

LATE HOLOCENE PALAEOENVIRONMENT OF TSE DURA, A LATER STONE AGE (LSA) ROCK SHELTER, NORTH-CENTRAL NIGERIA

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Abstract

Palynological and archaeobotanical analyses were conducted on excavated sediments from Tse Dura, a Later Stone Age rock shelter in north-central Nigeria with the aim of reconstructing the environment conditions at the site within the last millennium. From 933 ± 29 BP to 802 ± 29 BP, the environment alternated between Guinea savanna with dry conditions, and secondary and riverine forests with humid conditions. During these periods of environmental fluctuations, the LSA populations engaged in the management of economic plants the most significant of which included *Dioscorea* spp., *Pennisetum glaucum* and *Elaeis guineensis*, and exploited wild plants such as *Pavetta crassipes*, *Sarcocephalus latifolius* and *Lophira cf. lanceolata* for dietary and ethnomedicinal purposes. Around 310 ± 30 BP cal, the environment became very wet after which it was succeeded by a drier period. It was during this period that *Sorghum bicolor* became prominent, and the environment attained its current status dominated by Guinea savanna elements and secondary forests.

Key words: Microliths, Vegetation history, Plant management, Tiv, Middle Benue Valley, Nigeria.

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INTRODUCTION

The environment has been recognised as a significant factor which influences the cultural evolution of humans. Some of the major defining moments in human history have been linked to, directly or otherwise, or accompany environmental change. One of such recent changes occurred during the Later Stone Age (LSA) when the use of microliths replaced heavy core tools; this period is recognised in Nigeria to have begun around *ca.* 12,000 BP (Shaw and Daniels, 1984). Majority of dates surrounding the occupation period of LSA rock shelter sites in Nigeria cluster around 2,000 BP giving the impression that the LSA ended around that time or was succeeded by Iron Age groups shortly after. However, there is evidence that LSA populations lasted until *ca.* 1,000 BP in Kariya Wuro (Allsworth-Jones, 2015). An attempt was made to use palynology to reconstruct the palaeoenvironment during the cultural change at Iwo Eleru but the sediments proved too oxidised hence no pollen grains were preserved. However, the change in lithics was linked to environmental (vegetation) change (Shaw and Daniels, 1984). It was inferred that microliths were adapted for hunting when the vegetation changed from a forest to savanna and similar open vegetations. This interpretation was based on palaeobotanical records obtained from other areas in the West African sub-re-

gion such as those of Kintampo and Bosumpra in Ghana, which lie in the same forest zone, have similar archaeological finds and were occupied at about the same time. Although, the inference is plausible it has not been established. Compared to the number of LSA rock shelters investigated in Nigeria so far (Soper, 1965; York, 1978; Andah, 1983; Fatunsin, 1996; Alabi *et al.*, 2009; Allsworth-Jones *et al.*, 2012), very few, namely Kariya Wuro (Sowunmi and Awosina, 1991) and Abeokuta (Orijemie *et al.*, in press) have been directly studied with palaeoenvironmental interest. The general idea, which is not significantly different from the interpretation at Iwo Eleru, is that microliths were developed for hunting in the savanna or at least in an open environment. This view has recently been questioned by Alabi (2016) who argued, based on the recovery of microliths from rock shelter sites in the rainforest zone, that they could have been used in both environments.

In the north-central part of Nigeria, the vegetation of which is Guinea savanna and forest-savanna ecotones with pockets of drier forest type, and gallery forests, some rock shelters have been investigated (Allsworth-Jones *et al.*, 2012) but the palaeoenvironmental conditions under which they were occupied are uncertain. At Itaakpa rock shelter in Kogi State, north-central Nigeria where microliths were recovered in abundance (Allsworth-Jones *et al.*, 2012), pollen from an 80cm sediment-core of a pond near



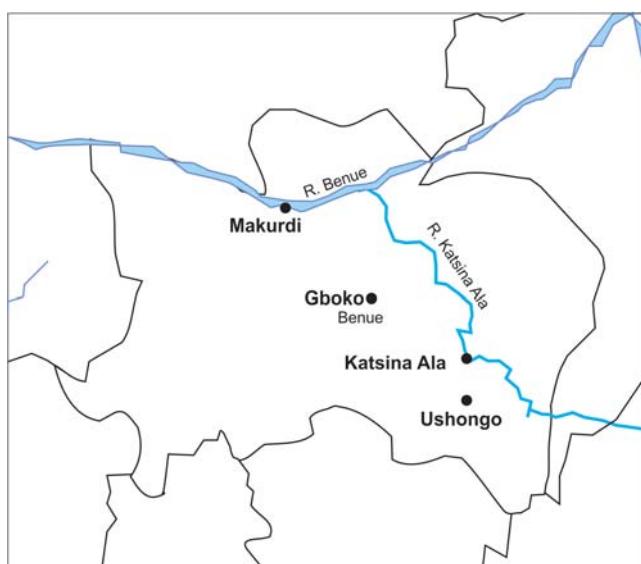


Fig. 1. Map of the study area showing Tse Dura and other localities in the Middle Benue Valley.

the rock shelter indicated a marked decrease in forest elements (at the earliest period) to that of open vegetation dominated by *Elaeis guineensis* and herbaceous elements in the upper levels (Oyelaran, 2002). Unfortunately, the sequence was undated hence its relationship with the occupation of the rock shelter remains hazy. At Tse Dura rock shelter site, north-central Nigeria, the subject of this paper, the earliest occupants (before 2,330 BP) used pottery decorated mainly with string roulette; other decoration patterns were grooves, incisions and comb-stamping. Subsequently, after ca. 2,000 BP, pottery with knitted mat impression appeared; other decoration types occurred but the latter remained dominant throughout. This indicated the arrival of a new population in the region (Andah, 1983). Sedimentological and mineralogical analyses of sediments from the Tse Dura rock shelters, and floodplains of the Rivers Katsina Ala, Tete and Ojapo (Cross River basin) revealed three climatic phases in the area, namely (a) an early very wet and warm phase assigned to a time shortly before 2,330 BP., (b) a middle wet and warm phase of $1,100 \pm 80$ BP and (c) a later dry and cool phase assigned to post 1,100 BP (Tubosun, 1981, 1995; Tubosun and Andah, 1983). However, the vegetation history was not investigated. This paper discusses the palaeoenvironmental conditions surrounding the occupation of the LSA archaeological site of Tse Dura KA 4 in Ushongo, Benue State, north-central Nigeria in the light of recent environmental archaeological investigations in the site.

REGIONAL SETTING

The Tse Dura KA 4 rock shelters, RS 1 and RS 2 are located on a hill by the same name near Ushongo village in Benue State, north central Nigeria (Fig. 1). They were

first excavated from 1975 to 1983 (Andah, 1983). The rock shelter, KA4 RS 1 ($N06^{\circ}56'08.38''$, $E009^{\circ}15'49.24''$), is located on a lower ridge (ca. 298 m above sea level) on the south west of the hill complex while the second rock shelter, K4 RS 2 is on a higher ridge (ca. 306 m asl) at the southeast of the major ridge hill complex. The hill complex is made up of granitic rock; the vegetation on the hill is characterised by grasses dominated by *Pennisetum* sp., *Andropogon* sp.; trees and shrubs included *Alchornea* sp., *Bridelia ferruginea*, *Daniellia oliveri*, *Dracaena arborea*, *Hymenocardia acida*, *Prosopis africana*, *Isoberlinia* spp., *Ficus* spp., and *Lophira lanceolata*; weeds include *Aspilia africana*, *Chromolaena odorata*, *Tridax procumbens*, *Sida acuta*; protected plants include *Elaeis guineensis*, *Parkia biglobosa*, *Tectonia grandis* and *Bombax costatum*. Most areas on the hill slopes and plains have been heavily cultivated with *Dioscorea* spp., *Manihot esculenta*, *Arachis hypogaea*, *Sorghum bicolor*, *Zea mays*, *Mangifera indica* and *Citrus* spp. Several river channels which run near the Tse Dura hill complex were more active in the past than now. Two of which are Rivers *Dura* and *Amire Tamen*; both are tributaries of the Katsina Ala River.

