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Rethinking Agriculture:
Archaeological and Ethnoarchaeological Perspectives

Edited by
Tim Denham, José Iriarte and Luc Vrydaghs

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CHAPTER 17

The Development of Plant Cultivation in Semi-Arid West Africa

Stefanie Kahlheber and
Katharina Neumann

INTRODUCTION

Semi-arid West Africa[1] is a key area for the understanding of Africa's pathway to agriculture. Classified as a 'non-centre' of plant domestication (Harlan 1971), the vast area between Senegal and Lake Chad is the place of origin of several African crops. In the last decade, a number of systematic archaeobotanical investigations on charred fruits and grains, impressions in ceramics and charcoal from archaeological sites have become available. We present here the major results of our archaeobotanical work in Burkina Faso and Nigeria and additional evidence from Mali, Ghana, Mauritania, Senegal and Cameroon. These data, though still patchy, draw a new outline on the development of sub-Saharan plant food production[2], which is unique and distinctly different from other regions of the world.

While in the pristine agricultural centres of the Near East, China and Mesoamerica plant domestication preceded animal domestication (Smith 1998), in Africa herding of domesticated animals developed first and flourished for several millennia before crop cultivation was adopted (Hassan 2002; MacDonald 2000; Marshall and Hildebrand 2002). In addition, foraging economies had been very successful in the vast grasslands and savannas of the Sahara and sub-Saharan Africa for 2.5 million years, including the Early and Middle Holocene humid period (Neumann 2003, 2005). In contrast to farming, foraging and pastoralism have one important feature in common: the need for mobility. As the development of agriculture is usually closely linked with sedentism, the high mobility of hunter-gatherers and pastoralists in the Sahara and in the adjacent savannas postponed the evolution of farming longer than on other continents.

The palaeoenvironmental background for increasing sedentism and incipient plant cultivation is the abrupt termination of the Holocene African humid period around 3500 cal BC[3] (DeMenocal et al 2000). In the course of a few centuries or even decades, the hitherto complete plant cover of the Sahara was probably replaced by patchy vegetation, restricted to favourable areas, and floristically impoverished (Schulz 1991). The increasing desiccation of the

Sahara culminated in a severe dry spell around 2500 cal BC (Guo et al 2000) when the southern Saharan lakes dried out and human populations were forced to move southwards. During the second half of the third and the second millennium BC, population density increased in the Sahara–Sahel region between 19° N and 14° N (Vernet 2002), and a northern influence in the material culture is traceable farther south, such as in the Méma, Mali (MacDonald et al 2003), in Gajiganna, Nigeria (Breunig and Neumann 2002a), and even as far as Central Ghana (Davies 1980; Flight 1976; Watson 2003). It is in this context that domesticated plants appear for the first time in sub-Saharan Africa.

THE BEGINNING OF PLANT FOOD PRODUCTION

Archaeobotanical Evidence

Unequivocal evidence of plant food production in West Africa is traceable from the second millennium BC[4] onwards. The domesticated form of pearl millet (*Pennisetum glaucum*) appears in sites from the modern southern Sahara to the Sudanian zone (Figure 17.1) and seems to have been the preferred crop of the first West African farmers, although its roles in the economy and archaeological contexts vary considerably from site to site.

In the Sahel of Burkina Faso, sites of the second millennium BC are of small spatial extent and have a rather low amount of cultural remains (Breunig and Neumann 2002a). At Oursi West and Tin Akof, mobile groups cultivated pearl millet on a small scale (Kahlheber 2004; Kahlheber et al 2001; Neumann and Vogelsang 1996; Neumann et al 2001; Vogelsang et al 1999). It is assumed that these communities largely depended on hunting and gathering, and pearl millet was just an additional carbohydrate source in a diversified subsistence. Archaeobotanical evidence of pearl millet consists of charred caryopses (cereal grains) and of imprints in organically tempered potsherds (Figure 17.2). One caryopsis from Tin Akof has been AMS dated to 1035–915 cal BC, but the crop is already present in the first of the three occupational phases beginning around 1800 cal BC (Kühltrunk 2000). Cultivation does not seem to have altered the natural vegetation considerably, as in the charcoal samples from Tin Akof indicators of fallows or typical park savannas are absent (Neumann et al 2001).

For the Mauritanian sites of the Tichitt-Oualata tradition a more intensive cultivation of pearl millet is suggested. From the numerous imprints of domesticated pearl millet in potsherds, one has been AMS dated to 1935–1685 cal BC (Amblard 1996). Indirect evidence comprises architectural features, which have been interpreted as remnants of granaries or walls of field and garden enclosures (Amblard 1996; Amblard-Pison 1999; Munson 1971, 1976). The existence of gardens is corroborated by micropalaeontological analyses of sediments (Person et al 2001). The architectural evidence for cultivation corresponds with the development of larger settlements occupied by a sedentary population. During the height of Tichitt-Oualata around 1600 cal BC its characteristic elements, including domesticated pearl millet, also

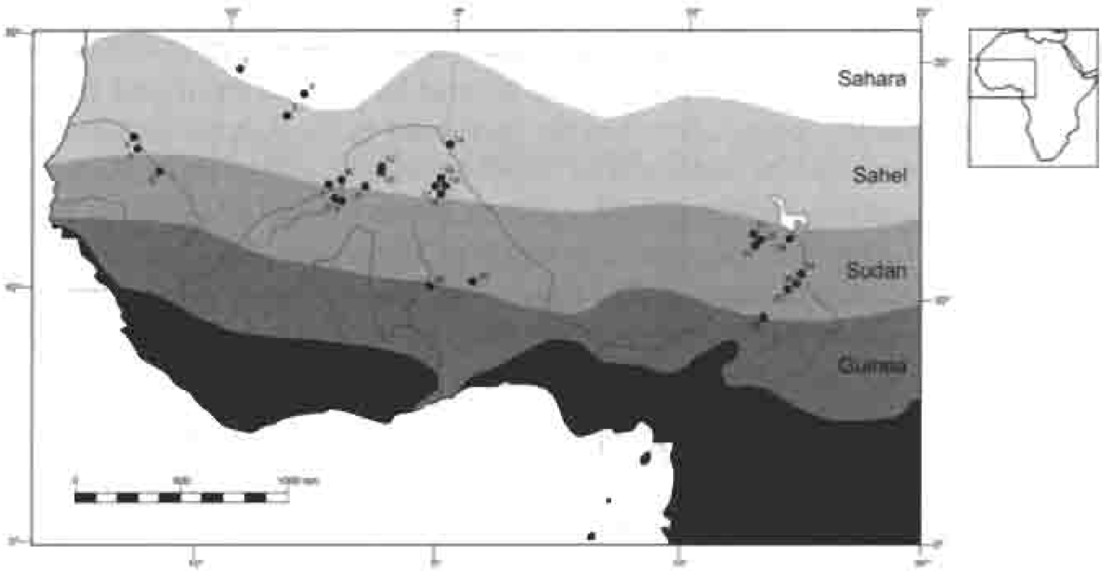

Figure 17.1 Archaeological sites in West Africa with remains of domesticated crops.

