EMBODIED LIFE EXPERIENCES: BIOARCHAEOLOGICAL ANALYSIS OF HUMAN REMAINS IN SOUTHWEST NIGERIA

by

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ABSTRACT

CASSIDY B. RUSSELL. Embodied Life Experiences: Bioarchaeological Analysis of Human Remains in Southwest Nigeria. (Under the direction of SARA JUENGST)

Bioarchaeological study is on the rise in West Africa, with a focus on human migration, diet, and environmental reconstructions. Oftentimes these analyses focus on the broader patterns, obscuring the individual lives in the process. This study focuses on the lived experiences of five individuals excavated from what is now modern-day Nigeria. I will present results from light stable isotopes (C, N, O), heavy isotope (Sr), and osteological analysis, from individuals from three different sites, BSM6, EDI, and ODG1. By using multiple lines of evidence, I am able to provide a more nuanced understanding of daily life in the Yoruba region of Southwest Nigeria.

DEDICATION

I dedicate this thesis to my family and friends. This would not have been possible without their unwavering support.

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I would like to thank the many people who have provided me with support and patience over the last several years. Thank you to my committee chair, Dr. Sara Juengst, for encouraging me to pursue bioarchaeology. Your guidance over the last several years has been invaluable. Thank you to my other committee members, Dr. Akin Ogundiran and Dr. Luca Lai. I would not have been able to complete this thesis without your expert knowledge and readiness to help. Thank you to the Department of Anthropology for allowing me to grow as an anthropologist and for bringing me some of my closest friends.

Lastly, thank you to my family. Your love and support will forever be cherished.

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CHAPTER I: INTRODUCTION

In the last few decades, bioarchaeology has become more common across the African continent, with many studies focusing on the movement of pastoralists in the Neolithic era, or the reconstruction of paleoclimates (Sealy and Pfeiffer 2000; Holl 2020). Bioarchaeologists have recently been turning their focus to studying evidence of diet and mobility (Janzen et al. 2020). However, little to no bioarchaeological analysis has been conducted in the Yoruba culture region of West Africa, an area with a rich and long enduring history.

While there have been major discoveries of group-level processes that took place in West Africa over time (Sealy and Pfeiffer 2000; Holl 2020; Janzen et al. 2020), little is known about the individual life experiences of the people who lived and were buried at BSM6, EDI, and ODG1. In recent years, bioarchaeologists have turned their attention to life course theory, or studying the lives of individuals in different social contexts, especially political and economic, to see how social processes impact personal biology and experience. One approach to analyzing these experiences is through isotopic analysis of the dental and skeletal remains. Through isotopic analyses, we can see evidence of power, migration, and identity, as reflected in access to dietary resources through the study of carbon and nitrogen isotopes, and movement across landscapes through isotopes oxygen and strontium. This project will thus take a life course approach to analyze the individuals excavated from three archaeological sites in southwest Nigeria (Yoruba culture area), focusing on the isotopic indicators of diet and mobility, as part of the larger investigation of individual life experiences during two periods: 390-40 BC and AD 1600-1836.

CHAPTER II: RESEARCH SAMPLES

The samples for this research consist of isolated human skull fragments and dental remains, and horse remains (primarily teeth) excavated from three respective sites located in southwest Nigeria: BSM6, EDI, and ODG1 (Figure 1). These sites were excavated as part of a broad research agenda to understand long-term settlement history, regional interactions, and processes of social complexity in the Yoruba region. The sites BSM6 and EDI are connected to the powerful Oyo Empire (1575-1836). BSM6 is a pre-Oyo and Early Iron Age settlement in Bara (Oyo metropolis), with dates that cluster between 390 BC and 40 BC. EDI was a colony of the Oyo Empire, dating to AD 1600-1836. The site ODG1 stands as an outlier with no connection to the empire. It is a sacred grove dedicated to the veneration of Oduduwa, the founder of the royal dynasty in Ile-Ife. It hosts the mausoleum for the kings of Ile-Ife and it is an important site for the coronation and burial rituals of Ife kings. The archaeological context from which the bioarchaeological samples at ODG1 were collected dates to 1600-1800. Using a life course approach, I investigate the migration and dietary histories of these individuals in order to show the diversity of experiences in West Africa over different time periods and environments.

The three sites in this thesis are all in the Yoruba region of Nigeria (Figure 1) and date to two time periods, with varied association to the Oyo Empire. This combination of sites and periods allows us to investigate change over time, broadly and at the two Oyo-associated sites, and regional variation during the same period, comparing between two sites in use from AD 1600-1800. The sites and samples are described in more detail below.

The majority of remains originated from an Early Iron Age site, BSM6, located in the northwest Yoruba region. BSM6 is a pre-Oyo complex, predating the Oyo Empire and its capital, Oyo-Ile, by approximately 1800 years. The isolated human remains found at BSM6 are from

380-40 cal BC deposits, deeming them the oldest Iron Age human remains in southwest Nigeria so far. BSM6 is a site located about 2.5 km northeast of the outermost walls of Oyo-Ile, the capital of the empire (Figure 1). It is unknown how many individuals make up this collection at this time.

The second collection of remains were excavated from EDI, an abbreviation for Ede-Ile, a colony of the Oyo Empire. Ede-Ile, located in central Yoruba (Figure 1), had only one occupation period between AD 1600-1836. The remains of one individual were excavated, along with arrow points, cowries, pottery, and iron slag.

The third site, ODG1, also known as Oduduwa Grove, is located in central Yoruba (Figure 1). The grove is notably a sacred site in the ancient city of Ile-Ife where its new kings were consecrated. The human remains found at ODG1 come from disturbed deposits possibly dating between AD 1600-1800. While the remains from ODG1 date to the same as those from EDI, there is no relationship between them or with the Oyo Empire.

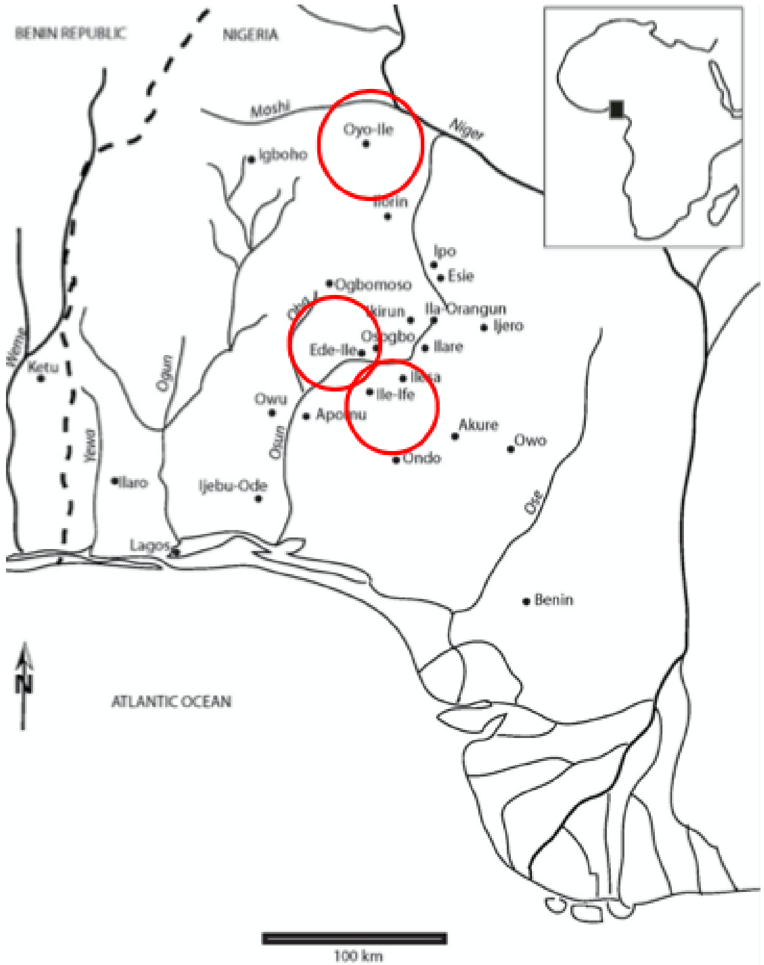

Figure 1. Map of Yorubaland with relevant sites circled with red (Map from Ogundiran 2012, 223)

CHAPTER III: THE SITES IN THE CONTEXT OF YORUBA ARCHAEOLOGY AND CULTURAL HISTORY

It is important to note that the three sites contain remains from two periods in Yoruba cultural history, specifically the Archaic (300 BC- 300 AD) and Atlantic period (1630-1840 AD). During the Archaic period, a major environmental phenomenon known as the Big Dry took place. Ogundiran (2020, 39) writes that the Big Dry is “characterized by a new seasonal pattern that reduced the duration and predictability of rainfall and increased the length and intensity of the dry season,” and lasted from the third century BC to the fourth century AD. While some cultural traditions were unable to adapt their subsistence strategies to the drastic environmental changes, others adapted agricultural strategies more suited to the new climate. Coinciding with the Big Dry was the more frequent use of iron technology. Increased use of iron technology allowed for the creation of iron farming tools, which in turn made subsistence farming easier and achievable in more areas.

