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Urban Herders: An Archaeological and Isotopic Investigation into the Roles of Mobility and Subsistence Specialization in an Iron Age Urban Center in Mali

Abigail Chipps Stone

Washington University in St. Louis

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WASHINGTON UNIVERSITY IN ST. LOUIS

Department of Anthropology

Dissertation Examination Committee:

Fiona Brigid Marshall, Chair

Stanley Ambrose

Michael Frachetti

Gayle Fritz

T.R. Kidder

Robert Lamberton

Xinyi Liu

Susan Keech McIntosh

Urban Herders: An Archaeological and Isotopic Investigation into the Roles of Mobility and
Subsistence Specialization in an Iron Age Urban Center in Mali

by

Abigail Chipps Stone

A dissertation presented to the
Graduate School of Arts & Sciences
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

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List of Abbreviations

I occasionally use the following abbreviations for site names and places in the figures and tables in this text:

Dj Djenné (archaeological context)

HAMB Hambarketolo

IND Inland Niger Delta

J-j Jenné-jeno

JJSC Jenné-jeno Settlement Complex

KAN Kania

TaS Tato à Sanouna

Th Thièl

TBZ2 Tombouze 2

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ABSTRACT OF THE DISSERTATION

Urban Herders: An Archaeological and Isotopic Investigation into the Roles of Mobility and

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Professor Fiona B. Marshall, Chair

This dissertation investigates the relationship between mobility and urbanism in an Iron Age West African city. Isotopic and archaeological evidence reveal complex relationships among mobility, sedentism, and the livestock economy of Jenné-jeno, one of the earliest and best known urban systems in sub-Saharan Africa (occupied ca. 250 BC to AD 1400). Drawing on excavations at the ancient city of Jenné-jeno and those conducted at two neighboring sites (Tato à Sanouna and Thièl), and on serial, intra-tooth isotopic analysis ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{13}\text{C}$, $\delta^{18}\text{O}$) of cattle, sheep, and goat teeth, this analysis shows that multiple populations involved in animal husbandry, from seasonally mobile pastoral specialists to household-level producers, coexisted at Jenné-jeno. These findings provide the first concrete evidence of the nature of the livestock economy at Jenné-jeno. Furthermore, the importance of small-scale animal husbandry within the subsistence economy challenges prior assumptions of specialized subsistence economies at Jenné-jeno. While the excavations and the human and animal isotopic data presented here reinforce the importance of Jenné-jeno within the broader region as a market and population center, they also run counter to expectations that agricultural intensification and specialized

subsistence economies are necessary for the sustenance of a dense urban population. In a relatively lush environment like that around Jenné-jeno, diversified, small-scale producers were able to meet the needs of the local population through a variety of strategies. In a context like Jenné-jeno, mobility (in the form of local and extralocal herd movements and trade routes), far from being anathema to urbanism, was in fact crucial to the maintenance of the urban system. This work builds upon previous studies demonstrating that analysis of food production strategies, small-scale interactions, and the role of mobility in urban settings can have profound implications for global discussions of urbanism and urban development.

Chapter 1 – Introduction

Studies of the development of complex societies world-wide have focused on social and economic organization in urban centers and on the genesis of inequality. Traditional indicators of urbanism include social stratification, centralized authority, and craft and subsistence specialization (Childe 1950; Zeder 1991). In recent years, however, scholars have introduced concepts like heterarchy and non-uniform complexity to better understand the diverse development and organization of complex societies (Crumley 1987; Ehrenreich, et al. 1995; Frachetti 2009). In Africa, monumental contexts like Predynastic and early Dynastic Egypt and ancient Aksum largely match traditional models of urbanism, whereas others like the sites of Great Zimbabwe and Jenné-jeno offer insights into quite different forms of ancient Africa complex societies.

The site of Jenné-jeno is a large anthropogenic mound rising above the floodplains of Mali's Inland Niger Delta. The site is large at 33 hectares, with an additional 66 hectares of occupied space within one kilometer in the surrounding mound cluster. With over six meters of stratified cultural deposits spanning its original occupation at 250 BC through its abandonment at AD 1400, Jenné-jeno was clearly a center of population aggregation in the area. Despite its size, densely packed population, and the extensive local and regional trade connections attested to in its archaeological record, Jenné-jeno lacks many of the traditional hallmarks of urbanism, at least in any archaeologically-visible form. Other than a city wall constructed around AD 900, the site lacks monumental architecture and other signs of centralized political control. Furthermore, the relatively consistent size and form of buildings and the absence of grave goods in most burials suggests a low level of social stratification (McIntosh 1995a:1-26; 1999a:73-77).

Along with craft and subsistence specialization, social stratification and centralized authority are considered fundamental tenets of urbanism (Childe 1950; Zeder 1991). The apparent absence of these latter two factors at Jenné-jeno led archaeologists to hypothesize that power at Jenné-jeno was distributed in a more heterarchical fashion, possibly across disparate groups of subsistence specialists, craft guilds, founding lineages, and religious factions (McIntosh 1998, 2005; McIntosh 1999a; McIntosh and McIntosh 1993). Dispersal of power amongst these groups would prevent the rise of a powerful elite population, thereby negating the need for aggrandizing monumental architecture and limiting the potential for social stratification.

This non-hierarchical urban system still faced the problem of feeding a large population within a limited space. In traditional narratives of urban systems, agricultural intensification and specialized production are considered vital to sustaining a large urban population. At Jenné-jeno, although domestic African rice (*Oryza glaberrima*) and livestock (cattle, sheep, and goats) are known from the earliest levels, there are no signs of large-scale irrigation projects or any other evidence for agricultural intensification. Instead, scholars argue that in a heterogeneous, but relatively fertile environment, specialized subsistence producers were key to producing enough surplus food to maintain the urban population (McIntosh 1998:166; 2005:52; McIntosh 1999a:73-74).

This proposition rests partially on the fact that subsistence specialization is crucial to modern populations in the area. Throughout the Inland Niger Delta, and particularly around Djenné, the highly variable ecology enables numerous economically specialized ethnic groups to thrive within a relatively small area (Gallais 1967b). In Djenné, Bambara millet farmers, Marka rice farmers, Bozo floodplain fishers, Somono open-water fishers, and seasonally-present Fulani pastoralists have forged an intricate, interdependent society where ethnicity is strongly tied to

economic specialization (Gallais 1967b, 1984; Monteil 1971 [1932]; N'Diaye 1970; Sundström 1972). Various merchant guilds, religious groups, and artisan castes loosely associated with the larger ethnic groups add to this complexity (LaViolette 1987, 2000). With these modern populations as a compelling analogy, subsistence specialization seemed to be both a logical response to the area's environmental heterogeneity and a solution to the question of how Jenné-jeno's dense population sustained itself.

This model of heterarchy at Jenné-jeno is highly influential within Africanist archaeology and history circles and impacts discussions of the diversity of early urban forms more broadly. Despite its plausibility, however, specialization has not been conclusively identified in the archaeological record of Jenné-jeno or its surrounding sites. This situation raises several major questions including 1) Was specialized subsistence production responsible for sustaining Jenné-jeno's population from the earliest levels on? 2) How did interactions among disparate elements in this urban system (sites of various scales; human constituents, specialized or not) function in the apparent absence of centralized political control? And 3) In light of the increasing evidence for a diversity of urban configurations, what exactly is urbanism?

In regards to the question of interaction, I was particularly interested from the outset of this project in the relationship between various mobile and sedentary populations in the area. Although remains of domestic livestock are found in the archaeological record of sub-Saharan Africa from at least 5500 BP (MacDonald and MacDonald 2000; Marshall 2000; Smith 2005), mobile pastoralism remains the big unknown in West African archaeology (MacDonald 1999). Specialized mobile pastoralists are a critical element of modern subsistence in Mali and have

powerful influence on modern African urban economies and politics¹ (Azarya 2001). Their presence is also postulated in many West African archaeological contexts, including Jenné-jeno.

Archaeologists and historians have debated the relationship between mobile and sedentary populations since at least the 14th century AD when Ibn Khaldun discussed the disparate subsistence systems, psychologies, and ideologies of mobile and sedentary communities and the consequent cycle of conflict, warfare, and conquest (cited from Kuznar and Sedlmayer 2008:559). This narrative of inherent incompatibility has affected discussions of mobile-sedentary interactions ever since. With this discourse in mind, I was particularly interested in how mobile-sedentary interactions might differ in a non-hierarchical urban system and whether these relations could in fact help to explain the unique urban configurations of Jenné-jeno.

1.1 Project Orientation and Objectives

I report here on archaeological investigations at Tato à Sanouna and Thièl, two smaller, outlying sites within the broader landscape surrounding Jenné-jeno. A team of Malian colleagues and I excavated these sites between November of 2010 and March of 2011. I followed this fieldwork with extensive isotopic analysis of archaeological human, cattle, sheep, and goat teeth, conducted between January 2012 and May 2013 at the University of Illinois at Urbana-Champaign. This research was designed to answer questions about the emergence and nature of urbanism in sub-Saharan West Africa and the relationship between these new presumably sedentary communities and various mobile herding populations in the area.

¹ In fact, an uprising by nomadic Tuareg populations in northern Mali in 2011 helped precipitate the country's present political problems.

Questions that I asked include: Were mobile herds present in the IND before the arrival of Fulani groups in the 12th to 15th centuries CE, and if present, were these herds part of a generalized or specialized subsistence regime? In other words, do the material assemblages at the excavated sites show any evidence for subsistence specialization during the periods of occupation? I was also interested in the degree to which mobile groups or individuals were incorporated (as shown by settlement proximity, material culture, and burial practices) into IND sedentary populations and how this varied through time. The final, and most theoretical, question I posed asked how interactions between sedentary and mobile pastoral populations influenced both urban configurations in the IND and the nature of these populations themselves.

I approached these questions through two distinct, but related projects: five months of excavation at two small, previously unexcavated sites near the Iron Age city of Jenné-jeno and extensive isotopic analysis of archaeological human, cattle, sheep, and goat teeth aimed at identifying human and herd mobility patterns. This work (outlined in the subsequent sections) allowed me to address my original research questions and to move beyond them towards interrogations of the role of mobility (rather than just mobile groups *per se*) in an urban context and how individual interactions and household-level economic practices could create an apparently non-hierarchical urban system.

1.1.1 Excavation within the Jenné-jeno Settlement Complex

Excavations targeted two small sites, Tato à Sanouna and Thièl. Both are located several kilometers beyond the densest cluster of sites around Jenné-jeno and in areas used heavily by modern mobile pastoral populations. Excavation at such smaller, outlying sites was designed to document the degree of variability within the broader urban system. Despite the importance of Jenné-jeno to archaeological and historical discussions of West Africa's past and the variability

of urban forms, very few of the several hundred mound sites clustered around Jenné-jeno had been excavated before this project and none thoroughly. Susan and Roderick McIntosh placed single units at Kaniana and Hambarketolo (McIntosh 1995a) and Mary Clark (2003) excavated surface features on 10 sites within the narrowly-defined JJSC. This project was the first excavation of sites more than one kilometer distant from Jenné-jeno or Djenné and the first thorough excavation of smaller sites within the broader urban system (see Figure 1.5). Excavations at Tato à Sanouna and Thièl were designed to compare the nature and diversity of the material culture at these sites to that at Jenné-jeno, to assess the variability and integration of the urban system, and to test for the presence of disparate populations at outlying sites.

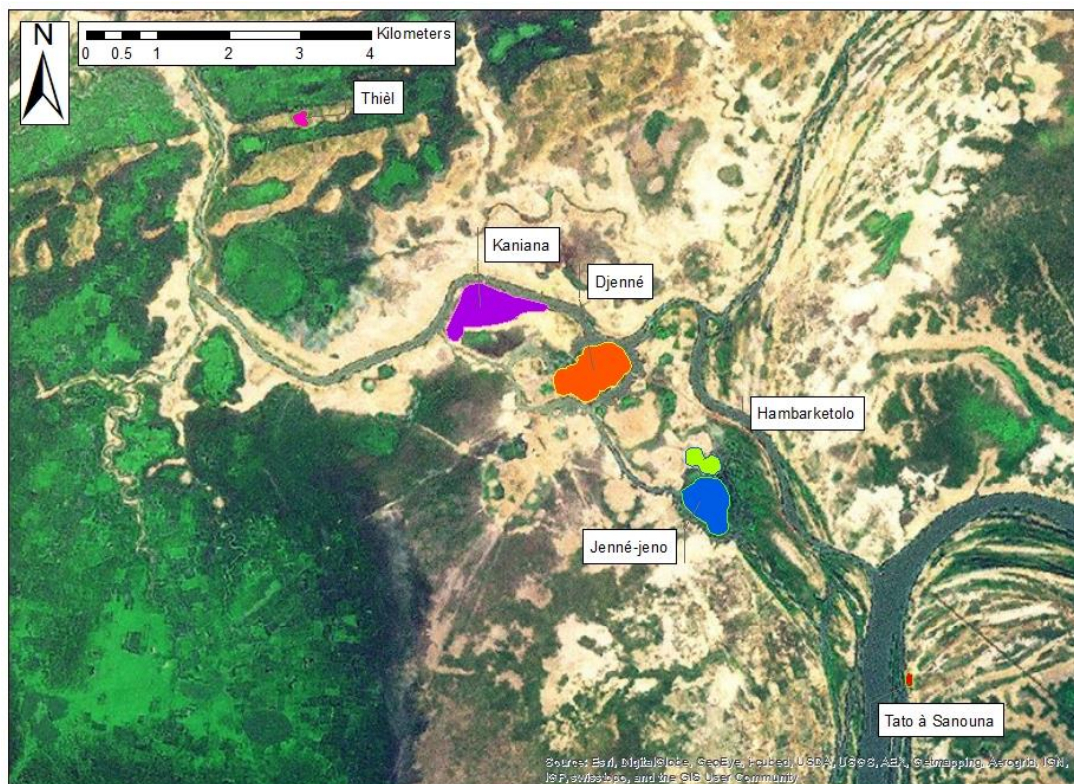


Figure 1.1 – Excavated sites mentioned in the text

By excavating archaeological sites in microenvironments used extensively by modern herders, my goal was to find sites whose populations interacted extensively with mobile pastoral

groups in the past, even if the sites themselves were not primarily occupied by herders. This interaction could have manifested itself as distinct or more diverse material culture relative to that seen at Jenné-jeno (including differing ceramics, iron objects, lithics, burial practices, or architecture), artifacts or features specifically related to animal husbandry (like terra cotta cattle figurines or enclosed animal pens), or even a greater reliance on herd animals in diet, as opposed to fish or other wild species. No distinctly pastoralist ceramic assemblage is known for this area, either archaeologically or contemporarily, which complicated this analysis.

From its conception, the project had a specific emphasis on understanding past subsistence regimes, including identifying differences across time and space. The project design and recovery methods reflect this focus. Excavation explicitly targeted contexts like hearths and middens likely to produce faunal and botanical remains and all soil was either floated or fine screened. Comparison to prior excavations was somewhat difficult due to divergent recovery methods, but the project provided a detailed examination of subsistence through time at Tato à Sanouna and Thièl.

A final consideration for the excavation phase was the question of subsistence specialization. Specialization is a central concern for archaeologists working in and around the IND (Bedaux, et al. 1978a; Clark 2003; K. C. MacDonald and W. Van Neer 1994; Mayor 2010), and underpins several central theories about how urbanism operated at Jenné-jeno (McIntosh 1998, 2005; McIntosh 1999a). One enduring question is whether specialization can be identified through inter-site analysis within the broader urban area; if specialization was a salient socio-political force, would it result in divergent residential patterns that are discernable archaeologically?

1.1.2 Isotopic analysis of enamel apatite from human and cattle, sheep, and goat teeth

The second phase of the project, isotopic analysis of enamel apatite from human, cattle, sheep, and goat teeth, was designed to investigate the mobility patterns of the inhabitants of Jenné-jeno and surrounding sites and the animals they consumed. The theory and justification of isotopic analysis is discussed in greater detail in Chapter 4. Very briefly, the project looked at $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and $^{87}\text{Sr}/^{86}\text{Sr}$, which have implications for both diet and mobility in human and bovid populations. Although archaeologists have used isotopic analysis of archaeological materials for over three decades, this project was the first to employ strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) in Mali and one of only a handful of studies employing any type of isotopic analysis in all of West Africa (but see Finucane, et al. 2008; Sereno, et al. 2008; Zeitoun, et al. 2005).

Cattle, sheep, and goat molars were sampled multiple times down the length of the tooth. Such serial, intra-tooth sampling captures isotopic signatures incorporated into tooth enamel over an extended period of time, generally a year to a year and a half, depending on tooth and species. This sampling strategy allowed for discussion of seasonal shifts in diet and mobility. Relatively sizable faunal assemblages from Jenné-jeno and Djenné, analyzed by Kevin MacDonald and Chester Cain respectively, were available for sampling. Excavations at Tato à Sanouna and Thièl also supplied intact bovid teeth for the analysis.

Although no prior analyses of $^{87}\text{Sr}/^{86}\text{Sr}$ existed in Mali, underlying geology suggested that the IND and the area immediately surrounding it, particularly the plateau east and southeast of Djenné where many modern Fulani groups have wet season pasture, would have distinct $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (Makaske 1998). Modern IND pastoral groups typically spend the wet season (July through December) dispersed beyond the IND and the dry season (December through June) near permanent water in the IND (Gallais 1967a, 1975; Imperato 1972) (see Figure 1.6). These

migrations range from 40 to 500 km (Turner and Niamir-Fuller 1999). It seemed likely that past herders followed roughly similar patterns of mobility given the area's relatively stable ecological conditions and the nutritional needs of their herds. If this was true, archaeological bovid teeth from mobile herds should have distinct isotopic signatures reflecting this mobility. After creation of a baseline of $^{87}\text{Sr}/^{86}\text{Sr}$ variability for the region using archaeological small mammal teeth, the $^{87}\text{Sr}/^{86}\text{Sr}$ signatures found in herd animal teeth from different phases at the different sites would show whether the animals consumed at these sites were seasonally mobile or remained in the IND year-round and whether this changed through time.

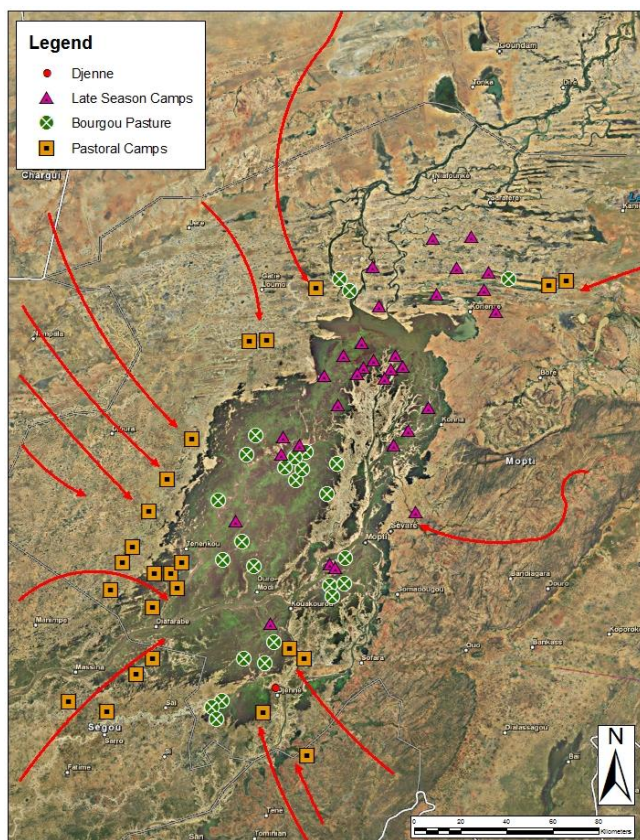


Figure 1.2 – Seasonal migrations into the IND of modern mobile pastoral groups. Imagery from ArcGIS World Imagery

I also proposed an isotopic analysis of human teeth from burials at the sites to augment discussions of herd mobility by providing a general idea of the mobility of the human population.

It was by no means guaranteed that the individuals tested had been active in pastoral migrations. Nevertheless, this information provides the first direct test of the lifetime mobility of IND residents. If mobile individuals were found buried at the sites this would suggest a degree of incorporation of mobile individuals into the sedentary populations, potentially leading to interesting insights into specialization and identity among the human populations.

The results of the excavations and isotopic analysis conducted for this project allowed me to both answer and deconstruct the assumptions inherent in the questions I originally proposed.

1.2 Dissertation Organization

This dissertation comprises three stand-alone articles intended for publication and a more discursive discussion that draws out the major points from all three articles and unites them in a discussion of the broader impact of this research.

Chapter 2 provides an overview of the theoretical orientation of the dissertation and a brief discussion of the geography and archaeology of Mali's Inland Niger Delta.

Chapter 3, *Subsistence and Specialization in a West African Urban Context: Investigating the Jenné-jeno Urban System*, serves as an introduction to the archaeology of the Djenné region and a report on the results of excavations at Tato à Sanouna and Thièl. Using the data from excavation and artifact analysis, I discuss the relationship between large and small sites within the region and the question of subsistence and craft specialization in the archaeological past. This paper was written for submission to an African Archaeology Journal, *Azania*.

In Chapter 4, *Detecting Seasonal Herding Practices using $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ in Archaeological Teeth from an Urban West African Context*, I present the findings of my isotopic

analysis of cattle, sheep, and goat teeth from Tato à Sanouna, Thièl, Jenné-jeno, and archaeological contexts in Djenné. I use isotopic evidence to document the presence of herders employing various scales of mobility in and around Jenné-jeno throughout its occupation. As part of this project I present the first known baseline data of $^{87}\text{Sr}/^{86}\text{Sr}$ variability in Mali, using both modern and archaeological samples. Using this baseline, I then identify three major types of herd mobility (long-distance mobility, local mobility, and non-mobility) employed in the archaeological past. This study demonstrates that analysis of intra-tooth samples can provide nuanced data about herd mobility and herding strategies, moving beyond basic classifications of mobile versus non-mobile or local versus non-local. I argue that the analysis of multiple isotopes and multiple teeth per animal, when possible, increases our understanding of the manifold ways animals were raised and exchanged within this dense urban context. I close the chapter with brief thoughts on how this type of analysis informs our understanding of herding strategies and populations in the past and their role in densely-occupied areas. This paper is intended for submission to the *Journal of Archaeological Science*.

Chapter 5, *Feeding Jenné-jeno: How Mobility and the Livestock Economy Shaped an Emerging African Urban System*, is a more theoretical investigation of the relationship between mobility, sedentism, the livestock economy, and urban configurations in and around Jenné-jeno. In the chapter I show that multiple populations involved in animal husbandry, from seasonally mobile pastoral specialists to household-level producers, coexisted at Jenné-jeno. These findings provide the first concrete evidence of the nature of the livestock economy at Jenné-jeno. Moreover, the evidence showing the importance of small-scale animal producers within the subsistence economy challenges prior assumptions of specialized subsistence economies at Jenné-jeno. While the human and animal isotopic data reinforce the importance of Jenné-jeno

within the broader region as a market and population center, they provide further evidence of the divergence of urbanism at Jenné-jeno from traditional narratives of urban development. This work builds upon previous studies demonstrating that analysis of food production strategies, the role of mobility in urban settings, and the impact of household and small-scale producers on an urban economy can have profound implications for discussions of urbanism and urban development worldwide. The target journals for this paper are the *Journal of Anthropological Archaeology* or *Current Anthropology*.

Chapter 6, *Discussion*, brings together the information and ideas discussed in the preceding three articles. I briefly recap the data presented in the articles and how they apply to the questions of mobile pastoralism and subsistence and craft specialization within the Jenné-jeno urban system. I also provide a more detailed discussion of the project's analysis of isotopes from human teeth, including its impact on our understanding of the urban system and its methodological contributions. Following the data section, I discuss the broader implications of this research, including a reevaluation of the Jenné-jeno urban system, the nature and impact of interactions between populations characterized by various scales of mobility and sedentism, and the impact of this study on broader understandings of urban configurations.

Archaeobotany Appendix: Dr. Shawn Sabrina Murray conducted an archaeobotanical analysis of samples collected from the excavations at Tato à Sanouna and Thièl. Her report of this work is included as an appendix following the main text of this dissertation.

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Chapter 2 – Theoretical Orientation and Background

2.1 Theoretical Orientation

Due to this dissertation's organization into three distinct articles, many of its theoretical implications are discussed throughout Chapters 3, 4, and 5. Here I provide a brief summary of the major theoretical background for this dissertation, including urbanism and the diversity of urban configurations and the nature of interactions between mobile and sedentary populations.

V. Gordon Child's *The Urban Revolution* (1950) argued that urbanism was fundamentally different from other forms of human organization and established ten major traits of urban configuration: large size and dense population; presence of non-food producing classes; taxation or tithing of agricultural surplus; monumental public buildings; a ruling class; systems of recording; exact sciences (i.e., calendrical and mathematical); craft specialists and artisans; regular long-distance trade; and state organization based on residence rather than kinship. This trait list had enormous influence on succeeding generations of archaeologists. Although not all of Childe's characteristics are now considered necessary to identifying a site as urban, attributes such as centralized governance, social stratification, and specialized or centralized subsistence regimes remain central to our understanding of urbanism and the more ambiguous concept of *complexity*.

Increasingly, however, archaeologists identify contexts that diverge from the standard model, including low-density urbanism (Isendahl and Smith 2013; Peuramaki-Brown 2013; Smith 2011) and heterarchical political organization (Crumley 1987; Ehrenreich, et al. 1995; Feinman 2000; McIntosh 1991; McIntosh 1999b; Rautman 1998). These studies use local

contexts to explore the diversity of urban expressions rather than dismissing atypical examples outright.

This growing recognition of variability in urban configurations raises interesting questions about the nature of urbanism and how urban systems functioned internally and in relation to their broader landscapes. Following this trend, recent studies of urbanism have contributed nuanced analyses of issues like the drivers, mechanisms, and motivations for population aggregation (Kim 2013; Mattingly and Sterry 2013; Sindbæk 2007); how urban populations dealt with organizational concerns like food storage and dispersal (Chesson and Goodale 2014) and maintenance of a unified identity (Birch 2012; Chase, Ajithprasad, et al. 2014); how power was distributed within urban centers and their broader landscapes (Osborne 2013), and the experiences and perspectives of non-elite populations within urban systems (LaViolette and Fleisher 2005).

As I mentioned in Chapter 1, specialized subsistence production is considered vital to the sustenance of a large urban population. As population in an area increases, agricultural intensification, including specialization of subsistence regimes, is required to increase the productivity of available farmland. Although recent work deconstructs the connection between specialized craft production and urbanism (Flad and Hruby 2007), the link between subsistence specialization and urbanism is often considered so fundamental that the presence or absence of subsistence specialization is used as evidence of the nature of social organization (Twiss 2012:366).

In areas of the world where seasonal mobility is the most productive form of animal husbandry, specialized subsistence regimes lead to divergent ways of life between sedentary

farmers and other urban dwellers and the mobile herders in the more distant landscape. The nature and impact of interactions between these mobile and settled peoples have long been debated by anthropologists and historians. This grew out of theoretical discussions of the “desert versus the sown,” which generally argued that nomads and farmers were inherently in conflict (e.g., Peake and Fleure 1928:2). Many models of mobile-settled relationships still characterize mobile populations as being developmental offshoots of settled agricultural populations that are necessarily economically, politically, and culturally linked to settled peoples (Adams 1974; Bar-Yosef and Khazanov 1992; Khazanov 2001; Sadr 1991; Zeder 1991). These models are based primarily on studies from the Near East, and while they may be accurate portrayals of pastoral trajectories in specific regions, they should not be indiscriminately applied to other world areas.

Recent research has called the broader applicability of these models into question both within the Near East (Abdi 2003; Betts 2008; Rosen 2008) and in other world areas (Azarya 1996; Bernbeck 2008; Browman 2008; de Bruijn and van Dijk 2001, 2003; Frachetti 2008a, b; Gifford-Gonzalez 2005, 2010; Smith 2008:357). This work demonstrates the wide variety of forms that pastoralism can take and the correspondingly varied cultural, ecological, economic, and political interactions between mobile and settled populations. Pastoralists often play a vital role in regional trajectories, but this is often ignored or downplayed due to adherence to theoretical models that privilege settled populations.

Further work on the archaeology of pastoral groups and their interactions (or lack thereof) with sedentary populations is necessary for our fuller understanding of the nature of pastoralism and the archaeological record. The sub-Saharan African record, with its unique trajectories to food production (Marshall and Hildebrand 2002; Murray 2005b; Neumann 2005)

and urbanism (LaViolette and Fleisher 2005; McIntosh and McIntosh 1993), is an important part of this story.

2.2 Background

2.2.1 The Physical Geography and Human Landscape of the Inland Niger Delta

Although I discuss the geographic and archaeological background of the Inland Niger Delta (hereafter IND) in Chapter 3, some background is necessary here to frame the questions and motivations behind this research.

The IND is a complex riverine environment covering roughly 32,000 km² in central Mali (see Figure 2.1). Inland deltas, unique manifestations of anastomosing rivers, form when a river distributes its water over numerous roughly parallel channels that are laterally connected to form a complex aquatic network (Makaske 1998:17). These systems form vast floodplains with extensive arable and pasture land. In the IND, water, wind, and human forces have created a complex environmental mosaic of swamps, ponds, lakes, rivers, levees, dunes, and grasslands (Makaske 1998:115-128; McIntosh 2005:58).

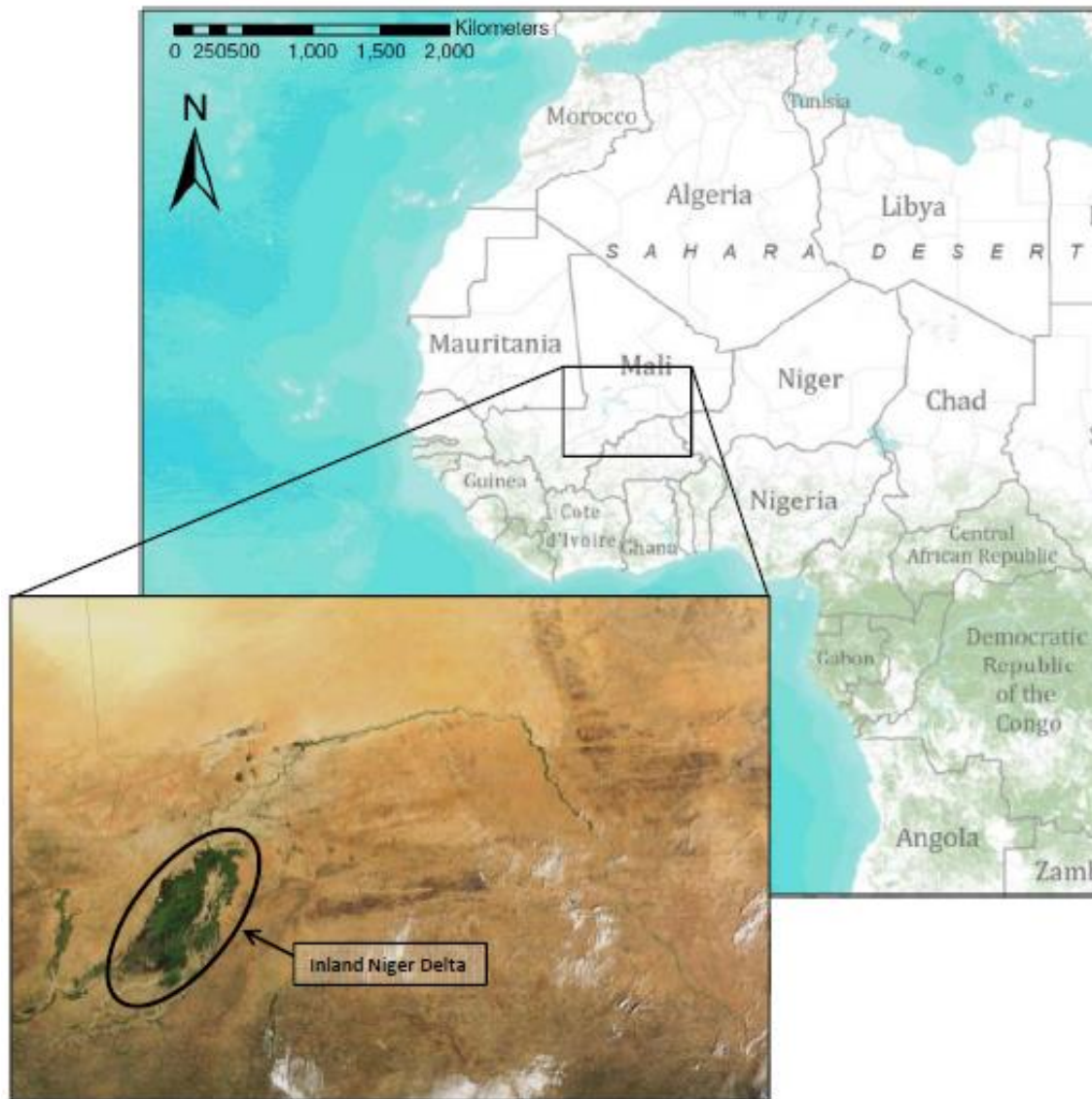


Figure 2.1 - West Africa showing enlarged view of the Niger River and Inland Niger Delta. Imagery from ArcGIS World Topographic Map and Wikipedia Commons

The human history of the IND is intimately linked to the climate, rainfall, and seasons of the region. The movements of the Intertropical Convergence Zone give Mali distinct wet and dry seasons. In the IND these seasons are compounded by the rising and falling water levels in the region's myriad rivers, lakes, seasonal channels, and marshes. Rainfall at the headwaters of the Niger and Bani Rivers and their tributaries in Guinea and the Ivory Coast gradually makes its way into the delta, resulting in high floods several months after the end of the rainy seasons (see

Figure 2.2). This gives the delta four to five distinct seasons (Gallais 1967b:73-76): 1) Rainy season: Late June through September; 2) Season of high waters (*la crue*): October through mid-December; 3) Cold season: December and January; 4) Season of receding waters (*la décrue*): Late December through March; and 5) Hot, dry season: April through early June.

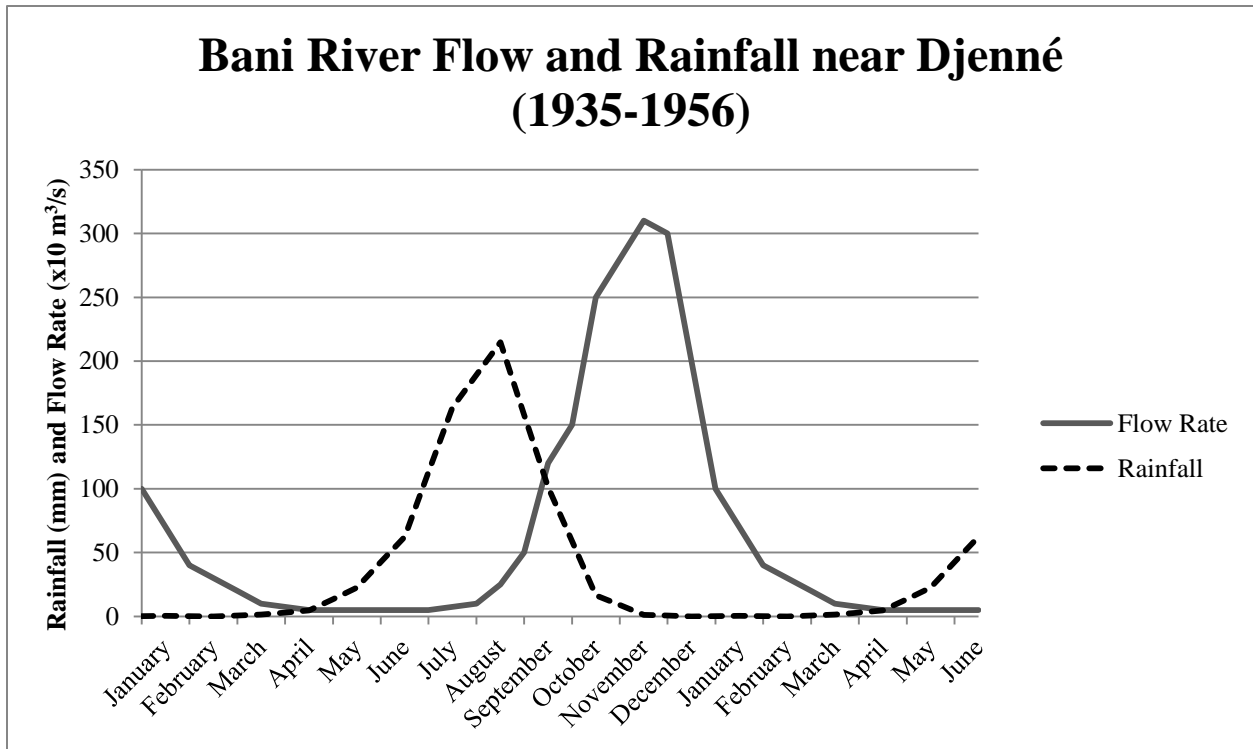


Figure 2.2 - Rainfall and water flow near Djenné. Data taken from Gallais (1967b:52-57).

The landscape heterogeneity and seasonal fluctuations that characterize the IND have made the region a highly productive and invaluable source of fish, crops, and livestock for ancient and modern peoples alike. Today, fishing and herding groups incorporate the seasonal variability into their economic strategies, using mobility (along river courses, streams, and marshes; and into and out of the IND) to maximize the yield of aquatic resources and the productivity of cattle, sheep, and goat herds (Gallais 1967b, 1975; N'Diaye 1970; Sundström 1972). Different features on the landscape are employed for distinct subsistence-related activities. For example, high, dry dunes are ideal for millet cultivation and keeping livestock

herds warm at night while basins and marshes of various depths are utilized for wet rice agriculture, various fishing practices, and dry season pasture (Gallais 1967b:101, 114; 1984:37-39).

The productivity of the IND, particularly when contrasted with the relative aridity of the surrounding regions, has made the area attractive to human populations for at least the past three millennia. The earliest known inhabitants of the IND entered the now arid Méma region northwest of the modern delta in several waves, beginning between 3300 and 2900 bp. These populations probably came from both the Mauritanian Sahel and the Algerian Sahara as a result of widespread drying trends (Bedaux, et al. 2005; MacDonald 1994:112; 1996; Van Neer 2002:253). Continued drying trends opened up portions of the upper (southern) IND to permanent human settlement during the Iron Age and large population aggregations emerged at sites like Dia and Jenné-jeno.

2.2.2 History of IND Archaeology

Throughout the first half of the 20th century, archaeology in the IND was restricted to surface collections or amateur digs conducted by French teachers and administrators who described mound sites with funerary urns eroding from their surfaces (Desplagnes 1903, 1906; Frobenius 1929; Mauny 1961; Monod 1955). Many of these informal archaeologists were preoccupied by the terracotta statuettes from the region, though none were found in secure archaeological contexts (Haselberger 1965, 1966; Ligers 1957; Malzy 1967; Masson-Detourbet 1953; Mauny 1949; Monod 1943; Vieillard 1940).

It wasn't until the 1950s that the first systematic excavations were conducted in the IND. Szumowski, an archaeologist working at IFAN in Bamako, excavated several sites near Mopti in

the early 1950s (Szumowski 1954, 1955, 1956). Over the next several decades, excavation in the region was sporadic: Gallay excavated a site near Tiebala in 1964; in the early 1970s Barth and Sarr excavated sites near Mopti and a Dutch team excavated at Toguérés Doupwil and Galia. (Barth 1976, 1977; Bedaux, et al. 1978b; Bedaux and Huizinga 1975; Gallay 1970; Sarr 1972). For more on the history of excavations in the IND see McIntosh and McIntosh (1980a; 1995:15-16) and Clark (2003).

Some of the most extensive excavations in the IND were carried out at the site of Jenné-jeno (near the modern town of Djenné in the southeastern Delta). The site sits at the intersection of three distinct ecological zones: the high clay levees along the Bani river to the south, suitable for millet and sorghum cultivation; the deep *Pondori* basin to the west, used for rice cultivation; and the higher inundated plains and dunes to the north, used for dry season pasture (McIntosh 1998:157; McIntosh 1995a:3-5) (see Figure 2.3). Even within the diverse IND, this variability of landforms in such close proximity is remarkable.

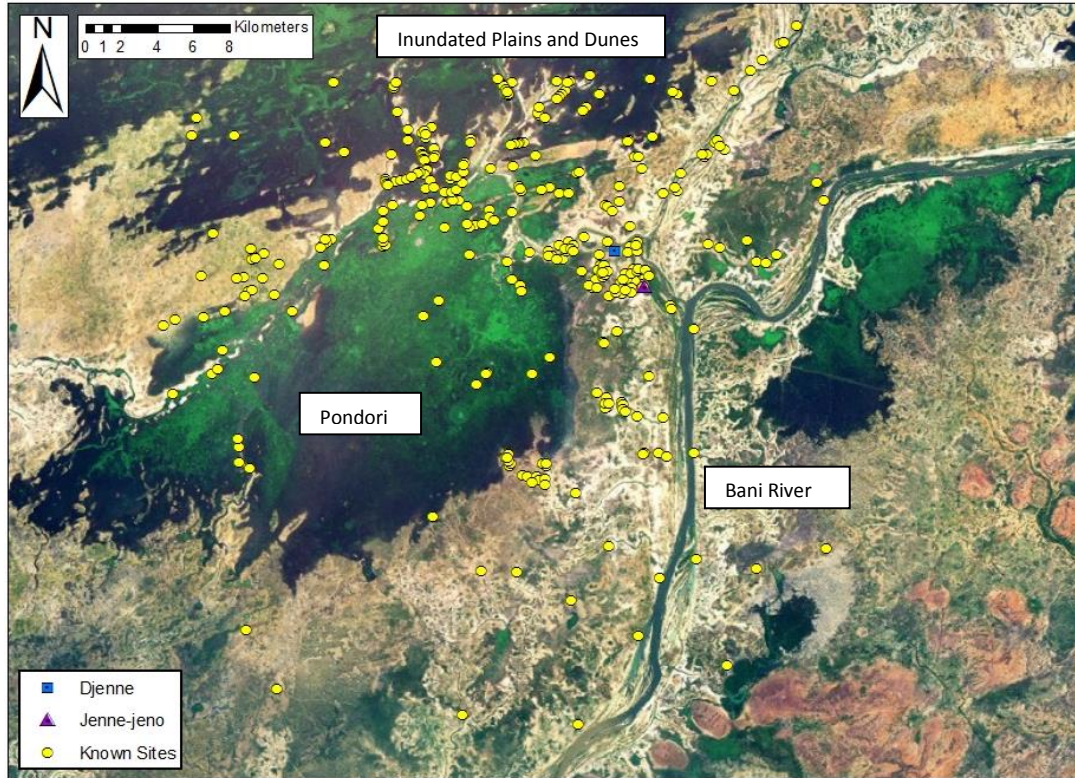


Figure 2.3 – Major geographic features surrounding Jenné-jeno

The first modern excavations at Jenné-jeno were conducted by Susan Keech McIntosh and Roderick McIntosh in 1977 (McIntosh and McIntosh 1981; McIntosh and McIntosh 1980a, b, 1984). This work identified dense, longstanding occupation at Jenné-jeno (from roughly 250 BC through AD 1400), which makes the site one of the earliest urban centers known in sub-Saharan Africa (see Table 2.1 for an overview of site chronology). Over the course of the next several decades, the McIntoshes and a handful of other scholars conducted extensive excavation, survey, and ethnoarchaeological research in the area to provide the first comprehensive picture of early IND settlement (Clark 2003; LaViolette 1987; McIntosh 1995a).

More recently, major excavations at Malian sites like Akumbu, Tombouze, the Windé Koroji Complex, and Dia (alternately spelled Ja) help to illuminate the diversity of human occupation in and around the IND throughout the previous three millennia (Bedaux, et al. 2005; MacDonald 1996; McIntosh 1995a; McIntosh and McIntosh 1980a, b; Park 2012; Togola 2008).

Jenné-jeno	PHASE I/II 250 BCE - CE 400	PHASE III CE 400 - 900	PHASE IV CE 900 - 1400
SITE AREA	CE 100: 12 ha CE 400: 25 ha	CE 800: 33 ha (maximum extent)	gradual contraction after CE 1100 abandoned by CE 1400
FAUNA	Surprisingly consistent across phases		
Domestic	Cattle; dwarf sheep and goats	Dwarf and non-dwarf cattle, sheep, and goats; at least two breeding populations of cattle; domestic chickens	N'Dama/dwarf shorthorn-sized cattle; dwarf sheep and goats;
Fish	Plentiful and diverse	Plentiful and diverse; increased <i>Synodontis</i> sp. and <i>Lates niloticus</i> ; decreased Tilapiini	Plentiful and diverse; decreased Clariidae and <i>Synodontis</i> sp.; increased <i>Lates niloticus</i> and Tilapiini
Other wild	Wild bovids, esp. <i>Kobus kob</i> ; warthog; waterfowl; turtle; crocodile	Decreased wild bovids; warthog; waterfowl; turtle; crocodile	Decreased wild bovids; warthog; waterfowl; turtle; crocodile
PLANTS	Surprisingly consistent across phases		
African rice	Present; major crop	Present; major crop	Present; major crop
Millet, sorghum, and fonio	Present but minor	Present but minor	Present but minor
Wild	<i>Brachiaria ramosa</i> (possibly cultivated), <i>Oryza barthii</i>	<i>Brachiaria ramosa</i> (possibly cultivated), <i>Oryza barthii</i>	<i>Brachiaria ramosa</i> (possibly cultivated), <i>Oryza barthii</i>
ARCHITECTURE	Daub-smeared pole-and-mat huts	Banco huts c. 3 m diameter	Cylindrical mud brick round huts c. 3 m diameter c. CE 900: city wall c. CE 1000: rectilinear mud brick houses appear
CERAMICS	Fineware Phase - Twine-rouletted decoration - Simple open or closed rims - Distinctive fine fabric "chinaware"	Painted Ware Phase - White and/or black painted geometric designs - Simple carinated rims with painted channeling and plaited twine	Fine Channeled and Impressed Ware Phase - Fine, closely spaced channeling and geometric impressed decoration (comb, punctate, stamped) - Carinated rims, T-rims, and ledged T-rims
EXCHANGE/TRADE	Iron Stone from ≤ 50 km Rare Mediterranean-sphere glass beads	CE 500: copper from ≥ 300 km CE 900: gold from ≥ 600 km Geometric painted ware found from Jenné-jeno to Lakes Region	From CE 1000: North African brass, glass, spindle whorls
BURIALS	Single flexed inhumation No grave goods	Large funerary urns in cemetery precincts; inhumation also practiced No grave goods	Funerary urns in cemeteries or associated with residences No grave goods
SYMBOLIC	None evident	Potsherd pavements	Terracotta statuettes c. CE 1200: warrior styles appear
Adapted from S.K. McIntosh (1999a:70) (Table 5.1), with input from S.K. McIntosh (1995a)			

2.2.3 Discussion of Terms used in this Text

Throughout this dissertation I use several terms that may be unfamiliar to the reader because they refer to the archaeological context directly in and around Jenné-jeno. These include

the Jenné-jeno Settlement Complex (JJSC), which is defined by Clark (2003) as comprising Jenné-jeno and the 66 sites that cluster most closely around it. S.K. McIntosh (1999a) refers to this as the Jenné-jeno cluster, encompassing sites within one kilometer of Jenné-jeno. Sites within five kilometers are variously called the maximal settlement cluster (McIntosh 2000:156) or the Jenné-jeno Urban Complex (McIntosh 2005:184). Although I occasionally use JJSC to refer to the sites in Jenné-jeno's immediate vicinity, I generally discuss what I call the Jenné-jeno Urban System. I use this name to signify Jenné-jeno; the landscape and relatively dense conglomeration of sites found within roughly ten kilometers of the site, but without a firm cutoff; the resources and people who passed through or lived in this area; and the political, social, and economic ties that united it.

Some scholars argue that *urban* and *urbanism* are inappropriate terms to use in archaeological contexts because the terms imply modern, Western understandings. *Population aggregation* is a possible, less ideologically-charged alternative. I continue to use the terms *urban* and *urbanism* in this West African context precisely because they have cultural salience that I believe is applicable to Jenné-jeno. To restrict these terms to European and Near Eastern contexts would, I believe, create a hierarchical relationship between places with *true* urbanism and those with mere *population aggregation*. The term *urban* connotes a scale and degree of interconnectivity beyond that implied by *population aggregation*.

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Chapter 3 – Subsistence and Specialization in a West African Urban Context: Investigating the Jenné-jeno Urban System

3.1 Introduction

Specialization of craft production and subsistence regimes is a central tenet of urban configurations in archaeological discourse. In his seminal article *The Urban Revolution*, V. Gordon Child argued that specialists, controlled by and essential to the political and religious elite, were central to the functioning of early urban systems (1950:16):

Peasants, craftsmen, priests and rulers form a community, not only by reason of identity of language and belief, but also because each performs mutually complementary functions, needed for the well-being (as redefined under civilization) of the whole. In fact the earliest cities illustrate a first approximation to an organic solidarity based upon a functional complementarity and interdependence between all its members such as subsist between the constituent cells of an organism.

Although contemporary discussions of urbanism have moved beyond the trait list Childe proposed, craft and subsistence specialization, along with power centralization and non-egalitarian wealth distribution, remain central to most discussions of urbanism.

The site of Jenné-jeno, near Djenné, Mali, is well known within Africanist archaeology and history circles for its contributions to our understandings of the development and nature African urbanism. The site is unquestionably urban, given its size and regional importance, but it lacks obvious markers of social stratification and centralized power structures. As I discuss below, scholars proposed that power was distributed in a more egalitarian manner, possibly across various kinship groups and production guilds (McIntosh 1998, 2005; McIntosh 1999a). Craft and subsistence specialization were essential components of these models.

Despite Jenné-jeno's importance to African archaeology and broader discussions of urban configurations, very little is known about the numerous sites surrounding Jenné-jeno and their

integration within the urban system. The research described in this article was undertaken with two major goals in mind. First, by excavating small sites somewhat distant to Jenné-jeno in diverse microenvironments, I aimed to illuminate the variability and interrelationships of settlements in the upper Inland Niger Delta during the period of Jenné-jeno's occupation (ca. 250 BCE to CE 1400). The second goal was to understand the role of specialization (in craft production, and particularly in subsistence production) in the region's origins and development. In addition to the importance of economic specialization to theories of urban organization, specialization is a perennial question in Malian archaeology and is often invoked in explanations of the region's development. Firm archaeological evidence for economically specialized economies in the past has, however, been elusive.

This article outlines the findings of excavations conducted near Djenné, Mali in 2010 and 2011. Excavations at two small sites, Tato à Sanouna and Thièl, provide the first detailed information about settlement in the broader landscape around Jenné-jeno and in specific microenvironments. In the heterogeneous landscape around Jenné-jeno, different landforms are currently employed for specific farming or herding activities. Excavating sites in two distinct ecological zones, namely a high clay levee along the Bani River and in the network of marshes and sand dunes northwest of Jenné-jeno, allowed me to explore the relationship between landscape, settlement patterning, and subsistence.

Here I report on these excavations, discuss the possible relationship between these sites and Jenné-jeno, and examine the nature of subsistence and specialization in the upper Inland Niger Delta from initial human occupation to the present. I argue that in spite of the expectation of specialized subsistence production in an urban system like Jenné-jeno, the economy appears to have been more generalized. Although the local landscape influenced subsistence patterns at

both sites to a certain extent, inhabitants of these sites employed similarly diverse subsistence strategies. Sites were not, as had been hypothesized, occupied by occupational specialists. In such a heterogeneous landscape, generalized subsistence production regimes appear to have met the needs of a densely-occupied urban population.

3.2 The Inland Niger Delta

The Inland Niger Delta (IND hereafter) is a complex riverine environment covering roughly 32,000 km² in the otherwise semi-arid Sahelian zone of central Mali (Makaske 1998) (see Figure 3.1). The delta is formed when the waters of Niger and Bani Rivers fan out into numerous roughly parallel channels, creating a rich floodplain with extensive arable and pasture land. Water, wind, and human forces have created a complex environmental mosaic of swamps, ponds, lakes, rivers, levees, dunes, and grasslands (Makaske 1998; McIntosh 2005). This landscape diversity and the aridity of surrounding regions have rendered the IND a highly productive source of fish, crops, and livestock for ancient and modern peoples alike.

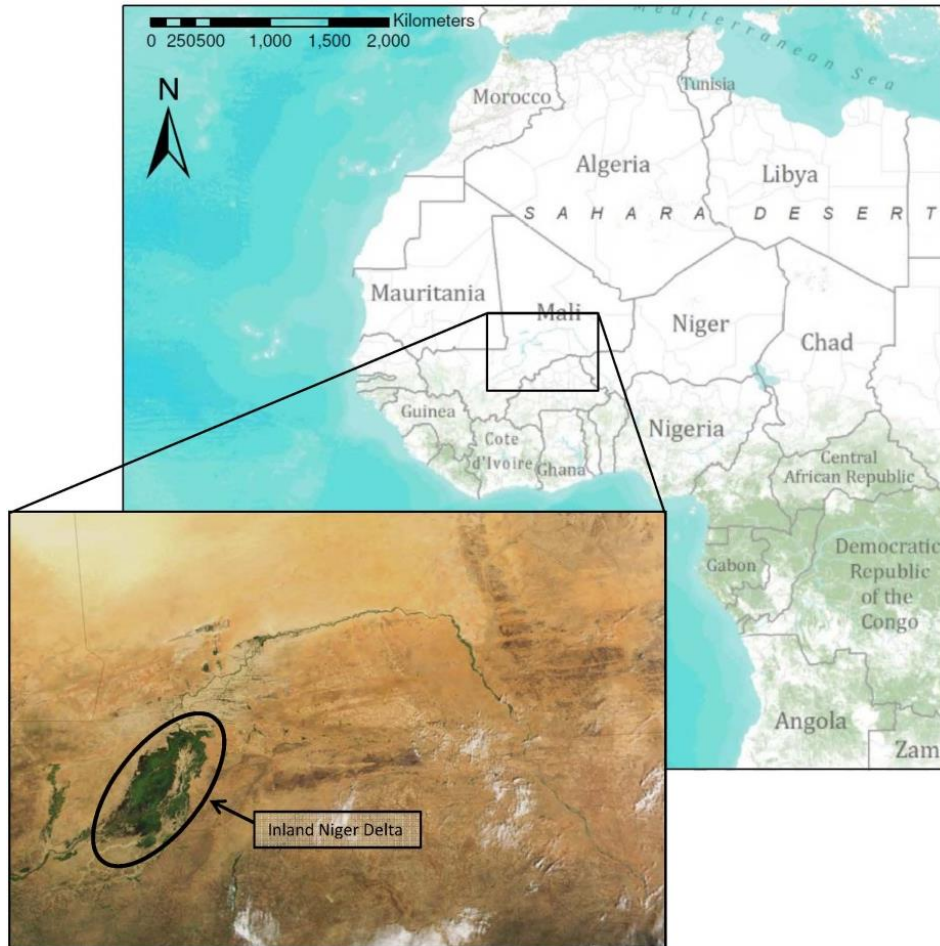


Figure 3.1 – Location of the Inland Niger Delta within Mali

The earliest known inhabitants of the IND entered the now arid Méma region northwest of the modern delta in several waves, beginning between 3300 and 2900 BP. Scholars suggest these people were drawn to the well-watered IND from both the Mauritanian Sahel and the Algerian Sahara following widespread drying trends (Bedaux, et al. 2005; MacDonald 1994:112; 1996; Van Neer 2002:253). Domestic livestock, including cattle, sheep, and goats, arrived in the Méma with these populations, though fishing and hunting also contributed significantly to diet (MacDonald 1994; Van Neer 2002). Evidence for agriculture during this period is scarce, but domesticated pearl millet (*Pennisetum glaucum*) was cultivated by around 3500 bp in the

southwestern Sahara (Neumann 2005:261) and populations entering the Méma may have brought millet agriculture with them.

Dramatic cultural changes are evident beginning in the second half of the first millennium BCE. These include the propagation of iron technology, development of larger settlements throughout the IND, and diversification of agricultural regimes, including the emergence of domesticated African rice (*Oryza glaberrima*), which would revolutionize IND subsistence systems (Childs and Herbert 2005; MacEachern 2005:443-446; Murray 2004; Neumann 2005:262). Continued drying trends opened up portions of the upper (southern) IND to human settlement for the first time; in contrast to the dryer Méma region, there is no evidence for Stone Age occupation in this part of the IND, which may have been too wet for sustained human settlement prior to this time.

Major excavations at Malian sites like Akumbu, Tombouze, the Windé Koroji Complex, Dia (alternately spelled Ja), and Jenné-jeno help to illuminate these changes and how human occupation developed over the ensuing centuries in and around the IND (Bedaux, et al. 2005; MacDonald 1996; McIntosh 1995a; McIntosh and McIntosh 1980a, b; Park 2012; Togola 2008). This article is primarily concerned with the site of Jenné-jeno (discussed below) and the surrounding area.

3.2.1 Jenné-jeno

Some of the most extensive excavations in the IND were carried out at the site of Jenné-jeno (near the modern town of Djenné in the southeastern Delta). The site sits at the intersection of three distinct ecological zones: the high levees of the Bani river to the south, suitable for millet and sorghum cultivation; the deep *Pondori* basin to the west, used for rice cultivation; and

the higher inundated plains and dunes to the north, used for dry season pasture (McIntosh 1998:157; McIntosh 1995a:3-5) (see Figure 3.2). Even within the diverse IND, this variability of landforms in such close proximity is remarkable.