	Site/site complex	*Country*
1	Dhar Tichitt	Mauritania
2	Dhar Oulata: Oued Chebbi	Mauritania
3	Dhar Nema: Djiganyai, Bou Khzama	Mauritania
4	Cubalel/Siwré (MSV)	Senegal
5	Sıncu Bara (MSV)	Senegal
6	Arondo (USV)	Senegal
7	Dia (NID)	Mali
8	Jenné-Jeno (NID)	Mali
9	Toguéré Doupwil (NID)	Mali
10	Toguéré Galia (NID)	Mali
11	Tellem (Falaise de Bandiagara)	Mali
12	Tongo Maaré Diabel (Gourma)	Mali
13	Windé Koroji Ouest I (Gourma)	Mali
14	Gao Gadei	Mali
15	Tin Akof (BF94/133)	Burkina Faso
16	Kissi (BF96/22, BF97/31, Ki 40)	Burkina Faso
17	Mare d'Oursi area: Corcoba (BF97/5), Oursi West (BF94/45), Oursi Nord (BF97/13), Oursi Ost (BF97/25), Oursi 1 (BF97/26), Oursi 2 (BF97/27), Oursi 3 (BF97/28), Oursi 4 (BF97/29), Oursi hu-beero (BF97/30), Kolël Nord (BF97/23)	Burkina Faso
18	Saouga area: Saouga A (BF 94/120), Saouga B (BF95/7), Sirkangou (BF96/17)	Burkina Faso
19	Yohongou	Benin
20	Birimi	Ghana
21	Gajiganna (BDC)	Nigeria
22	Zilum (BDC)	Nigeria
23	Dorota, Elkido Nord (BDC)	Nigeria
24	*firki* plain: Daima, Kursakata, Mege,	Nigeria
25	Yaéré: Kayam, Mongossi	Cameroon
26	Diamaré Plain: Balda Tagamré, Goray, Jiddere Saoudjo, Salak, Tchere	Cameroon
27	Piémonts Mandara: Louggéréo, Mowo	Cameroon
28	UBV: Bé, Douloumi, Sumpa	Cameroon

abbreviations:
BDC: Bama Deltaic Complex
MSV: Middle Senegal Valley
NID: Niger Inland Delta
UBV: Upper Benue Valley
USV: Upper Senegal Valley

appear in the more southerly located Dhar Nema (MacDonald et al 2003). Whether, however, the appearance and increasing percentages of pearl millet imprints in the second millennium Tichitt ceramics are an expression of an in situ development (MacDonald et al 2003; Munson 1976) or the tradition arrived with fully developed agro-pastoral practices from elsewhere (Amblard 1996) remains a matter of discussion.

At Birimi, a site of the Kintampo complex[5] in northern Ghana, two samples of domesticated *Pennisetum glaucum* have been directly dated to 1620–795 cal BC and to 1980–1520 cal BC (D'Andrea et al 2001). As pearl millet represents by far the most common species in the archaeobotanical samples, it seems that the subsistence of northern Kintampo groups highly relied on this crop. Cultivation at Birimi might have taken place in a swidden horticulture system, in small plots of relatively uniform stands (D'Andrea and Casey 2002). Pearl millet, a storable resource for sustaining sedentary people through the long dry season, was integrated into existing subsistence systems as an effective adaptation to the seasonal dry climatic regime of the Sudanian woodland savanna.

For the Gajiganna culture in the Chad Basin of Northeast Nigeria, plant impressions in ceramics illustrate the development from a pastoral to an agro-pastoral economy where plant cultivation was added to a diversified subsistence with cattle keeping, fishing and hunting. The first Gajiganna settlers immigrated as environmental refugees from the southern Sahara into the Chad Basin around 1800 cal BC (Breunig 2004; Breunig and Neumann 2002a, 2002b; Breunig et al 1996). They were pastoralists in an environment with permanent lakes and rich wild animal and plant resources (Klee and Zach 1999; Klee et al 2004; Van Neer 2002). Around 1500 cal BC, the settlement pattern changes, and larger sites as well as storage facilities indicate permanent occupation (Breunig and Neumann 2002a,

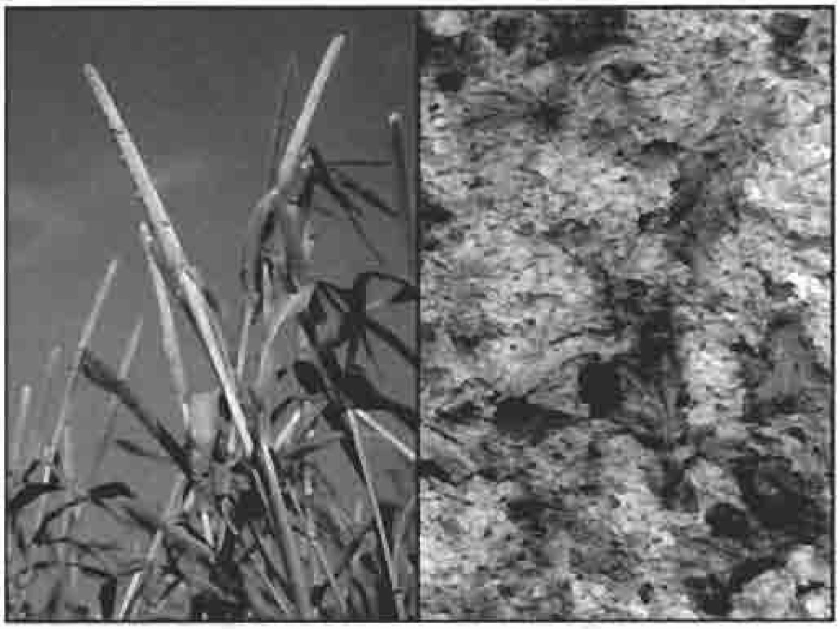

Figure 17.2 Domesticated pearl millet (*Pennisetum glaucum*): modern cultigen (left) and imprints in potsherds from the site Tin Akof/Burkina Faso (right).

2002b; Gronenborn 1998). Domesticated pearl millet is present in plant impressions from 1300–1100 cal BC onwards, and its proportions increase until it gains absolute dominance around 1000 cal BC. At that time, farther east in the *firki* clay plains, the site Kursakata was occupied by mobile cattle herders and fishers. Some caryopses of domesticated pearl millet have been found in the Late Stone Age layers of the site, but cereal cultivation played a minor role; the use of Paniceae grasses (*Brachiaria* sp., *Digitaria* sp., *Echinochloa* sp.) and wild rice (*Oryza* sp.) was more important (Klee et al 2000; Zach and Klee 2003).

At Windé Koroji Ouest in southern Gourma, Mali, domesticated *Pennisetum glaucum* is also present in the second millennium BC. Settlement mounds point to a sedentary occupation, and pearl millet cultivation is interpreted as part of a diversified subsistence with hunting, fishing, gathering and herding. The charred finds of Windé Koroji Ouest are dated by context as early as 2180–1780 cal BC (Capezza 1997; MacDonald 1996). Ceramic sherds with imprints of pearl millet have also been reported for the site of Karkarichinkat Sud, in the lower Tilemsi Valley, Mali. The original publication of the finds consists of a short, vague comment (Smith 1984) and remains somewhat doubtful. However, as a site with some of the earliest evidence (dated to c 1400 cal BC at the latest) (Smith 1974, 1975) Karkarichinkat Sud has been repeatedly cited in the secondary literature (eg Marshall 1998; Neumann 2003).

