Persistence of Middle Stone Age technology to the Pleistocene/Holocene transition supports a complex hominin evolutionary scenario in West Africa

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Abstract:

The evolutionary origins of *Homo sapiens* and associated behavioural changes are increasingly seen as complex processes, involving multiple regions of Africa. In West Africa, Terminal Pleistocene/Holocene aged human fossils, demonstrating the late continuity of archaic morphological features in the region have been linked to models of surprisingly recent admixture processes between late archaic hominins and *H. sapiens*. However, the limited chronological resolution of the archaeological record has prevented evaluation of how these biological records relate to patterns of behaviour. Here, we report the first dated Stone Age site in northern Senegal which features the youngest Middle Stone Age (MSA) technology yet documented in Africa. Ndiayène Pendao features classic MSA core axes, basally thinned flakes, Levallois points and denticulates made from chert, limestone and quartzite, which allow association with several, larger surface sites in the vicinity. From this, it is postulated that populations using anachronistic technologies in the Lower Senegal Valley ~11,600 years ago were widespread, in sharp contrast to other areas of Senegal and West Africa. The chronology and technology of Ndiayène Pendao provides the first cultural evidence to support a complex evolutionary history in West Africa. This is consistent with an overall persistently high degree of Pleistocene population substructure in Africa and the spatially and temporally diffuse emergence of behavioural and biological modernity.

Keywords: West Africa; Middle Stone Age archaeology; lithic technology; Pleistocene-Holocene transition; human evolution

1. Introduction

Evolutionary and palaeoenvironmental processes in the West African Pleistocene are currently extremely poorly understood, limiting assessments of the pan-African demographic complexity now invoked in models of the origin of *Homo sapiens*

(Gunz et al., 2009; Veeramah and Hammer, 2014). This notwithstanding, genetic patterns consistent with late *H. sapiens* and African archaic admixture in West Africa and the regional persistence of 'archaic' morphological features into the Holocene, indicate that the transition to 'anatomical modernity' was complex and long-lasting in West Africa (Hammer et al., 2011; Harvati et al., 2011; Mendez et al., 2013).

The potential for material culture to shed light on these emerging patterns of biological persistence, admixture and turnover in West African populations is significant. Material culture is a product of learned traditions as well as other factors (e.g. environmental constraints) and therefore subject to selective processes affected by the structure and evolutionary dynamics of the population producing it. However, little is known about the Pleistocene archaeology of West Africa. In view of this, a new programme of fieldwork was initiated to map patterns of cultural variability in the Senegal region of West Africa, commencing with the Lower Senegal region (Scerri et al., 2016). The Lower Senegal River straddles the boundary between the present-day xeric Sahelian savannah to the north and more wooded western Sudanian savannah to the south and links the arid northwest African coast to the tropical forest interior. Variability in precipitation during the Late Pleistocene appears to have been limited in this region (see Scerri et al., 2016), suggesting that the Senegal River presented an area of enduring habitability in the arid North. Early research in the Lower Senegal Valley established a relative framework of geomorphological activity as well as the presence of Middle Stone Age (MSA) sites in the Late Upper Pleistocene (Michel 1976). Here, we report the results of archaeological, geomorphological and chronometric analyses from Ndiayene Pendao, the first directly dated Pleistocene archaeological site in the Lower Senegal Valley

2. Ndiayène Pendao

The Ndiayène Pendao quarry (N16° 29' 03.6", W15° 02' 54.4") is located near Saint-Louis, northern Senegal, and is situated 10km south of the modern course of the Senegal River, which forms the border with Mauritania (Figure 1). The site is located within the *Ferlo*, the low-relief Neogene sandstone plateau (>10 above mean sea level), not far from the *Walo*, which comprises the modern alluvial plains (<10 m above mean sea level). Along much of the lower course of the Senegal River, the interface between the *Walo* and the *Ferlo* is punctuated by the exposure of ferricretes from overlying sand sheet and dunes. The diversity of ferricrete deposits indicate both an *in situ* weathering profile and dismantling of the iron crust (Michel, 1976; Scerri et al. 2016). Recent quarrying activities have exposed the upper facies of these dismantling iron crust deposits, which are repeatedly associated with the presence of MSA archaeological assemblages (Scerri et al., 2016). Ndiayène Pendao is typical of exposed sequences at the *Walo-Ferlo* interface, including spatial variability in sediment profiles at a landscape scale. Within the lowermost topographic positions observed, indurated ferricrete deposits displaying bleaching zones were exposed, clearly indicating the local weathering of underlying sandstone bedrock. However, the majority of ferricrete deposits observed occur as dismantled iron crust nodules, up to 0.5 m thick, overlying *in situ* pseudo-conglomerate facies (Figure 1).

