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Paleopathology at the Shady Grove Site (22QU525): A Study of Health in the Upper Yazoo Basin During the Middle Mississippian Period

Christopher Brady Davis
University of Southern Mississippi

PALEOPATHOLOGY AT THE SHADY GROVE SITE (22QU525):

A STUDY OF HEALTH IN THE UPPER YAZOO BASIN

DURING THE MIDDLE MISSISSIPPIAN PERIOD

by

Christopher Brady Davis

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Approved:

____
Dr. Marie E. Danforth, Committee Chair
Professor, Anthropology and Sociology

____
Dr. Homer E. Jackson, Committee Member
Professor, Anthropology and Sociology

____
Dr. Jeffrey C. Kaufmann, Committee Member
Professor, Anthropology and Sociology

____
Dr. Karen S. Coats
Dean of the Graduate School

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ABSTRACT

PALEOPATHOLOGY AT THE SHADY GROVE SITE (22QU525):

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The Mississippian Period (AD 1000-1539) is characterized by increasingly sedentary populations, mound building, ranked societies, and intensified agriculture. As agriculture spread throughout the Eastern Woodlands, it led to widespread health consequences, including poor nutrition and increased levels of infection. Also, environmental shifts during the Mississippian Period (AD 1000-1539) caused drier conditions, potentially leading to crop failures further exacerbating nutritional problems.

This thesis focuses on the health of the Shady Grove site in the Upper Yazoo Basin, a Middle to Late Mississippian medium sized mound center where an ossuary containing up to 100 individuals was excavated in 2010. Focusing only on the adult portion of the ossuary population, health of the population was assessed using multiple childhood and nonspecific indicators of stress, including stature, linear enamel hypoplasias, anemia, and periosteal reactions. Levels of specific infection such as treponemal disease, tuberculosis, and osteomyelitis were also investigated. Analysis by bone element was conducted, and long bone minimum number of individuals ranged from 32 to 39, along with 52 isolated crania. Twenty-two reconstructed individuals using long bones were analyzed to provide data to assist making intrasite comparisons between males and females at Shady Grove, and intersite comparisons with other skeletal samples in the region.

Results suggest that Shady Grove was more nutritionally stressed than their counterparts. Mean stature was 159.2 cm for males and 149.04 cm for females, the shortest for both sexes among all the comparative groups. Linear enamel hypoplasia (LEH) were observed on 88% of left mandibular left canines, a rate which once again was very high among the populations in the region. Data regarding porotic hyperostosis (PH) and nonspecific infection was similar with Shady Grove showing the second highest frequency of each indicator relative to the comparative populations.

Reliance on maize agriculture cannot be the only contributing factor to the high rates of nutritional stress endured by the individuals at Shady Grove, but likely these findings reflect the interplay of multiple variables including subsistence strategies, political organization and climate change. The picture that emerges provides a nuanced interpretation of the effects of Mississipianization in the Upper Yazoo Valley.

DEDICATION

This work is dedicated to my wife, Cristina, and our children, Ethan Hammitt and Hannah Skye.

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I would like to thank my advisor, Dr. Marie Danforth, for all the time she has spent with me in the lab studying the Shady Grove skeletal collection or working on other projects. Also, for her support and assistance throughout this entire project, I am truly grateful. I am very thankful to have a mentor as dedicated to her students as she. In addition, I would like to express my gratitude to my committee member, Dr. Ed Jackson, for his guidance and leadership on projects relating to this thesis and others in the lab and field. I wish to thank my other committee member, Dr. Jeff Kaufmann, for taking time out of his busy schedule and the delightful conversations in his office while I was in Hattiesburg. I still write with my Wahl Eversharp every day. I would like to thank Susan Oubre, Tyler Cargill, Heather Guzik, and Katy Grant for their work on Shady Grove site and their companionship in the Physical Anthropology laboratory during the many hours spent there analyzing the material. I also am grateful to John Connaway for his incredible insights into archaeology in the Yazoo Basin.

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CHAPTER I

INTRODUCTION

The Lower Mississippi Valley, in particular the Mississippi Delta, also known as the Yazoo Basin, is home to one of the highest densities of human-made earthworks in the United States and is considered one of the most archaeologically rich areas in the nation. However, its level of comprehensive representation in the professional literature is lacking relative to other populated areas (Hogue, 2008), and regarding bioarchaeological literature, the discrepancy is even greater. This gap in information regarding one of the most highly populated areas in the prehistoric Southeast cannot be attributed to any single variable, but one major cause is that poor preservation in the well-drained soils of the Delta has limited the number of populations that have been recovered and are available for analysis. This lack of data restricts our fields understanding of both local and regional biological and social change through time.

One of the most important and influential changes in culture during the Mississippian period, and one that led to widespread health consequences, was the transition to intensive agriculture. During the Archaic and Woodland periods, populations across the Southeastern United States began practicing small scale horticulture, eventually domesticating local, wild plants such as sunflower, maygrass, goosefoot, and chenopodium (Bense, 1996; Steponaitis, 1986). Groups during this transition became more sedentary due to dwindling seasonal migratory spheres caused by population growth. There is a clear and dramatic change in settlement and organization in the Eastern Woodlands between AD 500 and 1000. The cycle of subsistence change and population growth, which in the interplay of food production and social organization is most important, continued into the Late Woodland as these populations, especially in the American Bottom region began practicing agriculture on a larger scale (Muller, 1997).

By this time, maize had made its entrance into the Eastern Woodlands, slowly starting off as only a minor addition to subsistence strategies; many groups were growing maize as a secondary staple years before “Mississippianization” (Muller, 1997). Social organization of hunters and gatherers and small scale horticulturalists was commonly based on achieved status in which leaders of a community were not likely always born into the position but rather earned their leadership through acts. However, once populations began creating a seasonal surplus of crops, another level of political organization became established. Elite headmen and their kin began to control other portions of the population’s production, both agricultural and artistic; this required tribute, causing a split in the socioeconomic fabric of society. Along with the change in political organization came other consequences associated with the transition to intensive agriculture. Populations were now tied to their fields, requiring a fully sedentary lifestyle. Food surpluses along with a fully sedentary lifestyle allowed for a dramatic increase in population. Negative side effects then became apparent, including resource depletion, malnutrition, and unsanitary living conditions that became breeding grounds for parasites and infectious diseases.

One of the few sites in the Delta that has yielded well-preserved human remains is Shady Grove, a Middle/Late Mississippian mound center located in Quitman County, Mississippi. Excavations there, in early 2010, recovered one of the largest ossuaries recorded in the Southeast, numbering up to 100 individuals, and its analysis is the basis of this research. In this thesis, specific questions regarding population demography and health in the Upper Yazoo Basin were addressed, facilitated by bioarchaeological investigation of the Shady Grove ossuary. Determination of the demographic profile seen at the site allowed the exploration of questions regarding age at death, sex distribution, mortality, and fertility (Larsen, 1997). General health in adults was assessed in the population using multiple nonspecific indicators of stress, including linear enamel hypoplasias (LEH), stature, anemia, periosteal reactions, and osteomyelitis; this allowed evaluation of the interplay of the effects of dietary stress, and population density. The synthesis of these data in a bioarchaeological analysis of the Shady Grove series contributes to creating a much more nuanced picture of lifeways during the Mississippian period in the Upper Yazoo basin.

Hypotheses Tested

The primary focus of this research was to place nutrition and disease patterns at Shady Grove in a diachronic regional framework allowing an understanding of both spatial and temporal context. Data from populations ranging from pre-agricultural late Middle Woodland through maize dependent protohistoric period were compared to those from Shady Grove to gain a better understanding of health status of inhabitants of the Upper Yazoo Basin during the Middle/Late Mississippian period.

Hypothesis One. Males have a weaker immune system while in the developmental stage (Buikstra & Cook, 1980). Therefore, it was expected that males from Shady Grove should have higher frequencies of childhood health disruptions, including LEH, anemia, and periosteal reactions, relative to those seen in females at the site.

Hypothesis Two. As maize agriculture was increasingly adopted through time, a decline in general population health occurred in many populations across the Eastern

Woodlands (Larsen, 1997). Therefore, it was expected that males and females from Shady Grove, being an agricultural site, should show decreased stature, and higher levels of LEH, anemia, and periosteal reactions, relative to those observed in the pre-agricultural populations of the region; however, the Shady Grove population would be anticipated to show lower frequencies of these indicators when compared to the Late Mississippian populations.

Contributions of the Research

This research is significant for several reasons. There is very little data published on the health of populations in the Upper Yazoo Basin (Delta), and what does exist is limited, mostly due to small population sample sizes. This research provides valuable information about the effects of the transition and intensification to agriculture in the northern Delta and the social and physical effects of Mississippianization at smaller mound centers in this region, especially in terms of understanding potential status differences between sites. The study also gives unique insight into the social and political interplay between social organization, status, production, and health of populations in the Upper Yazoo Basin through time.

CHAPTER II

PALEOPATHOLOGICAL INDICATORS AND THEIR RELATIONSHIP TO AGRICULTURE AND HEALTH

> One of the most fundamental developments in the history of our species—and one having among the most profound impacts on landscapes and the people occupying them was the domestication of plants and animals. (Larsen, 2006, p. 12)

The Role of Paleopathology

Simply stated, paleopathology is the study of disease manifestations in human remains in history and prehistory. The role of paleopathology has changed through time. Its initial focus was on the description of mummies and skeletal anomalies; however, as the ability of paleopathology to provide a greater understanding of human health and disease access time increased, more of its potential was realized (Buikstra & Cook, 1980). This led to more complex studies of population health and human disease coevolution, acknowledging the synergism between inadequate nutrition and unsanitary living conditions in causing poor health (Cohen, 1977; Cohen, 1984; Roberts & Manchester, 2005; Steckel & Rose, 2002). With these efforts, a better understanding of disease processes, and how populations and the environment interact, referred to as the biocultural approach, emerged (Aufderheide & Rodriguez-Martin, 1998; Ortner, 2003).

The study of archaeological remains has also given insight into how disease processes have affected human populations through time. Paleopathologists have developed a general interpretative understanding of how many of these diseases manifest in skeletal populations, and quite a few attempts have been made to better appreciate the relationship between humans and infection (Larsen, 1997; Ortner, 2003; Roberts &

Manchester, 2006; Waldron, 2009). Before the advent of agriculture, there was a harmony shared between humans and the environment, and this was destroyed once deforestation and the advent of intensive agriculture arose (Cohen, 1977). Sedentary life and population increases followed the intensification of agriculture, bringing with it less sanitary living conditions and a dramatic increase of infectious agents.