MATERIALS AND METHODS

After extensive discussions with some members of the 1975–1983 excavation team and consulting the 1983 excavation reports (Andah, 1983; Tubosun and Andah, 1983), a 2×2 m (B1) and another 2×1 m (B2) trenches were sunk in undisturbed deposits in Chamber 1 of RS 1 at the southernmost narrow end of the rock shelter. This report is based on the 2×2 m trench (B1). Excavation followed 10 cm spit levels and came to an end at a sterile layer of depth 110 cm below the surface (Fig. 2). Sediment samples for pollen analysis were collected from the eastern wall of the trench at 5 cm intervals; the eastern wall was the most intact (Fig. 2). However, this wall was a bit slant such that 0–20 cm of the 110 cm deposit was not present. Nineteen samples were collected representing 20–110 cm of the B1 trench; Soil colour and texture were noted using Munsell Soil Colour and soil particle size/class charts (Table 1). Five grams from each sample was subjected to standard pollen analysis procedure (Faegri and Iversen, 1988) but without acetolysis because of the presumed fragile nature of the palynomorphs. Afterwards, the final residue recov-

Table 1. Lithology of sediment samples from trench B1, Tse Dura RS 1.

Depth (cm)	Stratigraphic Units	Soil	
		colour	texture
20–35	A	dark grey	loose/sandy
35–55	B	brown	gritty/sandy
55–70	C	light brown	semi-compact/clay
70–95	D	yellowish brown	gritty/sandy
95–110	F	red	compact/ clay

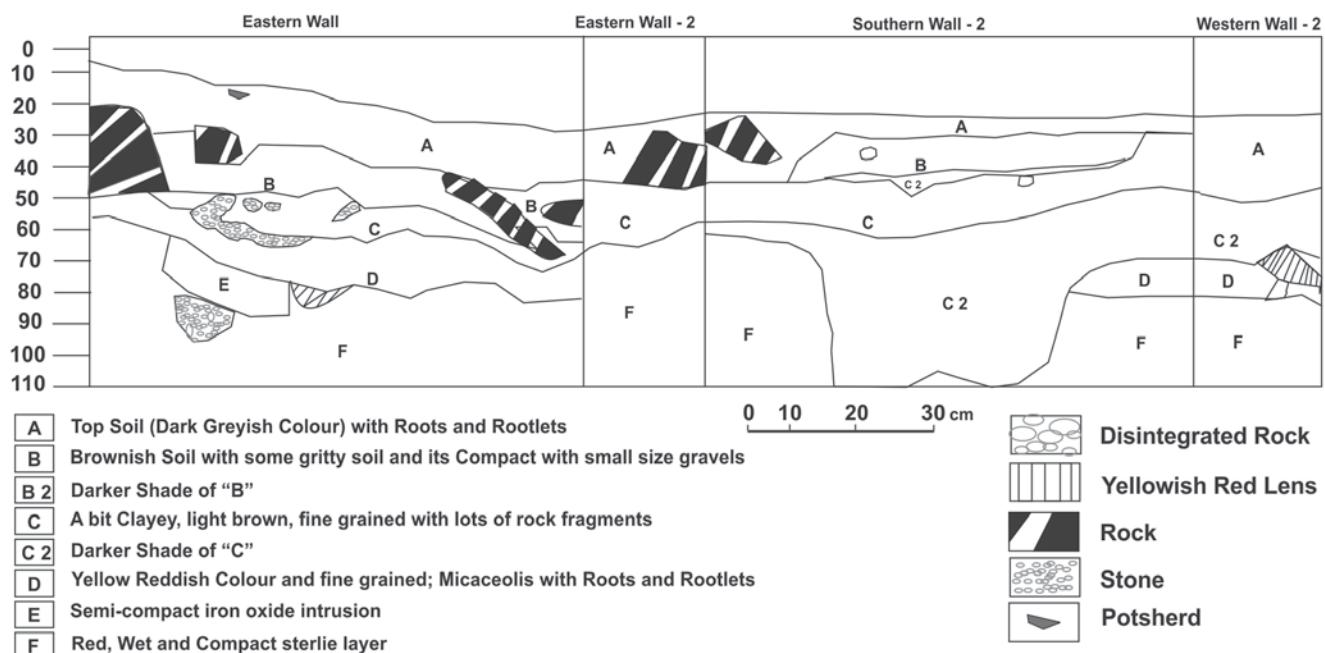


Fig. 2. Stratigraphic profiles of Square B 1, Tse Dura KA4 RS 1.

ered came to 2 ml; a micropipette was used to draw 10 µl from the residue onto duplicate slides; 10 µl was mounted on each slide. The slides were studied under ×40 and ×100 objectives of an Olympus Light Microscope. All palynomorphs including pollen, spores (pteridophytes and fungi) and algae were counted. However, fungal spores, algae and phytoliths were not included in the pollen sum but their occurrence was expressed as percentages of the total number of palynomorphs recovered. As much as possible, palynomorphs were classified into phytoecological groups based on the natural habitats of their identified parent plants (Keay, 1959; Hutchinson and Dalziel, 1958–1972) and/or hosts in the case of fungi (Argant *et al.*, 2006; Barboni *et al.*, 2007; van Geel *et al.*, 2011).

Pollen diagrams were produced with TILIA software; those of pollen and pteridophyte spores were plotted separately from those of fungal spores, algae and phytoliths. To have a better understanding of the past climate of the site, a comparison was made between taxa known to be natural to wet and dry environments. In addition, soil samples from all the levels of the excavated trench were floated and screened through 1 mm and 300 µm set of sieves for seeds, fruits and charcoal, the main results of which are presented elsewhere (Orijemie, in press) but shall be highlighted here.

Charcoal samples recovered during the excavation from the trench were sent to SUERC Radiocarbon Laboratory, Glasgow for AMS dating (Table 2). The date ranges were calibrated using the IntCal13 atmospheric calibration curve (Reimer *et al.*, 2013). Presented in Tables 3 and 4 are the archaeological finds materials recovered from the excavation and constituent palynomorphs of the phytoecological groups respectively.

RESULTS

Lithologic context of B1 Tse Dura rock shelter 1 (Fig. 2)

Layer A is the top soil; it is a sandy deposit, dark grey in colour and approximately 15–35 cm thick. Layer B is a brown, gritty sandy soil that is approximately 10–20 cm thick; in the southern wall, a slightly different layer, B2 occurs within layer B; it is ca. 15 cm thick. Layer C is a light brown clayey soil that is about 5–15 cm thick. In the eastern wall directly below layer C is a slightly similar layer (i.e. in terms of colour and texture) C2, although it is darker due to lots of charred materials and charcoal contained therein. It is ca. 50cm thick and was initially ca. 45 cm wide but

Table 2. Radiocarbon dates from Benue Valley, north-central Nigeria.

Sample	Source	Depth (cm)	C14 Age	2 Sigma Cal (95% Probability)
Beta 444814	Sediment core	55	310 ± 30 BP	cal AD 1485–1650
SUERC-73889	Tse Dura RS1	60–70	802 ± 29 BP	cal AD 1274
SUERC-73890	Tse Dura RS1	100–110	933 ± 29 BP	cal AD 1161

Table 3. Summary of materials recovered from KA4 RS 1 B1.