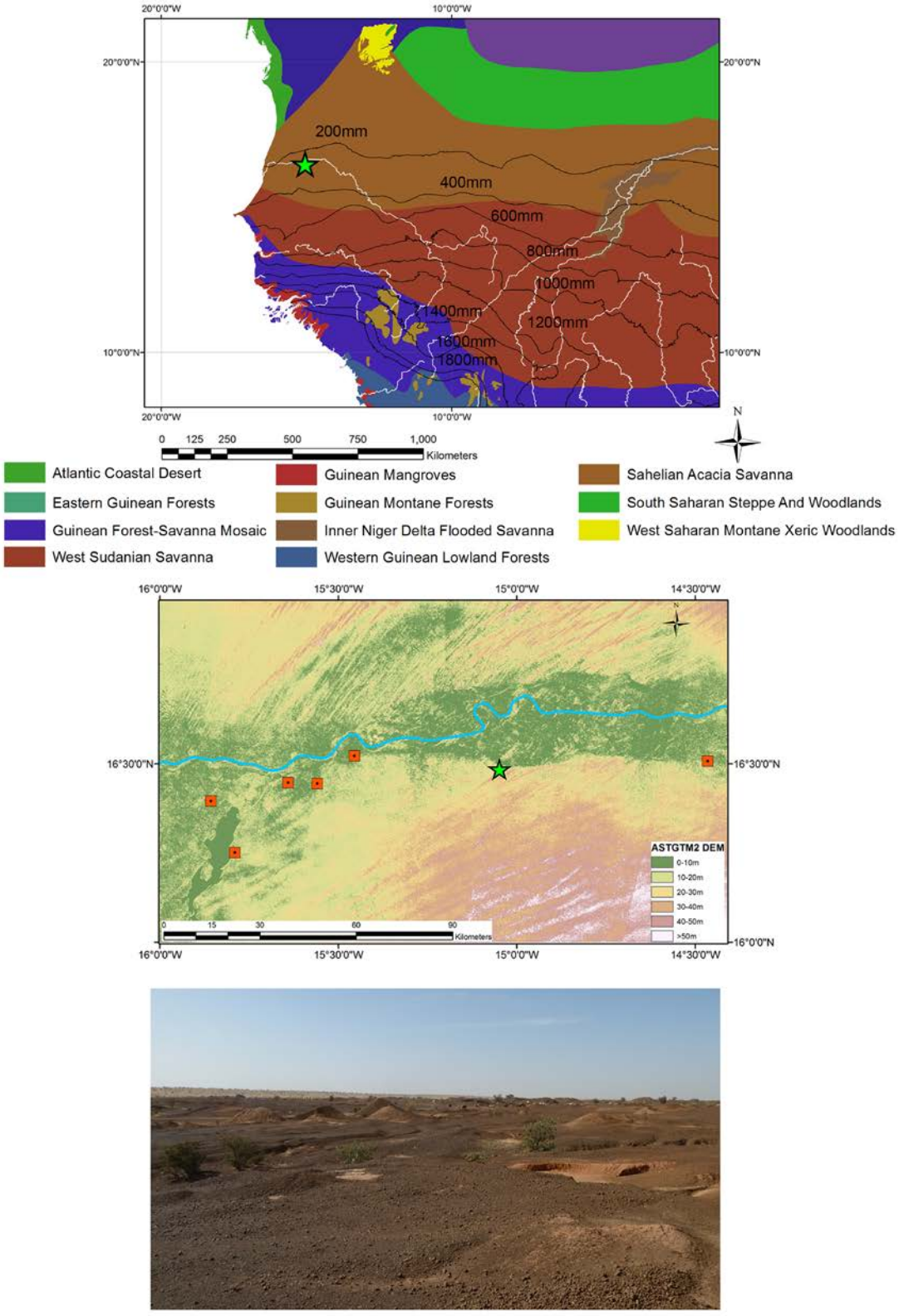

Figure 1: Top: Digital elevation map showing the position of Ndiayène Pendao (green star) and other MSA sites (red squares) in the Lower Senegal Valley; Middle: the position of Ndiayène Pendao in West Africa, showing modern isohyets and WWF ecozones (following Olson et al. 2001)); Bottom: landscape view of Ndiayène Pendao showing gently sloping surface of dismantled iron crust nodule horizon punctuated with quarry pits and spoil (bottom).

Through systematic survey of exposed sediment sections and quarry spoil, spatially restricted concentrations of lithic artefacts were identified. Survey across the rest of the quarry revealed no further artefacts and local workers maintained that only discrete concentrations of chert pieces occurred. Shallow excavations (ca. 0.5m depth) were conducted at Ndiayène Pendao, targeting three concentrations of stone tool find spots. The common sediment profile at the excavation sites comprised: (a) a pseudoconglomeratic nodular facies, with decreasing nodular bridging upwards in the sediment profile; overlain by (b) a purple-brown pseudo-pisolitic deposit of indurated ferricrete nodules with concentric rinds, which are the dismantled product of underlying ferricretes, with a thin upper horizon of small nodules (<5mm) overlying a thicker deposit of coarser nodules (<10mm); capped with (c) friable aeolian sand deposits.

In all cases, excavations located lithic artefacts within the upper levels (0.05-0.3m) of the pisolitic deposits, and no evidence for archaeological finds deflated on top of the iron crust surface were observed across the landscape, indicating that all artefacts recovered share a common stratigraphic provenance. All lithic artefacts recovered through excavation were significantly larger than the ferricrete nodules, most appearing in fresh condition, with no indication of significant weathering or rolling. The absence of distinct or mixed fluvial facies within the dismantled iron crust deposits suggests that fluvial activity is not responsible for their mobilisation across the landscape. Instead, the mobilisation of ferricrete nodules may have resulted from sheetwash across the iron crust deposits. In light of the highly limited topographic relief, it is likely that this sheetwash would have occurred at relatively low