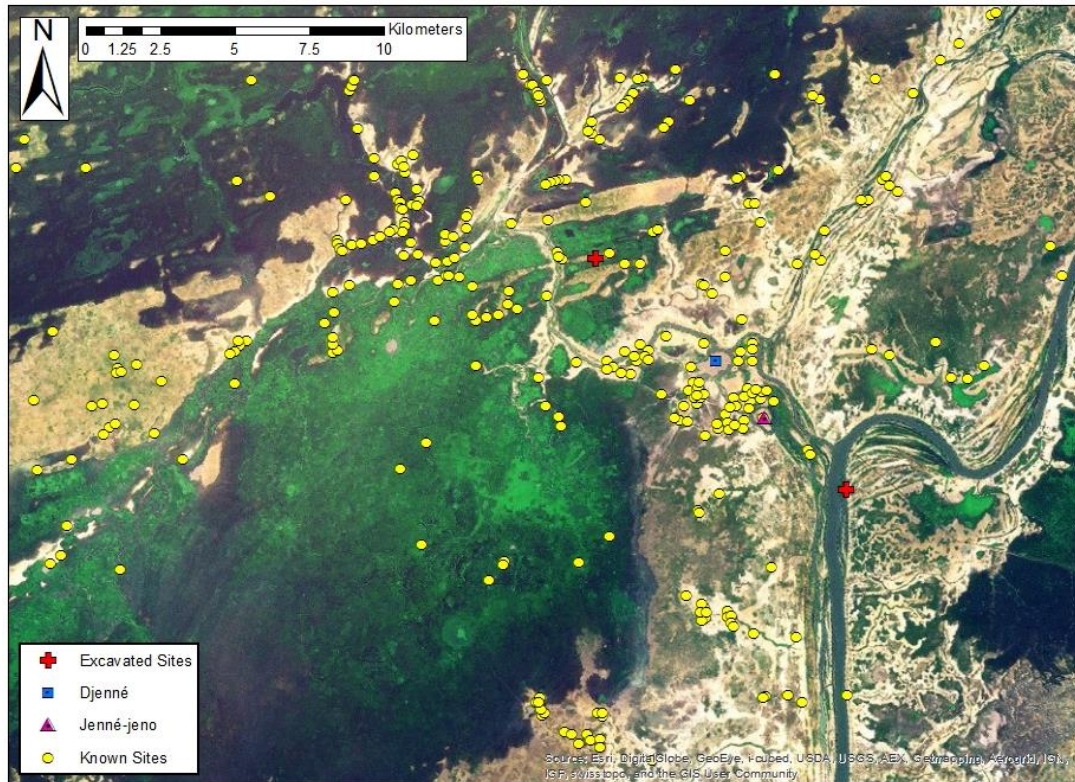


Figure 3.2 – Upper IND landforms and known sites

The first modern excavations at Jenné-jeno were conducted by Susan Keech McIntosh and Roderick McIntosh in 1977. Over the course of the next several decades, they and a handful of other scholars conducted extensive excavation at Jenné-jeno and neighboring sites Hambarketolo and Kaniana to provide the first comprehensive picture of Iron Age IND settlement.

The earliest inhabitants of Jenné-jeno arrived around 250 BCE when dryer conditions first opened up the area to year-round settlement (McIntosh 1999a). The site grew rapidly and

reached 12 ha by CE 100, 25 ha by CE 400, and 33 ha (its maximal extent) by CE 900. Furthermore, Jenné-jeno was part of a dense network of sites; survey by Susan Keech McIntosh and Roderick McIntosh identified at least 67 mounds and over 100 ha of occupied surface within 4 km at Jenné-jeno's height (McIntosh and McIntosh 1980b). During this time, Jenné-jeno was an active, densely populated site engaged in expansive interregional trade networks bringing goods like beads, stone, iron ore, and copper to the delta.

After CE 900, Jenné-jeno and many surrounding sites went into decline. This period is marked by a dramatic increase in Saharan trade evidenced by the increased presence of brass, glass beads, and spindle whorls, a shift from circular to rectilinear houses, the conversion of local leaders to Islam between CE 1200 and 1400, and the expansion of the Empire of Mali. By CE 1400 Jenné-jeno and three fourths of neighboring mounds were abandoned and population was re-concentrated at the modern town of Djenné, which became a vital cog in the Saharan trade through its connection to the Akan gold fields in the south and its northern neighbor Timbuktu (McIntosh 1999a:71; 2000:161). Gold, ivory, ebony, kola, and slaves from the southern forests and savannas were traded for Saharan salt and luxury goods, with IND grains, fish, and meat nourishing the trade (McIntosh 1998:155).

3.2.2 Urbanism, Heterarchy, and Specialization in the IND

From the first excavations at Jenné-jeno, it was evident that traditional models of urban development and political control were a poor fit for the site. Despite being a large population center with significant local and regional trade connections even before the true rise of the trans-Saharan trade, Jenné-jeno shows few signs of social stratification or centralized political control. Other than a large city wall (3 m wide and 2 km long) built around 900 CE, there are no signs of monumental architecture at the site. Additionally, no stratification is evident in burials or

residential buildings and there does not appear to be intensification of subsistence regimes or centralization of craft production throughout the 1600 year history of the site (LaViolette 2000; McIntosh 1995a:1-26; 1999a:73-77).

The presence of a large, densely packed population without evident signs of hierarchy challenged prevailing notions of political complexity and urbanism. Rather than hierarchy, scholars hypothesize that power was dispersed in a more heterarchical fashion, perhaps among various subsistence specialists, trade or craft guilds, founding lineages, and/or religious factions (McIntosh 1998, 2005; McIntosh 1999a, 2000; McIntosh and McIntosh 1993). Heterarchy is a concept that is increasingly recognized as a valid organizing principle in disparate world areas, including India, the southwestern US, and China (Crumley 1987; Ehrenreich, et al. 1995; Feinman 2000; McIntosh 1991; McIntosh 1999b; Rautman 1998).

The concept of economic specialization is key to current understandings of heterarchy in the IND. Specialization with intense intergroup interactions is seen as a logical response to both the environmental heterogeneity of the IND and the variability and unpredictability of rainfall and climate (McIntosh 1998:166; 2005:52; McIntosh 1999a:73-74).

Specialization is clearly a salient feature in modern ethnic organizations in the area. Throughout the IND, and particularly around Djenné, the highly variable ecology enables numerous economically specialized ethnic groups to thrive within a relatively small area (Gallais 1967b). This proximity necessitates frequent intergroup interactions and is largely responsible for the heterogeneous nature of the city of Djenné. In Djenné, Bambara millet farmers, Nono rice farmers, Bozo floodplain fishers, Somono open-water fishers, and seasonally-present Fulani pastoralists have forged an intricate, interdependent society where ethnicity is strongly tied to

economic specialization (Gallais 1967b, 1984; Monteil 1971 [1932]; N'Diaye 1970; Sundström 1972). Various merchant guilds, religious groups, and artisan castes loosely associated with the larger ethnic groups add to this complexity (LaViolette 1987, 2000). Furthermore, forms of economic specialization are hinted at in the archaeological record throughout the IND and West Africa (Bedaux, et al. 1978a; Bedaux, et al. 2001; Bedaux, et al. 2005; Clark 2003; LaViolette and Fleisher 2005:335; MacDonald 1994; K. C. MacDonald and W. Van Neer 1994; MacEachern 2005:440; McIntosh 2005; Togola 1996), though not unequivocally (Linseele 2010).

Excavations at Jenné-jeno show that the site's inhabitants had access to a diversified diet including domestic stock, numerous fish species, wild hunted resources, domesticated rice, several species of wild cereals, and small amounts of pearl millet and sorghum. Existing evidence does not, however, give us much information how food production was organized and whether modern modes of subsistence specialization are a valid model for our understanding of past patterns. An investigation into the nature of subsistence and specialization at Jenné-jeno in the past was clearly the next step in our understanding of the site, its political organization, and the trajectory of IND and West African subsistence.

3.3 The Research Sites

3.3.1 Research Goals

To better understand the unique trajectory of urban development in the Jenné-jeno area and to test the hypothesis that subsistence specialization has deep roots in the region and thereby had a profound impact on nascent urban configurations, it was necessary to undertake significant excavations on several smaller, outlying sites. Despite the extensive excavations conducted at Jenné-jeno, and its immediate neighbors Hambarketolo and Kaniana, very little is known about

the numerous other sites in the area. Analysis of the surface scatters of many of these sites shows that the vast majority were occupied contemporaneously with Jenné-jeno (McIntosh and McIntosh 1980b), and are thus important to our understandings of Jenné-jeno's development and character.

Survey identified at least 67 archaeological sites within 4 km of Djenné, and by analyzing Google Earth satellite images and the various formal and informal surveys conducted in the area (DNGR 2007; McIntosh and McIntosh 1980b), I identified an additional 268 definite and potential sites in an area within 10 km of the modern town of Djenné (see again Figure 2.2). The locations of these sites represent a cross section of IND environmental and geological heterogeneity: sites are found on river levees, in the midst of deep basins, perched on sand dunes, and encircling shallow marshes.

Different landforms within the IND are suitable to specific subsistence regimes and are thus valued by different modern ethnic groups: shallow- and open-water are utilized by Bozo and Somono fishers respectively, the Nono occupy low-lying areas suitable for wet rice agriculture, Bambara millet farmers prefer peninsulas and levees with sandy soils, and Fulani pastoralists prize a combination of sandy dunes and levees near deep basins with dry season pasture (Gallais 1967b, 1984). These ethnically-linked landscape preferences are not mentioned in an attempt to trace modern ethnic configurations back into the archaeological record. Rather, they are presented here to highlight the fact that modern subsistence practices are highly attuned to local environmental heterogeneity, and it is possible that similarly diverse groups exploited the landscape in the past. To better understand past subsistence practices in the IND it was thus necessary to excavate sites from varied microenvironments.

Between November 2010 and March 2011 I led archaeological excavations at two small sites within the large site cluster around Djenné: Tato à Sanouna, which sits on the banks of the Bani River, and Thièl, located on a sand dune in the midst of numerous shallow and medium-depth basins (See Figure 3.3). This project was a partnership between the *Mission Culturelle de Djenné* and me as part of my doctoral research.

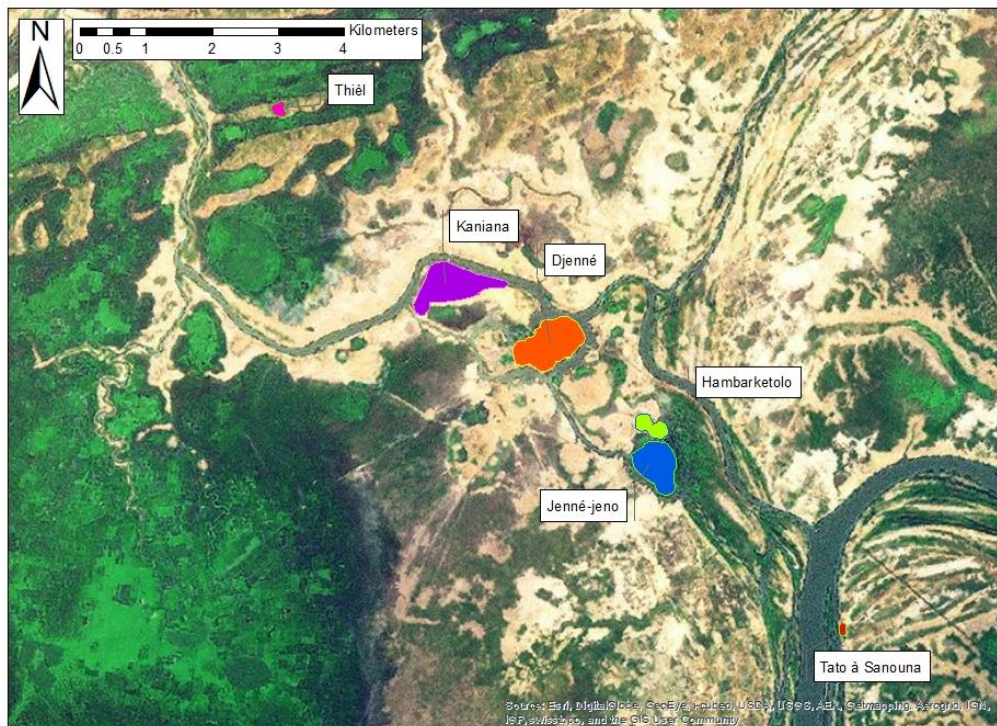


Figure 3.3 – Locations of excavated sites mentioned in the text

By excavating sites somewhat distant from Jenné-jeno (beyond the densest cluster around Jenné-jeno) and in distinct microenvironments, this project aimed to identify the degree of regional settlement variability and to better understand the interrelationship of local sites. Furthermore, the project had an explicit focus on subsistence in its recovery strategies and methods of analysis. I aimed to identify past subsistence patterns, their variability, and how they may or may not have shifted through time. One aspect of this goal was to determine how far the

specialized subsistence strategies seen in the modern IND extend into the past and, if it was present, whether this specialization could help explain Jenné-jeno's unique urban configurations.

3.3.2 Excavation Methods

As with previous archaeological projects in the hard, clay-rich soils of Djenné area, iron agricultural hoes called *dabas* were the primary tools of excavation. The team used trowels and brushes whenever we encountered features and *in situ* artifacts or when levels were unclear. We conducted excavation along natural levels except where these levels were greater than 10 cm in depth, in which case they were subdivided. Depth was controlled and recorded using line levels, with the absolute location and altitude of the point of origin determined using a Trimble GeoXH handheld GPS and Zephyr high-gain antenna.

We collected a single six liter cloth sac of bulk sediment for flotation from each excavation level, and took additional flotation samples opportunistically from ash lenses and other promising contexts. All sediments not collected for flotation were passed through a 0.5 cm screen and sorted into sacs by artifact class (bone, shell, stone, pottery, iron, etc.) by two of the workers for further analysis in the field lab.

3.3.3 Tato à Sanouna

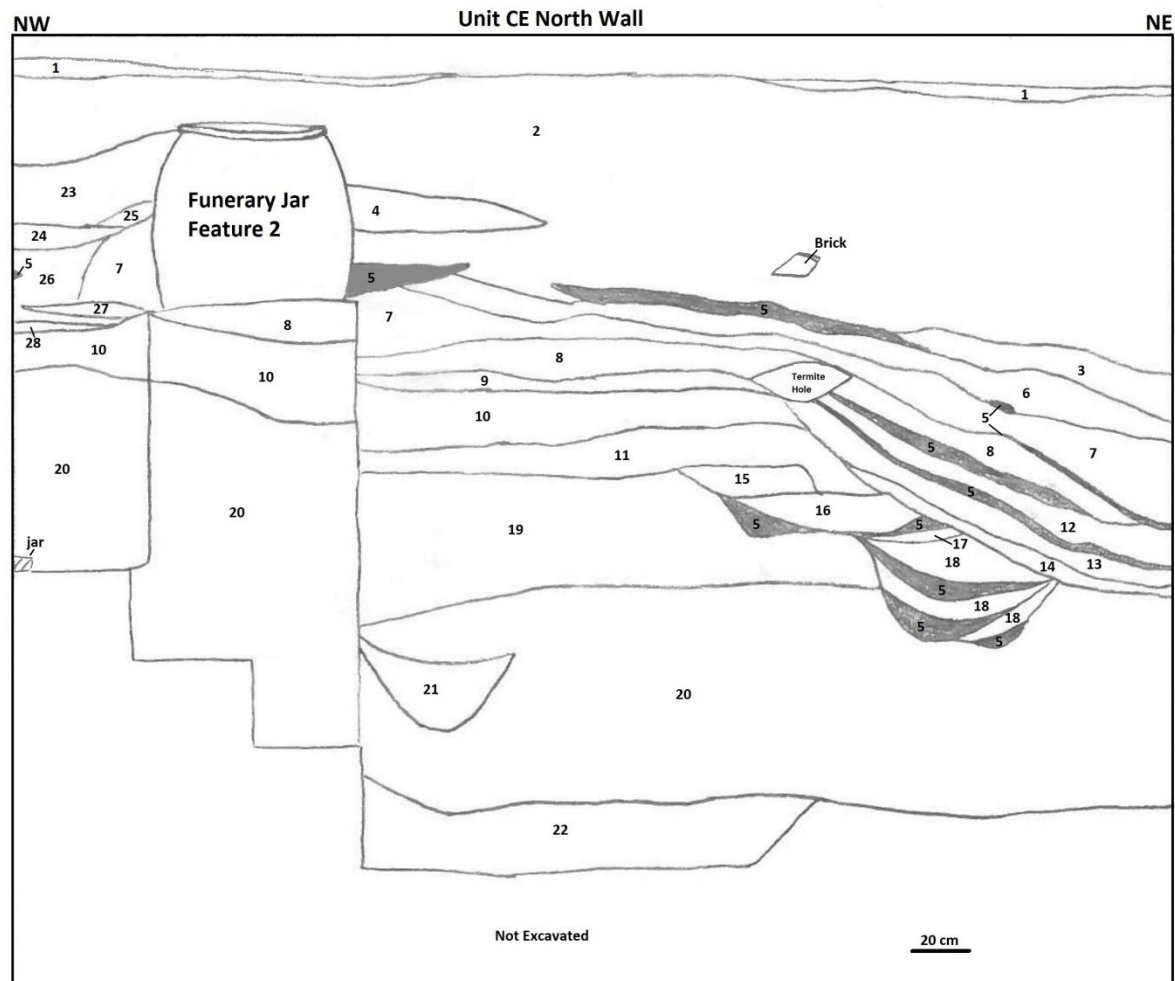
Tato à Sanouna is a small (2.3 ha) site 3.5 km southeast of Jenné-jeno. It sits on a high, silty-clay levee on the eastern bank of the Bani River. During the period of excavation (mid-November 2010 through late January 2011) Bozo fishers and Fulani pastoralists used the area around the site extensively for camping, netting and smoking fish, and watering and pasturing herds of sheep, goats, and cattle. Fields in the immediate vicinity were also used for both pearl millet (*Pennisetum glaucum*) and wet rice (*Oryza glaberrima*) cultivation.

Although the western edge (closest to the river) is deeply gullied, obscuring the true form and extent of the site, it was evident during survey that occupation at the Tato à Sanouna had been extensive: the site forms a roughly 3 m high *tell*, carpeted with sherds and mud-brick wall debris. Furthermore, the team documented 177 funerary urns eroding from the site's surface.

The team excavated three units at Tato à Sanouna: CE (2x4m), CTR (3x1.5m), and SO (2x2m) to get a glimpse of the variability and extent of settlement at the site. In all three units, including SO, which was located at the extreme southwest edge of the site, we excavated over 2.75 m of stratified cultural deposits before reaching the sterile orange clay of the underlying levee.

Based on radiocarbon dates, stratigraphy, architectural features, and ceramic décor, the excavated levels at Tato à Sanouna correspond very well with the archaeological phases identified by Susan McIntosh at Jenné-jeno: Phase I/II (250 BCE – CE 400), Phase III (CE 400 – 900), and Phase IV (CE 900 – 1400). A conventional radiocarbon date from the lowest levels in Unit SO dates the initial occupation to between 2698 and 1820 cal BP. Occupation at the site was long and apparently continuous throughout these three major phases. The upper two levels in unit CE suggest a brief reoccupation event at the site, but in general the site appears to have been abandoned contemporaneously with Jenné-jeno around CE 1400. Figures 3.4 through 3.15 document the stratigraphy of the three units and Tables 3.1, 3.2, and 3.3 give an overview of excavated levels.

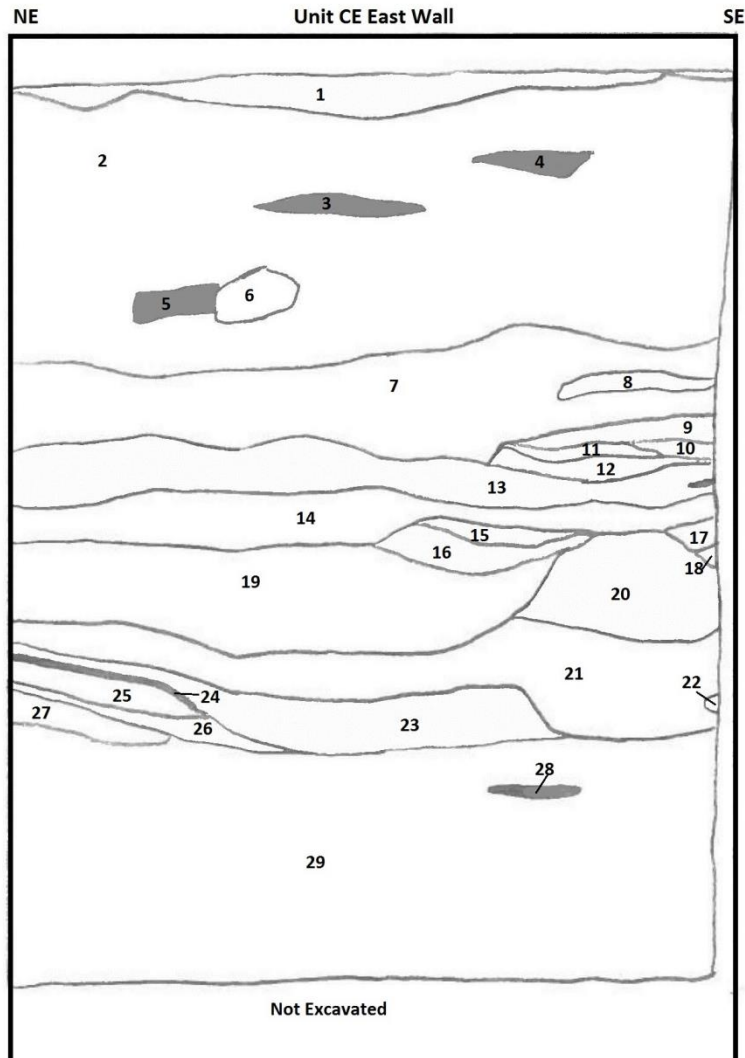
Figure 3.4 – Unit CE North Wall Stratigraphy



Key to CE North Wall Stratigraphy

- 1 – Loose, gray 10YR 5/3
- 2 – Heterogeneous, compact yellow-gray 10YR 5/4
- 3 – Loose, yellow-gray 10YR 5/3
- 4 – Loose, heterogeneous gray 10YR 4/3
- 5 – Black ash lens 10YR 4/1
- 6 – Heterogeneous yellow/gray 10YR 5/4
- 7 – Loose, heterogeneous gray 10YR 5/3
- 8 – Very loose, heterogeneous yellow 10YR 5/4
- 9 – Compact, reddish 7.5YR 4/4
- 10 – Compact, yellow 10YR 6/4
- 11 – Compact yellow with orange flecks 10YR 6/6
- 12 – Loose, heterogeneous brown 10YR 4/4
- 13 – Loose, yellow 10YR 6/4
- 14 – Loose brown 10YR 4/3
- 15 – Compact, orange 5YR 5/6
- 16 – Loose, heterogeneous olive 2.5Y 5/4
- 17 – Compact, orange 5YR 4/4
- 18 – Heterogeneous, yellow 2.5Y 6/4
- 19 – Heterogeneous, yellow 10YR 6/4
- 20 – Compact, yellow-gray with orange intrusions 10YR 6/4 and 5YR 5/8
- 21 – Heterogeneous, gray 7.5YR 4/4
- 22 – Compact, yellow with orange and white intrusions 10YR 6/1, 5YR 5/2, and 10YR 6/3
- 23 – Compact, yellow 10YR 6/6
- 24 – Friable, white-yellow 10YR 6/3
- 25 – Very loose, gray 10YR 5/4
- 26 – Heterogeneous, yellow 10YR 6/4
- 27 – Heterogeneous, red/yellow/black 7.5YR 4/4, 10YR 5/4, and 10YR 4/2
- 28 – Loose, white-grey 10YR 6/2

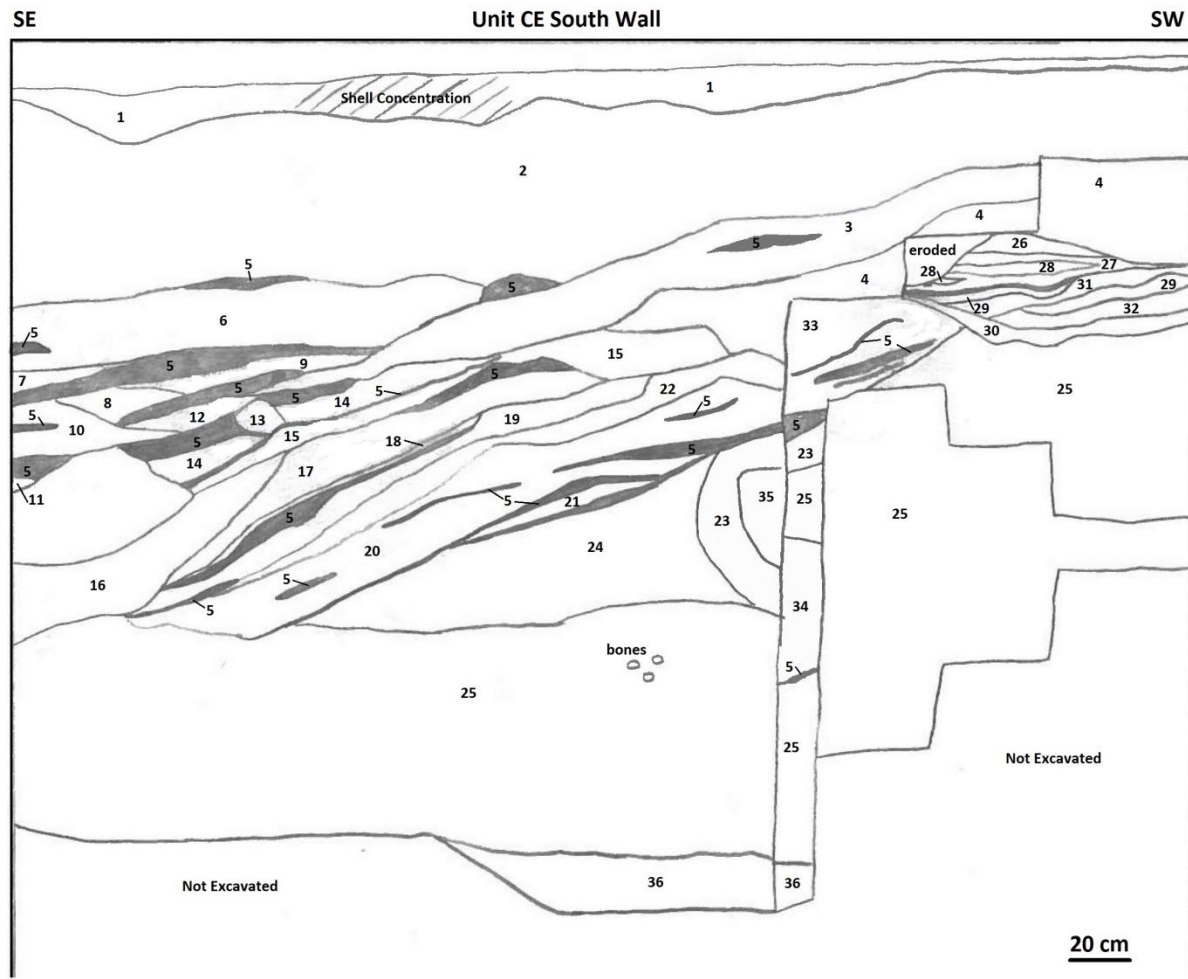
Figure 3.5 – Unit CE East Wall Stratigraphy



Key to Unit CE East Wall Stratigraphy

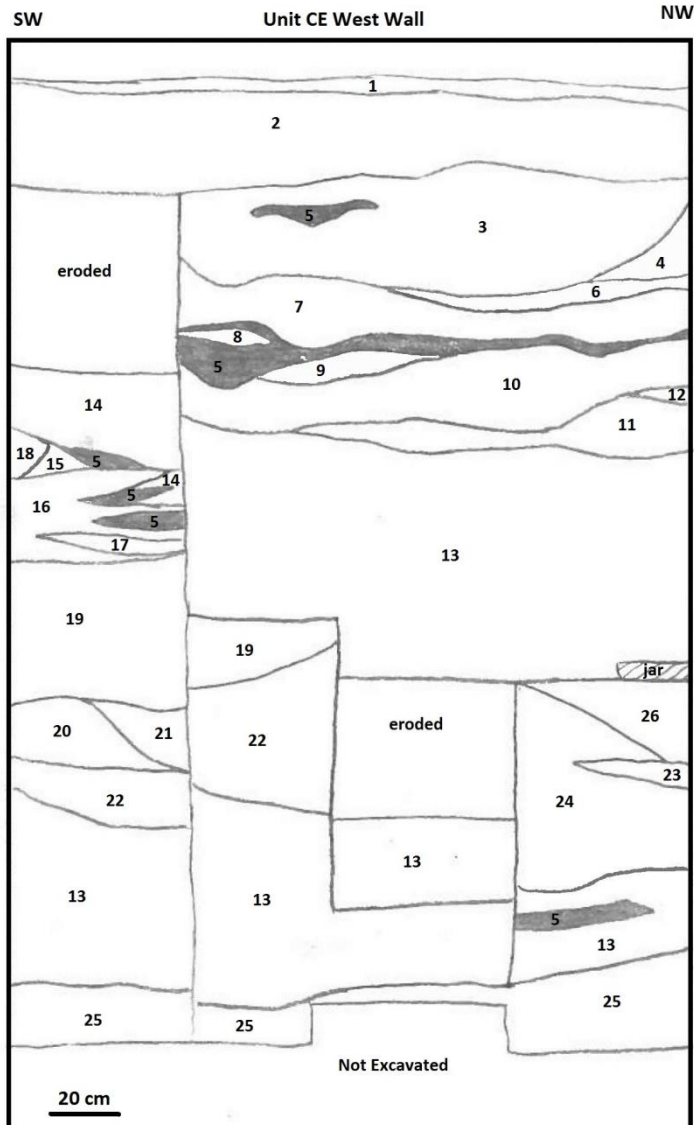
- 1 – Loose, gray 10YR 5/4
- 2 – Compact, heterogeneous 10YR 5/4
- 3 – Black ash lens 10YR 2/2
- 4 – Black ash pocket 10YR 3/2
- 5 – Black ash pocket 10YR 4/1
- 6 – Termite hole
- 7 – Compact, heterogeneous 10YR 5/6
- 8 – Gray ash lens, 10YR 5/2
- 9 – Compact, yellow 10YR 5/4
- 10 – Black ash lens 10YR 3/2
- 11 – Loose, pink with charcoal flecks 10YR 6/4
- 12 – Loose, brown 10YR 4/4
- 13 – Loose, yellow-gray 10YR 5/3
- 14 – Heterogeneous, yellow 10YR 5/6
- 15 – Loose, yellow-gray 10YR 5/4
- 16 – Loose, gray 10YR 4/2
- 17 – Loose, gray 10YR 4/2
- 18 – Loose, yellow 2.5Y 6/4
- 19 – Compact, heterogeneous, yellow 10YR 6/6
- 20 – Pink-gray, laminated layers 7.5YR 6/4
- 21 – Very loose gray, 10YR 4/3
- 22 – Loose, yellow 10YR 6/6
- 23 – Compact, yellow 10YR 6/4
- 24 – Black ash lens, 10YR 3/1
- 25 – Heterogeneous, yellow-gray 10YR 5/3
- 26 – Loose, brown-gray 10YR 4/3
- 27 – Compact, yellow 10YR 6/4
- 28 – Loose, gray ash 10YR 4/3
- 29 – Compact, yellow-grey with orange intrusions increasing with depth 2.5Y 6.4 and 5YR 5/8

Figure 3.6 – Unit CE South Wall Stratigraphy



- Key to Unit CE South Wall Stratigraphy**
- 1 – Loose, gray, 10YR 5/3
 - 2 – Compact, heterogeneous, yellow-gray 10YR5/4
 - 3 – Loose, gray-yellow 10YR 5/4
 - 4 – Compact, yellow 10YR 6/4
 - 5 – Ash lens 10YR 4/1
 - 6 – Compact, gray 10 YR 5/4
 - 7 – Compact, gray 2.5Y 6/4
 - 8 – Loose, heterogeneous, gray-white 10YR8/1 and 10YR 5/3
 - 9 – Loose, yellow-gray 10YR 5/3
 - 10 – Compact, yellow-gray 10YR 6/3
 - 11 – Loose, yellow 2.5Y 6/4
 - 12 – Loose, gray 10YR 5/3
 - 13 – Termite hole
 - 14 – Loose, heterogeneous, gray 10YR 5/4
 - 15 – Loose, heterogeneous, yellow 10YR 6/4
 - 16 – Very loose, gray 10YR 5/3
 - 17 – Loose, heterogeneous, gray 10YR 5/3
 - 18 – White ash 10YR 8/1 and 10YR 7/3
 - 19 – Loose, gray 10YR 6/3
 - 20 – Loose, heterogeneous, yellow 10YR 6/4
 - 21 – Loose, gray 10YR 6/4
 - 22 – Loose, dark gray 10YR 6/2
 - 23 – Compact, gray laminations 7.5YR 6/4
 - 24 – Compact, yellow 2.5Y 6/4
 - 25 – Compact, yellow, increasingly flecked with orange 2.5Y 6/4 and 5YR 5/8
 - 26 – Loose, heterogeneous, pink 5YR 4/4
 - 27 – Loose, gray organics 5YR 5/2
 - 28 – Loose, pink organics 5YR 6/6
 - 29 – Loose, white organics 5YR 6/2
 - 30 – Loose, heterogeneous, yellow 10YR 5/4
 - 31 – Heterogeneous, brown ash 5YR 4/3
 - 32 – Heterogeneous, gray and white organics 10YR 5/2 and 10YR 6/2
 - 33 – Heterogeneous, gray-yellow 10YR 5/3
 - 34 – Heterogeneous, gray-yellow 2.5Y 6/4
 - 35 – Compact, gray 10YR 5/4
 - 36 – Compact, yellow-gray with orange and white intrusions 10YR 6/1, 10YR 6/3, and 5YR 5/8

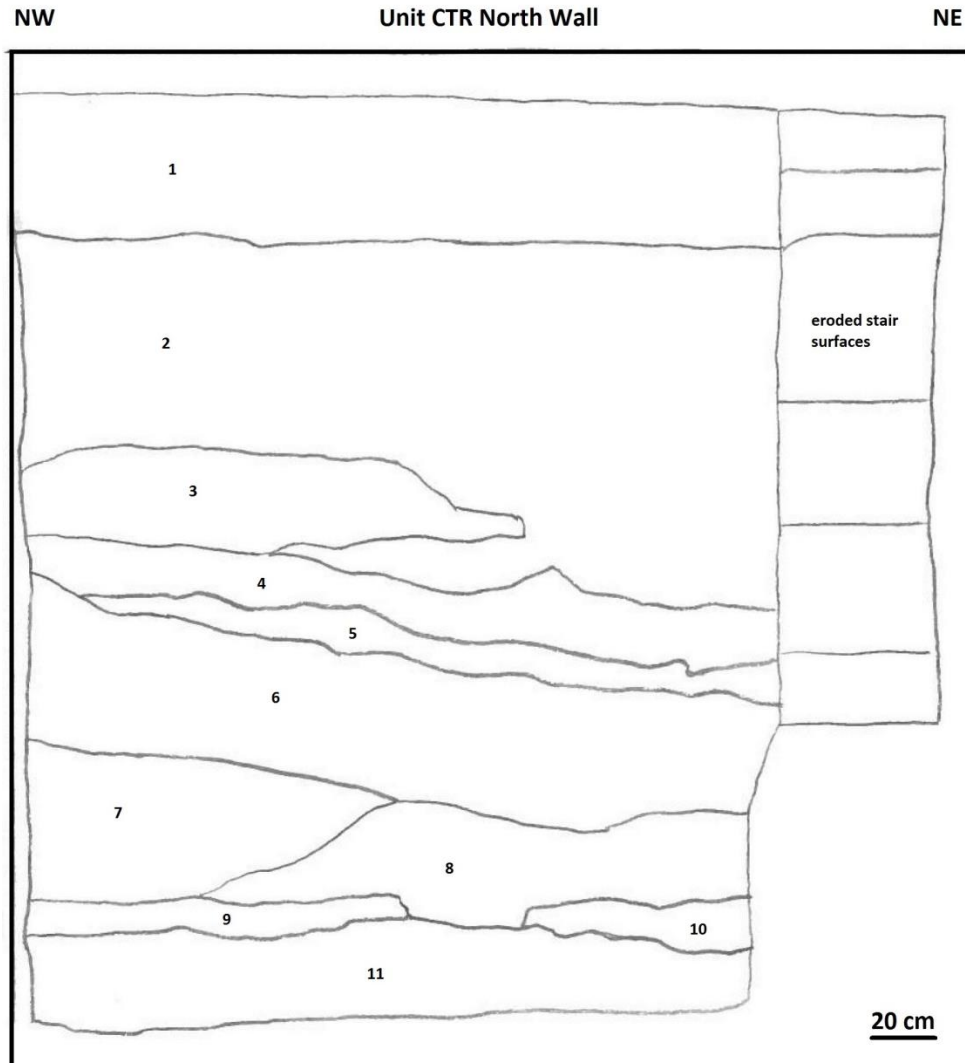
Figure 3.7 – Unit CE West Wall Stratigraphy



Key to Unit CE West Wall Stratigraphy

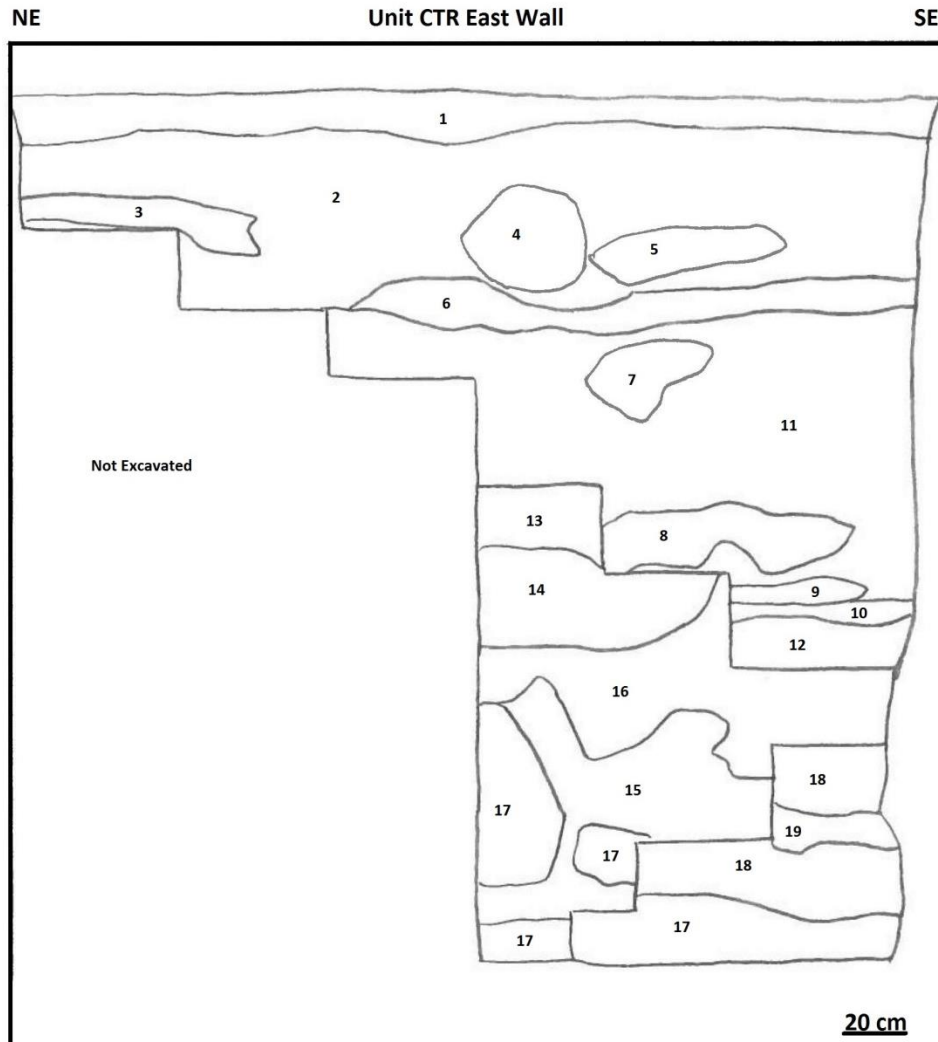
- 1 – Friable, gray 10YR 5/3
- 2 – Compact, yellow-gray 10YR 5/4
- 3 – Compact, heterogeneous, yellow-gray 10YR 5/4
- 4 – Compact, yellow 10YR 6/6
- 5 – Black ash lens 10YR 4/1
- 6 – Friable, white-yellow 10YR 6/3
- 7 – Compact, yellow 10YR 6/4
- 8 – Loose, pink-brown organics 5YR 5/6
- 9 – Loose, heterogeneous yellow-gray 10YR 5/4
- 10 – Compact, yellow-orange 7.5 YR 6/4 and 7/5YR 6/8
- 11 – Heterogeneous, gray 10YR 6/4
- 12 – Loose, white-gray 10YR 6/2
- 13 – Compact yellow with orange flecks 10YR 6/4 and 5YR 5/8
- 14 – Loose, heterogeneous gray 10YR 5/3
- 15 – Compact, yellow 10YR 6/4
- 16 – Loose, gray-pink laminations (aeolian) 7.5YR 6/4
- 17 – Loose, gray 10YR 5/3
- 18 – Loose, dark gray 10YR 6/2
- 19 – Compact, gray 10YR 5/4
- 20 – Compact, heterogeneous, yellow 10YR 6/4
- 21 – Loose, yellow-gray 10YR 6/4
- 22 – Loose, heterogeneous, gray 10YR 6/4
- 23 – Loose, dark brown and black ash 7.5YR 4/4
- 24 – Compact, heterogeneous, yellow-gray with charcoal 10YR 5/4
- 25 – Compact, yellow with orange and white intrusions 10YR 6/1, 10YR 6/5, 5YR 5/8
- 26 – Heterogeneous, yellow 10YR 6/4

Figure 3.8 – Unit CTR North Wall Stratigraphy



- Key to Unit CTR North Wall Stratigraphy**
- 1 – Compact, homogenous, yellow-brown 10YR 5/4
 - 2 – Compact, heterogeneous, light yellow-brown 10YR 6/4
 - 3 – Friable, heterogeneous, burnt earth, dark yellow-brown 10YR 4/4
 - 4 – Compact, heterogeneous, light yellow-brown 10YR 6/4
 - 5 – Friable, heterogeneous, burnt earth, dark gray-brown 10YR 3/2
 - 6 – Compact, heterogeneous light yellow-brown 10YR 6/4
 - 7 – Friable, heterogeneous, brown 10YR 5/3
 - 8 – Very compact, heterogeneous, light yellow-brown flecked with orange 10YR 6/4
 - 9 – Friable, heterogeneous brown-yellow 10YR 6/6
 - 10 – Friable, heterogeneous brown 10YR 5/3
 - 11 – Very compact, homogenous, very pale brown 10YR 7/4

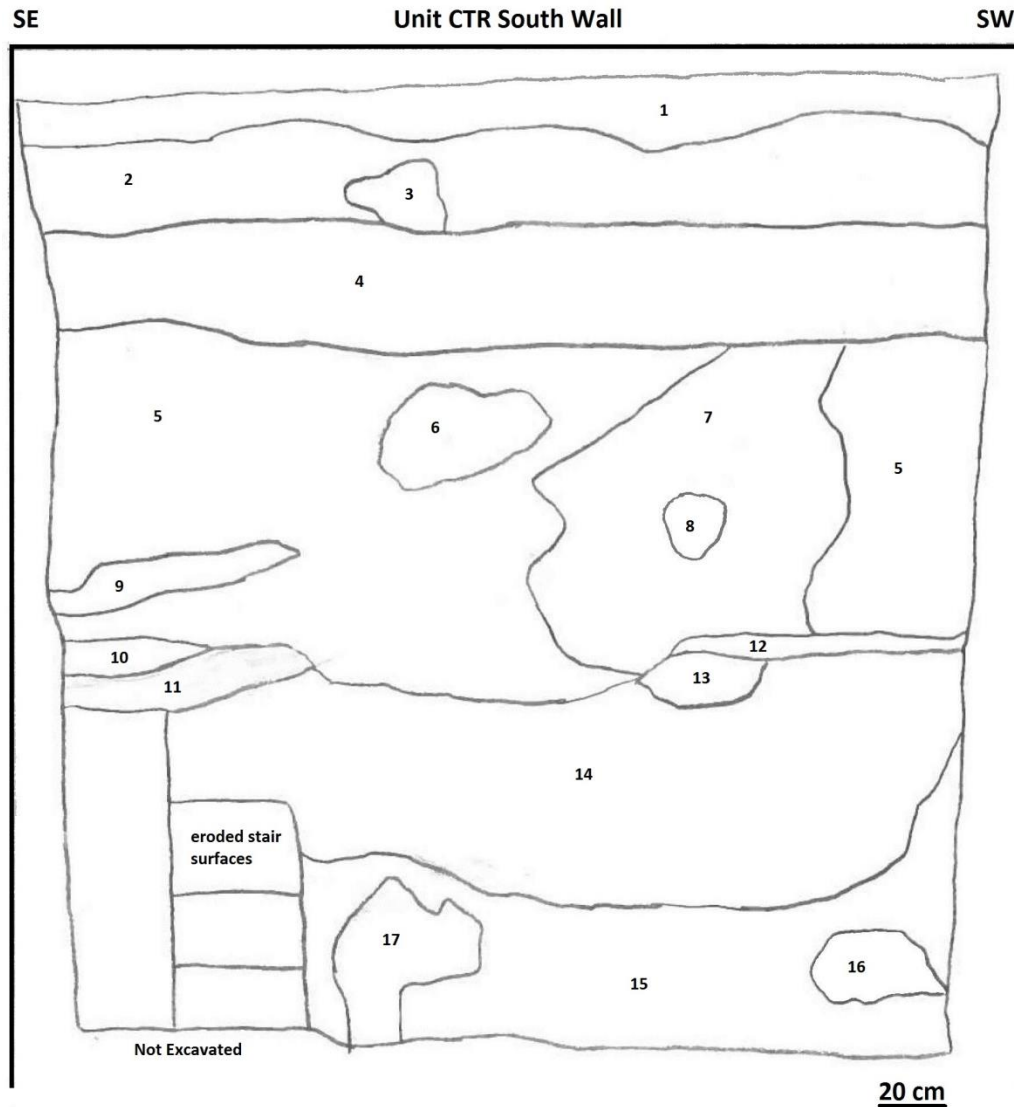
Figure 3.9 - Unit CTR East Wall Stratigraphy



Key to Unit CTR East Wall Stratigraphy

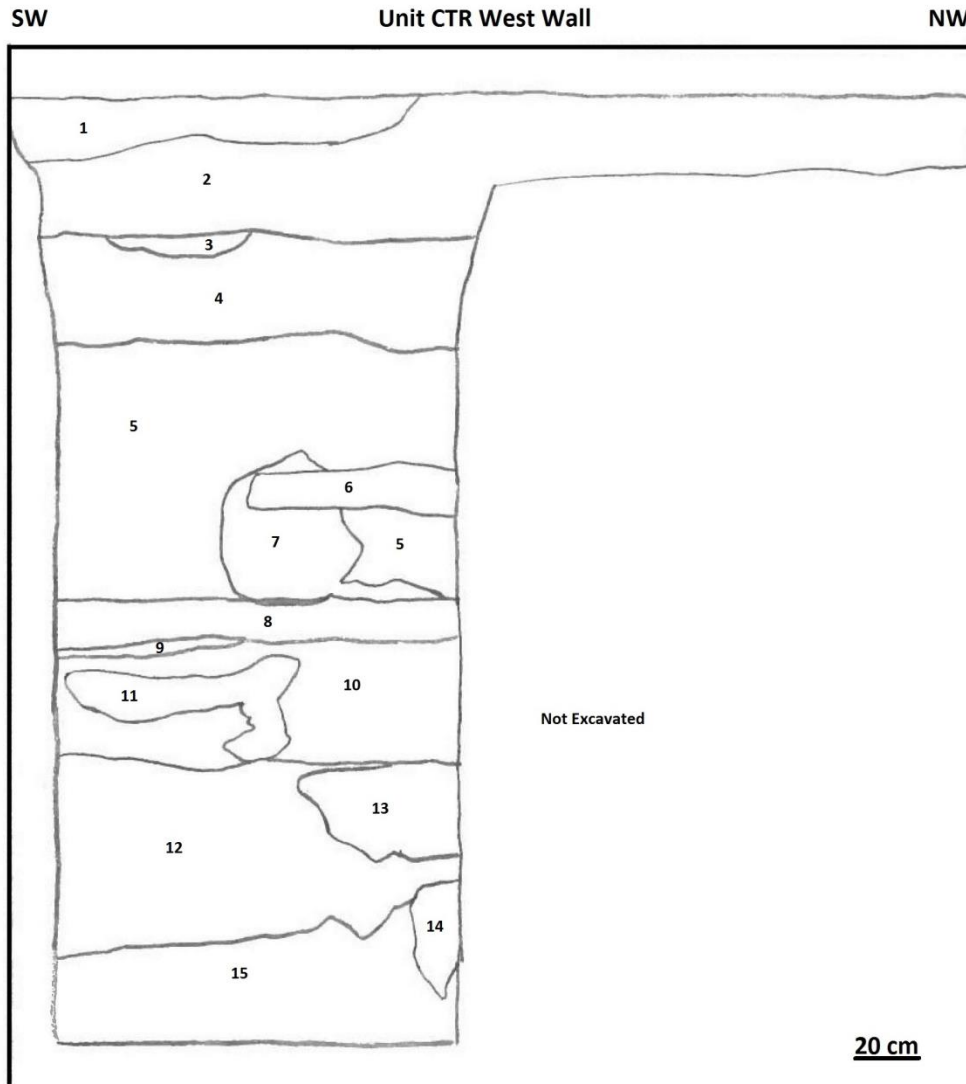
- 1 – Compact, homogenous, yellow-brown 10YR 5/4
- 2 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 3 – Friable, heterogeneous, brown 10YR 5/3
- 4 – Friable, heterogeneous yellow-brown 10YR 5/4
- 5 – Compact, heterogeneous, yellow-brown 10YR 5/4
- 6 – Friable, heterogeneous brown 10YR 5/3
- 7 – Friable, heterogeneous, dark gray-brown 10YR 3/2
- 8 – Friable, heterogeneous brown 10YR 4/3
- 9 – Compact, homogenous, brown 7.5YR 4/4
- 10 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 11 – Compact, heterogeneous, yellow-brown 10YR 6/4
- 12 – Compact, homogenous, yellow-brown 10YR 5/4
- 13 – Compact, homogenous, light yellow-brown 10YR 6/4
- 14 – Friable, heterogeneous brown-yellow 10YR 5/4
- 15 – Friable, heterogeneous, brown 10YR 5/3
- 16 – Compact, heterogeneous, yellow-brown 10YR 5/4
- 17 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 18 – Friable, heterogeneous, brown 10YR 4/3
- 19 – Compact, heterogeneous, light yellow-brown 10YR 6/4

Figure 3.10 - Unit CTR South Wall Stratigraphy



- Key to Unit CTR South Wall Stratigraphy**
- 1 – Compact, homogenous, yellow-brown 10YR 5/4
 - 2 – Compact, homogenous, light yellow-brown 10YR 6/4
 - 3 – Very compact, homogenous, burnt earth, orange 5YR 5/8
 - 4 – Friable, heterogeneous brown 10YR 5/3
 - 5 – Compact, heterogeneous, light yellow-brown 10YR 6/4
 - 6 – Friable, heterogeneous, burnt pocket, brown 7.5YR 5/4
 - 7 – Friable, heterogeneous, yellow-brown 10YR 5/4
 - 8 – Homogenous, burnt earth, reddish-brown 5YR 5/4
 - 9 – Friable, heterogeneous, burnt pocket, brown 10YR 5/3
 - 10 – Compact, heterogeneous, light yellow-brown 10YR 6/4
 - 11 – Friable, burnt pocket, very dark gray-brown 10YR 3/2
 - 12 – Very friable, gravel pocket, yellow-brown 10YR 5/4
 - 13 – Large sherd
 - 14 – Friable, heterogeneous, burnt earth, very dark gray 10YR 3/1
 - 15 – Very compact, heterogeneous, very pale brown 10YR 7/4
 - 16 – Friable, heterogeneous, yellow-brown 10YR 6/4
 - 17 – Friable, homogenous, yellow-brown 10YR 6/4

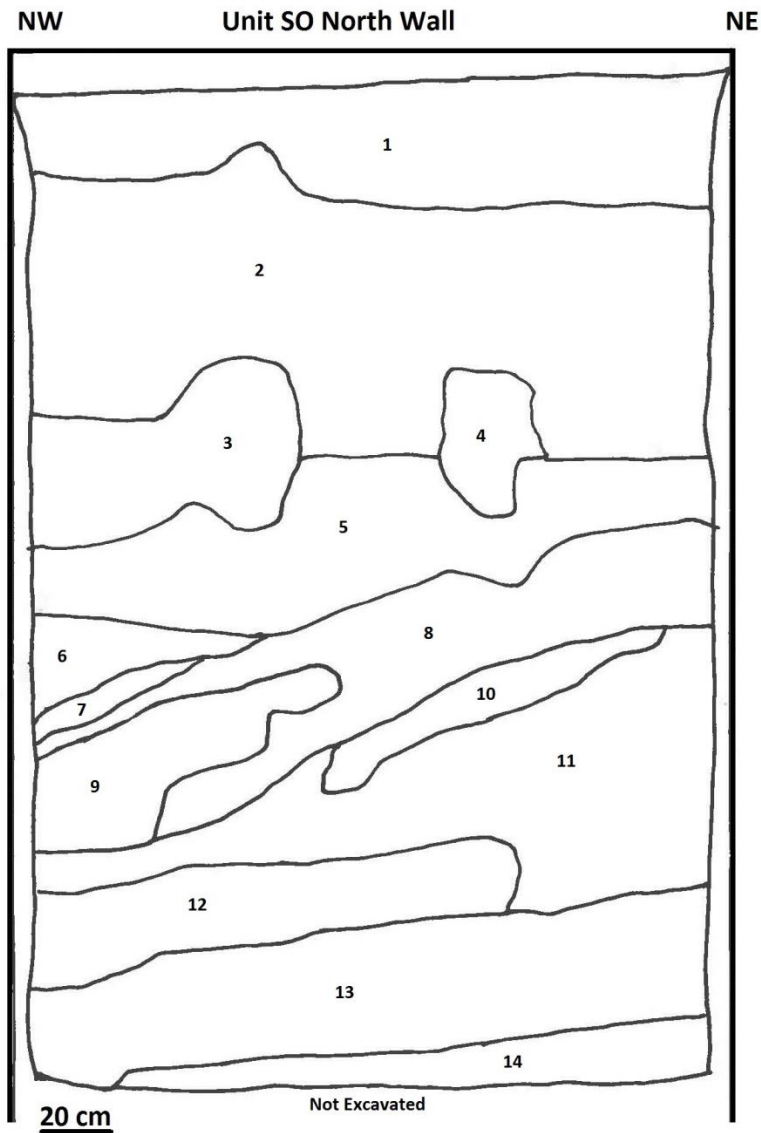
Figure 3.11 - Unit CTR West Wall Stratigraphy



Key to Unit CTR West Wall Stratigraphy

- 1 – Friable, homogenous, yellow-brown 10YR 5/4
- 2 – Compact, homogenous, yellow-brown 10YR 5/4
- 3 – Compact, homogenous, yellow-red 5YR 5/6
- 4 – Compact, heterogeneous, dark brown 10YR 4/4
- 5 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 6 – Friable, heterogeneous, burnt pocket, brown 10YR 4/4
- 7 – Friable, heterogeneous, yellow-brown 10YR 5/4
- 8 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 9 – Very friable, gravel pocket, yellow-brown 10YR 5/4
- 10 – Compact, heterogeneous, yellow-brown 10YR 5/4
- 11 – Very friable, heterogeneous, burnt pocket, brown 10YR 5/3
- 12 – Compact, heterogeneous, light yellow-brown with red flecks 10YR 6/4
- 13 – Compact, homogenous, brown 10YR 5/3
- 14 – Friable, homogenous, very light brown 10YR 7/4
- 15 – Compact, heterogeneous, brown-yellow with red flecks 10YR 6/6

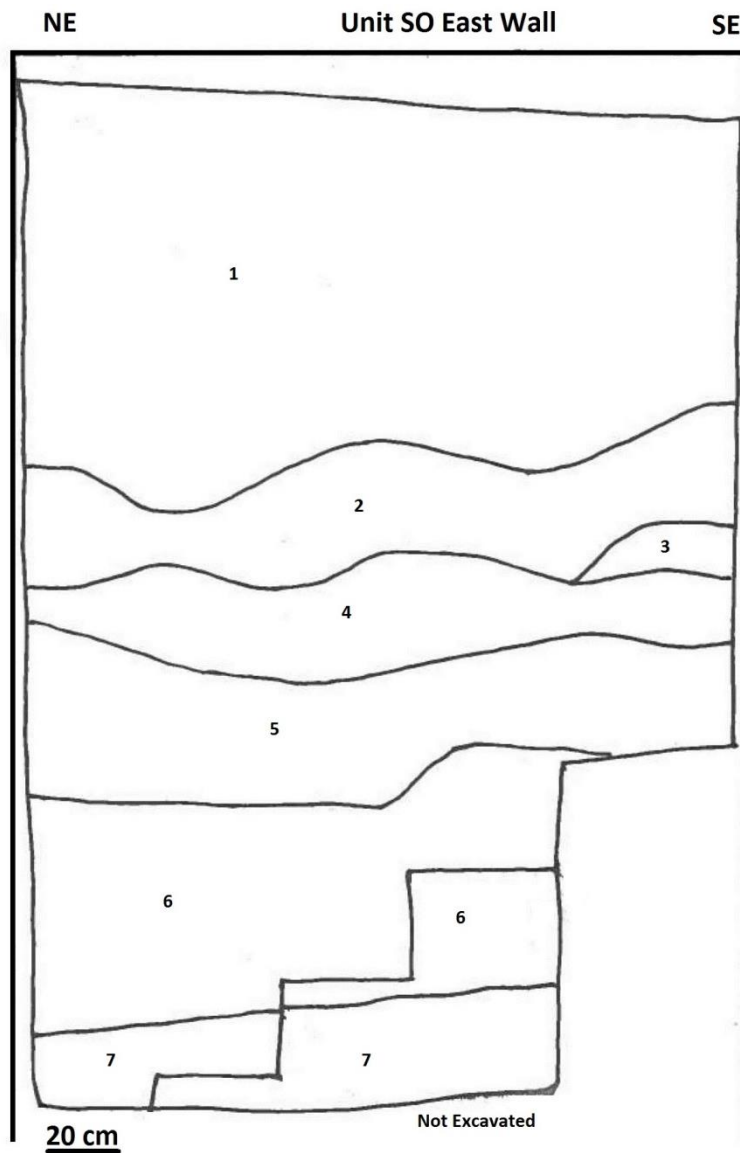
Figure 3.12 - Unit SO North Wall Stratigraphy