Artefacts/Level (cm)	Surface	0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110	Total
Pottery	228	103	180	638	1009	429	115	48	133	16	27	16	2942
Animal bones	1	—	—	2	11	1	—	—	—	—	—	—	15
Animal teeth	—	—	—	1	—	1	—	—	1	—	—	—	3
Bone tool (tanged)	—	—	—	1	—	—	—	—	—	—	—	—	1
Charcoal	—	—	—	+	+	++	+++	++	++	+	+	+	+++
Charred Wood	—	6	—	—	—	—	—	—	1	—	—	—	7
Groundnut	7	1	—	—	—	—	—	—	—	—	—	—	8
Unidentified seed	1	—	—	—	—	—	—	—	—	—	—	—	1
Oil palm kernel	9	21	3	—	—	—	—	—	—	—	—	—	33
Iron Slag	—	240	—	45	7	4	11	6	7	2	4	—	326
Lithics	2	—	—	53	223	60	151	51	72	—	4	1	617
Total	248	371	183	740	1250	495	277	105	214	18	35	17	3953

Table 4. Palynomorphs of the phytoecological groups/ hosts recovered from sediment samples of B1 Tse Dura RS1.

Phytoecological groups/ hosts		Taxa
Freshwater/aquatics		Cyperaceae, <i>Lemna</i> sp., <i>Liliaceae</i> , <i>Nymphaea lotus</i> , <i>Typha australis</i>
Freshwater swamp forest		<i>Allophylus africanus</i> , <i>Alstonia boonei</i> , cf. <i>Ancistrophyllum secondiflorum</i> , <i>Pterocarpus santalinoides</i> , <i>Uapaca acuminata</i>
Dry forests		<i>Antiaris</i> sp., <i>Bosqueia angolense</i> , <i>Ceiba pentandra</i> , <i>Centroplacus glacinus</i> , <i>Celtis/Ficus</i> sp., <i>Diospyros</i> sp., <i>Entada gigas</i> , <i>Piptadeniastrum africanum</i> , <i>Irvingia gabonensis</i>
Secondary forest		<i>Alchornea</i> cf. <i>cordifolia</i> , <i>Elaeis guineensis</i> , <i>Lecaniodiscus</i> sp., <i>Macaranga</i> sp., <i>Pycnanthus angolensis</i>
Montane forest		<i>Anthocleista djalonensis</i> , <i>Ericaceae</i> , <i>Justicia flava</i> , <i>Podocarpus milanjanus</i> , <i>Myrica arborea</i>
Guinea savanna		<i>Berlinia</i> cf. <i>grandiflora</i> , <i>Bombax costatum</i> <i>Borassus/Hyphaene</i> , <i>Bridelia</i> cf. <i>ferruginea</i> , <i>Bridelia</i> cf. <i>micrantha</i> , <i>Canarium schweinfurthii</i> type, <i>Cissampelos mucronata</i> , <i>Hymenocardia acida</i> , <i>Lannea</i> cf. <i>microcarpa</i> , <i>Lophira</i> cf. <i>lanceolata</i> , <i>Hymenocardia acida</i> , <i>Pavetta</i> cf. <i>crassipes</i> , <i>Pericopsis angolensis</i> , <i>Prosopis africana</i> , <i>Parinari</i> cf. <i>kerstingii</i> , <i>Pterocarpus erinaceus</i> , <i>Milletia</i> cf. <i>oblata</i> , <i>Nauclea latifolia</i> , <i>Parkia biglobosa</i> , <i>Senna hirsuta</i> , <i>Syzygium guineense</i> , <i>Trema</i> sp., <i>Xyris</i> sp.
Cultivars		<i>Citrus</i> spp., <i>Corchorus olitorius</i> , <i>Dioscorea</i> spp., <i>Mangifera indica</i> , <i>Manihot</i> cf. <i>esculentus</i> , <i>Ocimum gratissimum</i> , <i>Sesamum</i> cf. <i>indicum</i> , <i>Vigna</i> sp.
Open vegetation		<i>Alternanthera</i> cf. <i>repens</i> , <i>Amaranthaceae/Chenopodiaceae</i> , <i>Asteraceae</i> , <i>Asystasia gangetica</i> , <i>Celosia</i> sp., <i>Celosia</i> cf. <i>argentea</i> , <i>Crassocephalum</i> , <i>Phyllanthus amarus</i> , <i>Poaceae</i>
Ferns	Triletes	<i>Cyathea</i> sp., <i>Congulisporites ornatus</i> , <i>Lycopodium cernuum</i> , <i>Ophioglossum</i> sp., <i>Pteris</i> sp., <i>Selaginella</i> sp.
	Monoletes	<i>Cyclosorus</i> sp., monolete spores, <i>Polypodium vulgare</i>
Fungi (commensals)	Soil and dung	<i>Arnium</i> sp., <i>Brachydesmiella</i> sp., <i>Caryospora</i> sp., <i>Cercophora</i> sp., <i>Podospora</i> sp., <i>Sordaria</i> sp., <i>Sporormiella</i> sp.
	Local fire and erosion	<i>Chaetomium</i> sp., <i>Diporotheca</i> sp., <i>Glomus</i> sp., <i>Venturia</i> sp.
	Domesticated animals	<i>Coniochaeta</i> cf. <i>lignaria</i> , <i>Lasiodiplodia theobromae</i> , <i>Picaria</i> sp., <i>Podospora</i> sp.
	Cultigens	<i>Alternaria</i> cf. <i>tenuissima</i> , <i>Aspergillus</i> cf. <i>flavus</i> , <i>Fusarium</i> sp., <i>Curvularia</i> sp.
Human settlements		<i>Arthrinium</i> sp., <i>Delitschia</i> sp., <i>Endophragmia</i> sp., <i>Valsaria</i> sp.
Algae (freshwater)		<i>Botryococcus</i> sp., <i>Pseudoschizaea</i> sp., <i>Zygema</i> sp.
Phytoliths	Bulliform	leaf
	Culm	stem
	Elongate echinate	inflorescence
	Cross	leaf
	Bilobate	leaf

reached 1m in width when the trench was extended. It protruded into the sterile layer; it is almost u-shaped, and gives the impression it was a storage pit (Fig. 2). Layer D is yellowish brown (mottled yellowish brown in several areas), gritty and sandy; its thickness is in the range of 5 cm to 25 cm. Layer E lies directly below layer D but is within

layer F, the sterile layer. It is semi-compact with a concentration of ferric-oxide which is an indication of oxidation. It is about 17 cm thick, and occurs only in the northern wall. Layer F is mainly red in colour, wet and sticky clay; it also contained mottled yellowish brown “patches” in few areas, and is the sterile layer. It is mainly 20–25 cm thick. Layer G