After the Archaic period came the Early Formative (250-750 AD), Late Formative (650-1050 AD), and Classical periods (1000-1420 AD). Major political and cultural developments took place during these time periods. The Early Formative period included the return of annual rainfall, rapid growth and expansion, and the emergence of House societies “with formalized political institutions headed by priest-chieftains” (Ogundiran 2020, 7). As the Late Formative period approached, social networks and trade had begun to intensify, as did the emergence of mega-House polities. These polities were characterized by large villages and were populated by people with diverse familial backgrounds. Towards the end of the Late Formative period came the emergence of divine kingship institution and ideologies. These would become the preferred model of governance in the Classical period. This period witnessed the rise of the Ifè Empire, which included a vast network of colonies and client states (Ogundiran 2020, 7).

Further into the 17th century (Archaic period) came the rise of another empire, the Oyo Empire, which dominated the political landscape of the Yoruba region through the beginning of the 19th century. The Oyo Empire "controlled regions and peoples far beyond its heartland, took over polities, indirectly controlled other hegemonic and expansionist states, and succeeded in manipulating the political structures of those other polities in ways that made it exercise sovereignty over them" (Ogundiran 2012, 222). The Oyo Empire was able to expand in multiple ways, such as through external military attacks and conquests, as well as through colonization. Ogundiran describes the importance of understanding colonization in empire formation, and in this case, the colonization in the Upper Osun area of central Yorubaland, resulting in the settlement of Ede-Ile. Through the use of archaeological analysis, there have been many different lines of evidence that indicate that Ede-Ile was a colony of the Oyo. One prominent indicator of the Oyo colonization is ceramics. For example, "the stylistic lexicon of the ceramics at Ede-Ile, especially the forms of surface patterns, are the same as those at Oyo-Ile, the imperial metropolis, and other settlements in the heartland of the empire such as Ipapo-Ole and Koso" (Ogundiran 2012, 231). Another interesting indicator of colonization is the presence of baobab trees. Ede-Ile was located in the rainforest belt, yet there are currently baobab trees in the area, which are generally a tree found in the savanna. Because of this, Ogundiran notes that their presence in a rainforest is deliberate and that the range that they cover in the area coincides with the range that the ceramics also cover (Ogundiran 2012, 235). The final line of evidence that Ogundiran discusses is the excavation of horse remains, which indicates Oyo militarism. There were remains of both adult and juvenile horse remains. Horses were one of the most important weapons used by the Oyo to expand their empire, and the remains of both young and old horses signify that horses were also being bred to serve the empire (Ogundiran 2012, 238). Lastly, the colony itself was very successful in that it achieved self-sufficiency within a generation, and because of this, was able to participate in booming commercial networks within the area (Ogundiran 2012, 243).

Ede-Ile had great importance regarding the domestic economy in the Oyo Empire. The colonization of Ede-Ile was an attempt by the Oyo to gain control over trade in the Upper Osun, and not only was the colony successful but "it was cosmopolitan in its consumption and most of its everyday material culture originated from specialized production processes" (Ogundiran 2009, 381). Atlantic imports (especially cowries) and local commodities fueled the domestic economy of Ede-Ile and the Oyo Empire itself. There was also a rising demand for the export of human cargo for the Atlantic Slave Trade, and while this did play a role in the economy, it did not have as large an impact as cowries. Because of its large role in trade, Ede-Ile ultimately became a highly specialized colony to keep up with its booming commercial economy (Ogundiran 2009, 282). Horses were also important to the domestic economy, and the remains of some of these horses were found in one restricted area—the governor's quarters. This implies that horse ownership was highly selective and restricted to the center of power (Ogundiran 2009, 283). The horses were symbols of wealth status and political commodities.

CHAPTER IV: BIOARCHAEOLOGY AND ISOTOPIC ANALYSIS

Bioarchaeology is a field of study within anthropology that ultimately consists of the scientific study of human remains in their archaeological context in order to interpret the past. Martin (2013, 1) specifically defines bioarchaeology as "the study of ancient and historic human remains in a richly configured context that includes all possible reconstructions of the cultural and environmental variables relevant to the interpretations drawn from those remains." Martin also notes that bioarchaeology is rooted in the human experience. This is due to the fact that bioarchaeological studies are informed by scientific methods and theories from the other subdisciplines of anthropology, such as biological anthropology, cultural anthropology, archaeology, and linguistics.

The traditional study of human remains focuses on the medical and forensic aspects of osteology and paleopathology, while bioarchaeology integrates information from human remains with aspects of the environment and culture that the individual once lived in (Martin et al. 2013, 5). Some of this information consist of age at death, sex, stature, pathology, and trauma, among other identifiable characteristics. These characteristics can be used to identify environmental factors, population density, food sources, living conditions, and power structures during the time in which the individual lived. With this, bioarchaeologists are not simply studying the skeletal remains as artifacts, but also studying the remains with an emphasis on humans, both biological and cultural beings.

A common line of investigation in bioarchaeology that uses scientific method and theory is isotopic analysis of human remains. This analysis can provide information on both individual and group-level processes, showing how an individual was once connected to their environment, both physically and socially. The composition of stable isotopes found in bone can provide evidence of migratory patterns, diet, and paleoclimates. The use of isotopic analysis has become increasingly useful to bioarchaeologists in reconstructing the past.

Life Course Theory and Embodiment

Bioarchaeologists have become increasingly interested in life course theory, or “the study of individual lives and their connection to their historical and socioeconomic contexts" (Agarwal 2016, 131). The life course includes both social and biological changes and experiences, and thus bioarchaeologists combine techniques from both biological and social sciences. Agarwal (2016) argues that there are two key concepts to life course theory: trajectory and plasticity. Through the use of trajectory, it is possible to imagine the obstacles that can influence the course of one's life. Trajectory can be altered due to a range of different influences, making it an adaptive process that can change over time (Agarwal 2016, 131). It is important to note that trajectories are followed, based upon, and directed through evolutionary processes that allow human bodies to have the plasticity to adapt to a changing environment. Plasticity thus embodies both growth and development over time and explains phenotypic variability (Agarwal 2016, 131).

There is a difference between growth and development, as growth pertains to the enlargement of tissues associated with chronological age while development refers to biological milestones along the lifecycle (Agarwal 2016, 132). However, growth and development are both a product of social, biological, and environmental influences, and plasticity is the ability of the body to adapt to these influences. During an individual's life course, the body experiences stress, disease, damage, among other factors that could stem from a social environment, but ultimately result in biological processes that can alter the phenotype (physical characteristic) of the individual, and in this case, the human skeleton. Hosek and Robb (2019) note that bioarchaeologists rely on the concept of skeletal plasticity to address how social, environmental, and material influences shape the biological body (6). By understanding that the body is a result of the interactions between genes and the environment, one can better understand the life course of an individual, especially when examining human remains.

Over time, the human skeleton will provide evidence of growth and development. Agarwal (2016) describes embodiment as a way in which individuals incorporate the world into their lives biologically, socially, and economically (132). Some of the key social and biological moments in human lives include birth, maturation, reproduction, and death. Because of this, embodiment "is applicable to archaeological studies that deal with the reconstruction of past societies through the study of material culture" (Lozada 2018, 595). There are many markers on the human skeleton that provide evidence of the life courses of another individual. Some of these include disease, body modifications, and stress, among others. Skeletal remains also challenge what bioarchaeologist know about sex and gender in past societies. For example, "characteristics of the body, such as age, sex/gender, and health, are based on a lifetime of culturally negotiated activities" (Hosek and Robb 2019, 6). Hosek and Robb (2019) note that embodiment is also a concept that implies that bodies are dynamic and fluid, and are constantly changed by experiences over a lifetime (137). As these events occur, they will be recorded on the skeleton of the individual, and thus archaeologists are able to hypothesize the life experiences of each individual.

Osteobiographies

Using concepts such as life course theory and embodiment, an osteobiography can be constructed. An osteobiography is a written source that reconstructs the life history of an individual through the examination of "bony indicators of food consumption, activity patterns, disease experience and movement across biosocial landscapes" (Agarwal 2016, 138). The archaeological and contextual information of human burials is also critical to osteobiographies (Agarwal 2016, 138). Interestingly, while the study of individual skeletons is the primary goal of an osteobiography, evidence from the individual study can provide information about group-level processes. However, the analysis of individuals provides a more nuanced understanding of everyday life, and can aid in understanding the range of plasticity of the skeleton over a lifetime (Agarwal 2016, 138).

Isotopic Analysis

The human skeleton is composed of numerous compounds, many of which provide information regarding the identity, diet, and migratory patterns of an individual. Isotopes are atoms of the same element with the same number of protons, but different numbers of neutrons (Katzenberg 2008). Isotopes vary in their masses as the atomic mass is determined by the number of protons and neutrons present in the nucleus. Variations in neutrons and atomic mass result from static and active processes and mean that these isotopes are measurable in ways accessible to bioarchaeologists (described more below).