Key to Unit SO North Wall Stratigraphy

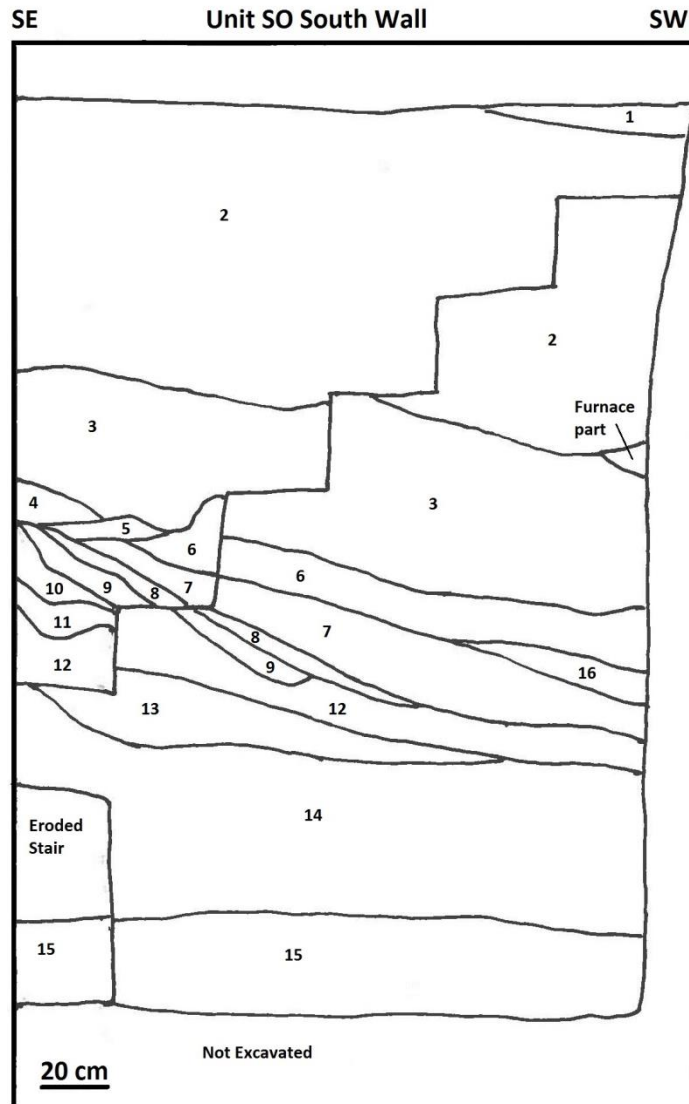
- 1 – Compact, heterogeneous, brown 10YR 5/3
- 2 – Compact, heterogeneous, light yellow-brown 10YR 6/4
- 3 – Friable, heterogeneous, gray-brown 10YR 5/2
- 4 – Friable, homogenous, brown 10YR 5/3
- 5 – Compact, heterogeneous, yellow-brown 10YR 5/4
- 6 – Friable unevenly, heterogeneous, dark gray-brown 10YR 3/2
- 7 – Friable, heterogeneous, dark gray-brown 10YR 3/2
- 8 – Compact, heterogeneous, brown 10YR 5/3
- 9 – Friable, heterogeneous, gray-brown 10YR 5/2
- 10 – Friable, heterogeneous, gray-brown 10YR 4/2
- 11 – Compact, heterogeneous, gray-brown 10YR 5/2
- 12 – Compact, heterogeneous, gray-brown 10YR 5/2
- 13 – Friable, heterogeneous, dark brown 10YR 3/3
- 14 – Compact, heterogeneous, very light brown 10YR 7/4

Figure 3.13 - Unit SO East Wall Stratigraphy



- Key to Unit SO East Wall Stratigraphy**
- 1 – Compact, heterogeneous, yellow 2.5Y 5/4
 - 2 – Heterogeneous, yellow 10YR 5/4
 - 3 – Compact, olive 2.5Y 5/3
 - 4 – Very heterogeneous, gray 10YR 4/3 and 10YR 5/2
 - 5 – Homogenous, gray 10YR 4/3
 - 6 – Compact, yellow-gray 10YR 5/4
 - 7 – Compact, heterogeneous, orange-gray 7.5YR 5/8 and 10YR 6/3

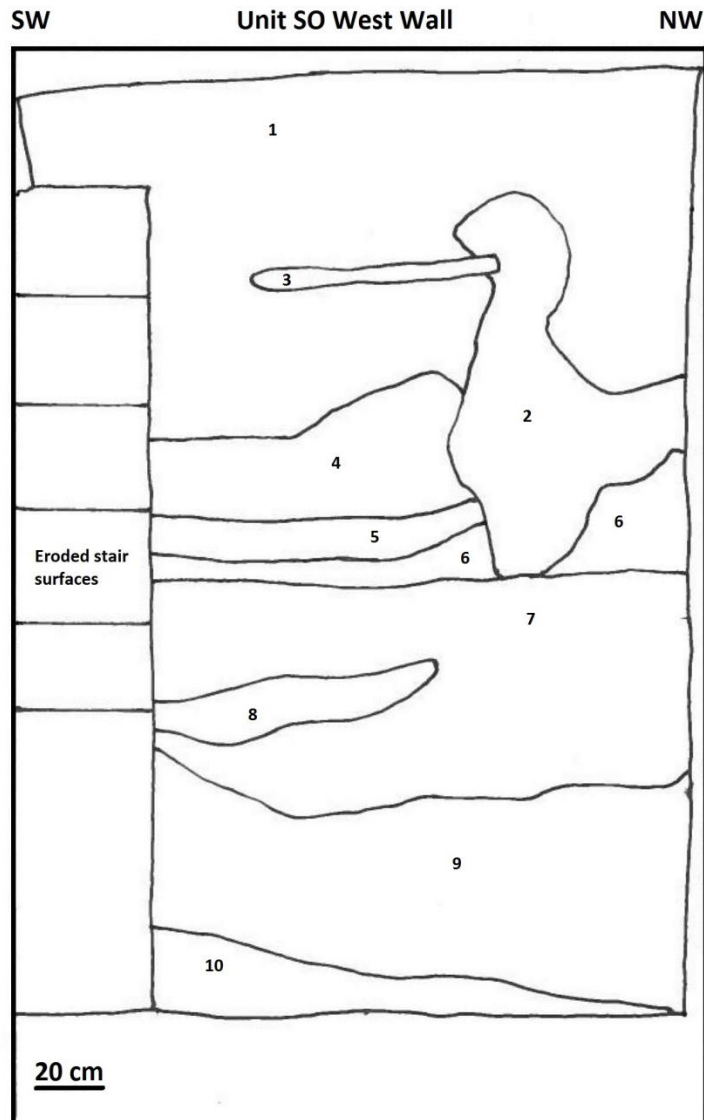
Figure 3.14 - Unit SO South Wall Stratigraphy



Key to Unit SO South Wall Stratigraphy

- 1 – Friable, gray 10YR 5/4
- 2 – Compact, heterogeneous, yellow-gray 2.5Y 5/4
- 3 – Compact, heterogeneous, yellow 10YR 5/4
- 4 – Compact, olive 2.5Y 5/3
- 5 – Compact, heterogeneous, yellow 10YR 6/4
- 6 – Compact, yellow-gray 10YR 3/1
- 7 – Compact, heterogeneous, olive 2.5Y 6/6
- 8 – Compact, red-gray 7.5YR 4/4 and 7.5YR 3/2
- 9 – Compact, heterogeneous, olive, 2.5Y 5/3
- 10 – Friable, gray 2.5Y 4/2
- 11 – Compact, heterogeneous, yellow-gray 2.5Y 7/6 and 2.5Y 4/3
- 12 – Homogenous, gray 10YR 4/3
- 13 – Compact, heterogeneous, yellow-grey 10YR 6/8 and 10YR 5/1
- 14 – Compact, yellow-gray 10YR 5/4
- 15 – Compact, heterogeneous, orange-gray 7.5YR 5.8 and 10YR 6/3

Figure 3.15 - Unit SO West Wall Stratigraphy



Key to Unit SO West Wall Stratigraphy

- 1 – Compact, heterogeneous, yellow-brown 10YR 6/4
- 2 – Friable, heterogeneous, yellow-brown 10YR 5/4
- 3 – Very compact, heterogeneous, brown 7.5YR 5/2
- 4 – Compact, heterogeneous, brown 10YR 5/3
- 5 – Compact, heterogeneous, gray-brown 10YR 5/2
- 6 – Compact, heterogeneous, brown 10YR 5/3
- 7 – Compact, heterogeneous, gray-brown 10YR 5/4
- 8 – Compact, heterogeneous, pale brown 10YR 6/3
- 9 – Friable in places, heterogeneous, light gray-brown 10YR 6/2
- 10 – Friable, heterogeneous, gray-brown 10YR 4/2
- 11 – Compact, heterogeneous, very light brown 10YR 7/3

Phase	Levels	Characteristics
V	1-2	More recent, transient reoccupation; burnt lens with lots of shells and bird bones; clay beads/spindle whorls
IV	3-9, 11	Compact layer with a large Phase IV funerary jar (F.2) and a partial mud-brick wall (F.3) in apparent association; habitation/burial area during this phase as occupation expanded the site's eastern border
III to IV Transition	10, 12-17	Slightly mixed layer; overall is a small ash pit deposited just after the large midden below; probably near the eastern extreme of the site at this time; area outside of the main ash deposit includes many smaller ash pockets (possibly the refuse of individual fires?); no architectural features
III Late	18-21, 23-27, 29-30, 35-36	Large, heterogeneous, stratified midden sloping down sharply from west to east; deposited relatively rapidly: no more than 200 years and probably much faster; slope suggests that this was the eastern edge of the site at this time; furnace remains and large slag concentration found at base of midden
III Early	22, 28, 31-34, 37-39	Fairly compact layer below the midden; much of the hard soil in the west appeared to be wall-fall (soil had worked appearance); artifact levels low; packed earth <i>banco</i> wall (F.5) and Phase III funerary jar (F.6) are possibly contemporaneous; mostly whole vessels found in several levels; habitation and burial area
I/II	40-51	Layer looks very similar to that above, including several in situ, mostly whole pots and large pottery concentrations; burnt, poorly preserved human remains (F.7) found in Level 40 (possibly a secondary inhumation); possible habitation area, though no architectural features found

Phase	Levels	Characteristics
IV	1-8	Generally low levels of artifacts, aside from several sherd clusters; several distinct burnt lenses with burnt clay elements may have been hearths (including F.1); possible habitation area despite lack of architectural features
II	9-19	Burnt lenses appear in these levels as well, but are less distinct than those above; pressed earth <i>banco</i> walls (F.8 and F.9) appear in Levels 11 and 17 attesting to two construction and habitation events during this period
I/II to III Transition	20-26	Several large storage or cooking pots found mostly intact and <i>in situ</i> in Levels 20 and 22; several burnt patches throughout; shallow midden found in Levels 24-26; Possible habitation area despite lack of architectural features
I/II	27-32	Artifact-poor levels; ash lens extends from Level 28 to 30, but no animal bones found; use of area is not clear during this phase

Phase	Levels	Characteristics
IV	1-7	Relatively homogenous yellowish clay; no architectural features or hearths; use of area unclear during this phase
III Late	8-12	Similar to levels 13-17 below; upper levels of a midden: dark and artifact rich; remains of furnaces in Level 8 (F.10) and Level 9 profile; possible fish processing site
III	13-17	Closely related to levels 8-12 above; stratified midden sloping to the southwest; saturated with water from seasonal inundation
I/II	18-25	Mixed levels characterized by yellowish clay flecks increasing towards last, sterile levels; furnace fragment found in Level 22

Architecture:

Excavations at Jenné-jeno and the neighboring sites Kaniana and Hambarketolo revealed clear shifts in architectural practices in the southeastern IND over time: Daub-smearred pole-and-mat structures in Phase I/II; round, pressed-earth *banco* structures ca. 3 m in diameter in Phase III; and structures (first round then rectilinear) constructed with cylindrical, sun-dried mud bricks in Phase IV (McIntosh 1995a:64-66; 1999a:70-71).

Although only partial walls were found at Tato à Sanouna, they show that building practices and materials did not differ greatly from those patterns delineated at Jenné-jeno during Phase III and Phase IV (see Table 3.4 below). Though no definite architectural remains were recovered from Phase I/II, several burnt lumps of clay in Phase I/II deposits in Units SO and CTR could be from wattle and daub construction, but this identification is tentative.

Unit	Phase	Feat #	Associated Levels	Type	Description
CE	IV	3	3 - 6	Mud-brick wall	Partial, poorly defined wall made of cylindrical mud bricks; three to four bricks wide; bricks ~12 cm in diameter
CE	Early III	5	32, 37, 38	Packed earth wall	Partial circular packed earth wall; 35-50 cm wide; structure estimated at 3m diameter; hard earth and rice chaff differentiate wall from surrounding matrix
CTR	III	8	11 - 14	Packed earth wall	2 m long section of packed earth wall; 31-35 cm wide; hard earth and rice chaff differentiate wall clearly from surrounding matrix; shape and size of structure indeterminate
CTR	III	9	17 - 19	Packed earth wall	Rectilinear, packed earth wall cutting across unit from east to south; thin layer of burnt <i>crépissage</i> (resurfacing clay) esp. on SE side, clearly defines limits of wall; 31-35 cm wide; burnt lens in Lev. 18 (SE of wall) is possibly a short-term hearth related to the structure, though very few botanical remains were found in the flotation; Feature 9 underlies Feature 8 by 50 cm so were separate, successive structures

At Jenné-jeno, excavators found fired, red-slipped bricks in contexts associated with houses from Phase IV or Phase III/IV transitional deposits. It is clear that these bricks were not a primary construction material, but S. McIntosh suggests that they could have been used to

reinforce areas like door sills subjected to frequent wear or simply as a decorative element (1995a:215-216). We recovered three similar fired, red-slipped bricks during excavations at Tato à Sanouna, one from the late Phase III midden in Unit CE (Level 27) and two from Phase I/II deposits in Unit SO (Levels 20 and 22). Interestingly, the Unit SO bricks come from much older contexts than those recovered in previous excavations in the area.

Inhumations:

At Tato à Sanouna we excavated four burials, all in Unit CE (see Table 3.5, below). One was a possibly intrusive inhumation from the uppermost levels of the unit, immediately adjacent to a Phase IV wall and funerary urn. It was not possible to tell from the context whether the inhumation was contemporaneous with these features or post-dated them. The other three burials were clearly associated with the occupational phases at the site. Very poor preservation made it impossible to determine factors like age, sex, and pathologies in most cases.

Unit	ID	Phase	Type	Preservation	Age	Sex	Grave Goods	Notes
CE	F.4	V or IV	Inhumation	Very poor	Adult	Indt.	None	Possibly intrusive N-S oriented burial; laying on left side facing east; possibly Muslim; only legs extended into unit; feet missing
CE	F.2	IV	Urn	Very poor	Adult	Indt.	2 iron bracelets	Urn ca. 50 cm wide at rim, 85 cm deep, Tw. 1 decor; invaded by termites reducing bone to dust; no teeth recovered
CE	F.6	III Early	Urn	Very poor	16-20 years	Indt.	3 iron bracelets	Urn 45 cm wide at rim, 55 cm deep, Tw. 5 décor; urn lid collapsed in antiquity and used as trash pit; powdered bone, several teeth, and iron bracelets at very bottom
CE	F.7	I/II	Inhumation	Very poor	Adult	Indt.	None	Secondary inhumation of human bones extending into south wall of unit

Metals and Metallurgy:

Copper and gold ornaments were recovered in excavations at Jenné-jeno (McIntosh 1995a), but metal artifacts at Tato à Sanouna were restricted to iron objects and refuse. In total, 71 fragmented iron objects weighing 809 grams were recovered from the three excavation units. Notable forms include spear or harpoon tips, blade fragments, rods or nails, and bracelets. Excluding the five iron bracelets found in the two jar inhumations, which together account for nearly a third of the iron by mass, the quantity of iron recovered at Tato à Sanouna is relatively low. This suggests that, as at Jenné-jeno, iron was a valuable resource and was probably extensively recycled and conserved (McIntosh 1995a). The high worth attached to iron is also supported by the use of iron objects as grave goods in the two jar inhumations at the site.

Refuse associated with iron production was found in all excavated units at Tato à Sanouna. In total, 4.5 kg of iron slag was recovered in excavations. The vast majority of this comes from six contexts where fragments of a ceramic furnace (relating to either smelting or smithing) were attached to iron slag. In levels 8 and 9 of Unit SO and level 36 of Unit CE (both late Phase III deposits) circular furnace bases and burnt soils suggest *in situ* iron working. Although the majority of recovered slag comes from Phase III and Phase I/II to III transitional deposits, slag was found in levels associated with all phases at the site, which suggests that iron was worked at Tato à Sanouna throughout its occupational history. Sources for the iron ore used at Jenné-jeno and other sites in the area have not been definitively identified, but were certainly beyond the bounds of the IND (McIntosh 1995:381-381).

Ceramics:

As at Jenné-jeno, a massive quantity of sherds was recovered at Tato à Sanouna: over 405 kg from the three units excavated. Ceramic analysis was greatly aided by the fact that an

excellent ceramic chronology for the area was previously described by Dr. Susan Keech McIntosh, including a thorough discussion of recovery methods, recording, and analysis (1995a:132-144). Body sherds were described only in terms of decoration (twine impressed, painted, slipped, plastic motifs, multiple attributes) because previous excavations in the area have shown that feature sherds (rims, bases, handles) alone can provide enough information about non-decorative aspects.

For the three units at Tato à Sanouna, we analyzed 4,765 body sherds. As at Jenné-jeno, the vast majority of these sherds were decorated with twine impressions, with a significant minority covered with red slip. Fourteen distinct varieties of twine décor were identified at Jenné-jeno, most of which were present at Tato à Sanouna. Two classes were by far the most common: accordion-plaited strip roulettes (Twines 4, 5) accounted for the vast majority of sherds in Phase I/II, while use of braided twine roulettes (Twines 1, 2, 3, 10) exploded in Phase IV. Phase III has intermediate levels of both types (McIntosh 1995a). These shifts in twine décor are clearly evident in the ceramic assemblage at Tato à Sanouna and were instrumental in delineating archaeological phases at the site.

Analysis of feature sherds (rims, bases, lids, etc.) is, unfortunately, incomplete. A planned return trip in spring 2012 to finish this analysis was cancelled due to Mali's political instability. The sherds that were analyzed (31 of 51 levels from Unit CE only), including a selection shown to Susan Keech McIntosh in early 2011, revealed few differences from the assemblage at Jenné-jeno, though several decorative motifs that were rare or unknown at Jenné-jeno were noted. Complete analysis of this assemblage would greatly aid our understanding of regional diversity in ceramic production and use. The Tato à Sanouna ceramic assemblage, and

that from Thièl, is stored in metal bins at the residence of my co-director, Mr. Yamoussa Fané in Djenné.

Stone:

Stone outcroppings are rare or completely absent within the Inland Niger Delta, making stone artifacts uncommon at IND sites. Excavations at Dia-Shoma recovered a small number of quartz microliths (Bedaux, et al. 2005:288). Chipped stone artifacts were absent at Jenné-jeno, but a moderate number of ground sandstone pieces were recovered in excavations at that site (McIntosh 1995a:246-247). At Tato à Sanouna, we recovered 39 ground sandstone artifacts weighing 6.6 kg in total. The stones were relatively small and uniformly-sized, averaging 171 g with a standard deviation of 96.6 g. The vast majority were rectangular or triangular in profile, with a small number of spherical form. Over 60% of the stones had traces of red or orange pigment, suggesting that they were used to grind ochre for pottery slip and other decorations. Although some of the stones could have been used to process grains or other foods, their rarity suggests that they were not the primary means of food processing at any time. Wooden mortars and pestles used to process grains are ubiquitous in the area today.

Middens and Hearths:

Botanical and faunal remains were recovered from levels throughout the occupational sequence at Tato à Sanouna, but several large middens, ash concentrations, and hearths account for a large percentage of these remains (see Table 3.6 below). Unfortunately, the majority of these features are associated with Phase III deposits, meaning that Phase I/II and Phase IV are poorly represented in the faunal and archaeobotanical assemblages.

Unit	Phase	Associated Levels	Description
CTR	IV	7, 8, Feat. 1	Shallow (ca. 6 cm) hearth or ash lens; relatively good botanical preservation
CE	III to IV Transition	10, 12-17	Small midden or series of ash lenses; moderate botanical preservation
CE	Late III	18-21, 23-27, 29-30, 35-36	Large, stratified midden with good organic preservation; several large concentrations of faunal remains; includes remains from iron working activities
CE	Early III	38, Feat. 6	The top of the Feature 6 funerary jar caved in and filled with soil post-dating the burial (human remains found in bottom 10 cm of jar); plentiful ash and excellent botanical preservation (refuse from cooking activities?)
SO	Early III	13-17	Stratified, sloping midden at edge of site; soils seasonally inundated, resulting in very poor botanical preservation
CTR	I/II to III Transition	20-26	Several small burnt patches and <i>in situ</i> pots in these levels; no definite hearths, but good botanical preservation

Botanical Remains:

Botanical remains were relatively poorly preserved at Tato à Sanouna, with 25% (29 of 116) of analyzed flotation samples containing no charred remains. Unit SO had particularly poor preservation, with only 4 of 19 samples containing charred remains. This is likely because Unit SO, at the margin of the site adjacent to the river, was seasonally inundated; soils in the lower 1.5 meters of the unit were still wet during excavation. Units CTR and CE had better preservation (only 14% of samples contained no charred remains) and provide valuable information about plant consumption at the site.

In Units CTR and CE, over half of the categories of remains belong to the family Poaceae. This includes both domestic and wild species, but cultivated species (African rice, fonio, and millet) dominate the sequence. Rice, both wild and domesticated (cf. *Oryza glaberrima*, *O. barthii*, and *O. longistaminata*), was consumed from the earliest levels. At over 50% ubiquity in all phases (excepting the Phase V reoccupation), rice was the most common and

ubiquitous grain at the site. Fonio (*Digitaria* sp.) was the next most ubiquitous taxon, being found in over 50% of post-Phase I/II contexts. Millets and sorghums (*Pennisetum glaucum*, *Pennisetum* sp., *Sorghum* sp.; presence combined) are found in 24% of samples, but are rare in Phase I/II and almost completely absent after Phase III. Other wild grains (*Brachiaria* sp., *Eleusine indica*, cf. *Eragrostis/Sporobolus*, cf. *Panicum laetum*, cf. *Panicum turgidum*, *Paspalum scrobiculatum*, and *Setaria* sp.) are present in lower frequencies at the site and may have been cultivated or gathered for food, used as animal fodder, or deposited with animal dung.

A variety of non-grass herbaceous species were identified in flotation samples. Many are weedy species, but some could have been consumed. Seeds belonging to Leguminosae and *Portulaca* sp. (*P. foliosa*, *P. oleracea*, and *P. quadrifida*) are most common. Fruits remains are rare at the site, but included baobab (*Adansonia digitata*), jujube (*Ziziphus* sp.), and *Vitex* sp.

Overall, the flotation samples attest to the centrality of rice and fonio to the diet, with millets contributing significantly in Phase III. Numerous species of wild grasses, herbs, and fruits were also used at the site.

Faunal Remains:

I identified the faunal assemblages for these sites, with the aid of the comparative collection at Washington University in St. Louis and numerous photographs and published identification resources. Fish identification was severely hampered by the lack of Niger River fish species in the comparative collection. The identifications presented here are therefore preliminary, until I am able to access a comparative collection with a wider representation of Niger River fish species.

Faunal remains at Tato à Sanouna are dominated by fish. Mammalian remains account for only 13% of the identifiable specimens. Many of these remains are impacted by calcium leaching and other preservation issues and come from non-diagnostic portions of the axial skeleton, making identification to genus or family difficult. Excepting several rodent and canid elements, all highly identifiable mammal remains (primarily teeth) come from domestic bovids: *Bos* sp. remains (NISP=12; MNI=6) outnumber *Capra/Ovis* elements (NISP=4; MNI=4), but both are present.

The identifiable fish remains suggest that the inhabitants of Tato à Sanouna primarily exploited deep, open water habitats, though several shallow-water species are also present. Nile Perch (*Lates niloticus*) and Siluriforms (particularly *Synodontis* sp.) dominate the assemblage. Cyprinidae and Tilapini elements are found in smaller numbers. Of particular interest are the 18 Tigerfish (*Hydrocynus* sp.) teeth recovered from throughout Phase I/II and III deposits in Unit SO (identified using the descriptions and images in (Otero, et al. 2009, 2010)). *Hydrocynus* sp. remains are uncommon in IND excavations: 3 were identified in the extensive 1981 excavations at Jenné-jeno and 9 were recovered in the Dia excavations (Manning and MacDonald 2005; Van Neer 1995). This relatively high concentration across multiple levels within a single unit at Tato à Sanouna may indicate that targeted *Hydrocynus* sp. processing occurred near the river.

Several fragments of worked turtle carapace (cf. *Cyclanorbis senegalensis*) were recovered in Phase III to IV transitional deposits (see Figure 3.16). A similar fragment was recovered at Jenné-jeno (MacDonald 1995) and also from early Iron Age deposits at the site of Kursakata in northeastern Nigeria (Linseele 2007:43). A large (19 x 34 cm) section of turtle carapace (cf. *Trionyx triunguis*) was recovered *in situ* from Phase III deposits in Unit CE and several smaller, as yet unidentified turtle fragments were found in other levels. No other reptile

remains have been securely identified. Small quantities of shell from an unidentified freshwater bivalve were recovered from throughout the occupation levels.



Figure 3.16 - Turtle carapace pendant with drilled holes (Tato à Sanouna, Unit CE, Level 15)

The faunal remains from Tato à Sanouna attest to an aquatic orientated subsistence economy dominated by deep water fish species, but supplemented by several shallow water species and occasional turtles (see Figures 3.17 and 3.18). Domestic bovids were a small, but significant element of the diet. The lack of evidence for hunting wild bovids, aquatic reptiles (aside from turtles), and birds is surprising, given their importance in the Jenné-jeno assemblage, particularly in early levels.

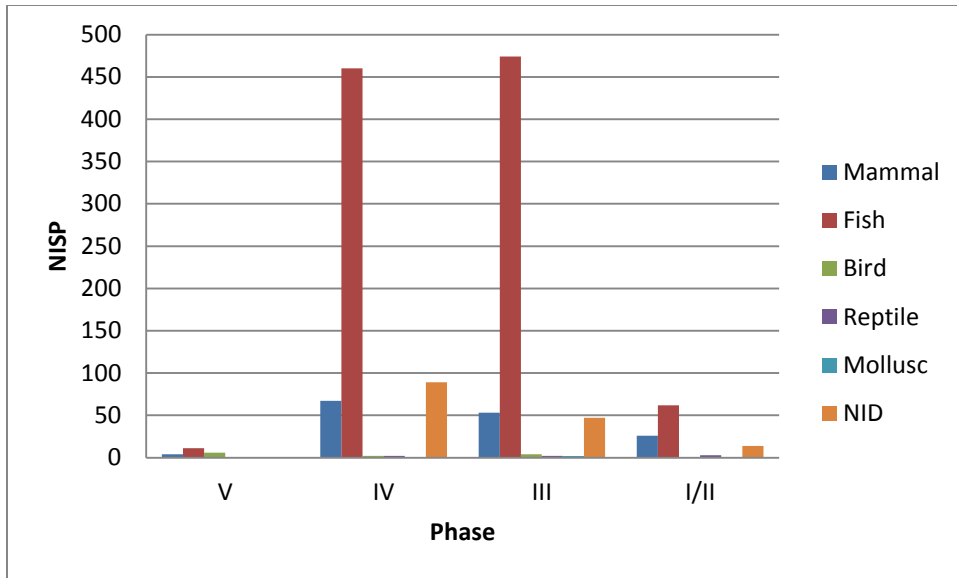


Figure 3.17 – Fauna (NISP) by class at Tato à Sanouna, presented by phase

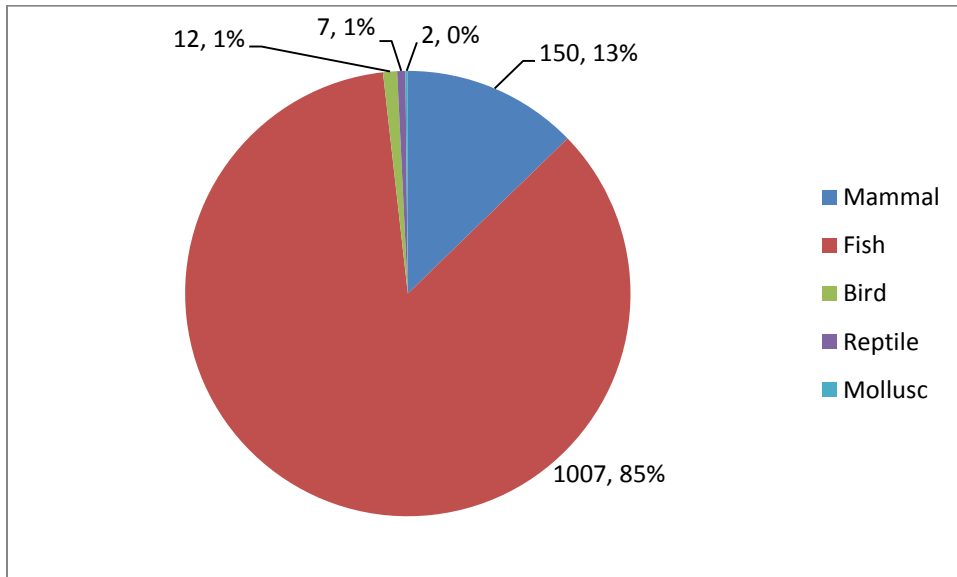


Figure 3.18 – Fauna (NISP) by class at Tato à Sanouna for entire assemblage

Site Development and Space Use

The three units excavated at Tato à Sanouna represent only a tiny fraction of the volume of the site, so interpretations of site development and use are necessarily provisional. Based on the early radiocarbon date from the lower levels of Unit SO and the extensive Phase I/II deposits in Unit CTR, it is likely that early settlement at the site was most extensive in the west, on the natural clay levee near the river. Settlement gradually spread east beyond the limits of the levee

over time. A unit in the eastern half of the site could confirm this hypothesis, but it does seem consistent with the shape and position of the large Phase III midden in Unit CE, which slopes sharply down from west to east as if this were the edge of the site at that time.

Based on excavated deposits and surface features, habitation zones, burials, and production areas are dispersed across the site. Burials are frequently associated with habitation areas, and no cemetery precinct, such as that seen at Jenné-jeno, is evident. In contrast to persistent expectations that iron working was a feared and privileged activity that would require spatial segregation, the limited evidence for iron working at Tato à Sanouna was not restricted to a single part of the site; rather, evidence for iron working was found in all excavated units.

3.3.4 Thièl

Thièl is a roughly five hectare site perched on a sandy dune 7.5 km northwest of Jenné-jeno. The site is surrounded by a maze of seasonally inundated plains, streams, ponds, and narrow, east-west oriented sand dunes. Until the floodwaters begin to recede in December and January the site and neighboring villages are islands in a marshy sea. In fact, it was not until late January that the site was at all accessible by automobile.

The exact outline of the site is somewhat difficult to determine since the surface of the dune and much of the site's outskirts are actively used for millet and sorghum cultivation. Several linear and circular structures were visible on the surface, particularly in the north portion of the site, along with a few broken funerary urns, animal bones, and iron fragments, but the surface scatter is much less dense than that at Tato à Sanouna. This is probably due to plowing of the site's surface and less extensive deflation than at the former site, rather than to less intensive occupation at Thièl. A second ceramic scatter located approximately 100 m east of Thièl along

the same dune may in fact be an extension of the site rather than a separate settlement, but agricultural activities have resulted in two discrete surface scatters.

In addition to millet cultivation, the area around Thièl was used extensively by cattle herders to pasture their flocks during the excavation period. The combination of deep basins and sand dunes provide ideal fodder and insulation against cool night air for cattle herds during the latter part of the dry season (Gallais 1967b). Furthermore, the modern town of Worondjikoye, situated 300 meters south of Thièl, is occupied exclusively by Rimmaybe, a caste of former Fulani slaves, which could indicate a longstanding relationship between Fulani cattle herders and the local area.

The team excavated two units at Thièl between late January and early March 2011: GTC (3x3m) targeted the highest point of the *tell* in order to get a picture of the full settlement sequence, and AMS (3x3m) was positioned around a rectilinear mud brick wall visible on the site's surface. Two recent graduates of the University of Mali, Gilbert Togo and Abdrahamane Maïga directed excavation of Units GTC and AMS respectively, overseen by me. The units were located only ten meters apart, in part to allow me to supervise both units simultaneously since it was Mr. Maïga and Mr. Togo's first experience directing excavations. Both units captured deep, stratified occupation sequences, 3.9 m in AMS and 4.4 m in GTC, before hitting the sterile orange sands of the underlying dune.

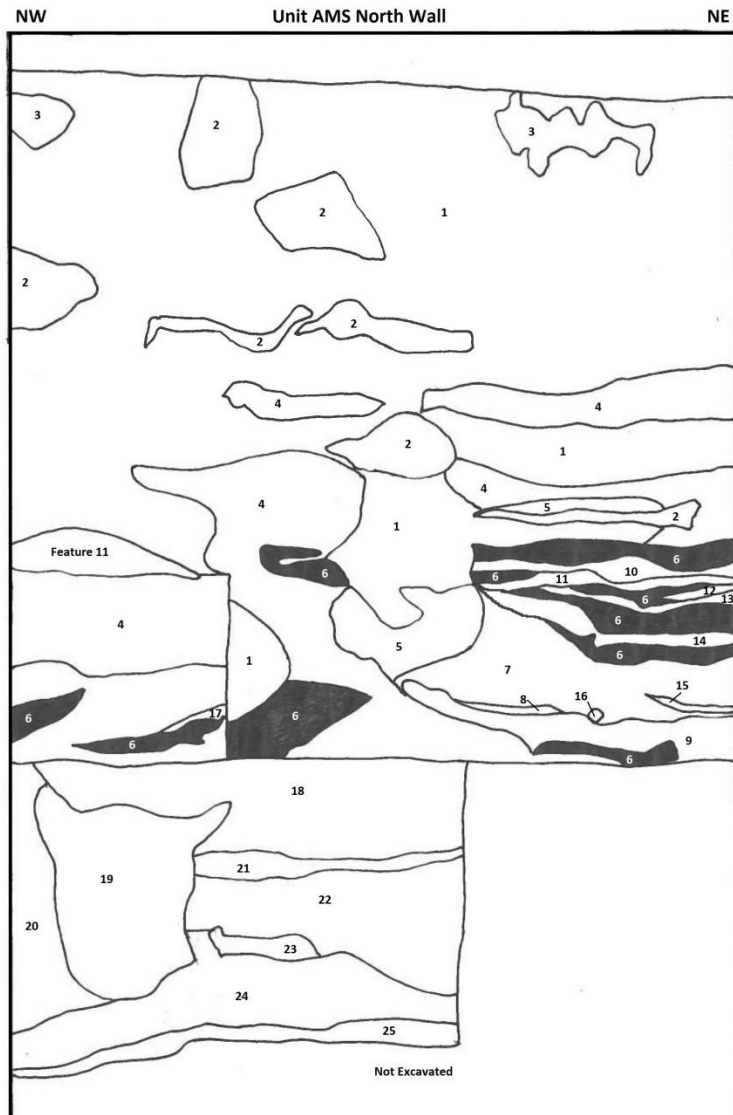
As at Tato à Sanouna, the cultural sequence at Thièl corresponds very well with the three major phases documented at Jenné-jeno. Occupation was continuous across these phases. A conventional radiocarbon date from the lowest levels in Unit GTC dates to between 2300 and 1835 cal BP. The topmost levels in both units were disturbed by eight more recent human

burials. Orientation of the bodies was not uniform, but the remains were set aside and then reinterred without analysis based on the possibility that they were Muslim burials. It is accepted practice in the area to excavate pre-Islamic, but not Islamic burials. Aside from these burials, the site appears to have been abandoned roughly contemporaneously with Jenné-jeno around CE 1400. Figures 3.19 through 3.22 document the stratigraphy of Unit AMS and Tables 3.7 and 3.8 outline the occupation levels in the two units.

Phase	Levels	Characteristics
IV/V Mix	1-5	Mixed layer with five intrusive human burials; strong bioturbation throughout this layer, including old termite holes
IV	6-19	Relatively homogenous layer with no architectural features, but numerous ashy lenses; two clearly-delineated pits excavated, one of which contained a statuette and pedestaled bowl (F.8), apparently intentionally interred
III Late	20-29	Habitation and burial area; artifacts found in low to moderate quantities; exact relationship between wall (F.12) and child burial (F.14) is unclear, but were possibly contemporaneous
III Early	30-35	Artifact rich levels with no architectural features; funerary jars (F.15, 16) probably intrusive from late Phase III deposits above
I/II	36-43	Artifact rich levels with no architectural features; some mixing from jar interments possible; sterile sand found below ash lens in Level 42

Phase	Levels	
IV/V Mix	1-3	Mix of Phase IV deposits and three intrusive Ph. V burials (partial remains only); two mud brick walls (F.1, 6) visible at or near surface; bioturbation and disturbance not as extensive as in Unit GTC
IV	4-10	Habitation area including an intact vessel and a mud-brick wall (F.7); relatively artifact rich
III/IV Transition	11-18	Habitation and burial area; mud brick wall (F.9) and three funerary jars (F. 10, 11, 13) are roughly contemporaneous
Late III Pit	20-21, 23, 28, 32, 35	Stratified ashy pit in NE corner of unit; possibly slightly disturbed by F.10 burial; artifact rich; furnace remains in lowest levels
III	19, 22, 24-27, 29-31, 33-34, 36-37	Heterogeneous soils with several burnt patches and moderate artifact quantities; layer disturbed by large animal burrow (excavated as levels 26, 30)
I/II	38-48	Artifact rich levels with large Twine 5 decorated pot <i>in situ</i> ; several burnt clay patches near top of unit; early midden in lowest levels above sterile sand

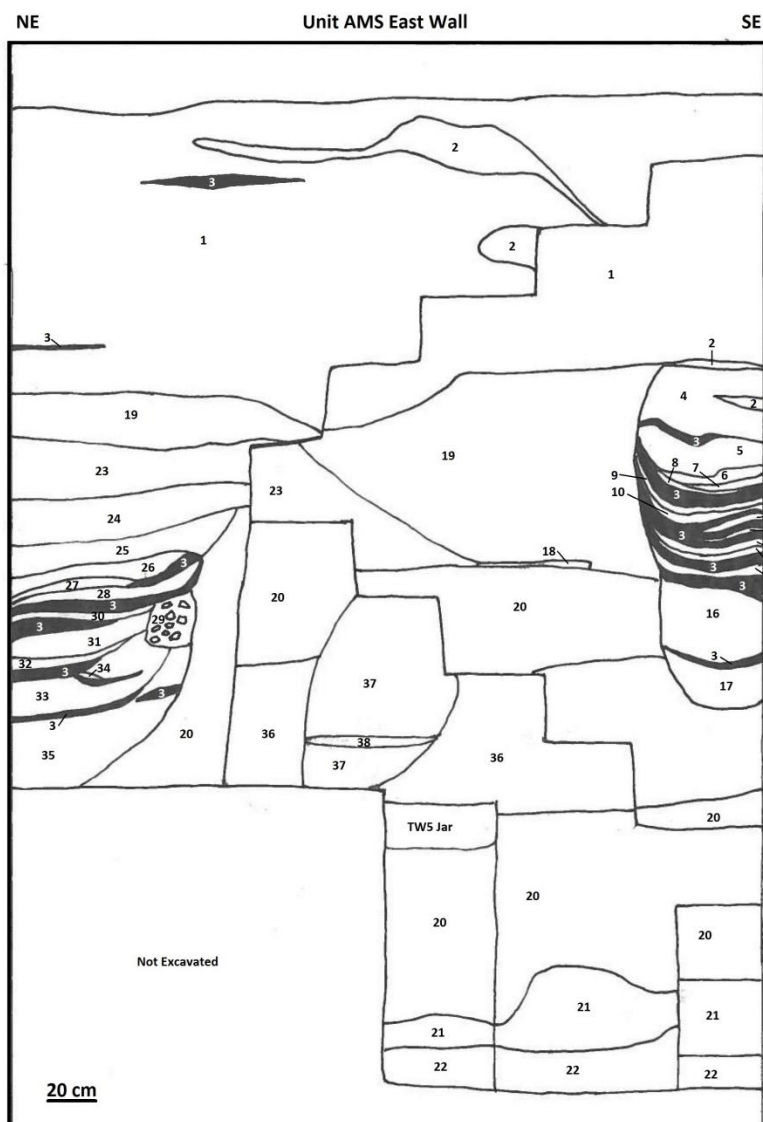
Figure 3.19 – Unit AMS North Wall Stratigraphy



Key to Unit AMS North Wall Stratigraphy

- 1 – Compact, heterogeneous, brown 10YR 5/3
- 2 – Friable, heterogeneous, pocket of sand 10YR 6/4
- 3 – Friable, heterogeneous, brown 10YR 5/3
- 4 – Compact, heterogeneous, brown 10YR 5/3
- 5 – Friable, pocket with pebbles, gray-brown 10YR 5/2
- 6 – Heterogeneous, ash lens, gray-black 10YR 5/1
- 7 – Friable, heterogeneous, gray brown 10YR 5/2
- 8 – Compact, heterogeneous, pale olive 5Y 6/3
- 9 – Compact, heterogeneous, light olive-gray 5Y 6/2
- 10 – Friable, ash pocket, light brown-gray 10YR 6/2
- 11 – Friable, heterogeneous, light brown 10YR 6/3
- 12 – Friable, pocket with visible rice hulls, heterogeneous, brown 10YR 5/3
- 13 – Very friable, pocket with visible rice hulls, heterogeneous, brown 10YR 5/3
- 14 – Friable, heterogeneous, pale olive, 5Y 6/3
- 15 – Friable, heterogeneous, light gray-brown 2.5YR 6/2
- 16 – Compact, homogeneous, nodules, light yellow-brown 10YR 6/4
- 17 – Friable, heterogeneous, mixed with sand, light brown, 10YR 6/3
- 18 – Compact, heterogeneous, brown 10YR 5/3
- 19 – Compact with friable portions, heterogeneous, brown, 10YR 5/3
- 20 – Compact, heterogeneous, brown 10YR 5/3
- 21 – Compact, flecks of charcoal, heterogeneous, brown 10YR 5/3
- 22 – Compact, heterogeneous, brown, 10YR 5/3
- 23 – Friable, heterogeneous, pocket of sand, brown 7.5YR 5/4
- 24 – Compact, heterogeneous, fine-grained sand, light yellow-brown 10YR 6/4
- 25 – Compact, heterogeneous, fine-grained sand, brown-yellow 10YR 6/6

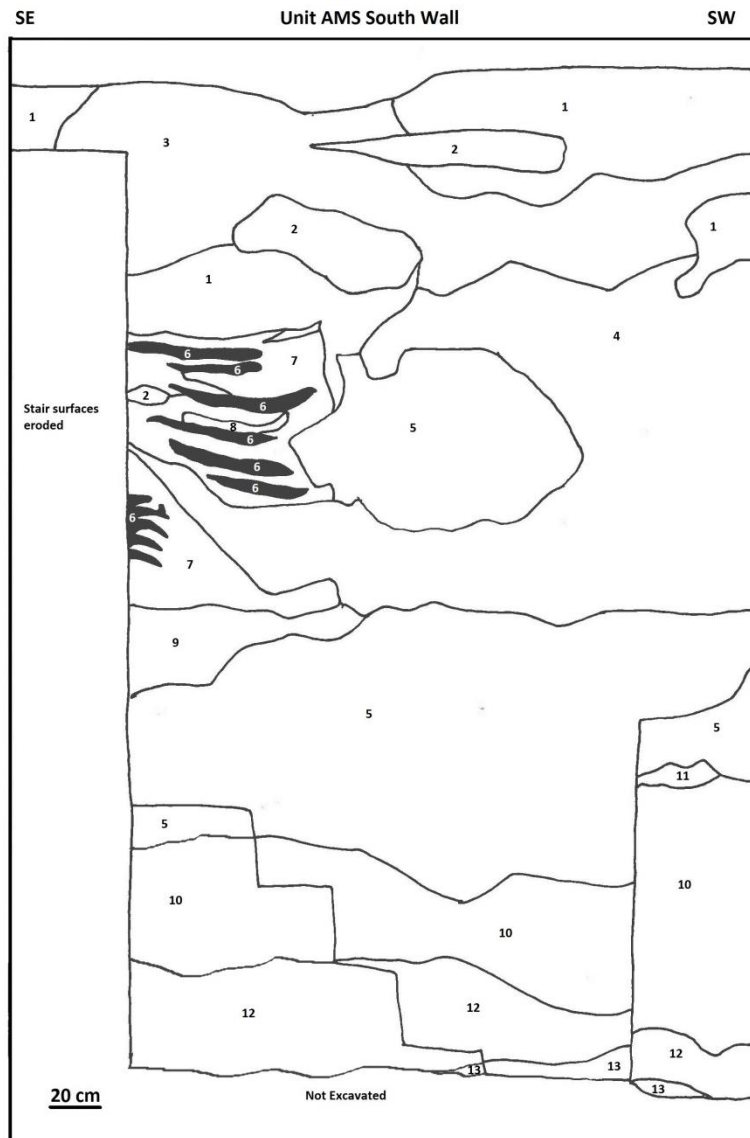
Figure 3.20 – Unit AMS East Wall Stratigraphy



Key to Unit AMS East Wall Stratigraphy

- 1 – Heterogeneous, grey 10YR 5/3
- 2 – Friable, wind-blown sand 5YR 5/3
- 3 – Burnt lens, 10YR 5/1, 10YR 2/1
- 4 – Friable, heterogeneous, gray 1-YR 4/3
- 5 – Compact, heterogeneous, olive 10YR 5/4
- 6 – Friable, homogeneous, gray 10YR 5/3
- 7 – Friable, heterogeneous gray 10YR 5/2
- 8 – Friable, homogeneous, pink 7.5YR 5/4
- 9 – Friable, heterogeneous, organics, 7.5YR 5/3
- 10 – Friable, heterogeneous, rice chaff, 10YR 4/4
- 11 – Friable, heterogeneous, organics, 10YR 4/3
- 12 – Friable, heterogeneous, rice chaff, 7.5YR 5/4
- 13 – Friable, homogeneous, pink 7.5YR 5/3
- 14 – Friable, heterogeneous, organics, 10YR 4/2 and 10YR 6/2
- 15 – Friable, homogeneous, pink 7.5YR 5/4
- 16 – Homogeneous, olive, 10YR 5/4
- 17 – Friable, homoteneous, white 7.5YR 6/2
- 18 – Compact, homogeneous, pink 7.5YR 6/4
- 19 – Compact, heterogeneous, olive-gray 5Y 5/3
- 20 – Compact, heterogeneous, gray 10YR 5/3 and 10YR 4/4
- 21 – Friable, heterogeneous, sand and soil, 7.5YR 6/8 and 5/4
- 22 – Friable, pure sand, orange, 7.5YR 6/8
- 23 – Compact, white-gray 10YR 6/3
- 24 – Compact, olive-gray 2.5Y 5/4
- 25 – Heterogeneous, grey 10YR 5/3
- 26 – Friable, organics, gray, 10YR 4/3
- 27 – Friable, white ash, 10YR 6/2
- 28 – Friable, homogeneous, gray 10YR 5/4
- 29 – Compact, gray with large sherds, 10YR 5/3
- 30 – Homogeneous, gray 2.5Y 5/3
- 31 – Friable, gray 10YR 4/2
- 32 – Friable, olive 5Y 5/4
- 33 – Friable, olive gray 2.5Y 5/3
- 34 – Friable, gray organics 10YR 5/1
- 35 – Compact, olive, 2.5Y 5/4
- 36 – Compact, light olive 2.5Y 5/4
- 37 – Friable, heterogeneous, white, 10YR 7/3 and 6/3
- 38 – Friable, rice chaff, white, 10YR 8/1 7/1

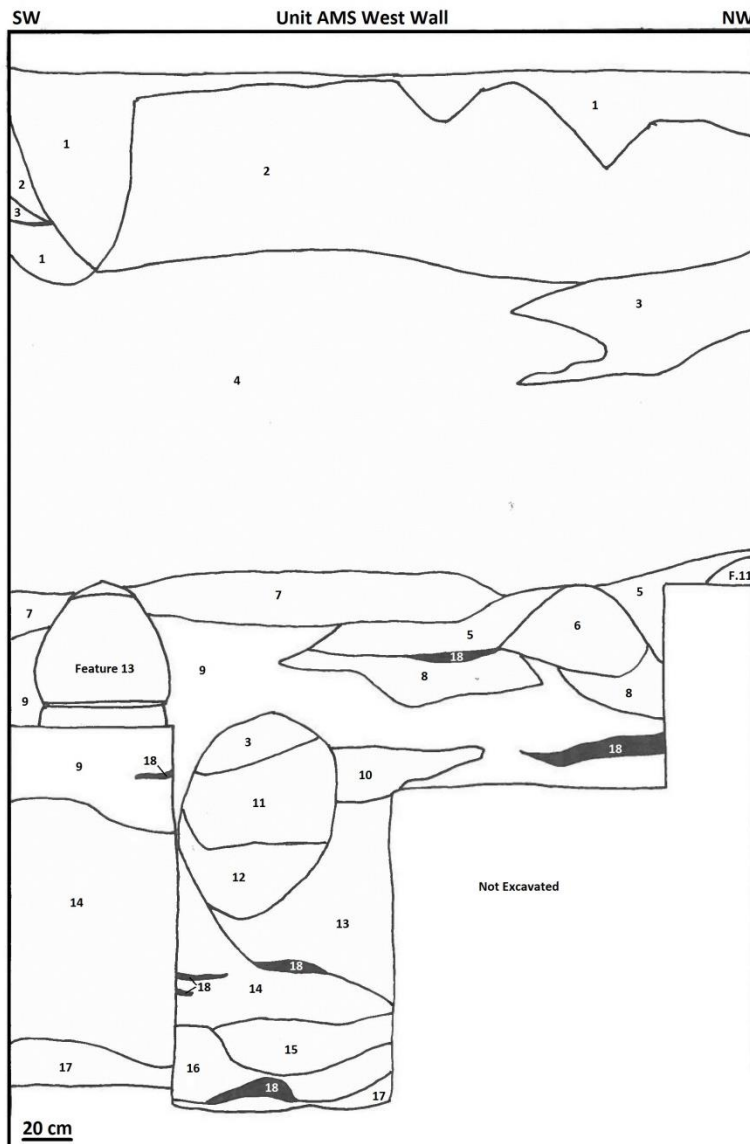
Figure 3.21 – Unit AMS South Wall Stratigraphy



Key to Unit AMS South Wall Stratigraphy

- 1 – Friable, heterogeneous, brown 10YR 5/3
- 2 – Friable, heterogeneous, pocket of sand, light yellow-brown 10YR 6/4
- 3 – Compact, heterogeneous, brown 10YR 5/3
- 4 – Compact, heterogeneous, brown 10YR 5/3
- 5 – Compact, heterogeneous, light olive-brown 2.5Y 5/3
- 6 – Heterogeneous, ash lens, gray-black 10YR 4/3
- 7 – Friable, heterogeneous, brown 10YR 5/3
- 8 – Friable, heterogeneous, burnt band with white ashes, pale brown 10YR 6/3
- 9 – Friable, heterogeneous, very light gray-brown 10YR 6/2
- 10 – Compact, heterogeneous, brown 10YR 5/3
- 11 – Compact, heterogeneous, light yellow-brown and brown 10YR 6/4, 10YR 4/3
- 12 – Friable, sand pocket with clay flecks, heterogeneous, light yellow-brown 10YR 6/4
- 13 – Compact, heterogeneous, brown-yellow, 10YR 6/6

Figure 3.22 – Unit AMS West Wall Stratigraphy



Key to Unit AMS West Wall Stratigraphy

- 1 – Friable, heterogeneous, sandy, dark brown 10YR 4/3
- 2 – Friable, heterogeneous, gray 10YR 5/3
- 3 – Friable, wind-blown sand, red-brown 5YR 5/3
- 4 – Compact, heterogeneous, gray 10YR 4/4
- 5 – Friable, heterogeneous, gray 10YR 6/3
- 6 – Friable, homogenous, olive 2.5Y 5/3
- 7 – Heterogeneous, gray-brown 10YR 5/4
- 8 – Heterogeneous, gray 10YR 5/2
- 9 – Friable, olive 5Y 5/3
- 10 – Compact, heterogeneous, olive-gray 10YR 6/2
- 11 – Compact, heterogeneous, olive-gray 2.5Y 5/4
- 12 – Friable, heterogeneous, gray 10YR 4/3
- 13 – Heterogeneous, white-gray, 10YR 5/3
- 14 – Heterogeneous, gray, 10YR 4/3
- 15 – Heterogeneous, light olive-brown 2.5Y 5/3
- 16 – Heterogeneous, gray-green 2.5Y 4/2
- 17 – Friable, sand, yellow 10YR 7/6
- 18 – Ash lens, black

Architecture

In general, the architectural features excavated at Thièl follow the trends seen at both Jenné-jeno and Tàto à Sanouna: cylindrical mud brick walls in Phase IV and pressed-earth *banco* walls in Phase III (see Table 3.9 below). Several burnt clay lumps in Phase I/II deposits of GTC could be related to the wattle and daub construction characteristic of that period.

Unit	Phase	Feat #	Associated Levels	Type	Description
AMS	IV	1	1, 2	Mud-brick wall	Partial rectilinear wall made of cylindrical mud bricks; two bricks wide; bricks ~12 cm in diameter
AMS	IV	6	2	Mud-brick wall	Partial rectilinear wall made of cylindrical mud bricks; two bricks wide; bricks poorly defined
AMS	IV	7	8, 9	Mud-brick wall	Partial curvilinear wall made of cylindrical mud bricks; four bricks wide; bricks ~8-12 cm in diameter; two grindstones and plated remains of five vessels immediately SE of the wall; burnt orange floor below all
AMS	III-IV trans.	9	16 - 18	Mud-brick walls	Two walls of partial rectilinear structure made of large, cuboid mud bricks (16x23x8 cm); two bricks wide; bricks 16x23x8 cm; lots of hard wall-fall to west of the structure
GTC	Late III	12	21, 22	Packed earth wall	Wide (~55 cm), poorly-defined curvilinear, packed earth wall; evidenced by hardened earth and rice chaff; white ash lens on part of NE side

Inhumations

We uncovered seven burials at Thièl, not including the nine intrusive burials from the upper levels (see Table 3.10). Two urns extended far into the unit profile and were thus not excavated. Preservation of the excavated burials ranged from moderate to extremely poor. I determined age and sex, where possible, using the standards listed in White (2005).

Unit	ID	Phase	Type	Preservation	Age	Sex	Grave Goods	Notes
AMS	F. 10	III to IV trans.	Urn	Poor	30-35 years	Indt.	None	Large jar with smaller, inverted jar as cover; empty except for powdered adult bones at bottom and old termite trails; parallel tibias suggest primary internment, though poor preservation makes determination difficult
AMS	F. 11	III to IV trans.	Urn	Unopened	Indt.	Indt.	Indt.	Large horizontal jar oriented E-W with base in east; jar heavily cracked, but intact; not opened because extended into W and N profiles
AMS	F. 13	III	Urn	Unopened	Indt.	Indt.	Indt.	Large, squat jar inverted over second jar; human bones visible inside through crack; unexcavated because extended into west profile
GTC	F. 14	Late III	Urn	Poor	5-7 years	Indt.	Indt.	Small (48 cm from top of lid to base) jar with simple lid; empty except for juvenile bones at bottom cemented into termite-made matrix; bones powder when removed, so not fully excavated
GTC	F. 15	Early III	Urn	Moderate	40-55	Male	Iron circlet and other frags	Large, squat jar inverted over larger jar; empty except for single set of adult human bones and iron objects; bones friable but intact; interment apparently primary; flexed position, though head fell as body decomposed; large number of fragmentary iron objects with bones
GTC	F. 16	Early III	Urn	Moderate	30-50 years	Female	3 gourd-shaped bottles	Large, squat jar inverted over two larger stacked jars; base of middle jar broken; two sets of adult human remains recovered from bottom jar, one presumably from the collapsed middle jar; three finely decorated, red-slipped, gourd-shaped vessels grouped around the lip of the middle jar
					40-50 years	Female		
GTC	F. 17	I/II or Early III	Inhumation	Very Poor	30-40	Indt.	None	Poorly preserved human remains in Phase I/II deposits, but adjacent to F.16 burials, so possibly related to or disturbed by the double urn inhumation

Metals and Metallurgy

A single copper ring (20.7 g, 28mm diameter) was recovered at Thièl in Early Phase III deposits from Unit GTC. The ring was found immediately adjacent to Feature 15, a jar inhumation, but its relationship to that burial is indeterminate. Decorative copper artifacts and crucibles used in copper production were recovered at Jenné-jeno (McIntosh 1995a), but were completely absent from Tato à Sanouna. There is no evidence for onsite copper working at Thièl.

As at Tato à Sanouna, iron was used for both decorative objects (rings and bracelets) and utilitarian items (fish hooks, nails, blades). 75 iron artifacts totaling 526.5 grams were found in depositional contexts from throughout the site's occupation, though in relatively low frequencies outside of burial deposits. A fragmented iron circlet from the Feature 15 burial accounts for over 20% of the site's iron, by mass. This scarcity corroborates the idea, suggested by the paucity of iron artifacts at Tato à Sanouna and Jenné-jeno, that iron was a valuable resource that was carefully conserved and reused.

Although no *in situ* furnace bases were excavated at Thièl, the quantity of iron slag, including five concentrations where slag was attached to fragments of ceramic furnaces, attests to the fact that iron was worked at the site. 4.4 kg of iron slag were recovered from Units AMS and GTC. Nearly 85% of this by mass comes from Phase I/II and III deposits. This mirrors the trend seen at Tato à Sanouna of a decrease in iron production refuse in Phase IV deposits. Given the tiny fraction of the sites excavated, it is difficult to determine whether iron working activities actually declined at the sites through time or whether this is simply the result of a biased sample. It is clear, however, that iron working was practiced throughout the occupational sequence, if possibly in lower levels in later phases.