Infection stems from entry of a bacterial or viral agent into the body. Infection can affect a bone in five different ways: abnormal bone formation, abnormal bone destruction, abnormal bone density, abnormal bone size, and abnormal bone shape (Ortner, 2003, p. 45). The most common pathology in archaeological skeletal collections is abnormal bone formation and shape in the form of nonspecific skeletal infection (Aufderheide & Rodriguez-Martin, 1998; Ortner, 2003). Other indicators can also be used to estimate the general health of a population. These include indicators of childhood stress, such as stature, porotic hyperostosis, and linear enamel hypoplasias.

One role of paleopathological analysis is to reconstruct aspects of human health in the past, as the discipline is not experimental but reconstructive, and this has been done in a variety of contexts (Ortner, 2003). There is, however, one disclaimer when attempting to analyze indicators of stress and infection in a skeletal population. Only a small percentage of individuals who are afflicted with some type of infection or other physical stress will live long enough show skeletal evidence of it. In other words, the individuals in a population exhibiting skeletal lesions may have been healthier than many who became sick and died rather quickly, fighting the disease long enough for the skeletal manifestations of the disease to form. This could mean that the frequency of individuals infected in the sample is not truly representative of the actual population (Ortner, 2003;

Wood, Milner, Harpending, & Weiss, 1992). This is referred to as the osteological paradox, which has been challenged by anthropologists such as Alan Goodman and Mark Cohen who suggest that a sample should reflect a general health pattern, and under some circumstances high frequencies of stress or infection in bone does suggest a population in poor health (Wood et al., 1992). It is true, however, that many skeletal lesions are caused by chronic infections that individuals lived with for extended periods of time, thus causing the skeletal manifestation. Although we must acknowledge and accept the limitations involved when attempting to learn about a culture from a skeletal sample, advances have taken place in previous years. Wright and Yoder (2003) present a strong argument for this. The complexity of bioarchaeological research has increased, and the acknowledgement of multiple variables, including not only pathological data but information regarding diet, childhood stress, and indicators of adult health influencing morbidity and mortality, is important.

Indicators of Childhood Stress

The interaction of malnutrition and disease has been evaluated intensively, becoming a major facet in bioarchaeological studies. Before adolescence, the immune systems of children have not fully developed, making them more susceptible to dietary or environmental stressors (Stinson, 1985). There is a direct association between malnutrition and disease, meaning the lower the quality of nutrition obtained, the more susceptible to disease the an individual or population will be; furthermore, illness frequently limits the ability for the body to metabolize nutrients, creating a vicious cycle (Larsen, 1997). It must be taken into consideration, however, that additional variables affect growth and health from a young age, including but not limited to genetic, hormonal, and psychological factors (Larsen, 1997). The present study focuses on three indicators which provide clear evidence of childhood stress, namely stature, linear enamel hypoplasias (LEH), and porotic hyperostosis (PO).

Stature

Stature is a significant indicator of childhood stress considering that terminal height has generally been viewed as a product of disease load and diet throughout childhood. Reduced mean stature in a population has been used as a marker of high stress and poor health during developmental stages (Steckel & Rose, 2002). According to Kondo and Eto (1975), during the early years of childhood environment and nutrition have a significant effect on stature, while genetic factors often take a leading role during adolescence; however, during instances of severe malnutrition, genetic factors may lose sway.

Subsistence strategies can dictate the type of environment where a population lives, which can in turn affect their health and play a significant role in overall stature. Inadequate nutrition due to a lack of protein can greatly inhibit the body's ability to grow. Protein is an essential aspect of the human diet especially during development (Larsen, 1997; Steckel & Rose, 2002). Results from many studies all over the world, from the Neolithic in Europe to the beginnings of agriculture in the New World, show populations practicing non-agricultural hunter gatherer lifestyles on average were taller than groups practicing agriculture (Cohen, 1977; Cohen, 1984; Larsen, 1997). In *The Anthropology of St. Catherine's Island*, Larsen and Thomas (1982) note a steady decline in the overall stature of the coastal agriculturists in Georgia when compared to the foragers who preceded them. The authors documented a 3% decrease in both male and female height, attributing this loss to a decrease in nutritional quality and variability in subsistence practices (Larsen & Thomas, 1982). Kennedy (1984) also observed a decline in stature with the intensification of agriculture in South Asia as did Goodman, Lallo, Armelagos, and Rose's (1984) study of Dickson Mounds in the Illinois River Valley. In many, but not all, of these studies, the diet of agricultural populations was less varied than hunter gatherers and contained higher levels of carbohydrates and significantly less protein. Essential vitamins and minerals were also lacking. As has been noted, diet high in carbohydrates and low in protein, vitamins, and minerals will cause shorter stature than what is seen in groups who have better access to a variety of subsistence resources (Steckel & Rose, 2002).

Linear Enamel Hypoplasias

Tooth enamel is the strongest and most well preserved tissue in the human body, yet it is very sensitive to environmental and metabolic disturbances, specifically during development of deciduous teeth between the second fetal month and 12 months after birth and during the development of permanent anterior teeth from birth to seven years of age (Steckel & Rose, 2002). Depending on the type of tooth, formation begins at the termination of either the incisal or cuspal crown and continues evenly to the cementoenamel junction (CEJ) during normal growth circumstances (Larsen, 1997). Enamel formation, however, can be disrupted by acute episodes of stress during development. Handler and Corruccini (1986) define linear enamel hypoplasias (LEH) as "…a deficiency in enamel formation on the growing tooth, temporarily retarding its genetically determined growth potential" (p. 114).

Enamel disruptions are caused more so by acute episodes of stress during development (Larsen, 1997; Steckel & Rose, 2002). These lesions are commonly visible without the use of magnification and can take a variety of forms. Examples include small pits or furrows and, in more extreme cases, become deep grooves of very thin enamel or no enamel at all that run horizontally across the tooth. Enamel does not remodel, and thus the hypoplasia is permanent becoming a significant indicator of stress in an individual or population through time. Depending on the type of LEH defect, the probable cause of the stress can sometimes be evaluated, and etiologies commonly fall under three categories: hereditary anomaly, localized trauma, or systemic metabolic stress (Steckel & Rose, 2002).

The ability to determine age at formation is one of the most important aspects of LEH analysis. Age at formation measures systemic growth disruptions within individuals, and this process has allowed researchers to study the timing of possible episodes of stress relating to environment, status, and social change in individuals and within and between populations both synchronically and diachronically (Cucina & Iscan, 1997; Goodman, Armelagos & Rose, 1980; Larsen, 1997). Hypoplastic defects have been studied since the late 1800s. They were first applied to bioarchaeology in the 1960s by Swardstedt, a Swedish dentist who studied age at formation in a medieval population. However, it was the method of Goodman et al. (1980) with its .5 year age intervals that became the discipline scoring standard, and many variations and alternative techniques have been developed since (Goodman et al., 1980; Handler & Corruccini, 1986; Hillson, 2005).

A variety of metabolic stresses such as weaning, severe illness, and dietary deficiencies can cause the formation of linear enamel hypoplasias. Because of the stress associated with the transition from nutrient-rich breast milk to regular food, Handler and Corruccini (1986) were able to use age at formation of linear enamel hypoplasias to show that American slave children were weaned at an earlier age than Caribbean slave children. Cucina (2002) performed a diachronic study of linear enamel hypoplasias on foragers practicing horticulture-limited agriculture and others practicing intensive agriculture. He found a significant increase in the frequency of hypoplasias in the moderate and intensive agriculturalist populations. While his sample sizes were small, he suggested that there is a viable trend based off the large number of studies that have shown a similar increase of hypoplastic defects with a transition from a hunter gather subsistence strategy to one strictly dependent on agriculture.

In another investigation, Goodman et al. (1984) assessed the increase in enamel hypoplasia in relation to a change in subsistence in the Dickson Mounds population of the Illinois River Valley. They used only complete permanent dentitions and also observed a significant increase in enamel disruptions from the Late Woodland through the Late Mississippian. The percentage of individuals with one or more hypoplasias varied from 45% in the Late Woodland to 60% in the Mississippian acculturated Late Woodland and 80% in the Middle Mississippian period (Goodman et al., 1984). It is very likely that the transition from foraging to agriculture was not the only reason for the fluid increase in enamel hypoplasias in these populations, but rather the explanations included a combination of malnutrition and unsanitary living conditions, which allowed the spread of pathogens causing illness in a large percentage of the population.

Porotic Hyperostosis

Porotic hyperostosis, a term coined by Angel (1966), is one of the most commonly reported skeletal pathologies (Larsen, 1997; Stuart-Macadam, 1992; Walker, Bathurst, Richman, Gjerdrum, & Andrushko, 2009). Furthermore, researchers have documented this pathology in both prehistoric and historic populations, and most often have attributed the lesions to health and nutritional deficiencies. Porotic hyperostosis can be observed macrosocopially and is defined by Walker et al. (2009, p. 109) as circumscribed areas of pitting and porosity on the external surface of the cranial vault. Lesions are formed when red blood cell production is intensified to make up for the loss of iron in the blood stream. The diplöe expands, producing a "hair on end" look with the trabecular bone often projecting from the cranial vault or on the inferior orbital plate. When located on the cranial vault, the pathology is referred to as porotic hyperostosis, but when it manifests on the inferior aspect of the orbital plates, it is called cribra orbitalia.

Since the 1950s, porotic hyperostosis has been widely associated with iron deficiency anemia (El-Najjar, Andrews, Moore, & Bragg, 1982); iron is a critical element in hemoglobin that circulates oxygen throughout the body (Larsen, 1997). However, other competing theories exist, but all are still linked to unsanitary environments and dietary deficiencies causing physical stress. In one major proposition, Stuart-Macadam (1992) argues that porotic hyperostosis is an adaptive response to stress with lower levels of iron in the diet decreasing the risk of infection. Many microorganisms require iron to replicate; humans also need iron in their diet. However, absorption of iron, to a large degree, is relative to the need. For example, iron-deficient individuals will absorb up to 25% of the available mineral, while non-deficient individuals absorb only 3 to 5%. The same pattern exists for the metabolism of the mineral. Deficient adults will only lose 0.9mg, while non-deficient individuals lose up to 2mg (Stuart-Macadam, 1992). This indicates there is much variability in the body's need for iron. Stewart-Macadam suggests that an individual can reduce his or her iron absorption as an adaption to high disease load to lower the frequency of infection. If humans become iron deficient when affected, then these microorganisms cannot multiply within the body. Her idea stipulates that the body will stress itself to a degree to protect itself from more dangerous disease.