Origin and Domestication of Pearl Millet

Until now, our knowledge of the when, where and how of pearl millet domestication has been patchy and to a large degree hypothetical. All existing archaeobotanical assemblages with pearl millet point to an introduction of the domesticated form, either at the beginning of the occupation or in later phases of the sequences. There are single finds of wild pearl millet (*Pennisetum glaucum* ssp. *violaceum*), but no archaeological site provides convincing evidence for its conscious use.

Based on the modern distribution of wild pearl millet Brunken et al (1977), Harlan (1971) and others have placed the domestication area at the southern fringe of the Sahara, in a belt across the continent. More recently, Tostain (1998) suggested from enzyme studies an area in southern Mauritania, Senegal and eastern Mali as a centre of early domestication from where the crop could have spread across the continent. This is in accordance with a cluster of early dates west of Lake Chad and later dates for other parts of Africa (Kahlheber 2004). The nearly contemporaneous appearance of domesticated pearl millet shortly after 2000 cal BC in Mauritania, northern Ghana, Mali and Burkina Faso, ie in different biogeographical zones and in varying subsistence systems, implies that to that point in time it had already spread from its centre of origin. As all these archaeobotanical finds show distinct morphological domestication features (Table 17.2, Figure 17.3), the available chronological data might thus serve as a *terminus ante quem*[6]. The small size of caryopses reported from Birimi, Tin Akof and Kursakata, however, do not necessarily

Table 17.1 Domesticated food crops represented in archaeobotanical assemblages of semi-arid West Africa (cf identification in brackets)

Site	Country	Period* (calibrated)	Reference	*Pennisetum glaucum*	*Sorghum bicolor*	*Oryza glaberrima* /sp.[†]	*Digitaria exilis*	*Eleusine coracana*	*Triticum aestivum*/ *T. turgidum* conv. *durum*	*Vigna subterranea*	*Vigna unguiculata*	*Abelmoschus esculentus*	*Hibiscus sabdariffa*	*Citrullus lanatus*
Yohongou	Benin	AD 650–1200	Petit 2002; Petit et al 2001	x	x	–	–	–	–	–	–	–	–	–
Kissi 22 (BF96/22)	Burkina Faso	AD 80–200	Kahlheber 2004	x	–	–	–	–	–	–	x	–	–	–
Kissi 40		AD 900–1050	Kahlheber 2004	x	–	–	–	–	–	–	x	–	(x)	–
Kissi 40 (BF97/31)		AD 1000–1200	Kahlheber 2004	x	–	–	–	–	–	–	(x)	–	–	–
Kolèl Nord (BF97/23)		AD 900–1200	Kahlheber 2004	x	(x)	–	–	–	–	–	–	–	–	–
Oursi Ost (BF97/25)		AD 1000–1200	Kahlheber 2004	x	–	–	–	–	–	–	–	–	–	–
Oursi Nord (BF97/13)		AD 400–1250	Kahlheber 2004	x	AD 700–800	–	–	–	–	x	x	–	x	AD 1000–1100
Oursi West (BF94/45), Final Stone Age		1200–1100 BC	Kahlheber 2004	x	–	–	–	–	–	–	–	–	–	–
Oursi West (BF94/45), Iron Age		AD 50–250	Kahlheber 2004	x	–	–	–	–	–	x	x	–	x	–
Oursi 1 (BF97/26)		AD 0–250	Kahlheber 2004	x	–	–	–	–	–	–	x	–	–	–
Oursi 2 (BF97/27)		AD 850–1000	Kahlheber 2004	x	–	–	–	–	–	–	x	–	–	–
Oursi 3 (BF97/28)		AD 850–1000	Kahlheber 2004	x	–	–	–	–	–	–	–	–	–	–
Oursi 4 (BF97/29)		AD 850–1000	Kahlheber 2004	x	–	–	–	–	–	–	–	–	–	–
Oursi hu-beero (BF97/30)		AD 1000–1200	Kahlheber 2004	x	x	–	–	–	–	x	x	–	x	–

Table 17.1 (*Continued*)

Site	Country	Period* (calibrated)	Reference	*Pennisetum glaucum*	*Sorghum bicolor*	*Oryza glaberrima* /sp.[†]	*Digitaria exilis*	*Eleusine coracana*	*Triticum aestivum*/ *T. turgidum* conv. *durum*	*Vigna subterranea*	*Vigna unguiculata*	*Abelmoschus esculentus*	*Hibiscus sabdariffa*	*Citrullus lanatus*
Saouga A (BF 94/120)		AD 750–1150	Kahlheber 2004	x	–	–	–	–	–	x	x	–	(x)	–
Saouga B (BF95/7)		AD 750–1350	Kahlheber 2004	x	–	–	–	–	–	x	x	–	–	–
Sirkangou (BF96/17)		AD 950–1050	Kahlheber 2004	x	x	–	–	–	–	–	–	–	–	–
Tin Akof		1900–900 BC	Kahlheber 2004	x	–	–	–	–	–	–	–	–	–	–
Kayam (Yaéré)	Cameroon	AD 500–1900	Otto 1996	–	x	–	–	–	–	–	–	–	–	–
Mongossi (Yaéré)		AD 400–1650	Marliac 1991; Otto and Delneuf 1998	–	–	–	–	–	–	–	x	–	–	–
Balda Tagamré (Diamaré)		AD 700–1900	Delneuf et al 1998; Otto 1996; Otto and Delneuf 1998	–	x	–	–	–	–	–	x	–	–	–
Goray (Diamaré)		AD 900–1750	Marliac 1991[1]; Otto and Delneuf 1998[2]	x[1]	x[2]	–	–	–	–	–	–	–	–	–
Jiddere Saoudjo (Diamaré)		AD 500–1900	Otto 1996	–	x	–	–	–	–	–	–	–	–	–
Salak (Diamaré)		AD 500–1950	Otto 1998; Otto and Delneuf 1998	–	x	–	–	–	–	–	x	x	x	–
Tchere (Diamaré)		AD 500–1900	Otto 1996	–	x	–	–	–	–	–	–	–	–	–
Louggéréo (Piémonts Mandara)		AD 1300–1600	Delneuf and Otto 1995	–	x	–	–	–	–	–	–	x	x	–
Mowo (Piémonts Mandara)		AD 1600	Delneuf and Otto 1995; Otto and Delneuf 1998	–	x	–	–	–	–	–	x	x	x	–