Ceramics:

Over 283 kg of sherds were recovered in Units AMS and GTC, not including funerary urns and several *in situ* pots protruding from the unit profiles. Body sherds and feature sherds (rims, bases) were again analyzed separately.

In total, we recorded 3,718 body sherds. As at Jenné-jeno and Tato à Sanouna, changes in popularity of several classes of twine décor closely reflect shifts in archaeological phases. The popularity of accordion-plaited strip roulettes (Twine 4/5) in Phase I/II and the increased use of braided twine roulettes in Phase IV décor can be clearly seen in Figure 3.23 below:

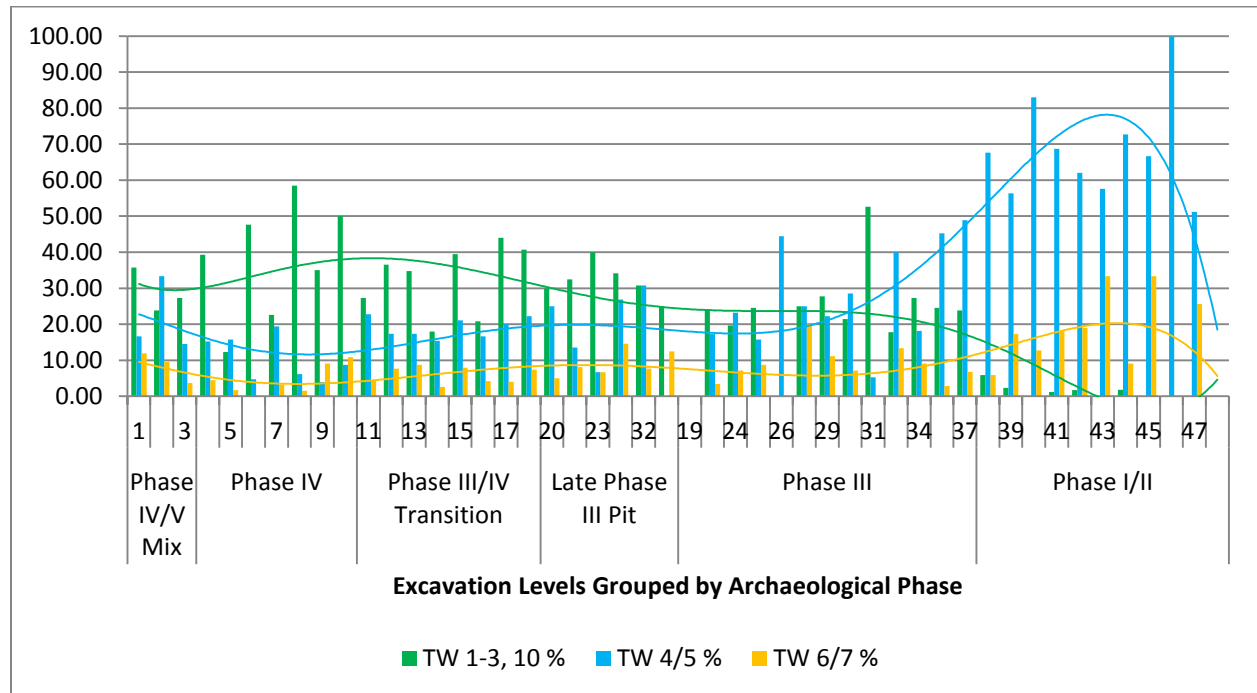


Figure 3.23 – Common body sherd décor in Unit AMS, graphed by percentage of assemblage by level

Ceramic form and décor at Thièl were generally similar to that at Jenné-jeno. I noted several slight differences, such as a high percentage of thick-walled, coarsely tempered sherds, in my field notes, but unfortunately feature sherd analysis remains incomplete so these variations cannot be quantified.

Stone:

As at Tato à Sanouna, the only stones recovered at Thièl were a small number of ground stone tools. Excavations at Thièl uncovered 30 pieces of ground sandstone weighing 17.3 kg and distributed relatively evenly across occupational phases. There was greater variability in the size of stones recovered at Thièl; they averaged 577 g with a standard deviation of 1131.2 g. A single stone from Phase I/II levels in Unit GTC weighed 6.3 kg, but even excluding this stone, the average mass and standard deviation was much higher than at Tato à Sanouna. It is possible that ground stone tools served a wider variety of functions at Thièl than at Tato à Sanouna, but given the small numbers represented in the sample, this disparity is equally likely to be the result of sampling bias. As at Tato à Sanouna, over 60% of the stones at Thièl had traces of red or orange pigment, suggesting their use in grinding ochre for ceramic slip and other decorations.

Middens and Hearths:

In contrast to the situation at Tato à Sanouna, middens and ash concentrations were found in all phases at Thièl (see Table 3.11). This resulted in a much more balanced picture of botanical and faunal use than at the former site where Phase III assemblages dominated. Indeed, two shallow middens in the very earliest levels of both Unit GTC and AMS provide a picture of diet for the very earliest inhabitants of the site. Although several burnt patches and ash lenses were excavated, no clearly-defined hearths were identified.

Unit	Phase	Associated Levels	Description
GTC	IV	13, 15, 17, Feat. 8	Two shallow pits (ca. XXX cm deep and 1.5 m diameter) associated with the Feature 8 statuette; Good botanical preservation; possible ritual deposit
AMS	III to IV Transition	12, 13	Ash pockets or small, poorly-defined midden; moderately good botanical preservation
AMS	Late III	20-21, 23, 28, 32, 35	Deep, stratified midden extending ca. 1 m into the NE corner of the unit; good botanical preservation in several levels; furnace remains at bottom of pit
AMS	I/II	38, 39	Burnt clay lenses; good botanical preservation
AMS	I/II	43, 44, 47	Small midden in SW corner of unit immediately overlying sterile dune sands; good botanical preservation
GTC	I/II	42	Large, poorly defined midden or ash lens immediately overlying sterile dune sands; good botanical preservation

Botanical Remains:

Botanical remains from Thièl were slightly more poorly preserved than in Units CTR and CE at Tato à Sanouna. 23 of 108 (21%) flotation samples contained no charred remains. As mentioned previously, the uppermost levels in both units contained more recent, intrusive burials and were strongly impacted by bioturbation. Plant remains from these levels could thus date to either Phase IV or the Phase V interment event, and are discounted in the analysis below.

As at Tato à Sanouna, grass species account for well over half of the identified categories. Rice, fonio, and millets again dominate the assemblage. In Phase I/II African rice (*Oryza* sp.) is the most ubiquitous species at 88%, followed by millet and sorghum (*Pennisetum glaucum*, *Pennisetum* sp., *Sorghum* sp.; presence combined) at 63%, and fonio (*Digitaria* sp.) at 44%. In Phase III all three are represented relatively equally. By Phase IV, millets are the most ubiquitous category at 42%, with rice nearly as frequent at 37%, and fonio falling to only 21%

ubiquity. Phase IV samples were, in general, much less rich than those from Phases III and I/II, which could partially account for these shifts. Other wild grains, including *Panicum* sp., *Paspalum scrobiculatum*, and *Setaria* sp., were present in low numbers, particularly in Unit AMS.

A variety of non-grass herbaceous species, including *Commelina* sp. and *Portulaca foliosa*, were identified, but none were particularly common. The only identified fruit remains at Thièl are three fragments of *Vitex* sp. shell found in mixed deposits at the top of Unit GTC.

Overall, the analyzed samples attest again to the centrality of African rice, fonio, and pearl millet in diet, with rice dominating the earliest assemblages. *Pennisetum* millets were more ubiquitous and more consistent through time at Thièl than at Tato à Sanouna.

Faunal Remains:

As at Tato à Sanouna, fish species dominate the faunal record at Thièl. Mammalian remains account for only 12% of identified specimens. Preservation of mammalian bone is particularly poor at Thièl, with calcium leaching affecting most specimens. Teeth were again amongst the only elements that could be securely classified to genus, and again only domestic bovids were identified. Even more starkly than at Tato à Sanouna, cattle clearly predominate at Thièl: 18 teeth (MNI = 10) were securely identified as *Bos* sp. while only three caprine teeth, all *Ovis aries*, (MNI = 2) were found. The small numbers represented here mean that the high percentage of cattle teeth could simply be a matter of sampling bias; at Jenné-jeno MacDonald found wildly divergent species counts in contemporaneous deposits in adjacent units (MacDonald 1995).

Siluriformes (especially *Clarias* sp., *Clarotes* sp., and *Synodontis* sp.) clearly dominate the fish assemblage, though Tilapini and *Lates niloticus* were also significant. The importance of shallow water species like Tilapia and Clariid catfishes is unsurprising given the numerous shallow basins and creeks surrounding the site. Several large *Lates niloticus* elements, however, affirm that the site's occupants also exploited open water habitats or traded with those who did.

Very small numbers of bird, reptile (principally Testudines), and freshwater bivalve shell were found in the assemblage, but were not identifiable to species.

The faunal remains at Thièl suggest a subsistence economy focused on aquatic resources, but exploiting a range of habitats from shallow marshes to open water (see Figures 3.24 and 3.25). This variety could be largely the result of seasonal fluctuations in water levels: at the height of the floods in October through December the site becomes an island surrounded by shallow to medium-depth waters, which might be deep enough for medium to large open water species to access. During the rest of the year the shallow basins and marshes surrounding the site would be more amenable to shallow water species. This same flood regime makes it unlikely that large numbers of domestic stock could have been kept at the site year-round. During the wet season the site would have been too cold and wet for successful, large-scale husbandry, but the area would have been suitable for herds during most of the dry season. It seems possible that Thièl's inhabitants traded for the cattle and sheep found at the site or raised small numbers of animals as a non-primary resource.

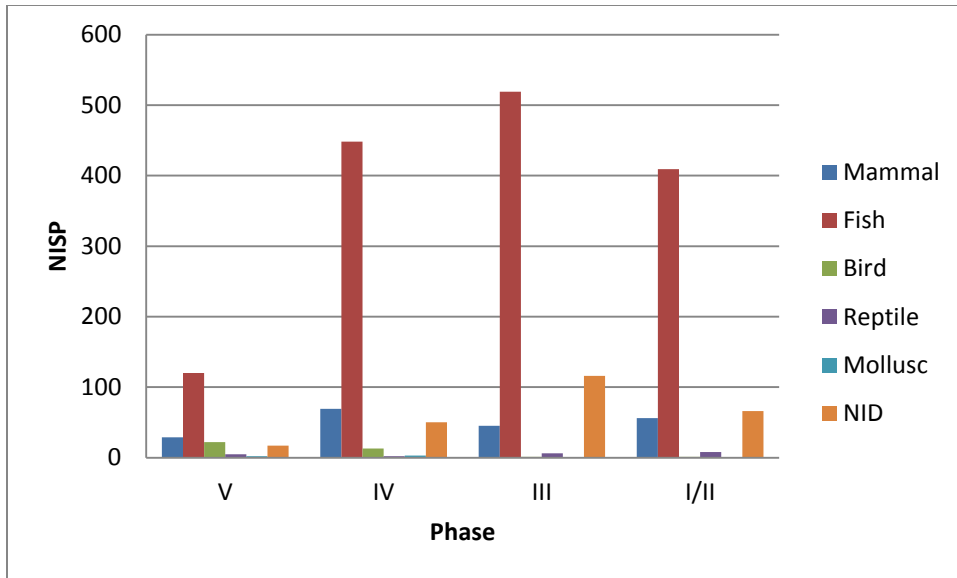


Figure 3.24 – Fauna (NISP) by class at Thièl, presented by phase

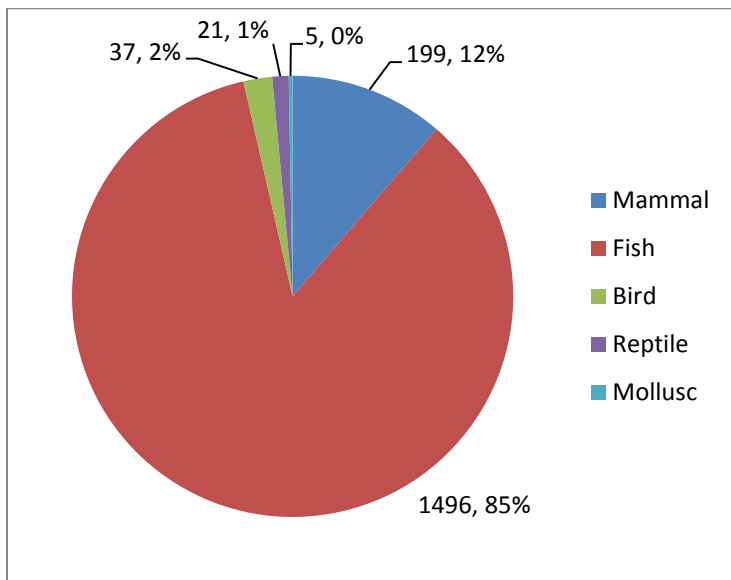


Figure 3.25 – Fauna (NISP) by class at Thièl for entire assemblage

Site Development and Space Use

The fact that the two units excavated at Thièl were positioned only ten meters apart limits our understanding of intra-site variability and site development. The units, particularly GTC, were located at the highest point on the mound, so it is possible that settlement was most extensive on that part of the site, but this is not confirmed. As at Tato à Sanouna, burials at Thièl were frequently associated with habitation areas. The use of much of the site for millet and

sorghum cultivation in recent years obscures many surface features, but the scatter of iron slag suggest that metallurgical activities were not restricted to a specific area of the site. The surface of the northern portion of the site contains numerous walls and is extensively covered with wall-melt. This could indicate that habitation was particularly dense in this portion of the site during the final occupation period, but more excavation would be required to say this for sure.

3.4 Discussion

3.4.1 Culture History

Building culture history is an essential first step in archaeological field research. Due to a dearth of research, in many parts of Africa regional chronologies are based on only a handful of sites and their broader applicability is uncertain. Though a number of sites around Jenné-jeno have been excavated or surveyed (Clark 2003; DNCR 2007; McIntosh 1995a; McIntosh and McIntosh 1980a, b), the local chronology rests almost entirely on excavations at Jenné-jeno. The excavations at Tatoro à Sanouna and Thièl thus represent an important test of the broader applicability of these chronologies and a measure of the degree of regional variability in such things as settlement occupation, subsistence regimes, and artifact typologies.

A significant contribution of this work to our understanding of IND culture history is the evidence that early occupation (Phase I/II: 250 BCE – 400 CE) was widespread in the area. Both sites excavated as part of this project have significant Phase I/II occupation levels, which raises the possibility that many, if not most of the hundreds of nearby sites were occupied from this early period. Previously, Jenné-jeno and Hambarketolo, which is immediately adjacent, were the only sites known to have been occupied during this initial phase (aside from an early hearth, Kaniana's occupations begin in Phase IV) (McIntosh 1995a). Without additional excavation at outlying sites it is impossible to know how extensive this early settlement in the upper IND was,

but it is clear that Jenné-jeno was not a solitary pioneering settlement. This in turn raises additional questions of how Jenné-jeno became the large market center that it appears to have been, if it is not simply on the basis of being the longest established settlement in the area.

Excavations at Tato à Sanouna and Thièl confirm that basic patterns in architecture and artifact form outlined at Jenné-jeno hold true for the wider area. Ceramic styles, iron artifacts and manufacture, and stone tool form and use are very similar at all excavated sites. Architectural remains uncovered in the course of this project corroborate the broad shifts in building practices seen at Jenné-jeno, with a few minor differences. Excavation of a rectilinear *banco* wall in Phase III deposits at Tato à Sanouna shows that rectilinear structures were known in the region prior to the widespread shift to rectilinear buildings in late Phase IV. Additionally, the rectilinear wall made of large cuboid mud-bricks in Phase III to IV transitional deposits at Thièl may simply be a local anomaly that is not reflected widely in the region. Alternatively, it could reflect an early step in the shift from packed-earth walls to cylindrical mud brick walls where small “bricks” of packed earth were used in construction. Similar cuboid mud bricks were used in wall construction in Iron Age deposits at Akumba A (Togola 2008:29-32), so this construction could represent a connection with populations in the Méma region. Although there was certainly interaction, and possibly loose cultural affinity, between the upper IND and the Méma during this period, the absence of other Méma-style artifacts at Thièl makes this kind of direct architectural influence somewhat unlikely. Overall, architectural traditions at Tato à Sanouna and Thièl are not markedly different from that at Jenné-jeno.

In terms of plant subsistence, the evidence from Tato à Sanouna and Thièl attests to a subsistence economy centered on African rice and supplemented by significant amounts of fonio (*Digitaria* sp.) and pearl millet (*Pennisetum glaucum*) from the earliest occupation on. In Jenné-

jeno samples from the 1981 season (McIntosh 1995b), *Pennisetum/Sorghum* is present from the earliest levels, but never rises above 25% ubiquity, and fonio only appears in significant amounts (22% ubiquity) in Late Phase IV deposits. Instead, a wild grass, *Brachiaria ramosa*, is the most ubiquitous species. *B. ramosa* is harvested and sold in markets today in the IND, and could have been cultivated in the past (McIntosh 1995b:351). *Brachiaria* sp. is only represented by four seeds at Thièl and is completely absent at Tato à Sanouna. This would seem to indicate a starkly different subsistence pattern between the latter two sites and Jenné-jeno. However, unpublished analysis of flotation samples from the 1997 and 1999 excavations at Jenné-jeno (Shawn Murray, personal communication, 4 May 2014) show a pattern much more akin to that found at Tato à Sanouna and Thièl than to the Jenné-jeno 1981 assemblage. Differing collection and identification practices may have had profound effects on the earlier Jenné-jeno assemblage, though the original *B. ramosa* identification was independently verified before publication.

Without further excavations with consistent recovery techniques, one can only say that African rice, fonio, and pearl millet were central to the plant diet of the region across a significant period of time. Other wild grains, including *B. ramosa*, were certainly gathered or cultivated as well, but their dietary importance is hard to gauge at this point. The evidence from Tato à Sanouna and Thièl does not point to any localized food preferences or specialized production.

As with the archaeobotanical assemblages, it is difficult to compare the relative importance of various animal species at Jenné-jeno, Tato à Sanouna, and Thièl due to differences in collection practices; screens were not used in excavations at Jenné-jeno, meaning that small species, particularly fish, could be underrepresented. It is safe to say, however, that aquatic resources, especially a diverse array of fish, were a primary component of diet at all three sites

throughout their occupation. Domestic bovids, particularly cattle, were present at all sites from the earliest levels, but, at least at Thièl and Tato à Sanouna, were of secondary importance to fish in diet. Material correlates of fishing, including harpoons, fishhooks, and net weights, are found at all three sites, suggesting that inhabitants of these sites were actively engaged in fishing rather than simply acquiring them through trade (see Figure 3.26). The most marked difference between the faunal assemblages at Jenné-jeno, Tato à Sanouna, and Thièl is the dearth of wild bovids and birds at the latter two sites. This could again be due to a biased sample given the small sizes of the faunal assemblages at these sites, particularly in the early phases (wild bovids were most plentiful in Phase I/II deposits at Jenné-jeno), but it could also represent localized food procurement practices.



Figure 3.26 - Fishing-related artifacts from Tato à Sanouna and Thièl: a. Harpoon, Unit SO Lev. 13; b. Fishhook, Unit AMS Lev. 28; c. Possible net weight, Unit CE Lev. 18; d. Fishhook, Unit AMS Lev. 28; e. Possible net weight, Unit GTC Lev. 6 (images Photoshopped to darken background)

Of interest to our understanding of subsistence is a shift in vessel size over time seen in Unit CE rim sherds. Rims from early Phase I/II levels had an average diameter of 22.8 cm, while

early Phase III sherds averaged 32.8 cm (subsequent phases averaged between 31 and 35 cm). This increase in vessel size in early Phase III almost identically mirrors the trend documented at Jenné-jeno. Susan Keech McIntosh tentatively suggested that this size increase, along with a preponderance of simple, open bowls and a lack of evidence for fire blackening in Phase I/II pots, could denote a change in cooking practices: from grilling or roasting meats and baking unleavened bread in hearths in Phase I/II to stewing foods and porridges in later phases (McIntosh 1995a:157-161). The fact that this shift is found at Tato à Sanouna gives credence, at least, to the idea that the size increase is not simply the product of a biased sample, but instead reflects real changes in the production and use of pottery between Phase I/II and Phase III throughout the area.

In general, these excavations attest to broad similarities in material culture and subsistence amongst upper IND archaeological sites. The phases and chronologies established at Jenné-jeno are broadly applicable to the wider region.

3.4.2 Craft and Subsistence Specialization

Craft and subsistence specialization are, as mentioned previously, key to major theories of how the Jenné-jeno urban system functioned (R. McIntosh 1998, 2005; S.K. McIntosh 1999a). Clark explored the possibility that sites within Jenné-jeno's immediate vicinity were occupied by various specialized populations (2003). Through excavation of surface features at several of these sites she found a degree of inter-site diversity, but there was no conclusive evidence for the sorts of occupational specialists found in the area today and postulated in archaeological theories. Part of the motivation for excavating Tato à Sanouna and Thièl was to expand on Clark's work and search for evidence of specialization in the broader landscape around Jenné-jeno.

Today, various forms of craft production, particularly iron working and potting, are associated with specialists castes within or loosely affiliated with modern IND ethnic groups (Frank 2002; LaViolette 2000; Mayor 2011). Although ceramic and iron technologies have both been present in the IND for the past several millennia, it is unclear when either became a specialized craft. Frank argues that the widespread and consistent association of specialized potters and blacksmiths in contemporary Mande society suggests a certain antiquity for this relationship. In fact, it may be the emergence of blacksmithing technology that transformed pottery production from a domestic chore to a specialized craft (2002:125):

Indeed, if we can assume that it was the technology of iron production that necessitated the economic separation of smiths from the rest of society, it makes sense for their wives to have specialized in pottery production. The two crafts share parallel technologies of using fire to transform earthly materials (iron ore and clay). In addition, for both the busiest time of year is the end of the dry season, a time when those who rely on farming for a livelihood are spending long days clearing the fields. Thus it not surprising that pottery making and blacksmithing would become inter-related specialized crafts apart from farming.

If the specialized nature of potting and iron working is indeed longstanding, one would expect to find traces of specialized production in the archaeological record, including areas of intensive production, spatial segregation of these activities, and broad uniformity of craft goods. Based on her ethnographic work with modern IND craft specialists, LaViolette suggests evidence for specialized ceramic production in the archaeological record may be difficult to find due to the perishable nature of many of the key tools and the absence of exclusive pottery work spaces (1987:350). However, items like pots filled with clay, clay or stone pounders, and firing sites would be archaeologically visible evidence for ceramic production, though tying them to specialized production could be tricky. The material indications of iron production, including burnt orange fire pits containing high quantities of charcoal and accompanied by iron or iron

slag, are likely to be more readily discernable than those for potting. Evidence for multiple, contemporaneous furnaces would indicate iron production beyond the level of an individual producer (LaViolette 1987:347).

Once signs of ironworking or potting activities are identified, their placement within a site could indicate the relationship of the craft producers to the general population. If, as Frank suggests, the economic and social separation of blacksmiths and potters is longstanding, one would expect the traces of their activities to be spatially segregated from the general population, either on separate sites or in discrete areas within a site. Finally, for either ceramic or iron objects, uniformity of form and materials could also indicate organized production (LaViolette 1987:348).

Given these proposed archaeological correlates, the excavations at Tato à Sanouna and Thièl do not provide strong evidence for specialized craft production. Although remains of small iron furnaces and iron slag provide direct evidence of on-site iron working activities at both sites throughout their occupations, the quantities of iron slag recovered from the excavated units and the relative scarcity of these furnaces suggest that iron working did not dominate the economy of either site. It is more likely that iron worked at the sites satisfied local demand rather than being sold to a broader market. Given the absence of iron ore sources within the IND (McIntosh 1995:381), any level of iron working at these sites attests to their involvement in long-distance trade networks.

There is no direct evidence of ceramic production, specialized or not, at either Tato à Sanouna or Thièl. The presence of ochre stains on over 60% of grindstones at Tato à Sanouna and Thièl, however, could indicate pottery production at both sites, since ochre was commonly

used in pottery slip. Ochre was likely used for various decorative purposes in addition to pottery slip, but its strong presence at both sites is somewhat suggestive of local pottery production.

The limited evidence for small-scale iron working (and possibly potting) at both sites suggests that craft production activities were not restricted to large, spatially-segregated workshops. Such workshops, which could still exist at any of the numerous unexcavated sites in the region, would be clear evidence of specialized craft production. This evidence of small-scale production is more difficult to interpret. On the one hand, it could indicate limited need-based production by the sites' inhabitants. On the other hand, it could represent the activities of itinerant, but specialized producers. LaViolette documented the activities of itinerant iron workers around Djenné in her ethnoarchaeological work in the 1980s (LaViolette 1987:325). These specialists give far flung villages access to essential craft goods and in return provide Djenné with a wider resource extraction area and a source of grain not grown by city residents themselves.

The broad similarity in material and form of craft goods excavated at Tato à Sanouna, Thièl, and Jenné-jeno is the only real indication of specialized craft production in the region. Uniformity of goods can also appear in situations with unspecialized production, however, so alone it is not definitive evidence. Overall, these excavations do not present any strong evidence either for or against the presence of specialized craft producers in and around Jenné-jeno at any point during the site's occupation.

In contrast to the craft production evidence, the faunal and archaeobotanical data demonstrate more clearly that subsistence at Tato à Sanouna and Thièl was not specialized. Although exchange of foodstuffs can mask specializations in food production/procurement

practices, truly specialized populations are still visible in the archaeological record when a certain type of food dominates the assemblage or when nearby sites have starkly differing remains (K. MacDonald and W. Van Neer 1994). At Tato à Sanouna and Thièl, African rice, fonio, and pearl millet were all crucial components of diet. Given their relative stability through time and the presence of suitable areas for their cultivation near the sites, it is probable that the sites' inhabitants engaged in much of this cultivation themselves rather than simply trading for it.

Faunal remains and artifacts show that inhabitants at both sites were actively engaged in exploiting aquatic resources, particularly fish. Domestic bovids, however, have a smaller, but ubiquitous presence in the faunal assemblage. It is possible that the sites' inhabitants were fisher-farmers who traded with neighboring populations for the occasional herd animal. The strontium isotopic data from these animals (discussed at length in Chapters 4 and 5) demonstrate that while some of these animals were in fact raised in other parts of the delta, others have very localized signatures. Either the inhabitants of these sites or their very near neighbors were engaged in small-scale animal husbandry.

The faunal and archaeobotanical data demonstrate that the inhabitants of these sites did not have the sort of specialized diets that you would expect from subsistence specialists like those found in the delta today. The diversified assemblages at Jenné-jeno could have been the result of a strong market center attracting the assorted food products produced in the wider area. The presence of similar diversity at the smaller village sites of Tato à Sanouna and Thièl is more likely the result of non-specialized food production practices. At the very least, there is no compelling evidence for specialized subsistence practices at either site.

3.4.3 Population Heterogeneity

Site clustering is one of the most notable features of the anthropomorphic landscape around Jenné-jeno. Despite the fact that the borders of these sites shift over time due to hydraulic forces (Clark 2003), they do represent acknowledged boundaries on some level, as evidenced by the city wall erected solely around Jenné-jeno circa AD 900. Scholars argue that such visible spatial segregation in the midst of dense population aggregation must have had some sort of social meaning (LaViolette 1987:328; McIntosh 1999a). In fact, previous discussions of heterarchy at Jenné-jeno suggest that site clustering could be evidence that diverse groups were present within a limited area, with the physical separation of sites both reflecting and reinforcing social boundaries (McIntosh 1991, 2005). As Susan McIntosh said “Whoever these groups may have been and whatever their function within the complex of settlements around Jenné-jeno, the most salient point of the clustered pattern is the maintenance of spatial boundaries in the face of cheek-by-jowl proximity” (1999a:76).

A major part of these discussions was the idea that separate sites were occupied by various craft and subsistence specialists. The evidence from these and earlier excavations does not, however, suggest that separate mounds clustered around Jenné-jeno were occupied by occupational specialists. What then was the motivation for this clustered settlement pattern?

Despite the lack of clear evidence demonstrating craft or subsistence specialization, there are indications of a degree of population heterogeneity in the region in the past. This is hinted at in the ceramic assemblages at Jenné-jeno and in a comparison of burial forms across Jenné-jeno, Thièl, and Tato à Sanouna.

Although there is broad similarity in the pottery from the excavated sites, there is some evidence for the existence of multiple ceramic traditions in the area. At Jenné-jeno, a specific type of fine, thin-walled pottery (nicknamed chinaware) was diagnostic of Phase I/II deposits and absent in more recent levels. Despite the relatively rich Phase I/II deposits at Tato à Sanouna and Thièl, no chinaware sherds were recovered in excavation. Thus chinaware may represent an independent ceramic tradition restricted (within the region) to Jenné-jeno. Similar chinaware is known at early deposits at Dia (McIntosh 1995a:162).

Survey of archaeological sites in the area around Djenné attests to the use of common funerary practices, in the form of large ceramic funerary urns, throughout the region during Phases III and IV (McIntosh and McIntosh 1980b). These urn inhumations are not uniform: most are vertical, but some are horizontal; some are single- and others double-inhumations; some urns are capped with lids, others by inverted jars of variable size. This diversity does not seem to reflect temporal, spatial, gender, or age-based differences, but could, as LaViolette suggested, reflect a degree of population heterogeneity (1987:328), with differing forms indicating disparate identities on some level.

The urn burials at both Tato à Sanouna and Thièl fall clearly within the range of variability known from previous excavations and thus do not suggest markedly independent burial practices. Additionally, the variability displayed at Thièl (where contemporaneous urn inhumations were single, double, upright, and horizontal) shows that the diversity extends beyond Jenné-jeno to smaller, more distant sites. Interestingly, however, there are several small differences between the burials at Tato à Sanouna, Thièl, and Jenné-jeno. At Tato à Sanouna both excavated urn burials have large, flattened lids, while at Thièl all adult burials used large inverted urns as lids. This could indicate distinct local preferences for burial forms, but much

more excavation at these sites and others within the broader landscape is needed before we can securely identify any spatial patterning or infer social meaning from it.

The presence or absence of grave goods is a more intriguing indicator of social differences in the area. At Jenné-jeno, the vast majority of these urn burials contained no grave goods, which was cited as evidence for a lack of social stratification at that site (McIntosh 2005; McIntosh 1999a; McIntosh and McIntosh 1993). The presence of grave goods in both excavated urn burials at Tator à Sanouna and in two of the three fully excavated urns at Thièl is therefore somewhat surprising. These grave goods were not extravagant, but they do suggest that the social pressures that limited the use of grave goods at Jenné-jeno may not have been as salient at smaller, more distant sites.

The evidence from ceramics and burial forms does suggest a slight degree of inter-site heterogeneity. With the widespread similarity of artifact forms and the lack of clear evidence for subsistence and craft specialization at these sites, however, it is difficult to determine the social meaning behind these differences or their effect on urban configurations. Future excavations exploring the diversity of occupation within the area will help to answer this question with important implications for our understanding of the Jenné-jeno urban system.

3.5 Conclusions

This article outlined the findings from excavations that I conducted near Djenné, Mali in 2010 and 2011. This work demonstrates the broad similarity in settlement temporality, artifact forms, and subsistence regimes between sites in this region. The evidence from these excavations goes against theories suggesting that subsistence specialization was a critical element of the non-traditional urban configurations at Jenné-jeno. Although there is slight evidence for inter-site

differences in ceramic traditions and burial practices, these excavations leave open the question of how this heterogeneity relates to social boundaries and urban configurations.

Further excavation at sites of various scales around Jenné-jeno would greatly improve our understanding of the Jenné-jeno urban system. This work was planned to be the first in a series of excavations of small sites around Djenné, but return trips to Mali have not been possible because of the country's recent political problems. This situation has disrupted the progress of archaeological investigations in Mali, which are primarily funded by money brought in by foreign researchers. Our Malian colleagues are left without the means to conduct large scale excavations on their own or to protect sites from looting.

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Chapter 4 – Detecting Seasonal Herding Practices using $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ in Archaeological Teeth from an Urban West African Context

Abstract

Mobile populations are notoriously difficult to document archaeologically. Particularly in cases of dense population aggregation, the traces of mobile groups are frequently obscured, thereby limiting our understanding of the role of mobile populations in more sedentary contexts. This study uses isotopic evidence ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ in serial intra-tooth samples of enamel apatite) to document the presence of herders employing various scales of mobility at the Iron Age urban center of Jenné-jeno (occupied ca. 250 BC –AD 1400) in Mali's Inland Niger Delta. $^{87}\text{Sr}/^{86}\text{Sr}$ variability provides evidence for three major types of herd mobility in archaeological cattle, sheep, and goat teeth. This study demonstrates that analysis of intra-tooth samples can provide nuanced data about herd mobility and herding strategies, moving beyond basic classifications of mobile versus non-mobile or local versus non-local. The analysis of multiple isotopes and multiple teeth per animal, when possible, increases our understanding of the manifold ways animals were raised and exchanged within a dense urban context. This has important implications for our understanding of herding strategies and populations in the past and their role in densely-occupied areas.

Keywords

Pastoralism, urbanism, mobility, isotopes, seasonality, West Africa

4.1 Introduction

Mobile populations are notoriously difficult to document archaeologically. They move across the landscape leaving ephemeral traces and often favoring light, perishable goods that are not preserved in the archaeological record (but see Grillo 2014). In recent years archaeologists have made great advances in documenting mobile populations using such diverse approaches as landscape archaeology, ethnoarchaeology, zooarchaeology, geoarchaeology, and rock art analysis (e.g., Barnard and Wendrich 2008; Shahack-Gross, et al. 2004; Zeder 2006a). Despite the utility of these methods, mobile populations remain more difficult to document archaeologically than their sedentary neighbors, particularly in situations where mobile habitations cannot be located or are overwhelmed by larger sedentary populations.

Over the past decade, archaeologists have begun using serial, intra-tooth isotopic analysis to document patterns of seasonality and herd mobility in archaeological bovids. This method takes advantage of the fact that teeth form sequentially from the tip of the crown to the root over an extended period of time. In animals with hypsodont teeth, sequential samples down the length of the tooth provide a record of that animal's diet and life over the period of enamel mineralization (Balasse 2002; Zazzo, et al. 2005).

Recent work demonstrates the utility of serial, intra-tooth sampling targeting $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in identifying mobility patterns and birth seasonality in modern and archaeological samples from numerous geographic locales (Balasse, et al. 2012; Balasse, et al. 2002; Balasse, et al. 2003; Bocherens, et al. 2001; Fricke, et al. 1998; Henton, et al. 2014; Towers, et al. 2011). $^{87}\text{Sr}/^{86}\text{Sr}$ has been used for several decades to trace human and animal migrations, identifying individuals with local and non-local signatures (eg. Bentley 2006). More recently, scholars began to explore the utility of $^{87}\text{Sr}/^{86}\text{Sr}$ in delineating herd migrations using serial, intra-tooth sampling (R. Alexander Bentley and Corina Knipper 2005; Britton, et al. 2009; Chase, Meiggs, et al. 2014; Evans, et al. 2007; Hoppe, et al. 1999; Julien, et al. 2012; Meiggs 2007). This method allows us to trace seasonal movements in addition to single migration events.

Serial, intra-tooth isotopic analysis holds great promise for augmenting our understanding of mobile populations, particularly mobile pastoralists. Although individual mobile people and their settlements might be obscured in the archaeological record, traces of their movements and interactions are cemented in the isotopic signatures of their herds. The combined use of $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ across multiple molars from a single animal gives the best picture of mobility, though single teeth are also useful scales of analysis.

This study assesses the utility of serial, intra-tooth isotopic analysis in identifying mobile herding patterns over the past two thousand years in Mali's Inland Niger Delta. In this article I present a map of baseline biologically-available $^{87}\text{Sr}/^{86}\text{Sr}$ in and beyond Mali's Inland Niger Delta; I identify three discrete mobility strategies in archaeological cattle, sheep, and goat teeth from in and around the ancient city of Jenné-jeno using $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$; and I close with remarks about methodology in this still new approach and a brief discussion of how such analysis can inform our understandings of mobile populations and their role within large urban centers.

4.2 Background of the Inland Niger Delta and Jenné-jeno

The Inland Niger Delta (hereafter IND) is a complex aquatic environment created when the waters of the Bani and Niger Rivers fan out into a vast network of marshes, lakes, streams, rivers, levees, dunes, and grasslands. The IND currently extends over 32,000 km² in the otherwise semi-arid Sahelian zone of central Mali (Makaske 1998). Human populations have made use of this extremely productive environment for at least the past three millennia (MacDonald 1994) and the extensive fish, wild animals, farmland, and pasture found there today make it a vital resource for modern Malians as well. Seasonal flooding and deep permanent water resources make the IND a central element of the seasonal rounds of large numbers of modern Fulani and Tuareg herders, who rely on the IND for dry season water and pasture for their animals.

The site of Jenné-jeno, located in the southeastern corner of the IND (see Figure 4.1), is one of the earliest-known urban centers in West Africa. Occupied between 250 BCE and CE 1400, Jenné-jeno had wide-ranging local and regional trade connections and a large, cosmopolitan population (McIntosh 1998, 2005; McIntosh 1999a; McIntosh and McIntosh

1980a). Jenné-jeno and the subsequent town of Djenné became vital cogs in the emerging trans-Saharan trade, sending foods and other goods upriver to Timbuktu (McIntosh 1998:155).

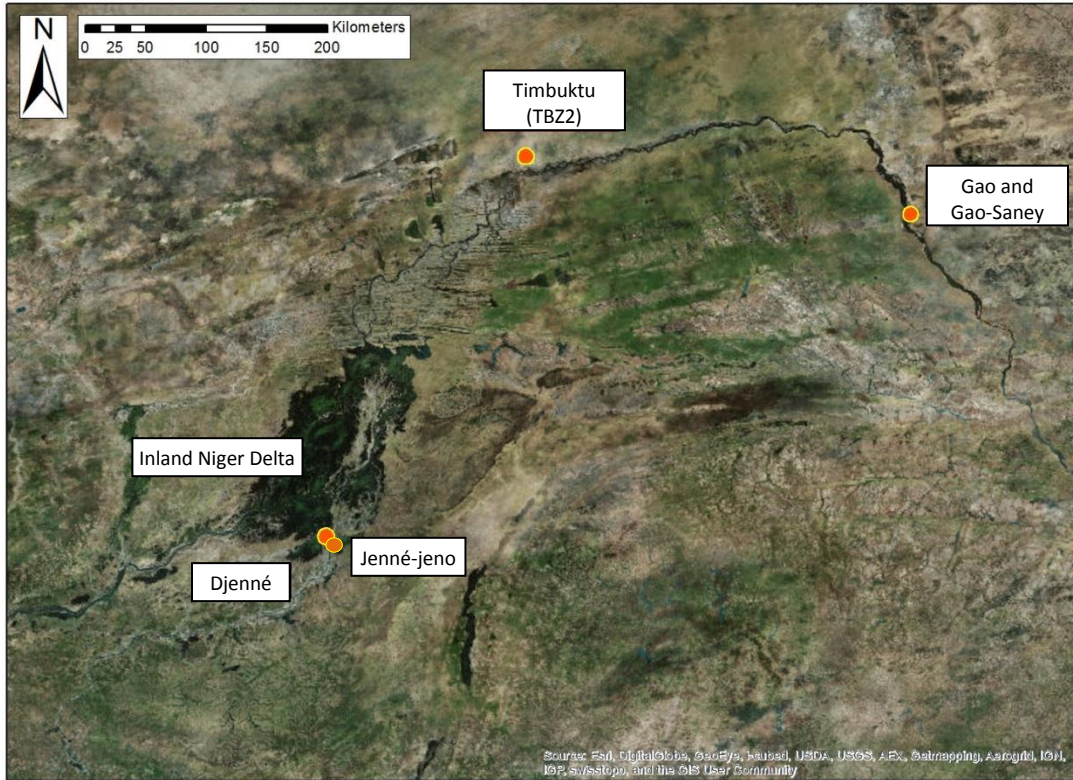


Figure 4.1 – Mali’s Inland Niger Delta, showing locations of sites mentioned in the text

Despite extensive excavations carried out at Jenné-jeno and a handful of neighboring sites since the late 1970s, which made important contributions to African archaeology and broader discussions about diversity of urban forms, much remains poorly understood. This analysis is the first stage of an investigation into the region’s animal economy, which has implications for understanding the integration of the urban market into local and regional trade networks and the nature of the urban population and their interactions with dispersed groups.

4.3 Samples and Methods

4.3.1 Baseline Samples

Before undertaking this study, the utility of $^{87}\text{Sr}/^{86}\text{Sr}$ analysis in the IND region was uncertain. A baseline map of biologically-available $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in the area was needed to show whether values varied enough to reveal mobility patterns and not so much that differences were meaningless. To create this baseline, I drilled bulk enamel samples from seven small animal teeth (including a rodent, several small carnivores, and a tiger fish), a stingray toothplate (cf. *Dasyatis garouaensis*, which is known from other portions of the Niger River system today), and one freshwater bivalve shell. Samples were excavated in and around the site of Jenné-jeno and represent both the terrestrial and aquatic environments (see Table 3.2 in section 3.5 for details). I also drilled serial, intra-tooth samples on teeth from a modern cow raised locally in the Gao area of northeastern Mali, an archaeological sheep from the site of Tombouze 2 near Timbuktu, and an archaeological *Kobus kob* from Hambarketolo, a site immediately adjacent to Jenné-jeno. Kobs are a highly water-dependent antelope species (IUCN 2008), and so this sample was included as a potential representative of the local aquatic environment. Ideally, I would have sampled more teeth from more locales to create this baseline, but the available archaeological samples were limited. However, these samples do provide a coherent preliminary picture of $^{87}\text{Sr}/^{86}\text{Sr}$ diversity in Mali, with an emphasis on the southeastern Inland Niger Delta.

To ease interpretation of mobility signatures in archaeological samples, I sampled teeth (8 teeth from 3 animals) from modern animals butchered in Djenné whose mobility patterns were known. These samples were intended to illustrate local and seasonally-mobile herding strategies.

4.3.2 Archaeological Cattle, Sheep, and Goat Samples

To gain an understanding of herd mobility patterns through time, I selected 40 teeth from 29 archaeological cattle, sheep, and goats, for serial, intra-tooth isotopic analysis. Samples come from excavations undertaken by Susan Keech McIntosh and Roderick McIntosh at Jenné-jeno (taxonomic identification by K. MacDonald) and Djenné (identification by C. Cain) and from excavations I undertook at two neighboring sites, Tato à Sanouna and Thièl (identified by me). Selected samples were readily identifiable to species, had lengths of intact enamel (occlusal surface to cervical margin), and were relatively free of cracks and discoloration. When multiple teeth from the same animal were available, these teeth were preferentially selected. For isolated teeth, I selected second and third molars (both upper and lower) in preference to first molars to avoid the confounding factors of weaning and maternal influence. Three isolated first molars were included from Tato à Sanouna because of the limited sample of complete bovid teeth available from that site. Samples represent a broad cross section of time and space, spanning 2000 years across the four archaeological sites (see Table 4.1).

Site	Phase	Date	Cows		Sheep/Goats	
			Animals	Teeth	Animals	Teeth
Jenné-jeno	I/II	250 BCE - CE 400	3	4	2	4
Jenné-jeno	III	CE 400 - 900	5	7	0	0
Jenné-jeno	IV	CE 900 - 1400	2	4	3	6
Tato à Sanouna	I/II-IV	ca. CE 200 - 1400	4	4	2	2
Thièl	I/II-IV	ca. CE 300 - 1400	1	1	2	3
Djenné	V	ca. CE 1400 - 1900	4	4	1	1

4.3.3 Drilling, Cleaning, and Running Samples

I cleaned and drilled all samples personally using the standard methods of the Environmental Isotope Paleobiogeochemistry Laboratory at the University of Illinois at Urbana-Champaign (see Balasse, et al. 2002):

Prior to drilling, I cleaned all samples using a carbide drill tip and then a diamond abrasive drill tip to remove foreign substances from the enamel surface. Under 10x magnification, I then drilled all samples using a 0.9 mm or 1.0 mm diameter diamond abrasive drill tip. To prevent cross contamination, the work area and drill tip were cleaned with alcohol and 1 M HCl between samples. I drilled sequential samples of enamel in horizontal bands (1-1.5 mm wide) every two to four millimeters along the length of the crown from occlusal surface to cervical margin, capturing successive periods of tooth mineralization (see Figure 4.2 for an example of a drilled tooth). The number of samples drilled per tooth varied according to the tooth's condition: older, worn teeth and young teeth with incompletely mineralized portions had the shortest lengths of usable enamel and consequently had the fewest samples drilled. Additionally, once results from an early subset of teeth demonstrated that more widely spaced samples adequately captured shifts in isotopic signatures, I moved to sampling every 4 mm instead of every 2 mm. Each enamel sample weighed approximately 10-12 mg.



Figure 4.2 - Modern *Bos* sp. third molar (3rd loph broken off) showing sequential sampling pattern and the relative ages of the samples

To minimize diagenetic contamination, I treated all drilled samples with a 50% Clorox solution to remove organics and with 1 M acetic acid to get rid of any absorbed carbonates prior to their analysis. I then divided the samples of this purified enamel apatite for $^{87}\text{Sr}/^{86}\text{Sr}$ analysis (4 mg) and $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ analysis (the remainder of the sample).

Samples intended for $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ analysis were run on a Kiel III device interfaced with a Finnegan MAT 252 isotope ratio mass spectrometer operated jointly by the Department of Anthropology at UIUC and the Illinois State Archaeological Survey. Six

standards (NBS 18 and 19) were run for every thirty-eight samples and sample values were corrected using deviation from known standard values.

I prepared samples for $^{87}\text{Sr}/^{86}\text{Sr}$ at the Isotope Geochemistry Laboratory in the Department of Geology at UIUC. Strontium was eluted using 0.2 ml of Eichrom Sr spec. resin in Teflon cation exchange columns, following lab methods outlined in Slater et al. (2014). Strontium measurements were performed on a Nu Plasma HR multi-collector inductively coupled plasma mass-spectrometer (MC-ICPMS). Blank samples showed minimal voltage, demonstrating a lack of cross contamination. Standards (NBS-987, coral, and E&A standard) were run every five samples and sample values were corrected for error and machine drift using deviation from known standard values.

4.4 Tooth development and mineral absorption

Numerous studies have shown the utility of isotopic analysis in archaeological studies. Briefly, these studies are based on the idea that a record of the various chemicals to which an individual is exposed throughout the period of bone or tooth development is preserved in that hard tissue. Bone is continuously remodeled, meaning that isotopic signatures in bone reflect the averaged signatures of the last several years of life. In contrast, tooth enamel is not remodeled, meaning that signatures reflect the discrete period of enamel secretion. Additionally, the high density, crystallinity, and low porosity of tooth enamel makes it highly resistant to diagenesis (Bentley 2006:167; Budd, et al. 2000; Hoppe, et al. 2003; Koch 2007:102; Lee-Thorp and Sponheimer 2003).

Archaeologists take advantage of the unique properties of tooth enamel to study diet and migrations in archaeological populations through analysis of several chemical isotopes, most

notably oxygen ($\delta^{18}\text{O}$), carbon ($\delta^{13}\text{C}$), and strontium ($^{87}\text{Sr}/^{86}\text{Sr}$). These elements are incorporated into enamel during the period of mineralization when they substitute for various chemical components of hydroxyapatite [$\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$], the primary mineral in tooth enamel (Humphrey, et al. 2008:6834). Oxygen and carbon are found in carbonate ions (CO_3), which can substitute for both the phosphate and the hydroxyl components in hydroxyapatite (Wright and Schwarcz 1998:4). Strontium substitutes for calcium in hydroxyapatite given their similar chemical properties. (Bentley 2006:137; Burton, et al. 2003:88; Smith and Tafforeau 2008:219).

The utility of these isotopes is related to their geographic and environmental variability. The specifics of this have been discussed extensively by others (e.g., R. A. Bentley and C. Knipper 2005; Bentley 2006; Montgomery 2010), but briefly: environmental concentrations of $\delta^{18}\text{O}$ are the result of differential fractionation of ^{18}O versus ^{16}O during the hydrological cycle. Precipitated $\delta^{18}\text{O}$ varies according to altitude, latitude, temperature, and distance away from the sea (R. A. Bentley and C. Knipper 2005:630). Likewise, during primary production in plants, fractionation results in different $\delta^{13}\text{C}$ values between plants with separate photosynthetic pathways, primarily C_3 and C_4 (R. A. Bentley and C. Knipper 2005:632). $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, which result from the slow decay of ^{87}Rb , reflect the age of underlying bedrock. Strontium is incorporated into the body through diet. Thus, these ratios reflect local geologic signatures encountered at the time of enamel formation (Bentley 2006).

Isotopic signatures found in hard tissues are not a one-to-one reflection of signatures found in drinking water and diet, and interpretation of isotopic values is rarely straightforward. Fractionation in the body has a significant impact on $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values (Ambrose 1993; Passey, et al. 2007; Passey, Robinson, et al. 2005; Podlesak, et al. 2008), which complicates efforts, for example, to calculate the exact quantities of C_3 or C_4 plants in an animal's diet,

particularly in the case of species with omnivorous diets. Additionally, while it is known that $^{87}\text{Sr}/^{86}\text{Sr}$ enters the body primarily through plant sources and that meat is only a minor contributor to the composition of bones and teeth (Burton and Price 2000), the incorporation of $^{87}\text{Sr}/^{86}\text{Sr}$ into the body may be more complicated than with $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$. These latter two elements are consumed in high quantities such that blood bicarbonate values and thus enamel apatite values are closely reflect dietary isotopes during the period of tooth development (Ayliffe, et al. 2004). Strontium, on the other hand, is relatively scarce in diet and is discriminated against in the gut, further reducing the level of strontium entering the bloodstream through dietary sources.

Strontium in the blood is affected by the continual process of bone remodeling, during which calcium and strontium are reabsorbed from bone into the bloodstream. Rates of bone remodeling and resorption are influenced by both age and injury to the skeletal system, but because of this process, $^{87}\text{Sr}/^{86}\text{Sr}$ values circulating in the blood reflect both recently consumed strontium and that ingested during the period that the recently resorbed bone itself developed. This means that $^{87}\text{Sr}/^{86}\text{Sr}$ values recorded in tooth enamel are affected by past as well as present strontium signatures. This sort of strontium reservoir effect is postulated by several others (Balasse, et al. 2002; Montgomery 2010:330), but experiments have not yet been performed to document turnover, time lags, and dampening. Reservoir effect is thus not regularly taken into account in archaeological studies using strontium. For a highly mobile animal, this pooling of past and current strontium might lead to a slight dampening in the amplitude of the curve seen in its strontium signatures. Nevertheless, $^{87}\text{Sr}/^{86}\text{Sr}$ values remain useful for tracing seasonal and lifetime mobility.

It is also important to note that individual intra-tooth enamel samples do not represent discrete points of time. Rather, each sample contains the averaged chemical signature of an indeterminate length of time (Balasse 2002, 2003; Montgomery 2010:33; Passey and Cerling 2002; Passey, Cerling, et al. 2005). Samples are, however, of known age relative to one another within a single tooth, with the youngest samples coming from near the cervical margin and the oldest closest to the occlusal surface. The total length of time represented by the series of samples taken from a single tooth varies according to tooth and species but is roughly 7-13 months (Balasse, et al. 2012:359; Balasse 2002:158; Brown, et al. 1960:15; Zazzo, et al. 2010:3574), for fully mineralized, but unworn teeth. First molars start forming in utero and therefore are influenced heavily by maternal signatures. Second and third molars mineralize during the first and second year of life, respectively, with some overlap (Balasse 2002:158).

4.5 Results

4.5.1 $^{87}\text{Sr}/^{86}\text{Sr}$ baseline and modern mobility signatures

The local landscape in the southern Inland Niger Delta is a complex matrix of dunes, levees, swamps, and rivers. Although the underlying geology is primarily Cenozoic sedimentary deposits, aeolian and aquatic forces have deposited significant sediments from far beyond the local area. Such forces are known to strongly impact biologically-available strontium in other world areas (Bataille, et al. 2012), so before this study, the range and variability of $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in the IND was unknown.

The strontium data show a clearly defined range of signatures: local samples cluster together and can be divided into discrete aquatic (Bani River) and terrestrial ranges. Furthermore, samples from the *Kobus kob* (a water-dependent species) suggest a secondary

water source close to Jenné-jeno, while teeth from Gao and Timbuktu on the edge of the Sahara have a significantly lower signature. Archaeological human tooth apatite from the Sahara in Niger and Libya ranged between 0.70975 and 0.71293 (Sereno, et al. 2008; Tafuri, et al. 2006), so the relatively elevated samples from Gao and Timbuktu may result from a mixing of Saharan desert and Niger River sediments. See Table 4.2 and Figures 4.3 and 4.4 for an illustration of the baseline $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in the study area.

Species	Tooth	Source	$^{87}\text{Sr}/^{86}\text{Sr}$	Geographic Zone
<i>Kobus kob</i>	LRM2	Hambarketolo	0.72075-0.72118	Secondary water source
<i>Kobus kob</i>	LRM3	Hambarketolo	0.72071-0.72088	Secondary water source
Rodentia	UI1	Tato à Sanouna	0.72025	Djenné terrestrial
<i>Canis familiaris</i>	Canine	Hambarketolo	0.72002	Djenné terrestrial
<i>Felis libica/catus</i>	ULC	Jenné-jeno	0.71962	Djenné terrestrial
Carnivora	Canine	Tato à Sanouna	0.71956	Djenné terrestrial
<i>Canis sp.</i>	Canine	Tato à Sanouna	0.71936	Djenné terrestrial
Freshwater bivalve	Shell	Tato à Sanouna	0.71916	Bani River
<i>Hydrocynus sp.</i>	Tooth	Tato à Sanouna	0.71894	Bani River
cf. <i>Dasyatis sp.</i>	Toothplate	Tato à Sanouna	0.71860	Bani River
<i>Ovis aries</i>	LRM3	Timbuktu (TBZ2)	0.71486-0.71598	Desert
<i>Bos sp.</i>	URM3	Gao modern	0.71487-0.71549	Desert

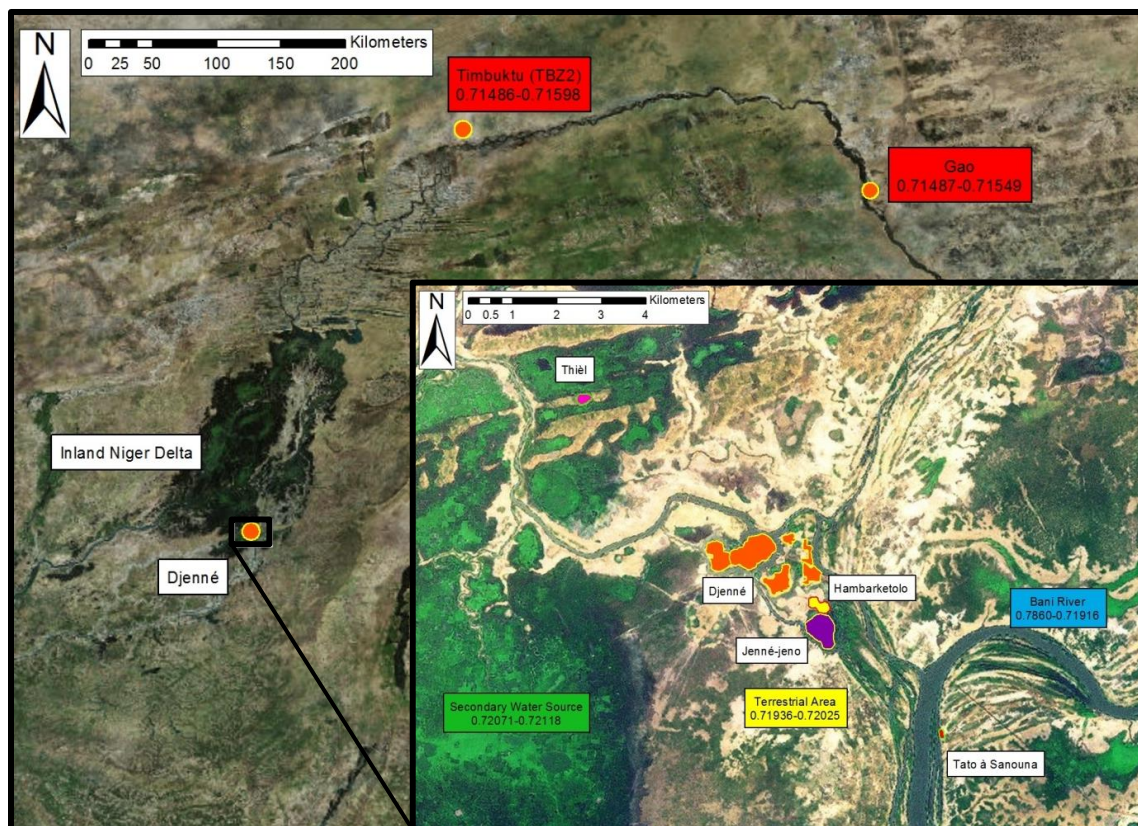


Figure 4.3 – Schematic map showing locations of the various geographic zones identified by their strontium signatures. The secondary water source (shown in green) is speculatively placed in areas with deep basins that contain water year-round. The source could, however, be further into the delta.

Although samples from across Mali were not available for this study, it seems possible that the IND $^{87}\text{Sr}/^{86}\text{Sr}$ signatures are elevated relative to the surrounding area due to millennia of accumulations of sediment deposited by the Niger and Bani Rivers. Headwaters of these rivers originate in Guinea and the Ivory Coast, where the Precambrian West African Craton forms the underlying bedrock.

Serial sampling of modern cow and goat teeth purchased from the Djenné butcher demonstrate that seasonal migrations across these disparate geographic zones are recorded in $^{87}\text{Sr}/^{86}\text{Sr}$ signatures (see Figure 4.4). The goat demonstrates limited mobility, with a seasonal migration towards the secondary water source. One cow exhibits signs of long-distance mobility into and out of the known IND signatures across all three molars. Although a strontium reservoir

effect may have dampened the amplitude of the $^{87}\text{Sr}/^{86}\text{Sr}$ curves for this animal, seasonal movements between areas with disparate $^{87}\text{Sr}/^{86}\text{Sr}$ signatures are clearly visible. A second cow, although brought to Djenné as part of a seasonally-mobile herd, proves to have spent its period of tooth development in a completely non-local area. The signature of this cow falls within the range found in the Gao and Timbuktu areas, but as noted, the $^{87}\text{Sr}/^{86}\text{Sr}$ variability across Mali is unknown outside of the samples tested for this project, so the geographic origins of this animal cannot be ascertained at this point. What is clear, however, is that the mobile Fulani herders who brought the animal to Djenné engage in trade in live animals with groups they encounter during their seasonal rounds, thereby increasing the diversity of animals consumed at Djenné today.

