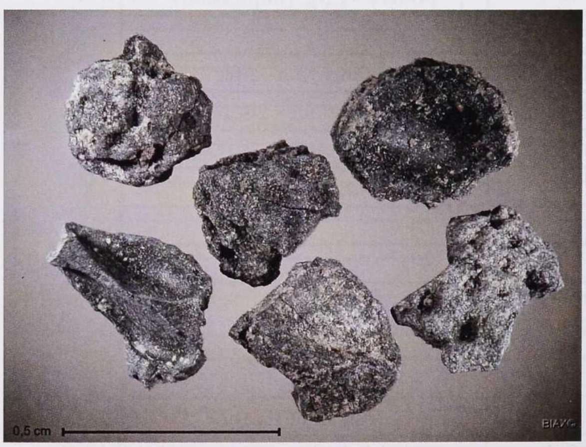

Fig. 1. Charred remains of Zizyphus fruit stones recovered from the midden at Kadero (Square A2, 1999).

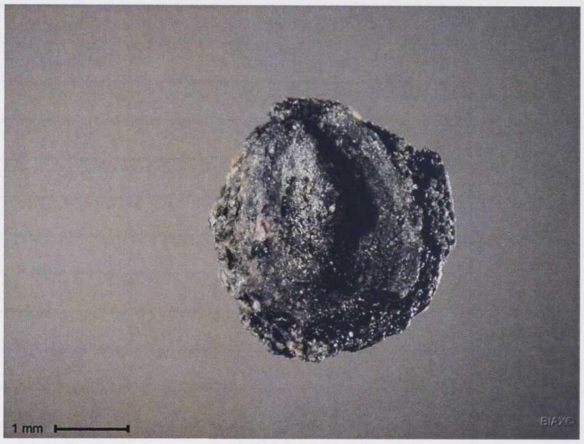

Fig. 2. Charred fruit stone of Celtis with some flesh still attached to the stone, recovered from the Grave No.226 at Kadero in 1999

2). Numerous mineralized stones of African hackberry (*Celtis integrifolia*) from the Kadero middens were earlier reported by Krzyżaniak (1991), and one specimen was photographed by Stempler (1990). Presumably the cherry-like fruits of African hackberry were consumed at Kadero. Closely related to African hackberry is *Celtis australis*, fruit stones of which are known from Neolithic Çatalhöyük in southern/central Anatolia, Turkey (Helbaek 1964). At Çatalhöyük, fruits of *Celtis* were interpreted as a useful seasonal food source.

Charcoal analysis and a reconstruction of woody vegetation around the site

The analysis of wood charcoal from the midden deposits and the graves was carried out by Barakat (1995). The main objective of this study was to reconstruct the woody vegetation at and around the site during the occupation period. Before presenting the results, however, a few preliminary remarks have to be made.

Assuming that the people at Kadero collected the firewood for their hearths in areas easily accessible from the site, the charcoal represents trees and shrubs that would have been part of the local vegetation. Moreover, people at any site, and hence also at Kadero, would have needed wood for other purposes as well - such as artefacts and construction - for which they may have deliberately selected wood of a specific type and species. After having been used for other purposes this wood may eventually also have ended up as fuel. One charcoal assemblage may therefore contain a mixture of firewood, which is usually collected near the settlement, and wood for other purposes, which may have come from local stands of woody vegetation but may also have been gathered farther away.

The most noticeable characteristic of the charcoal assemblages from both the middens and the graves in Kadero is the relatively large proportion of *Acacia* species, including *Acacia senegal* (gum acacia), *A. seyal* (red acacia) and *A. nilotica* (gum Arabic tree) (Barakat 1995). *Acacia seyal* and *A. nilotica* both grow on high slopes and along the banks of the Nile and its tributaries, on clayey soils. These two high-growing trees are a common element of the vegetation in seasonally inundated areas, which stresses the proximity of Kadero to the Nile floodplains (Barakat 1995), or at least to the small tributary of the Nile as suggested by more recent geological research (Stankowski, this volume). Other taxa represented in the charcoal assemblage include *Balanites aegyptiaca*, a tree belonging to a riparian type of vegetation which tolerates a wide variety of soil types, from sand to heavy clay. On clayey soils in the short grass savanna, but also on the mud plains of the Nile and its main tributaries in the Central Sudan, it is often associated with A. seyal. Perhaps also associated with a riverine environment is another tree, the dum palm (*Hyphaene thebaica*), fruit stones of which were found in one of the Early Neolithic inhumations at Kadero (Krzyżaniak 1991).