Be (Benue)		AD 800–1700	David 1976, 1981	–	x	–		x						
Douloumi (Benue)		AD 500–1500	David 1976, 1981	–	x	–	–	–	–	–	–	–	–	–
Sumpa (Benue)		AD 1200–1900	David 1976, 1981	–	–	–	–	x	–	–	–	–	–	–
Birimi	Ghana	1750–1100 BC	D'Andrea and Casey 2002; D'Andrea et al 2001	x	–	–	–	–	–	–	–	–	–	–
Jenné-Jeno (NID)	Mali	250 BC– AD 1400	McIntosh 1995	x	x	x	AD 400	–	–	–	–	–	–	AD 1200–1400
Toguéré Doupwil (NID)		AD 1100–1500	Bedaux et al 1978; Lange 1978	x	–	x	x	–	–	–	–	–	–	–
Toguéré Galia (NID)		AD 1150–1600	Bedaux et al 1978; Lange 1978	x	–	x	x	–	–	–	–	–	–	–
Dia (NID)		800 BC– AD 1700	Bedaux et al 2001; Murray 2004, 2005	x	AD 1000–1600	x	–	–	AD 800–1200	–	–	–	–	–
Tellem (Bandiagara)		AD 1000–1600	Bedaux 1972	x	–	–	–	–	–	–	–	–	–	–
Windé Koroji Ouest I (Gourma)		2100–1100 BC	Capezza 1997; MacDonald 1996	x	–	–	–	–	–	–	–	–	–	–
Tongo Maaré Diabel (Gourma)		AD 200–1200	Capezza 1997; MacDonald 1998	x	–	–	–	–	–	–	–	–	–	–
Gao Gadei (Niger Bend)		AD 700–1600	Fuller 2000; Insoll 2000	x	–	x	–	–	–	–	–	–	–	x
Dhar Tichitt	Mauritania	2000–500 BC	Jacques-Félix 1971; Munson 1971, 1976	c 1000 BC	–	–	–	–	–	–	–	–	–	–
Oued Chebbi (Dhar Oulata)		2000 BC–0 BC/AD	Amblard 1996; Amblard and Pernès 1989	x	–	–	–	–	–	–	–	–	–	–
Djiganyai (Dhar Nema)		1650–1500 BC	MacDonald et al 2003	x	–	–	–	–	–	–	–	–	–	–
Bou Khzama (Dhar Nema)		800–400 BC	MacDonald et al 2003	x	–	–	–	–	–	–	–	–	–	–
Gajiganna (BDC)	Nigeria	1800–800 BC	Klee et al 2004	1200–1000 BC	–	x	–	–	–	–	–	–	–	–
Zilum (BDC)		600–400 BC	Magnavita et al 2004	x	–	–	–	–	–	–	x	–	–	–
Dorota (BDC)		AD 450–600	Magnavita 2002; Kahlheber in press	x	x	–	–	–	–	–	–	–	–	–

(*Continued*)

Table 17.1 (*Continued*)

Site	Country	Period* (calibrated)	Reference	*Pennisetum glaucum*	*Sorghum bicolor*	*Oryza glaberrima* /sp.[†]	*Digitaria exilis*	*Eleusine coracana*	*Triticum aestivum*/ *T. turgidum* conv. *durum*	*Vigna subterranea*	*Vigna unguiculata*	*Abelmoschus esculentus*	*Hibiscus sabdariffa*	*Citrullus lanatus*
Elkido Nord (BDC)		AD 350–450	Magnavita 2002; Kahlheber in press	x	x	–	–	–	–	–	–	–	–	–
Daima (*firki*)		550 BC– AD 1150	Connah 1981	c AD 1100	c AD 800	–	–	–	–	–	–	–	–	–
Kursakata (*firki*)		1200 BC– AD 150	Klee et al 2000; Zach and Klee 2003	x	–	x	–	(x) c AD 100	–	–	–	c 800 BC	–	–
Mege (*firki*)		850 BC– AD 1983	Klee and Zach 1999; Gronenborn 1998, 2001	x	AD 1400–1600	x	–	–	–	–	–	–	–	–
Cubalel/Siwré (MSV)	Senegal	AD 0–1200	Bocoum and McIntosh 2002	x	–	–	–	–	–	–	–	–	–	–
Sincu Bara (MSV)		AD 0–1200	Bocoum and McIntosh 2002; McIntosh and Bocoum 2000	x	–	–	–	–	–	–	–	–	–	–
Arondo (USV)		AD 400–1000	Gallagher 1999	x	x	–	–	–	–	–	–	–	–	–

For abbreviations see Figure 1.

*Approximate period covered by archaeobotanical remains. For crops that appear later in the sequence, the radiocarbon dates of first evidence are given separately.

[†]Differentiation between grains of domesticated rice, *Oryza glaberrima*, and wild forms is difficult and often not carried out. Therefore, evidence for all *Oryza*

indicate an early state in cultivation history, as argued by D'Andrea et al (2001) and Zach and Klee (2003). Though increases in grain size and weight are major and primary objectives in cereal breeding, high rates of cross-pollination and the sympatric distribution of wild and domesticated forms of pearl millet may have prevented rapid selection for larger grains. Instead, improved cultivation methods and a long farming experience are required. It seems that people cultivated first with comparatively simple techniques and consciously selected for special traits only in later periods.

Once domesticated, the physiological characters of pearl millet, particularly high drought resistance and fast maturation, might have favoured its cultivation. In the Sahel, pearl millet is preferably grown on light sandy dune soils, which possess a relatively high water storage capacity, are easy to cultivate and, due to their scattered woody vegetation, unproblematic to clear. All these factors enabled basic pearl millet cultivation with simple tools and limited agricultural experience, even within a mobile way of life.

The First Agricultural Communities of the Second Millennium BC: Cultivation and Risk Minimisation

The available archaeobotanical evidence suggests that plant cultivation in the second millennium BC was integrated into existing pastoral or foraging life-ways as a means for risk minimisation and for greater predictability of resource exploitation. Its development is correlated with large-scale population

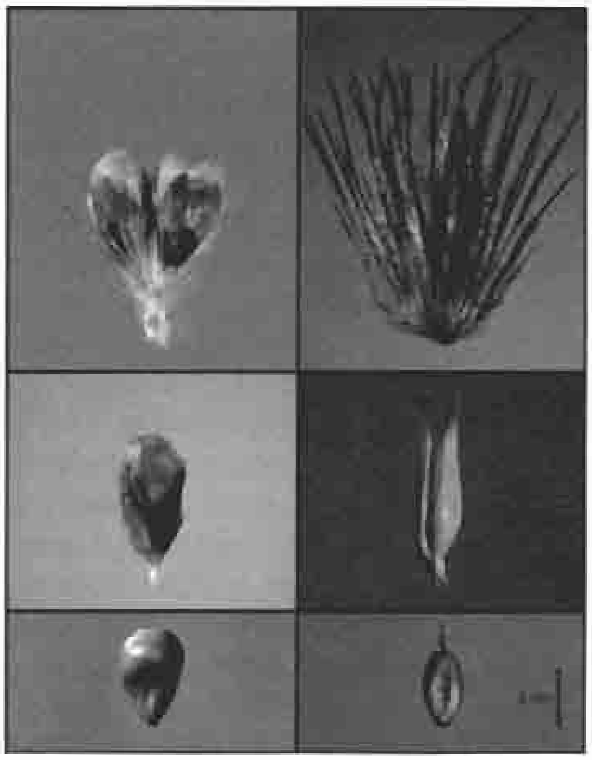

Figure 17.3 Involucres, spikelets and caryopses of modern domesticated pearl millet (*Pennisetum glaucum* ssp. *glaucum*, left) and its wild ancestor (*Pennisetum glaucum* ssp. *violaceum*, right) (scale is valid for both figures).