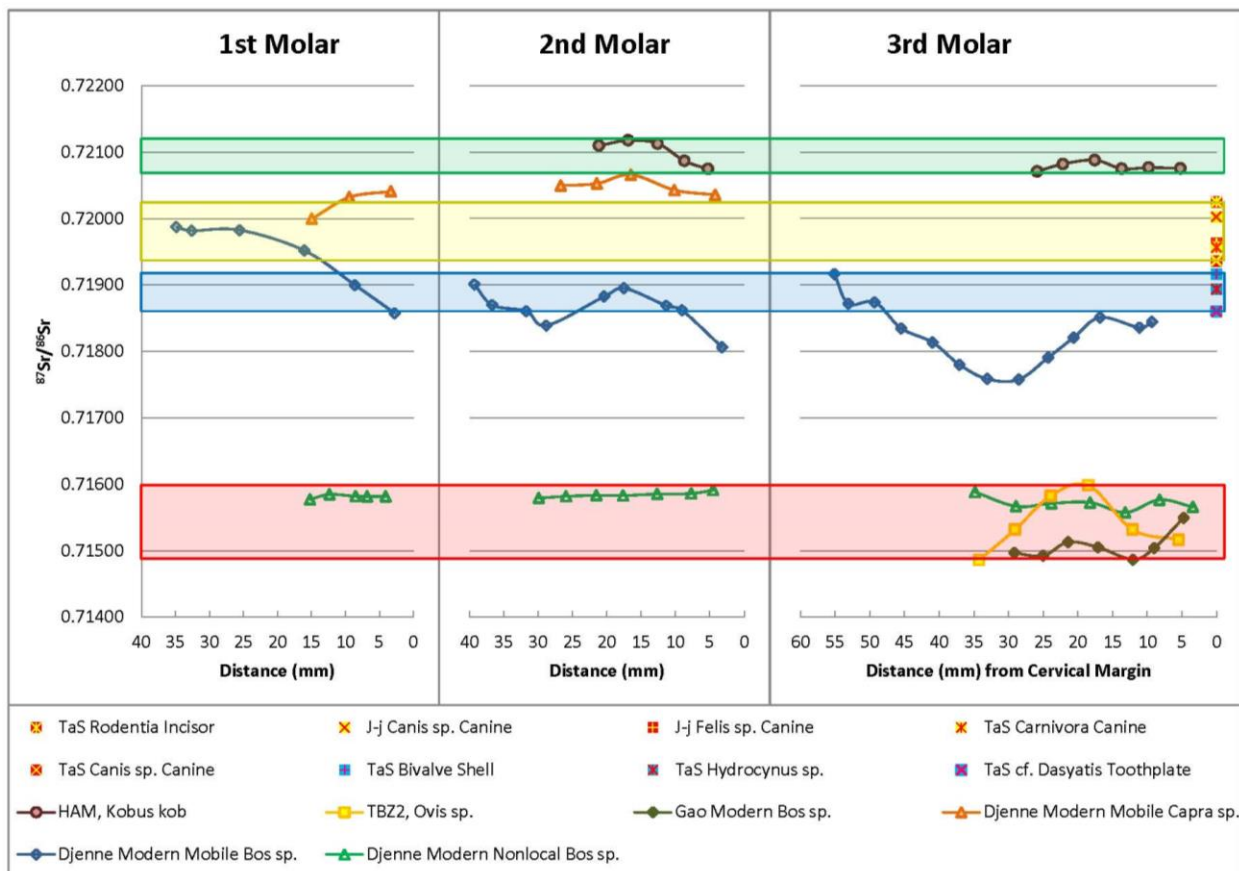


Figure 4.4 – Baseline $^{87}\text{Sr}/^{86}\text{Sr}$ signatures based on archaeological samples (colored bands represent geographic areas as defined by these baseline samples: green is an unknown secondary water source, yellow is the terrestrial area around Djenné, blue is the Bani River, and red is a desert area, defined by the signatures of animals coming from Gao and near Timbuktu); three modern samples from the Djenné market illustrate known mobility patterns

4.5.2 Archaeological $^{87}\text{Sr}/^{86}\text{Sr}$ signatures

These modern samples provide a template for interpreting the mobility patterns in archaeological cows, sheep, and goats, though the archaeological samples proved far more diverse than the modern ones. In total, I identified three major mobility strategies, which can each be broken down into several variations: 1) Extralocal mobility, which includes seasonal movement in and out of the known delta signatures (Figure 4.5A) and completely non-local animals imported after the period of tooth development (Figure 4.5B); 2) Local mobility (within the known delta signatures), which includes seasonal movement between the terrestrial signatures and the Bani river (Figure 4.6A) and seasonal mobility between the terrestrial delta and a secondary water source (Figure 4.6B); and 3) completely non-mobile animals raised in a variety of contexts including the terrestrial delta (Figure 4.7A), by the secondary water source (Figure 4.7B), and by the Bani River (Figure 4.7C). I classified individual teeth to mobility type visually, based on where their signatures fell numerically and their amplitude. In general, extralocal animals have the greatest range of signatures and standard deviation per tooth, while non-mobile animals have the lowest. Locally mobile animals have values that fall between these extremes. See Table 4.3 for a breakdown of strontium data by tooth. The unknown impact of strontium pooling and time averaging means that the precise geographic locale of an animal during the period of enamel maturation may not be reflected in a direct correlation with enamel apatite $^{87}\text{Sr}/^{86}\text{Sr}$ signatures (Montgomery et al. 2010:40), but movements between disparate locations are readily apparent in the teeth analyzed here.

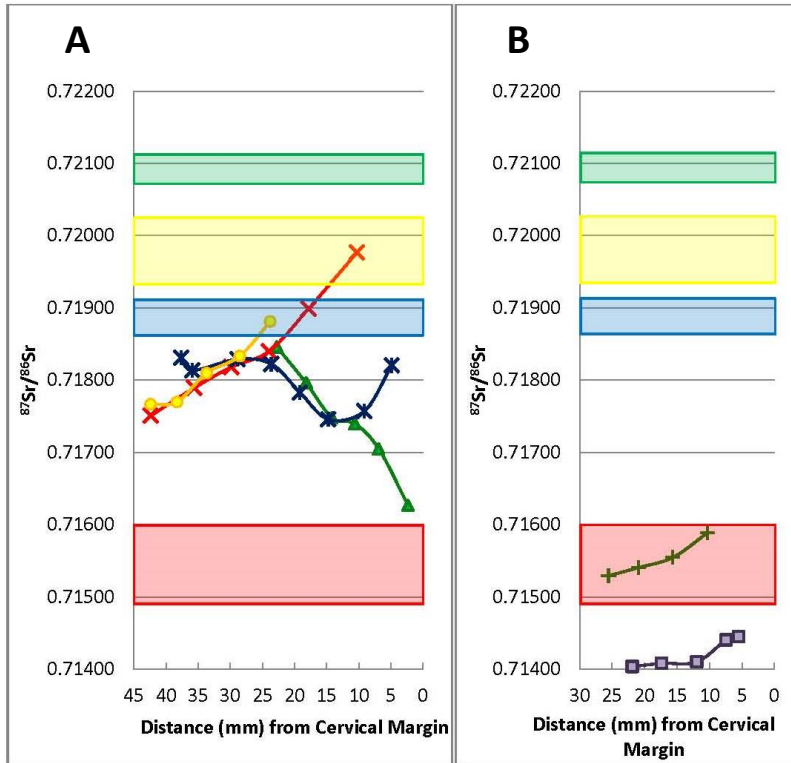


Figure 4.5 – Patterns of extralocal mobility: (A) animals engaged in seasonal mobility into and out of the known Delta signatures; (B) animals imported to the Djenné area from non-local areas.

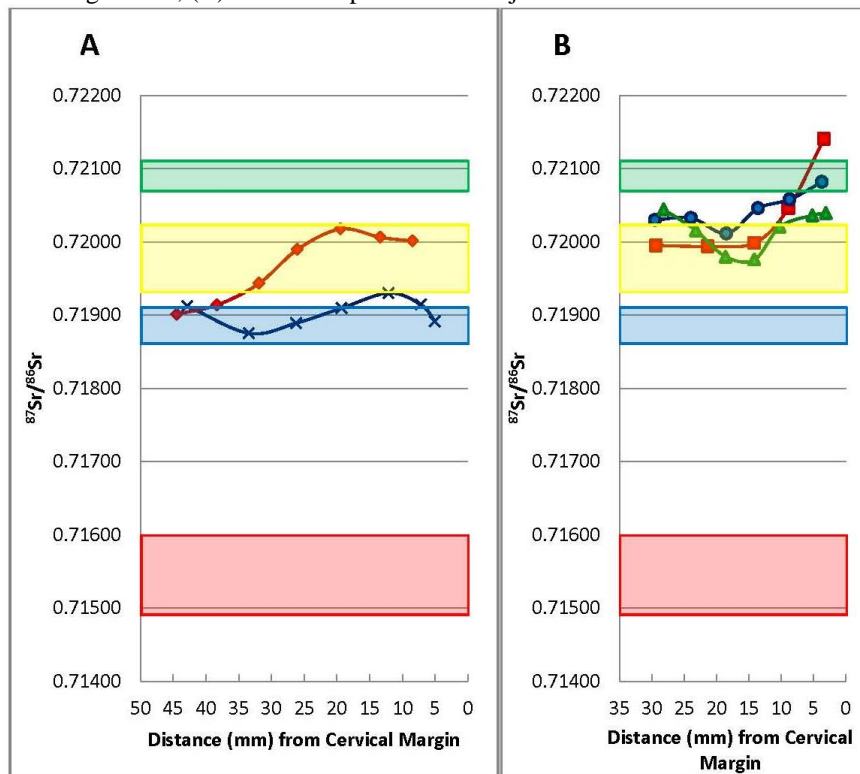


Figure 4.6 – Patterns of local mobility between the terrestrial area and (A) Bali River signatures; (B) secondary water source signatures.

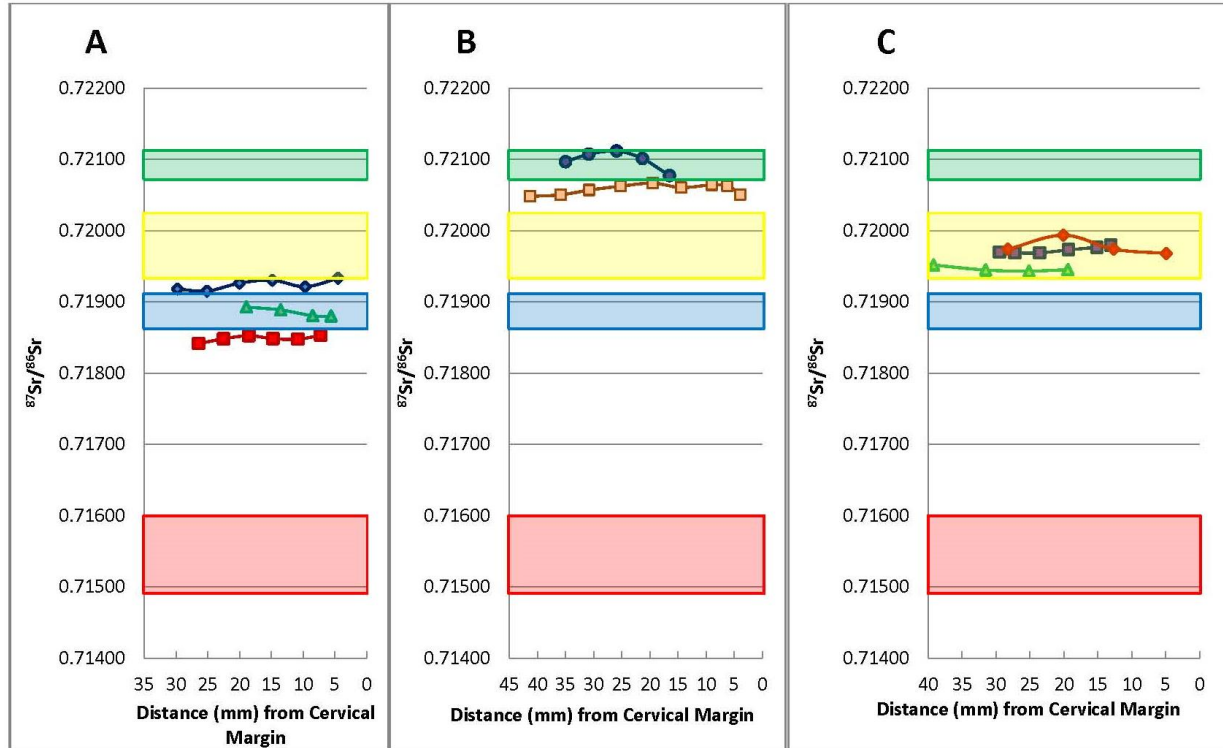


Figure 4.7 – Signatures of non-mobile animals: (A) animals raised near the Bani River; (B) animals raised near the secondary water source; (C) animals raised within the know terrestrial signatures

Table 4.3 – $^{87}\text{Sr}/^{86}\text{Sr}$ data by tooth, arranged by mobility type

Extralocal (Seasonally-mobile into and out of Known IND Signatures)									
Extralocally-Mobile Animals	Genus	Provenance	Tooth	Samples Run	Average	Max	Min	Range	SDp
	<i>cf. Capra</i>	J-j LXN L52	URM2	5	0.71818	0.71848	0.71785	0.00062	0.00024
	<i>cf. Capra</i>	J-j LXN L52	URM3	6	0.71744	0.71846	0.71627	0.00219	0.00069
	<i>Bos</i>	J-j LXN L27	LLM2	6	0.71846	0.71977	0.71751	0.00226	0.00074
	<i>Bos</i>	Dj SMO L84	ULM2	8	0.71800	0.71831	0.71746	0.00085	0.00031
	<i>Bos</i>	Dj SMO L90	ULM3	8	0.71701	0.71762	0.71620	0.00143	0.00056
	<i>Bos</i>	Dj SMO L33	LRM3	5	0.71812	0.71881	0.71767	0.00115	0.00043
	Averages				6.3	0.71787	0.71858	0.71716	0.00142
Non-local, Imported									
Extralocally-Mobile Animals	Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
	<i>Bos</i>	J-j LXN L52	LRM2	5	0.71422	0.71445	0.71404	0.00042	0.00018
	<i>Capra</i>	Dj SMO F29	ULM2	4	0.71554	0.71589	0.71529	0.00060	0.00022
Averages				4.5	0.71488	0.71517	0.71467	0.00051	0.00020
Locally-mobile to Bani River									
Locally-Mobile Animals	Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
	<i>Bos</i>	J-j ALS L12	URM1	5	0.71970	0.72012	0.71942	0.00070	0.00026
	<i>Bos</i>	J-j ALS L12	URM2	6	0.71988	0.72023	0.71960	0.00062	0.00026
	<i>Bos</i>	J-j TK L34	ULM2	7	0.71903	0.71930	0.71875	0.00055	0.00017
	<i>Bos</i>	J-j TK L34	ULM1	4	0.71940	0.71971	0.71906	0.00065	0.00025
	<i>Bos</i>	J-j TK L34	ULM3	6	0.71894	0.71917	0.71877	0.00040	0.00013
	<i>Bos</i>	J-j LXS F21	LLM2	7	0.71968	0.72018	0.71901	0.00116	0.00044
	<i>Bos</i>	J-j LXS F21	LLM3	7	0.71984	0.72006	0.71963	0.00043	0.00014
	<i>Bos</i>	TaS SO L18	ULM2	4	0.71958	0.71980	0.71931	0.00049	0.00018
	<i>Bos</i>	TaS CE L42	LRM2	5	0.71972	0.71993	0.71932	0.00061	0.00022
	Averages				5.7	0.71953	0.71983	0.71921	0.00062

Locally-mobile to Secondary Water Source								
Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
<i>Capra</i>	J-j LXN L49	LRM1	4	0.72038	0.72078	0.72015	0.00063	0.00025
<i>Capra</i>	J-j LXN L49	LRM2	3	0.72016	0.72020	0.72010	0.00010	0.00004
<i>Bos</i>	J-j LXN L48	URM3	7	0.72016	0.72044	0.71976	0.00069	0.00026
<i>Bos</i>	J-j WFL L15	ULM3	6	0.72043	0.72082	0.72012	0.00070	0.00022
<i>Bos</i>	Dj SMO L11	LLM2	6	0.72061	0.72081	0.72040	0.00041	0.00014
<i>Ovis</i>	Th AMS L30	LRM2	5	0.72035	0.72141	0.71994	0.00147	0.00056
Averages			5.2	0.72035	0.72074	0.72008	0.00067	0.00025
Non-mobile Around Bani River								
Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
<i>Bos</i>	J-j LXN L44	ULM3	6	0.71924	0.71933	0.71915	0.00018	0.00006
<i>Bos</i>	TaS CE L18	URM1	4	0.71886	0.71893	0.71880	0.00013	0.00005
<i>Bos</i>	TaS CE L18	LRM2	6	0.71849	0.71853	0.71842	0.00012	0.00004
<i>Ovis</i>	Th GTC L16	LLM1	7	0.71949	0.71965	0.71934	0.00031	0.00009
<i>Ovis</i>	Th GTC L16	LLM2	4	0.71946	0.71952	0.71943	0.00008	0.00003
Averages			5.4	0.71911	0.71919	0.71903	0.00016	0.00006
Non-Mobile Around Secondary Water Source								
Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
<i>Bos</i>	J-j ALS L9	ULM2	9	0.72058	0.72067	0.72048	0.00019	0.00006
<i>Ovis</i>	J-j LXN L46	LLM2	5	0.72099	0.72112	0.72077	0.00035	0.00012
Averages			7.0	0.72079	0.72089	0.72063	0.00027	0.00009
Non-Mobile in Terrestrial Area								
Genus	ID	Tooth	Samples Run	Average	Max	Min	Range	SDp
<i>Bos</i>	J-j WFL L18	URM3	6	0.72047	0.72056	0.72040	0.00016	0.00005
<i>Ovis</i>	J-j LXN L18	ULM2	4	0.71974	0.71979	0.71967	0.00012	0.00004
<i>Ovis</i>	J-j LXN L18	ULM3	4	0.71977	0.71994	0.71968	0.00026	0.00010
<i>cf. Ovis</i>	J-j LXN L24	LLM1	4	0.71967	0.71971	0.71962	0.00009	0.00004
<i>cf. Ovis</i>	J-j LXN L24	LLM2	5	0.71976	0.71985	0.71967	0.00018	0.00007
<i>cf. Ovis</i>	J-j LXN L24	LLM3	6	0.71973	0.71979	0.71969	0.00010	0.00004
<i>Ovis</i>	TaS CE L27	URM1	3	0.72025	0.72042	0.72001	0.00041	0.00017
<i>Ovis</i>	TaS CE L36	ULM1	5	0.71989	0.72010	0.71975	0.00036	0.00013
<i>Bos</i>	Th GTC L20	LLM2	6	0.72004	0.72016	0.71995	0.00021	0.00009
<i>Bos</i>	J-j LXN L27	LLM3	7	0.72030	0.72056	0.72003	0.00053	0.00016
Averages			5.0	0.71996	0.72009	0.71985	0.00024	0.00009

For animals with multiple teeth available for sampling, $^{87}\text{Sr}/^{86}\text{Sr}$ patterns generally remained constant across the tooth row, increasing the reliability of the identified mobility strategy. This was even true for first molars, demonstrating the utility of isolated first molars for this type of analysis (see Figure 4.8A). Interestingly, such analysis of multiple teeth from a single animal resulted in the identification of one cow that had markedly different mobility patterns between its second and third molars (see Figure 4.8B), demonstrating either fluidity in mobility patterns within a population or exchange of live animals between groups engaged in different mobility strategies. Continuity in $^{87}\text{Sr}/^{86}\text{Sr}$ signatures across multiple teeth contrasts with the

possibility raised elsewhere that shifting $^{87}\text{Sr}/^{86}\text{Sr}$ values reflect single migration events rather than seasonal movements (Montgomery 2010:36).

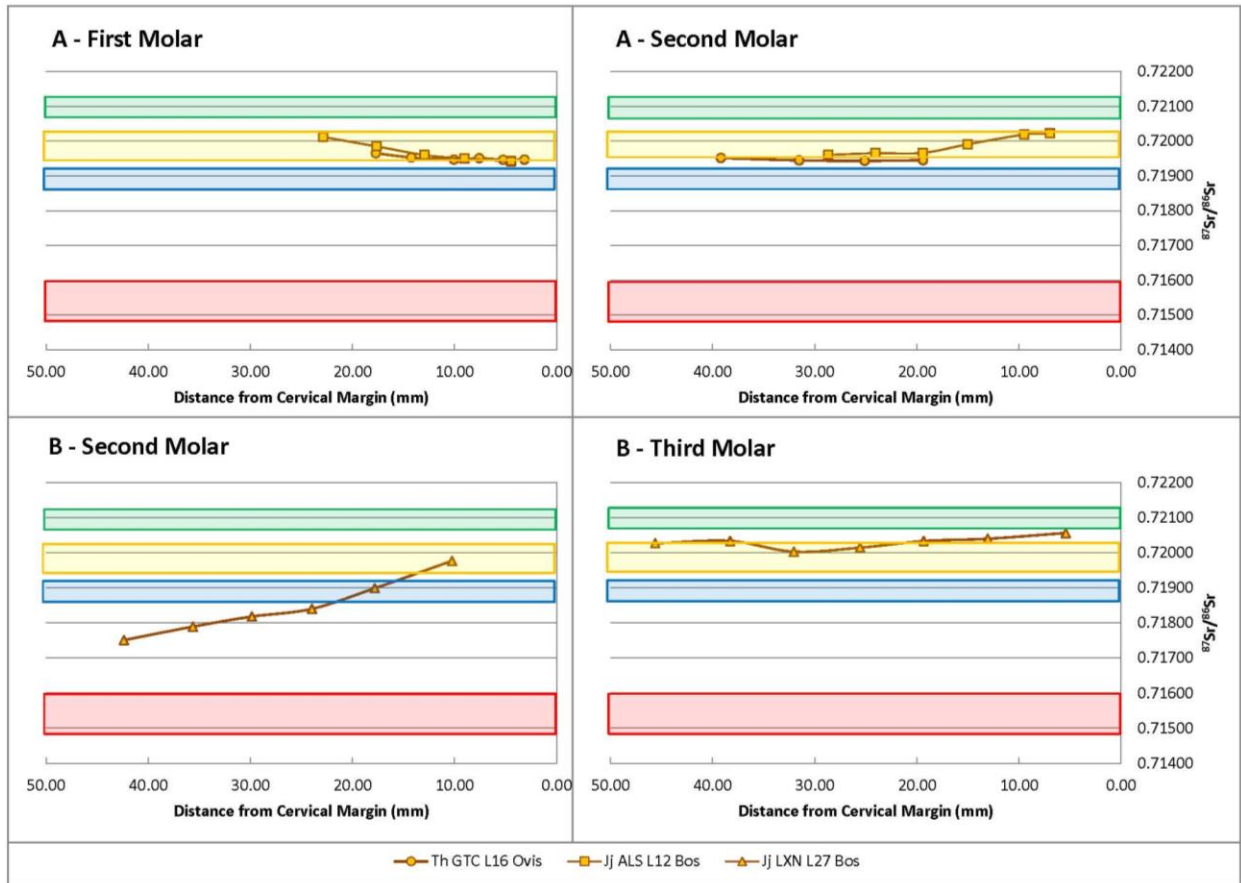


Figure 4.8 – (A) Data showing similarity in mobility patterns across M1 and M2 of a cow and a sheep; (B) Data showing a shift in mobility pattern between the M2 and M3 of a cow

4.5.3 $\delta^{18}\text{O}$ and seasonality of movement

Although $\delta^{18}\text{O}$ signatures are notoriously difficult to interpret given that they are influenced by numerous factors, in this context there appears to be clear shifts in $\delta^{18}\text{O}$ signatures between the wet and dry seasons. $\delta^{18}\text{O}$ values in precipitation and in the Bani and Niger Rivers peak in late April and early May at the height of the dry season, and then drop precipitously to their lowest levels in June and July during the rainy season (Gourcy, et al. 2000; IAEA 2007:47-51). Strong seasonal shifts are visible in the $\delta^{18}\text{O}$ data recorded in both modern and archaeological animals that, according to their strontium profiles, lived in or across a diversity of

areas. In Figure 4.9A, below, a non-mobile sheep demonstrates the dramatic shifts in oxygen that result from seasonal fluctuations, rather than mobility.

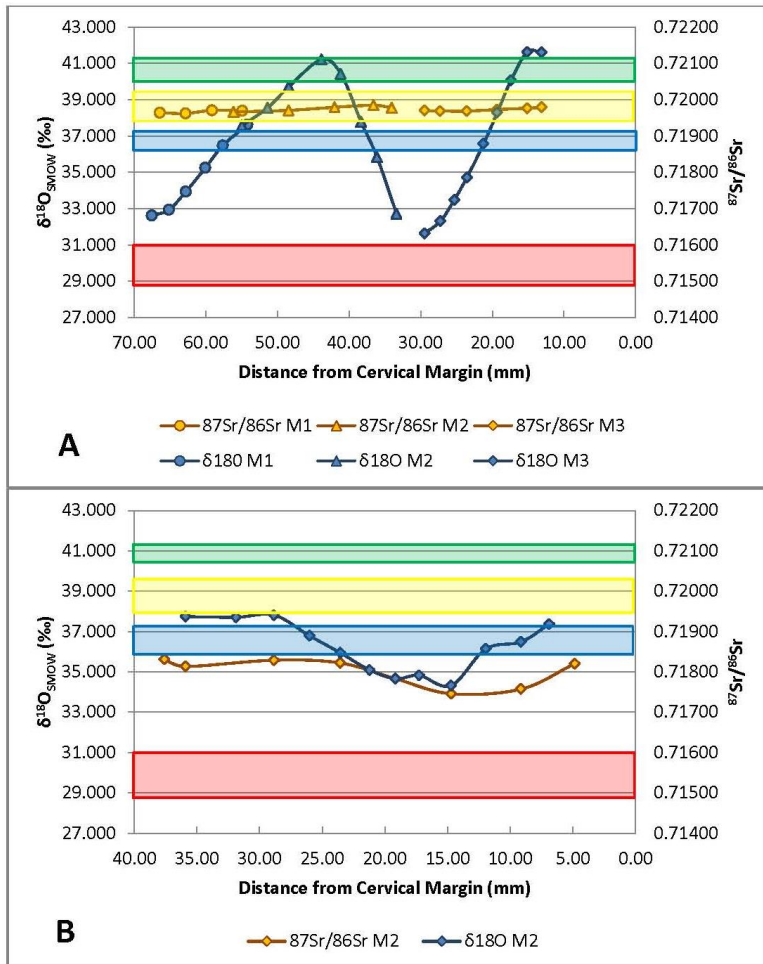


Figure 4.9 – ⁸⁷Sr/⁸⁶Sr and δ¹⁸O_{SMOW} variability in (A) a non-mobile cf. *Ovis aries* (J-j L24) (distance from cervical margin increased by 26 mm for M2 and by 50 mm for M1 in order to show teeth in series); (B) an extralocally-mobile *Bos* sp. (Dj L84 ULM2).

In animals that were moving, however, the oxygen data give a possible estimate of the season of mobility. In Figure 4.9B, above, the cow is tied closest to the Bani River area when δ¹⁸O values are greatest (hot and dry) and moves away from the known delta signatures in wetter conditions with lower δ¹⁸O values. This mobility pattern is identical to that seen in the modern cow known to have been extralocally-mobile, and is the pattern used by modern mobile herders moving into and out of the delta. Two locally-mobile cows also demonstrate movement from the

terrestrial area to water (the Bani River or the secondary water source) during times with high $\delta^{18}\text{O}$ (see Figure 4.10). As noted by Montgomery (2010) there is some doubt about the synchronicity of strontium and lighter isotopes in tooth enamel, so these interpretations are tentative.

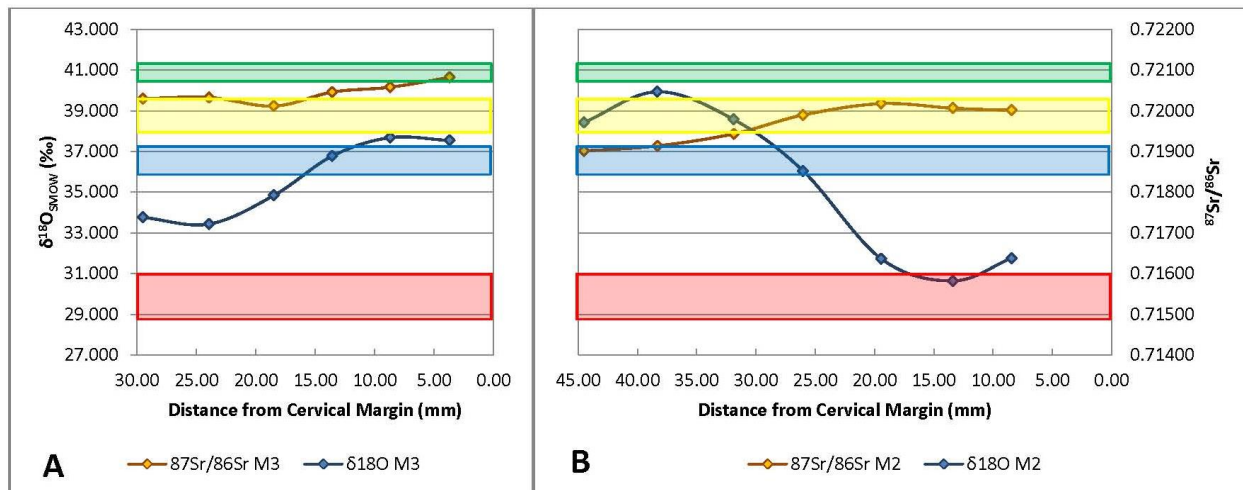


Figure 4.10 - $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ variability in two locally-mobile *Bos* sp.: (A) (J-j L15 ULM3) mobile between terrestrial and secondary water source areas; (B) (J-j F21 LLM2) mobile between terrestrial and Bani River areas.

There is considerable variability in absolute $\delta^{18}\text{O}$ signatures between different animals, which likely represents inter-annual variability in rainfall and temperature. With a larger sample it might be possible to differentiate draught years from those with heavy rainfall and to discuss how annual rainfall affected mobility patterns, but this analysis was not attempted here. As there is more variability in $\delta^{18}\text{O}$ values within mobility types identified using $^{87}\text{Sr}/^{86}\text{Sr}$ than between them, this analysis suggests that the mobility types outlined here reflect distinct mobility strategies that are more than reactions to annual climatic conditions.

4.5.4 $\delta^{13}\text{C}$ demonstrates dietary differences

$\delta^{13}\text{C}$ data were helpful in distinguishing between sheep and goats, which can be difficult to do osteologically. In general goats browse more than sheep, resulting in a higher proportion of C_3 plants in their diets and more negative $\delta^{13}\text{C}$ values when raised within C_4 grasslands (Balasse

and Ambrose 2005a). For the ten archaeological caprines analyzed here, animals with average $\delta^{13}\text{C}$ values reaching below -5.4‰ were classified as goats, while ones with average values above -4.1‰ were classified as sheep. This resulted in seven caprines classified as sheep and three as goats. Interestingly, of those classified as sheep, six had strictly non-mobile patterns, and only one was locally-mobile. The three classified as goats were involved in mobility either locally or extralocally. Goats are more suited to long migrations than sheep, so this pattern makes a certain amount of sense. It does, however, raise the possibility that some of the non-mobile animals classified as sheep were actually goats in contexts with sufficient grazing resources.

Interestingly, when looking at the $\delta^{13}\text{C}$ data in cows, it is apparent that there are slight differences between animals in the three major mobility classes based on both the ratio of browse to graze and the variability in their diets (See Table 4.4). Although there is overlap between mobility classes and considerable variability within classes, the average $\delta^{13}\text{C}$ values suggest that non-mobile cows consumed the least browse, while locally-mobile cows browsed the most, though still considerably less than either sheep or goats (average $\delta^{13}\text{C}$ value for all cows is 1.1‰). Extralocally-mobile cows are intermediate. Given the small sample size, the differences are not significant, but they suggest that most non-mobile cows are kept in particularly rich grazing areas or are brought C_4 grasses as fodder for most of the year. On the other hand, the relatively more negative $\delta^{13}\text{C}$ signature of locally-mobile cattle suggests that many of these animals have a more variable, less optimal diet, including detectable quantities of C_3 plants.

Table 4.4 – Average $\delta^{13}\text{C}$ values for all <i>Bos</i> sp. second and third molars				
Non-Mobile Cows				
Source	Tooth	Samples Run	AVG ‰	SDp
J-j L44	ULM3	6	1.171	0.686
TaS L18	LRM2	6	0.849	0.960
J-j L18	URM3	6	2.374	0.293
Th L20	LLM2	9	2.297	0.120
J-j L9	ULM2	15	1.541	0.417
Averages			1.646	0.577
Locally-Mobile Cows				
J-j L13	URM2	10	0.241	0.722
J-j L34	ULM2	15	0.978	0.813
J-j L34	ULM3	6	0.620	0.394
J-j F21	LLM2	7	0.855	1.111
J-j F21	LLM3	7	1.275	0.928
TaS L18	ULM2	4	1.696	0.507
TaS L 42	LRM2	5	-0.597	1.169
J-j L48	URM3	12	0.987	0.640
J-j L15	ULM3	6	0.483	0.816
Dj L11	LLM2	6	1.193	0.292
J-j L27	LLM3	7	0.836	0.537
Averages			0.773	0.721
Extralocally-mobile Cows				
J-j L27	LLM2	6	-0.181	0.395
Dj L84	ULM2	12	1.794	0.322
Dj L90	ULM3	8	0.664	1.008
Dj L33	LRM3	6	1.865	0.983
Averages			1.035	0.677

4.6 Discussion

This study demonstrates the utility of serial, intra-tooth isotopic analysis for identifying both the presence of mobile herders and the nature of herding strategies within a dense, urban context. This analysis provides the first direct evidence of seasonally-mobile herders engaged in long-distance mobility beyond the IND during Jenné-jeno's occupation. Such herders are the norm in the modern IND, but their presence archaeologically had not been demonstrated.

Equally importantly, this study demonstrates that many animals were kept locally, in both non-mobile and locally-mobile strategies. The implications of the coexistence of multiple herding strategies at Jenné-jeno are examined at length in Chapter 5. Briefly, however, it challenges the prevailing idea that subsistence specialization was prevalent at Jenné-jeno, by highlighting the important role small-scale and household level stock keeping played in the urban economy. Furthermore, it emphasizes the fact that interactions between stock keepers at various scales, from household level to fully specialized, contributed to making Jenné-jeno an important market center. This study clearly shows the potential of this type of isotopic analysis to advance our understanding of relations between mobile and more sedentary populations, moving discussions of such interactions beyond an assumption of inherent conflict between groups with divergent resource needs.

Although the utility of $^{87}\text{Sr}/^{86}\text{Sr}$ analysis depends on the variability of the underlying geology and the activity of aeolian and aquatic forces within the study area, this study joins others showing its effectiveness in many world areas. In contexts like the IND with relatively high variability in $^{87}\text{Sr}/^{86}\text{Sr}$ values and where local features of the landscape have distinct $^{87}\text{Sr}/^{86}\text{Sr}$ signatures, relatively closely-spaced sampling (no more than 4-5 mm between horizontal samples on a tooth) allows for nuanced discussion of local and non-local mobility patterns. Sampling less frequently than this will almost certainly miss variability in $^{87}\text{Sr}/^{86}\text{Sr}$ values and might not capture the full range of variability in past herding strategies.

In certain areas, $\delta^{13}\text{C}$ is extremely useful for showing seasonal mobility, particularly in cases with vertical movement where changes in altitude result in significant changes in available plants (e.g., Balasse and Ambrose 2005b; Bocherens, et al. 2001). In the Inland Niger Delta, however, such shifts are not as straightforward. $\delta^{13}\text{C}$ alone would be insufficient for identifying

mobility patterns. In this study, however, it was useful in distinguishing between sheep and goats based on the percentage of browse versus graze in the diet.

The extreme seasonal variability of $\delta^{18}\text{O}$ signatures within the study area limits the utility of $\delta^{18}\text{O}$ for identifying seasonal mobility of herd animals; even a conclusively non-mobile sheep demonstrated marked shifts in $\delta^{18}\text{O}$ across its tooth row (see again Figure 4.9A). It is possible that less striking $\delta^{18}\text{O}$ shifts could result from mobility strategies designed to maintain access to reliable water sources year-round. However, extreme inter-annual variability in rainfall, temperature, and consequently $\delta^{18}\text{O}$ signatures in this area means that such interpretations are merely speculative. $\delta^{18}\text{O}$ was useful for demonstrating the season of mobility in many animals displaying local and extralocal mobility. As expected, animals were moved towards permanent water sources along the Bani River and deeper within the delta during periods of hot, dry weather (high $\delta^{18}\text{O}$ signatures) and away from these areas in wetter conditions (low $\delta^{18}\text{O}$ signatures) when seasonal water sources would have been available. Furthermore, the lack of marked differences in average $\delta^{18}\text{O}$ values between the three major mobility types shows that mobility strategies were not simply reactions to variations in water availability.

Although neither $\delta^{18}\text{O}$ nor $\delta^{13}\text{C}$ could have been used alone to identify mobility strategies in this study, both isotopes helped to confirm the configurations suggested by $^{87}\text{Sr}/^{86}\text{Sr}$ signatures. All three contribute to our understanding of management strategies employed in and around Jenné-jeno. Additionally, sampling of multiple teeth from a single animal helps to confirm mobility patterns seen in a single tooth over a more limited period of time and, in at least one case, shows how an animal changed mobility patterns between its second and third molars, suggesting that it was traded between groups or that its owners shifted their own mobility

strategy. Together, the results of this study reinforce the utility of analyzing multiple isotopes across multiple teeth when possible.

Going forward, this analysis would benefit from a greater number of baseline samples, particularly from outside of the southeastern IND. Although it is always difficult to pin down the source of non-local $^{87}\text{Sr}/^{86}\text{Sr}$ signatures, a greater spread in baseline samples would allow for more nuanced discussion of where animals leaving the IND were going. Additionally, although the forty archaeological cattle, sheep, and goat teeth sampled for this project represent a broad array of times and sites, a larger number of samples would help to confirm the initial temporal and spatial differences identified using this sample (see Chapter 5). Furthermore, going forward, analysis of existing cattle, sheep, and goat teeth excavated in and around Gao and Timbuktu would allow for an interesting comparative analysis of herding strategies in Mali's Iron Age cities.

As serial, intra-tooth $^{87}\text{Sr}/^{86}\text{Sr}$ analysis of herd animal teeth becomes more common, controlled testing of modern animals will become necessary. The degree and impact of a strontium reservoir effect is poorly understood and must be clarified, possibly through controlled feeding studies. Additionally, the degree of variability between individuals of the same herd is unknown. Some divergence is almost certain between individuals from different birth year cohorts, but the degree of separation and the impact of birth seasonality are not clear. Extensive sampling of animals with known ages and mobility patterns from within single herds could help to clarify the impact of annual variability and birth seasonality on $^{87}\text{Sr}/^{86}\text{Sr}$ patterns.

4.7 Conclusions

This project used serial, intra-tooth sampling of bovid teeth in Mali's IND to illustrate mobility patterns and herding strategies in the archaeological past. It provides the first baseline map of biologically-available $^{87}\text{Sr}/^{86}\text{Sr}$ in Mali and demonstrates the utility of $^{87}\text{Sr}/^{86}\text{Sr}$ analysis in at least the southeastern Inland Niger Delta. Using this baseline and samples from forty archaeological cattle, sheep, and goat teeth, this study also illustrates the variability of herding strategies behind the animals consumed in this densely-occupied, urban context. Although the presence of mobile pastoralists had been postulated at Jenné-jeno, no distinctly "pastoralist" artifacts or sites have been identified. This analysis provides the first definitive evidence that seasonally-mobile pastoralists passed through and traded with Jenné-jeno from that site's earliest occupation. Furthermore, the variability in herding strategies seen in animals consumed at Jenné-jeno and neighboring sites suggests that small-scale and household-level herding strategies were integral to the local animal economy. The implications of this diversity are discussed extensively in Chapter 5.

Although methodological and interpretive issues (particularly the impact of strontium pooling on seasonal $^{87}\text{Sr}/^{86}\text{Sr}$ values) still need to be clarified, this study joins others in demonstrating the utility of intra-tooth isotopic analysis in reconstructing past herd mobility patterns. I argue that employing multiple isotopes across multiple teeth and sampling relatively frequently down the length of the tooth allows for the identification of nuanced herding strategies. As similar studies are conducted in more areas, intra-tooth isotopic analysis will contribute significantly to the archaeology of mobility. Although this paper primarily discussed animals, each seasonal movement documented in an animal tooth was also undertaken by human herders. The length of bovid teeth allows for close examination of seasonal patterns that cannot

be clearly seen in human remains. This opens the door for identification of multiple scales and strategies of mobility within both primarily sedentary and primarily mobile populations, which will have significant impact on discussion of interactions between “mobile” and “sedentary” groups.

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Chapter 5 – Feeding Jenné-jeno: How Mobility and the Livestock Economy Shaped an Emerging African Urban System

Abstract

Isotopic and archaeological evidence reveal complex relationships among mobility, sedentism, and the livestock economy of Jenné-jeno, one of the earliest and best known urban systems in sub-Saharan Africa. Drawing on excavations at the ancient city of Jenné-jeno and those conducted at two neighboring sites, and on serial, intra-tooth isotopic analysis ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{13}\text{C}$, $\delta^{18}\text{O}$) of cattle, sheep, and goat teeth, this analysis shows that multiple populations involved in animal husbandry, from seasonally mobile pastoral specialists to household-level producers, coexisted at Jenné-jeno. These findings provide the first concrete evidence of the nature of the livestock economy at Jenné-jeno. Furthermore, the importance of small-scale animal husbandry within the subsistence economy challenges prior assumptions of specialized subsistence economies at Jenné-jeno. While the human and animal isotopic data presented here reinforce the importance of Jenné-jeno within the broader region as a market and population center, they also provide further evidence that urbanism at Jenné-jeno diverges from traditional narratives of urban development. This work builds upon previous studies demonstrating that analysis of food production strategies and the role of mobility in urban settings can have profound implications for global discussions of urbanism and urban development.

5.1 Introduction

The relationship between mobile groups, particularly mobile pastoralists, and sedentary populations is often cast as a conflict between peoples with incompatible resource needs, or as control of a subservient herding population by a more powerful urban one (e.g., Adams 1974; Bar-Yosef and Khazanov 1992; Sadr 1991). This idea of inherent incompatibility and animosity between mobile and sedentary populations has deep roots, often articulated in Eurasian history as the conflict between the steppe and the sown (e.g., Peake and Fleure 1928). When investigated, discussions of mobile-sedentary interactions often get mired in definitional debates over whether a certain site or population was mobile or semi-mobile or sedentary (e.g., Berelev 2006). Preoccupations with defining a population as mobile or sedentary create a false dichotomy,

however, which obscures the myriad ways in which mobility impacts apparently sedentary systems.

This article investigates the complex relationship between mobility, sedentism, and the livestock economy in urban systems, using the well-known site of Jenné-jeno, located in Mali's Inland Niger Delta and occupied from 250 BC through AD 1400, as a case study. The importance of animal economies in early cities is well established (Bar-Oz, et al. 2007; Twiss 2012; Zeder 1991, 2003), but we know very little about the relationships amongst the people who drive these economies. Such analyses can shed light on less visible aspects of urban life like small-scale, household economies, as well as increasing our understanding of the variability of urban configurations.

This study, though rooted in a specific West African context, has implications for understanding the relationships between mobile pastoral groups and urban centers more broadly. Many discussions of these interactions focus on large states and military conquests rather than on smaller-scale relationships (e.g., Khazanov 1994). Neither sedentary nor mobile populations are monolithic, yet it has been methodologically very difficult to examine this diversity, particularly in regards to mobile groups. Isotopic analysis of herd animal teeth has the ability to illuminate details about the individuals who raised, traveled with, traded, and consumed specific animals, as well as their relationship to urban populations. Such interrelationships are critical to our understanding of urban economies and the character of urban systems; as Cowgill (2004:528) said in a review of the archaeology of urbanism, "Ancient cities... cannot be well understood without taking explicit account of individuals – their practices, perceptions, experiences, attitudes, values, calculations, and emotions".

In this paper I investigate the diversity of mobility and stock-keeping practices amongst the heterogeneous population drawn to the ancient city of Jenné-jeno. I attempt to understand how individuals involved in the livestock economy interacted with each other and the broader urban population, and how these interactions impacted overarching socio-political and economic structures within the urban system. The data presented here demonstrate the importance of small-scale and household-level husbandry practices and challenge prevailing ideas about the importance of specialized subsistence production at Jenné-jeno. This has clear implications for broader discussions of urbanism and urban development, suggesting that a complex urban system can be forged out of small-scale local trade connections. Moreover, this study demonstrates that mobility operated on many scales within communities that could traditionally be termed sedentary and more mobile populations were often seasonal residents within sedentary communities. Mobility and mobile individuals, far from being anathema to urbanism, may have been key to the development and maintenance of the ancient city of Jenné-jeno.

5.2 Background

5.2.1 African Pastoralism and Early Urbanism

Africa's recent human past was significantly impacted by the emergence and spread of pastoralism on the continent. Generally, scholars agree that domestic cattle appeared by around 7500 bp in the northeastern Sahara and spread widely throughout North Africa well before the domestication of local crops (Barich 2002; Gifford-Gonzalez 2005; Marshall and Hildebrand 2002; Smith 2005:116). Pastoralists, broadly defined as "groups who depend primarily on the products of their hoofed domestic animals, and who organize their settlement and mobility strategies to suit the dietary needs of their livestock" (Gifford-Gonzalez 2005:188) are attested to widely in the archaeology and rock art of North Africa at this time (Di Lernia 2006). By around

5500 bp pastoral populations had largely left the Sahara as a consequence of desiccating conditions, bringing domestic cattle, sheep, and goats to sub-Saharan Africa (MacDonald and MacDonald 2000; Marshall 2000; Smith 2005). These groups encountered radically different human and environmental landscapes as they dispersed throughout sub-Saharan Africa, resulting in a rapid diversification of pastoral strategies and varied forms of interactions with neighboring groups (Gifford-Gonzalez 1998; Lane, et al. 2007; MacDonald 1996, 1999; Marshall 1990; Marshall and Stewart 1994; Van Neer 2002).

Traditional models of urbanism, derived primarily from Mesopotamian and classical Mediterranean examples, highlight non-egalitarian wealth distribution, power centralization, and craft and subsistence specialization as essential foundations of large-scale population aggregation (Childe 1950) Using these criteria, urban centers appear to be scarce in sub-Saharan Africa and primarily the result of foreign influences. More functional definitions, however, such as Trigger's widely-cited statement that "whatever else a city might be it is a unit of settlement which performs specialized functions in relationship to a broad hinterland" (1972:577) allow us to identify African urbanism in many highly-variable forms (LaViolette and Fleisher 2005:329; McIntosh 1997:463; 1999b). Centers like Kerma, Napta, Meroë, Aksum, Kilwa, and Great Zimbabwe emerged as nexuses linking the interior of the continent with markets in Egypt, across the Red sea and Indian Ocean, and throughout the Mediterranean world. These cities were previously dismissed as offshoots of foreign influence, and thus irrelevant to broader theoretical discussions about the development of urbanism. Under this mindset, sites that lack the monumentality or sedentism of existing models of urbanism, like Jenné-jeno and the mobile capitals of Ethiopia's post-Aksumite Christian states, hardly registered. Detailed analyses dating back to the 1930s, but particularly since the 1980s, however, demonstrate the indigenous,

African nature of these urban centers and emphasize the way that particular local environments, histories, and populations resulted in highly variable urban forms (Caton-Thompson 1930; Caton-Thompson 1971[1931]; LaViolette and Fleisher 2005; McIntosh 1991; McIntosh 1997, 1999b; McIntosh and McIntosh 1984).

Despite the long history of pastoralism in Africa, the relatively high density of scholarship focused on African urbanism over the past several decades, and the important position of pastoral peoples in African cities today (e.g., Azarya 2001), we know very little about the relationship between pastoral groups and the emergence and development of urbanism in sub-Saharan Africa. Intriguingly, several studies suggest that pastoral wealth played a role in centers like Aksum and Great Zimbabwe (Garlake 1978; Phillipson 1998:57). Although urban centers are often studied in isolation, they existed within larger human landscapes in which numerous groups, including mobile pastoralists, played a vital role (Stahl 2004). Correspondingly, the development of urban centers almost certainly had profound impacts on later pastoral strategies.

5.2.2 Jenné-jeno and the Inland Niger Delta

The Inland Niger Delta (hereafter IND) is a complex riverine environment created when the courses of the Niger and Bani Rivers fan out into numerous intersecting channels covering an area of roughly 32,000 km² in central Mali (Makasse 1998). A mosaic of swamps, ponds, lakes, rivers, levees, dunes, and grasslands renders the IND a highly productive zone and a valuable source of fish, crops, and pasture for ancient and modern peoples alike. Populations involved in fishing, herding, and rice cultivation were present in the IND by at least the first millennium BC (Bedaux, et al. 2005; MacDonald 1994, 1996; McIntosh and McIntosh 1980a). For modern mobile pastoralists, the IND underpins seasonal migrations, drawing herds in search of water and

pasture into the area in the dry season and expelling them during the annual summer rains, when seasonal water sources are plentiful outside of the delta (Benjaminsen and Ba 2009:72).

The site of Jenné-jeno, located in the southeastern IND, is one of the earliest- and best-known urban centers in sub-Saharan Africa. The first inhabitants arrived around 250 BC when drier conditions opened the area to year-round settlement. The site grew rapidly and reached 12 ha by AD 100, 25 ha by AD 400, and 33 ha (its maximal extent) by AD 900. At its height, Jenné-jeno was part of a densely occupied landscape, with over 300 sites located within 10 km (DNGR 2007; McIntosh and McIntosh 1980b). Jenné-jeno itself was part of a dense cluster of settlements with over 66 additional hectares of occupied space within 1 km of the site. The 29 mounds located immediately to the north and west of Jenné-jeno might be more accurately described as neighborhoods in a clustered city than as separate sites, their forms and boundaries defined by natural streams and levees. During this time, Jenné-jeno was an active, densely populated urban area, central to the local economy and engaged in expansive interregional trade networks bringing goods like beads, stone, iron ore, and copper to the delta (Clark 2003; McIntosh 1995a; McIntosh and McIntosh 1980a).

After CE 900, Jenné-jeno and many surrounding sites went into decline. This period is marked by a dramatic increase in Saharan trade, evidenced by the increased presence of brass, glass beads, and spindle whorls; a shift from circular to rectilinear houses; the conversion of local leaders to Islam between CE 1200 and 1400; and the expansion of the Mali and Songhai empires. By CE 1400 Jenné-jeno and three fourths of neighboring mounds were abandoned and population was re-concentrated at the modern town of Djenné (3km NE of Jenné-jeno). Djenné became a vital cog in the Saharan trade through its connection to the Akan gold fields in the south and its northern neighbor Timbuktu (McIntosh 1999a, 2000). Gold, ivory, ebony, kola, and

slaves from the southern forests and savannas and salt and luxury goods from the Sahara passed through Djenné and IND grains, fish, and meat nourished the trade (McIntosh 1998:155).

Jenné-jeno is well-known as one of the earliest identified urban centers in sub-Saharan Africa and for its divergence from commonly accepted urban forms. Despite its large size (nearly 100 ha when you include its contiguous neighbors) and evidence that it functioned as a locus of local and regional trade, Jenné-jeno lacks many traditional markers of urbanism, including centralized governance and social stratification, at least in any archaeologically-visible form. Susan Keech McIntosh and Roderick McIntosh postulate that the site functioned in a more heterarchical manner, with power distributed across various roughly equivalent populations or individuals, including religious sects, kin groups, and craft and subsistence specialists (McIntosh 1998, 2005; McIntosh 1999a, 2000; McIntosh and McIntosh 1993). In the modern IND, subsistence specialization, divided along self-ascribed ethnic lines, is a highly visible organizing principle (Gallais 1967b, 1984; LaViolette 1987, 2000; Monteil 1971 [1932]; N'Diaye 1970; Sundström 1972). Scholarship describes such specialization as a logical response to environmental heterogeneity and climatic uncertainty, and much research in and around the IND has focused on the identification of subsistence specialists in the archaeological record (McIntosh 1998:166; 2005:52; McIntosh 1999a:73-74) (Bedaux, et al. 1978a; Bedaux, et al. 2001; Bedaux, et al. 2005; Clark 2003; LaViolette and Fleisher 2005:335; MacDonald 1994; K. C. MacDonald and W. Van Neer 1994; MacEachern 2005:440; McIntosh 2005; Togola 1996). However, subsistence specialization has not been conclusively demonstrated at Jenné-jeno or in the surrounding landscape.

Excavations at Jenné-jeno and neighboring sites show that the area's inhabitants had access to a diversified diet including domestic stock, numerous fish species, wild hunted

resources, and a variety of domesticated and wild plant species. Existing evidence does not, however, give us much information about how food production was organized. Archaeobotanical evidence suggests that the Jenné-jeno's subsistence regime did not intensify throughout its occupation, despite the dramatic increase in size (McIntosh 1999a). Using metric analysis MacDonald suggested that both dwarf and non-dwarf cattle, sheep, and goats were present at Jenné-jeno, indicating the existence of multiple breeding populations in the area, particularly during Phase III (CE 400-900) (1995, 1999). The presence of larger species, more adapted for long-distance mobility, suggested that Jenné-jeno could have engaged in trade with mobile pastoral populations during this phase, but the metric data alone do not tell us much about mobility patterns and the role of mobile populations at Jenné-jeno throughout the site's occupation.

5.3 Isotopic Analysis: Methods and Results

To better understand Jenné-jeno, its connection to neighboring sites, and the role of mobile pastoral groups in the region's economy and political organization, I conducted an analysis of the isotopic signatures of cattle, sheep, and goat teeth excavated at Jenné-jeno; two smaller, nearby sites, Tato à Sanouna and Thièl; and the modern town Djenné. This analysis provides information about the mobility patterns of the animals consumed at these sites and, by proxy, the movements of the people who tended them.

Over the past several decades archaeologists have developed methods of isotopic analysis of bones and teeth that can elucidate ancient patterns of diet and mobility. This type of analysis is now widely used in archaeological studies to infer information on economy, patterns of social organization, spheres of interaction, etc. (Sealy 2006:574). The utility of various isotopes for archaeological study has been sufficiently outlined elsewhere, but briefly $\delta^{13}\text{C}$ signatures reflect

ratios of C3 versus C4 plants in an animal's diet over the period of bone or tooth development; $\delta^{18}\text{O}$ signatures reflect a combination of temperature, humidity, and altitude; and $^{87}\text{Sr}/^{86}\text{Sr}$, which is highly variable, reflects the age of the underlying bedrock (Bentley 2006; Sealy 2001).

More recently, archaeologists have begun using serial, intra-tooth isotopic analysis (primarily using $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{13}\text{C}$, $\delta^{18}\text{O}$) to document patterns of seasonality and herd mobility in archaeological livestock (Balasse, et al. 2002; R. Alexander Bentley and Corina Knipper 2005; Bocherens, et al. 2001; Chase, Meiggs, et al. 2014; Evans, et al. 2007; Meiggs 2007; Towers, et al. 2011). This method takes advantage the fact that teeth form sequentially from the tip of the crown to the root over an extended period of time. In animals with hypsodont (high-crowned) teeth, sequential samples of enamel down the length of the tooth provide a record of that animal's diet and life over the period of enamel mineralization (Balasse 2002; Zazzo, et al. 2005). This allows us to trace patterns of seasonal mobility rather than simply single migration events. This sort of serial, intra-tooth isotopic analysis holds great promise for augmenting our understanding of mobile populations, particularly mobile pastoralists. Although individual mobile people and their settlements might be obscured in the archaeological record, traces of their movements and interactions are cemented in the isotopic signatures of their herds.

All samples were drilled and cleaned by the author at the Environmental Isotope Paleobiogeochemistry Laboratory at the University of Illinois at Urbana-Champaign using the methods outlined by Balasse et al. (2002). $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ were analyzed using a Kiel III device interfaced with a Finnegan MAT 252 isotope ratio mass spectrometer. Samples for $^{87}\text{Sr}/^{86}\text{Sr}$ were prepared and analyzed at the Isotope Geochemistry Laboratory in the Department of Geology at UIUC using a Nu Plasma HR multicollector inductively-coupled-plasma mass-spectrometer (MC-ICPMS). Lab methods are detailed in Slater et al. (2014:122).

Samples from archaeological and modern animal teeth (183 samples across 23 teeth from 16 animals) with known origins show that local geographic features (the Bani River, a secondary water source tentatively identified as the Pondori zone of permanent marshes, and the terrestrial zone) have discrete $^{87}\text{Sr}/^{86}\text{Sr}$ signatures. Furthermore, samples from as far apart as Gao and Timbuktu demonstrate a separate, more unified desert signature. The differences between these known features on the landscape allow us to trace mobility patterns across the teeth of archaeological cattle, sheep, and goats (see Figure 5.1).