Walker et al. (2009) propose an alternative explanation. They state porotic hyperostosis cannot be caused by iron deficiency anemia. Iron is a key element in the replication of red blood cell and bone production, and iron deficiency inhibits marrow hypertrophy. If the body is iron deficient, the researchers questioned, how can it produce an osteoblastic effect. Instead, other anemias such as hemolytic and megaloblastic anemia, caused by a deficiency in vitamin B12 and B9 respectively, are suggested as the primary causes of over production causing the marrow causing the expansion of these types of lesions, as both have the potential to cause the marrow hypertrophy associated with porotic hyperostosis (Walker et al., 2009). They note the pathology is seen more often in children and relates to how the body stores the vitamin. Adults store reserves of B12 in the liver and can go years before showing the physical effects of the condition, while children do not store B12 to the same degree as adults, therefore showing symptoms frequently within a few months. Yet, another cause for a deficiency in iron and B12 is intestinal parasites which leach nutrients from the diet caused by unsanitary living conditions (Walker et al., 2009).

Porotic hyperostosis may thus have multiple etiologies sometimes working in synergy to produce skeletal manifestations. Meat is the primary source for both iron and B12. Both of these minerals lack the potential to lower the immune system making people more susceptible to infection and disease. However, iron is absorbed differently depending on if it comes from meat (hume) or plant (nonhume) resources. Iron from meat does not have to be processed in the stomach, and amino acids from meat actually enhance absorption, while digestion of iron from plant food is inhibited due to plant proteins and phytates (Larsen, 1997; Roberts & Manchester, 2005; Steckel & Rose, 2002). In other words, humans have the ability to ingest iron from both faunal (hume) and botanical (nonhume) resources, but the absorption rate varies depending on the source and processing methods.

In late prehistoric North America, the heavy reliance on maize agriculture and high population density in populations dating to post AD 1000 support the hypothesis that anemias and unsanitary living conditions were variables supporting a high frequency of porotic hyperostosis. Larsen and Sering's (2000) dichronic study of health in populations from the Georgia coast and northern Florida shows a dramatic increase in porotic hyperostosis from hunter gatherer populations to groups practicing intensive agriculture. The percentage of juveniles affected by porotic hyperostosis in early prehistoric populations from Georgia was 0%, but by early contact, populations had shifted to a heavy reliance on agriculture, and nearly 50% of the studied juvenile remains showed evidence of the condition. The authors argue that the switch in subsistence strategy from hunting and gathering to agriculture lowered the nutritional quality of the diet along with making it less variable, increasing the frequency of dietary stress and disease.

This pattern has also been seen in a number of other prehistoric populations. Rose and colleagues (1984) noted that maize agriculture intensification in the Lower Mississippi Valley and Caddoan region resulted in a significant increase in the presence of porotic hyperostosis and cribra orbitalia where populations were affected at a rate of 15.0% in contrast with the earlier foragers who were affected at a frequency of 1.0%. The authors suggest that the increased level is due to a decrease in the variability of subsistence resources and an intensive reliance on low iron maize cultivation (Rose, Burnett, Blaeuer, & Nassaney, 1984). Goodman and coauthors (1984) also found similar results at Dickson Mounds in Illinois. In their study, porotic hyperostosis was seen in 13.6% of the Middle Woodland, 32.2% of the Mississippian acculturated Late Woodland, and 51.5% of the Middle Mississippian. Most lesions in the Late Woodland occurred as cribra orbitalia and as time progressed with more reliance on maize, the lesions became more severe on the squamous portions of the cranium. This change in pathology frequency is attributed directly to the reliance on maize agriculture combined with poor sanitation in the highly sedentary population (Goodman et al., 1984). El-Najjar and Lozoff (1976) also performed a study on prehistoric Puebloan populations and found porotic hyperostosis in 34.3% of the population. The Chaco Canyon population he investigated had a surprising 71.8% occurrence of lesions associated with iron deficiency anemia. The researchers believe that the intensive maize cultivation along with processing techniques such as lime treatment severely affected the already low nutritional value of maize and are likely the primary cause of porotic hyperostosis.

Specific and Nonspecific Indicators of Stress

It has become standard in bioarchaeological studies to use infectious lesions in association with other indicators to evaluate general population stress. Unlike childhood indicators, they can provide a picture into health closer to the time of death as well as help interpret other questions of interest, such as social status. They can manifest in two forms, periostitis and osteomyelitis.

Periosteal reactions, which manifest in a unique pattern and/or appearance on the human skeleton, aid in the diagnosis of specific infectious diseases as these diseases have common manifestations, indicating a multitude of bacteria can be responsible for the formation of periosteal reactions (Ortner, 2003). The periosteal layer covering bone remains active even after bone growth is completed. Irritation of this layer stimulates reactive bone growth. Periosteal reactions, which most commonly take on a vascular woven appearance later, may be remodeled into lamellar bone, thus becoming part of the primary cortex. However, bone does not always remodel perfectly, and evidence of trauma or infection can be seen for a considerable time. It is very uncommon for the bone to regain its original contour without some indication of the episode (Ortner, 2003; Steinbock, 1976).

If a disease or trauma is sufficiently severe, the infection can enter the bone, causing an inflammation of the medullary cavity referred to as osteomyelitis. Some 90% of the time, osteomyelitis is caused by *Staphylococcus aureus*, while the other 10% of cases can be caused by a multitude of bacteria including streptococci, pneumococci, meningococci, and salmonella (Steinbock, 1976). There are two ways an infection can be introduced to bone. First, it can enter through the blood stream; second, it can enter through an abscess or compound fracture, which allows easy access directly into the bone. Periostitis and osteomyelitis can be associated with both specific and nonspecific diseases in which it takes on a primary or secondary role. Ortner (2003) states that “the designation of primary periostitis in paleopathological skeletons may mean only that more specific diagnosis is impossible and does not eliminate the possibility that the periosteal reaction is secondary to a specific disease process” (p. 208), such as the distribution of periosteal reactions associated with treponemal infection.

During the transition from hunting and gathering to agriculture, a significant increase in nonspecific infection is commonly seen. At Dickson Mounds in the Illinois River Valley, there was a dramatic increase between Early Mississippian and later prehistoric populations. Goodman et al. (1984) not only showed evidence for greater consumption of maize, but a decrease in the levels on animal protein in the diet. This led to a jump from 30% of the Early Mississippian displaying infectious lesions to well over 65% of the Late Mississippian sample being affected. Rose, Marks, and Tieszen (1991) studied levels of infection among populations in the central and Lower Mississippi River Valley. They were able to show dramatic increases in levels of infection from the Late Woodland thru the Late Mississippian period. Rose and colleagues stressed it was the adoption of intensive maize agriculture and the decreases in resource availability that accompanied it, which caused the increases in infection and population stress through time.

In summary, agriculture laid a base for specialization, surplus, stratification, and political boundaries allowing a more socially complex society to emerge; however, with these changes came consequences. Studying the effects of these consequences on past populations provides valuable knowledge regarding the cultural and social transformations along with a general understanding of human health and subsistence change. The use of childhood indicators of growth disruptions and nonspecific infection to estimate the general stress on a population allows us to infer not only the health of the specific population being studied, but also it provides a window into the possible social and cultural changes along with the stability of a region.

CHAPTER III

BIOARCHAEOLOGY IN THE YAZOO BASIN

The Yazoo Basin is a unique physiographic region and was one of the most populous areas in North America during the late prehistoric period. This chapter will introduce the Yazoo Basin along with a discussion of maize agriculture and previous bioarchaeological research within the region.

The Yazoo Basin

Located in northwest Mississippi, the Yazoo Basin sits within the east central portion of the Mississippi Alluvial Plain (McNutt, 1996). With a maximum width of 60 miles, the Yazoo Basin is bordered to the east by rolling uplands and to the west by the Mississippi River. It extends from Memphis, Tennessee, southward 200 miles tapering into the loess bluffs just south of Vicksburg, ultimately encompassing roughly 7600 square miles (Figure 1). Many bodies of water, such as the Yazoo River, Sunflower River, and Deer Creek, flow across the basin, mostly running north to south. The region is further divided into the upper and lower halves occurring at the prehistoric Winterville site (McNutt, 1996; Phillips, Ford, & Griffin, 1951).

The Upper Yazoo Basin, with an elevation drop of only 115 feet over 200 miles, is relatively flat, being shaped over the last 20,000 years by the east-west meandering of the Mississippi River (McNutt, 1996). The consequent soil deposits with the lateral movement combined with a warm climate are very conducive to agriculture. They provide a rich and varied ecosystem, with a long annual growing season of over 220 days allowing for multiple harvests (McNutt, 1996). In terms of natural resources, the Yazoo Basin has a multitude of flora and fauna, so much so that prehistoric inhabitants of the Lower Yazoo Basin relied very little on tropical cultigens until very late in prehistory.

One of the few natural resources available in limited quantities is high quality spalls of workable stone, which can only be found in gravel bars in the Mississippi River and its tributaries. In sum, the Yazoo Basin is an ecologically diverse and resource-rich area and is home to a wide variety of animal, plant, and other natural resources, making it capable of supporting a large prehistoric agricultural population (McNutt, 1996).

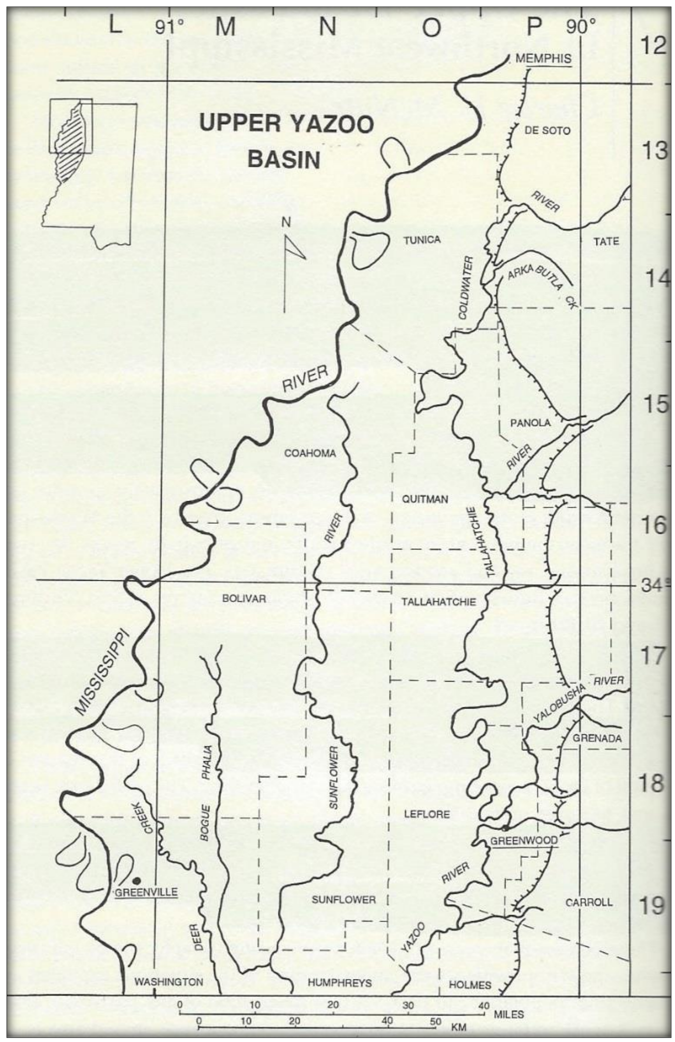

Figure 1. The Upper Yazoo Basin. Taken from McNutt (1996, p. 156).