Table 17.2 Selected morphological characters of wild, weedy and domesticated pearl millet (after Brunken 1977)

	Wild *Pennisetum glaucum* ssp. *violaceum*	Weedy *Pennisetum glaucum* ssp. *sieberianum*	Domesticated *Pennisetum glaucum* ssp. *glaucum*
Involucrum			
callus	existent: involucrum deciduous	existent: involucrum deciduous	missing: involucrum persistent
stalk	short or missing, <0.25 mm long	short to long, 0.2–1.5 mm long	long, 1.1–25 mm long
bristles	thick, dense, longer than spikelet(s)	longer than spikelets	small in number, mostly shorter than spikelets
number of spikelets	1 (–2)	mostly 2	(1–) 2 (–9)
floral bracts	long; tightly enclosing caryopsis	almost or completely enclosing caryopsis	persistent, lush; only partly enclosing caryopsis
length of lemma of upper floret	≥5 mm (5–6.5 mm)	3.5–5.5 mm	<4 mm (1.4–4 mm)
Caryopsis			
shape	elliptic to lanceolate, truncate, dorsally compressed	elliptic to obovate, obtuse to truncate, terete or moderately dorsally compressed	obovate, obtuse to acute, terete, also angular
length	2–3 mm	2–4.5 mm	2–5.5 mm
width	1–1.5 mm	1–2.2 mm	1.6–3.2 mm
depth	0.6–1 mm	1–2 mm	1–3 mm

movements in the southern Sahara and the Sahel and increasing sedentism. Although the archaeological contexts are variable and indicate a wide range of subsistence strategies, they all display monocrop assemblages; pearl millet is the only domesticate reported for this period in semi-arid West Africa. On sites from the Tichitt-Oualata or Gajiganna traditions, where direct archaeobotanical evidence comes exclusively from ceramic impressions, this pattern may be due to the special suitability of pearl millet chaff for tempering. But the data from Tin Akof, Kursakata and Birimi suggest that pearl millet was indeed the only crop. The archaeological contexts of the Sahelian sites in Mali, Nigeria and Burkina Faso show a common pattern: full sedentism was not yet established and plant cultivation probably played a minor role in a mixed economy. Birimi and Tichitt-Oualata are both unique and have no equivalent in the settlement history of semi-arid West Africa. In Birimi, it seems that pearl millet constituted a significant resource for a sedentary population, whereas for the Tichitt-Oualata villages, there is only faint evidence for plant utilisation so far, and the presence of an agro-pastoral economy remains to be confirmed by more archaeobotanical and archaeozoological data.

ADVANCED AGRICULTURE IN THE IRON AGE

The West African Iron Age is chronologically defined from the middle of the first millennium BC to the early second millennium AD (McEachern 1997) and culturally circumscribes a large range of variations. The archaeological defining characteristic of this period – indigenous iron metallurgy – may not have played a significant role in all cultures and the initial appearance of metal technology varies substantially in timing (DeCorse and Spiers 2001). Typical features of the Iron Age are more permanent settlements and the appearance of complex social formations. Groups of large settlement mounds, furnishing long archaeological sequences, are a common Iron Age site type in several West African regions (Breunig and Neumann 2002b; McIntosh 1994).

In conjunction with sedentism and demographic growth, an intensification of food production has been postulated (DeCorse and Spiers 2001). Indeed, domesticated animals such as cattle, sheep and goat were widely raised during the Iron Age, but this had already been the case in former periods (MacDonald and MacDonald 2000). The evidence for the intensification of plant food production is quite clear. Several archaeobotanical assemblages illustrate the development of new agricultural systems distinctly different from final Late Stone Age cultivation practices. They laid the economic base for growing populations, increased division of labour and social stratification, finally resulting in the emergence of the famous West African empires.

Archaeobotanical Evidence: New Crops

The first obvious change at the beginning of the Iron Age is the diversification of crop inventories. In sites of northern Burkina Faso dating shortly after the start of the common era this is manifested in the appearance of *Hibiscus sabdariffa* (roselle) and of the pulses *Vigna subterranea* (Bambara groundnut) and *V. unguiculata* (cowpea; Figure 17.4) (Kahlheber 2004). With their high protein content, pulses are an excellent nutritional complement to a cereal-based carbohydrate diet and, to a certain extent, a replacement for animal proteins. The value of *Hibiscus sabdariffa*, a species of the family Malvaceae, consists in a multiplicity of uses: leaves serve as a vegetable, flower parts are used for drinks rich in vitamins, and the seeds are a source of vegetal fat. New crops were also found in Iron Age sites of northern Cameroon and northeastern Nigeria (Table 17.1; Delneuf and Otto 1995; Klee et al 2000; Otto 1996, 1998; Otto and Delneuf 1998; Zach and Klee 2003). From these, *Abelmoschus esculentus* (okra), whose fleshy fruits are a relished vegetable, is restricted to the broader Lake Chad region. It might well have been domesticated in this area, as *A. ficulneus*, one of its possible ancestors, is distributed there (Burkill 1985–2000).

Noteworthy, pearl millet remained the basic cereal crop and major carbohydrate source throughout the West African Iron Age. In northern Burkina Faso persistent and intensive cultivation led to an alteration of its gene pool, as grain size increased in the course of the period (Kahlheber 2004). The role of the other important African cereal, *Sorghum bicolor*, is not always clear. Sorghum has been reported for a number of West African Iron Age sites, for example in Daima, Nigeria (Connah 1981), northern Benin (Petit et al 2001), northern Cameroon (David 1976; Otto 1996) and Mali (Lange 1978; McIntosh 1995[7] (Table 17.1). Its significance, however, is in many cases difficult to assess either because selective archaeobotanical sampling methods resulted in an under-representation of smaller-grained cereals like pearl millet or because quantification of the finds has not been undertaken. However, some archaeobotanical assemblages clearly demonstrate that *Sorghum bicolor* was of minor importance. In northern Burkina Faso, the appearance of sorghum around AD 700–800 has been interpreted in terms of a local engagement in trade, and the crop might have been an imported luxury food or a remnant of passing caravans (Kahlheber 2004). In other locations the crop also occurs in minor quantities as, for example, at Arondo in the Senegal Valley (Gallagher 1999). Only in the samples from Elkido Nord and Dorota in northeast Nigeria is sorghum clearly more important than pearl millet (Kahlheber in press). With two direct AMS dates of AD 384–426 and AD 449–592, the sorghum finds are among the oldest for West Africa (Magnavita 2002). Farther east in the *firki* clay plains, today the region of dry season sorghum cropping *par excellence*, sorghum actually appeared late, such as in Mege during the 15th–16th centuries (Gronenborn 1998, 2001; Klee and Zach 1999). This late emergence of *Sorghum bicolor* in West Africa and its, for the most part, minor position in Iron Age sites are astonishing, given the fact that sorghum today is widely cultivated in the southern Sahel and Sudanian zones.