energy. The local instability of dismantling iron crust deposits is likely to have occurred during periods of heightened climatic flux in which sand sheet or dune cover was unable to stabilise on the surface and highly seasonal precipitation enabled limited mobilisation of nodular deposits. As a result, the inclusion of fresh lithic artefacts within the dismantled iron crust deposits appears best explained by localised creep of ferricerete nodules.

3. Lithic Technology

166 lithic artefacts were collected, mostly from spoil heaps by the edges of shallow hand-dug quarry pits. Excavation in three test trenches extending quarry pits at these locations led to the discovery of 32 buried lithic artefacts (Table S1). The artefacts are mostly made from chert, sometimes grading into limestone. The source of the raw material was not found, however the typically small size of the artefacts and the presence of rounded cortex suggests that good quality chert river cobbles were being sourced for flaking.

The surface and buried lithics are technologically and typologically indistinguishable and display a MSA (typically ~300-30ka, see McBrearty and Brooks, 2000) technological structure. Technologically, Ndiayène Pendao features Levallois reduction methods (Figure 2., d-e, Figure 3), alongside the production of simple blades from single and multiplatform cores. Levallois methods appear to be employed on chert for the production of points (unidirectional convergent methods)

and flakes (centripetal preferential). Levallois products feature finely faceted platforms (average of seven facets), all also featuring abrasion between the platform and the dorsal surface of the flake/point. Non-Levallois chert flakes were on average more laminar, with plain platforms and typically unidirectional scar patterns. A few large limestone and quartzite flakes also form part of the assemblage. These large flakes have all been subsequently used as cores. Together with the small average size of cores, these 'flaked flakes' indicate a high degree of flaking intensity. The presence of flake debitage, core management flakes (e.g., débordant flakes, core tablets) and a hammerstone indicates that flaking took place on site or nearby. The small number of unbroken Levallois products (n=2) suggests that these artefacts were taken away from the site.