Maize in the Yazoo Basin

In the Central and Lower Mississippi River valleys, maize has been present-since the Middle Woodland period. Kernel fragments have been found at some Baytown period sites alongside other native domesticates. Sites attributed to the Plaquemine culture in the Lower Mississippi River valley south of Winterville Mounds show less evidence of maize agriculture than do the more northern Middle Mississippian populations (Listi, 2007). There was very little use of tropical cultigens in the region, even into late prehistory. Listi (2007) suggests that late Coles Creek peoples from the Lake George site relied very little on maize and consumed high quantities of wild plants and native domesticates. The environment was so rich with diverse fauna and wild and native domesticated flora that there was no force driving a need for a change in subsistence strategies.

The earliest evidence for maize in the Upper Yazoo is from the McNight site in Coahoma County, where kernel fragments recovered are believed to date to AD 300-400 (Wallings & Chapman, 1999). Although evidence of maize consumption has been found at such an early date, it has been in very small quantities. Just the south, the Rock Levee site in Bolivar County provided indications of notable use of maize by AD 1000, but at significantly lower quantities than later prehistoric Middle Mississippian middens. Also, artifacts associated with agriculture, such as hoes, have been located at Winterville, Carson, and other sites in the Northern Yazoo Basin (Connaway, personal communication, May 24, 2012). An analysis of midden pits from Winterville mounds suggests that maize was an important staple by AD 1150 just as mound building increased, and by AD 1300 it was a major staple food (Flosenzier, 2010).

The issue of dietary change and the consequences of the transition to agriculture have included studies of Yazoo Basin populations. Danforth and colleagues in 2007 summarized bioarcheological data from the Mississippi Delta, central Tennessee, northern Alabama and the Tennessee-Tombigbee waterway. They argued that general health patterns are associated with the adoption of agriculture and conclude that health was not greatly affected during the transition in the Lower Mississippi Valley. This has also been supported by further analysis of Coles Creek dietary patterns conducted by Listi (2007, 2011).

Overall, there has been little research carried out on Upper Yazoo populations. Part of the problem is that there are very few skeletal samples recovered from this region; furthermore, much of what little research that has been done has not been published. Also, research has focused primarily on the Lower Yazoo where the Plaquemine culture was predominant, but some Upper Yazoo and Central Mississippi River Valley research has been done. Powell's 1983 analysis of Upper and Middle Nodena indicated large Late Mississippian village populations in the Arkansas Delta exhibited tall stature, but also high frequencies of nonspecific infection and developmental stress with the exception of a low occurrence of anemia (Powell, 1989). This was attributed to aggregated village populations and heavy reliance on maize agriculture. Robinson's (1976) thesis studying social status and pathology at Late Prehistoric Chucalissa showed similar results with lower stature than Upper Nodena, but also high frequencies of nonspecific infection, caries, and abscesses consistent with populations reliant on intensive maize agriculture. Listi (2007) analyzed Early Woodland, Late Woodland, and Coles Creek sites in the Lower Mississippi River Valley, including the Lower Yazoo Basin, ranging from 800 BC to AD 1200. Based on oral health, she concluded that Coles Creek populations in the Lower Mississippi Valley and Lower Yazoo Basin were not substantially different from pre-Coles Creek populations, suggesting that maize agriculture was not relied on as intensively as in more northern Upper Yazoo and Central Mississippi River Valley populations. Middle Mississippian groups were present in the Upper Yazoo and likely depended more on maize agriculture than their Plaquemine counterparts.

Bioarchaeology in the Yazoo Basin

Some of the first organized activities related with biological anthropology in the Yazoo Basin were associated with the U.S. Army Medical Museum's George Otis who in 1867 called for field surgeons to collect Indian crania "to aid in the progress of anthropological science by obtaining measurements of a large number of aboriginal races of North America" (Danforth, 2012, pp. 5-6). Ahead of his time, Otis even asked for relevant data associated with the remains, including context, age, and sex estimations. As a result of the announcement, Dr. Ebenezer Swift of Vicksburg began excavating skeletal remains from the Kings Crossing site (22WR584), at the time known as the Chickasaw Bayou. Swift sent 30 crania to Otis from Kings Crossing and possibly other basin sites along with notes containing some preliminary observations.

During the last third of the 19th century, the Bureau of American Ethnology (BAE) began to fund mound exploration with the purpose of identifying the original builders along with gaining an understanding of native burial practices. Cyrus Thomas and other early archaeologists with the BAE removed countless burials out of many mounds in the Yazoo Basin including Champlin (22YZ596) and Emerald Mound (22AD504), sending them for curation at the Smithsonian Institution. Also, during the late nineteenth century another BAE explorer, Col. W. P. Norris, conducted excavations at Dickerson Mounds (22CO502) in the Upper Yazoo, collecting remains from nearly 100 individuals (Danforth, 2012). Clarence B. Moore, the doctor-explorer from Philadelphia who spent his summers on his paddle boat, The Gopher, navigating river channels and excavating mound sites in search of museum quality antiquities, also made his way into the Delta. From 1908 to 1911, Moore dug at multiple sites in the region, including Winterville (22WS500), Lake George (22YZ577), and Stella Landing (22YZ510). During excavations at Stella Landing, he was surely looking for burials: "In quest of a cemetery, twenty-four trial holes were put down…." (Moore, 1908, p. 264). Many early excavators, especially Moore, included preliminary demographic information about the burials that were excavated; however, it is often rare for complete individuals to have been curated. Often only crania along with any interesting pathological elements were kept.

This was also seen with the more academic excavations of Harvard in the early twentieth century who sent the first academic professionals into the field, excavating mounds in northern Mississippi in search of De Soto's path through the Southeast. Charles Peabody, the nephew of the Charles Peabody who established the museum at Harvard which now bears his name, excavated at the Oliver Mound site during 1901-1902. There he located over 158 burials; however, only 45 were kept and sent to the University for curation. It was noted that only the unique skeletal elements were chosen for inclusion into the sample, such as well-preserved individuals with unusual trauma or pathological examples (Danforth, 2012).

During the 1920s, Moreau B. Chambers, the head archaeologist at the Mississippi Department of Archives and History, conducted surveys throughout Mississippi, including ones in the Big Black and southern Yazoo Rivers. Chambers, needing help with the surveys, hired a young James Ford to assist. As with the antiquity explorers of the late nineteenth century, Chambers and Ford provided only preliminary demographic information about the burials they encountered. All of the skeletal remains then recovered were believed to have been lost; however, a very small sample of the remains were located in curation at Louisiana State University and have since been analyzed by Dr. Marie Danforth and Lynn Funkhouser (Danforth, Jackson, & Funkhouser, 2011).

During the 1940s and into the 1950s, the Mississippi Delta saw a spike in archaeological work increasing the recovery of human skeletal remains. Major excavations were carried out at Jaketown (22HU505), Manny (22IS506), and Thornton (22IS507). In his 1940 publication, *Catalog of Human Crania in the USNM Collections: Indians of the Gulf States,* Aleš Hrdlička, using existing collections in the Smithsonian Institution obtained during the 1800s, reported crainometric data for more than 100 individuals from six sites in Mississippi. Hrdlička was primarily attempting to create a racial typology for Native Americans. During the 1950s, Harvard continued excavations in the Delta region at the Lake George site, which revealed over 125 mostly Coles Creek period burials. A preliminary analysis of the human remains was conducted by Egnatz in 1961 as an honors thesis, and was included as an appendix to the 1983 publication, *Excavations at the Lake George Site Yazoo County, Mississippi 1958-1960*. As was typical for the time, he produced a descriptive typological analysis, including long bone metrics that allowed the estimation of stature; he also performed ad hoc pathology assessments with little original interpretation. His descriptions and data are arguably deficient due to inconsistencies, but further analysis on health and diet at the site has since taken place (Danforth, 2012; Listi, 2007; Williams & Brain, 1983).

The most extensive work in the region has been done by Nancy Ross-Stallings. She produced the first bioarchaeological master's thesis based on skeletal material from Mississippi while a student at the University of Mississippi in 1977. Her project analyzed a sample of materials from the Humber site (22CO601), attempting to answer general questions about health using paleopathological data. Since her thesis, Dr. Ross-Stallings has continued to analyze skeletal remains from the Yazoo Basin. Beginning in 1988, she undertook an examination of the prehistoric skeletal collections curated by the Mississippi Department of Archives and History, paying special attention to sites located in the Upper Basin. Her studies encompassed over 200 skeletons from over 21 sites, including the largest skeletal sample from a single site in the state, the Austin village (22TU549) where 147 individuals were recovered (Hogue, 2008; Ross-Stallings, 1988, 1989a, 1989b, 1991). Ross-Stallings (2007) also undertook an analysis of decapitation, scalping, and cannibalism, and the taking of human trophies at sites such as Bonds (22TU530), Austin (22TU549), and Oliver (22CO503); in the associated report, she noted that she eventually intends to produce a bioarchaeological synthesis of the region incorporating questions about health, diet, status and warfare (Ross-Stallings, 2007, p. 365). However, the only publications from that work have been a few case studies highlighting infectious disease processes (Ross-Stallings, 1989,1997, 2007), as well as several short preliminary reports/ proposals and a number of conference presentations between 1992 and 2002; published data is almost non-existent. Even with the limited number of products, the extensive effort by Ross-Stallings to provide a voice to the prehistoric populations of the Mississippi Delta must be acknowledged.

Other than the work of Ross-Stallings, the focus of bioarchaeological studies has been in southern half of the delta and the Lower Mississippi River Valley. The first bioarchaeological dissertation on material in the state was finished by Ginesse Listi (2007) who performed a diachronic study of subsistence strategies in the Lower Mississippi Valley with a primary emphasis on pre Coles Creek and Coles Creek cultures in the Lower Yazoo Basin and the greater Lower Mississippi Valley. Listi looked at multiple sites from Louisiana, Mississippi, and Arkansas, assessing the dental health, including caries, antemortem tooth loss, and abscesses in association with the adoption of maize agriculture. Her primary research goal was to answer the question regarding the level of agriculture adopted by the Coles Creek culture in the Lower Yazoo. Her results supported earlier findings that suggested that Coles Creek cultures relied more on wild nuts, seeds, and game as primary modes of subsistence considering the lack of any significant difference between pre Coles Creek and Coles Creek groups. This accords well with the conclusions that the Lower Mississippi Valley is rich in natural resources and the need to adopt agriculture was not seen as important. Again, this work was focused on the Lower Yazoo not taking into account subsistence shifts in the Upper Yazoo which is more associated with the Middle Mississippian culture.