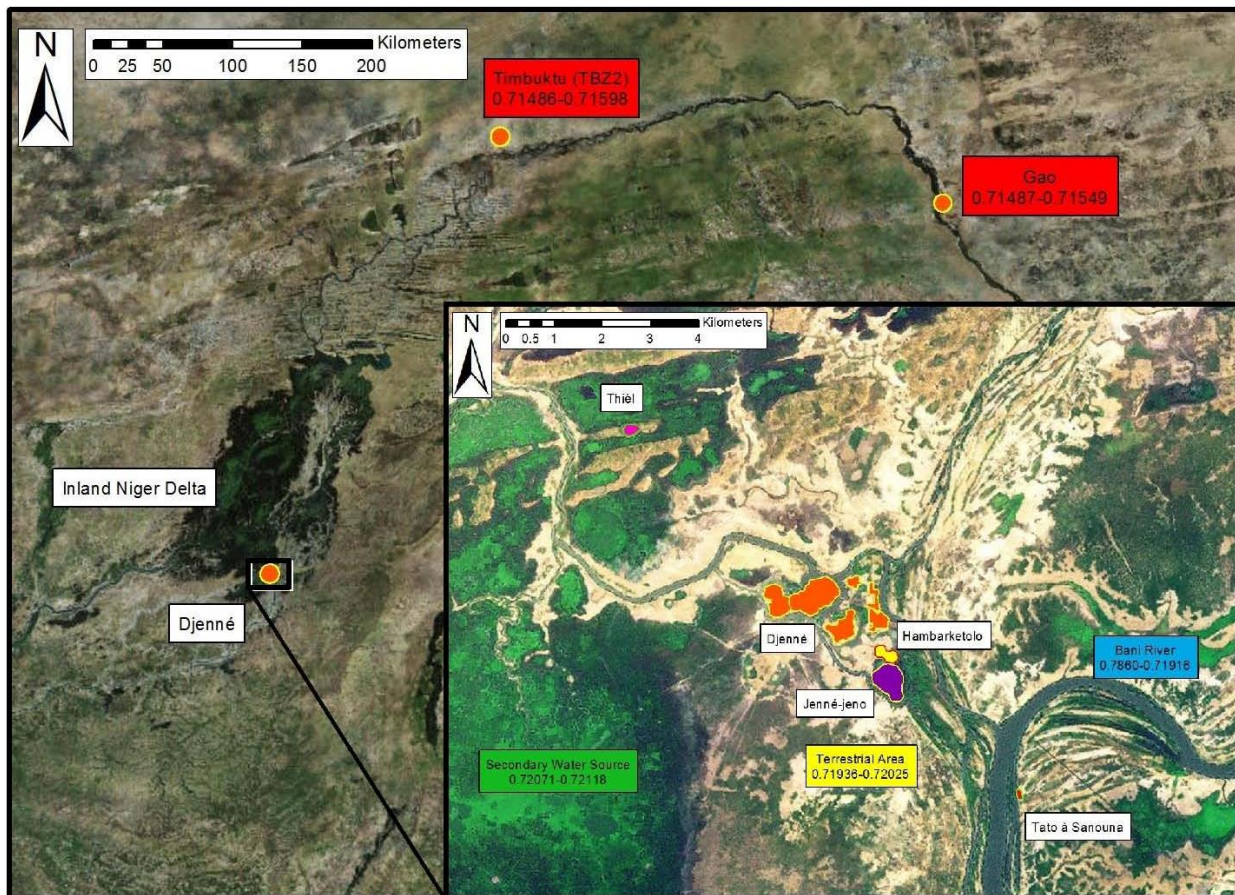


Figure 5.1 – Schematic map showing locations of the geographic zones identified by their strontium signatures. The secondary water source (shown in green) is speculatively placed in the Pondori, an area with deep basins that contain water year-round.

Oxygen data are particularly difficult to interpret owing to the numerous factors that can influence $\delta^{18}\text{O}$ signatures. Data from the Bani and Niger Rivers, however, show distinct seasonal shifts in river oxygen values from nearly 37.0‰ in May before the rains to 24.7‰ in August at the end of the rainy season (Gourcy, et al. 2000). This tentatively suggests that for samples from in and near the delta, high $\delta^{18}\text{O}$ signatures relate to the hot, dry season, while lower signatures are tied to the rainy season. Even so, factors like non-river water sources and water consumed through plants in the diet may complicate the $\delta^{18}\text{O}$ interpretations.

In many areas $\delta^{13}\text{C}$ data are useful in determining seasonality and mobility, because of differences in dry and wet season pasturage. In the IND these differences are not stark, but $\delta^{13}\text{C}$ signatures are helpful in distinguishing between sheep and goats, which is difficult to do osteologically (Balasse and Ambrose 2005a). In cattle, different mobility patterns result in more or less variable $\delta^{13}\text{C}$ signatures, but these signatures alone could not differentiate mobility patterns. Fluctuations in $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ signatures largely corroborate divergent mobility patterns identified using $^{87}\text{Sr}/^{86}\text{Sr}$, but for this paper I rely primarily on $^{87}\text{Sr}/^{86}\text{Sr}$ data. The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ data, and the relationship between $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{13}\text{C}$, and $\delta^{18}\text{O}$ are discussed in much greater detail in Chapter 4.

After taking 320 samples across 40 teeth from 29 archaeological cows, sheep, and goats (samples represent a cross section of time and space (see Table 5.1)), I identified three classes of mobility: 1) extralocal mobility, including seasonal mobility into and out of the known delta signatures and non-local animals imported to the area after the period of tooth development; 2) local seasonal mobility within the known delta signatures; and 3) completely non-mobile animals raised in a variety of local environments. The divergence of $^{87}\text{Sr}/^{86}\text{Sr}$ signatures for various local delta features (the Bani River, the Pondori, and the terrestrial zone) allows me to identify specific

landforms utilized by locally-raised herds and to further subdivide the animals. For example, although all of the animals with locally mobile patterns spent part of the year in the terrestrial zone, some migrated to the Bani River during the dry season and others to the Pondori. Given the complex pathways and timings of the incorporation of strontium into tooth enamel (see Montgomery 2010), these local mobility subsets are somewhat tentative. Differences between the three overarching classes of mobility are, however, clear.

Table 5.1 – Sources of archaeological bovid teeth sampled

Site	Phase	Date	Cows		Sheep/Goats	
			Animals	Teeth	Animals	Teeth
Jenné-jeno	I/II	250 BCE - CE 400	3	4	2	4
Jenné-jeno	III	CE 400 - 900	5	7	0	0
Jenné-jeno	IV	CE 900 - 1400	2	4	3	6
Tato à Sanouna	I/II-IV	ca. CE 200 - 1400	4	4	2	2
Thièl	I/II-IV	ca. CE 300 - 1400	1	1	2	3
Djenné	V	ca. 1400 - 1900	4	4	1	1

The data demonstrate that multiple mobility patterns exist simultaneously within each major phase at Jenné-jeno. In Phase I/II (250 BCE-CE 400), for example, two animals have extralocal signatures (a cow was a non-local import and a goat evidences seasonal migrations into and out of the local area), and two cows and a goat show various patterns of local mobility (see Figure 5.2). This diversity continues across Phases III (CE 400-900) and IV (CE 900-1400) (see Figures 5.3 and 5.4). In the phase that shows the weakest isotopic evidence for long-distance mobility (Phase III, CE 400-900), other studies using metric analysis found the strongest evidence for the presence of multiple herds at the site (MacDonald 1995, 1999). Combined, the isotopic and metric analysis suggests that herds of variable size and mobility patterns were consumed at Jenné-jeno throughout its 1600 year sequence.

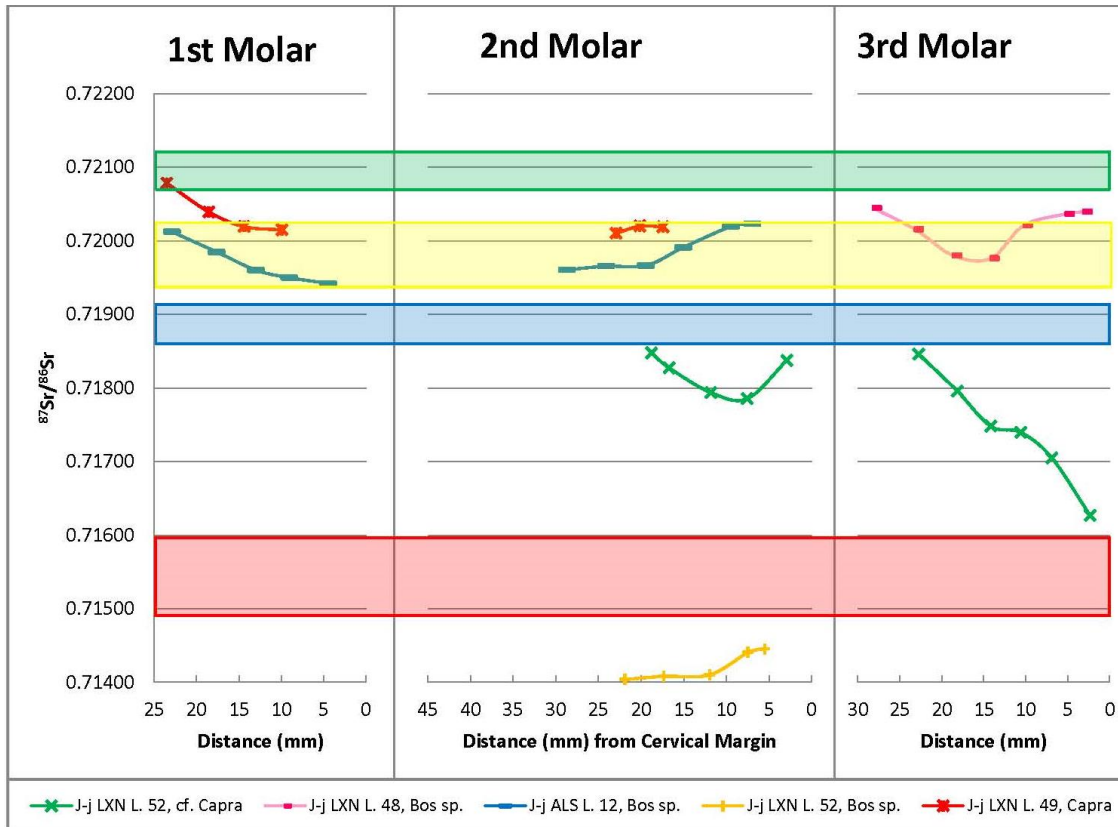


Figure 5.2 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from Phase I/II contexts at Jenné-jeno (colored boxes correspond to geographic areas identified using baseline samples (see Fig. 5.1))

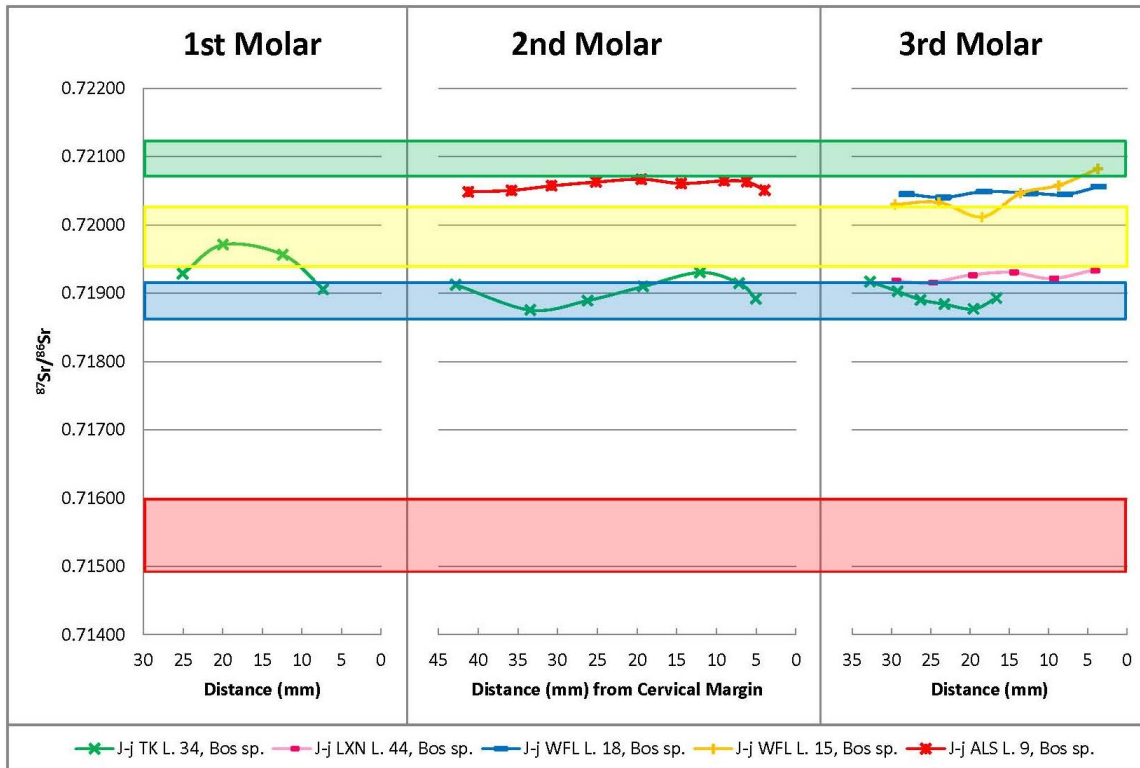


Figure 5.3 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from Phase III contexts at Jenné-jeno

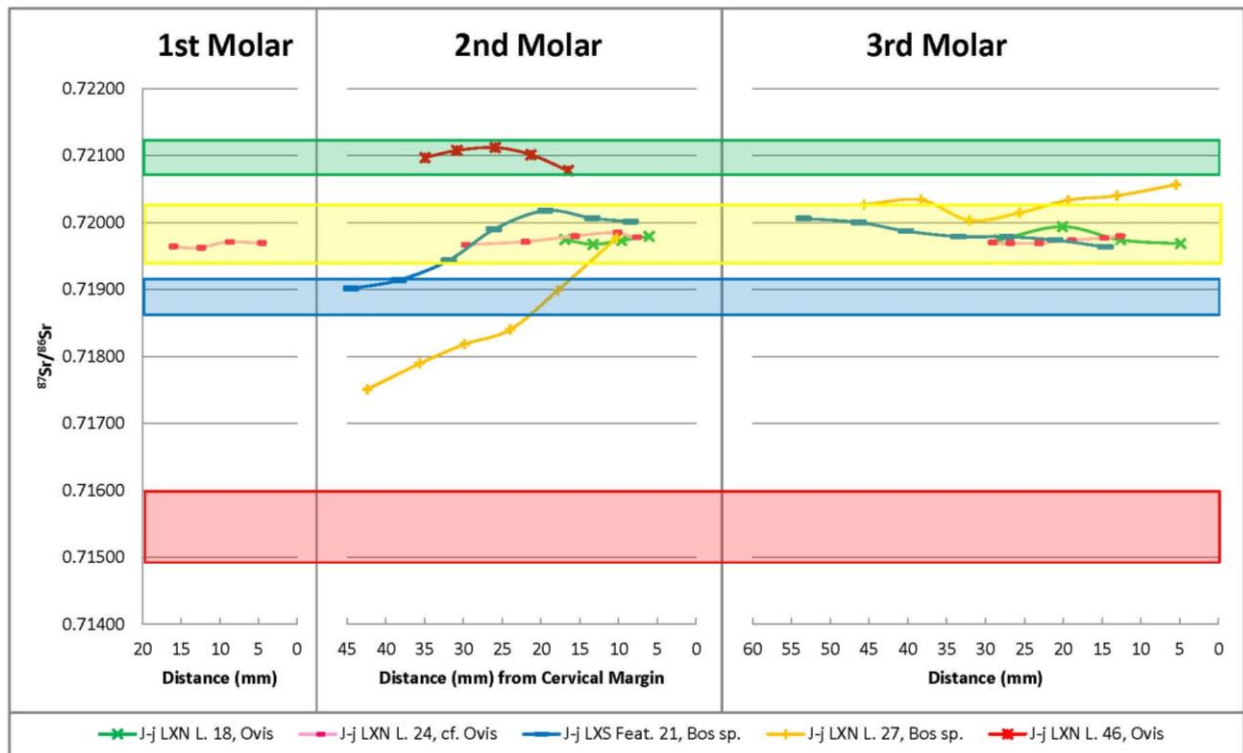


Figure 5.4 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from Phase I/V contexts at Jenné-jeno

Animal teeth from excavations at Tato à Sanouna, Thièl, and Djenné provide a compelling comparison to Jenné-jeno. While there is some diversity in the signatures of animals consumed at Tato à Sanouna and Thièl (see Figures 5.5 and 5.6), none of the animals show signs of extralocal mobility. This could be a factor of sample size, given the limitations of this study, but it suggests that groups engaged in mobility beyond the delta traded at Jenné-jeno, but not with smaller sites. In striking contrast, four out of five of the Djenné animals have strongly extralocal mobility patterns, though the fifth was clearly raised locally (see Figure 5.7). These animals, which come from excavation levels dating between CE 1400 and 1800, evince a radical shift in herding patterns concurrent with the abandonment of Jenné-jeno and growth of Djenné.

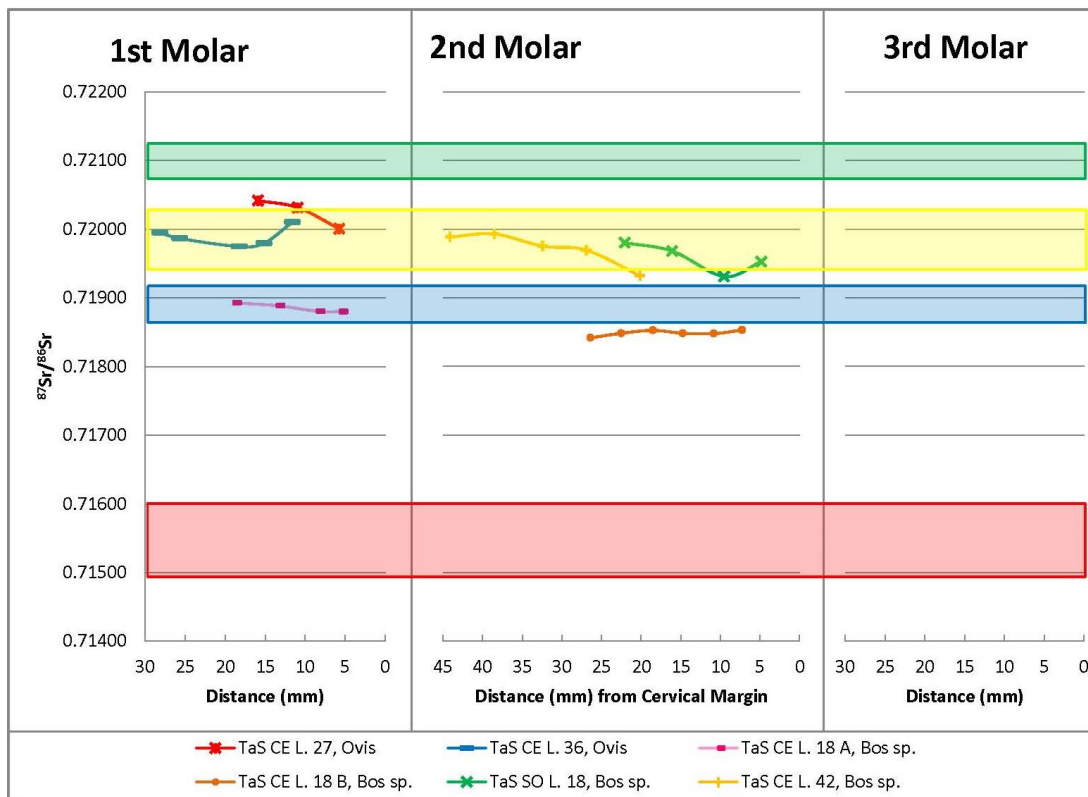


Figure 5.5 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from contexts at Tato à Sanouna

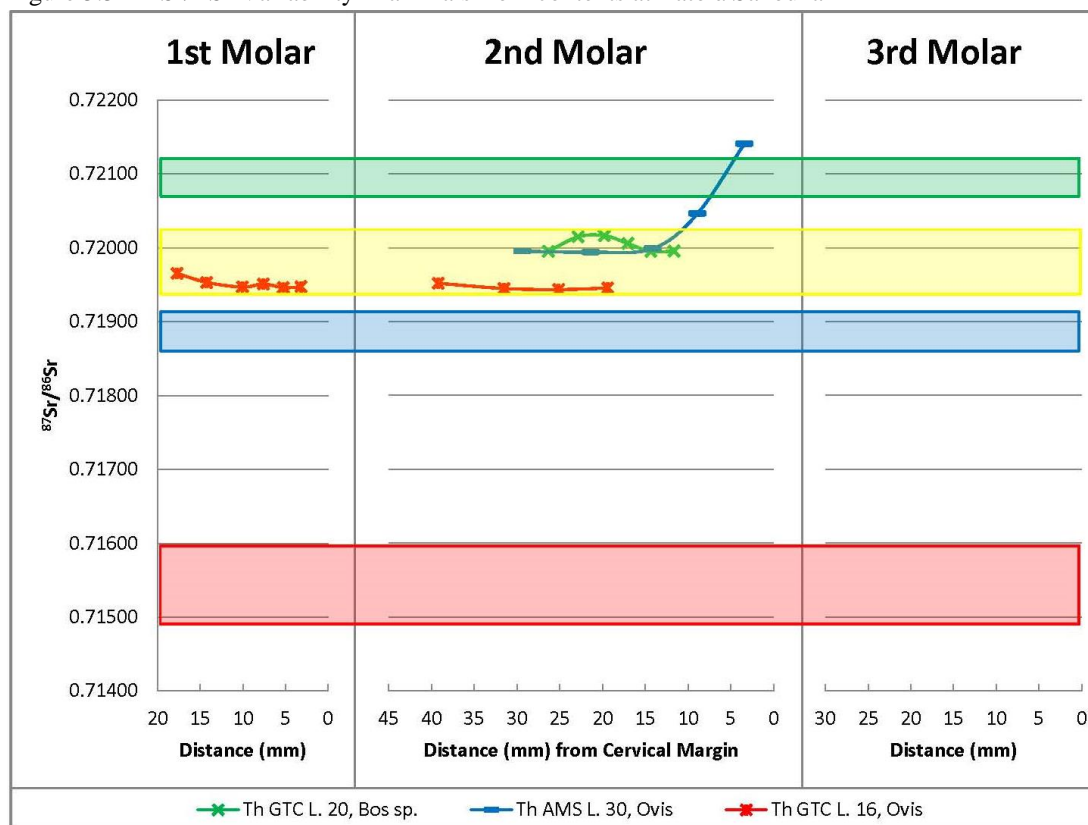


Figure 5.6 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from contexts at Thièl

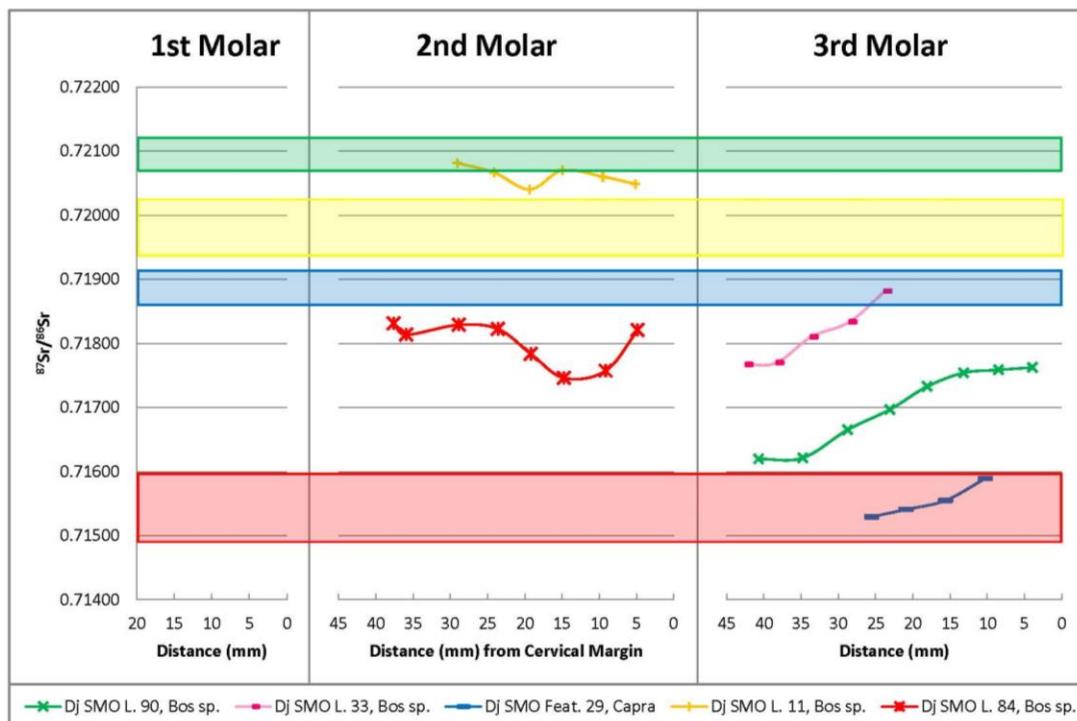


Figure 5.7 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability in animals from archaeological contexts at Djenné

Although most animals with multiple teeth sampled show consistent patterns of mobility throughout the period of tooth mineralization a Phase IV cow from Jenné-jeno shows a strong extralocal signature in its second molar, but a minimally mobile signature in its third molar (see Figure 5.8). This could attest to a herding population which shifted its mobility patterns or, more likely, the exchange of a live animal between groups engaged in different stock-keeping practices.

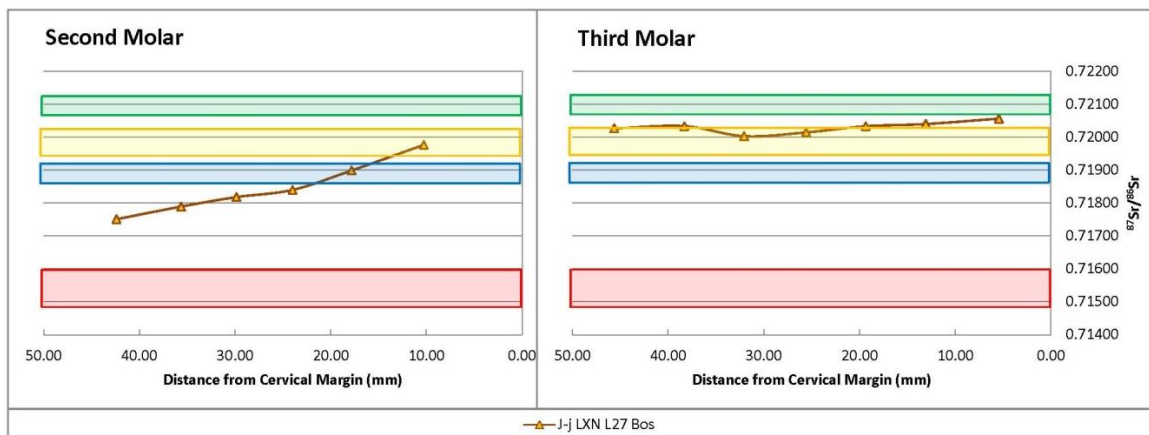


Figure 5.8 – $^{87}\text{Sr}/^{86}\text{Sr}$ Variability across two teeth in a cow from Jenné-jeno

I also took bulk enamel samples from a limited number of human teeth from burials at Jenné-jeno (n=3), Tato à Sanouna (n=1), and Thièl (n=6) to better understand the patterns of human mobility at the three sites (see Figure 5.9). These samples show no signs of extralocal mobility, but this does not preclude the possibility that certain inhabitants of the sites were seasonally mobile or that seasonally mobile individuals interacted with the more sedentary populations of the sites. Interestingly, the individuals from the smaller sites have highly localized strontium signatures: the individual from Tato à Sanouna, located adjacent to the Bani River, has a strong Bani River signature and the six individuals from Thièl all have tightly clustered terrestrial signatures. In contrast, the three individuals sampled from Jenné-jeno show a high degree of variability. These findings, along with the presence of seasonally-mobile animals and various trade goods at Jenné-jeno, highlight the fact that Jenné-jeno acted as a commercial and population center for the area, attracting a wider range of goods and people than smaller neighboring sites.

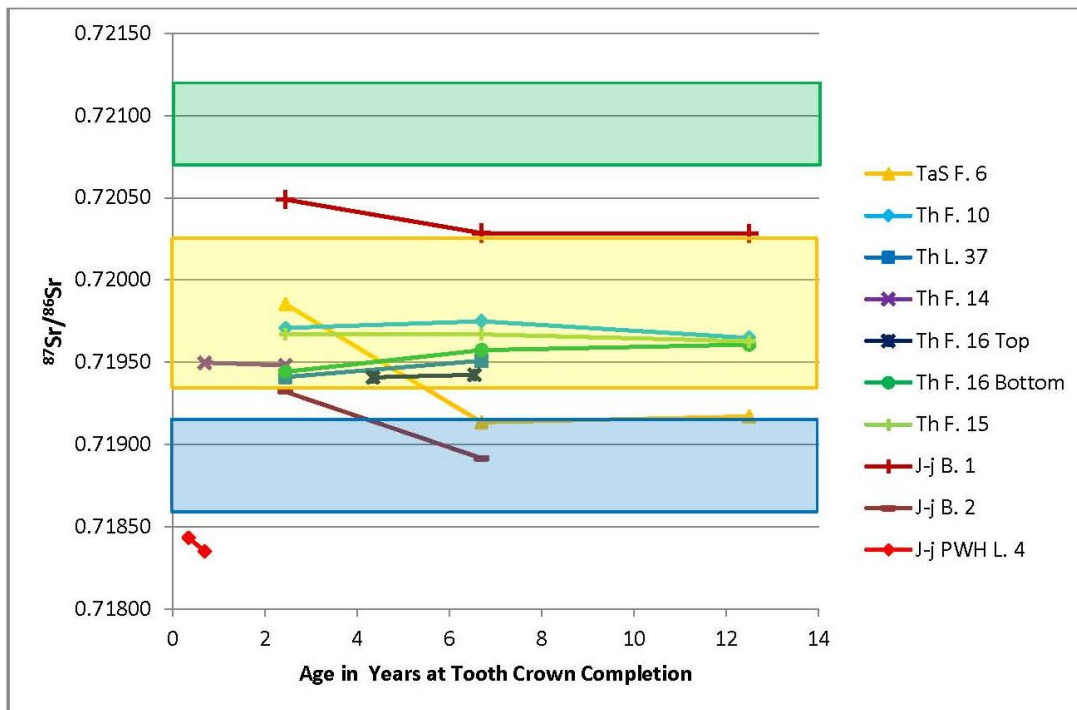


Figure 5.9 – $^{87}\text{Sr}/^{86}\text{Sr}$ variability in human teeth from Jenné-jeno, Tato à Sanouna, and Thièl

5.4 Discussion: Subsistence Specialization, Mobility, and Urbanism at Jenné-jeno

5.4.1 Subsistence Specialization, Centralization, and Urbanism

The archaeological and isotopic data attest to a vibrant, heterogeneous economy and population at Jenné-jeno and in the surrounding area throughout the site's occupation. However, the coexistence of multiple herding practices challenges the way that archaeologists have thought about two significant aspects of urbanism: 1) the need for densely populated areas to be organized around specialized production and 2) the necessity of centralized control of subsistence regimes to meet the needs of an urban population.

The concept of subsistence and craft specialization is fundamental to most traditional models of urban development. These models posit that specialized producers allow a large population to live in a limited area by creating food surpluses and allowing others to focus on different pursuits, including developing hierarchical structures to control and organize the populace (Childe 1950). Excavations at Jenné-jeno challenged this model because while the site is recognizably urban, burials and architecture reveal no evidence of centralized governance or social stratification (McIntosh 1998:166; 2005:52; McIntosh 1999a:73-74). This research did not question that subsistence and craft specialization existed as part of the urban system. It argued that specialization was a logical response to environmental heterogeneity and a possible means of dispersing power in a densely populated urban area.

This model was largely based on the subsistence specialization of modern Djenné in which most of the prominent ethnic groups in the area self-identify with a particular subsistence regime: Bambara millet farmers, Nono rice farmers, Bozo floodplain fishers, Somono open-water fishers, and seasonally-present Fulani pastoralists (Gallais 1967b; Monteil 1971 [1932]; N'Diaye 1970; Sundström 1972). Various merchant guilds, religious groups, and artisan castes

are also loosely associated with the larger ethnic groups and add to the segmented, interdependent, but nonetheless specialized organization (LaViolette 2000).

As compelling as these modern ethnic configurations are, isotopic data showing a diversity of herding practices suggest that specialization was not as clear-cut in the past as it is today, and that modern, ethnically-linked subsistence specialization is a poor analogy for the archaeological context. Today, though the droughts of the 1970s broke down some of the farmer-herder distinction, extralocally mobile Fulani herders are responsible for the majority of animals consumed in the IND (Habou and Danguioua 1991; N'Diaye 1970; Turner 2004:872). Individual households may keep a sheep or two for religious festivals like Eid al-Adha, but they rarely keep larger herds. In contrast, across all three phases at Jenné-jeno, 33% of the animals sampled were essentially non-mobile, 47% were involved in some form of local mobility, and only 20% were extralocally mobile (moving significant distances in and out of the delta on their seasonal rounds).

It is difficult to know exactly what each of these mobility patterns looked like in terms of the human actors involved. However, the environmental context, biological needs of the animals, and the variable degree of specialized knowledge required provide some insight into the identity of the actors. Long-distance, seasonally-mobile (extralocal) pastoralism requires a great deal of specialized knowledge, including information about water and fodder locations across long distances of variable terrain, knowledge of animal health, and understanding of the dispersed communities that the herds come in contact with. The contemporary Fulani certainly consider themselves specialized pastoralists. Even for individuals who have become sedentary, Fulani identity is inextricably linked to their animals, particularly their cattle, and a nomadic way of life (Azarya 2001:265). Furthermore, specialized pastoralists have a long history in northern

and western Africa: Di Lernia argues for the existence of cattle cults in the Sahara in the 7th millennium BP (Di Lernia 2006) and archaeological evidence from the nearby Mema region of Mali suggests that specialized herders were seasonally present in that area in the millennium preceding Jenné-jeno's occupation (MacDonald 1999).

It is thus probable that the individuals who brought extralocally-mobile herds to Jenné-jeno considered themselves specialized pastoralists. If so, the whole group was probably seasonally mobile rather than simply entrusting a subset with care of the animals. It is also, of course, possible that these individuals, despite their specialized knowledge, identified more as a segment of the larger IND population than as a distinct herding group. In this case, a subset, probably young men, would most likely have undertaken the seasonal rounds alone.

Until we are able to identify and excavate areas occupied by these herders, it is impossible to know with certainty to what degree they can be considered specialized pastoralists. Regardless of the self-identity of these individuals, however, because of the diversity of ways that people were managing herd animals in and around Jenné-jeno, they probably did not function in the urban system in the same way that modern Fulani herders do (as the quintessential animal producers).

The data presented here suggest that locally-raised animals were far more important to Jenné-jeno's economy and subsistence than extralocally-mobile ones. Within this classification is a wide variety of husbandry practices, from animals that were apparently penned and brought fodder, to those who were locally mobile and taken during the height of the dry season to the nearby Bani River or the Pondori marshes (distances of roughly one to ten kilometers).

It seems unlikely that these local animals were raised by herding specialists for two reasons. First, is the diversity of local mobility patterns. If there were local, sedentary herding specialists, it is likely that the isotopic signatures would be consistent, reflecting the practiced and stable strategy of feeding and watering herds that accompanies specialized knowledge. The diversity of the signatures suggests a diversity of feeding and watering practices.

Second, raising herd animals in the IND year-round is somewhat risky due to the high prevalence of tsetse flies and trypanosomiasis (sleeping sickness) during the rainy season. This risk is a primary spur for contemporary herders to leave the IND during this time. It is possible that the archaeological animals were of a trypanotolerant variety like several modern breeds including the N'Dama or the West African Shorthorn, both noted for their small statures (Shaw and Hoste 1987; Smith 2005). There is evidence that dwarf animals were consumed at Jenné-jeno, but whether these animals were in fact disease-resistant remains an open question (MacDonald 1995). Even if the small animals were disease resistant, some non-dwarf animals were raised locally, suggesting that disease would have been a concern to local stock keepers. Such risk would seem to make specialization in local animal husbandry a fraught and delicate economic strategy. In the local environment, generalized economic strategies may have been the more logical choice.

This precariousness, coupled with the diversity of locally-anchored mobility patterns in the archaeological samples, suggests that an array of non-specialized husbandry practices representing household-level or small-scale agro-pastoral activity existed in the past. Small-scale, locally-hinged husbandry would require much less specialized knowledge than long-distance herding and could have supplemented household diet, allowed households or groups to hedge resources in the event of droughts or floods damaging agricultural output, acted as a

resource reserve for future events like marriages and deaths, and served as a valuable commodity in the urban market. Groups involved in these forms of local husbandry would have been primarily sedentary, with a small subset of the population, such as young men and boys, taking herds for daily or slightly longer rounds, or bringing fodder and water to penned animals.

In addition to demonstrating the influence of small-scale animal husbandry on Jenné-jeno's economy, the diversity of herding practices seen at Jenné-jeno and the surrounding sites show that the livestock economy was not centrally controlled. Even in highly urbanized, hierarchical situations like those seen in Mesopotamia, herding groups can be difficult for centralized authorities to govern, though they often exert enough influence to ensure that their own needs are met (Zeder 1991, 2003). However, the herding populations of the IND were successfully centralized under Séku Amadu in the 19th century. Azarya contends that under the Fulbe Empire of Maasina, animal husbandry throughout the delta was strictly regulated, down to prices and transhumance routes (1997:76). Such control would result in strikingly regular $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in herd animal teeth.

The isotopic data demonstrate that similar centralized control did not exist at Jenné-jeno at any time during its 1600 year occupation. Instead, stock keeping was practiced on multiple scales by diverse populations who were economically specialized to highly divergent degrees. Any centralizing or organizational role Jenné-jeno played in the livestock economy was probably indirect by virtue of its markets, which would have attracted diverse populations seeking to trade numerous craft and subsistence goods from within and beyond the delta. Although Jenné-jeno was certainly central to the local and regional economy as a locus for exchange, it was the independent, interrelated actions of individual producers that built and sustained the urban marketplace rather than the calculated dictates of a centralized authority.

These isotopic data demonstrate that the livestock economy in and around Jenné-jeno was primarily non-specialized and free from centralized control. This mirrors archaeological data demonstrating a lack of agricultural intensification over the course of the site's occupation (McIntosh 1999a). This does not mean that specialized craft producers (and possibly even production guilds) couldn't have had social and economic importance at Jenné-jeno (see Frank 2002:125), though no definitive evidence of specialized craft production is known at this point. This economic configuration does, however, counter traditional models of urban economies wherein subsistence specialization and centralized control are considered critical to a city's ability to feed its populace. I discuss the implications of this divergence and a possible explanation for it in a subsequent section (Reinterpreting Urbanism) below.

5.4.2 Mobility & Urbanism

The original goals of this project were to understand interactions between mobile herders and a sedentary, urban population. The isotopic data presented here suggest that in the case of Jenné-jeno, the labels 'mobile' and 'sedentary' create a false dichotomy. It appears that many members of the primarily sedentary population raised domestic stock and may have needed to move their animals seasonally to find adequate food and water (evidenced by the large number of animals with locally-mobile isotopic signatures). Conversely, herders involved in more specialized, extralocal husbandry were intimately involved with the urban economy, though the urban population was not solely reliant on these long-distance herders for meat.

Moving beyond the mobile-sedentary dichotomy, the interrelationship between Jenné-jeno and its various scales of livestock keepers has profound implications for our understanding of Jenné-jeno's development and the role it played within the wider landscape. Moreover, by analyzing the nature of the interpersonal interactions that framed this relationship and the

motivations behind them, we can understand how both locally-anchored household economies and extralocal mobility impacted Jenné-jeno's economy and role as a regional market center.

Extralocally-mobile herders brought animals into the delta during the dry season in search of water and pasture, but it is likely that they were also attracted to the large urban markets where they could exchange animals, milk, and goods like leather for grain and other necessities. Furthermore, the absence of these extralocally mobile animals at smaller sites like Tato à Sanouna and Thièl reinforces the centrality of Jenné-jeno and helps elucidate the herders' motivations: From a herder's perspective, the decision to engage with Jenné-jeno's markets rather than those of smaller, nearby sites makes a good deal of sense. Bringing herd animals into a densely occupied area is a dangerous undertaking: space and fodder are in short supply and, unless they are tightly controlled, herds can easily destroy crops leading to tensions with farmers. It stands to reason that a mobile herder would only undertake such risk for a tangible reason, perhaps in search of goods like salt and kola nuts that would not have been readily available at the numerous smaller sedentary communities found in less densely occupied areas of the IND. Along with forging connections with far-flung populations, this trade would have augmented the importance of Jenné-jeno as a regional economic hub by increasing the quantity and variety of goods passing through its markets.

Equally, integration into the urban economy would have impacted culling practices and seasonal migrations of extralocally mobile herders. The exchange in live animals between extralocal and local stock keepers, as is demonstrated by the Phase IV cow eventually consumed at Jenné-jeno (see again Figure 5.8), was another important facet of these relations. Such exchanges could have been used by stock keepers of various scales of mobility to augment herds, replace animals lost by disease or trade, and diversify breeding pools. This would both increase

the importance of extralocal herders to the local economy and provide another impetus for these herders to include the Jenné-jeno area as part of their seasonal rounds, despite the difficulty of bringing large herds into densely occupied areas.

Modern ethnography shows that mobile and more sedentary populations in West Africa are deeply interconnected today. Even in cases with marked ethnic divisions between herders and farmers, there can be strong personal, ritual, and economic relationships across group lines. Farmers frequently buy stock as a safeguard against crop failure, but entrust the animals to nomadic herders for management purposes and also as a means of hiding wealth from neighbors (e.g., Breusers, et al. 1998; Turner 2004). These sorts of close relationships between herders and farmers provide compelling analogies for past interactions, even if ethnic and group lines were drawn in completely dissimilar ways in the past. Such relationships would have had profound impacts on both the urban economy and pastoral strategies.

Many studies of relations between mobile pastoralists and sedentary populations highlight the fractious nature of these interactions, focusing particularly on large states and military conquests, or cast mobile pastoralists into a dependent position supplying food to a dominant urban population (e.g., Adams 1974; Bar-Yosef and Khazanov 1992; Khazanov 2001). This characterization is no doubt the case in certain contexts, particularly in locations where nomadic and sedentary population occupy discrete territories, helping to cultivate distinct, antagonistic identities. In the context of the IND, however, extralocal herders were in close contact with various more sedentary populations for much of the year. In this setting, the daily interactions of farmers and herders would have done much to frame the narrative of their relationship.

Given the diversity of herding practices seen in and around Jenné-jeno, specialized extralocally-mobile pastoralists would have been a useful, but non-essential segment of the population. Potential conflicts with local producers over pasture land, possible crop destruction, and competition within the livestock economy would likely have been mitigated by demand for their animals as meat and to augment local herds and by appreciation of their role as consumers within the broader urban market. For the extralocal pastoralists, interactions with Jenné-jeno's markets and urban population would have been beneficial, particularly as a means of obtaining desired goods as I discussed above, but it is unlikely that they were dependent on this particular relationship. Extralocal herders would have had connections with numerous communities from throughout their seasonal rounds. If interactions with Jenné-jeno soured, they could turn to others for any required products that they could not produce or obtain themselves.

This study demonstrates that mobile and sedentary populations should not be characterized as inherently conflicting entities (though conflict can always occur) and that mobility can be crucial to an urban system. In the context of Jenné-jeno and its surrounding settlements, mobility existed on multiple scales and these populations engaged in trade and interactions that appear to have been primarily mutually beneficial. These interactions, framed by an environment where non-specialized stock-keeping could meet the needs of an urban population, had profound impacts on urban configurations.

5.4.3 Reinterpreting Urbanism

This study joins a growing body of literature which argues that a city must be analyzed in the context of its broader human and geographic environment – that ancient cities are highly influenced by their neighboring towns and villages and that urban configurations are the direct product of their local conditions (LaViolette and Fleisher 2005; Marcus and Sabloff 2008:333).

The isotopic data presented here provide insight into the nature of Jenné-jeno's urban markets, the relationship between large and small sites within the wider urban system, and suggest how local environmental conditions may have enabled the urban system to function.

Despite its size, cosmopolitan population, and role as an important local and regional market, Jenné-jeno could be dismissed as an anomalous population aggregation rather than a true urban center; it lacks evidence of many of the traditional hallmarks of urbanism, including centralized governance, social stratification, and as presented here, specialized or centralized subsistence regimes. It is more useful, however, to try to understand how Jenné-jeno, as a densely populated area, functioned and why it differed from the standard model.

The archaeological record clearly demonstrates that Jenné-jeno was an important hub of commercial activity with strong regional connections. This characterization is echoed in the isotopic record as well. Although animals raised locally were found at all three archaeological sites (Jenné-jeno, Tato à Sanouna, and Thièl), it is only at Jenné-jeno that we find animals involved in mobility out of the delta. This is in spite of the fact that Tato à Sanouna and Thièl were targeted precisely because of their location in microenvironments heavily used by mobile pastoral herds today. As discussed in the prior section, these findings demonstrate the centrality of Jenné-jeno's markets to the local and regional economy by showing how they attracted consumers and producers from a wide area.

Perhaps not surprisingly, the human isotopes from Jenné-jeno, Tato à Sanouna, and Thièl mirror the relationships seen in the patterns of animal mobility, further emphasizing the centrality of Jenné-jeno. Samples from Thièl cluster tightly together and the single sample from Tato à Sanouna is consistent with the site's location along the Bani River. In contrast, the three

humans sampled from Jenné-jeno show wide diversity, suggesting that individuals or families were drawn to Jenné-jeno from throughout the region (see again Figure 5.9). The presence of these individuals at Jenné-jeno would have established and reaffirmed interpersonal links between Jenné-jeno's population and numerous smaller, dispersed communities in the area. Jenné-jeno's cosmopolitan population would also have given the settlement a distinctly different character from these smaller sites.

In spite of the clear importance of Jenné-jeno as a market center and the absence of animals who moved out of the delta at Tato à Sanouna and Thièl, the data indicate that smaller sites were not relegated to the role of producers sustaining a dominant urban population: several animals consumed at Tato à Sanouna and Thièl have signatures showing that they were raised within the delta but not in the immediate vicinity of those sites, suggesting that these smaller sites were consumers as well as producers in a wider subsistence economy. This begs the question of whether this trade was routed through Jenné-jeno or represents interactions independent of the central market, a question that the isotopic data cannot answer thus far. Regardless, this sort of intra-regional trade would have strengthened local connections between individuals and populations living somewhat distant from one another and often in distinct ecological zones.

Above all, the results of this analysis demonstrate the fact that Jenné-jeno functioned as a social and economic center, drawing people and goods from throughout the wider landscape. Rather than being controlled by a centralized authority, however, these movements and exchanges appear to reflect the logical choices of independent actors. Intriguingly, these data suggest that an urban context like Jenné-jeno can be forged out of non-specialized, un-

centralized household and small-scale local trade connections. This begs the question of why this situation differed so strikingly from traditional models of urban configurations.

Many of the world's earliest urban centers existed in marginal or arid environments where agricultural intensification and centralized organization were the only means to feed a growing, specialized population. As Zeder argues in the context of Ur III cities, production is likely to become specialized and more susceptible to higher-order control if traditional forms of production fail to meet the larger needs of the urban community or if they come into conflict with other forms of production (1991:43). In fact, J. Desmond Clark used the wide availability of arable land and favorable climate to explain the apparent absence of indigenous sub-Saharan African urban centers; there simply wasn't sufficient incentive for population aggregation (Clark 1962). Although indigenous urban centers have now been shown to exist in sub-Saharan Africa (Kusimba 2008; LaViolette and Fleisher 2005), these favorable factors could help to explain why many of these centers do not match Mesopotamian models of urbanism.

In contrast to the situation in Mesopotamia, the Inland Niger Delta is an extremely fertile environment today and was perhaps even more so in the past (Gallais 1967b; Makaske 1998). Fish would have been an essentially unlimited resource for much of the year, and seasonal floods open up much of the land to low-intensity wet rice agriculture. Large scale irrigation projects were simply not required to feed a sizable population. At the same time, environmental heterogeneity and inter-annual variability would have encouraged economic diversification, not only within urban society, but also within families or small associative units. A small herd would be an invaluable resource if floods wiped out the rice or millet crop and crops would be a critical fallback if disease decimated the animal herds. Such small-scale agro-pastoral activity is seen in the high percentage of non-mobile and locally-mobile animals identified in the isotopic record.

Even those individuals not engaged primarily in food production could keep a couple of animals penned and foddered as assurance against need.

In this environment, small-scale, non-specialized food production would likely meet the needs of the urban populace and higher-order organization of the subsistence economy may not have been required. The market economy could have essentially been self-regulating, with diversified small-scale producers altering their output to match demand. The wide variety of craft and subsistence goods available would attract larger permanent and itinerant populations. In this environment, any attempts at centralization of the production economy would have been both unnecessary and potentially destructive to the urban population because they could lessen the incentive to live in or trade with Jenné-jeno. A dissatisfied population could easily relocate within the relatively lush and open IND.

This lush environment, however, was not deterministic. Numerous economic, political, and social factors contributed to Jenné-jeno's urban configurations, and later, resulted in their complete upheaval. As mentioned previously, Jenné-jeno and at least 75% of surrounding settlements were abandoned by CE 1400 and population was concentrated at the modern town of Djenné. Isotopic analysis of cattle, sheep, and goat teeth excavated in Djenné and dating to between CE 1400 and 1800 demonstrate a complete reversal of the diversity that characterized all three phases at Jenné-jeno; only one of the five animals sampled was raised locally, while the other four were engaged in mobility outside of known delta signatures, in patterns mirroring modern mobile herding strategies. This very likely represents the arrival of mobile Fulani herders to the region and a major upheaval of local animal husbandry practices (although the history of the Fulani is murky, they are believed to have arrived in the IND as part of a large westward migration around this time (Fey 1997:173)).

This shift coincided with several other major changes taking place around CE 1400, including the conversion of local leaders to Islam, incursions by the Mali and Songhai Empires, and the rise of the trans-Saharan trade (with Djenné as a vital node supplying food to its northern neighbor, Timbuktu) (McIntosh, et al. 2003:175; Monteil 1971 [1932]). These changes, particularly the arrival of the Fulani as an ethnic group identifying as specialized, nomadic pastoralists and the increased commercialism brought on by the increase in trans-Saharan trade, may have paved the way for the modern system of specialized, ethnically-linked subsistence practices. In this new economic and social environment, subsistence specialization may have been a rational response to the IND's heterogeneity and unpredictability, just as diversification had been in the past.

5.5 Conclusions

The isotopic data from Jenné-jeno, Tato à Sanouna, and Thièl demonstrate that while seasonally-present, highly-mobile herders played a role in Jenné-jeno's emergence and subsequent development, locally-anchored husbandry strategies were far more important to the city's subsistence regime. Despite this importance, local strategies were not part of a specialized production regime. Rather, I argue that these animals were the output of small-scale agro-pastoral and household-level practices. Such small-scale stock-keeping activities underpinned the entire urban subsistence economy at Jenné-jeno and neighboring sites.

The absence of a dominant, specialized animal economy is surprising given the centrality of specialized Fulani pastoralists to the modern IND subsistence regime. This absence also runs counter to established theories of urbanism and urban development, which stipulated specialized production as one of the central tenets of urban development. I argue that in a relatively lush, but unpredictable and heterogeneous landscape, subsistence specialization may not have been the

most stable, sustainable option. In fact, modern modes of ethnically-linked subsistence specialization may not have emerged until the arrival of Fulani mobile pastoralists around the time that Jenné-jeno was abandoned and Djenné became the regional market center. Songhai traders and the rise of the trans-Saharan trade may have worked to commercialize the local subsistence economy, leading to a total reorganization of subsistence practices. Although Jenné-jeno and its non-specialized subsistence practices did not last, the city is far from alone in its non-hierarchical urban configurations.

Further, this paper argues that while mobility and mobile populations were core elements of the urban system, the diversity of herding strategies documented in the isotopic record breaks down the strict dichotomy between mobile and sedentary populations. Instead, individuals and groups practicing a wide array of mobility strategies interacted in a variety of economic and social spheres. Such strategies and relationships must have been symbiotic to display the kind of continuity we see across Jenné-jeno's 1600 year occupation. A preoccupation with the distinction between mobile and sedentary populations in archaeological studies can mask a complex array of interactions between individuals with diverse occupations and identities. These small-scale interactions are vital for understanding the nature of the economic, political, and social organization in an urbanized system.

Beyond this specific West African context, this research informs our understanding of the relationship between subsistence regimes, specialization, mobility, and urbanism. Although the analysis presented here may not be practicable in all contexts, this study also shows that serial, intra-tooth sampling for isotopic analysis is a valuable strategy for understanding mobile herding strategies and urban configurations in areas with suitable isotopic variability. This project joins a

growing body of work suggesting that pathways to urbanism and urban configurations are more diverse and locally-situated than previously believed.

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Chapter 6 – Discussion

At its heart, this project is an investigation into the relationship between mobility and sedentism within an urban system. Using excavation and isotopic analysis, I break down the dichotomy between mobile and sedentary populations. I show that diverse forms and scales of mobility were present in the archaeological records of Jenné-jeno, Tatio à Sanouna, and Thièl in Mali's Inland Niger Delta. These findings reveal intricate interrelationships between populations engaged in various forms and scales of mobility. Here I synthesize my findings as a whole and discuss the nature of urbanism at Jenné-jeno and the reasons for its divergence from typical models of urban organization. I think that mobility may be key to this nonconformity. In fact, this research shows that mobile groups and mobility as a strategy, far from being anathema to sedentary urban centers, can be central to their ability to sustain large populations within a limited area. At Jenné-jeno, mobility in the form of local and extra local herding, long distance trading, human migrations, and possibly itinerant craft specialists, brought dispersed resources to the urban center and allowed the city to sustain itself without centralized organization of subsistence regimes or agricultural intensification. These configurations are certainly tied to Jenné-jeno's specific environmental and social context, but this study highlights a compelling example of divergence from expected urban forms.

The articles presented in the prior three chapters provide detailed information about subsistence and specialization in the Jenné-jeno urban system, identifying seasonal herding practices in a dense urban context, the impact of mobility and the livestock economy on urban configurations. In this discussion I briefly reiterate the results of these analyses, discuss how the results of this study caused me to reevaluate my original research objectives, and then examine

the broader impacts of the project. I discuss this project's impact on our understanding of urban configurations in and around Jenné-jeno, the relationship between mobility and urbanism, and finally, how this West African case study complicates prevalent theories of the forces leading to and the consequences of urbanism.

6.1 Results Part I: Excavations at Tato à Sanouna and Thièl

I presented the results of the excavations more detail in Chapter 3. For convenience, however, I provide a brief recap here.

Excavation took place between October 2010 and January 2011 at Tato à Sanouna. As illustrated in Figures 6.1 and 6.2, Tato à Sanouna is located on a high clay levee on the banks of the main channel of the Bani River. Three units from the central and southwestern portions of the site suggest that settlement began on the edge of the river and expanded eastward over time. Ceramic décor and radiocarbon dates indicate that the site was occupied contemporaneously with Jenné-jeno. Although the conventional radiocarbon date from the earliest levels of unit SO is imprecise, there was certainly some occupation during Phase I/II (250 BC to AD 400) (see Figure 6.3 and Table 6.1). The dates from unit CE suggest two rapid accumulation events at that part of the site, but evidence from the site as a whole suggests that occupation was continuous across Phases I/II, III (AD 400 to 900), and IV (AD 900 to 1400). A date of 1440 to 1481 cal AD taken from a hearth associated with a brief, small-scale reoccupation of the site shows that the site was abandoned by the 15th century AD, along with the majority of the surveyed sites in the Djenné region (McIntosh and McIntosh 1980b).