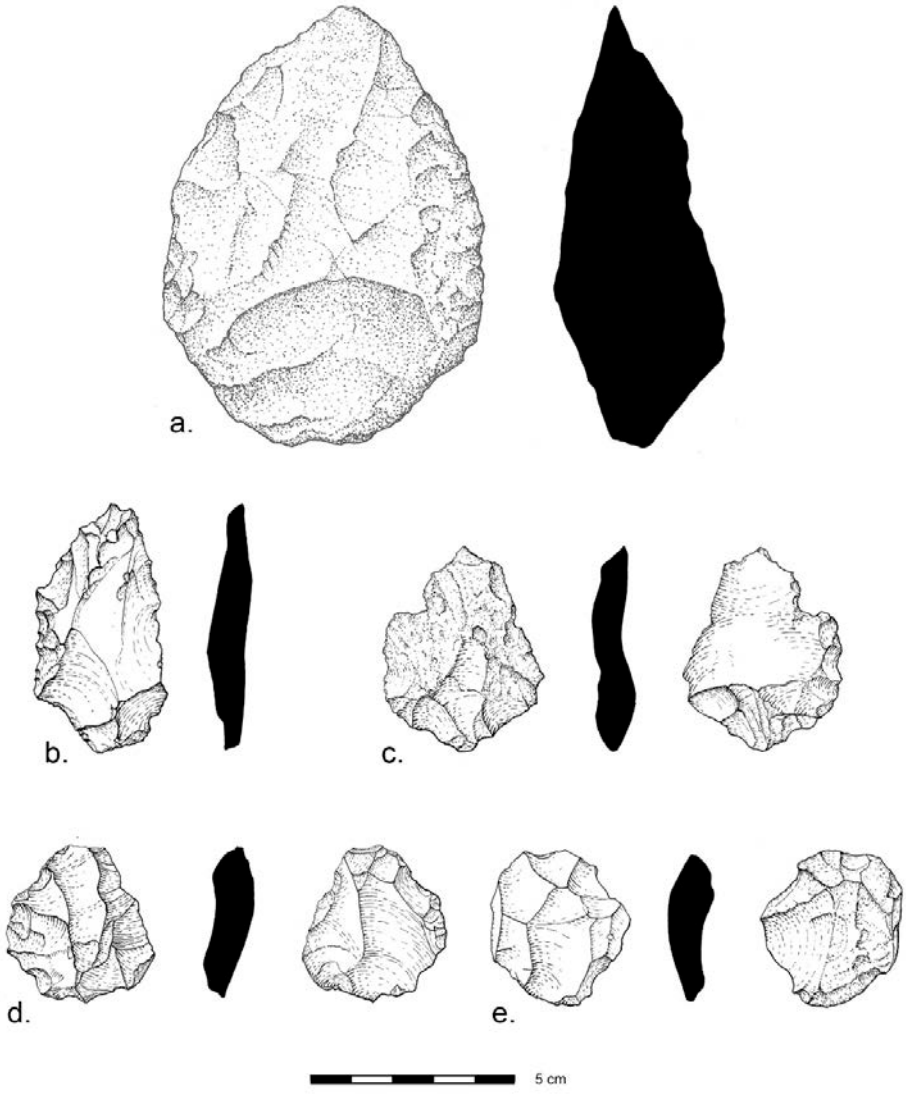

Figure 2: a. Core axe; b. Denticulate; c. Basally thinned flake; d-e. Levallois cores.

Retouch was either regular or denticulated, and bases were sometimes modified through bifacial thinning (Figure 2, b, c). Two core axe was also discovered (Figure 2,

a), together with a thick bifacial thinning flake made out of the same chert-limestone material. The assemblage was indistinguishable to other surface assemblages collected in Northern Senegal during the same field season (Scerri et al., 2016).

Figure 3: Left: denticulated Levallois flake found buried in Trench 3; Right: Recurrent centripetal Levallois core found buried in Trench 2.