Acacia senegal, a small acacia tree represented in the charcoal record (Barakat 1995), is an element of several types of vegetation in the Sudan, from semi-desert grassland on sandy soils to short grass vegetation on clayey soils, as well as the savanna woodlands. Other species present in the charcoal assemblage include three typical desert and semi-desert species such as *Cassia senna*, *Capparis decidua*, and *Maerua crassifolia*. They mainly grow on sandy soils but can also be found on the short grass savanna in Central Sudan. Two other plants in the charcoal assemblage, *Cadaba glandulosa* and *Grewia villosa*, represent Sahelian taxa.

One single fragment of charcoal was attributed by Barakat (1995) to a gymnosperm species belonging to the Cupressaceae family, possibly *Juniperus* (juniper). According to Barakat, wood or charcoal of this taxon must have arrived at the site from a great distance, possibly from the Red Sea hills which is the nearest location where *Juniperus* grows, but which are 500 km away.

To summarize: Barakat (1995) concluded that the charcoal assemblage at Kadero indicates that the vegetation around the site during the occupation period consisted of dry scrub and thorn savanna. She tentatively interprets the absence of species characteristic of the northern sections of the dry thorn and scrub savanna such as *Acacia tortilis* and *Leptadenia pyrotechnica*, as possible evidence for a more southern type of vegetation dominated by *Acacia senegal*. Barakat further suggested that the vegetation around the Neolithic settlement at Kadero was strongly influenced by human activities such as (controlled) fires, the felling of trees (for firewood and timber) and grazing.

Plant impression on pottery from Kadero

Plant impressions on pottery are impressions made by plant materials as temper and burnt away when the pottery was fired.

Two series of studies have been carried out on plant impressions on the pottery from Kadero. The first series was carried out by Dr. Melania Klichowska and published in 1984. Klichowska studied nearly 170 impressions of plants on the potsherds and claimed to have identified domesticated sorghum (*Sorghum vulgare* = *S. bicolor*) and finger millet (*Eleusine coracana*) as the two most frequent impressions on Kadero pottery. In addition, Klichowska identified impressions of wild grasses including *Setaria*, *Antropogon*, *Digitaria* and *Panicum*. Unfortunately Klichowska's conclusions are unreliable, mainly because none of her identifications has been convincingly documented or photographed. The most serious objection, however, is the fact that these identifications of – supposedly - domesticated sorghum were largely based on measurements of the casts of plant impressions, while size is in itself not a sufficiently diagnostic feature to distinguish wild varieties from domesticated ones.

The second series of studies was a re-examination of earlier work on Kadero material, carried out by Dr. Ann Stemler and using scanning electron microscopy (1990). In addition to Kadero pottery Stemler also studied plant impressions on pottery from other Neolithic sites in Central Sudan including El Zakiab, Um Direiwa and El Kadada. In the Kadero pottery, Stemler identified mainly wild sorghum (*Sorghum bicolor* ssp. *arundinaceum*) and other grasses from the wild millet group (probably *Setaria*). In addition to grasses, there were impressions of hackberry (*Celtis*) fruit stones/fruits, and possibly also of seeds of watermelon (*Citrullus* sp.) and water lily (*Nymphaea* sp.). Stemler's identifications of wild sorghum were mainly based on impressions of spikelets, which morphologically closely resembled those of *Sorghum bicolor* ssp. *arundinaceum*. Stemler suggested that although all studied impressions of sorghum spikelets 'look like wild sorghum' the possibility cannot be ruled out that the sorghum in the pottery impressions from Kadero is a primitive domesticate, or a morphologically wild but nonetheless cultivated form. Stemler (1990) also found wild sorghum and other panicoid grasses (*Setaria*, *Pennisetum*) as spikelet or grain impressions on pottery from three other Neolithic sites in Central Sudan, including El Zakiab, Um Direiwa and El Kadada.

Pre-domestication cultivation of sorghum

Although the early use of wild sorghum as food throughout the eastern Sahara is archaeologically well documented (Wasylikowa and Kubiak-Martens 1995; Barakat and Fahmy 1999; Wasylikowa and Dahlberg 1999), the evidence for its early domestication remains elusive and highly questionable. Domestication is generally considered to have succeeded the method of harvesting cereals whereby the grain-bearing inflorescence is cut off. In time, this practise would lead to the development of domesticated cereals, because it selects for genotypes that retain their grains rather than shed them upon maturity, as wild cereals do to facilitate natural dispersal. Harvesting by sweeping or stripping the grain off the plant or inflorescence, however, does not lead to cereal domestication, because this method affect the plant populations no different than natural processes (Stemler 1990).