It is important to note that there are both stable and unstable isotopes. Stable isotopes such as ^{12}C and ^{13}C are present in animal and human remains, based on naturally occurring variants in carbon. These variants occur because of differential carbon uptake in the various photosynthetic pathways in plants. Unstable isotopes result from radioactive decay of one element into another, such as the creation of ^{87}Sr from ^{87}Rb (Katzenberg 2008, 415). These isotopes are incorporated into human bone and teeth during development and over the life course through consumption of food and water. Human teeth remain unchanged after mineralization, making them one of the best tools for analyzing diet, as they provide a long-lasting record of diet through childhood (Schroeder 2009, 549). Bones, however, are constantly changing and skeletal elements form at different times. Thus, they provide evidence of diet over the lifetime and closer to the time of death. Archaeologists can thus conduct isotopic analysis of stable and unstable isotopes present in human remains to identify evidence of diet and migration, and extrapolate from these indicators, power and social complexity.

The light, stable isotope carbon is one of the most regularly used indicators of the diet of individuals from the past (Ambrose et al 1997, 344). Carbon isotopes aid in determining diet because carbon "can be used to discriminate between terrestrial plants that fix atmospheric CO_2 by different photosynthetic pathways, named C_4 and C_3" (Ambrose et al. 1997, 345). Carbon and nitrogen isotope analysis are often paired together. However, nitrogen is not present in dental enamel, which primarily makes up the samples being used for analysis. Carbon present in dental enamel, also known as carbonate, reflects the plants consumed during childhood and early adulthood. Carbon in bone collagen is primarily derived from dietary proteins, and carbon incorporated into bone mineral "represents the bulk average of all dietary macronutrients" (Wright 1998, 3). According to Ambrose et al. (1997), notable plants that are composed of C_4 include maize and sugarcane, while C_3 plants include rice, root crops, vegetables, nuts, fruit, wheat, and barley (346). CAM (Crassulacean acid metabolism) plants can also be detected in carbon analysis. These plants have adapted to their environment and often photosynthesize during the day whilst releasing atmospheric gas at night, which will also appear as C_3 and C_4 in analysis. (Males and Griffiths 2017, 550). Examples of these plants consist of Cactaceae (cactus), Agavaceae (agave), and even orchids. Carbon analysis will ultimately reveal the plants consumed which in turn will provide evidence of diet through early childhood.

The isotopic analysis of oxygen in human remains is used to determine migratory patterns in past individuals and broader environmental reconstructions. The analysis of the two stable isotopes ^{18}O and ^{16}O reflects the isotope values of water ingested at the time of tissue formation (Lightfoot et. al 2016, 3). The oxygen present represents the water consumed as a liquid as well as the water in food (Wright 1998, 3). Lightfoot (2016) notes that the ingested water often reflects the isotopic composition of meteoric precipitation. This composition can vary temporally and based on geographic location. The composition at a given location is based on environmental parameters such as the amount of precipitation, latitude, altitude, distance to the coast, season, and surface temperature. The isotope value of precipitation correlates most strongly with surface temperature at high latitudes. In a tropical region, the oxygen isotope is negatively correlated with the amount of rainfall. According to Lightfoot et. al (2016, 3) "(t)hese factors also cause temporal variations associated with past climatic changes in a given location, allowing oxygen isotopes to be used as a palaeoclimatic indicator but limiting the comparability of results for migration studies." Archaeologists have not only been able to reconstruct migratory patterns through the study of ^{18}O and ^{16}O, but also reconstruct paleoclimates (Wright 1998, 3).

The isotope strontium present in bone has allowed archaeologists to study models of migration, culture change, colonization, trade, and exchange (Slovak and Paytan 2012, 743). Strontium is a trace element found in igneous, metamorphic and sedimentary rock, as well as in water, plants, soil, and animals (Slovak and Paytan 2012, 743). Because of this, strontium isotopes ($^{87}Sr/^{86}Sr$) vary due to age and geo-composition of the area (Schroeder et al. 2009, 550). Strontium moves through a number of different sources, starting from bedrock, through soil and groundwater, and finally into the food chain (Schroeder et al. 2009, 550). When studying the strontium found in enamel, archaeologists will be able to understand the diet of individuals during childhood, as mineralization is complete at around fifteen years of age (Schroeder 2009, 549). Strontium will also indicate the location of where the person lived throughout their childhood, as strontium reflects the geological terrain that the individual inhabited while their teeth were forming (Schroeder 2009, 549). Evidence of strontium in bone reflects diet and mobility throughout adulthood, as bones are remodeled over a lifetime (Schroeder 2009, 549). Archaeologists note that if there is a difference in strontium ratios between the teeth and bones, it is possible that the individual migrated during their lifetime (Slovak and Paytan 2012, 74).

CHAPTER V: WEST AFRICAN ENVIRONMENTAL BASELINES AND SUBSISTENCE HISTORY

The cultivation and domestication of plants has been an ongoing process across Africa for several thousand years. Ehret (2017) writes that "in West Africa, the beginning stages of an independent shift toward agricultural ways of life took place in the tenth millennium BC." (57). This shift prompted the cultivation and domestication of numerous crops, most importantly, pearl millet, which was domesticated by pastoralists as early as the 2nd millennium BC (Neumann 2018, 6). The domestication of pearl millet took place in the Sahara, but around 2000 BC, pearl millet began to spread rapidly across West Africa, making its way into the savanna region of West Africa, where there is seasonal rainfall and a broad variety of vegetation, ranging from pure grasslands with sparse tree cover to dense woodlands. Such an ecosystem provides natural resources including honey, edible fruits, wild yams, and wild game (Neumann 2018, 4). Neumann (2018) suggests that a possible reason for the domestication of pearl millet in the Sahara was likely due to the low seed production of the perennial grasses located in the savannas (1). However, the climate in the woodland savanna region would soon allow for a multitude of crops to be cultivated throughout the year, such as pearl millet and later sorghum, which can be cultivated through the rainy seasons.

Further into 1st and early 2nd millennia AD, Neumann (2018) notes that there was "demographic growth, intensification of agricultural production, establishment of urban centers and long-distance trade networks, and eventually the rise of West African empires," all which would come to rely on the surplus crop production in rural areas (13). With higher demand came the mixed cultivation of cereals and legumes, such as fonio, roselle, and okra (Neumann 2018, 14). Despite the new mix of crops, pearl millet remained the dominant plant cultivated well into the 1st and 2nd millennia AD. Another important crop cultivated during this time was sorghum. The cultivation of sorghum has many benefits, as sorghum can be grown in most soils and can withstand waterlogging, which farmers capitalized on (Logan 2016, 517).

Also during the 1st and 2nd millenia was the arrival of maize in West Africa. Brought over from the Americas, maize "transformed African agriculture due to its increased yield potential compared to African grains" (Logan 2016, 517). This increased yield is a result of maize's short growing season, which allows it to be grown twice in one year. Because of this, it is hypothesized that there was a heavier reliance on maize during times of stress such as famine, as it can produce more food in a shorter period of time.

Comparison with environmental and plant and animal baselines is critical to isotopic analyses. Some of the most major crops in West Africa, such as maize, sorghum, and millet, are classified as C_4 plants, and consist of a carbon composition that ranges from -9‰ to -17‰. Alternatively, the consumption of C_3 plants such as rice or soybeans, are going to have carbon composition ranging from -24‰to -36‰ (Loftus 2015, 90). These compositions are present in both human and non-human animal bones, and can indicate diet over time. They can also be linked to the overall environment. According to Loftus (2015), "C_3 plants are frequently limited to forested and mixed woodland-grassland ecologies, with C_4 grasses and sedges found in more insulated, warmer grassland biomes," which indicates that geographic location ultimately determines the diet of both human and non-human animals in an area (91).

Carbon composition is also linked to dietary habits in human and non-human animals. For example, according to isotopic analyses on dental enamel from West African bovids, specifically, tragelaphins, it was found that their diet primarily consists of a C_3 browsing diet, as the carbon composition present in their enamel had an average value of -13.4‰. Conversely, the

Reduncins (primarily species of antelope had a diet dominated by C_4 grasses, as their average carbon values equaled -1.2‰. (Cerling et. al 2003, 464). More importantly, the consumption of animals who are consuming a strictly C_4 or C_3 diet can be reflected in human carbon analysis. Not only could an individual or population consume a large amount of C_4 diets, but they could also consume an animal who eats large portions of C_4 plants, in turn impacting the human's carbon signature. While the specific plant or animal cannot be pinpointed, overall carbon composition present in dental enamel (and even bone) can give an overall indication of food consumption during a lifetime.

Oxygen isotope chemistry varies temporally and geographically as a response to atmospheric circulation patterns (Goni 2006, 745). As humans ingest water, the isotopic chemistry, specifically oxygen, will remain in bone, tooth dentin, and dental enamel in carbonates within the mineral hydroxyapatite, and can indicate region of origin and movement from one geographical location to another (France et. al 2019, 299). According to France et. al, (2019) $\delta^{18}O$ values in Africa range from approximately -11 to +4%, and prior to the 20th-century, drinking water in Africa was largely obtained from local meteoric water, where oxygen values correlated to latitude and general region of origin (France 2019, 300). Schroeder et al. (2009, 555) note that there is data showing that from West and West Central Africa, $\delta^{18}O_{dw}$ values gradually decrease from about -2.0 to -4.0‰ on the coast to -7.0 or -8.0‰ in inland and highland areas. While this data does not always pinpoint the exact region of origin, it aids in determining the general region, as $\delta^{18}O$ values in local and non-local streams and basins will be reflected in the bone and dental enamel of the individuals drinking from them.