In summary, since the last third of the nineteenth century the Mississippi Delta has seen an array of explorers, collectors, academics, and contract firms all adding to the bioarchaeological knowledge of the region. Interest in the diet, health, biological distance, and mortuary patterns of populations in the Delta has grown in the last twenty years and continues to do so. The data void is being filled on a daily basis and it is important to continuously update projects such as Danforth's (2012) *Compilation of Bioarchaeological Studies of Prehistoric and Early Historic Sites from Mississippi,* which not only provides a historical review of bioarchaeological work conducted but details sites known to contain human skeletal remains, how many were present and what kind of studies have been undertaken. The results of studies must be made available before researchers can continue adding to the understanding of native peoples' lifeways in the Yazoo Basin and Mississippi as a whole throughout prehistory.

The Shady Grove Site (22QU525)

Shady Grove is a multicomponent Woodland to Mississippian period mound center located in Quitman County in the Upper Yazoo Basin (Figure 2). Originally believed to have had as many as eight mounds on the site, today only one mound remains (Brain, 1967). Philips, Ford, and Griffin (2003) at the time of their survey in 1941 documented two mounds: one large platform mound and one smaller conical mound oriented to the northeast; also located at the site was a large late Woodland shell ring. Phillip's ceramic analysis suggested the sites major occupation extended from the Middle Woodland Marksville period through the Middle Mississippian period. Jeffery Brain visited the site in 1968. Brain surface collected three areas and documented a third mound, a second conical Woodland period mound adjacent to the large Mississippian period platform mound (Steponaitis et al., 2002).

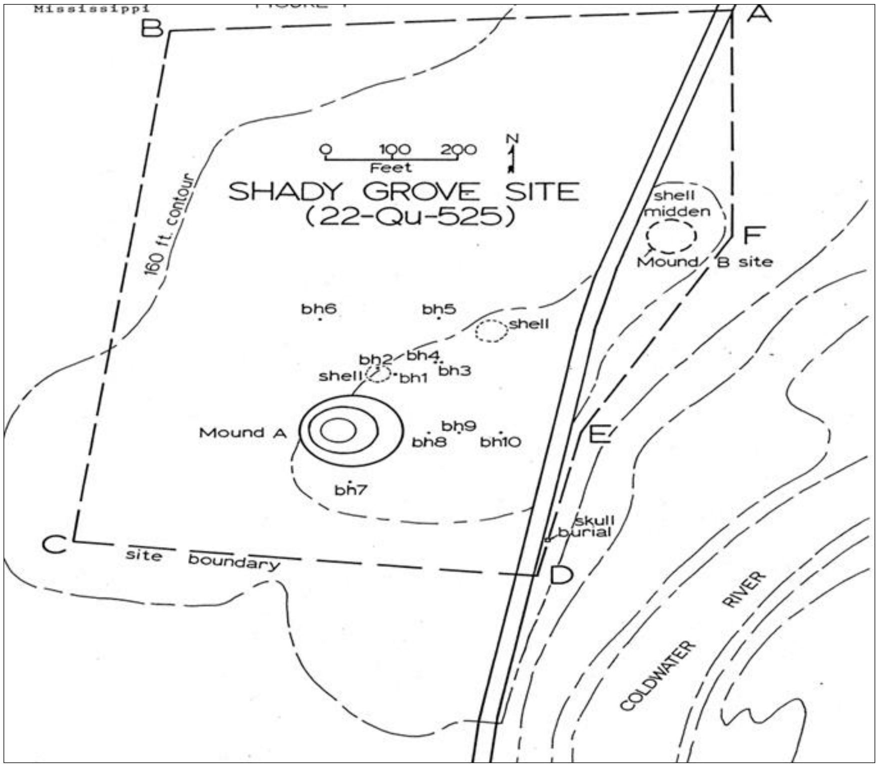

Figure 2. Plan view of the Shady Grove Site in 1983. Taken from Connaway (1983).

Following Brain's surface collection, the first archaeological excavation at Shady Grove took place in 1975 when the Mississippi Department of Archives and History (MDAH) received a call from a concerned resident about the impending destruction of the smaller conical mound described by Phillips, Ford, and Griffin. Archaeologists John Connaway and Sam Brookes received permission to conduct salvage excavations for two days. They opened three units, one 5ftx5ft, one 2ftx2ft and a final 6ftx6ft unit. All of their excavations around the bulldozed mound entered a two foot thick predominantly Middle to Late Woodland shell midden containing fresh water mussel shells and faunal remains as well as Mulberry Creek Cordmarked, Baytown Plain, an Mississippi Plain pottery. Along the roadside, other artifacts were collected suggestive of Mississippian period occupation including effigy bowls and a plain vessel. Their investigations indicated possible occupations of the site spanning from the Late Archaic through Late

Mississippian period. As they excavated the 6ft by 6ft unit, they came across a Mississippian ossuary that intruded into the Woodland shell midden and contained up to 25 individuals (Scott, 2009). According to Connaway, the burials seemed haphazardly tossed into the pit with no apparent orientation. Human remains were continuous into both the eastern and western wall, but before they were able to discover the extent of the ossuary, time had expired and they had to abandon the remaining skeletal remains (Connaway, 1981, 1983). Only parts of this ossuary have been available for analysis, which was conducted by Scott and several colleagues (Scott, 2009).

During the winter of 2009-2010, Stacy Scott, then a graduate student at The University of Southern Mississippi, along with Mississippi Department of Archives and History archaeologist John Connaway, returned to Shady Grove in search of the rest of the 1975 ossuary before it was destroyed by impending cultivation. After searching extensively for the original ossuary, a collector suggested they move eastward where remains had been found on the surface in the past. After removing the vegetation and shovel skimming the area, they noticed a circular stain of organic material. Here they located a second ossuary dating to the middle/late Mississippian period, containing up to 100 individuals (Scott, 2009). As with the one discovered in 1975, this ossuary is also believed to be a single interment event of loose bundles that were previously stored in a charnel house for an extended period of time before being placed as secondary bundle burials within the Late Woodland shell ring (Connaway, 1981). This and other associated archaeological data mentioned below suggest that the charnel house was in use for an extended period.

The context of the ossuary makes this research important. The ossuary is directly intrusive into the eastern perimeter of the previously mentioned shell ring. It is well-known that shell middens often provide excellent preservation of faunal remains and other organic artifacts due to the calcium carbonate from the shell (Classen, 1998). Thus, it offered much opportunity for analysis. Shady Grove is not a large mound center, and it is very possible there was a single charnel house in use for an extended period of time during the Mississippian period (Connaway, personal communication May 24, 2012). This study of stress inflicted upon the Shady Grove population continues adding to the growing body of bioarchaeological knowledge of the Upper Yazoo River Valley. Hopefully, in the future, other late prehistoric populations from this region will be similarly investigated, bringing together a larger body of knowledge synthesizing the general health patterns of an entire region we know little about.

CHAPTER IV

METHODS AND MATERIALS

This chapter will discuss the methods used in the data collection as well as individual and diachronic comparative analysis of the Shady Grove population. It will also present a description of those populations used to provide a comparative context for findings.

Demographic Analysis

Studying a comingled ossuary has its challenges, such as developing a confident MNI and properly aging and sexing isolated remains. To simplify this study, the analysis only involved adults within the Shady Grove population. The methodological decision to exclude juveniles was based on the fact that the study would have required a separate interpretative framework beyond the scope of the research question. Nevertheless, an analysis of the stress upon this adult population allowed investigation of health patterns by age and sex providing comparative data for other populations in Yazoo Basin.

The level of comingling in the Shady Grove ossuary was quite high, although several relatively complete bundle burials were present. In order to carry out the present analysis, adults first had to be separated from the rest of the collection. Some skeletal reconstruction and long bone refitting was completed when possible. Isolated long bones were measured, observed for epiphyseal closure, entheseal marker size as well as overall bone size to determine whether bones were adult or juvenile. Those long bones deemed adult were separated by element and then were labeled and placed in numerical order on tables in the laboratory. Bone provenience, size, length, color, pathology, and post mortem fractures were used to refit and pair long bones allowing the reconstruction of 22 partial individuals. Long bone length, overall size, and entheseal marker size along with humeral and femoral head diameter were used to sex isolated long bones. Age and sex estimation of complete individuals and isolated crania was conducted according to *Standards for Data Collection of Human Skeletal Remains* (Buikstra & Ubelaker, 1994). After age and sex estimations were made, demographic distributions by complete individual, isolated crania, and isolated long bones were compiled as indicated. The results were used to provide a means to determine whether the Shady Grove population is a representative sample, and to evaluate possible nutrition and disease patterns within the population, especially in comparison to findings seen at other sites.

Pathological Analysis

The methods used to evaluate the four health markers used in this study, namely stature, linear enamel hypoplasias, porotic hyperostosis/cribra orbitalia, and infection, are discussed in this section.

Stature

The first paleopathological indicator analyzed was stature. The left femur was used if possible when handling complete individuals; if the left was present, but not well preserved the right was used. For isolated remains the left femur was used to estimate stature considering it gave the largest sample (Scott, 2009). The maximum length of the femur was taken, and stature was estimated using the Sciulli and Geisen's (1993) formulae. Following individual stature estimation inter- and intrasite comparisons by sex were made.

Linear Enamel Hypoplasias

Linear enamel hypoplasias (LEHs) were the second paleopathological health indicator used. The maxillary right canines and the mandibular left canines were included in the study considering LEH formation favors the anterior dentition (Condon & Rose, 1992). Teeth were examined under 10x magnification using ambient light to determine episode presence. LEH severity data was assessed using a three point scale taken from Corruccini, Handler, and Jacobi (1985). A score of 1 indicated a thin or faint enamel disruption, which the fingernail tip should be able to feel the presence of but not fit within its boundaries. It must be taken into consideration that a LEH with the score of 1 may not have a clear visual boundary. A score of 2 was considered a moderate lesion that could be clearly seen and felt; the observer should be able to catch the tip of the finger nail within the boundary of the defect. A score of 3 was considered to be severe. It indicated the LEH was large enough to wiggle the finger nail tip inside the defect. Determination of LEH age at formation followed Rose et al. (1985) and Goodman et al. (1980). It was established by measuring the distance from the middle of the LEH to the cementoenamel junction and comparing the value with growth tables for dentition. Data for LEH count, severity, and age at formation was calculated for each tooth type.