4. Chronology

Optically stimulated luminescence (OSL) samples were recovered from the excavated sequence and measured standard procedures (See SI for details). Shfd15009 was sampled from the sand sheet overlying dismantled iron crust horizons and was not associated with any artefacts. Shfd15010 and Shfd15011 were both sampled from Trench 3 (Figure 4). Shfd15011 was sampled at the interface between a thin (0.08 m) layer of fine iron crust nodules (<5 mm) underlying the recent sand sheet and a thicker unit (>0.2 m) comprising iron crust nodules ranging between 5 and 10 mm and was in direct association with fresh, broken artefacts. Shfd15010 was sampled from the middle of the lower dismantled iron crust deposit and also associated with a number of complete, fresh artefacts. Heavy cementation of underlying deposits prevented recovery of further samples to offer a lower chronological bracket.

OSL measurement at the single aliquot level was applied to coarse quartz grains extracted from the three samples (Table 1). Dose rates are based on elemental concentrates determined by inductively coupled plasma - mass spectrometry and atomic emission spectroscopy (ICP-MS, ICPAES) both from sampled sediments and adjacent sediment which would have contributed dose. The data shows that all samples were reset prior to burial (See SI and figures and tables therein). The sand sheet covering at the site has an age pf 1.34±0.06 ka (Shfd15009), suggesting recent mobility of sand sheet deposits in the region. Shfd15011 returned an age of 22.7±1.2 ka and Shfd15010 returned and age of 11.63±0.51 ka (Shfd15010). The apparent stratigraphic inversion of these dates is explained by the occurrence of sample Shfd15011 at the interface between the two iron crust nodule deposits and within close proximity to the surface. This may have complicated the sample dose rate

history during weathering of the iron crust nodules. This age therefore may not be reliable. We interpret the results from Shfd15010 as being consistent with the burial of lithic artefacts around the Pleistocene/Holocene transition, at ~11.6ka, supported by the relatively fresh condition of the artefacts associated with this sample. The identification of limited sediment flux in the Lower Senegal Valley during the MIS 2/1 transition corroborates the tentative chronology of geomorphological evolution proposed by Michel (1976).