In southwest Nigeria, rainfall averages between 1200mm to 1500 mm per year. More importantly there are two distinct seasons, a wet season that lasts from March to

October/November, and a dry season that typically lasts from November to February, with the months of September and October as most commonly the wettest (Loehnert 1988, 580). Through analysis, Loehnert notes that the $\delta^{18}O$ values of precipitation have an average of -3‰ during the wet seasons. Similarly in streams, “wet season samples contribute to the cluster around -3‰ $\delta^{18}O$ and -12‰ D while dry seasons are shifted toward SMOW as a result of evaporation” (Loehnert 1988, 580). These $\delta^{18}O$ values will then also be reflected in streams and basins within the area. In 1979, Loehnert (1988) collected samples from seven perennial streams in Southwest Nigeria during both the wet and dry seasons. The $\delta^{18}O$ values will aid in indicating movement within or outside of the Southwest Nigerian region (582). As individuals ingest the water in these streams, the $\delta^{18}O$ signatures should reflect those in the region, which could indicate movement or reflect the climate during their lifetime.

Table 1. $\delta^{18}O$ values present in Southwest Nigerian Streams (Loehnert 1988, 584)

Table 1

Upper Owena third-order perennial streams

Stream	Sampling date	Total ions [meq/l]	Order of cations [meq/l]	Lab. No. Heidelberg	^{3}H[TU]	δD[‰]	$\delta^{18}O$[‰]
1 Okun	28/2/79	0.64		1899	29.0 ± 2.8	−11.05	−3.24
	31/3/79	0.66		1935	22.8 ± 4.0	− 9.85	−3.09
2 Opapa	28/2/79	0.74		1900	34.8 ± 3.2	−11.65	−3.36
	31/3/79	0.78		1936	30.7 ± 4.3	−11.05	−3.17
3 Alura	28/2/79	0.76		1901	29.2 ± 3.0	−10.91	−3.26
	31/3/79	0.9		1937	23.7 ± 4.1	−10.65	−3.16
4 Ohoo	28/2/79	1.28		1902	12.7 ± 2.6	−14.87	−3.28
	31/3/79	1.44	Na > Ca > Mg/K	1938	8.7 ± 3.9	−12.30	−3.18
5 Erinta	28/2/79	1.68	Na > Ca > Mg > K	1903	12.8 ± 2.7	−11.24	−2.78
	31/3/79	1.66	Na > Ca > K > Mg	1939	9.5 ± 3.8	−14.09	−3.31
6 Erin	28/2/79	5.48	Na > Ca > Mg > K	1904	13.4 ± 2.6	−13.19	−3.28
	31/3/79	5.14	Na > Ca > K > Mg	1940	8.6 ± 3.9	−12.95	−3.20
7 Anini	28/2/79	10.84	Na > Ca > Mg/K	1905	7.7 ± 3.0	−13.22	−3.28
	31/3/79	10.94	Ca > Mg > Na > K	1941	8.0 ± 3.5	−13.20	−3.32

The size and geologic complexity of West to Central Africa makes the study of geographic origin using $^{87}Sr/^{86}Sr$ signatures quite difficult. However, there is some data that can aid in providing general regional locations. In a 2009 study, Schroeder et al., conducted isotopic analysis on remains from Barbados that they note were “possibly African born,” most likely in

West to West Central Africa, as they were involved in the Atlantic Slave Trade (552). The $^{87}Sr/^{86}Sr$ values of these individuals suggested that while all of them were likely African born, they lived in different regions. Some individuals had high $^{87}Sr/^{86}Sr$ values of 0.71906 and 0.71866, suggesting that they originated from the Gold Coast, where cratonic rock formations hold similar values (554). This data also ruled out parts of Southern Nigeria, where values are thought to be lower due to differences in geology. Other individuals with intermediate values of 0.71290 and 0.71364, were compared to soil from Benin City in southern Nigeria that contained values of .71366. Schroeder does point out that it is almost certain that other areas in West Africa and even Central Africa are characterized by similar values, so pinpointing origin is not entirely possible. Interestingly, some individuals did contain $^{87}Sr/^{86}Sr$ values of 0.71046 and 0.71092, which is not consistent with West Africa's Precambrian geology, and "points toward younger and/or less radiogenic areas as potential regions of origin." (554). Once again, these areas do apply to parts of West Africa, notably the Niger Basin, and parts of the Senegambia. While the $^{87}Sr/^{86}Sr$ data is limited for Western and Central Africa, these baselines ultimately aid in determining whether individuals were born in the same region as well as if they migrated within their lifetime.

African Bioarchaeology

Bioarchaeologists working in West Africa have become increasingly interested in a number of phenomena such as mobility, diet, and environmental reconstruction (Sealy and Pfeiffer 2000; Holl 2020; Janzen et al. 2020) Evidence of these phenomena can appear in the pathology of the human skeleton, raising questions about the individual themselves, and the physical, social, and ecological environments that they once inhabited.

Evidence of mobility and diet in the human skeleton has long fascinated bioarchaeologists, especially when movement and diet can be traced over the course of a lifetime. A recent bioarchaeological study consisted of the evaluation of mobility strategies for maintaining herds during the Pastoral Neolithic era in southern Kenya (Janzen et al. 2020, 1). The movement of pastoralists and other groups of people provide evidence of not only the geographic locations traveled over the course of a lifetime, but also how social and environmental interactions appear in skeletal pathology.

Similarly, a study of the diet of the Holocene People of South Africa analyzed the reliance on seafood within the Southern Cape, and whether these diets changed over the course of a lifetime. Evidence of seafood, or lack thereof, also provides clues regarding settlement patterns within the region (Sealy and Pfieffer 2000, 644). These studies on diet and subsistence are useful because they tell us about human-animal interactions, and more broadly, provide insight into how people once engaged with their environments.

Another common area of research in African bioarchaeology is the reconstruction of paleoclimates. A 2020 study conducted on climate change and its effects on mid-Holocene Saharan pastoralists provides detailed information on how climate change affected individuals, both directly and indirectly (Holl 2020, 491). The drastic climb of aridity during the Holocene period caused major changes in fodder and water distribution, ultimately changing human behavior and overall health (Holl 2020, 492). These changes in health later become evident on the human skeleton, capturing interest among bioarchaeologists across the continent. Ultimately, studies of diet, mobility, and paleoclimate reconstruction have been the focus of bioarchaeology in Sub-Saharan Africa. However, systematic studies are lacking, as are studies that investigate individual life experiences.

This thesis will focus on the life experiences of individuals from ancestral communities in present-day Yoruba region of southwest Nigeria. We already know broader patterns and environmental phenomena of their lifetimes; however we do not know how such patterns affected their personal life experience. By focusing on their lived experiences, we will have a more nuanced understanding of who they were and how they were affected by their physical and social surroundings.

CHAPTER VI: METHODS

Only teeth were used for this study due to sample availability. Demographic age information for these individuals were analyzed prior to isotopic sampling through the analysis of tooth eruption and occlusal surface wear. Age estimation was also based on the approximate timing for dental and enamel root formation. The following chart (Table 2) details the approximate time of dental crown formation and dental root formation.

Table 2. Approximate Timing of Dental Root and Crown Formation. (Slovak and Paytan 2011)

Permanent tooth type	**Approximate timing of dental crown formation**	**Approximate timing of dental root formation**
First incisor	3 months to 5 years old	5-9½ years old
Second incisor	3 months to 5 years old	5-10½ years old
Canine	6 months to 4 years old	4-12 years old
First premolar	2–5 years old	5-12½ years old
Second premolar	3–6 years old	6-14 years old
First molar	0–2½ years old	2½-9 years old
Second molar	3½–6½ years old	6½-14½ years old
Third molar	9½–12 years old	12-20 years old

As an individual ages, dietary reconstructions are enhanced, and more attrition is associated with coarser foods. Often, this can be linked to a specific age group (Buikstra and Ubelaker 1994, 49). Evidence of dentin exposure, thin enamel, loss of crowns, among other indicators also provided evidence of the age at death of these individuals. Buikstra and Ublaker (1994) was used to identify these stages of wear. There are some possible challenges with dental age estimation concerning the physiological basis of age-related changes such as cement layering

(Hillson 1996, 292). However, this will not likely cause any issues in the interpretation of data as the study primarily focuses on the enamel on the crown of the teeth, not the cementum.

To prepare the remains, serial sampling techniques were used to collect samples needed for the analysis. These techniques consist of closely drilling in millimeter increments along the growth axis from the cemento-enamel junction (CEJ) to the crown of the tooth. The enamel collected from each line was then placed, stored, and tested for isotopic analysis separately. This technique is relatively cost-effective and provides insight on seasonal dietary differences and migratory patterns (Guiry et. al. 2016, 1). Three enamel samples were submitted for each individual: the first from just superior to the cemento-enamel junction (reflecting 9-10 years of life), the second from inferior to the enamel crown (10-12 years of life), and the third as a bulk sample of the remaining enamel (reflecting an average of early life experiences) (Moorrees et al. 1963, 1496). Samples from each individual are presented in Table 3. Only one bulk sample from individual BSM6/N12W5-IX was submitted due to limited availability.