Porotic Hyperostosis

Porotic hyperostosis (PH) and cribra orbalitia (CO) was the third indicator examined. PH and CO were observed under normal light conditions and no magnification using a system similar to that given in Buikstra and Ubelaker (1994, pp. 120-21). The frontal and both the left and right parietal bones of the Shady Gove sample were evaluated for porotic hyperostosis, while the orbits were observed for cribra orbitalia. Percentage of bone present was scored on a four point scale: 1 is 75-100%, 2 is 50-75%, 3 is 25-50%, and 4 is 0-25% complete. Fragment size was noted according to a four point scale: 1 is small, 2 is medium, 3 is large, and 4 is mixed. The percentage of each bone affected by one of the conditions was recorded. Porosity type was evaluated on a three point scale. A score of 1 indicated indistinct porosity, 2 showed true porosity, and a score of 3 indicated coalesced (large) porosity. If expansion of the diploe was observed it was noted as present. Comparisons of the frequency and severity of PH and CO were also made between males and females at Shady Grove. Then the data were considered against data for the males and females from the comparative samples.

Infection

The final pathologies evaluated were periosteal lesions and osteomyelitis. Each long bone (humerus, radius, ulna, femur, tibia, fibula) was observed under normal artificial light and 10x magnification. The bone was divided into five sections: proximal epiphysis, proximal third, medial third, distal third, and the distal epiphysis, as outlined by Buikstra and Ubelaker (1994). Each section was scored for completeness. A 1 was <75% complete, 2 50-75%, 3 25-50% complete, 4 >25% complete, and 5 meant not present. After bone completeness was analyzed, a detailed description noting location, size, and type of any lesion present was recorded. The lesion was identified as either periosteal lesions or osteomyelitis based on presence of cloacae and penetration of the lesion into the medullary cavity. When osteomyelitis was identified, the severity and number of cloacae were recorded. Finally, the lesions were assessed as to whether it was active, remodeled, or both at the time of death. Depending on which side of each long bone rendered a higher number of elements present it was used in comparisons. The frequency of infection by age and sex from the Shady Grove was also assessed and those patterns were compared among sites.

If frequency and distribution of lesions on any individual began to follow a pattern, differential diagnosis was used to determine the possible etiology. A visual full skeleton form provided in *Standard for the Recording of Human Skeletal Remains* was used to show lesion distribution to aid specific disease diagnosis. If specific infectious diseases were encountered they were evaluated. The number of cases by sex and sample were compared to typical expressions of the disease outlined in the bioarchaeological and clinical literature and a differential diagnosis took place. Specific infectious diseases were expected to have been observed, they include tuberculosis and treponemal disease.

Comparative Samples

To test these hypotheses patterns of stress, the findings of the Shady Grove population will be compared to multiple collections from the Upper Yazoo Basin, as well as populations near the region, spanning from the Coles Creek Period, or Terminal Woodland, through the Protohistoric (AD 1539 to 1685).

Lake George (22YZ557)

Lake George (22YZ557) is a multicomponent (Middle Woodland-Late Mississippian) Mississippian mound center located along the south shore of Lake George in Yazoo County, Mississippi. It was excavated from 1957 to 1968 by Stephen Williams and Jeffery Brain of Harvard as part of the Lower Yazoo Basin Survey. Twenty-five mounds and an earthen embankment are originally believed to be associated with the site. Williams and Brain recovered over 120 burials from the Coles Creek period from Mound C. Listi (2007, 2011) details that only 41 remains enjoyed sufficiently good preservation for their inclusion in her osteological study. Results from her dissertation analysis (Listi, 2007, 2011) were used.

Austin (22TU549)

Austin (22TU549) is a late Terminal Woodland/ Early Mississippian village site located on natural levee on a cutoff of an old Mississippi River channel in Tunica County, Mississippi. In 1988 a plantation owner was leveling land for a rice field and encountered human remains. Mississippi Department of Archives and History archaeologist John Connaway began excavations during the summer of the same year. Three years later 46 wall trench structures, 3000 features, and 164 burials had been excavated. Many of the burials, especially the juveniles, were removed in blocks, and have yet to be excavated. Some have been initially analyzed by Nancy Ross-Stallings, and the summarized findings were given in Ross-Stallings (1990, 1991).

Humber (22CO601)

Located 22 miles west by southwest from Shady Grove in Coahoma County, this site rests on a natural levee along an extant portion of the Mississippi river (Scott, 2011). Humber is a Late Mississippian village site and burial ground known for its extensive ceramic collection, and copper ornaments (Connaway, 1984). Excavated by Louis Tesar in 1974, 40 individuals were analyzed by Nancy Ross-Stallings for her master's thesis. It is thought to represent a high status skeletal assemblage.

Chucalissa (40SY1)

Located on the Chickasaw Bluffs overlooking the Mississippi River, Chucalissa (40SY1) is a large Mississippian mound center with occupations spanning the entire period; the most dense being Late Mississippian Walls Phase (AD 1400-1500). Following early testing by the University of Tennessee and the Memphis Archaeological and Geological Society (Smith, McNutt, & Barnes, 1993), the largest excavations were conducted by Charles Nash and Gerald Smith of Memphis State University in 1955. Eighty-seven burials have been recovered during the archaeological investigations and were analyzed by Robinson (1976) for his master's thesis.

Upper and Middle Nodena

The Late Mississippian site of Upper Nodena was comprised of 15 acres inside a palisade located eight miles northeast of Wilson, AR. A second population, initially called Middle Nodena, was located 1.3 miles away, but both populations are considered to be from one extended habitation area. Powell (1989) analyzed the Upper and Middle Nodena skeletal material, representing 228 individuals from both sites.

Summary

While only the adult population of the Shady Grove ossuary was used, studying a comingled population still had its challenges. This chapter discussed the methodology used in the data collection as well as individual and diachronic comparative analysis of the Shady Grove ossuary. While little data is available for the Upper Yazoo Basin, this analysis of the stress upon this adult population allowed for future study of reliable heath patterns by age and sex providing comparative data for other populations in Yazoo Basin.

CHAPTER V

RESULTS

This chapter presents the results of the demographic and health pattern analysis of the adult population of Shady Grove ossuary. Findings are presented in two sections: intra-site and inter-site comparisons.

Minimum Number of Adult Individuals

Counts of crania and long bones such as the femora, tibiae, humeri, and ulnae were used to calculate the minimum number of individuals (MNI). While few bones were entirely complete, the radii and fibulae were not included toward determination of MNI due to their extremely fragmented condition. Traditionally, the left side is used in osteological studies; however, in the present study whichever side yielded the higher MNI count for a particular element was used. With these criteria, estimates for the individual long bones ranged from 26 to 39 individuals (Table 1). In contrast, the total MNI of crania was 52: 35 isolated crania and 17 associated with complete individuals. Therefore, the final adult MNI of the Shady Grove ossuary was 52, relying on the consolidated crania count.

Scott (2011) previously conducted a demographic analysis of the entire Shady Grove ossuary, including juveniles and recorded slightly different results (Table 1). Based on her initial adult cranial inventory, 48 individuals were present as compared to 52 in this study. Her MNI study of long bones concluded 41 individuals were present. The left humerus in the present study gave the highest MNI at 39, whereas Scott found 33. While Scott recorded 41 middle-third diaphyseal fragments of the right femora, this study recorded 38. The current study recorded 37 right tibiae, while Scott recorded 28.

This study also incorporated ulnae MNI of 32, while Scott did not include this long bone in her study.

Table 1

Isolated Crania and Long Bone Minimum Number of Individuals

Bone	Side	MNI This Study	MNI Scott (2011)
Cranium	N/A	52	48
Femur	R	38	41
Tibia	R	37	28
Humerus	L	39	34
Ulna	R	32	N/A

Note. MNI= Minimum number of individuals. Shady Grove 2011 data taken from Scott (2011).

Although the differences are small, they represent different approaches to determining MNI. A more liberal approach was taken in this study, and the totals are much more consistent across elements. There were many small, damaged medial fragments of long bones that could be confidently identified as to which element they belonged, but were unable to be assigned a side, and thus were not used. There is a small possibility this inconsistency could be due to taphonomic processes, as proximal and distal ends of long bones are more susceptible to degradation.

Age and Sex Estimation

Twenty-two adult individuals from the Shady Grove population were reconstructed using methods such as taphonomic, entheseal, and pathological similarities (Table 2). Metric analysis and refitting were also used. Each individual minimally consisted of two associated long bones. Among these individuals, the number assigned to each sex is balanced, 10 males and 10 females; only two of the complete individuals were unable to be sexed. Equal numbers of both males and females possibly suggest a representative sample. The age distribution is also quite similar with half the population of both males and females consisting of middle aged adults; however, females are slightly more represented among younger adults.

Table 2

Shady Grove Age Distribution: Reconstructed Individuals

	Young Adult	Middle Adult	Older Adult	Indeterminate Adult	Total
Male	2	5	2	1	10
Female	4	5	1	0	10
Indeterminate	1	1	0	0	2
Total	7	11	3	1	22

Among the isolated crania, determination of sex could be made for 31 individuals. However, both age and sex had to be estimated for a cranium for it to be included in the study and only 19 qualified. Relatively few females (5/19) were present while males dominated in this category (14/19); however, age was very difficult to assess due to the fragmentary nature of the remains. Of the 19 crania included, middle-aged adults comprised the largest category with 12 individuals. Older adults included four crania and younger adults included three. The female age distribution showed one young adult, two middle adults, and two older adults, while the male age distribution for crania showed two young adults, ten middle adults, and two older adults. Age could not be estimated for five males and seven females. Sex could not be estimated for one young adult and one middle adult, while age nor sex could be estimated for three isolated crania (Table 3).

Considering not all reconstructed individuals contained a cranium, the two data sets could not be combined. The results for isolated crania age and sex distributions are similar to the reconstructed individuals with the exception of middle adults. Middle aged adult males dominated this category, characterizing the most individuals in both age and sex distribution samples, followed by young adults; this is possibly due to the fact that in skeletal populations, younger and middle aged adults will outnumber older adults due to better preservation (Walker, Johnson, & Lambert, 1988).