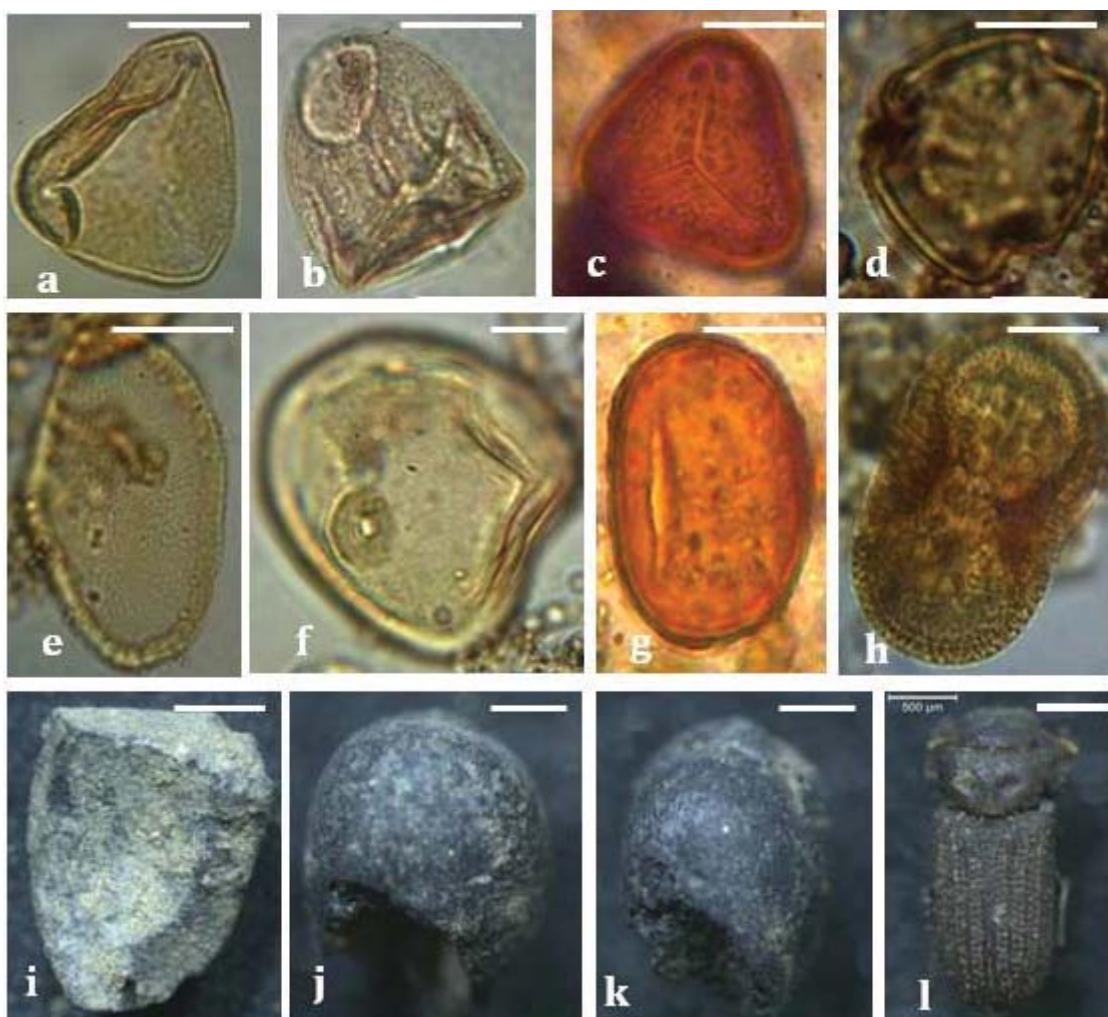


Fig. 3. Pollen, spores, seeds and beetle recovered from the archaeological sequence of B1 Tse Dura rock shelter 1 a–f: pollen grains; g: pteridophyte spore; i–k. seeds; l. beetle a. *Elaeis guineensis*, b. Cyperaceae, c. *Pteridium* sp., d. *Sarcocephalus latifolius* (syn. *Nauclea latifolia*), e. *Dioscorea* sp., f. Poaceae, g. Monolete spore, h. *Justicia* sp., i. cf. *Canarium schweinfurthii*, j–k. *Pennisetum glaucum*, l. cf. *Palorus subdepressus*

occurs as lens in two areas of the eastern wall; it is directly below layer B adjacent to C, and above C2. Both are ca. 15 cm thick; the soils therein are a mixture of red and black inclusions. With regard to the palaeoclimatic inference based on wet and dry taxa, the former group consisted of riverine forest, freshwater (aquatics) and aquatic algae, while the latter consisted of Guinea savanna and montane forest taxa.

Palynology

One hundred and forty-nine palynomorph types were recognised. Of this number, eighty-nine (59.7%) were pollen grains, forty-three (28.9%) were fungal spores, nine (6%) were pteridophyte spores, five (3.4%) were phytoliths and three (2%) were algae types. Four pollen zones I, II, III and IV were identified based on changes in the pollen assemblage and lithology of the sediments. All the pollen zones but that of pollen zone II had two sub-zones each. They are as follows: TD B1 1a (100–110 cm), TD B1 1b

(85–100 cm), TD B1 2 (70–85 cm), TD B1 3a (60–70 cm); TD B1 3b (45–60 cm) and TD B1 4a (30–45 cm) and TD B1 4b (20–30 cm). Pollen sum (pollen and pteridophyte spores) recovered from duplicate slides ranged from 190 to 685; pollen concentration ranged from 4,290/g to 13,700/g. The photographs of some pollen, pteridophyte spore, seeds and beetle (cf. *Palorus subdepressus*) are shown in Fig. 3; the pollen diagrams are shown in Figs 4–5 while Fig. 6 shows a reconstruction of the palaeoclimate of the area in the last one millennium.

POLLEN ZONES (TSE DURA B1)

Pollen Zone TD B1 1a (100–110 cm)

At the beginning of the zone, Guinea savanna (35%) was the most dominant vegetation type. Other taxa that were present included those of secondary forest, cultivars (*Dioscorea* spp.) and montane forests which were 8.7%

each; herbaceous plants, aquatics, dry forests and Poaceae were 4.3% each. Trilete spores (1.5%) occurred briefly but disappeared afterwards. Subsequently, secondary forest (38.3–40.3%) became the most dominant taxa while Guinea savanna (17.7–13.6%) and dry forests (4.3–3.2%) both decreased; Cultivars (8.7–8.1%) fluctuated but montane forest disappeared. Aquatics (13.6–1.6%) decreased while Poaceae (18.2–4.6%) which had an initial increase later decreased at the end of the zone. Fungal spores associated with erosion and fire such *Chaetomium* sp., *Venturia* sp., *Valsaria* sp., *Cercophora* sp. and *Alternaria* cf. *tenuissima* dominated; bulliform phytoliths (Poaceae) were also abundant.

Pollen Zone TD B1 1b (85–100 cm)

Secondary forest species (40–40.3%) were the most dominant taxa; they were followed by those of Guinea savanna (11.7–17.7%), Poaceae (13.3–17.7%) and dry forests (3.2–9.4%). Cultivars (8.1–5.9%), aquatics (7.4–11.6%) and herbaceous taxa (2.9–4.8%) were also well represented. Combretaceae/ Melastomataceae species (1.1–2.9%) which exhibited similar pattern as those of dry forests, and riverine forest species (5.9–8.3%) occurred for the first time. At the end of the zone, secondary forest (40–20%) though quite abundant experienced some decrease; in contrast, Guinea savanna elements (20–30%) became dominant; herbaceous plants (2.9–8.3%) and aquatics (4.6–11.6%) increased; cultivars (5.9–5.0%) fluctuated, while dry and montane forests disappeared. Fungal spores such as *Chaetomium* sp., *Venturia* sp. and *Alternaria* cf. *tenuissima* as well as bulliform phytoliths (Poaceae) decreased markedly while *Valsaria* and *Cercophora* fluctuated; in contrast, *Delitschia*, *Brachydesmiella* and fungal spore baculate were dominant. Other spores namely *Fusarium*, *Curvularia* and *Aspergillus* cf. *flavus* were present.

Pollen Zone TD B1 2 (70–85 cm)

Secondary forest elements (20–37.2%) were quite abundant they later decreased (19.2–10.7%) and the end of the zone. Conversely, Guinea savanna taxa which decreased at the beginning (30–16.6%) increased (19.2–24.8%) at the end of the zone. Poaceae (13–19.2%), cultivars (5–13.7%) and herbaceous plants (10.2–12.2%) were well represented. Riverine forests (8.3%) and aquatics (9.6%) which had good representation later decreased to 4.6% and 4.5% respectively at the end of the zone. During the same period, Combretaceae/ Melastomataceae were 3.8% while dry (1.3–7.6%) and montane forests (1.5–3.8%) represented by *Podocarpus milanjanus* reoccurred at 80cm. The major fungal spores included fungal spore baculate, fungal spore long. Others include *Chaetomium* and *Valsaria*, *Brachydesmiella*, *Cercophora*, cf. *Endophragmiella* and cultigen commensals (*Alternaria* cf. *tenuissima* *Fusarium*, *Curvularia* and *Aspergillus* cf. *flavus*); bilobate phytoliths (Panicoideae) also occurred at 80cm.