Table 3. Dental Enamel Samples

Country	ID	Context	UF BCL No.	Taxon	mm from CEJ
Nigeria	H1-1	B-1-14/V	5912.1	Equus	8
Nigeria	H1-2	B-1-14/V	5912.2	Equus	12
Nigeria	H1-3	B-1-14/V	5912.3	Equus	15
Nigeria	H1-4	B-1-14/V	5912.4	Equus	19
Nigeria	H1-5	B-1-14/V	5912.5	Equus	21
Nigeria	H1-6	B-1-14/V	5912.6	Equus	24
Nigeria	H1-7	B-1-14/V	5912.7	Equus	27
Nigeria	H1-8	B-1-14/V	5912.8	Equus	33
Nigeria	H1-9	B-1-14/V	5912.9	Equus	36
Nigeria	H1-10	B-1-14/V	5912.1	Equus	42

Nigeria	E1-1	EDI b.E	5913.1	Homo	1
Nigeria	E1-2	EDI b.E	5913.2	Homo	3.5
Nigeria	E1-3	EDI b.E	5913.3	Homo	bulk
Nigeria	B2-1	BSM 6/N0	5914.1	Homo	1
Nigeria	B2-2	BSM 6/N0	5914.2	Homo	3.5
Nigeria	B2-3	BSM 6/N0	5914.3	Homo	bulk
Nigeria	B3-1	BSM6/ N2W5	5915.1	Homo	0
Nigeria	B3-2	BSM6/N2W5	5915.2	Homo	4
Nigeria	B3-3	BSM6/N2W5	5915.3	Homo	bulk
Nigeria	O4-1	ODG1 Str5	5916.1	Homo	0
Nigeria	O4-2	ODG1 Str5	5916.2	Homo	3
Nigeria	O4-3	ODG1 Str5	5916.3	Homo	bulk
Nigeria	B5-1	BSM6/N12W5-IX	5917	Homo	bulk

The samples were then sent to the Isotopic Geochemistry Labs in the Department of Anthropology at the University of Florida where they were chemically processed and analyzed using a mass spectrometer following standard methods.

After receiving isotopic data, $\delta^{18}O_{dw}$ VPBD values were converted to $\delta^{18}O_{dw}$ [V-SMOW] values to have a better understanding of meteoric and atmospheric composition. First the $\delta^{18}O_{dw}$ VPBD values were converted to $\delta^{18}O_{enamel\text{-}carb}$ [VSMOW] values using the equation $\delta^{18}O_{enamel\text{-}carb}$ [VSMOW] = (1.03091 x $\delta^{18}O_{dw}$ VPBD) + 30.91 which provides atmospheric values in dental enamel. Following this calculation, is the conversion of enamel VSMOW values to phosphate -SMOW values using the equation $\delta^{18}O_{phos}$ [V-SMOW] = ($\delta^{18}O$ enamel-carb [V-SMOW] x 0.98) − 8.5. Lastly, the equation ($\delta^{18}O_{phos}$ [VSMOW] x 1.54) − 33.72 is used to calculate $\delta^{18}O_{dw}$ [VSMOW] values which are used for overall analysis (Iacumin et al. 1996).

Bone and enamel samples prepared for carbonate were powdered with an agate mortar and pestle, and then soaked in a solution of 2% bleach (NaOCl) and ddH20 for 24 to 72 hours until the cessation of degassing (which indicates that the majority of organic material has been removed). After degassing, the samples were centrifuged, rinsed with ddH20, and submerged a 0.2% acetic acid solution at 4°C for 2-4 hours to ensure the removal of contaminants (Turner et al. 2018). Following this, the carbonate samples were centrifuged, rinsed with ddH20, and freeze dried. These samples were analyzed in a Finnigan-MAT 252 IRMS with a Keil III carbonate preparation device. The analytical precision for this IRMS was ±0.07‰ for $\delta^{18}O$ and ±0.02‰ for $\delta^{13}C$carbonate (Turner et al. 2018).

Powdered enamel samples for strontium analysis were transferred to acid-cleaned Teflon vials and dissolved in 8 M HNO3 (optima) on a 120°C hot plate. Strontium was separated by ion chromatography from single aliquots as described in Valentine et al. (2008). Sr isotope ratios were measured using a Nu-Plasma multiple-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) and are reported relative to long-term lab reproducibility of the NBS 987 standard 87Sr/86Sr= 0.71024 (2σ= 0.00003).

CHAPTER VII: RESULTS

Bioarchaeological and isotopic analysis of teeth excavated from EDI, ODG1, and BSM6 have revealed distinct differences in diet, mobility, and life experiences. These results are presented in Figures 2, 3, 4 and Table 4, and described individually below.

Table 4. Isotope Composition in Dental Enamel

Context	δ13Cap (‰ vs. VPDB)	δ18Oap (‰ vs. VPDB)	δ18Oenamel-carb [VSMOW]	δ18Ophosphate [V-SMOW]	δ18Odw [V-SMOW]	$^{87}Sr/^{86}Sr$
B-1-14/V	1.6	-1.6	29.27964536	20.19405245	-2.62115922	1+2 together:
B-1-14/V	2.3	-0.9	29.97867155	20.87909812	-1.566188895	0.714513
B-1-14/V	lost	lost	lost	lost	lost	3+4 together:
B-1-14/V	0.6	-0.9	30.00667408	20.9065406	-1.523927472	0.714428
B-1-14/V	0.5	-0.9	30.00563695	20.90552421	-1.52549271	5+6 together:
B-1-14/V	-0.1	-1.5	29.38958123	20.30178961	-2.455244006	0.714525
B-1-14/V	0.1	-1.5	29.41239811	20.32415015	-2.420808773	7+8 together:
B-1-14/V	0.3	-2	28.85234745	19.7753005	-3.266037223	0.714724
B-1-14/V	1.2	-1.5	29.39476689	20.30687155	-2.447417817	9+10 together:
B-1-14/V	1.8	-1.1	29.80028505	20.70427934	-1.835409809	0.714524
EDI b.E	-9.2	-1.9	28.92909514	19.85051323	-3.150209621	too small
EDI b.E	-8.7	-2	28.82953057	19.75293996	-3.300472456	too small

EDI b.E	-9	-1.8	29.02036265	19.9399554	-3.012468688	0.711573
BSM6/N0	-5.9	-3.1	27.73224614	18.67760122	-4.956494124	0.722902
BSM6/N0	-5.3	-3.6	27.14937861	18.10639103	-5.836157808	exhausted
BSM6/N0	-6.1	-3.2	27.65653559	18.60340488	-5.070756489	0.723797
BSM6/N2W5	-3.2	-0.6	30.2628454	21.15758849	-1.137313718	0.72662
BSM6/N2W5	-3.2	-1.5	29.37920992	20.29162572	-2.470896385	exhausted
BSM6/N2W5	-3.4	-0.9	30.01185974	20.91162254	-1.516101283	0.726473
ODG1 Str5	-11.3	-2.8	27.98115754	18.92153439	-4.580837035	0.716545
ODG1 Str5	-10.8	-2.8	27.99049172	18.93068189	-4.566749894	exhausted
ODG1 Str5	-12	-3	27.82455079	18.76805977	-4.817187954	0.71613
BSM6/N12W5-IX	-3.3	-2.4	28.39393562	19.32605691	-3.962	0.726618

BSM6/N2W5

This individual was represented by a single maxillary first molar crown. The crown exhibited little to no dental wear, suggesting a young age (under 20 years old) at the time of death. The roots, however, were broken, ultimately making age estimation unreliable. Isotope tests showed that BSM6/N2W5 had a $\delta^{13}C_{ca}$ bulk value of -3.4‰ with only two other values equaling -3.2‰, indicating an extremely prominent C_4 diet with very little change over time. BSM6/N2W5 has a slightly higher overall average $\delta^{18}O_{ca}$ value of +30.01‰ in comparison to

BSM6/N0 with a range of +29.38‰to +30.26‰ which results in higher $\delta^{18}O_{dw}$ values in comparison with individuals from the same site, with an average of -1.56‰ and a range of -3.27‰ to -1.1‰ possibly indicating movement in early childhood. Lastly, BSM6/N2W5 had an average $^{87}Sr/^{86}Sr$ value of +.726473 with only one other value equaling +.72662.

BSM6/NO

BSM6/NO included the dentition of an adult individual, as was evident through the molars that exhibit moderate to extreme dental wear (Scott 1979), which generally suggested an age greater than 35 years at the time of death (Brothwell 1963). The maxillary teeth present consisted of the left second and third molars, right first premolar, and right canine, while the mandibular teeth included the left first, second, and third molars, right canine, right first premolar, and the right first and second molars. There is notable angular wear on both canines, perhaps suggesting intentional modification. Samples selected for this individual were the maxillary left third molar and mandibular right third molar.

Individual BSM6/N0 has significantly more negative $\delta^{13}C_{ca}$ values than BSM6/N2W5 with a bulk value -6.1‰ with a range of -5.9‰ to -5.3‰ although the values still indicate a prominent C_4 diet. The oxygen calculations have revealed that BSM6/N0 has an average $\delta^{18}O_{ca}$ value of +27.65‰ with a range of +27.14‰ to +27.73‰ resulting in much lower average $\delta^{18}O_{dw}$ value of -5.07‰ with a range of -5.83‰ to -4.95‰ indicating little to no movement during childhood. The $^{87}Sr/^{86}Sr$ values for BSM6/NO remain close, with an average value of +.723797 and another value equaling +.722902.