Besides *Sorghum bicolor*, a number of other plants enter the archaeobotanical record at the end of the Iron Age, in the West African Middle Age[8]. In most cases they presumably were trade items, though it is not always clear if these species were exclusively traded, or if traders introduced them and they were subsequently adopted for cultivation. Wheat (*Triticum aestivum/T. turgidum* conv. *durum*) found in Dia, Mali, (Murray 2005) and date palm (*Phoenix dactylifera*) reported for Gao Gadei, Mali (Fuller 2000), are examples of such luxurious trade goods. Cotton (*Gossypium* sp.) another such good, was confirmed by seed finds from the 14th–15th centuries from Dia and Gao Gadei as well as by textiles, for instance, from Tellem, Mali, dating between the 11th and 16th centuries AD (Bedaux et al 1991). The data for watermelon (*Citrullus lanatus*) are more ambiguous. Archaeobotanical remains of this species appear in small numbers at the beginning of the second millennium AD in trading centres such as Jenné-Jeno and Gao Gadei (Fuller 2000; McIntosh 1995) as well as in Oursi Nord, Burkina Faso. The status of *Citrullus lanatus* as an imported crop is a matter of debate as the origin and natural distribution of the species is still unknown (Wasylikowa and van der Veen 2004).

From an archaeobotanical perspective, medieval times are not only characterised by agricultural newcomers, but also by the intensified exploitation of wild plants for technological and other uses that can be correlated with crafts and trade. One example is *Acacia nilotica* from Oursi Nord whose pods and seeds serve as a tanning agent in leather fabrication (Kahlheber 2004).

Skins and leather are known to be important items in trans-Saharan trade with North Africa; therefore, the presence of *Acacia nilotica* indicates an intensification of commercial activities.

New Production Systems

The appearance of new crops goes hand-in-hand with the development of advanced cropping systems. For Burkina Faso, mixed systems have been reconstructed (Figure 17.4), with pearl millet as the main crop and *Vigna unguiculata*, *V. subterranea* and *Hibiscus sabdariffa* as intercrops (Kahlheber 2004). Such systems are commonly seen as a strategy to improve productivity as they allow better use of farming space and a more efficient cultivation schedule during the growing season. A further advantage of mixed cropping is a lower propensity to pests, plant diseases, climatic risks and soil erosion (Franke 1995). The capability of pulses to fix nitrogen permits the exploitation of additional marginal grounds. Soil fertility is maintained for longer and arable land can be cultivated more or less permanently, which complies ideally with the needs of a sedentary population.

More intensive land use was also permitted by the implementation of agroforestry systems, which combine the cultivation of crops and/or livestock breeding with the systematic exploitation of wild woody plants on the same plot (see Boffa 1999). The resulting park savannas are a constituent element of the modern West African landscape (Figure 17.5), and their variable species composition is correlated with different land-use systems (Pélissier 1980;

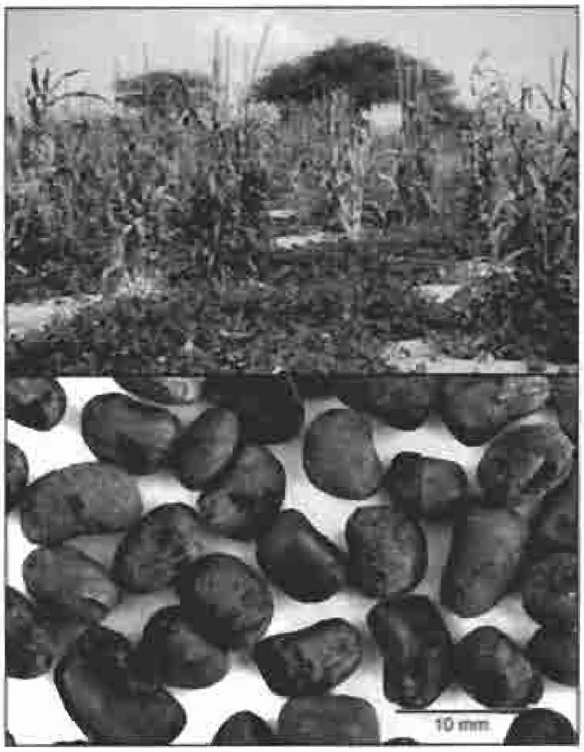

Figure 17.4 Mixed cropping with pearl millet and cowpea (top) and archaeobotanical finds of cowpea (*Vigna unguiculata*) from Iron Age Oursi hu-beero/Burkina Faso.

Pullan 1974; Seignobos 1982). The archaeobotanical assemblages from Iron Age sites in Burkina Faso illustrate the high diversity of utilised park savanna species, with *Vitellaria paradoxa* (shea butter tree; Figure 17.5), *Sclerocarya birrea* and *Adansonia digitata* (baobab) as the most important species (Table 17.3). Fruits, seeds and leaves were gathered and furnished vegetal fats, vitamins and microelements. Although these useful trees were never domesticated, they were protected during field clearance and their growth was thus greatly encouraged.

More efficient farming practices not only supported the sedentary life of a growing population but increasing yields also allowed the production of a surplus, giving security against the unpredictability of the Sahelian climate. The efficiency of farming systems favoured prosperity and hierarchical structures and laid the economic base for the medieval West African empires.

Environmental Change and the Limits of Intensified Production

The intensification of agricultural production is visible in the archaeobotanical assemblages of settlement mounds in northern Burkina Faso and northern Cameroon. In both areas, shifting cultivation systems and park savannas with shea butter trees (*Vitellaria paradoxa*) became established during the early Iron Age and the natural plant cover gradually changed into anthropic vegetation. The shifting cultivation cycle led to the dominance of woody species (mainly Combretaceae and *Piliostigma* spp.), which can produce suckers after being cut, and are therefore typical for fallows

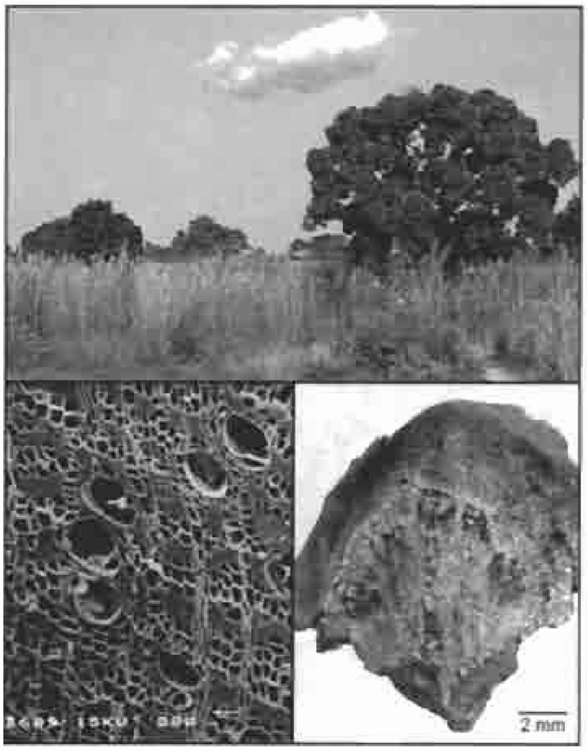

Figure 17.5 Modern park savanna with shea butter trees (*Vitellaria paradoxa*) (top), archaeological charcoal in cross-section (base, left) and a seed fragment of *Vitellaria paradoxa* from Iron Age Saouga/Burkina Faso (base, right).