Pollen Zone TD B1 3a (60–70 cm)

Guinea savanna (24.8–36.8%), Secondary forest (10.7–25.6%) and herbaceous elements (9.6–12.2%) were the most dominant. The herbaceous plant *Alternanthera repens* occurred for the first time at 60cm. Poaceae (15.3–9.6%) and cultivars (13.7–7.2%) fluctuated; aquatics (4.5–2.3%) and riverine forest (4.6–2.9%) species were also present. Dry forest (7.6–21.2%) and montane forest (1.5–8.0%) species had an increase at 65cm but later decreased to 2.4% and 0% respectively. Fungal spore long, and fungal spore baculate decreased while *Valsaria* and *Delitschia* increased; *Chaetomium* and *Brachydesmiella*, *Cercophora* and *Endophragmiella* occurred. The cultigen commensals were also present; *Diporotheca* occurred for the first time. Bulliform phytolith (Poaceae) re-occurred.

Pollen Zone TD B1 3b (45–60 cm)

Guinea savanna (24–36.8%) and Poaceae (9.6–32.1%) were the most dominant taxa encountered but secondary forest elements decreased (25.6–12.0%); aquatics (2.4–3.2%), dry forest (2.4–16.6%), Combretaceae/ Melastomataceae (1.2–1.6%) were well represented. In contrast, riverine (1.2%) and montane forests (5%) had low occurrences. At the end of the zone, dry forest (16.6–5.0%) and Poaceae (32.1–13.3%) decreased but Guinea savanna (18.5–48.3%) and herbaceous taxa (1.2–6.0%) dominated. Among the herbaceous elements was *Celosia* cf. *argentea* which, along with monolete occurred for the first time; both monolete (8–14.8%) and trilete spores (7.4%) were represented. Fungal spore long, fungal spore baculate, *Chaetomium* and *Arthrinium* were the dominant fungal spores; *Delitschia* decreased slightly but *Valsaria* had significant decrease. *Coniochaeta* cf. *ligniaria* occurred for the first time. Of the cultigen fungal spores, only *Aspergillus* cf. *flavus* occurred. Bulliform phytoliths decreased while elongate echinate and culm (cone-shaped) phytoliths were present.

Pollen Zone TD B1 4a (30–45 cm)

There was an abundance of secondary forest species (17.4–23.1%) while Guinea savanna (15.9–14.3%) and Poaceae (26.1–14.3%) experienced fluctuations. Aquatics (6.4–21.4%) became well represented at the end of the zone; cultivars (4.6–12.7%) and herbaceous plants (3.1–7.1%) were also present; *Asystasia gangetica* occurred for the first time at 35cm accompanied by new set of fungal spores. Dry forest (6.1–4.7%) and Combretaceae/ Melastomataceae (30–1.6%) decreased; monoletes decreased (6.3–0%) while triletes increased (1.6–14.6%). Riverine and montane forests disappeared. *Chaetomium*, *Aspergillus* cf. *clavus* and *Coniochaeta* cf. *ligniaria* were the dominant fungal spores; bulliform phytoliths were also well represented.

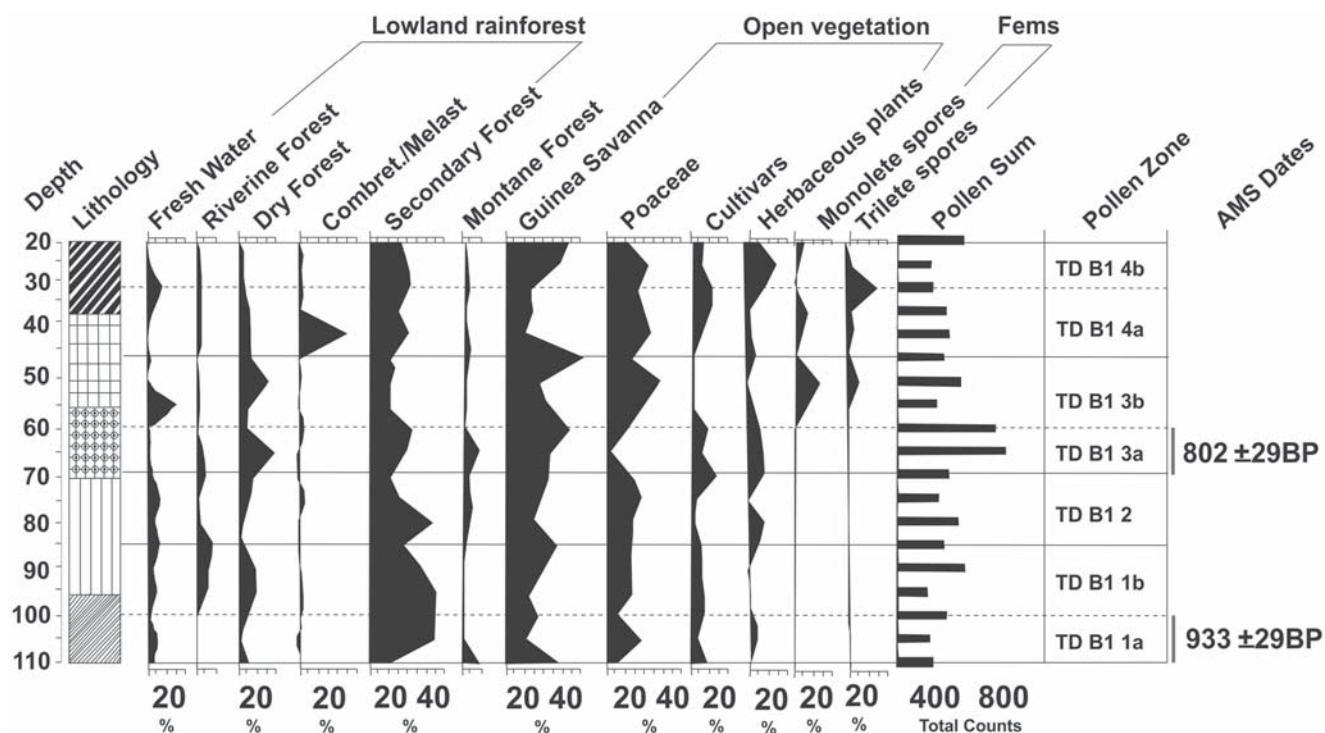


Fig. 4. Pollen diagram of KA4 Tse Dura rock shelter showing pollen and pteridophyte spores.

Pollen Zone TD B1 4b (20–30 cm)

Guinea savanna (15–38.4%) had a significant increase; secondary forests elements (17.4–24.4%) were also well represented. However, Poaceae (23.4–11.6%), herbaceous plants (19.8–6.9%) and cultivars (11.3–5.8%) experienced some decrease. Similarly, aquatics (21.4–1.2%) and trilete spores (14.3–1.2) had very significant decrease; monoletes were present (2.1–4.6%). Dry forests (6.1–1.2%) and Combretaceae/ Melastomataceae (2.7–1.2%) were very much reduced. *Coniochaeta cf. lignaria* remained the most dominant fungal spore; phytoliths were scanty.

DISCUSSION

Pollen Zone TD B1 1 (933 ± 29 BP – prior to 802 ± 29 BP)

The environment during the period, this part of the rock shelter was occupied was dated to 933 ± 29 BP (cal AD 1161). The environment was characterised by Guinea savanna and grasses (Fig. 4); it is likely that dry conditions prevailed. The soils are clayey and compact; they are red in colour and contain micaceous inclusions (Table 1). Although the soils are red in colour which indicated oxidation potentials (Eyre, 2013), pollen and spores were fairly well preserved. The lithology is in support of the inferred drier conditions. This is further reflected in the moderate values of secondary forest elements, as well as low values

of aquatics and dry forests. In addition, the occurrence of montane taxa (*Myrica arborea*) is indicative of cool conditions. In the region of Lake Chad, the basin of which covers northern Nigeria, Niger, Chad, Algeria, Libya and Sudan, dust arising from very arid climate experienced marked increase at 1,000 BP (Cockerton *et al.*, 2014). Similarly, after 2,000 BP water levels of Lake Chad dropped to 175m below Mid Holocene levels (Armitage *et al.*, 2015) which reflected the very arid conditions which prevailed during that period in the Sahara region. Arid conditions occurred in Lake Tilla ca. 3,800 BP; by 1,000 BP conditions had deteriorated owing to human intervention (Salzmann, 2000); Lake Tilla is ca. 450 km to the north of Tse Dura, and is in the Sudan-Sahel savanna zone in Northern Nigeria. Similar climatic and vegetation changes were recognised to have begun from ca. 1,470 ± 79 in Nsukka with evidence of some anthropogenic influence (Njokuocha and Akaegbobi, 2014); Nsukka is located in the Derived savanna, and approximately 170km west of Tse Dura. In addition, the inferred dry climate seems contemporaneous with those from Kariya Wuro (ca. 1,000 BP) to the north (Sowunmi and Awosina, 1991; Switsur *et al.*, 1994), and of the coastal areas (Lac Sélé) in Southern Bénin which take place around 1,000–1,100 BP (Salzmann and Hoelzmann, 2005) and around 1,190 ± 30 BP in Ogudu near Lagos, Nigeria (Orijemie, 2013).