Table 3

Shady Grove Age Distribution: Isolated Crania

	Young Adult	Middle Adult	Older Adult	Indeterminate	Total
Male	2	10	2	7	21
Female	1	2	2	5	10
Indeterminate	1	1	0	3	5
Total	4	13	4	15	36

Stature

The maximum length of the left femur was taken for 29 individuals, and stature was estimated using Sciulli and Geisen's (1993) formulae. Of the 29, 20 were male, and they averaged 159.2 cm, or roughly 62 inches tall, with a range from 153.3 to 167.4 cm. In comparison the nine females averaged 149 cm, or 56 inches tall, with a range from 145.4 to 152.8 cm (Table 4). It is interesting that there is no overlap in the stature distributions of males and females from Shady Grove. It is possible that the results are representative of the population, but the lack of overlap could also be due to measurement or sample size issues.

Table 4

Mean Stature by Sex at Shady Grove

	N	Minimum Stature	Maximum Stature	Average Stature
Male	20	153.34	167.38	159.2
Female	9	145.36	152.83	149.04

Overall, Shady Grove males and females exhibit the shortest stature relative to the other prehistoric populations from the region, as may be seen in Figures 3 and 4. The mean stature for males is four centimeters less than the site with the next shortest population (Austin) and nearly 13 centimeters less than the tallest population (Upper Nodena). For females, the comparative stature values are similar, being four and 11 cm respectively. Such short heights suggest that Shady Grove was under considerably more stress than the comparative samples. It is generally expected to see decreased stature in populations practicing maize agriculture relative to their pre maize agriculture counterparts as they often seem to be more physically stressed (Larsen, 1997). However, none of the populations fit the expected model for decreased stature through time; in fact it seems to be the opposite, but this still does not begin to explain why Shady Grove was considerably shorter than all of the comparative populations.

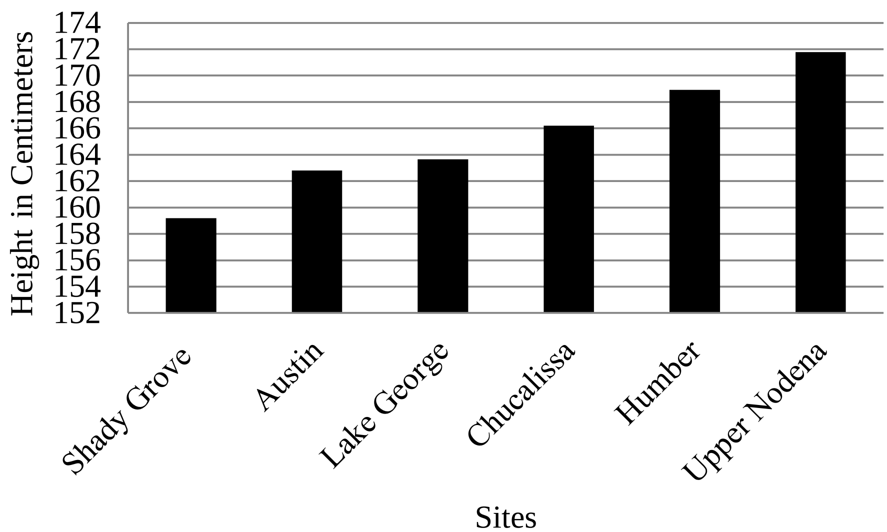

Figure 3. Mean stature of Shady Grove adult males relative to the comparative samples.

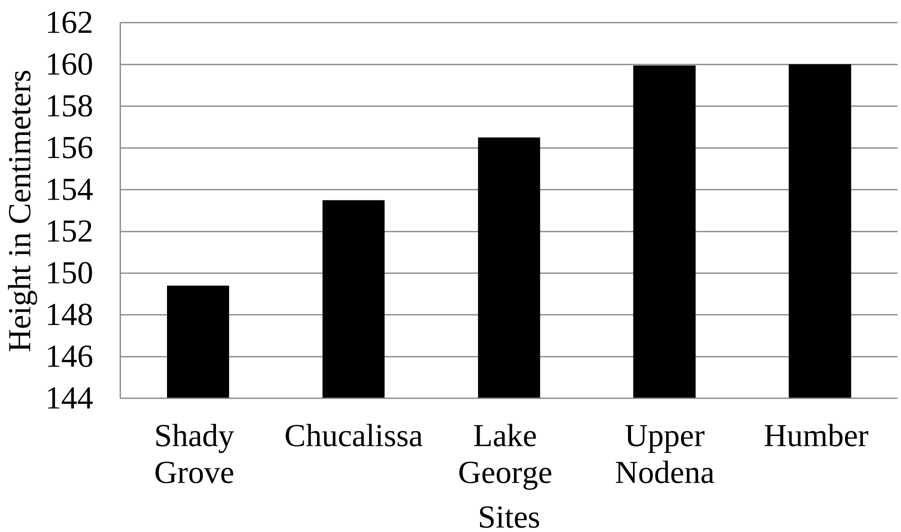

Figure 4. Mean stature of Shady Gove adult females relative to the comparative samples.

In the Shady Grove population, the lack of overlap of stature ranges between males and females might suggest a high degree of sexual dimorphism, which often is associated with a decrease in stress as males are more susceptible to retarded growth as subadults (Goodman et al., 1984). The level of dimorphism at Shady Grove is 6%, which is a bit higher than the levels seen at Humber (5%) and Lake George (4%) and a bit lower than those seen at Chucalissa (8%) and Upper Nodena (7%). Thus, there is no appreciable difference for this measure. However, Larsen (1984) argues for an increase in sexual dimorphism as stress increases based on his research on the Georgia coast.

Linear Enamel Hypoplasias

Tooth enamel is the strongest and most well preserved tissue in the human body, yet it is very sensitive to environmental and metabolic disturbances during development. Teeth included in the intra-site study had to be assigned to a complete individual or isolated cranium with a known sex. Few teeth could be assigned to a specific sex, thereby limiting the sample size. Maxillary right canines provided the largest sample size. Four teeth total, two from males and two from females, were compared (Table 5). The mean level of severity of male LEHs was two on a three point scale, while the female mean was 1.2. In terms of frequency, the male mean number of LEH per tooth was 1.6. In comparison, the female mean number of LEH per tooth was 2. Mean LEH age at formation for males was 3.25 years of age, while for the females it was 4 years. Overall, the males showed higher levels of severity, lower mean number of LEH per tooth, and a younger mean age at formation, but obviously with the extremely small sample sizes involved, little confidence can be placed in these findings.

Table 5

Patterns of Linear Enamel Hypoplasias at Shady Grove by Sex: Maxillary Right Canines

	N	Severity	Mean Number of LEH per Tooth	Mean Age at Formation
Male	2	2	1.6	3.25
Female	2	1.2	2	4

Taking into account all available teeth that could be assigned a sex, several broad trends were observed. Males had 13 teeth from ten burials, while females had nine teeth from eight burials. Generally, males showed a higher mean severity, higher mean LEH per tooth, and a lower age at formation. These observations are similar to the intra-site study with the exception of the higher mean LEH per tooth. The intra-site results suggest males were experiencing slightly higher levels of stress at an earlier age when compared to the females, which is a common occurrence in skeletal populations as female immune systems are generally stronger than males during early development (Buikstra et al., 1980; Stini, 1976; Stinson, 1985).

Since sex of the individual was not important for inter-site comparisons, mandibular left canines, the tooth that provided a highest sample size, was used (Figure 5). Eighteen were available. Eight-eight percent of the teeth studied (16/18) showed evidence for enamel disruptions consistent with LEH. The average level of severity was 1.8, and the average frequency of LEH episodes per tooth was 1.8. Age at formation was 5 years of age (Table 6) (Figure 6). Shady Grove showed very high frequencies of enamel disruptions relative to the comparative samples (Figure 7). The only population with a higher percentage of individuals displaying LEH was the protohistoric Upper Nodena. Generally, populations before the introduction of intensive agriculture will show lower frequencies of LEH and later populations who have adopted maize agriculture will show higher (Larsen, 1997). These results are consistent with this observation of Shady Grove being a later site than Austin but earlier than the Upper Nodena since it has a level of LEH formation falling between those two sites. There is a gradual increase between Austin and Shady Grove and less so between Shady Grove and the Upper Nodena, suggesting that between the subsistence practices at Austin and Shady Grove in the Upper Yazoo began to shift toward a greater reliance on maize agriculture. One exception is Humber, which has been previously interpreted as a high status population and thus would be expected to show lower frequencies of pathology. Therefore, the Shady Grove LEH data fits well within the expectations for the transition to agriculture within the Delta.

Figure 5. Mandible associated with burial 11b displaying LEH on lower left canine (photography by Brady Davis).

Table 6

Patterns of Linear Enamel Hypoplasias at Shady Grove: Mandibular Left Canines

Number Affected	Percent Affected	Mean Level of Severity	Mean Frequency of LEH per Tooth	Mean Age at Formation
16/18	88%	1.8	1.8	5

Figure 6. Frequency of hypoplastic episodes by age of formation (in years) in isolated mandibular left canines at Shady Grove.

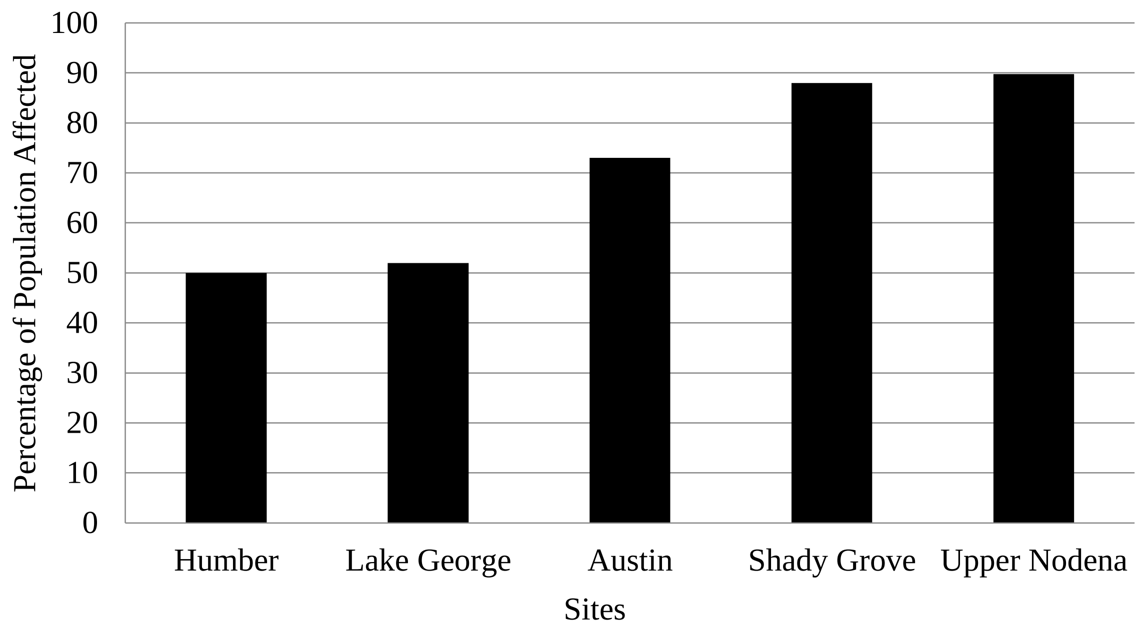

Figure 7. Percentage of population displaying LEH at Shady Grove relative to the comparative samples.