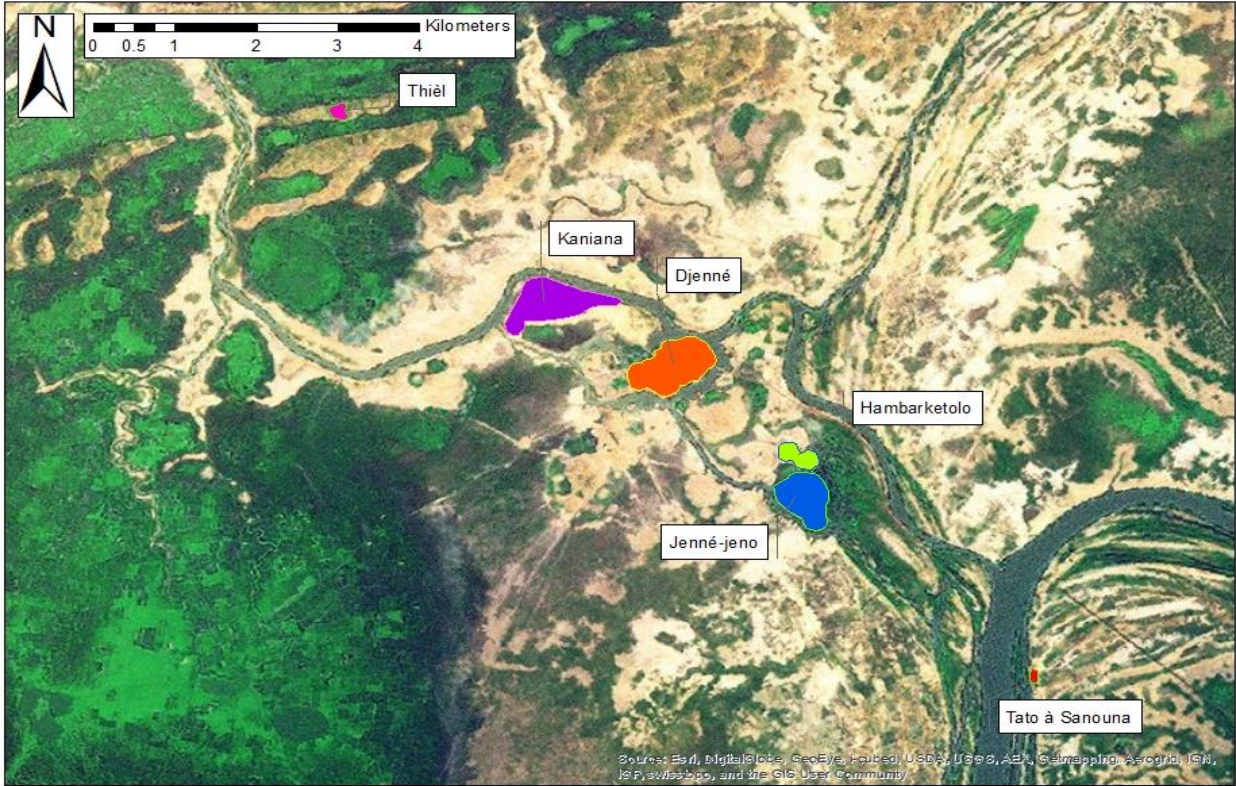


Figure 6.1 – Primary excavated sites in the Djenné region



Figure 6.2 – View south from Tato à Sanouna to the Bani River on 11 November, 2010 (photo by A.C. Stone)

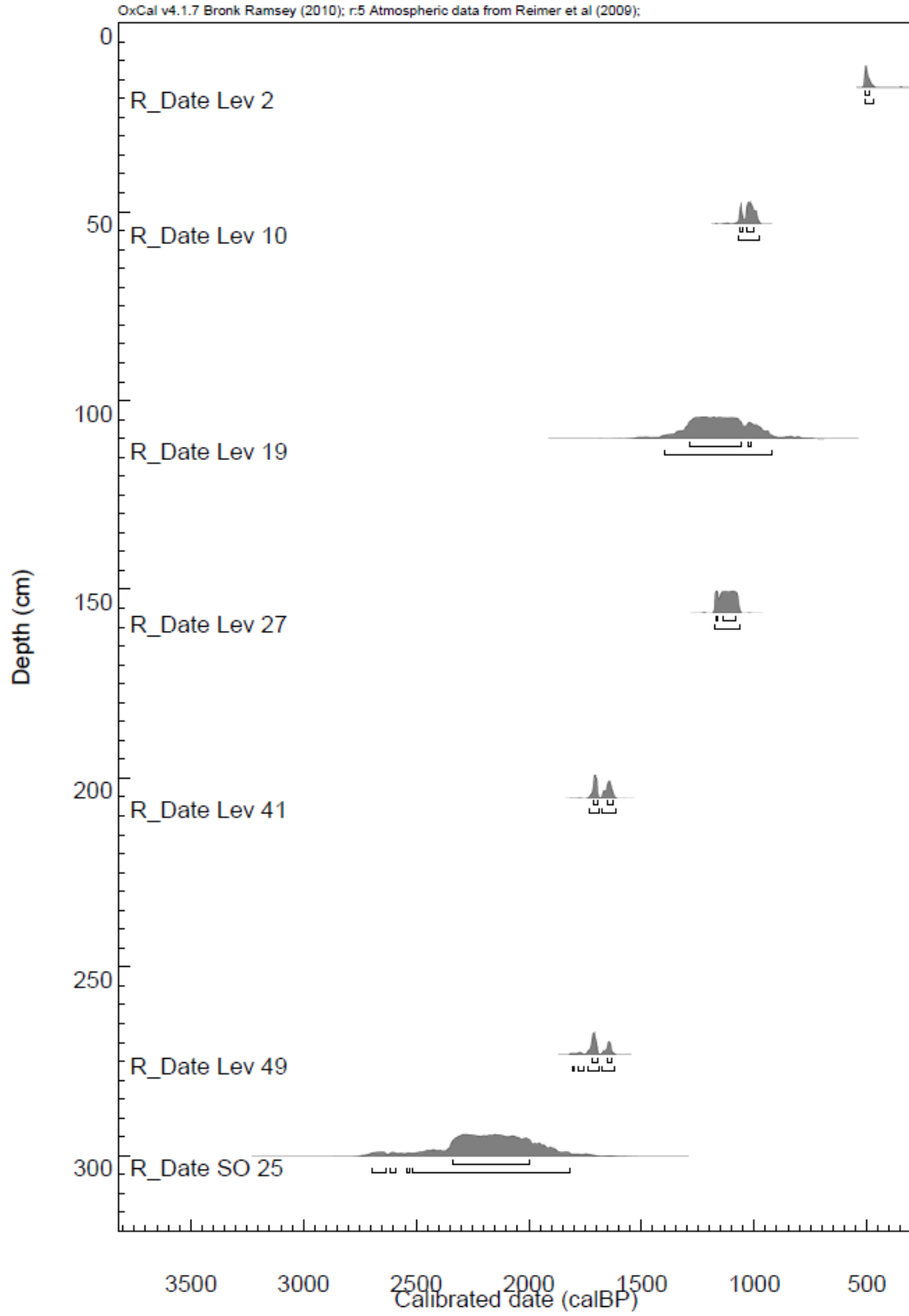


Figure 6.3 – Radiocarbon dates by depth at Tato à Sanouna (all from unit CE except Unit SO Lev. 25)

PROVENANCE	MATERIAL	RESULTS			Cal BP			Cal BCE/CE		
		Method	Date BP	±	From	To	%	From	To	%
Unit CE, Lev. 2, 17 cm; From more recent reoccupation of site; soft level of ash, shell, and bone	Wood charcoal	AMS	415	15	510	469	95.4	1440	1481	95.4
Unit CE, Lev. 10, 53 cm; From small pit full of ash and fish bone	Wood charcoal	AMS	1135	15	1068	978	95.4	882	972	95.4
Unit CE, Lev. 19, 110 cm; From greyish-white ash lens near top of large midden	Wood charcoal	Conv.	1240	130	1397	921	95.4	554	1030	95.4
Unit CE, Lev. 27, 156 cm; From ash lens at mid-bottom of large midden	Wood charcoal	AMS	1195	15	1172	1067	95.4	778	884	95.4
Unit CE, Lev. 41, 205 cm; From below lip of inverted pot	Wood charcoal	AMS	1770	15	1730	1615	95.4	220	335	95.4
Unit CE, Lev. 49, 273 cm; From below several large fish bones and above two sherds; earliest occupation level	Wood charcoal	AMS	1780	15	1803	1620	95.4	147	331	95.4
Unit SO, Lev. 23, 255 cm; Dates earliest occupation in SW portion of the site	Wood charcoal	Conv.	2170	150	2698	1820	95.4	-749	130	95.4

Similarly, excavations at Thièl (located on a sand dune 7 km NW of Jenné-jeno) (see Figure 6.1 and 6.4), which took place between late January and late March 2011, suggest an occupation contemporaneous with Jenné-jeno's. The site was reused as a burial ground, probably in the late 15th to 16th century AD, which resulted in extensive bioturbation. The top 50 cm of both units were totally disturbed, though several architectural features remained intact. This disturbance almost certainly accounts for the 15th to 16th century dates on charcoal coming from levels 11 and 27 in unit GTC, at depths of over one and two meters below the surface, respectively. The remaining radiocarbon dates and artifacts attest to a continuous occupation spanning Phases I/II, III, and IV (see Table 6.2 and Figure 6.5).



Figure 6.4 – View off Thièl showing surrounding marshes and a parallel sand dune on 10 February 2011 (Photo by A.C. Stone)

PROVENANCE	MATERIAL	RESULTS			Cal BP			Cal BCE/CE		
		Method	Date BP	±	From	To	%	From	To	%
Unit GTC, Lev. 2, Feat. 4A, 17 cm; Taken from within the mouth of an intrusive human burial; possibly from mixed fill	Wood charcoal	AMS	660	20	670	561	95.4	1281	1390	95.4
Unit GTC, Lev. 11, 111 cm; Thin, yellow level flecked with charcoal	Wood charcoal	AMS	375	15	501	331	95.4	1450	1620	95.4
Unit GTC, Lev. 17, 166 cm; From contents of bowl in ritual deposit (near statue)	Wood charcoal	AMS	950	15	926	796	95.4	1025	1155	95.4
Unit GTC, Lev. 27, 219 cm; General level near top of funerary urn (F.14); artifact poor	Wood charcoal	AMS	385	15	502	535	95.4	1448	1616	95.4
Unit GTC, Lev. 39, 353 cm; From near double jar inhumation, below human remains found west of the jar	Wood charcoal	AMS	1705	15	1692	1555	95.4	258	395	95.4
Unit GTC, Lev. 43, 419 cm; Taken from terminal cultural deposit; dark level stained with charcoal	Wood charcoal	Conv.	2050	70	2300	1835	95.4	-351	115	95.4

Taken together, the dates and artifacts at Tato à Sanouna and Thièl suggest widespread occupation in the Djenné area during Phase I/II and probably dating to the last centuries BC. Likewise, the data here corroborate evidence gathered from survey of surface materials at many of the surrounding sites, suggesting widespread abandonment of dispersed sites around AD 1400 (McIntosh and McIntosh 1980b). I discuss possible motivations for and implications of this abandonment later in this chapter.

Similar material culture, in terms of architecture and ceramic forms and décor, and parallel temporal shifts in these artifact types (see Chapter 3 for details) indicate a degree of unity and uniformity amongst the area's population. This unity itself, however, does not discount the possible presence of salient differences among sites or populations. Distinct social identities, be they ethnic, kinship-based, or linked to subsistence regimes, almost certainly existed within a population as large and widely-spread as that in and around the Jenné-jeno settlement complex. The diversity of burial practices, including use of ceramic lids on burial urns at Tato à Sanouna and inverted jars as lids at Thièl (see Figures 6.6 and 6.7), and the fact that both of these forms are found at Jenné-jeno, serves as confirmation of a certain degree of inter-site differences and the cosmopolitan nature of Jenné-jeno's population. The material remains excavated as part of this project, however, give few clues as to the nature of these differences.



Figure 6.6 – Lid of Feature 2 in Unit CE at Tato à Sanouna



Figure 6.7 – Feature 10 in Unit AMS at Thièl

In terms of plant subsistence, the evidence from Tato à Sanouna and Thièl attests to a subsistence economy centered on African rice and supplemented by significant amounts of fonio (*Digitaria* sp.) and pearl millet (*Pennisetum glaucum*) from the earliest occupation. This is somewhat divergent from the pattern seen in Jenné-jeno samples from the 1981 season, where African rice and a wild grass, *Brachiaria ramosa*, predominate (McIntosh 1995b). However, unpublished analysis of flotation samples from the 1997 and 1999 excavations at Jenné-jeno (Shawn Murray, personal communication, 4 May 2014) show a pattern much more akin to that found at Tato à Sanouna and Thièl than to the Jenné-jeno 1981 assemblage. Differing collection and identification practices could thus have had profound impacts on the earlier Jenné-jeno assemblage. Without further excavations with consistent recovery techniques, one can only say

that African rice, fonio, and pearl millet were central to the plant diet of the region throughout the occupation of the three sites. Other wild grains, including *B. ramosa*, were certainly gathered or cultivated as well, but their dietary importance is hard to gauge at this point. The evidence from TATO à SANOUNA and THIÈL does not point to any localized food preferences or specialized production.

As with the archaeobotanical assemblages, it is difficult to compare the relative importance of various animal species at Jenné-jeno, TATO à SANOUNA, and THIÈL due to differences in collection practices; screens were not used in excavations at Jenné-jeno, meaning that small species, particularly fish, could be underrepresented. It is safe to say, however, that aquatic resources, especially a diverse array of fish, were a primary component of diet at all three sites throughout their occupation. Domestic bovids were present at all sites from the earliest levels, but, at least at THIÈL and TATO à SANOUNA, were of secondary importance to fish in diet. Material correlates of fishing, including harpoons, fishhooks, and net weights, are found at all three sites, suggesting that inhabitants of these sites were actively engaged in fishing rather than simply acquiring fish through trade. The most marked difference between the faunal assemblages at Jenné-jeno, TATO à SANOUNA, and THIÈL is the dearth of wild bovids and birds at the latter two sites. This could again be due to a biased sample given the small sizes of the faunal assemblages at these sites, particularly in the early phases (wild bovids were most plentiful in Phase I/II deposits at Jenné-jeno), but it could also represent localized food procurement practices.

6.1.1 Mobile Pastoralism

Returning to the original question of the presence of mobile pastoral populations in the area around Jenné-jeno, the excavations at Tato à Sanouna and Thièl did not uncover any clear evidence for interaction with specialized herding populations. Remains of cattle, sheep, and goats occur in all phases at both sites, but they are hardly central to the diet, and if anything, are less frequent than in the Jenné-jeno assemblage. Likewise, no artifacts specifically associated with animal husbandry were uncovered at the sites. Ceramic cattle figurines uncovered in the 1981 excavations at Jenné-jeno (MacDonald 1995:301; McIntosh 1995a:237) indicate that humpless cattle were important to at least a certain subset of the site's occupants. A partial quadrupedal animal figurine was found at Tato à Sanouna, but it could represent any number of wild or domesticated animals, and can't be taken as evidence for occupation by or interaction with herding populations.

6.1.2 Craft and Subsistence Specialization

The question of specialization is multifocal, including the issue of whether economic activities were divided amongst the occupants of a site or the broader urban area and whether these specializations (if present) resulted in any broad socially-recognized differences in individual or group identity. Whether these differences (if present) relate at all to the modern, economically specialized ethnic groups living in the area today is another important area of inquiry. The inverse of this question, of course, is if noticeable subsistence specialization is not present at the sites, does this necessarily indicate that the ethnic groups known in the area today, or at least their economic specialization, are a product of distinctly recent forces?

Clark's (2003) survey and excavation of selected surface features at Jenné-jeno and a handful of neighboring sites tentatively identified dense concentrations of uniformly sized and

spaced furnaces on several sites, indicating specialized iron working activities. This finding is compelling, and ties into ethnographic and oral historical data suggesting that specialized iron smelting groups have significant time-depth in West Africa (Frank 2002). However, the differential erosion of site surfaces means that visible surface features are not necessarily contemporaneous; it is therefore difficult to argue for spatial differentiation of any activity based on surface features alone. The presence of these pyrotechnic workshops, as Clark terms them, does suggest intensive metal working activities in the past. Whether these activities were spatially or ethnically separated remains an open question, however.

The excavations at Tato à Sanouna and Thièl were an opportunity to examine the nature of the craft production economy, particularly in regards to iron working, at smaller, outlying sites. The small-scale iron working activities documented at both sites demonstrate that while they were occupied neither exclusively nor even primarily by iron working specialists, they were also not solely reliant on distant markets for their iron objects. The slag concentrations, burnt pits, and furnace remains found at both sites could equally represent non-specialized production by the sites' inhabitants or temporary workshops created by itinerant, specialized iron workers.

At this point, the presence of specialized iron workers (or other craft producers) in the IND during the period of Jenné-jeno's occupation (ca. 250 BC to AD 1400) is an open question. The relative uniformity of iron artifacts and Clark's identification of potential pyrotechnic workshops are suggestive, but not definitive evidence for specialized iron producers.

In regards to subsistence specialization, excavations at Tato à Sanouna and Thièl suggest a relatively generalized subsistence economy, in marked contrast to modern subsistence production practices. Although fish remains dominate the faunal assemblages at both sites,

domestic cattle, sheep, and goats are a ubiquitous presence from the earliest levels. The isotopic evidence for the mobility of these animals, which I discuss below, suggests that at least some of the animals consumed at these sites were raised in their immediate vicinities, probably by the inhabitants of the sites themselves. Similarly, the archaeobotanical data indicate diversified cultivation practices involving African rice, fonio, and pearl millet. It is always possible that, for example, the sites were occupied by specialized fishers who traded extensively with local farmers and herders to round out their diets. However, this is not the most parsimonious explanation. I think, instead, that diversified subsistence strategies are a logical response to the environmental heterogeneity of this part of the IND and the interannual variability in temperature and rainfall.

The diversified nature of the subsistence economy at the outlying sites of Tato à Sanouna and Thièl contrasts with several existing theoretical models of how Jenné-jeno and other urban sites functioned, providing fertile ground to discuss the nature of urbanism and alternate forms of urban organization. I follow up on this topic after briefly recapping the results of my isotopic analysis.

6.2 Results Part II: Isotopic Analysis

The results of the isotopic analysis of cattle, sheep, and goat teeth were discussed at length in Chapters 4 and 5. I recap these findings here only briefly to provide a basis for a broader discussion of the implications of this research in regards to interpretations of Jenné-jeno and the nature of mobile-sedentary interactions in the area and beyond. How this case study influences conversations about the beginnings of urbanism and diversity in urban configurations is also an important topic for consideration.

This study provides the first baseline of biologically-available strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) diversity in Mali, and is one of the first archaeological studies to employ $^{87}\text{Sr}/^{86}\text{Sr}$ in inland West Africa. Samples of tooth enamel apatite from a small number of modern and archaeological animal teeth indicate starkly different isotopic signatures between the desert areas around Timbuktu and Gao and the riverine environment of the Inland Niger Delta (see Chapter 4). Furthermore, archaeological samples from Tato à Sanouna, Thièl, Jenné-jeno, and Hambarketolo indicate differing ranges of $^{87}\text{Sr}/^{86}\text{Sr}$ for different features on the landscape: the Bani River, the terrestrial zone, and a secondary water source (tentatively identified as belonging to the Pondori network of permanent marshes and ponds present in the area). These differences are corroborated by the signatures found in enamel apatite from human teeth recovered from Thièl and Tato à Sanouna. This baseline map allows me to trace patterns of seasonal mobility in archaeological cattle, sheep, and goat teeth (using serial, intra-tooth sampling) both beyond and within the local IND.

6.2.1 Mobile Pastoralism

In “Invisible Pastoralists: An Inquiry into the Origins of Nomadic Pastoralism in the West African Sahel,” Kevin MacDonald characterized pastoralism as the big unknown in West African archaeology (1999). This question is firmly resolved by these isotopic data presented here. This study provides compelling evidence for the presence of mobile pastoral populations in the IND from the earliest phases at Jenné-jeno. Of the five animals sampled from Phase I/II at Jenné-jeno, two show evidence of movement beyond the known local delta signatures (what I call extralocal mobility). One of these was moving into and out of the delta seasonally, in a pattern strikingly similar to that seen in modern mobile herds. The second was brought to Jenné-jeno after the period of tooth mineralization from a completely non-local area (see Figure 5.2 in

Chapter 5). These animals, along with others from later phases at Jenné-jeno, demonstrate that seasonally-mobile herders were present in Sahelian West Africa for at least the last two millennia and that some of them engaged in trade relationships with emerging urban centers like Jenné-jeno.

Although the $^{87}\text{Sr}/^{86}\text{Sr}$ signatures from sampled herd animals at Jenné-jeno do provide evidence of extralocally-mobile herds, they also demonstrate that the majority of animals consumed at Jenné-jeno, Tato à Sanouna and Thièl were raised locally. I identified five distinct local mobility patterns, each of which can be classified as either limited seasonal mobility within the known local $^{87}\text{Sr}/^{86}\text{Sr}$ range or non-mobility within a specific local environment. As discussed in greater detail in Chapter 5, although long-distance mobility beyond the IND almost certainly required specialist knowledge and ability, the more locally-grounded forms of husbandry could represent non-specialist, small-scale or household-level activities. As I will argue later, these findings complicate existing theories about the presence of subsistence specialists at Jenné-jeno and suggest that diversified small-scale and household-level economic activities could have underpinned the local subsistence economy.

For this project I sampled cattle, sheep, and goat teeth from Tato à Sanouna, Thièl, all three major phases at Jenné-jeno, and levels dating between AD 1400 and 1800 from the modern town of Djenné. This allowed me to identify inter-site and temporal variations in herding practices. Compellingly, although extralocally-mobile animals were found in low numbers at Jenné-jeno, they were completely absent from contemporaneous deposits at Tato à Sanouna and Thièl (see Figures 5.2 to 5.6 in Chapter 5). With the small number of teeth sampled from these latter two sites, it is possible that this absence was the result of sampling bias. It is more likely, however, that seasonally present, extralocally-mobile herders interacted with a large market

center like Jenné-jeno very differently than with smaller, outlying villages. Jenné-jeno would have been a valuable source for scarcer goods and a ready market for any animals or animal products. Extralocal herders may have passed through the landscape around Tato à Sanouna and Thièl, but they did not have the same trade relationships with these sites as with Jenné-jeno.

As mentioned previously, extralocal mobility contributed to the animals consumed at Jenné-jeno, but locally raised animals were far more important to the site's subsistence regime. This situation contrasts markedly with that from Djenné (see Figure 5.7 in Chapter 5), where four of the five animals sampled are extralocal. These data corroborate archaeological evidence for widespread disruption of residence and subsistence patterns occurring around AD 1400 and possibly relate to the arrival of specialized Fulani herders to the IND. Some of the implications of these wide-ranging changes are discussed in a subsequent section.

Beyond this specific West African context, this study demonstrates the utility of using isotopic analysis to identify herd and human mobility patterns in a densely occupied urban area. Even when all obvious traces of pastoralist mobility are obscured, as they were at Jenné-jeno, analyses like this one can identify the patterns and scales of mobility in archaeological contexts.

6.2.2 Human Isotopes

To gain a greater understanding of the mobility of the human population in and around Jenné-jeno, I sampled tooth enamel apatite from a series of early- and late-developing teeth from ten individuals buried at Jenné-jeno, Tato à Sanouna, and Thièl. The sample sizes were not equal for each of these sites, but the evidence from these human samples provides a compelling corroboration of both the baseline $^{87}\text{Sr}/^{86}\text{Sr}$ data and the unique role of Jenné-jeno in the human landscape. The six individuals sampled from Thièl cluster closely together within the terrestrial

area range. Likewise, the single individual sampled from Tato à Sanouna, which is located on the banks of the Bani River, has $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in its second and third molar within the identified Bani River range. The populations from these small sites thus closely reflect their local environments. In contrast, the three individuals sampled from Jenné-jeno have the widest range in $^{87}\text{Sr}/^{86}\text{Sr}$ values found in the human samples that I studied with signatures nearly as diverse as the local baseline values. This divergence becomes even clearer when $^{87}\text{Sr}/^{86}\text{Sr}$ is mapped against $\delta^{18}\text{O}$, which also reflects location, amongst other influences (see Figure 6.8). These data show that Jenné-jeno was drawing its human population from settlements situated throughout the local landscape. These migrants would have contributed to the site's cosmopolitan population as well as ensuring strong, interpersonal connections between sites of various scales throughout the region. None of the human samples have $^{87}\text{Sr}/^{86}\text{Sr}$ signatures suggesting seasonal, extralocal mobility.

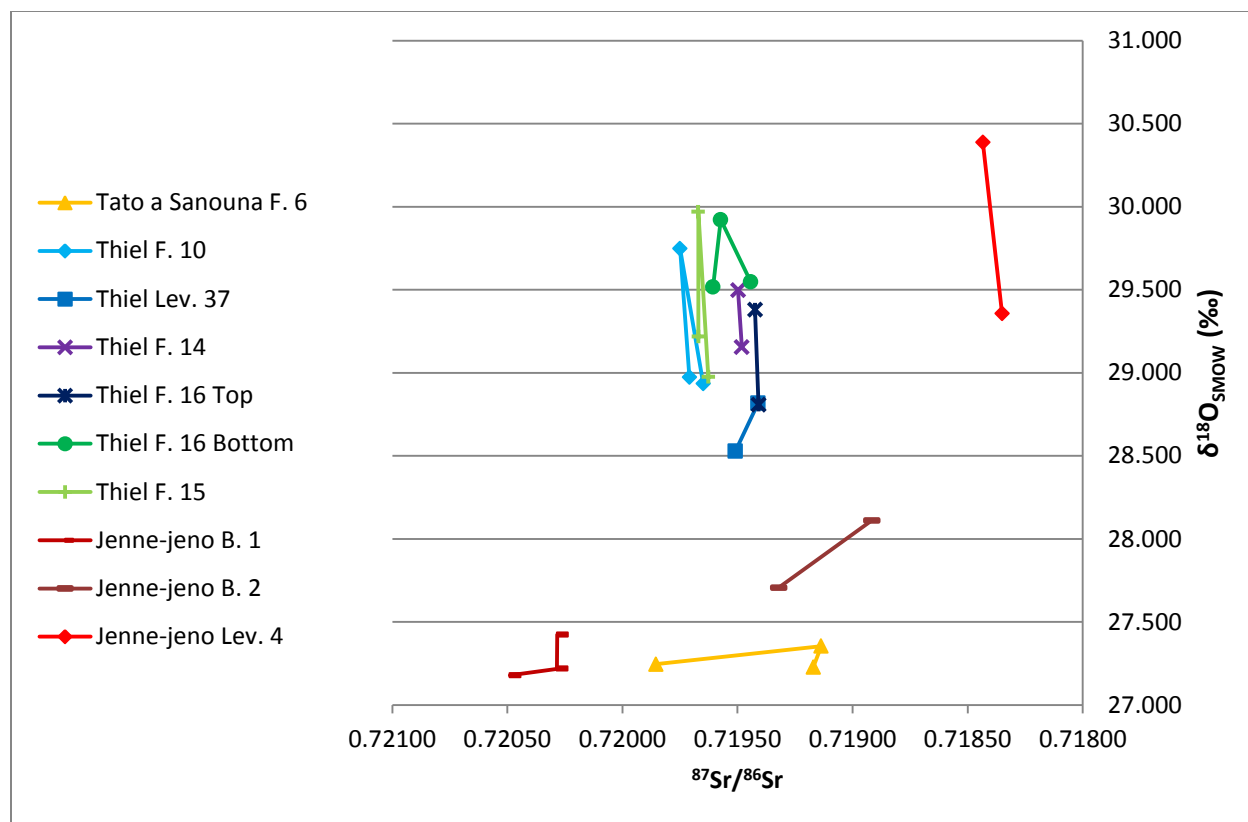


Figure 6.8 – Variability in archaeological human $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}$ signatures

Along with $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}$, I measured $\delta^{13}\text{C}$ in the human enamel apatite samples. These $\delta^{13}\text{C}$ values corroborate the archaeobotanical data, which suggest a diet focused on African rice (a C_3 plant) and pearl millet and fonio (both C_4 plants). $\delta^{13}\text{C}$ enamel apatite values in the human body range from roughly -14.5‰ for pure C_3 diets to -0.5‰ for C_4 diets. Values for the ten human individuals sampled as part of this project fall between these two extremes, suggesting a diet including both C_3 and C_4 plants (see Figure 6.9). In general, individuals from Thièl have more negative $\delta^{13}\text{C}$ values than those from Jenné-jeno and Tato à Sanouna. This may mean that rice was a more central component of diet at Thièl than at Tato à Sanouna, though there is only one individual from the later site sampled. The data clearly show that none of the sampled individuals had exclusively rice- or exclusively millet/fonio-based diets. If they were not themselves producing these crops, they were trading for them as dietary staples.

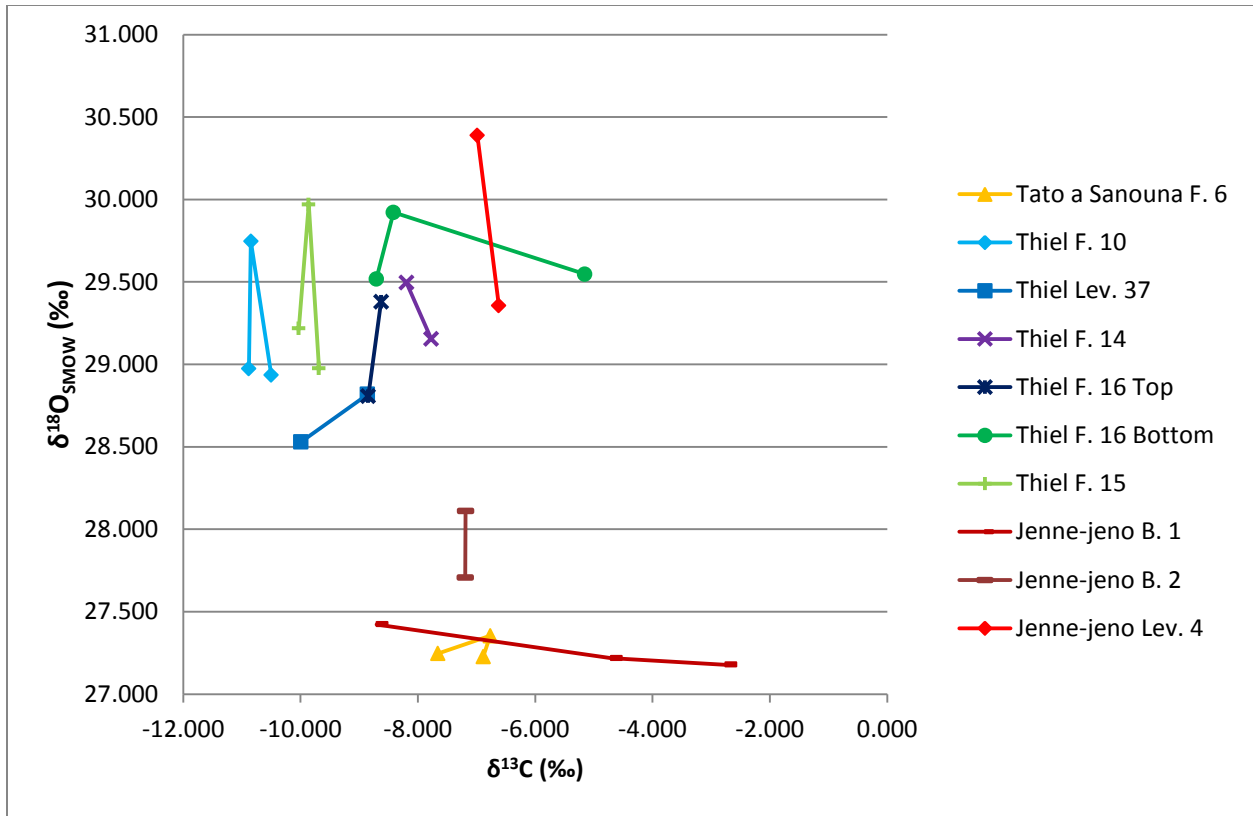


Figure 6.9 - Variability in archaeological human $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ signatures

In addition to the information the human enamel apatite samples supply about location and diet, this study suggests that maternal origins impact $^{87}\text{Sr}/^{86}\text{Sr}$ values in early-developing teeth of offspring. In contrast to $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$, which are abundant in the body and largely reflect very recent diet, strontium is relatively scarce in diet and is further selected against in the gut. This reduces the levels of strontium in the bloodstream, which means that $^{87}\text{Sr}/^{86}\text{Sr}$ values are impacted by strontium released from bone through remodeling as well as more recently consumed strontium (Balasse, et al. 2002; Montgomery 2010:330). As I discuss in Chapter 4, in large bovids this may have the effect of dampening the variability in an individual's $^{87}\text{Sr}/^{86}\text{Sr}$ signature. In humans, this means that $^{87}\text{Sr}/^{86}\text{Sr}$ values in a mother's milk reflect both her current environment and that of her recent past (~10 years). Studies of lead isotope values in modern

migrant populations demonstrate similar maternal influence on second generation signatures (Gulson, et al. 2003).

I included time as a variable in several of my graphs of human $^{87}\text{Sr}/^{86}\text{Sr}$ signatures (see Figure 6.10). While this is common practice in studies of intra-tooth isotope variability in ungulates, I have not seen this done with human samples. This perspective shows that many individuals have much greater divergence between their M1 and M2 signatures than between M2 and M3. I argue that M1 signatures are impacted by the values in maternal milk (first molar crowns form between birth and roughly 2.5 years of age (Smith 1991; White 2000:345)), so this divergence documents maternal mobility patterns. In many cases, it seems, childbearing women have moved beyond their childhood $^{87}\text{Sr}/^{86}\text{Sr}$ ranges, and this relocation is reflected in offspring M1 signatures. We have a great deal still to learn about how strontium is metabolized and incorporated into various body tissues, but this data set suggests great promise for identifying gendered mobility patterns in offspring $^{87}\text{Sr}/^{86}\text{Sr}$ values. Sampling a series of teeth (ideally M1, M2, and M3) instead of simply M1 and M3 as is standard practice, allows us to consider time as an important and nuanced variable.

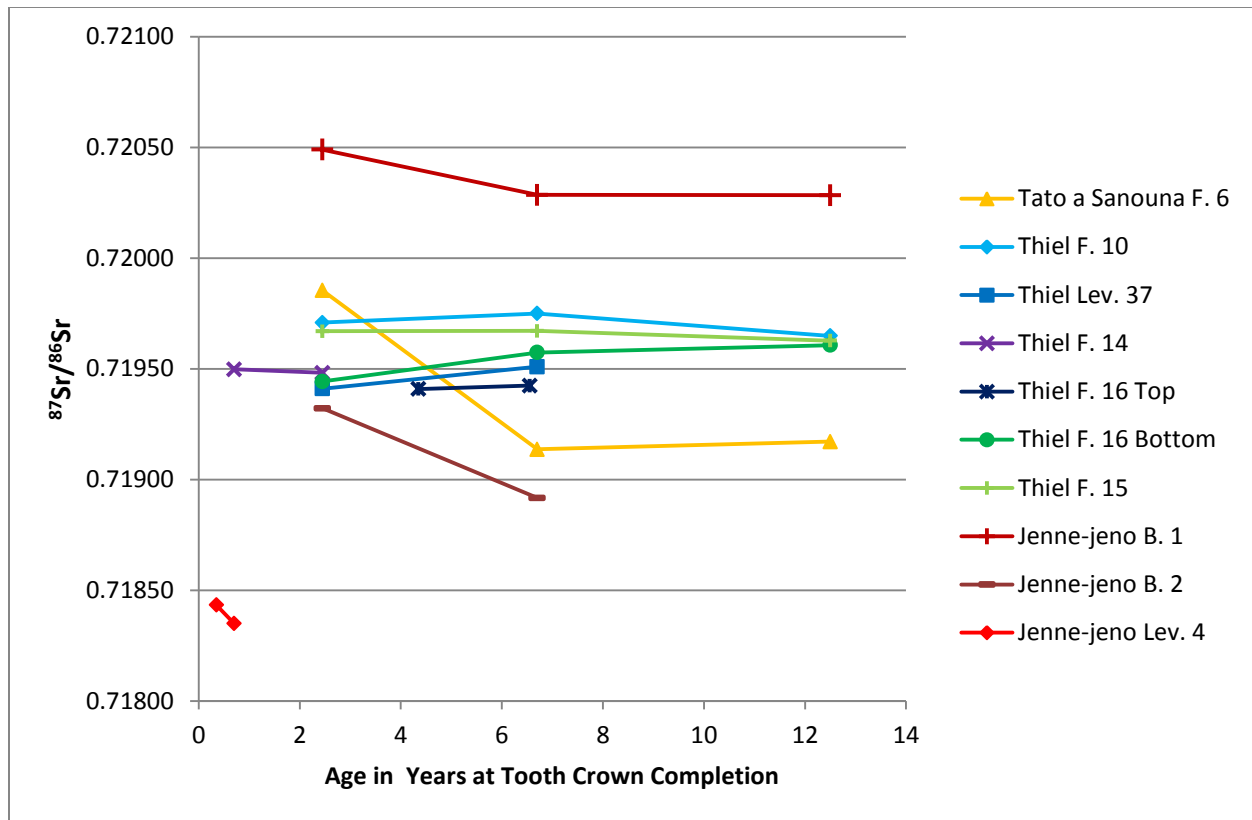


Figure 6.10 – Variability in archaeological human $^{87}\text{Sr}/^{86}\text{Sr}$ signatures over time

6.3 Reevaluation of the Project Objectives

Perhaps surprisingly, this study is able to give fairly definitive answers to several of the proposed research questions: yes, according to the isotopic data, there were extralocally-mobile herds present in the IND before the arrival of the Fulani in the 12th to 15th centuries AD. Additionally, based on the isotopic, faunal, and archaeobotanical data, while these extralocal herds may have belonged to mobile pastoral specialists, the subsistence economy around Jenné-jeno was apparently more generalized than specialized.

Interestingly, however, the data from this project also demonstrate the fallacy of some of my initial preconceptions about mobile populations in the African Sahel. Mobile and sedentary groups are often cast as inherently conflicting entities in archaeology and ethnography. Although I surmised that this might not have been the case at Jenné-jeno, I still conceived of them as

separate populations and thought that mobile groups were more likely to be found in rural, outlying areas than in the urban center itself. As I discuss below, the results of this project demonstrate the fallacy of the sedentary-mobile dichotomy in this case. Furthermore, in contrast to my expectations, the only traces of extralocally-mobile groups are found at Jenné-jeno and Djenné, the large market centers, and not at outlying sites like Thièl and Tato à Sanouna. This leads to interesting possibilities about the relationship between individuals involved in various scales of mobility within the urban system. As I argue below, mobility may have in fact been essential to the maintenance of a dense, urban population without obvious agricultural intensification or centralized organization of the subsistence economy.

6.4 Discussion Part I: Mobile-Sedentary Interactions

In contrast to expectations, the isotopic data presented here suggest that in the case of Jenné-jeno, the labels mobile and sedentary create a false dichotomy. It appears that many members of the primarily sedentary population raised domestic stock and may have needed to move their animals to find adequate food and water during certain seasons. Conversely, herders involved in more specialized, long-distance husbandry were intimately involved with the urban economy, though the urban population was not solely reliant on these long-distance herders for meat.

The interrelationship between Jenné-jeno and its various scales of stock keepers has important implications for our understanding of Jenné-jeno's development and the role it played within the wider landscape. Long-distance herders brought animals into the delta during the dry season in search of water and pasture, but it is likely that they were also attracted to the large sedentary communities where they could exchange animals, milk, and goods like leather for grain and other necessities. Along with forging connections with far-flung populations, this trade

would have contributed to making Jenné-jeno the market center it became. Conversely, integration into the urban economy could have impacted culling practices and seasonal migrations of mobile herders. The exchange in live animals between long-distance and local stock keepers, as is demonstrated by the Phase IV cow eventually consumed at Jenné-jeno (see again Figure 5.8), was another important facet of these relations. Such exchanges could have been used by stock keepers of various scales of mobility to augment herds, replace animals lost by disease or trade, and diversify breeding pools. This would both increase the importance of mobile herders to the local economy and provide another impetus for mobile herders to include the Jenné-jeno area as part of their seasonal rounds, despite the difficulty of bringing large herds into densely occupied areas.

Modern ethnography shows that mobile and more sedentary populations in West Africa are deeply interconnected today. Even in cases with marked ethnic divisions between herders and farmers, there can be strong personal, ritual, and economic relationships across group lines. Farmers frequently buy stock as a safeguard against crop failure, but entrust the animals to nomadic herders for management purposes and also as a means of hiding wealth from neighbors (e.g., Breusers, et al. 1998). These sorts of close relationships between herders and farmers provide compelling analogies for past interactions, even if ethnic and group lines were drawn in completely dissimilar ways in the past. Such relationships would have had profound impacts on both the urban economy and pastoral strategies.

Many studies of relations between mobile pastoralists and sedentary populations highlight the fractious nature of these interactions, focusing particularly on large states and military conquests, or cast mobile pastoralists into a dependent position supplying food to a dominant urban population (e.g., Adams 1974; Bar-Yosef and Khazanov 1992; Khazanov 2001).

This characterization is no doubt the case in certain contexts, particularly in locations where nomadic and sedentary population occupy discrete territories, helping to cultivate distinct, antagonistic identities. In the context of the IND, however, mobile herders were in close contact with various more sedentary populations for much of the year. In this setting, the daily interactions of farmers and herders would have done much to frame the narrative of their relationship.

The idea that mobile and sedentary populations have inherently conflicting needs had an unnoticed impact on the design of my project. I chose to excavate sites in more outlying areas partially because their specific local environments are conducive to animal husbandry, but also partly because I assumed that mobile herders were more likely to have lingered in more “peripheral” areas away from the highest density occupation. Contrary to expectations, classic extralocally-mobile animals are only found in the urban center, as discussed above. This finding highlights the need to think not just about the biological needs of the herds when designing studies investigating mobile pastoral populations. The needs and desires of the human population, such as the wish to trade animals for goods found only in large market centers, have equal impact on how pastoral groups structure their seasonal rounds. Pastoralists almost certainly didn’t troop their entire herds through the streets of Jenné-jeno, instead bringing only those animals and goods that they wished to exchange at the market. Although the majority of their animals probably remained in the relatively open area beyond Jenné-jeno, the archaeologically-visible traces of these populations remain only in those few animals that were exchanged with and consumed by individuals at Jenné-jeno.

6.5 Discussion Part II: Urban Configurations

The archaeology of urbanism is rooted in evolutionary progressions and trait lists of what it means to be urban or a city, primarily drawn from Mesopotamian and classical Mediterranean examples (Childe 1950). Traditional hallmarks of urbanism include centralized governance, social stratification, and specialized or centralized subsistence regimes. Although these models still have salience, archaeological discourse has increasingly moved beyond them, using local contexts to explore the diversity of urban expressions rather than dismissing atypical examples outright. This work has led to a growing recognition of variations on the typical urban model including low-density urbanism (Isendahl and Smith 2013; Peuramaki-Brown 2013; Smith 2011) and heterarchical political organization (Crumley 1987; Ehrenreich, et al. 1995; Feinman 2000; McIntosh 1991; McIntosh 1999b; Rautman 1998).

Use of the terms *city* and *urbanism* to describe these systems is sometimes considered a misrepresentation or reduction of past diversity; these words are certainly colored by modern Euro-American understandings. A site like Jenné-jeno might be less controversially labeled a large population aggregation, but this terminology is cumbersome. Furthermore, excluding exceptions to the rule from theoretical discussions because of nomenclature does nothing to advance archaeological discourse.

The acceptance of variability of urban forms, though incomplete, opens the door for more sophisticated understandings of what urbanism is and how urban systems functioned internally and in relation to their broader landscapes. Following this trend, recent studies of urbanism have contributed nuanced analyses of issues like the drivers, mechanisms, and motivations for population aggregation (Kim 2013; Mattingly and Sterry 2013; Sindbæk 2007); how urban populations dealt with organizational concerns like food storage and dispersal (Chesson and

Goodale 2014) and maintenance of a unified identity (Birch 2012; Chase, Ajithprasad, et al. 2014); how power was distributed within urban centers and their broader landscapes (Osborne 2013), and the experiences and perspectives of non-elite populations within urban systems (LaViolette and Fleisher 2005). This project builds upon these studies, showing how a large and densely occupied site like Jenné-jeno diverges from typical models of urban organization and offering an explanation for why these divergences emerged and how they impacted the nature of the urban system.

Many of the world's earliest urban centers existed in marginal or arid environments where agricultural intensification and centralized organization were the only means to feed a growing, specialized population. As Zeder (1991:43) argues in the context of Ur III cities, production is likely to become specialized and more susceptible to higher-order control if traditional forms of production fail to meet the larger needs of the urban community or if they come into conflict with other forms of production. In fact, J. Desmond Clark used this same argument to explain the apparent absence of indigenous sub-Saharan African urban centers; with a relatively favorable climate and abundant food resources, there wasn't sufficient incentive for population aggregation and power centralization (1962:29). Although indigenous urban centers have now been shown to exist in sub-Saharan Africa, these favorable factors could help to explain why many of these centers do not match Mesopotamian models of urbanism.

In contrast to the situation in Mesopotamia, the Inland Niger Delta is an extremely fertile environment today and was perhaps even more so in the past (Gallais 1967b; Makaske 1998). Fish would have been an essentially unlimited resource for much of the year, and seasonal floods open up much of the land to low-intensity wet rice agriculture. Large scale irrigation projects were simply not required to feed a sizable population. At the same time, environmental

heterogeneity and inter-annual variability would have encouraged economic diversification, not only within urban society, but also within families or small associative units; a small herd would be an invaluable resource if floods wiped out the rice or millet crop and crops would be a critical fallback if disease decimated the animal herds. Such small-scale agro-pastoral activity is seen in the high percentage of non-mobile and locally-mobile animals identified in the isotopic record. Even those individuals not engaged primarily in food production could keep a couple animals penned and foddered as assurance against need.

In this environment, small-scale, non-specialized food production would likely meet the needs of the urban populace and intensification and higher-order organization of the subsistence economy may not have been required. The market economy could have essentially been self-regulating, with diversified small-scale producers altering their output to match demand. The wide variety of craft and subsistence goods available would attract a larger permanent and seasonal population and a correspondingly increased network of interpersonal connections. Interactions between individuals (across households and settlements) could thus have built an interconnected, but non-centralized urban system. Using the language of complexity theory and complex adaptive systems (Bentley and Maschner 2008; Lansing 2003), individual interactions between many agents acted to create new, complex properties (in this case an urban system) without requiring higher-order control. In this environment, any attempts at centralization of the production economy could easily have been met with departure.

Mobility, in the form of local and extralocal herd migrations, long distance trade routes, human migrations from outlying areas to Jenné-jeno, and even possibly itinerant craft specialists and fishers, would in fact offset the need of a dense urban population to intensify its agricultural regimes. Although I have several qualms with Binford's (2001:346-347) discussion of

intensification versus extensification, his point about increased mobility enlarging the area available for resource extraction and greater social scale (defined as social connections) fits well with the data presented here. In this postulation, mobility, far from being in inherent conflict with sedentary urbanism, was a primary means by which the Jenné-jeno urban system sustained itself.

6.6 Conclusions

6.6.1 Future Research

Considering the vast number of unexcavated sites surrounding Jenné-jeno, the next step in understanding the nature of the urban system as a whole should be large-scale excavations at a diverse selection of these sites. The excavations at four of these sites (Tato à Sanouna, Thièl, Hambarketolo, and Kaniana) provide a very incomplete picture of the region's diversity and the relationships that smaller sites within the urban system had with each other and with Jenné-jeno. Given the influence Jenné-jeno has had and continues to have on discussions of African history and archaeology and on the nature and processes of urbanism worldwide, a more complete understanding of Jenné-jeno's urban system would have broad implications. Plans for future excavation in the area are on hold for the time being due to Mali's continuing political instability.

In the meantime, various specialist analyses of previously excavated materials have potential to greatly increase our understanding of settlement and daily life in the Jenné-jeno region. For example, despite the enormous quantity of pottery excavated from Jenné-jeno and nearby sites, residue analysis has never been attempted on any of this material. Such analysis could identify elements of subsistence, such as the relative importance of rice versus millet and the presence or absence of milk lipids at various times and locales. Outram et al. (2009)

employed residue analysis to separate the traces of horse fat and milk in 4th millennium BC ceramics from Kazakhstan. Similar methods could demonstrate the degree to which inhabitants of various sites in the Djenné area used bovid milk. These data would complement the existing information we have from faunal, archaeobotanical, and isotopic analyses about subsistence regimes and their variability in the past.

Additionally, an original goal of the project was to detect areas within the sites where animals were penned using $\delta^{15}\text{N}$ values in soil samples. I collected 100 mL soil samples from each excavation level at Tato à Sanouna and Thièl following procedures established by Shahack-Gross (Shahack-Gross, et al. 2003; Shahack-Gross, et al. 2008). Due to the excessive cost of shipping these samples from Mali to the United States, they remain in Mali unanalyzed. The low numbers of cattle, sheep, and goat remains found at these sites makes it unlikely that small excavation units would capture areas used for animal penning, if they exist at all. However, this analysis may be useful for future projects. In particular, I would like to obtain values from several relatively open areas at Jenné-jeno to determine if they could have been used to pen animals at any time.

This project demonstrates the valuable insights available through isotopic analysis into herd mobility patterns and interactions between herders and emerging urban populations. I have access to faunal remains from excavations at Gao-Saney and TBZ2 (near Timbuktu) and would like to conduct a similar analysis on cattle, sheep, and goat teeth from these excavations. This analysis would increase our understanding of Mali's baseline $^{87}\text{Sr}/^{86}\text{Sr}$ variability. Moreover, it would provide a broadly based picture of the nature of animal husbandry practices and herding populations in and around Mali's emerging Iron Age cities. Gao and Timbuktu are both perched on the edge of the Sahara desert and became intimately involved in trans-Saharan trade

networks. They would thus provide an interesting counterpoint to the situation I describe at Jenné-jeno and the surrounding Inland Niger Delta.

6.6.2 Forthcoming Publications

In addition to the three articles included in this dissertation, I am in the process of writing up several other elements of this project for publication. I am collaborating with Daphne Gallagher and Shawn Murray for an article on fonio (*Digitaria* sp.) cultivation and consumption as part of a mixed agricultural strategy (alongside African rice (*Oryza glaberrima*) and pearl millet (*Pennisetum glaucum*)). Although fonio is recovered regularly in flotation samples at Sahelian West African sites, this will be the first article specifically discussing its domestication and cultivation in archaeological contexts.

A particularly intriguing finding of the excavations at Thièl was a pit containing a pedestaled bowl alongside an intentionally broken terracotta statue of a woman birthing snakes. An AMS date of cal AD 1025-1155 from charcoal in this bowl fits with known dates for similar figurines in the IND. Terracotta figurines of similar size and intricacy are rarely found *in situ* in archaeological contexts. More commonly they enter the international art world after being looted from archaeological sites. This statue, with its undisturbed context and associated date, is thus an important contribution to our knowledge. I am in the early stages of writing this find up for publication, in collaboration with art historian Barbara Frank.

The human isotopic data collected as part of this project are critical evidence of the diet of the ancient populations in and around Jenné-jeno and of the differing compositions of small and large sites. Although I reference these implications in Chapters 4 and 5, I do not explicitly focus on them in either of these publications. I am in the midst of writing up the human isotopes

for a potential *Journal of Archaeological Science* focus article. This article focuses on the visibility of maternal $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in the first molars of offspring, and the utility of sampling a series of teeth and incorporating time as an explicit variable in our interpretations of human $^{87}\text{Sr}/^{86}\text{Sr}$ data.

Finally, this project has led to new insights into the organization of Jenné-jeno's economic system and the relationship between large and small sites in the region. My next major writing project will be a reinterpretation of Jenné-jeno using previously published data in concert with the archaeological and isotopic data collected for this dissertation.

6.6.3 Contributions of the Research

As discussed in this and other chapters in this dissertation, this project was the first in-depth study of smaller, outlying sites in the Jenné-jeno urban system. Methodologically, this project created the first baseline map of biologically-available strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) in Mali, proved the utility of the method in this region, and opened the door for future isotopic analyses addressing a variety of questions. Additionally, this project provided a compelling case study of the applications of isotopic analysis, particularly $^{87}\text{Sr}/^{86}\text{Sr}$, as a means of understanding past herd management strategies in a variety of contexts including densely-populated urban systems.

This research increased our understanding of the nature of settlement in the Djenné region of Mali over the past 2000 years, including the relationship between smaller and larger population centers in the area, the nature of the livestock economy, and the role of specialization in transforming the human landscape and subsistence economy over the past 500 years. This work highlighted the unique role Jenné-jeno played within a dispersed, but densely settled urban system. In comparison with smaller, outlying sites like Tato à Sanouna and Thièl, Jenné-jeno

acted as a locally- and regionally-important market center drawing goods and population from a wide area. In contrast to traditional models of emerging urbanism, however, this central economic role was not accompanied by any archaeologically-visible signs of power centralization, economic inequality, or agricultural intensification. I argue that in a relatively lush, productive area where various forms of mobility could greatly increase the accessible resource base, agricultural intensification and centralized control were not necessary to meet the resource needs of the population. Rather, small-scale or household-level producers with diversified resources could quickly respond to market demands without any sort of higher-level control.

This proposition of a seemingly divergent form of urban economic and political organization leads to the final contribution of this project. This case study joins a growing body of literature demonstrating the inappropriateness of traditional models of urbanism. Such work is providing novel insights into the nature of urbanism and the diverse forms it can take worldwide. Above all, this study demonstrates that mobility should not be seen as being in contrast to or in conflict with urbanism. Various forms of mobility can in fact be integral to the emergence and success of an urban system.

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Archaeobotany Appendix

ARCHAEOBOTANICAL ANALYSIS OF FLOTATION SAMPLES FROM TATO À SANOUNA AND THIÈL

By Shawn Sabrina Murray

This paper reports on the analysis of archaeobotanical samples taken from the mound sites Tato à Sanouna and Thièl, located in the Djenné area of central Mali. These sites were excavated as part of a dissertation research project conducted by Abigail Chipps Stone between 2010 and 2011. Principle questions from Stone's research investigate the possible presence of pastoralists at or near these sites prior to the arrival of Fulani in the 12-15th centuries CE. Identification of the recovered botanical remains may give insight into the use of plants at these sites, providing information on diet and food gathering activities. The 224 samples examined here derive from three units at Tato à Sanouna (SO, CTR, and CE) and two units at Thièl (AMS and GTC). Spatial and temporal comparisons of plant use at Tato à Sanouna and Thièl are examined, and then compared with archaeobotanical reports from neighboring occupations at Jenné-jeno and other sites in the greater Inland Niger Delta and Sahelian West Africa.

Methods

The 224 samples examined here were collected through bucket flotation by Stone and her team. Each flotation sample consisted of 6 liters of bulk sediment collected at each excavation level – determined by natural level or at 10 cm increments, whichever was smaller. Additional samples were taken from ash deposits and from other potentially promising contexts (midden, pits, and so on). The mesh opening of the flotation screen was approximately 0.30 mm in width. The samples were subsequently examined by this author during the winters of 2012 and 2013.

The samples were first size-sorted with geologic sieves and then systematically scanned using a binocular, dissecting microscope with 7-45x magnification. Only plant remains preserved through charring (*Celtis*, had it occurred, would have been the one exception) were identified to closest taxonomic level based on modern comparative materials collected in Mali and Senegal, and on drawings, photographs, and descriptions from a variety of sources, but primarily those made by myself, Stefanie Kahlheber and Daphne Gallagher. Many identifications are expressed as “cf”, meaning that it was difficult to make a specific determination, but that the identified material is comparable to the named taxon. More difficult determinations were made only to genus or family levels.

Tato à Sanouna – Description of Plant Assemblages by Unit

Unit SO

Tato à Sanouna SO: Plant remains from this unit were few, perhaps due to poor preservation in this part of the site, or due to function or use of this area. Fifteen of 19 samples contained no charred plant materials, and only three taxa were identified (Table 1). Overall, the four samples with charred remains might indicate, 1) a proximity to water, as evidenced by the single *Fimbristylus pilosa* (Cyperaceae family) achene, 2) the remains of a food processing event (seed fragments of edible jujube (*Ziziphus* sp.) fruits, and 3) use of medicinal plants, based on the presence of a single *Borreria* seed. The large genus of *Borreria* (syn. *Spermacoce*; Family Rubiaceae) contains some members that are known to be used in traditional medicines to treat a wide range of symptoms (Conserva and Ferreira Jr. 2012). No domesticated species were recovered from this unit.

Unit CTR

Recovery of plant materials was relatively high in the CTR unit compared to unit SO. Of the total 41 samples analyzed, 35 samples (85%) contained charred remains (Table 2). The latest levels (1-4) contained few charred materials, while the bulk of the remains came from the transitional I/II to III Phase and from Phase III. Notable are the high number of charred seeds (mainly rice grains) recovered from level 17 LRF 70 #1.

Grasses

Seventeen of the 30 categories of remains (57%) identifiable to some taxonomic level belong to the grass family of Poaceae. The most ubiquitous and numerous grass recovered was African rice (*Oryza*), the remains of which may represent both the wild (*O. barthii*) and domesticated (*O. glaberrima*) species. Rice grains were consistently present through time from the earliest to the latest levels, occurring in 22 of 41 samples (54%). The majority of these grains were highly fragmented, and in fact, few whole grains were recovered, which might indicate processing through threshing or pounding, or some other percussive activity.

The second most ubiquitous grass species was identified to the genus *Digitaria*, which represents both the domesticated and wild cereal grains of fonio. Two species are economically important as food staples in West Africa, *Digitaria exilis*, known as fonio or white fonio, and *D. iburua*, known as black fonio. Due to their small size (roughly 1 mm in length) and variability, determination of the ancient grains to one or other of these species can be difficult, so they remain identified to the genus level. Like African rice, the presence of these grains was fairly consistent through time, occurring in 17 of 41 samples (41%), however they were absent from the very earliest levels.

After African rice and fonio, a third commonly utilized grain at Tato à Sanouna appears to be pearl millet. In Unit CTR, grains identified as *Pennisetum glaucum* indicate the presence of this domesticated crop, but wide variation in the size of these grass seeds makes identification of the smaller grains to wild or domestic status less certain. The small *Pennisetum* grains do exhibit the diagnostic club-shape of the domestic species, *P. glaucum*, however, and their overall shape is elongated rather than round like *Sorghum*. Conservatively, all grains contained within *Pennisetum* could belong to domesticated, wild, or hybridized species, all of which are important food sources. Six grains in Phase IV were identified as either *Pennisetum* or *Sorghum* due to their large round shape. Overall, *Pennisetum* species were present through time and occurred in 15 of 41 samples (37%).

Of the wild grasses, *Paspalum scrobiculatum* was the most common, occurring in 27% of samples. Its utility as a crop is not well understood, but Harlan (1992) lists a closely related subspecies as a millet crop in southern India, and Blench (2003) discusses Portères' (1976) comparison of the two taxa. The African species is considered a weed of rice fields, but one that is harvestable in times of other crop failures (National Research Council 1996c), and Portères (1976) points to the apparent association of this grain and African rice fields and consumption. Nine other wild grasses occur in small numbers, and these also commonly occur in plant assemblages in sites across West Africa.

Herbaceous Taxa

Ten herbaceous taxa were found in small numbers throughout the different phases of unit CTR. Because of their low numbers it is difficult to claim any economic use of these species at Tato à Sanouna, although many of them, such as *Amaranthus/Chenopodium* (goosefoot family) and the *Portulaca* spp. (purslane family) in particular, and Leguminosae (bean family) in

general, are commonly used as food by different cultures around the world, past and present. Their habit of preferring disturbed soils however, also makes them very weedy and it is possible they entered the archaeological record through their spreading and adaptive habit.

Tree and Shrub Fruits

The remains of tree and shrub fruits were rare in this unit and all were recovered from a single sample in the Phase I/II to Phase III transition. Shell (stone) fragments of *Vitex* spp. (likely *V. doniana* or *V. simplicifolia*), trees in the mint family, Lamiaceae (*Vitex* previously contained in Verbenaceae), and *Ziziphus* sp. (probably *Z. mauritania*, but maybe the rarer *Z. spina-christi*), from the jujube tree of the buckthorn family (Rhamnaceae) indicate a fruit processing event. Both taxa have sweet and edible fruit pulp that is commonly eaten fresh or dried, and a flour rich in vitamins A and C can be ground from the *Ziziphus* fruits (Cuny, et al. 1997; Malgras 1992).

Unit CE

Similar to unit CTR, the trench of CE had relatively good preservation with 85% of samples (48 of 56 samples) containing charred remains. The majority (86%) of identified materials came from the earliest phases – up through Late Phase III., with a substantial decrease in quantity of remains and number of taxa occurring in the Phase III to Phase IV transition. Several samples contained a higher abundance of seeds than other contexts. An Early Phase III funerary jar (Feature 6) had a fairly wide range of taxa and number of remains associated with it, including fonio, rice, and several species of edible wild grasses. It is difficult to say if these grains were directly associated with the burial, or if the association represents contamination from other contexts. Level 39 in Phase I/II also contained a higher density of charred domestic cereals than other levels. Interestingly, there were a relatively high number of remains recovered

from Early Phase III, especially compared to what might be expected from the excavated midden in Late Phase III.