However, despite the prevalence of dry conditions, secondary forest was also an important part of the environment because it subsequently became dominant which

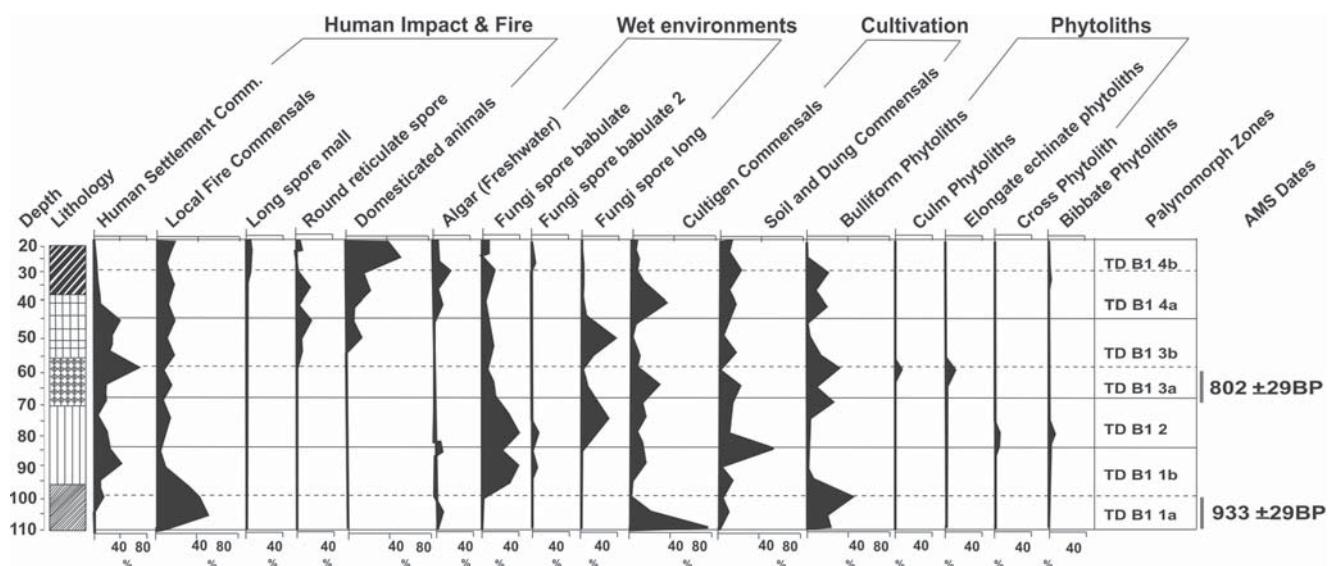


Fig. 5. Diagram of KA4 Tse Dura rock shelter showing fungal spores, algae and phytoliths.

seems to indicate a prevalence of humid and warm conditions. This is corroborated by the concomitant marginal decrease in Guinea savanna and disappearance of montane forest elements. Furthermore, the increase in aquatics, marginal increase in forests and appearance of riverine forests and ferns (represented by trilete spores) are in support of the inferred humid and warm climate. At the end of the zone, both Guinea savanna and secondary forest became the most abundant vegetation types in the landscape, an indication that the environment was open and probably drier than the previous times. Subsequently, the appreciable increase in riverine forest species and aquatics (freshwater) indicated that humid conditions persisted and were probably restricted to river banks and swamps. Human impact on the environment was quite prominent owing to the rise in herbaceous taxa (Amaranthaceae/ Chenopodiaceae and Asteraceae), the parent plants of which are usually found in anthropogenically disturbed places. Similarly, the fungi recovered were those associated with fire (*Chaetomium* sp. and *Venturia* sp.), human settlements (*Valsaria* sp.), soil and dung (*Cercophora* sp.) and cultigens (*Alternaria* cf. *tenuissima*) (Fig. 5). The subsequent increase in *Delitschia* and *Valsaria* indicated intensification of human impact on the landscape. In addition, intensified cultivation of plants (yams and pearl millet) is revealed by a diversification of the cultigens commensals (*Fusarium*, *Curvularia* and *Aspergillus* cf. *flavus*).

It is instructive that the occurrence of secondary forest taxa and cultivars, which were dominated by *Elaeis guineensis* (oil palm) and *Dioscorea* spp. (yams) respectively, indicated the importance of these food plants as part of the culture of the inhabitants of the rock shelter. The oil palm is one of the most important economic trees in West Africa and has been exploited since ca. 9,000 BP – Present (Oas et al., 2015; Sowunmi, 1981; Sowunmi and Awosina,

1991; Alabi, 2000). Hitherto, the exploitation of yams had been known only from linguistic evidence (Williamson, 1987, 1993). The recovery of its pollen indicated its possible exploitation. Although it is difficult to differentiate the pollen of cultivated *Dioscorea* from those of wild forms, the occurrence of beetle cf. *Palorus subdepressus*, one of the major pests of stored yams (Korada et al., 2010), suggests that the yams may not have been wild forms. The increase noted in the Poaceae and occurrence of bulliform phytoliths indicated the exploitation of grasses, among which was *Pennisetum glaucum* (pearl millet), the charred caryopses (1.5–2 mm in size) of which were also recovered (Fig. 3). The other plants which were exploited included those of Amaranthaceae/ Chenopodiaceae, some of which are consumed as leafy vegetables (Alyegba et al., 2013) and Cyperaceae (*Cyperus* cf. *esculentus*), the ripe fruits of which are eaten.

Three plants, the pollen of which were also recovered in substantial amount, and which are of ethnobotanical importance in northern Nigeria are *Pavetta crassipes*, *Sarcocephalus latifolius* (syn. *Nauclea latifolia*) and *Lophira* cf. *lanceolata* (Aliyu et al., 2008). The fruits of *Pavetta* and *Sarcocephalus latifolius* are known to have been exploited by LSA populations in Kariya Wuro, to the north of Tse Dura (Sowunmi and Awosina, 1991). Among the Tiv, the stems of *Pavetta crassipes* (*Ato a ik-pan*) and *Sarcocephalus latifolius* (syn. *Nauclea latifolia*) (*Ikurakase*) are used in the treatment of internal wounds and jaundice (Awai and Igoli, 2015). Burkhill (1985) stated that the leaves and roots of *Pavetta crassipes* are used in producing arrow-poisons, while Aliyu et al., (2008) recognised it for respiratory and related problems. *P. crassipes* seems to be a wonder plant as the ethnopharmacological importance has been well recognised (Amosa et al., 1998). On the other hand, both stems and roots of *Lophira* cf. *lan-*

ceolata (*Ikuranomso*) are used in aborting foetuses (Awai and Igoli, 2015). These indicate that the human population at Tse Dura engaged in the management of oil palm, yams (tubers), pearl millet (*Pennisetum glaucum*), grasses and vegetables as well as the exploitation of wild trees and shrubs for dietary and ethnomedicinal purposes.