BSM6/N12W5-IX

The sample used for BSM6/N12W5-IX included a fragment of the left mandible with the first and second molar roots in situ, and the crown of the mandibular left first molar, which was thus used for isotopic analysis. Significant wear of the crown suggests that this individual was at least 35 years of age at the time of death.

Due to limited sample availability, the calculations for BSM6/N12W5-IX only consist of bulk averages. BSM6/N12W5-IX only has a $\delta^{13}C_{ca}$ bulk average of -3.3‰ similar to BSM6/N2W5, also indicating a strongly reliant C_4 diet. BSM6/N12W5-IX also has an average $\delta^{18}O_{dw}$ of -3.89‰ comparable to streams in the regions. Finally, BSM6/N12W5-IX has a bulk $^{87}Sr/^{86}Sr$ value of +.726618.

EDI-E

Samples selected for this EDI-E were the maxillary right first and third molars. The burial also included all maxillary teeth except for a left lateral incisor, and all mandibular teeth except both lateral incisors and both left premolars. The presence of third molars as well as minimal dental wear across all teeth suggests this individual was between 20 and 25 years of age (Brothwell 1963; Ubelaker 1989). All third molars displayed a band of linear enamel hypoplasia around the base, suggesting a stress episode in late childhood. These teeth also displayed evidence of intentional modification. Both maxillary central incisors and mandibular central incisors were modified in Romero (1986) style C-5, with the lateral and medial edges sheared off at an angle. The maxillary right second incisor was also likely modified along the lateral edge in Romero (1986) style C-2.

It should be noted that EDI Human burial was also buried with arrow points, pottery, cowries, and iron slag. It is currently hypothesized that this individual was a blacksmith in the colony of Ede-Ile (Ogundiran 2012, 2022, personal communication). This also suggests that the individual was likely a male, as based on archaeological evidence and oral traditions, iron smithing and smelting were primarily done by men. In contrast to the individuals from BSM6, the individual from EDI presents significantly lower $\delta^{13}C_{ca}$ values with a bulk value of -9.0‰ with a range of -9.2‰ to -8.7‰ which indicates a moderate C_3 diet with little change over time. The $\delta^{18}O_{ca}$ values present in the individual from EDI consist of an average value of +29.05‰ with a small range of +28.85‰ to +28.95‰ which leads to $\delta^{18}O_{dw}$ values showing a bulk value of -2.97‰ with a range of -3.24‰ to -3.11‰. Lastly, EDI had an average $^{87}Sr/^{86}Sr$ value of +.711573.

ODG1-14

The samples from ODG1-14 included the fragmentary remains of a cranium and mandible, with two left premolars in situ. The sample taken for this individual was the mandibular left second premolar. Some cranial fragments included a left mastoid process of the temporal. The mastoid process was quite robust, also suggesting this individual was male (Buikstra and Ubelaker 1994). The premolars also had little wear, suggesting a relatively young adult (Brothwell 1963).

Isotopic analysis has revealed that ODG1-14 shows slightly more negative values of $\delta^{13}C_{ca}$ with a bulk value of -12‰ with a range of -11.3‰ to -10.8‰, indicating a C_3 diet. The bulk value, which represents overall value present in the tooth, does not fall within the range, likely a result of detecting seasonality in the incremental samples. ODG1-14 also has $\delta^{18}O_{ca}$ values very similar to EDI with an average value of +27.82‰, also with two other samples equaling +28.02‰, revealing that ODG1-14 had more negative $\delta^{18}O_{dw}$ values, with an average of

-4.83‰ and two equivalent values of -4.52‰, also indicating little change over time. ODG1-14 also has an average $^{87}Sr/^{86}Sr$ value of +.71613, with only one other value equaling +.716545.

B-1-14/V - Equus

These remains included the dentition of a horse from EDI. The sample used for B-1-14/V was a maxillary cheek tooth and ten samples were taken for isotopic analysis. One sample was lost in pretreatment.

Isotope tests showed that B-1-14/V had an average $\delta^{13}C_{ca}$ value of 0.9‰ with nine values ranging from -.1% to 2.3‰ indicating a concentration of C_4 grains and grasses with change over time. The ten $\delta^{18}O_{dw}$ values present a range from -3.26% to -1.52‰ with change over time. Lastly, B-1-14/V had five $^{87}Sr/^{86}Sr$ values ranging from +0.714428 to +0.714525, indicating a different place of origin than EDI-E.

CHAPTER VIII: DISCUSSION

Overall Trends

It is clear that each individual had a distinct diet, some consisting of refined C_4 values and others moderate to refined C_3 values. For the individuals excavated at BSM6 (Bara), their diet was significantly more concentrated in C_4 values than those from EDI (Ede-Ile) and ODG1 (Oduduwa Grove) (Figure 2).

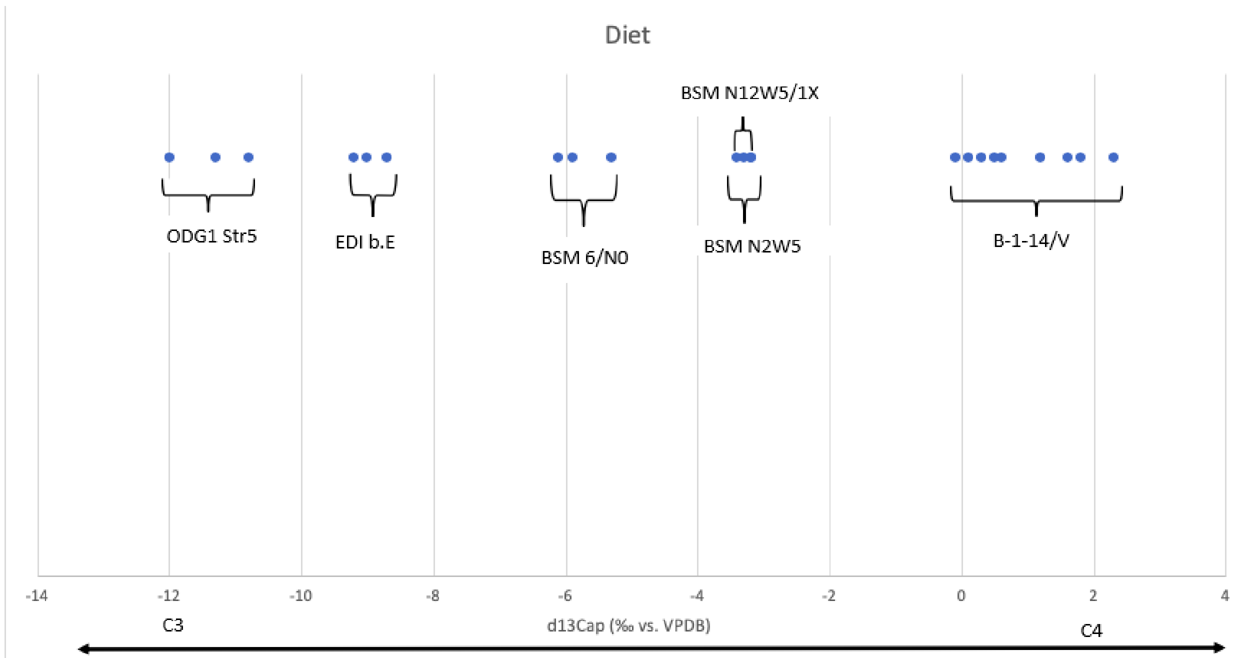

Figure 2. Carbon composition in dental enamel

This is likely due to a heavier reliance on local food sources, such as sorghum and millet which were dominant crops across the woodland savannas. Some African grazing bovids are known to have similarly high $\delta^{13}C_{ca}$ values, including *Syncerus caffer, Kobus ellipsiprymnus, and Damaliscus,* all of which are hypergrazers with diets of >95% C_4 grass. (Cerling et. al 2003, 464)

While it is unknown whether these animals were eaten, their concentrated C_4 diet is similar to those of the individuals from BSM6. The data here also indicates that these C_4 crops were in fact central to diets, probably in part due to their ability to survive the new drier climate regime, resulting in the very positive carbon signatures of these individuals.

The individual buried at EDI (Ede-Ile), however, has presented $\delta^{13}C_{ca}$ values that are consistent with a moderate C_3 diet. This could be a reflection of Ede-Ile's location along the rainforest, which would produce an abundance of C_3 plants (Ogundiran 2009, 353). This would have allowed more variety in C_3 plant availability or even meats of animals who had concentrated C_3 diets. Some animals with similar $\delta^{13}C_{ca}$ values to ED1-E and ODG-14 include *Taurotragus* oryx and *T. imberbis,* also known as hyperbrowsers or frugivores, with a diet of 18% C_4 grasses. Consumption of these bovids along with C_3 plants would ultimately be reflected in the dental enamel of all the individuals (Cerling et. al 2003, 464).

The horse from EDI had an extreme C_4 diet similar to those of the hypergrazing bovids with little change over time. This is likely due to grazing of C_4 grasses, likely including Andropogoneae, a tribe of C4 grasses that span across West Africa (Bocksberger et al. 2016, 308). Horses were also likely fed hay and stalks, especially that of maize, which would also present high C_4 values. Horses during this time were bred by elites of the Oyo Empire, and once they were aged or sick, they would often become an important source of meat, resulting in disarticulated remains (Ogundiran 2009, 371).