Grasses

Twenty-two of the 39 (56%) plant categories at Tato à Sanouna CE were identified as belonging to the grass family, similar to what was observed in unit CTR (Table 3). Again, the most ubiquitous and most numerous grass recovered was African rice (*Oryza* spp.), occurring in 52% of samples, much of it being highly fragmented. The most intensive frequencies of rice occurred in Early Phase III (86%) and in Late Phase III (71%). As well, *Digitaria*, or fonio, was found in all phases but was most common in Phases I/II through Late Phase III, and most intensively in Early Phase III, where it was recovered from 100% of samples. Overall, *Digitaria* was found in 36% of samples from CE. Pearl millet was not as dominant, however, but was as roughly ubiquitous (about 14%) as some other grasses of more minor economic importance. *Panicum laetum* (at 13% ubiquity), *Setaria* (13%), *Eragrostis/Sporobolus* (11%), and *Paspalum scrobiculatum* (11%) are all grass species that have been used for food around the world, but particularly in Africa, where many of these species are still occasionally gathered for their grain quality (Harlan 1992; Kahlheber 1999). All of these grasses occur across the modern West African Sahel.

Herbaceous Taxa

Twelve herbaceous taxa were recovered from Unit CE. All species were found in small numbers; however three in particular were present in 9% of samples examined. Similar to Unit CTR, unknown seeds of the bean family (Leguminosae or Fabaceae) and seeds identified as *Portulaca oleracea*, of the purslane family (Portulacaceae), may or may not represent the remains of food use. Unknown seeds of the tomato family (Solanaceae) were also present in 9%

of samples. These seeds appear different from others recovered from Unit CE and identified to *Physalis/Solanum*. Overall, seeds from herbaceous species occurred through all phases of Unit CE.

Tree and Shrub Fruits

The remains of tree and shrub fruits were rarely encountered in flotation samples from Unit CE, although this trench appears to contain more than any other unit excavated at Tato à Sanouna or Thièl. Seed fragments of *Adansonia digitata*, or baobab (Bombacaceae, recently moved to the cotton family of Malvaceae) were recovered from Feature 6, a funerary jar, as were fruit shell fragments and seed fragments of *Vitex* sp. and *Ziziphus* sp. All three of these taxa produce edible fruits that are commonly collected today, and all three have been frequently recovered from other archaeological sites in West Africa.

Summary of Tato à Sanouna Units CTR and CE

The relatively well-preserved plant remains recovered from units CTR and CE suggest that consistently through time, the occupants of Tato à Sanouna used African rice, fonio, and pearl millet, probably as dietary staples. Due to the apparent presence and quantity of wild and weedy species of these staples, it also seems possible that these grasses were grown and processed locally. Other plant species were low in abundance, indicating the likelihood that they were either used opportunistically or that they entered the site through means other than human activity. One particular sample from Unit CTR yielded a large quantity of rice grain fragments - Level 17 LRF 70 #1, and Feature 6 in Unit CE also contained a diverse array of cereal grains, particularly fonio, as well as tree and shrub fruits, including jujube, baobab, and *Vitex* sp.

Thièl: Description of Plant Assemblage by Unit

Unit AMS

Preservation in Unit AMS at Thièl was good, with 78% of the 60 samples containing charred botanical remains. Approximately 73% of the plant remains were recovered from the earliest phases, Phases I through Late Phase III. In general, it appears that Phase I/II deposits have the best preservation or presence of charred seeds of any phase in this unit. Several samples contained a higher abundance of seeds than other contexts. One sample from Level 20 and associated with a Late Phase III pit contained numerous grains and grain fragments of African rice (n=17 total). Another sample from Level 36 in Phase III contained a diverse range of domesticated and wild grass seeds, although this association is possibly due to an enormous animal burrow encountered during excavation. Levels 43 and 47 of Phase I/II are possibly associated with a midden and contain grains of several domesticated cereals: African rice, fonio, and pearl millet.

Grasses

Roughly 85% of plant remains from Unit AMS were identified to the grass family of Poaceae. The majority of these are attributed to one or more species of African rice (*Oryza*), fonio (*Digitaria*), and pearl millet (*Pennisetum* and *P. glaucum*). The most ubiquitous grass was African rice, occurring in 48% of samples. Most of these rice grains were associated with Phases I through III, but particularly with the Late Phase III pit (n=17) and the early Phase I/II midden (n=12). Grains identified as *Pennisetum*, most likely pearl millet, although small in size, occurred in about 28% of the 60 samples. Grains attributed to *Pennisetum glaucum* (domesticated pearl millet) and *Pennisetum/Sorghum* were recovered in several other samples. If taken as a whole, pearl millet grains occurred in all phases, although most came from levels in

Phase I/II and Phase III. *Digitaria*, or fonio, was the next most commonly recovered grass with a ubiquity of about 27%. These tiny grains were found in all phases, but, similar to African rice and pearl millet, the preponderance of fonio grains (90%) were associated with the earliest phases. *Sorghum bicolor* is another possible domesticated grain occurring in this unit. In some cases, it is easily confused with rounder, fatter specimens of pearl millet. A single grain attributed to cf. *Sorghum bicolor* was found in a transition Phase III/IV sample. In addition, several species of wild, but often cultivated, edible grasses could represent the remains of food gathering activities. Grains of *Paspalum scrobiculatum*, or kodo millet, *Setaria* spp., *Eleusine indica*, and *Pennisetum violaceum* (a close relative to pearl millet) occur variously throughout time, but indicate possible use, perhaps as a crop of secondary importance or as a weed of cultivated fields.

Herbaceous Taxa

Compared to grasses, there were few herbaceous species recovered from this unit. The most common species was of *Commelina* (the dayflower family of Commeliniaceae), which was found in four samples ranging from Phase I/II through the Phase III/IV transition.

Tree and Shrub Fruits

Only a few specimens of unknown tree- and shrub-like fruits were recovered from Unit AMS, and these occurred in the Phase III/IV transition.

Unit GTC

Similar to Unit AMS, approximately 79% of the 48 Unit GTC samples contained charred plant remains, although these seeds and seed fragments were fairly well distributed through time, rather than concentrated more heavily in the earlier phases. Phase V had few botanical remains

overall. One context in particular, a Phase IV pit (Level 13, associated with Feature 8) exhibited a concentration of botanical materials, especially African rice and fonio. A second context, Level 29 in Late Phase III, was comprised of two samples, which, if taken together, contained about half of the pearl millet grains recovered from this unit. This presence of charred plant materials coinciding in an area with many burials might indicate that, perhaps after a period of time, the remains of food processing activities were also disposed here as trash.

Grasses

Grasses comprised about 85% of the botanical remains found in GTC. The apparent staple food grasses of African rice, fonio, and pearl millet all occurred with about the same ubiquity, roughly 25-27%. A concentration of rice grains (n=16) was found in a pit (Level 13) in Phase IV, and a second cluster of grains (n=11) was also found in one of the earliest contexts in GTC, Level 42, indicating that African rice was likely used as a food from the earliest occupation. Small amounts of both fonio and pearl millet were also recovered from the first levels of Phase I/II, suggesting that a food system reliant on growing these three grains was in place early on. Small deposits of fonio grains were found in Level 15 of Phase IV and Level 29 of Late Phase III for pearl millet. Few wild grains were recovered from this unit.

Herbaceous Taxa

Roughly 7% of all botanical materials from this part of the site were identified as coming from plants with an herbaceous nature. Taken together, the seeds of *Solanum*, *Physalis*, and *Physalis/Solanum* might indicate some use of fruits of the tomato family Solanaceae, although many of these species are known to be weedy to disturbed ground

Tree and Shrub Fruits

The remains of tree and shrub fruits were rare throughout this unit. Three fruit shell fragments belonging to *Vitex* were found in Phase V.

Summary of Thièl Units AMS and GTC

Plant remains from Units AMS and GTC were fairly well-preserved with 78-79% of samples containing some charred specimens. Staple domesticated grasses of African rice, fonio, and pearl millet comprised the majority of all botanical finds, with seeds of few other kinds of plants recovered at all. Many of these staple grains occurred in either ashy or midden contexts.

Comparison of Archaeobotanical Remains from Tato à Sanouna and Thièl

The patterning of charred botanical remains from trenches excavated at Tato à Sanouna and Thièl suggests that subsistence at both sites was based largely on a possible triumvirate of cereals: African rice, fonio, and pearl millet. Grains from these crops occurred in small quantities fairly regularly through time, in most phases of the two sites, indicating that the earliest inhabitants likely practiced and relied on cereal agriculture and/or gathering of wild grasses, and that these practices remained consistent through the occupation of the sites. There is little evidence for change through time in the exploitation of these grains.

Significant evidence of plants of an herbaceous nature – either annual or perennial, low to the ground or climbing, dry-land adapted or aquatic, is generally lacking from Tato à Sanouna and Thièl. Those seeds that do occur originate mainly from the families of Leguminosae (Fabaceae), Solanaceae, Chenopodiaceae, and Portulacaceae. The quantity of seeds identified to each of these families suggests that there was no reliance on them for food, although all of these families contain many species that are edible. It is possible that these few seeds represent a

greater use of these kinds of plants, but that the parts used were not prepared for consumption through use of fire, and thus not preserved through charring. Use of these plants was more likely occasional, or their introduction to the sites could have been incidental, either washed or blown in, or brought in through some other unintended means.

Some tree and shrub fruits such as baobab, jujube, and *Vitex* were likely gathered opportunistically, perhaps as they were encountered on the landscape while traveling. Due to the scarcity of these harder and denser fruit parts, it seems probable that there would be a greater quantity of these materials if these plants were in close proximity to the sites. It could also be possible that the remains of these fleshy fruits were not discarded in fire pits and that their hard shells were simply not preserved through charring.

Comparison of Tato à Sanouna and Thièl to other West African Archaeological Sites

Over the past three decades, archaeobotanical remains have been recovered from numerous sites across West Africa. The pattern that has emerged from the analysis of these remains is one of fairly widespread homogeneity of some crops, such as pearl millet, and a patchy distribution of other crops such as African rice and fonio. Pearl millet (*Pennisetum glaucum*) has certainly emerged as the dominant staple crop, present in highly variable numbers, shapes, and sizes at practically all Late Stone Age (and later) sites from Senegal to Mauritania, Mali, Burkina Faso, Nigeria, and Cameroon (Amblard 1996; Amblard and Pernes 1989; Cissé, et al. 2013; Fuller, et al. 2007; Gallagher and Murray in press; Kahlheber 1999, 2004; Kahlheber, et al. 2014; Klee and Zach 1999; Manning and Fuller 2014; McIntosh 1995b; Murray, et al. 2007; Murray 2005a, b, 2008; Murray and Deme 2014). The pearl millet grains recovered at Tato à Sanouna and Thièl follow this pattern very neatly, especially in light of the ancient millet grains found in the clustered Jenné-jeno and Djenné sites neighboring Tato à Sanouna and Thièl

(McIntosh 1995b) (unpublished results from excavations in 1997 and 1999, analyzed by S. Murray). This is not surprising, as pearl millet as a crop grows well in most environments across the Sahel. It prefers well-drained sandier soils, rather than those in the lower, more inundated flood plain, and it is very drought and heat tolerant, and easy to grow (National Research Council 1996d).

African rice and fonio, in contrast, appear more confined to certain geographic and environmental conditions in West Africa, and thus occur in more limited numbers of sites in antiquity. Historically, African rice, for example, has been adapted to a wide range of growing conditions, from rain fed land to swamp. However, based on the distribution of the presumed wild ancestor (*Oryza barthii*) and early archaeological occurrences, the earliest rice types seem to prefer the rising and ebbing waters of shallow flood plains along major river banks (National Research Council 1996a). The earliest evidence of what appears to be domesticated African rice (*Oryza glaberrima*) has been found in archaeological sites located in the flood plain soils of the Middle Niger Delta in Mali. The sites of Dia and Jenné-jeno have preserved remains of many whole and fragmented grains dating to the early First Millennium BC and later (McIntosh 1995b; Murray, et al. 2007; Murray 2005a). Although it has been difficult to determine ancient African rice grains to wild or domestic status, studies by this author comparing ratios of the height, width, and thickness of modern wild (*Oryza barthii* and *O. longistaminata*) and domestic species (*O. glaberrima*), and ancient grains from Dia and Jenné-jeno, seem to show that the archaeological grains convincingly cluster with the domesticated species. This clustering suggests that the grains recovered at Dia and Jenné-jeno were already domesticated before the first occupation of these sites (Murray 2005a). Sites in northeastern Nigeria also provided evidence for the use of an indigenous rice species, but the long and narrow shape of the ancient

grains suggests that they are more likely identified as *Oryza longistaminata*, a wild relative of the domestic species (Klee and Zach 1999). Surprisingly, African rice has not been found in other flood plain sites, such as along the Middle Senegal River at Cubalel, Sincu Bara, and Walaldé (Gallagher and Murray in press; Murray, et al. 2007; Murray 2008; Murray and Deme 2014). Recovery of the ancient grains at Tato à Sanouna and Thièl correspond well with patterns established for African rice along the Niger River in Mali.

The emergence and domestication of fonio as a staple crop is less understood compared to African rice, pearl millet, and possibly sorghum, probably because it is often considered a “minor” crop and is little known outside of West Africa. According to Portères (1976) and the National Research Council (1996b), this small-seeded grass is widely cultivated across West Africa and its grains are highly nutritious (high in amino acids) and often greatly preferred in taste to African rice. However, processing the tiny grains is said to be highly labor-intensive, requiring the removal of two thin husks through two to three cycles of manual pounding and winnowing (De Leschery 1997). As a crop, fonio is fairly drought tolerant and adaptable to a diversity of soils. It can be a quickly maturing cereal with some varieties able to produce a crop within 6 to 8 weeks of sowing, while other varieties can take up to 6 months. It is widely used in making porridge, couscous, bread, and beer.

The two domesticated species of fonio are *Digitaria exilis* (white fonio) and *D. iburua* (black fonio), and there are maybe half a dozen wild species across West Africa. The cultivation of white fonio ranges from Senegal to Lake Chad, whereas black fonio is more confined to, and probably originated in, the Hausa area of Nigeria and a bit further south in parts of Togo and Dahomey (Portères 1976). Based on the greatest varietal diversification of *D. exilis* and on vernacular appellations of the term “fonio”, Portères (1976:421-424) has suggested a possible

area of domestication centered in the Guinean headwaters region of the Senegal and Niger Rivers, and spreading from there east towards Ougadougou. Appellations of the term “fonio” seem to center on the “Mandingo linguistic group or from the Nigritic languages of the Middle Niger (Songhai, Djerma, Bozo)”, while variations on the term “fundi”, another common name for *D. exilis*, derive from the Senegalese language group (Wolof and Fula), or the Kissi and Mende languages of the Sierra Leone area (Portères 1976:423).

Archaeologically, grains identified to *Digitaria* sp. in West Africa have been found mainly in Late Stone Age sites ranging from Senegal to Sudan. Most of the archaeobotanical assemblages from these sites list the finds as “*Digitaria*”, not distinguishing to species and rarely discussing them as more than wild grasses. As little work has been done to assess the range of shapes and sizes of *Digitaria* grains beyond the genus level, it is currently difficult to say if the recovered grasses are wild or domesticated. *Digitaria* grains, no doubt attributable to a range of species, have been recovered from Akumbu in the Mèma, Mali (unpublished data, S. Murray), Conical Hill in south Sudan (Radomski and Neumann 2011), Cubalel on the Senegal River (Gallagher and Murray in press), Dia in Middle Niger Delta (Murray 2005a, b), Jenné-jeno and Djenné in the Middle Niger Delta (McIntosh 1995b)(Murray, unpublished data), Mege in the Nigerian Chad Basin (Bigga and Kahlheber 2011), and Sincu Bara on the Senegal River (Murray 2008). It is worth noting that *Digitaria* grains occur at Tato à Sanouna and Thièl in percentages and ubiquity similar to *Pennisetum glaucum* and *Oryza*, indicating their importance through time, whether wild or domesticated, as a staple food crop.

Summary

Two hundred twenty-four flotation samples from the archaeological sites of Tato à Sanouna and Thièl were examined for the charred remains of plant materials. Of the five

trenches at these sites, only one (Tato à Sanouna – SO) trench had poor preservation and few botanical remains. The other four trenches had relatively good preservation, with 78-85% of samples containing some identifiable materials. As a whole, the samples from these sites were marked by the high ubiquity and relatively numerous remains of three grass genera: *Oryza*, *Digitaria*, and *Pennisetum*. Unfortunately, identification of grasses to wild or domesticated species is notoriously difficult and has hampered efforts to be more definitive about human food collecting behaviors. Were these grains the product of agricultural fields, or were they collected from wild stands, as is still practiced today in some areas of West Africa? Most likely, plant foods in general were, as they still are, amassed on a continuum that allows for all manners of harvest, depending on geographic location, seasonality, yearly weather changes, cultural preferences and history, and access to seed, among other things. It appears fairly clear that the occupants of Tato à Sanouna and Thièl, or at least some of them, were farming some part of the year, as well as actively or opportunistically collecting from encouraged, or intentionally cultivated, wild stands. This last behavior is very likely true for the tree and shrub fruit remains recovered at Tato à Sanouna and Thièl, of baobab, jujube, and *Vitex*, all economically important and ubiquitous across West Africa. What does set Tato à Sanouna and Thièl apart from other sites in West Africa is the presence in numbers and ubiquity of three of the four historically important grasses for this part of the continent. Most archaeological sites across West Africa have evidence for a reliance on pearl millet, African rice, sorghum, and fonio, but most often the reliance is on one or two of these species, not three.

Data Tables

Table A.1 – Tato à Sanouna Unit SO Archaeobotanical Inventory																					
(Charred only)	Level 1 LRF 86	Level 2 LRF 87	Level 3 LRF 88 #1	Level 10 LRF 95	Level 11 LRF 96 #1	Level 11 LRF 96 #2	Level 12 LRF 97	Level 13 LRF 98	Level 14 LRF 99	Level 15 LRF 100	Level 16 LRF 101	Level 17 LRF 102	Level 18 LRF 103	Level 19 LRF 104	Level 20 LRF 105	Level 21 LRF 106	Level 22 LRF 107	Level 23 LRF 108	Level 24 LRF 110	Total Count	% Ubiquity (4 samples)
	Sediment examined (ml)	17	12	11	7	13	10	16	14	7	7	5	2	15	2	5	5	1	4		
Phase	Phase IV			Phase III Late				Phase III					Phase I / II								
Borreria seed			1																	1	25.0
Fimbristylis pilosa seed													1							1	25.0
Tree/Shrub Fruits																				-	-
Ziziphus, cf, seed fragments													2							2	25.0
Unknown botanical	1														2					3	50.0
Nothing Recovered		X		X	X	X	X	X	X	X	X	X		X		X	X	X	X	15	-
Total counts per sample:	1	0	1	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	7	-

Table A.2A – Tato à Sanouna Unit CTR Archaeobotanical Inventory (Part 1 of 2)

(Charred only)	Level 1 LRF 1 #1	Level 2 LRF 2 #1	Level 2 LRF 2 #2	Level 3 LRF 4 #1	Level 3 LRF 4 #2	Level 4 LRF 5 #1	Level 4 LRF 5 #2	Level 4 LRF 5 #3	Level 6 LRF 7 #1	Level 7 LRF 8 #1	Level 7 LRF 8 #2	Level 8 LRF 9 #2	Feature 1	Level 9 LRF 62	Level 10 LRF 63 #1	Level 10 LRF 63 #2	Level 11 LRF 64 #1	Level 12 LRF 65	Level 13 LRF 66	Level 15 LRF 68	Level 16 LRF 69	Level 17 LRF 70 #1	Level 18 LRF 71	Level 19 LRF 72	Feature 8
	Sediment examined (ml)	33	43	13	5	19	9	45	12	10	35	18	13	68	7	9	11	3	55	5	15	5	20	5	6
Phase	Phase IV													Phase III											
Poaceae-Grass Family																									
Acroceras, cf-grain																									
Andropogonae, cf-grain																								1	
Brachiaria, cf-grain			1																						
Digitaria, cf-grain				1					1		6	3	4			1	1	4			1	1		3	1
Eragrostis/Sporobolus, cf-grain		2																1							
Oryza-grain fragments	1	1				1			4	6	1	2	2			1	1				1	63		1	
Panicaceae, cf-grains									3			3						2				1			
Panicum, cf-grain																		1							
Panicum turgidum, cf-grain																									1
Paspalum scrobiculatum-grain									1					1	1		1		1		1			1	
Pennisetum, cf-grain														1		1			1		1	1			
Pennisetum glaucum-grain																						1	1		
Pennisetum/Sorghum-grain									6																
Setaria, cf-grain		1	2															1							
unknown Poaceae-embryo																									
unknown Poaceae-floret																		1							
unknown Poaceae-grain										3	5	4						3						1	3
Herbaceous																									
Amaranthus/Chenopodium-seed																						1			
Fimbristylus, cf-seed									1																
Heliotropium-seed																		1							
Leguminosae, cf-seed									1																
Malvaceae, cf-seed																									
Monocot, cf inflorescence																						1			
Physalis, cf-seed																									
Portulaca foliosa-seed												2													
Portulaca oleracea-seed																									
Portulcaca quadifida-seed									1																
Tree/Shrub Fruits																									
Vitex-shell fragments																									
Ziziphus, cf-shell fragments																									
unknown fruit/fruit shell fragments																									
Unknown embryo		1																							
Unknown seed															3			2							
Nothing Recovered					X	X	X													X					
Total counts per sample:	1	5	3	1	0	1	0	0	17	10	12	14	6	2	4	3	2	17	2	0	6	67	2	6	5

Table A.2B – Tato à Sanouna Unit CTR Archaeobotanical Inventory (Part 2 of 2)

(Charred only)	Level 20 LRF 73 #1	Level 20 LRF 73 #2	Level 21 LRF 74	Level 22 LRF 75 #1	Level 22 LRF 75 #2	Level 22 LRF 75 #3	Level 23 LRF 76	Level 24 LRF 77 #1	Level 24 LRF 77 #2	Level 24 LRF 77 #2	Level 25 LRF 78 #1	Level 26 LRF 79	Level 27 LRF 80	Level 28 LRF 81	Level 29 LRF 82 #1	Level 30 LRF 83 #1	Total Count	% Ubiquity (41 samples)
	Sediment examined (ml)	38	8	2	14	2	5	10	10	15	15	41	10	5	5	15		
Phase	Phase I/II to III Transition												Phase I/II					
Poaceae-Grass Family																	-	-
Acroceras, cf-grain	1																1	2.44
Andropogonae, cf-grain																	1	2.44
Brachiaria, cf-grain				1		1											3	7.32
Digitaria, cf-grain	2								4	4	2	4					43	41.46
Eragrostis/Sporobolus, cf-grain																	3	4.88
Oryza-grain fragments	14					1	3	1		1	4	5			1	1	116	53.66
Panicaceae, cf-grains				1													10	12.20
Panicum, cf-grain				1							1						3	7.32
Panicum turgidum, cf-grain											1						1	2.44
Paspalum scrobiculatum-grain	1			1			1						1				11	26.83
Pennisetum, cf-grain	2				1		2	1	1	1		1					14	29.27
Pennisetum glaucum-grain				2													4	7.32
Pennisetum/Sorghum-grain																	6	2.44
Setaria, cf-grain																	4	7.32
unknown Poaceae-embryo								2	2								4	4.88
unknown Poaceae-floret																	1	2.44
unknown Poaceae-grain						1	2				1	2		1			26	26.83
Herbaceous																	-	-
Amaranthus/Chenopodium-seed																	1	2.44
Fimbristylus, cf-seed																	1	2.44
Heliotropium-seed																	1	2.44
Leguminosae, cf-seed																	1	2.44
Malvaceae, cf-seed								1									1	2.44
Monocot, cf inflorescence																	1	2.44
Physalis, cf-seed				1													1	2.44
Portulaca foliosa-seed																	2	2.44
Portulaca oleracea-seed															1		1	2.44
Portulaca quadifida-seed																	1	2.44
Tree/Shrub Fruits																	-	-
Vitex-shell fragments								3									3	2.44
Ziziphus, cf-shell fragments								1									1	2.44
unknown fruit/fruit shell fragments								5									5	2.44
Unknown embryo																	1	2.44
Unknown seed	1										1						7	9.76
Nothing Recovered		X	X														6	-
Total counts per sample:	21	0	0	7	1	3	8	14	7	6	9	12	1	1	1	2	279	-

Table A.3A - Tato à Sanouna Unit CE Archaeobotanical Inventory (Part 1 of 3)

(Charred only)	Level 1 LRF 10 #1	Level 1 LRF 10 #2	Level 2 LRF 11 #1	Level 5 LRF 15	Level 6 LRF 16	Level 7 LRF 17	Level 8 LRF 18	Level 11 LRF 21	Feature 2	Feature 4	Level 10 LRF 20	Level 12 LRF 22 #1	Level 12 LRF 22 #2	Level 13 LRF 23 #1	Level 13 LRF 23 #2	Level 14 LRF 24 #1	Level 14 LRF 24 #2	Level 15 LRF 25 #1	Level 15 LRF 25 #2	Level 16 LRF 26	
	21	13	12	11	6	5	4	5	5	5	14	7	3	5	4	94	51	5	25	15	
Sediment examined (ml)	Phase V			Phase IV							Phase III / IV Transition										
Phase	Phase V			Phase IV							Phase III / IV Transition										
Poaceae-Grass Family																					
Andropogonae, cf-grain									1												
Brachiaria, cf-grain																					
Digitaria, cf-grain		1					1														1
Eleusine coracana, grain																					
Eleusine indica, grain																					
Eragrostis turgida, cf-grain																					
Eragrostis/Sporobolus, cf-grain																					
Oryza-grain fragments								1		3				1	2		4				1
Oryza, cf-grain fragments				1								2									
Paniceae, cf-grains																	3				
Panicum, cf-grain																				1	
Panicum laetum, cf-grain																1	2				
Panicum subalbidum, cf-grain																					
Panicum turgidum, cf-grain																					
Paspalum scrobiculatum-grain																					
Pennisetum, cf-grain																					
Pennisetum glaucum-grain																					
Pennisetum/Sorghum-grain																					
Setaria-grain																					4
Setaria barbata, cf-grain																					
unknown Poaceae-embryo																					
unknown Poaceae-grain	1								1	2		1									
Herbaceous																					
Amaranthus/Chenopodium-seed																					1
Borreira-seed																					
Commelina-seed																					
Cyperaceae-seed		1																			
Leguminosae, cf-seed																					1
Malvaceae, cf-seed														1							
Physalis/Solanum-seed																					
Portulaca foliosa-seed		1			1																1
Portulaca oleracea-seed																					
Portulaca quadrifida-seed								1													
Pycreus macrostachyos-seed																					
Solanaceae-seed														1	1						
Tree/Shrub Fruits																					
Adansonia digitata, cf fruit shell frags																					
Vitex, fruit shell fragments																					
Ziziphus, cf, shell fragments																					
unknown fruit																	1				
unknown fruit/fruit shell fragments																					
Unknown Botanical										1											
Unknown Seed																					
Nothing Recovered			X			X					X		X							X	
Total counts per sample:	1	3	0	1	1	0	1	1	3	6	0	3	0	3	3	2	9	0	5	5	

Table A.3B – Tato à Sanouna Unit CE Archaeobotanical Inventory (Part 2 of 3)

(Charred only)	Level 18 LRF 28	Level 19 LRF 29	Level 20 LRF 30	Level 21 LRF 31	Level 23 LRF 33	Level 24 LRF 34	Level 25 LRF 35	Level 26 LRF 36 #1	Level 26 LRF 36 #2	Level 27 LRF 37	Level 29 LRF 39	Level 30 LRF 40	Level 35 LRF 45	Level 36 LRF 46	Level 31 LRF 41	Level 32 LRF 42	Level 37 LRF 47	Feature 6 #1	Feature 6 #2	Feature 6 #3	Feature 6 #4	Level 38 LRF 48	Level 39 LRF 40 #1	Level 39 LRF 40 #2	Level 39 LRF 49 #3
	Sediment examined (ml)	40	7	80	22	9	9	10	7	34	7	3	64	4	5	7	5	4	15	5	3	3	4	10	5
Phase	Phase III Late												Phase III Early												
Poaceae-Grass Family																									
Andropogonae, cf-grain	2															2		1							
Brachiaria, cf-grain								1			1			1				1							
Digitaria, cf-grain	4				1	1	1	2							1	2	1	15	6	2	2	5	3	1	7
Eleusine coracana, grain																		2							
Eleusine indica, grain									1		1			1		4	2								
Eragrostis turgida, cf-grain																	1								
Eragrostis/Sporobolus, cf-grain					2	4												7	1			1		1	
Oryza-grain fragments	3		2	2	2	2	2	3		1	1		2		2	3	2	5	3	3		1	11		13
Oryza, cf-grain fragments																									
Paniceae, cf-grains	3			1	1		3	2									4		2	1					
Panicum, cf-grain																1									
Panicum laetum, cf-grain													2	1				1							
Panicum subalbidum, cf-grain						2																			
Panicum turgidum, cf-grain	2								1									1							1
Paspalum scrobiculatum-grain	1					1		1								1		1							2
Pennisetum, cf-grain											1									3			5	2	
Pennisetum glaucum-grain																1									3
Pennisetum/Sorghum-grain										1															
Setaria-grain		2		1	1						1	1						2							
Setaria barbata, cf-grain									1																
unknown Poaceae-embryo			1			5																	4		2
unknown Poaceae-grain									2			3	3		2	2	1		1		1	2			
Herbaceous																									
Amaranthus/Chenopodium-seed																									
Borreira-seed													2												
Commelina-seed																1									
Cyperaceae-seed												1													
Leguminosae, cf-seed													1					1							1
Malvaceae, cf-seed																									
Physalis/Solanum-seed									1																
Portulaca foliosa-seed	1																								
Portulaca oleracea-seed	1		1							1	1		1												
Portulaca quadrifida-seed																									
Pycurus macrostachyos-seed										1															
Solanaceae-seed	1		2	1																					
Tree/Shrub Fruits																									
Adansonia digitata, cf fruit shell frags																		4							
Vitex, fruit shell fragments																		1							
Ziziphus, cf, shell fragments																		2							
unknown fruit																									
unknown fruit/fruit shell fragments					1													1				2	1		
Unknown Botanical																			1						
Unknown Seed								1	1				4	3		2		3		1					
Nothing Recovered																									
Total counts per sample:	18	2	6	5	8	15	6	9	3	8	7	1	13	12	5	22	5	51	13	11	2	10	26	4	29

Table A.3C-Tato à Sanouna Unit CE Archaeobotanical Inventory (Part 3 of 3)

(Charred only)	Level 40 LRF 50	Level 41 LRF 51 #1	Level 42 LRF 52 #2	Level 43 LRF 53	Level 44 LRF 54	Level 46 LRF 56	Level 47 LRF 57 #1	Level 47 LRF 57 #2	Level 48 LRF 58	Level 49 LRF 59	Level 50 LRF 60	Total Counts	% Ubiquity (56 samples)
	Sediment examined (ml)	3	5	9	5	5	4	6	5	10	6		
Phase	Phase I / II												
Poaceae-Grass Family												-	-
Andropogonae, cf-grain												6	7.14
Brachiaria, cf-grain												4	7.14
Digitaria, cf-grain			1									58	35.71
Eleusine coracana, grain												2	1.79
Eleusine indica, grain												9	8.93
Eragrostis turgida, cf-grain												1	1.79
Eragrostis/Sporobolus, cf-grain												16	10.71
Oryza-grain fragments				1	5			1	1			83	51.79
Oryza, cf-grain fragments												3	3.57
Paniceae, cf-grains												20	16.07
Panicum, cf-grain												2	3.57
Panicum laetum, cf-grain	1		1									9	12.50
Panicum subalbidum, cf-grain												2	1.79
Panicum turgidum, cf-grain												5	7.14
Paspalum scrobiculatum-grain												7	10.71
Pennisetum, cf-grain					1							12	8.93
Pennisetum glaucum-grain								1				5	5.36
Pennisetum/Sorghum-grain												1	1.79
Setaria-grain												12	12.50
Setaria barbata, cf-grain												1	1.79
unknown Poaceae-embryo												12	7.14
unknown Poaceae-grain												22	23.21
Herbaceous												-	-
Amaranthus/Chenopodium-seed												1	1.79
Borreira-seed												2	1.79
Commelina-seed												1	1.79
Cyperaceae-seed												2	3.57
Leguminosae, cf-seed			1									5	8.93
Malvaceae, cf-seed												1	1.79
Physalis/Solanum-seed												1	1.79
Portulaca foliosa-seed												4	7.14
Portulaca oleracea-seed												5	8.93
Portulaca quadrifida-seed												1	1.79
Pycrus macrostachyos-seed												1	1.79
Solanaceae-seed												6	8.93
Tree/Shrub Fruits												-	-
Adansonia digitata, cf fruit shell frags												4	1.79
Vitex, fruit shell fragments	1											2	3.57
Ziziphus, cf, shell fragments		2								2		6	5.36
unknown fruit												1	1.79
unknown fruit/fruit shell fragments					1							6	8.93
Unknown Botanical												2	3.57
Unknown Seed												15	12.50
Nothing Recovered						X	X				X	8	-
Total counts per sample:	2	2	3	1	7	0	0	2	1	2	0	358	

Table A.4A – Thièl Unit AMS Archaeobotanical Inventory (Part 1 of 3)

(Charred only)	Level 1 LRF 2 #1	Level 1 LRF 2 #2	Level 2 LRF 5	Level 3 LRF 7	Level 4 LRF 9 #1	Level 4 LRF 9 #2	Level 5 LRF 12 #1	Level 6 LRF 15	Level 7 LRF 16	Level 8 LRF 20	Level 9 LRF 23 #1	Level 9 LRF 23 #2	Level 10 LRF 26 #1	Level 10 LRF 26 #2	Level 11 LRF 28 #1	Level 11 LRF 28 #2	Level 12 LRF 31 #1	Level 12 LRF 31 #2	Level 13 LRF 34 #1	Level 13 LRF 34 #2	Level 13 LRF 34 #3	Level 14 LRF 36	Level 15 LRF 37	Level 16 LRF 39	Level 16 LRF 42	Level 17 LRF 43	Level 18 LRF 45 #1	Level 18 LRF 45 #2	
	2	30	20	5	15	2	2	2	1	1	16	3	15	1	5	1	2	35	5	4	12	4	3	2	120	1	11	3	
Sediment examined (ml)	Phase IV/V Mix				Phase IV										Phase III / IV Transition														
Poaceae-Grass Family																													
Andropogonae, cf-grain		1															1												
Brachiaria, cf-grain																													
Brachiaria deflexa, cf-grain		2																											
Digitaria, cf-grain			1								1																1		
Echinochloa colona, cf-grain																													
Eleusine indica-grain																													
Eragrostis/Sporobolus, cf-grain																													1
Oryza-grain fragments							1				1											1	1		1	1			
Oryza, cf-grain fragments					1																								
Paniceae, cf-grains					2						3						1												
Panicum, cf-grain																											2		
Panicum laetum, cf-grain																				1									
Panicum subalbidum, cf-grain																								1					
Panicum turgidum, cf-grain																			1				1						
Paspalum scrobiculatum-grain		4														1													
Pennisetum, cf-grain			1	1			1											2	3										
Pennisetum glaucum-grain			1																										
Pennisetum cf violaceum-grain																													
Pennisetum/Sorghum, cf-grain																													
Setaria, cf-grain		4																									3		
Schoenefeldia gracilis, cf-grain																													
Sorghum bicolor, cf-grain																			1										
unknown Poaceae-embryo																		2			1								
unknown Poaceae-grain		2			1					1							2		1		2								
Herbaceous																													
Borreira-seed																													
Brassicaceae, cf-seed																													
Commelina-seed																											1		
Cyperaceae-seed					1														1										
Heliotropium-seed																													
Leguminosae, cf-seed																													
Physalis/Solanum-seed		1																											
Portulaca foliosa-seed																			1		1								
Scleria, cf-seed			1																										
Tree/Shrub Fruits																													
unknown fruit																	1												
unknown fruit/fruit shell fragments																		3											
Unknown botanical			2																										
Unknown seed																										2		5	
Nothing Recovered	X				X	X	X		X	X	X	X							X										
Total counts per sample:	0	14	5	1	6	0	2	0	0	1	5	0	0	0	0	1	5	10	6	0	4	1	2	1	3	2	11	1	

Table A.4C – Thièl Unit AMS Archaeobotanical Inventory (Part 3 of 3)

(Charred only)	Level 38 LRF 90	Level 39 LRF 92	Level 40 LRF 94	Level 41 LRF 96	Level 42 LRF 98	Level 43 LRF 101	Level 44 LRF 102	Level 45 LRF 104	Level 46 LRF 106	Level 47 LRF 107	Total Counts	% Ubiquity (60 samples)
	Sediment examined (ml)											
Phase	Phase I / II											
Poaceae-Grass Family											-	-
Andropogonae, cf-grain	1				1						4	6.67
Brachiaria, cf-grain											1	1.67
Brachiaria deflexa, cf-grain											2	1.67
Digitaria, cf-grain		1		2	1	1					30	26.67
Echinochloa colona, cf-grain		1									1	1.67
Eleusine indica-grain			1								7	5.00
Eragrostis/Sporobolus, cf-grain											1	1.67
Oryza-grain fragments	3	7	1	3	3	7	1	1	2	12	88	45.00
Oryza, cf-grain fragments											2	3.33
Paniceae, cf-grains		1									13	10.00
Panicum, cf-grain											3	3.33
Panicum laetum, cf-grain											1	1.67
Panicum subalbidum, cf-grain											1	1.67
Panicum turgidum, cf-grain											2	3.33
Paspalum scrobiculatum-grain	2					1					14	13.33
Pennisetum, cf-grain	3	2		1			1	1		2	27	28.33
Pennisetum glaucum-grain				1							3	5.00
Pennisetum cf violaceum-grain	1	1									5	8.33
Pennisetum/Sorghum, cf-grain									1		1	1.67
Setaria, cf-grain											9	6.67
Schoenefeldia gracilis, cf-grain											1	1.67
Sorghum bicolor, cf-grain											1	1.67
unknown Poaceae-embryo											4	5.00
unknown Poaceae-grain		1	1	1		2					31	28.33
Herbaceous											-	-
Borreira-seed			1								1	1.67
Brassicaceae, cf-seed											1	1.67
Commelina-seed		1	4								8	6.67
Cyperaceae-seed											2	3.33
Heliotropium-seed									1		1	1.67
Leguminosae, cf-seed			1								1	1.67
Physalis/Solanum-seed											2	3.33
Portulaca foliosa-seed											2	3.33
Scleria, cf-seed											1	1.67
Tree/Shrub Fruits											-	-
unknown fruit											1	1.67
unknown fruit/fruit shell fragments											3	1.67
Unknown botanical			1								6	8.33
Unknown seed											15	8.33
Nothing Recovered											13	-
Total counts per sample:	10	15	10	8	5	11	2	2	2	16	296	-

Table A.5A – Thièl Unit GTC Archaeobotanical Inventory (Part 1 of 2)

(Charred only)	Lev 1 LRF 1	Lev 2 LRF 3	Lev 3 LRF 4	Lev 4 LRF 6	Lev 5 LRF 8	Lev 6 LRF 11 #1	Lev 6 LRF 11 #2	Lev 7 LRF 14	Lev 8 LRF 17 #2	Lev 9 LRF 21	Lev 10 LRF 22	Lev 11 LRF 24	Lev 12 LRF 25	Lev 13 LRF 26	Lev 14 LRF 29	Lev 15 LRF 32	Lev 16 LRF 33	Lev 17 LRF 35 #1	Lev 17 LRF 35 #2	Lev 18 LRF 38	Lev 19 LRF 40	Lev 20 LRF 41	Lev 21 LRF 47	Lev 22 LRF 48	Lev 23 LRF 51	Lev 24 LRF 54	Lev 25 LRF 58	Lev 25 LRF 60	Lev 26 LRF 63 #1	Lev 27 LRF 65	Lev 28 LRF 70	Lev 29 LRF 72 #1	Lev 29 LRF 72 #2				
	Sediment examined (ml)	15	6	5	4	10	8	28	3	2	4	5	2	6	10	2	15	8	8	3	5	3	1	15	10	20	10	2	2	2	2	2	7	10			
Phase	Phase V					Phase IV										Phase III Late																					
Poaceae-Grass Family																																					
Brachiaria, cf-grain																																					
Brachiaria ramosa, cf-grain																																			1		
Brachiaria/Setaria, cf-grain																																		1			
Cenchrus biflorus, cf-grain																																					
Digitaria, cf-grain														5		8	3																				
Echinochloa colona, cf-grain														1																							
Eragrostis/Sporobolus, cf-grain																																					
Oryza-grain fragments															16		5			1																	
Oryza, cf-grain fragments	2																		3																		
Panicum, cf-grain																																					
Panicum laetum, cf-grain										1			1	2			1																				3
Panicum turgidum, cf-grain											1			1																							
Pennisetum, cf-grain								1	1					2	4		1																			1	12
Pennisetum glaucum-grain																			1																	2	
Pennisetum cf violaceum-grain																																					
Pennisetum/Sorghum, cf-grain																																					
Schoenefeldia gracilis, cf-grain																				1																	
Setaria, cf-grain														1		1																					1
unknown Poaceae-embryo					1									1																							
unknown Poaceae-grain						1				1					1							1	1		2					1	3			1			
Herbaceous																																					
Amaranthus/Chenopodium-seed																																					
Brassicaceae, cf-seed																																					1
Commelina-seed														2			1																				
Cyperaceae-seed																2																					
Heliotropium-seed																																					
Physalis-seed							1						1																								
Physalis/Solanum-seed																																					
Portulaca foliosa-seed														1																							
Portulaca oleracea-seed																																					
Solanum, cf-seed														1																							
Tree/Shrub Fruits																																					
Vitex-fruit shell fragments				3																																	
Unknown fruit/fruit shell fragments											1																										
Unknown botanical																																					4
Unknown seed							1	1	1			1		3																							
Nothing Recovered	X	X																		X			X	X						X							
Total counts per sample:	0	2	0	3	1	1	2	2	1	2	3	1	1	38	1	20	8	1	3	0	1	1	0	2	0	3	3	3	3	0	9	4	13	15			

Table A.5B – Thièl Unit GTC Archaeobotanical Inventory (Part 2 of 2)

(Charred only)	Lev 30 LRF 75	Lev 31 LRF 80	Lev 32 LRF 85	Lev 33 LRF 86	Lev 34 LRF 89	Lev 35 LRF 93	Lev 36 LRF 99	Lev 37 LRF 103	Lev 38 LRF 108	Lev 39 LRF 111	Lev 40 LRF 112	Lev 41 LRF 113	Lev 42 LRF 115 #1	Lev 42 LRF 115 #2	Lev 43 LRF 116	Total Counts	% Ubiquity (48 samples)
	Sediment examined (ml)																
Phase	Phase III Early							Phase I / II									
Poaceae-Grass Family																-	-
Brachiaria, cf-grain													1			1	2.08
Brachiaria ramosa, cf-grain																1	2.08
Brachiaria/Setaria, cf-grain																1	2.08
Cenchrus biflorus, cf-grain																1	2.08
Digitaria, cf-grain	1				1			3			1		1			28	25.00
Echinochloa colona, cf-grain																1	2.08
Eragrostis/Sporobolus, cf-grain																2	4.17
Oryza-grain fragments	2			1				1			2		11	1		46	25.00
Oryza, cf-grain fragments																5	4.17
Panicum, cf-grains		1					2	1								12	16.67
Panicum, cf-grain							1									3	6.25
Panicum laetum, cf-grain						1										2	4.17
Panicum turgidum, cf-grain																1	2.08
Pennisetum, cf-grain		2			1		1		1							31	27.08
Pennisetum glaucum-grain						2										5	6.25
Pennisetum cf violaceum-grain	1					1										2	4.17
Pennisetum/Sorghum, cf-grain								1			1					2	4.17
Schoenefeldia gracilis, cf-grain																1	2.08
Setaria, cf-grain		1			1											5	10.42
unknown Poaceae-embryo																2	4.17
unknown Poaceae-grain		1			4			5								22	25.00
Herbaceous																-	-
Amaranthus/Chenopodium-seed	1															1	2.08
Brassicaceae, cf-seed																1	2.08
Commelina-seed																3	4.17
Cyperaceae-seed																2	2.08
Heliotropium-seed				1												1	2.08
Physalis-seed																2	4.17
Physalis/Solanum-seed						1										1	2.08
Portulaca foliosa-seed																1	2.08
Portulaca oleracea-seed							1									1	2.08
Solanum, cf-seed																1	2.08
Tree/Shrub Fruits																-	-
Vitex-fruit shell fragments																3	2.08
unknown fruit/fruit shell fragments																1	2.08
Unknown botanical																4	2.08
Unknown seed													1			8	12.50
Nothing Recovered			X						X		X			X		10	-
Total counts per sample:	5	5	0	2	7	5	5	11	1	0	4	0	13	2	0	204	-

Table A.6 – Archaeobotanical Inventory (% Ubiquity by Phase)

(Charred only)	Thièl					Tato à Sanouna					
	Ph V (N=6)	Ph IV (N=19)	Ph III-IV Trans. (N=12)	Ph III (N=32)	Ph I/II (N=16)	Ph V (N=2)	Ph IV (N=16)	Ph III-IV Trans. (N=7)	Ph III (N=36)	Ph I/II- III Trans. (N=10)	Ph I/II (N=12)
Poaceae-Grass Family											
Acroceras, cf-grain	-	-	-	-	-	-	-	-	-	10.00	-
Andropogonae, cf-grain	16.67	-	8.33	-	12.50	-	6.25	-	11.11	-	-
Brachiaria, cf-grain	-	-	-	3.13	6.25	-	6.25	-	11.11	20.00	-
Brachiaria deflexa, cf-grain	16.67	-	-	-	-	-	-	-	-	-	-
Brachiaria ramosa, cf-grain	-	-	-	3.13	-	-	-	-	-	-	-
Brachiaria/Setaria, cf-grain	-	-	-	3.13	-	-	-	-	-	-	-
Cenchrus biflorus, cf-grain	-	-	-	3.13	-	-	-	-	-	-	-
Digitaria, cf-grain	16.67	21.05	8.33	46.88	43.75	50.00	37.50	14.29	63.89	50.00	8.33
Echinochloa colona, cf-grain	-	5.26	-	-	6.25	-	-	-	-	-	-
Eleusine coracana, grain	-	-	-	-	-	-	-	-	2.78	-	-
Eleusine indica-grain	-	-	-	6.25	6.25	-	-	-	13.89	-	-
Eragrostis turgida, cf-grain	-	-	-	-	-	-	-	-	2.78	-	-
Eragrostis/Sporobolus, cf-grain	-	-	8.33	6.25	-	-	6.25	-	19.44	-	-
Oryza-grain fragments	-	26.32	33.33	50.00	87.50	-	62.50	57.14	66.67	70.00	50.00
Oryza, cf-grain fragments	16.67	10.53	-	3.13	-	-	6.25	14.29	-	-	-
Panicum, cf-grains	-	31.58	8.33	12.50	18.75	-	12.50	14.29	27.78	10.00	-
Panicum, cf-grain	-	5.26	8.33	6.25	6.25	-	-	14.29	5.56	20.00	-
Panicum laetum, cf-grain	-	5.26	8.33	3.13	-	-	-	28.57	8.33	-	16.67
Panicum subalbidum, cf-grain	-	-	8.33	-	-	-	-	-	2.78	-	-
Panicum turgidum, cf-grain	-	5.26	16.67	-	-	-	-	-	13.89	-	-
Paspalum scrobiculatum-grain	16.67	-	8.33	12.50	12.50	-	6.25	-	33.33	30.00	8.33
Pennisetum, cf-grain	16.67	36.84	16.67	37.50	50.00	-	-	-	25.00	70.00	8.33
Pennisetum glaucum-grain	16.67	5.26	-	9.38	6.25	-	-	-	11.11	10.00	8.33
Pennisetum cf violaceum-grain	-	-	-	15.63	12.50	-	-	-	-	-	-
Pennisetum/Sorghum, cf-grain	-	-	-	-	18.75	-	6.25	-	2.78	-	-
Schoenefeldia gracilis, cf-grain	-	5.26	-	3.13	-	-	-	-	-	-	-
Setaria, cf-grain	16.67	10.53	8.33	15.63	-	-	12.50	14.29	19.44	-	-
Setaria barbata, cf-grain	-	-	-	-	-	-	-	-	2.78	-	-
Sorghum bicolor, cf-grain	-	-	8.33	-	-	-	-	-	-	-	-
unknown Poaceae-embryo	16.67	5.26	16.67	3.13	-	-	-	-	11.11	20.00	-
unknown Poaceae-floret	-	-	-	-	-	-	-	-	2.78	-	-
unknown Poaceae-grain	16.67	31.58	25.00	43.75	31.25	50.00	31.25	14.29	33.33	40.00	8.33
Herbaceous											
Amaranthus/Chenopodium-seed	-	-	-	3.13	-	-	-	14.29	2.78	-	-
Borreira-seed	-	-	-	-	6.25	-	6.25	-	2.78	-	-
Brassicaceae, cf-seed	-	-	-	6.25	-	-	-	-	-	-	-
Commelina-seed	-	10.53	8.33	3.13	12.50	-	-	-	2.78	-	-
Cyperaceae-seed	-	10.53	8.33	-	-	50.00	-	-	2.78	-	-
Fimbristylis pilosa seed	-	-	-	-	-	-	-	-	-	-	8.33
Fimbristylus, cf-seed	-	-	-	-	-	-	6.25	-	-	-	-
Heliotropium-seed	-	-	-	3.13	6.25	-	-	-	2.78	-	-
Leguminosae, cf-seed	-	-	-	-	6.25	-	6.25	14.29	8.33	-	8.33
Malvaceae, cf-seed	-	-	-	-	-	-	-	14.29	-	10.00	-
Monocot, cf inflorescence	-	-	-	-	-	-	-	-	2.78	-	-
Physalis, cf-seed	-	10.53	-	-	-	-	-	-	-	10.00	-
Physalis/Solanum-seed	16.67	-	-	6.25	-	-	-	-	2.78	-	-
Portulaca foliosa-seed	-	5.26	16.67	-	-	50.00	12.50	14.29	2.78	-	-
Portulaca oleracea-seed	-	-	-	-	6.25	-	-	-	13.89	-	8.33
Portulaca quadrifida-seed	-	-	-	-	-	-	12.50	-	-	-	-
Pycnus macrostachyos-seed	-	-	-	-	-	-	-	-	2.78	-	-
Scleria, cf-seed	16.67	-	-	-	-	-	-	-	-	-	-
Solanaceae-seed	-	-	-	-	-	-	-	28.57	8.33	-	-
Solanum, cf-seed	-	5.26	-	-	-	-	-	-	-	-	-
Tree/Shrub Fruits											
Adansonia digitata, cf fruit shell frags	-	-	-	-	-	-	-	-	2.78	-	-
Vitex, fruit shell fragments	16.67	-	-	-	-	-	-	-	2.78	-	8.33
Ziziphus, cf, seed fragments	-	-	-	-	-	-	-	-	-	-	8.33
Ziziphus, cf, shell fragments	-	-	-	-	-	-	-	-	2.78	10.00	16.67

Site / Unit	Provenience	Length (mm)	Width (mm)	Thickness (mm)	L/W	L/T	Notes
Sanouna CE	Level 13 LRF 23 #1	3.6	1.2	1.6	3.00	2.25	
Sanouna CTR	Level 7 LRF 8 #1	4.8	1.2	2.3	4.00	2.09	
Thièl GTC	Level 13 LRF 26	5.0	1.5	2.0	3.33	2.50	
Thièl GTC	Level 42 LRF 115 #1	5.0	1.6	2.7	3.13	1.85	
Thièl GTC	Level 42 LRF 115 #1	4.4	1.1	1.6	4.00	2.75	Looks immature
Thièl GTC	Level 42 LRF 115 #1	3.6	0.6	1.5	6.00	2.48	Odd one
Thièl AMS	Level 30 LRF 72	5.2	1.5	2.7	3.47	1.93	
Thièl AMS	Level 32 LRF 76	5.0	1.8	2.0	2.78	2.50	
Thièl AMS	Level 38 LRF 90	5.0	2.5	1.9	2.00	2.63	Very wide

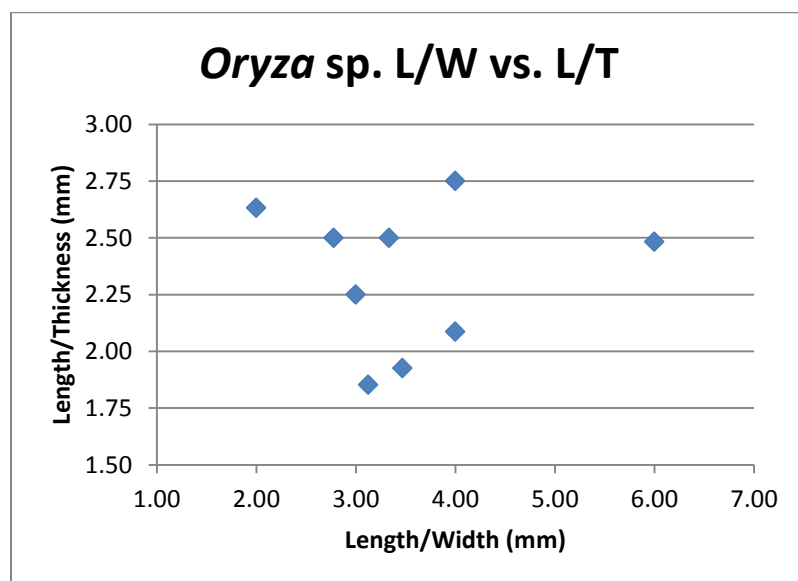


Figure A.1 – *Oryza sp.* dimensions; All fall into the range of *O. glaberrima* (African rice) and mostly out of the range of *O. barthii* (the wild progenitor); See Murray (2004) for a plot of modern *Oryza sp.* dimensions

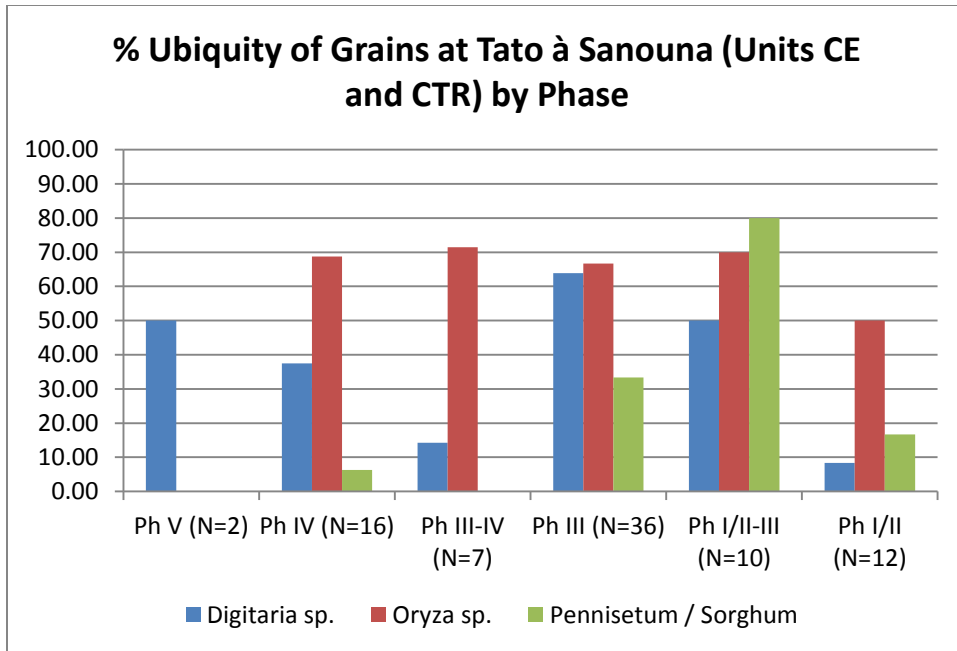


Figure A.2 - % ubiquity of common grains at Tato à Sanouna by Phase

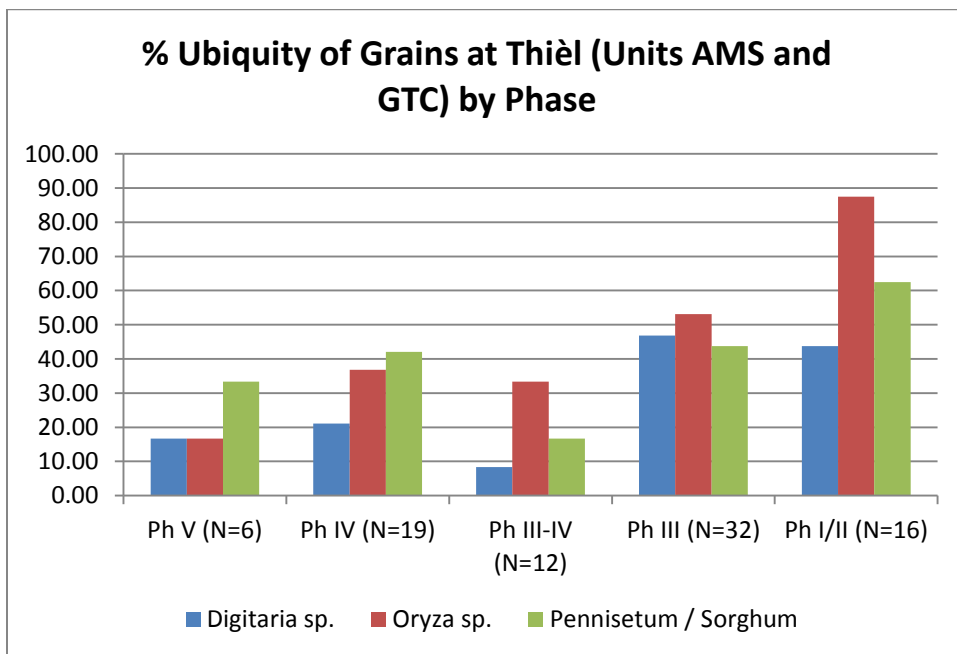


Figure A.3 - % ubiquity of common grains at Thièl by Phase

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