Pollen Zone TD B1 2 (Just before 802 ± 29 BP)

During the early phase of this period, the environment was basically secondary forest vegetation although Guinea savanna taxa occurred (Fig. 4); also present were riverine forests and aquatic species (freshwater) indicating humid climatic conditions. The pollen evidence revealed a change from an environment characterised by Guinea savanna with dry and cool conditions to a humid and warm one. Subsequently, there were marked increases in Guinea savanna elements, Poaceae and montane forests (*Justicia flava*, *Ilex mitis* and *Podocarpus milanjanus*) along with concomitant decrease in species indicative of wet conditions such as riverine forests and aquatics.

The re-occurrence of montane forests and dry forest type towards the end of the zone revealed the existence of cooler and drier conditions. However, the notable increase in Poaceae, cultivars and herbaceous plants in substantial amounts indicated a landscape that was still under strong anthropogenic influence. Continued human occupation of the rock shelter is depicted not only in the cultural artefacts but also in the diversification of fungi (Fig. 5) particularly those associated with human settlements (*Valsaria*) and human-related activities (*Brachydesmiella*, *Cercophora*, cf. *Endophragmiella*), as well as local fire and erosion (*Chaetomium*). The exploitation of *Pennisetum glaucum*, *Dioscorea* spp., *Elaeis guineensis*, *Pavetta* cf. *crassipes*, *Sarcocephalus latifolius* (Syn. *Nauclea latifolia*) and Cyperaceae, as major plant foods continued. The occurrence of cross and bilobate phytoliths which are produced in the leaves of Panicoideae grasses (Barboni *et al.*, 2007) suggest that Panicoideae grasses (to which *Pennisetum glaucum* belongs) were harvested and brought into the rock shelter for processing. The recovery of the caryopses of pearl millet continued throughout the trench until they disappeared after 20 cm. In addition, the occurrence of cultigen commensals (*Alternaria* cf. *tenuissima* *Fusarium*, *Curvularia* and *Aspergillus* cf. *flavus*) appears to be in support of local presence of pearl millets. Furthermore, the occurrence of *Prosopis africana* pollen is significant; *P. africana* is called *Gbaaye* among the Tiv, and its seeds are used as a local condiment (Alyegba *et al.*, 2013).

The vegetation changes were accompanied by some cultural changes. First, there was significant increase in pottery from 43 in the previous period to 149 (Table 3); this phenomenon may be reflective of an increased need to process higher number and types of foods, as well as growing human population. Second, there was an occurrence of pottery decoration types hitherto unrecovered. They constituted 4.7% of the total body sherds, and are

namely twisted mat impression, burnished and twisted cord roulette. Vessels with these decoration types are currently known among the Tiv people. Vessels with twisted mat impression are used mainly for processing pearl millet and sorghum into malt (*Lo*), non-alcoholic (*Bier*) and alcoholic (*Tashi*) drinks. On the other hand, vessels with burnished and twisted cord roulette decorations called *Tsuwa* are used for three different purposes namely serving soup, preparing herbal medicines and for cooking. The burnished effect is produced from the *Kpine* tree (*Bridelia ferruginea*), a tradition that continues till date in Tivland. The third change was an increase in microliths (side scrapers, backed blade and tanged piece), chips, chunks and flakes, and hammer stones (Table 3) as well as the occurrence of a tooth of *Thryonomys swinderianus* (greater cane rat/grasscutter). The diversification of lithics and occurrence of animal tooth indicated increased hunting activities.

Pollen Zone TD B1 3 (802 ± 29 BP – just before 310 ± 30 BP)

The dominance of Guinea savanna, secondary forest and herbaceous elements during the early period of this level indicated a continued occurrence of environmental conditions as was in the previous level (Fig. 4). The colour of the sediments was not significantly different from that of the previous level but they became semi-compact, clayey and fine in texture. These lithological features are characteristic of improved climatic conditions. Notable increases in Poaceae and cultivars revealed probable intensification of human impact. At the end of the zone, Guinea savanna, Poaceae, secondary forests and dry forests still remained the most dominant, an indication the landscape was still open. In addition, spores of ferns were recovered for the first time; some of them (*Pteris* sp.) are naturally found in moist environments and along freshwater swamps. The recovered fungi indicated the continued impact of humans on the environment. *Diporotheca* is linked with an almost treeless landscape (van Geel *et al.*, 2011), which was open or grassy environment as depicted in re-occurrence of bulliform phytoliths (Fig. 5). The subsequent decrease in fungi associated with humans (*Valsaria* and *Delitschia*) coincided with the first occurrence of *Coniochaeta* cf. *ligniaria*; *C. cf. ligniaria* is associated with herbivores hence might indicate a possible introduction of herbivores. In addition, the recovery of elongate echinate and culm phytoliths which are produced in the inflorescence and stems of grasses (Poaceae) indicated an increased use of grasses (cultivated and wild forms).

Among the herbaceous plants, *Alternanthera* cf. *repens* occurs for the first time. *Alternanthera repens* is a weedy species associated with anthropogenic disturbances; its occurrence supports a stronger impact of humans on the landscape. However, the increase in dry and montane forests was unexpected, and may be associated with some form of human action which enabled forest trees to regenerate (Fig. 4). Three significant cultural changes occurred during

this period namely (i) an initial and marked reduction in pottery from 149 in the previous level to 48 (60 cm) at the beginning of the level (Table 3); (ii) first occurrence of ground-stone axe concomitant with increases in herbaceous plants (*Celosia* cf. *argentea*) and (iii) significant increase in lithics and iron slags. The initial reduction in pottery suggests that there is the likelihood that some form of migration took place which seems to be supported by marked reduction in the fungi spores associated with human settlements (*Valsaria* and *Delitschia*) and the concomitant increase in forest species albeit of the drier type. The recovery of ground-stone axe, and appearance of new pottery technique (embossed) and decorations (carved wood roulette) are significant because they were accompanied by vegetation changes one of which was the occurrence of *Celosia* sp.; *Celosia* is a leafy vegetable consumed in the study area.

Pollen Zone TD B1 4 (just before 310 ± 30 BP – Present)

The dominance of secondary forest species and cultivars indicated a more significant impact on the vegetation by humans. Environmental conditions at the beginning of this period appeared to have been warm and humid with the occurrence of light brown-brown sandy soils, good representation of aquatics as well as concomitant fluctuations in Guinea savanna and Poaceae, and disappearance of montane forest elements (Fig. 4). In addition, the appearance of *Asystasia gangetica*, a weed of disturbed places is significant. It is almost intolerant of shade and can often be found in alluvium soils of river banks; Its occurrence was accompanied by increases in the fungal spores namely *Coniochaeta* cf. *lignaria*, *Canalisporium* sp. and *Chaetomium* sp. *Coniochaeta* cf. *lignaria* is indicative of high density of domesticated animals (van Geel *et al.*, 2011); *Chaetomium* sp. and *Canalisporium* are associated with forest clearance, fire and erosion (Argant *et al.*, 2006).

At 30 cm, there was an unprecedented increase in aquatics (21.4%) and fungal spores (30.8%); this was an indication that wet conditions prevailed during that period. Although the sediments from the layer were not dated, it seems contemporaneous with the lowest level (55 cm) of a sediment core drilled in the freshwater swamp of the Katsina Ala River. The Tse Dura hill is approximately 25 km away from the Katsina Ala River; however, a tributary of the Katsina Ala, River Amire Tamen flows near the Tse Dura hill complex. It is therefore not farfetched to infer that sediments of the Katsina Ala floodplains were partly derived from the hills; this phenomenon partly accounts for the similarities in the lithology of both sediments. The Tse Dura sediments (at 30 cm) are dark grey in colour, a bit loose and sandy; those of the sediment core (at 55 cm) were dark grey in colour, loose and sandy. The other similarity derives from patterns in the pollen and spore assemblages. The sediment core (55 cm) was dominated by an abundance of aquatic and freshwater species (12.6–28%) such as Cyperaceae, *Ludwigia* and *Typha* while fungal spores (35.7%) were also comparable to those from the rock shel-

ter. In contrast Guinea savanna elements (0–2.9%) had very low occurrence. This level, inferred to have been wet, was dated to cal. AD 1485–1650. However, the most significant occurrence among the fungi was *Coniochaeta* cf. *lignaria*, which are associated with the presence of herbivores (van Geel *et al.*, 2011). Accompanying these vegetation changes were cultural changes. The high amount of archaeological artefacts indicated that this level was the most diversified period in terms of human occupation at the site. Subsequently, it was also during this period that caryopses of cf. *Sorghum bicolor* were recovered. The environment became more open with the dominance of Guinea savanna and Poaceae. This was followed by drastic reduction in aquatics, triletes and dry forest species.