The individual from ODG1 (Oduduwa Grove in Ile-Ife) also had a refined C_3 diet. This was likely due to ODG1's location in a rainforest environment, which would have produced heavier root crops, rather than C_4 grains. However, the individual was also buried in a sacred grove dedicated to the veneration of the founder of the Ife dynasty (Oduduwa, 10th or 11th century) and where the kings of Ife were consecrated and buried. It thus seems likely that this individual's elevated status may have granted them greater access to a variety of different food resources.

Stable isotopes like oxygen and strontium are often used in tandem to trace movement and place of origin. All three individuals from BSM6 have high $\delta^{18}O_{dw}$ and $^{87}Sr/^{86}Sr$ values in comparison to the individuals from EDI and ODG1 (Figure 3). Due to limited Sr baseline data in West Africa and the complex geology of the region, these values present a number of possibilities in terms of movement and place of origin, making it difficult to pinpoint exact locations. Previous research on stable isotopes in West Africans suggest that such high $^{87}Sr/^{86}Sr$ values correlate with values associated with the coast. However, it is also possible that other areas in West Africa present similar $^{87}Sr/^{86}Sr$ values. Some of these areas include specific parts of Nigeria like Kano (north-central Nigeria), Abuja (central Nigeria), and Abeokuta (southwest Nigeria) (Pye 2004, 222). Limited published databases of $^{7}Sr/^{86}Sr$ values make it difficult to pinpoint the region of origin, especially in an area with complex geology. Though these areas present similar $^{87}Sr/^{86}Sr$ to those present in the BSM6 individuals, the $\delta^{18}O_{dw}$ values remain consistent with the Atlantic coast (Pye 2004, 222).

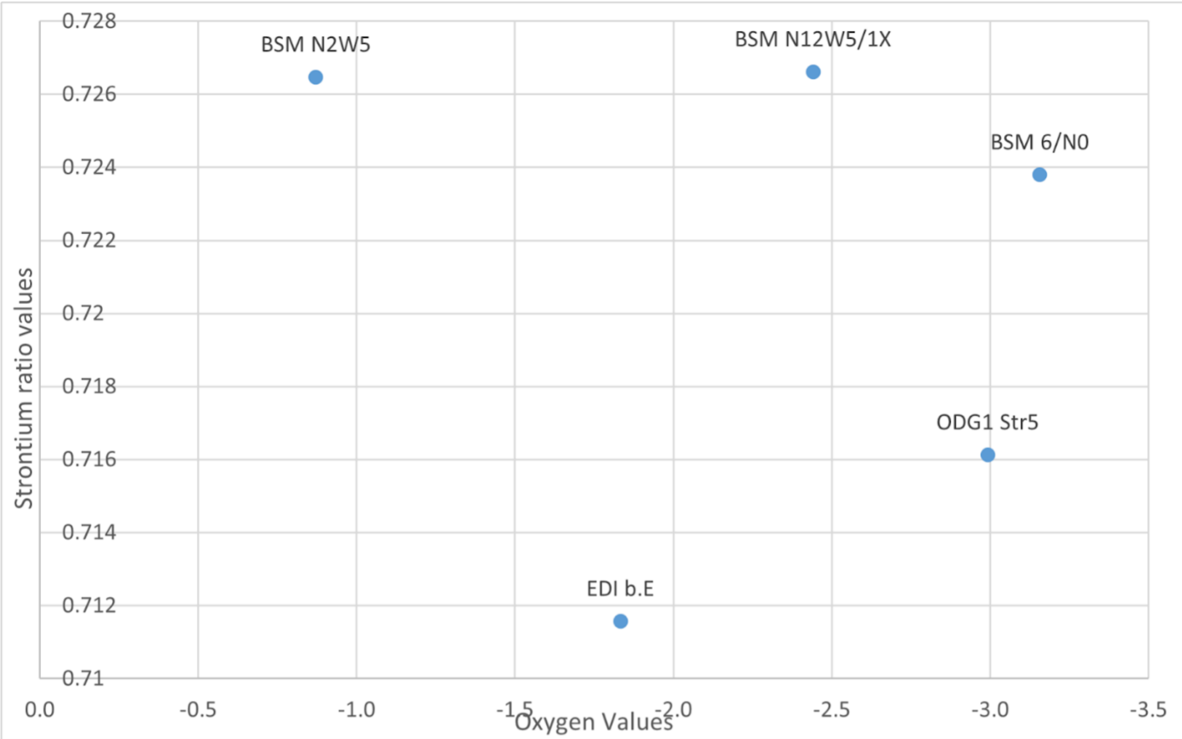

Figure 3. Oxygen and Strontium Values Present in Dental Enamel.

The $\delta^{18}O_{dw}$ values present in the BSM6 individuals also present several scenarios (Figure 4). First, they correlate with values closer to the Atlantic coast rather than local perennial streams in southwest Nigeria, which these individuals would have used for consumption and possibly irrigation. Alternatively, these $\delta^{18}O_{dw}$ values could have been affected by the Big Dry, where precipitation and overall water access was limited for most parts of the year. $\delta^{18}O_{dw}$ values can be affected by the amount of rainfall as rains less than 5 mm "have been shown to be heavier as a result of evaporation leading to loss of the lighter isotopes as rain droplets fall through drier air" (Goni 2001, 4332). If this is the case, the $^{87}Sr/^{86}Sr$ values do still suggest early life on the coast (Figure 4), but also suggest they could have lived closer to Ogbomosho (Pye 2004, 222). While their exact place of origin is still not known, it is likely that the BSM6 individuals did not spend early childhood in Bara.

Using the same baselines, the individuals from both EDI and ODG1 as well as the horse B-1-14/V, have $\delta^{18}O_{dw}$ values that align with southwest Nigerian streams, and are also consistent with $\delta^{18}O_{dw}$ values further inland from the coast (Loehnert 1988, 584). The $^{87}Sr/^{86}Sr$ values for ODG1-14 are also aligned closely with places like Benin City and Ibadan, making it likely that this individual was native to southwest Nigeria (Pye 2004, 222). B-1-14/V, however, was likely native to the dry savanna region, as horses did not thrive in the rainforest environments of Benin City and Ibadan.

The $^{87}Sr/^{86}Sr$ values for EDI, however, are very low. Current data (Pye 2004) shows that these $^{87}Sr/^{86}Sr$ values do not correlate with other values in Nigeria. The lack of correlation suggests that EDE-I is not local to Ede-Ile or Nigeria as a whole. Pinpointing the region of origin would require a broader $^{87}Sr/^{86}Sr$ database. However, this does not rule out that the individual was not from West Africa as their $\delta^{18}O_{dw}$ values align with areas like the Niger Basin, which could also produce similar $\delta^{18}O_{dw}$ values to the Nigerian streams (Schroeder 2009, 554). It is clear that the Oyo imperial and colonization project brought a diverse array of people from different backgrounds and geographies to Ede-Ile (Ogundiran 2012, 243).

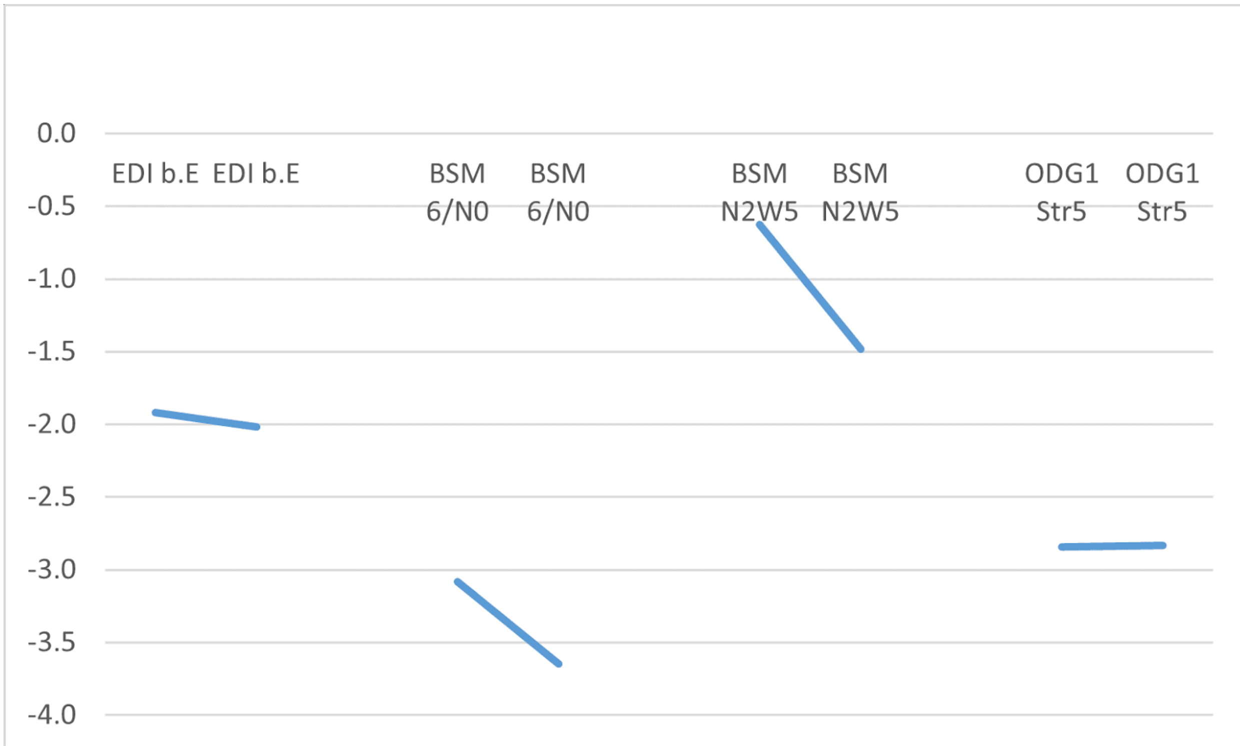

Figure 4. Oxygen values present in dental enamel samples from each individual, showing movement across the life course.