The oldest evidence of the use of wild sorghum as food has been recovered from the Early Neolithic site at Nabta Playa in South Egypt and dates to about 8000 BP (Wendorf et al. 1992, Wasylikowa et al. 1995). In addition to wild sorghum (assigned to *Sorgum bicolor* ssp. *arundinaceum*), there were also other grasses from the millet group (*Echinochloa colona*, *Panicum turgidum*, *Setaria*, *Digitaria* and *Brachiaria*) that were most likely harvested from wild stands (Wasylikowa and Kubiak-Martens 1995, Wasylikowa et al. 1997). Interestingly, grains of sorghum clearly outnumbered all other species in the assemblage of charred plant remains at Nabta Playa. This suggests that sorghum played a significant role relative to other grasses from the (wild) millet group. Perhaps wild sorghum was selected and harvested separately, which is easily accomplished due to its bigger grain size compared with other panicoid grasses. It seems that at one point (perhaps just in some years) sorghum have become a main cereal. Nabta may have been one of the locations where early attempts at the cultivation, but not yet domestication, of wild sorghum took place (Wasylikowa and Dahlberg 1999).

The question of possible pre-domesticated cultivation of sorghum has also been raised in association with the Neolithic settlement at Kadero. As Haaland has suggested (1987), the Early Neolithic farmers in Central Sudan harvested wild cereals either by stripping the grain from the plant or by sweeping the fallen grains off the ground. Neither method would favour the genetic changes usually associated with domestication.

It is quite possible that cultivation of morphologically wild cereals, particularly sorghum, was practiced by the early farmers in Kadero. Interestingly, lithic artefacts that could have been used as harvesting tools, such as sickle inserts, were noticeably absent at Kadero (Kobusiewicz, this volume). Grindstones, however, were present and show clear evidence of having been heavily used (Jórdeczka, this volume). They had most likely been used to grind grain, other uses being less likely, which suggests that grain was being processed at the site. Among the lithic implements from Kadero are a considerable number of blades of the type 'gouges', which display traces of intensive use and which were very likely originally hafted (Kobusiewicz, this volume). Although the function of these blades is unclear, various suggestions have been made. Haaland (1987), for example, has argued that these gouges, which are also known from other Early Neolithic sites in Central Sudan, were farming tools and specifically hoe blades, used to prepare the soil for the cultivation of sorghum,.

All current evidence - the impressions of wild sorghum spikelets on pottery, the absence of harvesting tools and the presence of possible farming tools (the 'gouges') and grindstones – in combination suggests that methods associated with pre-domestication cultivation of sorghum and possibly other grasses from the millet group were practiced at the Neolithic site at Kadero. In spite of the limited data available at Kadero, this seems to support the hypothesis of a late origin and dispersal of domesticated forms of African cereals.

The domestication of sorghum is indeed considered to be a late event, possibly even as late as the beginning of the Christian era (Clark and Stemler 1975, Rowley-Conwy et al. 1999). Although there is general consensus nowadays that sorghum was probably first domesticated in north-eastern Africa, most likely in the savanna zone (e.g. Doggett 1988, Harlan 1995), various authors have presented contradictory and unsubstantiated claims for an early domestication of sorghum in Arabia and India (see discussion in Rowley-Conwy et al. 1999). However, the most reliable evidence for domesticated sorghum comes from three locations in the Middle Nile region. These are Meroè, where sorghum remains were dated to 20 ± 127 BC non-cal. (Stemler and Falk 1981); Jebel el Tomat in Central Sudan, where remains from a storage pit were dated to AD 245 ± 60 non-cal. (Clark and Stemler 1975) and Qasr Ibrim in southern Egypt, where no radiocarbon dates are available for these remains but where stratigraphical evidence suggests a date of AD 100 (Rowley-Conwy 1991). This distribution pattern of the archaeological record of the oldest known domesticated sorghum is consistent

Fig. 3. Sorghum bicolor subsp. arundinaceum, South Africa
(photograph by D.B. Hoare).

with the results of studies of ancient DNA in sorghum. DNA analysis of the Qasr Ibrim sorghum indicated a fairly recent origin and dispersal of domesticated sorghum, possibly no earlier than the 1st millennium BC (Rowley-Conwy et al. 1999).

Conclusions

The charred plant remains recovered at Kadero are few in number and represent a small range of plant species. We cannot explain this lack of botanical evidence away by concluding that we didn't look properly for it, for clearly we did. It seems that we must consider other explanations for the limited presence of plant material. Preservation conditions are probably a significant factor. At any future excavations carried out at Kadero, the study of patterns of subsistence and food production and -processing should also involve other disciplines or complimentary archaeological approaches, such as phytolith analysis of the stone tools (especially grindstones), analysis of use-wear traces on flint implements and various other stone tools, and stable isotope analysis of human bone and last but not least, examination of calculus from human teeth.