PALAEOClimATIC RECONSTRUCTION

A comparison of the wet and dry taxa recovered from the Tse Dura rock shelter site is represented in Fig. 6. From the diagram, periods of major and minor climatic variability were revealed; the major variability included wet and warm, or dry and cool periods while the minor variability was a wet-dry transition period. From 110–95 cm, there were fluctuations in climate such that the environment alternated between dry and wet conditions with dry conditions occurring at 110 cm and wet at 105 cm. Hence a cyclic pattern of climatic events was established such that a dry and cool period was succeeded by a wet and warm phase and it succeeded by a transitional wet-dry phase. The earliest dry event occurred around 933 ± 29 BP (cal AD 1161), and agrees with Tubosun, (1981, 1995) who indicated that dry and cool environmental phase occurred just after 1,100 BP. This dry event appears to be the “relict” of the Late Holocene Dry Phase which began in north-eastern Nigeria around ca. 3,800 BP (Salzmann, 2000), and northern parts of Bauchi at ca. 1000 BP (Sowunmi and Awosina, 1991). Cockerton *et al.*, (2014)

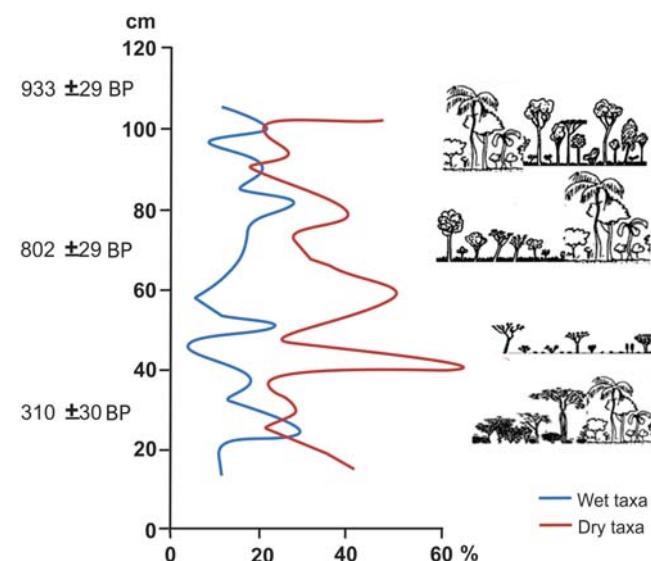


Fig. 6. Reconstructed palaeoclimate at Tse Dura based on a comparison between wet and dry taxa.

stated that the environment in the northernmost parts of Nigeria during this period was influenced by human activities but did not provide the drivers of this inferred human impact. The recovery of several figurines of animals (mostly large herbivores such as sheep, goat and cattle) in the Daima area of north-eastern Nigeria dating to the 1st–2nd millennium AD (Connah, 1981) alludes to grazing activities which would have had devastating effects on the already marginal landscape. In contrast, there seems to be no evidence of adverse effects of human-induced climate change at Tse Dura during this period. However, the occurrence of “new” pottery types (finger impressed and embossed pottery) in the archaeological record indicated migration of populations from northern Nigeria and Cameroon into the Middle Benue Valley. Finger impressed pottery occurred in NE Nigeria *ca.* 1,200 BP (Connah, 1981) and Dumbu site in the Gongola area around 810 ± 80 BP (Van Noten and De Ploey 1977); embossed pottery was recovered from Shum Laka rock shelter (Cameroon) from *ca.* 2500–900 BP (de Maret, 2013; Lavachery, 1996). The impact these migrations would have had on the indigenous populations (hunter-gatherers) is not clear. The fact that the dominant pottery type, the knitted mat impressed pottery, was not displaced suggested that some form of cultural assimilation rather than acculturation might have occurred.

Subsequently, a transition phase between wet and dry climate occurred during the period when level 90–80 cm was deposited. A second period of dry and cool condition occurred at 80–60 cm; it was during this period that cultivars (5–13.7%), dominated by *Dioscorea* spp., increased which was an indication that human impact on the vegetation was significant. In addition, pottery with wavy and/or circular lines appeared in substantial amount. Pottery with wavy lines has been associated with food producing communities of 7000–5000 BP in the Sudan (Mohammed-Ali and Khabir, 2003) but this Sudan Neolithic culture does not seem to have reached Tse Dura rather Iron Age (900–1000 BP) populations in Cameroon with similar pottery (Lavachery, 1996) may have migrated into the Middle Benue Valley and impacted Tse Dura. This dry and cool event which came to an end around 802 ± 29 BP (cal AD 1274) appeared to have lasted for a considerable length of time, and was succeeded by a wet and warm phase. Another major dry phase occurred afterwards, and this is probably contemporaneous with the Little Ice Age (LIA), a period which is believed to have commenced at *ca.* AD 1400 (Russell and Johnson, 2007). Another wet phase is inferred to have occurred at cal. AD 1485–1650, and it was succeeded by a transitional wet-dry phase. This phenomenon altered the cycle of climatic events which had begun since *ca.* 1,000 yr BP. The reconstructed vegetation during that time was dominated by grasses (22.2%), secondary forests (17.1%) and cultivars and herbaceous plants (15.9%).

It is likely that among the Poaceae pollen was *Sorghum bicolor*. It was during this period that the grains of *Sorghum bicolor* (Guinea corn) appeared in the archaeobotanical records. *Sorghum bicolor*, in comparison to *Pennisetum glaucum* requires higher amount of water hence its occur-

rence may be a cultural response by the people to the inferred wet phase. This data clearly indicated strong human impact on the environment, and their activities may have contributed significantly to the climate change beginning from that period. In fact, the several flooding events and prolonged dry seasons noted in the middle Benue Valley landscape particularly settlements located around the Rivers Makurdi and Katsina Ala areas might not be unconnected to anthropogenic impact. It appears quite interesting that the fairly high amount of riverine forest elements in periods inferred to have been dry indicated that the inhabitants adopted the strategy of exploiting these plants. They would have been collected from swamps and wetlands along the Katsina Ala River and its tributaries and brought back to the rock shelter. Conversely, during periods inferred to have been wet, the lack of any major change in the riverine forests indicates they may not have constituted the best and most rewarding areas from where plants would have been actively sourced.

CONCLUSION

A reconstruction of the vegetation history of Tse Dura, a Later Stone Age archaeological site in north-central Nigeria, using pollen and spores was carried out. The reconstruction revealed that the site experienced alternating vegetation changes almost throughout. These changes were also accompanied by cultural changes. The first period began *ca.* 933 ± 29 BP (cal AD 1161), was initially dominated by Guinea savanna and characterised by dry conditions although secondary forest existed. Managed plants (*Dioscorea* spp. and *Pennisetum glaucum*), *Elaeis guineensis* and wild species (*Pavetta crassipes*, *Sarcocaphealus latifolius* and *Lophira cf. lanceolata*) were exploited. The inhabitants also engaged in the production of pottery, iron and microliths, the latter were used in hunting game. There were favourable conditions shortly after 802 ± 29 BP (cal AD 1274). Riverine and drier forests flourished; however, human impact on the environment was most significant. Humid conditions continued until AD 1485–1650 when the environment became very wet after which it was succeeded by a drier period until it reached its current status.

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