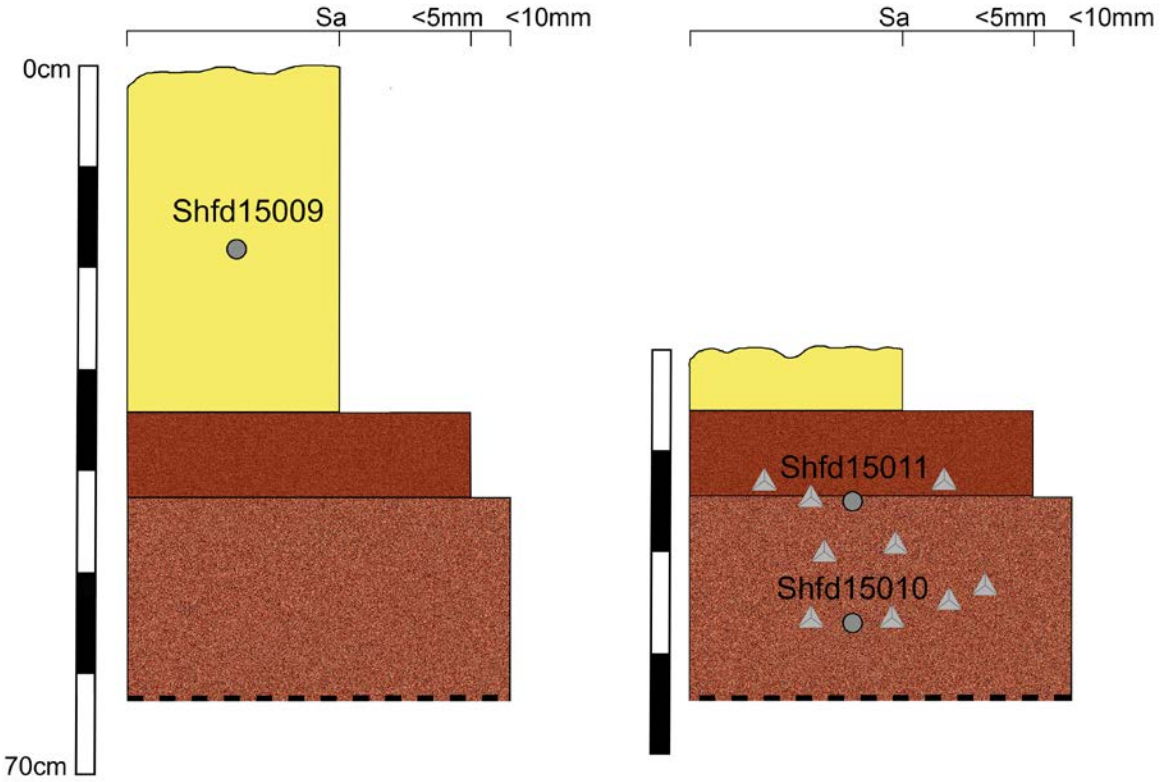

Figure 4: Stratigraphic log showing positions of the OSL samples Shfd5009, Shfd15010 and Shfd15011. The latter two samples were recovered from dismantled iron crust nodules directly associated with MSA artefacts.

Lab Code	Field Ref	Depth (cm)	De (Gy)	OD (%) [a]	Dose rate (µGy/a^{-1})	Age (ka)
Shfd15009	OSL 1	75	1.47 ± 0.04	17	1093 ± 36	1.33 ± 0.06
Shfd15010	OSL 5	28	30.11± 0.39	45	2590 ± 108	11.63 ± 0.51
Shfd15011	OSL 6	15	57.77 ± 1.68	23	2544 ± 105	22.72 ± 1.2[b]

Table 1: Summary of OSL results. [a] Overdispersion of De replicate data. [b] reliability questioned see text

5. Discussion

The MSA character of the assemblage from Ndiayène Pendao in the context of the Pleistocene/Holocene transition indicates the late persistence of technology long

replaced in every other studied region of Africa. The young timeframe for artefact deposition fits neatly with broader schemes of geomorphological evolution throughout the Senegal Valley. The dates also give the first benchmark for Pleistocene sediment sequences in the Lower Senegal Valley and constrain similar assemblages found elsewhere in similar stratigraphic contexts in the region.

Our findings demonstrate that the archaeological record from the Lower Senegal Valley mirrors the biological record, which supports a complex population structure in West Africa. The Iwo Eleru calvaria (Harvati et al., 2011; Stojanowski, 2013), which is the only known West African human fossil contemporary to Ndiayène Pendao, preserves archaic features and demonstrates a distinct lack of similarities with contemporary Saharan, and indeed any other African populations at the Pleistocene/Holocene transition. The presence of such archaic features supports genetic models suggesting unexpectedly late admixture between *Homo sapiens* and archaic hominins at ~35ka in the region (Hammer et al., 2011; Mendez et al., 2013). These data have been argued to demonstrate a strong degree of population subdivision, in which West African groups may have remained relatively isolated from others living elsewhere in Africa (Stojanowski, 2013).

While the mechanisms of this apparent population isolation are currently unclear, the Senegal and Gambia fluvial systems are notably the westernmost and most remote river basins in Africa. Of the West African fluvial networks, only the Senegal and the Niger reach the arid edges of the Sahara. Furthermore, unlike northeast Africa, where the Nile links the length of the Sahara with East and Central Africa, the West African systems run longitudinally in ecozones that are largely forested and tropical. At the onset of the African Humid Period, it is likely that Ndiayène Pendao was well within a forested ecozone. Further investigation of the extent to which these ecological and geographic circumstances structured the biological and cultural records of West Africa at the Pleistocene/Holocene transition is therefore likely to be instructive. This notwithstanding, the unexpectedly late persistence of both MSA technology and Late Pleistocene morphology in the same region is remarkable and, parsimoniously, unlikely to reflect entirely separate processes.

In this paper, we have shown for the first time that biological and cultural records in West Africa during the Pleistocene-Holocene transition are complementary, adding to a growing body of evidence demonstrating that Africa was until recently, more culturally and biologically diverse than has typically been considered. Differences in the tempo of innovation and cultural change in West Africa, compared with the rest of the African continent at this time, in particular demonstrate the depth and complexity of population structure in this region. More broadly, the evidence affirms that the documentation of evolutionary and cultural processes across all regions of Africa, many of which remain very poorly understood, is critical for unravelling human origins.

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