Table 17.3 Woody plants represented in fruit/seed assemblages of sites in northern Burkina Faso (cf identification in brackets)

phase	site	*Acacia nilotica*	*Acacia* sp.	*Adansonia digitata*	*Balanites aegyptiaca*	*Celtis integrifolia*	*Detarium* cf *microcarpum*	*Diospyros mespiliformis*	*Faidherbia albida*	cf *Ficus* sp.	*Grewia* cf *bicolor*	*Grewia* sp.	*Lannea* sp.	*Parkia biglobosa*	*Sclerocarya birrea*	*Tamarindus indica*	*Vitellaria paradoxa*	*Vitex doniana/simplicifolia*	*Ziziphus mauritiana/ spina-christi*
Final Stone Age	Corcoba (BF97/5)			x														x	
	Tin-Akof (BF94/133)			x	(x)		(x)											x	(x)
	Oursi West (BF94/45)			x	x	x									x				
Iron Age	Corcoba (BF97/5)			x											x			x	
	Kissi 22 (BF96/22)			x	x		x								x		x	x	x
	Kissi 40			(x)	x		x								x			x	x
	Kissi 40 (BF97/31)				x										x				x
	Kolèl Nord (BF97/23)	(x)			x										x				
	Oursi 1 (BF97/26)			x	x	x									x		(x)	x	x
	Oursi 2 (BF97/27)			x		x	(x)								x		x		x
	Oursi 3 (BF97/28)			x			x								x		x		x
	Oursi 4 (BF97/29)	(x)		x			x				x				x		x		x
	Oursi hu-beero (BF97/30)	x			x	x	x					x			x			x	x
	Oursi Nord (BF97/13)	(x)	x	x	x	x	x		x	x	x	x			x		x	x	x
	Oursi Ost (BF97/25)	(x)		x											x				x
	Oursi West (BF94/45)	(x)	x	x	x	x							x		x		x	x	x
	Saouga A (BF94/120)	(x)		x	x	x	(x)	x					x		x		x	x	x
	Saouga B (BF95/7)	(x)	x	x	x	x	(x)	x					x	x	x	x	x	x	x
	Sirkangou (BF96/17)						(x)						(x)		x		x	x	

(Hahn-Hadjali 1998; Renard et al 1993). Between the middle of the first millennium and the fourteenth century AD, pearl millet production intensified in northern Burkina Faso, coupled with livestock keeping, as indicated by the presence of pasture plants (eg *Aristida* sp., *Digitaria* sp., *Eragrostis* sp., *Schoenefeldia gracilis*) and *Faidherbia albida* (Höhn 2002; Höhn et al 2004; Kahlheber 2004; Kahlheber et al 2001). In medieval Saouga, this comes to pass in the course of a short occupation period, which lasted no longer than 100–250 years (Kahlheber 1999; Neumann et al 1998). In Salak, Cameroon, sorghum cultivation with massive clearings on clay soils extended considerably between AD 1000 and 1250 (Otto and Delneuf 1998).

Some communities seem to have reached the limits of agricultural growth. This is illustrated by the archaeobotanical sequence of Oursi Nord, Burkina Faso, ranging chronologically from about AD 400 to 1200 (Kahlheber 2004). While crop plants, especially *Pennisetum glaucum*, constitute a steady proportion of the assemblages, the number of finds and the diversity of fruit trees continuously decrease. At the same time records of pasture plants from more remote habitats increase. This points to an intensification of livestock breeding and to an expansion of cultivated areas, which resulted in shorter fallow phases and soil degradation and could have provoked conflicts between farmers and herders.

In the fourteenth century AD, the settlement mounds of northern Burkina Faso and northern Cameroon were abandoned. Similar developments occurred in other West African regions, for instance the Méma region of Mali (McIntosh 1994; Togola 1993). Climatic deterioration, political instability and warfare are cited as possible reasons for the large-scale population movements (Devisse and Vernet 1993; Marliac 1991; Pelzer et al 2004). However, the land-use conflicts of a growing population might also have initiated and intensified political destabilisation.

THE FIRST MILLENNIUM BC: A TRANSITIONAL PHASE

From the available archaeobotanical data, it becomes clear that the plant food production systems of the second millennium BC and the Iron Age were distinctly different in semi-arid West Africa. This is equally valid for other cultural traits, such as settlement patterns, material culture and social organisation (Breunig and Neumann 2002a, 2002b). Numerous innovations of the Iron Age, especially metallurgy, large centralised settlements and highly productive agriculture, have their roots in the first millennium BC, which thus may be understood as a transitional phase from the final Late Stone Age to the Iron Age. However, the dynamics and innovative processes in this period are not well understood due to a lack of targeted research and the rarity of suitable sites. In Burkina Faso, the settlement sequence shows a gap in the first millennium BC, and occupation becomes archaeologically almost invisible (Breunig and Neumann 2002b). The Tichitt, Gajiganna and Kintampo traditions all ended some time after 1000 cal BC (Breunig and Neumann 2002b; MacDonald et al 2003; Stahl 1993). It seems that living conditions became more difficult for the early agricultural groups at the beginning of the first millennium BC, probably due to an environmental crisis caused by increasing aridity.

On the other hand, increasing aridity opened up new areas to settlement that had been inundated and inaccessible before: the *firki* clay plains of the inner Chad Basin, the Niger Inland Delta, and the Senegal River Valley (Breunig 2004; McIntosh 1999). Here we have the first signs of more diversified agricultural systems. In Dia, Mali, subsistence around 800–400 cal BC was largely based on the cultivation of domesticated rice (*Oryza glaberrima*) (Murray 2004). Though pearl millet was known and wild plants were intensively used (Murray 2005), rice farming must have been a crucial advantage for the colonisation of the wetland habitats of the Niger Inland Delta. In Zilum, Nigeria, in the middle of the first millennium BC, cowpea (*Vigna unguiculata*) was grown beside pearl millet as the staple crop. Zilum belongs to the latest phase of the Gajiganna culture and witnesses an organisational complexity in archaeological structures and material culture (Magnavita et al 2004). Mixed cropping of pulses and cereals presumably contributed to an increase in agricultural productivity that supported the flourishing of this settlement.

The innovations at the transition from the final Late Stone Age to the Iron Age might be seen as adaptations to climatic instability and unpredictable resources (Breunig and Neumann 2002b). At least in some regions, the environmental changes of the first millennium BC seem to have worked as a kind of experimental field that paved the way for more elaborate forms of agricultural and sociopolitical systems, which emerged in the last centuries BC and became well established in the course of the Iron Age.

LOW-LEVEL PLANT FOOD PRODUCTION IN WEST AFRICA

The fact that only small quantities of domesticates occur in archaeobotanical samples from West Africa has sometimes been attributed to preservation, site context or recovery problems. Meanwhile, a number of studies have confirmed that the low diversity of crop plants is an overall characteristic of prehistoric sub-Saharan agricultural systems (Capezza 1997; D'Andrea and Casey 2002; Fuller 2000; Gallagher 1999; Kahlheber 2004; Klee et al 2000, 2004; Lange 1978; Magnavita et al 2004; Murray 2005; Otto 1996; Zach and Klee 2003). In addition, archaeobotanical assemblages with abundant remains of wild plants demonstrate that they played a substantial role in African subsistence throughout the Holocene even in agropastoral societies. The harvest of wild edible grasses, mostly belonging to the Paniceae, has been reported from numerous sites, for example from northeastern Nigeria, Mali and Senegal (Gallagher 1999; Klee et al 2000; McIntosh 1995; Murray 2005). The exploitation of woody plants has also a long tradition, which is impressively illustrated by the rich archaeobotanical diversity of useful trees in final Late Stone Age and Iron Age sites in Burkina Faso (Table 17.3).