Individual Life Experiences and Osteobiographies

BSM6/N0

The life experience of BSM6/N0 was likely heavily influenced by their physical and social environment. BSM6/N0 lived well into their adulthood, likely living past 35 years of age. BSM6/N0 had a refined C_4 diet, likely relying on staple crops such as sorghum and pearl millet, which were actively being cultivated in the West African savanna during the 1st and 2nd millennium. Carbon values revealed that BSM6/N0 had a refined C4 diet in early childhood, with little C3 plant consumption. However, BSM6/N0 had a notable change in diet, with a reduction in C_3 values in late childhood (9-12 years of age), as evidenced by the rise in their $\delta^{13}C_{ca}$ values. If this pattern continued into adulthood, it is likely that BSM6/N0 consumed virtually no C_3 plants or meat. Interestingly, BSM6/N0 likely moved during their lifetime, though their place of origin is still unknown. Both $\delta^{18}O_{dw}$ values and $^{87}Sr/^{86}Sr$ values do not correlate with values found in Southwest Nigeria, and have changed over time. The change in all three values suggest movement in early life between the ages of 10-12, whether that was due to climatic or cultural migration.

BSM6/N2W5

It is not clear how far into adulthood BSM6/N2W5 lived, although they were likely a young adult at their time of death. Their overall concentrated diet similarly compares to the other individuals in Bara in that the diet was strict in C_4 values. It is difficult to pinpoint BSM6/N2W5's place of origin, as their $\delta^{18}O_{dw}$ values were very high and showed signs of change, suggesting that BSM6/N2W5 migrated during early childhood into adulthood. There is also the possibility that their life experience was altered by the Big Dry, which could also be reflected in their changing $\delta^{18}O_{dw}$ values. While data was limited for BSM6/N2W5, it is likely that their life experience was heavily impacted by their environmental surroundings.

BSM6/N12W5-IX

The individual BSM6/N12W5-IX 5 lived much later into adulthood, despite some hardships that they may have faced due to climatic uncertainty. BSM6/N12W5-IX's very concentrated C_4 diet suggests limited root crop availability, and more of grain foods, especially millet and sorghum, though it is not clear that this caused nutritional stress, or at least not enough to be evident in their remains. Only bulk samples were used to study BSM6/N12W5-IX limiting the ability to see change over time; however, strontium suggests a similar place of origin to the other individuals excavated from BSM6. There is a possibility that BSM6/N12W5-IX was not local, and moved in Bara like the other individuals excavated from this site. It is impossible to tell whether BSM6/N12W5-IX was a male or female, or their overall social identity, but it is evident that BSM6/N12W5-IX survived a period of harsh environmental phenomena and witnessed a revolution in iron technology.

EDI-E

From its founding in the seventeenth century and its occupation in the eighteenth century, the colony of Ede-Ile had a flourishing domestic economy. After taking control of trade in the Upper Osun, Ede-Ile became known for its local commodities and Atlantic imports. To keep up with the booming economy, the colony needed to become more specialized, likely bringing people from all over the region seeking work in their field. One prominent and important specialization consisted of metallurgy.

The life of EDI-E was shorter than most, and was likely one filled with stress and intensive labor. Buried with an iron slag, iron knife, and cowries, the EDI-E is suggested to be an ironsmith, and would have played an important role in Ede-Ile's thriving economy. An ironsmith in an extremely specialized colony would have required laborious work, which would later become evident on the body, and in this case the teeth. Based on the bulk $^{87}Sr/^{86}Sr$ value, early life (childhood) for EDI-E was likely outside of Ede-Ile, where he experienced an episode of stress. The hypoplasias (lines of enamel disruption associated with bodily stress) on his third molars suggest a period with lack of proper nutrition during middle childhood (12-16 years of age). Carbon analysis suggests that EDI-E's had a refined C_3 in early childhood, which likely carried on into adulthood, as local crops in Ede-Ile were primarily root crops like yams and rice. While little is known about EDI-E's origin and access to resources, there are many factors that could contribute to such stress, such economic hardship, social status/class, and even intensive labor. Due to limited $^{87}Sr/^{86}Sr$ values, it is not possible to determine when EDI-E moved to Ede-Ile, though it is possible that the stress episode and the demand for specialized work could have played a crucial role in the decision to move. The Oyo Empire's policies for state expansion could have also played a role in such migration, as they were moving populations from one ecological zone to another, and were often met with warfare in the process, indicating that the Oyo was violent when conquering the region.

Although his life was short, EDI-E was likely highly skilled, and adored within his community. The presence of the arrow points, cowries, and iron slag within his grave suggest such adoration for who he was as an ironsmith and possibly also a soldier or hunter, even though he died in his early 20's. His skills would have developed during his episode of stress. Such stress could have been caused by environmental factors such as a period of illness, famine, warfare and other forms of hostilities, or displacement, loss, and forced migration. The stress could have come from the pressure from the antics of the Oyo Empire. Such high demand for specialized goods and territorial expansion could have required more labor productivity and high workload and decline in health conditions. Interestingly, EDI-E also had evidence of culturally modified incisors, and while it is not known if these are connected to Yoruba culture or personal identity, their presence likely has a symbolic meaning.

ODG1-14

Since the late first millennium AD, the ìlú--a city-state, town, kingdom, or urban space--developed by the Yoruba was led by divine kings or immortal gods. Ile-Ife heavily took part in such political traditions, and established Oduduwa grove, which was a sacred grove for the consecration of such kings. A single burial found in the Oduduwa Grove in the city of Ile-Ife presented small skull fragments and teeth of a young adult male, ODG1-14.

The life of ODG1-14 was also short, though it does not appear to be particularly stressful or laborious. Moreover, it was highly likely that ODG1-14 was from the region in which he was buried, as both $^{87}Sr/^{86}Sr$ values and $\delta^{18}O_{dw}$ correspond with samples taken from the region. It is clear that ODG1-14 had a refined C_3 diet with very little change, which could have been due in part to social status, and local resources. With limited samples of human remains and no recorded grave goods, it is unclear if ODG1-14 Str was a king or a chieftain, possibly a past priest/priestess of the sacred grove.

CHAPTER IX: CONCLUSION

Current knowledge about the life experiences of Early Iron age and Atlantic period people in Yoruba culture area of southwest Nigeria is limited, primarily due to limited human remains, and archaeological trends that focus on broader patterns, rather than the individual. There is considerable archaeological and ecological data on Early Iron age and Atlantic period Nigeria, particularly regarding climate and even economic trends (Ogundiran 2012; Ogundiran 2020). These include events such as the Big Dry (third century BC to the fourth century AD) forcing movement of peoples in order to survive, or the thriving domestic economy of the Oyo Empire and its colony, Ede-Ile. However, less is known about how these trends affect individuals, as represented on the human skeleton. The excavations at BSM6, EDI, and ODG1, prove that the life experiences of these ancient and early modern period populations are inherently unique, each with a distinct diet, mobility pattern, and possible place of origin.

The study of human populations aids in a broader understanding of trends surrounding diet, migration, and power. However, individual stories often get lost in the trends which in turn become an artifact of statistics or ill-conceived generalization. In order to understand the diversity of the human experience, focusing on the individual is crucial. Narrative accounts of such individuals provide a lived experience, and a more nuanced understanding of how their physical and social environment affected their lives. Whether their life was affected by a harsh climate, empire formation, a specialized economy, or life in a sacred grove, each individual's life experience is valuable and should not be lost in a data set.

This study leaves several questions unanswered, as there is limited data for stable isotope baselines, and the current sample only includes fragmentary human remains. Limited $^{87}Sr/^{86}Sr$ data across West Africa makes it difficult to pinpoint the region of origin and movement through time, especially in a region with complex geological features. In order to better trace movement using $^{87}Sr/^{86}Sr$ values, such baselines need to be created from samples taken across West Africa and the broader African continent. As these baselines are created, future archaeological studies will be able to identify migration patterns on a larger, more accurate scale. Accounting for the fragmentary human remains may be more difficult as it is unlikely that preservation will improve with such lateritic soils in southwest Nigeria. However, when available, the study of isotopes present in bone collagen will provide even more information about diet and movement over a lifetime. Ultimately, as bioarchaeological investigations continue, and stable isotope baselines grow, studies like this one could provide a more depth, and personal look at the lives of West Africans.

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