Ethnobotanical studies in West Africa have shown that the use of wild plants continues until modern times (eg Burkill 1985–2000). Woody plants are especially appreciated, and there is hardly a tree or shrub in West Africa without economic value. Besides the exploitation of natural populations (eg stands of wild grasses), a number of apparently wild plants undergo cultivation practices such as sowing, selective propagation and protection against predators. Prominent examples are herbaceous species serving as pot-herbs being found in most traditional West African dishes (eg *Amaranthus* spp., *Cleome gynandra*, *Corchorus* spp.). Woody plants in agroforestry systems are not planted, but selectively protected during clearing in the course of shifting cultivation cycles. Classification of these species is a matter of debate, ranging from crop status to intermediary or semi-domesticated to actually wild (eg Garine-Wichatitsky 1997; Harlan 1975). Their distribution might be heavily influenced by humans, as observed with the tree species *Adansonia digitata*, *Vitellaria paradoxa* and *Faidherbia albida* (Boffa 1999; Maranz and Wiesmann 2003; Pélissier 1980; Seignobos 1982). Nevertheless, neither morphological changes nor other domestication features have been observed. Despite their enormous benefits, these species have not been domesticated thus far and are referred to by the term 'Cinderella' species (Leakey and Newton 1994).

CONCLUSION

The earliest archaeobotanical evidence for plant cultivation in West Africa consists of pearl millet finds from Mauritania, Ghana, Burkina Faso, Mali and Nigeria dated shortly after 2000 cal BC. As all these remains of *Pennisetum glaucum* are fully domesticated, the domestication process must have taken place earlier, most probably somewhere in the southwestern Sahara. However, archaeobotanical records from the southern Sahara and the Sahel, which might illustrate the transition from wild to domesticated pearl millet, still remain to be found. Even less is known about the early history of other African crops such as *Vigna subterranea* and the Malvaceae species. *Sorghum bicolor*, although widely grown today, did not appear until Iron Age times in West Africa and was mostly of minor importance. There are a number of early records for wild sorghum in Northeast Nigeria as well as in other parts of the continent (eg Fahmy 2001; Klee et al 2000, 2004; Wasylikowa 1997). Nevertheless, domesticated sorghum was slowly adopted and turns up as late as other Iron Age crops, but does not predate the first millennium BC anywhere on the African continent (Fuller 2004). Connah (1985) and Sutton (2004) have postulated that the spread of sorghum is associated with the establishment of iron metallurgy. Only with adequate tools was it feasible to till heavy clays, which are still the preferred soils for sorghum cultivation and a substratum to which sorghum is better adapted than pearl millet. However, other Iron Age changes in plant food production, such as the development of mixed cropping, cannot be correlated with the technical advantages of metal use.

Two stages of agricultural development can be distinguished, which roughly parallel the archaeological phases of the final Late Stone Age (= West African Neolithic) and the Iron Age (Breunig and Neumann 2002b; Neumann 2003). From 2000 cal BC, Late Stone Age communities integrated pearl millet cultivation into diversified subsistence systems with hunting, gathering, fishing and pastoralism. These cultures, which might be called 'Neolithic' in a strict sense of the term (McIntosh 2001), flourished in the second millennium BC. The 'Neolithic' traditions ended during the transitional phase in the first millennium BC, most probably as a result of climatic change. The following centuries were a time of transformations and innovations, which remain poorly understood until now. People immigrated into the floodplains of the middle Niger, the Chad Basin and the Senegal Valley, and metallurgy and larger centralised settlements emerged. In the Inland Niger Delta, domesticated African rice (*Oryza glaberrima*) was cultivated, and the appearance of cowpea (*Vigna unguiculata*) in the Nigerian Chad Basin indicates the development of intensified farming. In the Iron Age, a fully agricultural economy became the dominant way of life in semi-arid West Africa. People cultivated pearl millet together with pulses and other crops in mixed systems and practised agroforestry to increase productivity and to satisfy the needs of a growing sedentary population.

Apart from pearl millet and other crops, the archaeobotanical record of the last 4000 years in West Africa has yielded numerous remains of wild plants, for example from fruit trees or edible grasses. The intensive use of wild plants and semi-domesticates was an important element of African subsistence throughout all periods and continues to be successful until modern times. Thus, West Africa can be regarded as a living laboratory for the understanding of agricultural origins. In diachronic as well as synchronic perspective, it presents numerous examples of the 'middle ground' between pure hunter-gatherers and agriculturalists largely dependent on domesticated crops. This transition, termed 'low-level food production', or 'wild plant food production' (Harris 1989, 1996; Smith 2001), has often been neglected in the archaeological literature, as it is difficult to reconstruct for prehistoric times. According to the current archaeobotanical data, many West African final Late Stone Age and even some Iron Age cultivators cannot be called 'farmers', but they practiced plant cultivation as one option in a diversified subsistence strategy. It is conceivable that some low-level food production developed long before domesticates appear in the archaeological record. Tracing and reconstructing these subsistence systems is one of the great challenges for African archaeobotany in the future.

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NOTES

1. Semi-arid West Africa is defined here as the area between the 100 mm and 1000 mm rainfall isohyets, coinciding in phytogeographical terms with the Sahelian and Sudanian vegetation zones.
2. Our terminology of plant food production as opposed to foraging follows Harris (1989, 1996). Cultivation is the sowing or transplanting of wild or domesticated plants. Domestication implies morphological and genetic changes of plants that occur under cultivation and usually result in their inability to reproduce in the wild. Farming/agriculture is largely based on the cultivation of domesticated plants.
3. The discussion on agricultural origins is hampered by the different timescales used in archaeological and palaeoenvironmental studies. We use here the conventional archaeological scale with ages indicated in calendar years, ie calibrated years BC/AD. Uncalibrated radiocarbon dates have been calibrated with Oxcal (Bronk Ramsey 1995, 2001).
4. The terminology for the period of early food production in Africa is not uniform and often contradictory. For the second millennium BC in West Africa the terms 'West African Neolithic' (McIntosh 2001) or 'Final Stone Age' (Breunig and Neumann 2002a) have been proposed, among others.
5. Seed finds of cowpea (*Vigna unguiculata*) from the Kintampo sites farther south in Central Ghana are dated as early as the second millennium BC and are currently under study (D'Andrea pers comm; Stahl 1985). It is still unknown if and how the development of plant food production at the more humid forest-savanna margins was related to final Late Stone Age pearl millet cultivation in semi-arid West Africa (see Neumann 2003).
6. Pearl millet finds in India, dating as early as 2500–2300 BC, provide another chronological marker (Fuller 2003; Fuller et al 2004). As the crop is not native to India, this probably indicates an earlier domestication in Africa.
7. Rare finds of Jenné-Jeno, Mali, attributed to the initial phase of the settlement around 250 BC– AD 400 (McIntosh 1995) urgently need confirmation concerning their age.
8. The West African Middle Age is the period of urban settlements, increasing Arabic influence and the rise of West African empires, starting around the eighth century (Huysecom 1987).

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