Porotic Hyperostosis

Porotic hyperostosis was the third indicator evaluated in the adult Shady Grove population. Results from isolated crania and complete individuals were pooled for the analysis. Some 66% (30/45) of those evaluated showed evidence of lesions. Males were much more frequently affected with 73% showing lesions as compared to 57% of females (Figure 8). While the majority of cases in both male and females were mild showing light indistinctive porosity, a few moderate cases of very distinct porosity were present, and none of the cases were active at time of death (Figure 9).

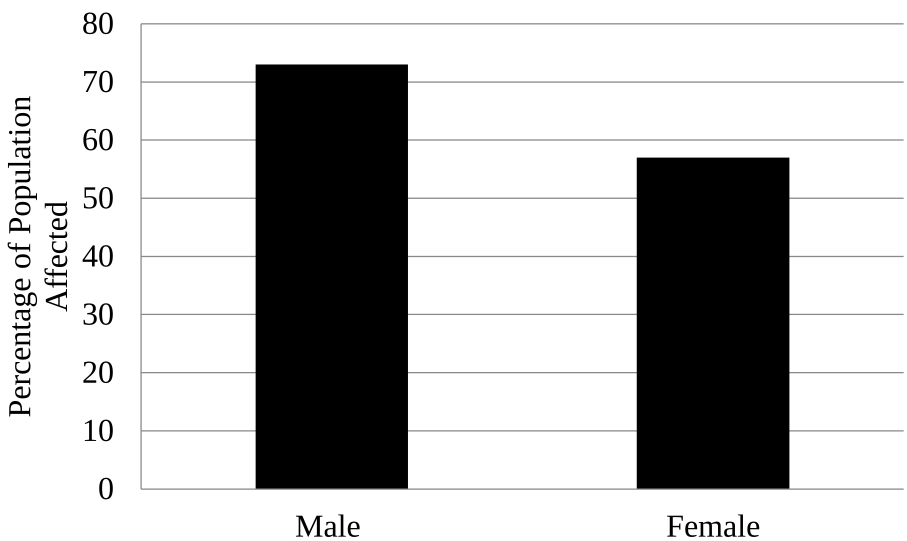

Figure 8. Percentage of Shady Grove population displaying porotic hyperostosis by sex.

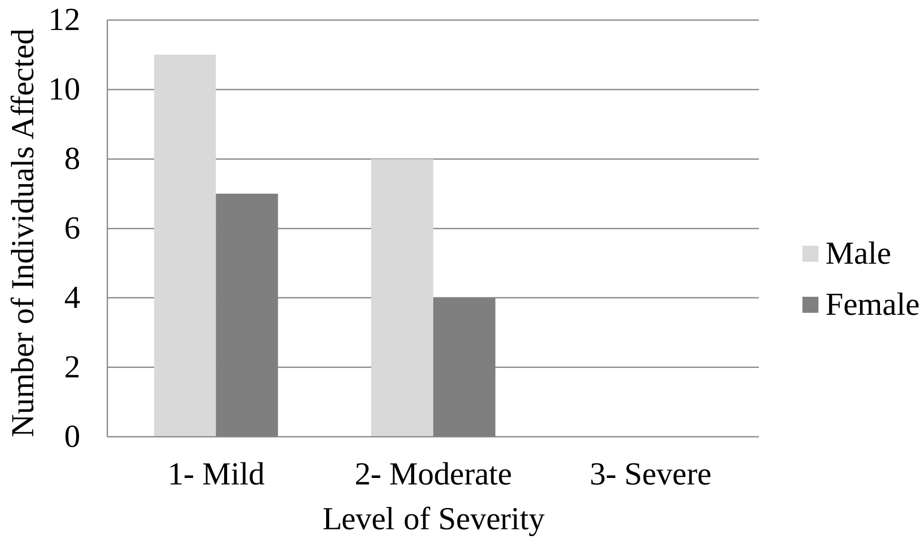

Figure 9. Number of individuals displaying specific levels of severity of porotic hyperostosis at Shady Grove by sex.

The pattern was similar for cribra orbitalia as well with 60% of the population (18/30) affected. Again, males showed a much higher percentage with lesions. Some 68% (13/19) exhibited evidence for CO, while only 45% (5/11) of females did the same (Figure 10). The majority of cases in the population were mild; however, the males did show more moderate and severe cases than the females, who exhibited no severe cases (Figure 11). Again, none of the cases were active. Examples of porotic hyperostosis and cribra orbitalia seen in the Shady Grove population are provided in Figures 12 and 13.

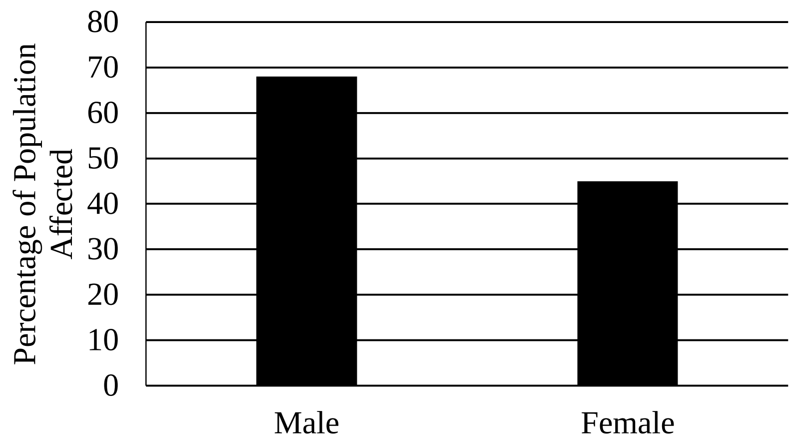

Figure 10. Percentage of Shady Grove population displaying cribra orbitalia by sex.

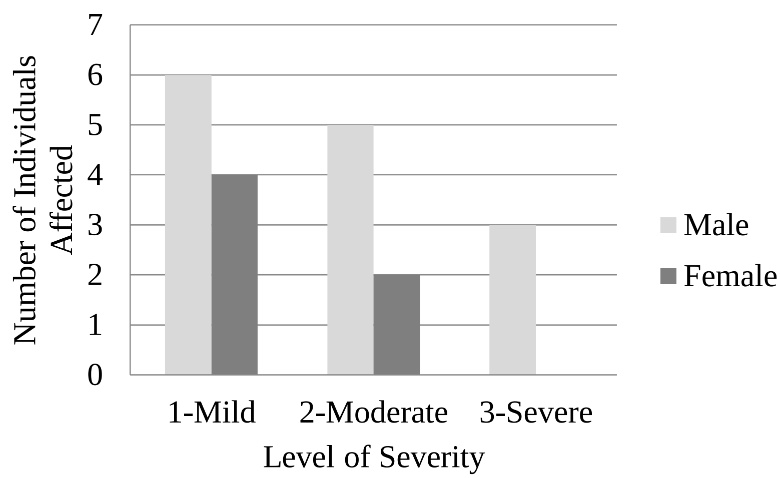

Figure 11. Number of individuals displaying specific levels of severity of cribra orbitalia at Shady Grove by sex.

Figure 12. Burial 1b displaying mild healed porotic hyperostosis (photography by Brady Davis).

Figure 13. Burial 20a displaying severe active cribra orbitalia (photography by Brady Davis).

In the intersite analysis, the frequency of porotic hyperostosis is considerably higher than that seen in all of the comparative samples except for the Coles Creek Lake George population in which 73% of the population was affected (Figure 14). It was expected that the potentially high status Humber population would show a lower frequency, and it did. Surprisingly, the two later and presumably most agriculturally dependent populations, Chucalissa and Upper Nodena, showed the lowest frequencies of porotic hyperostosis.

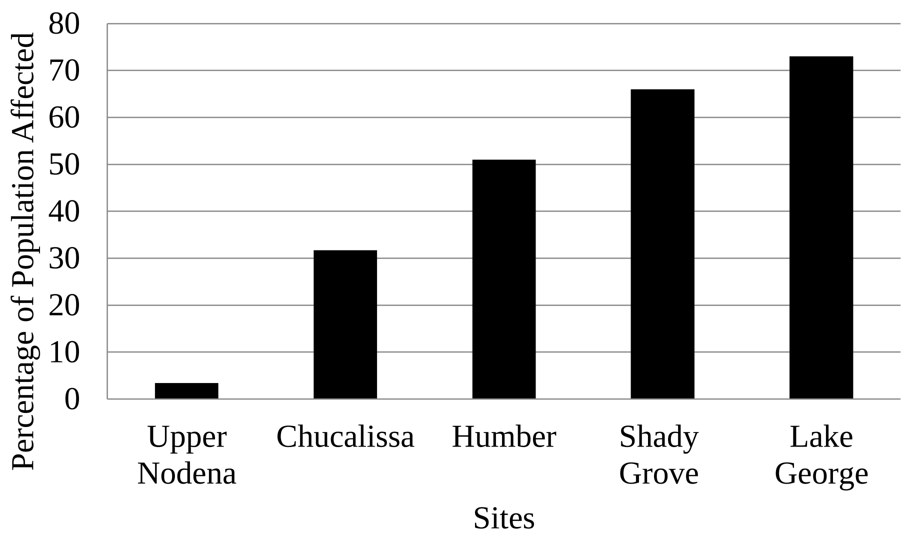

Figure 14. Percentage of Shady Grove population affected by porotic hyperostosis relative to the comparative samples.

Nonspecific and Specific Infection

All long bones with the exception of the fibula were used when assessing periosteal reactions. The fibula was not evaluated due to the extremely high fragmentation seen in most individuals. The frequency of periosteal reactions within the population of reconstructed individuals at Shady Grove was staggering with 100% of the males (N=10) and 90% of the females (N=10) exhibiting lesions on at least one bone.

The percentages were similar when looking only at the tibiae; some 88% of males (N=9) were affected and as were 62.5% of females (N=8), suggesting both sexes were severely stressed (Figure 15). Every male showed evidence of infection on multiple bones, and 66% of the females did as well. When the reconstructed individuals and isolated long bones were pooled, percentages of single bones affected by periosteal reactions remained high. The bone most affected was the tibia 64.5% (N=31), followed by 45% (N=22) of the radii. The femur was the third most frequently affected with 37% (N=40), followed by the ulna 33% (N=24), and the humerus 32% (N=34) (Figure 16).

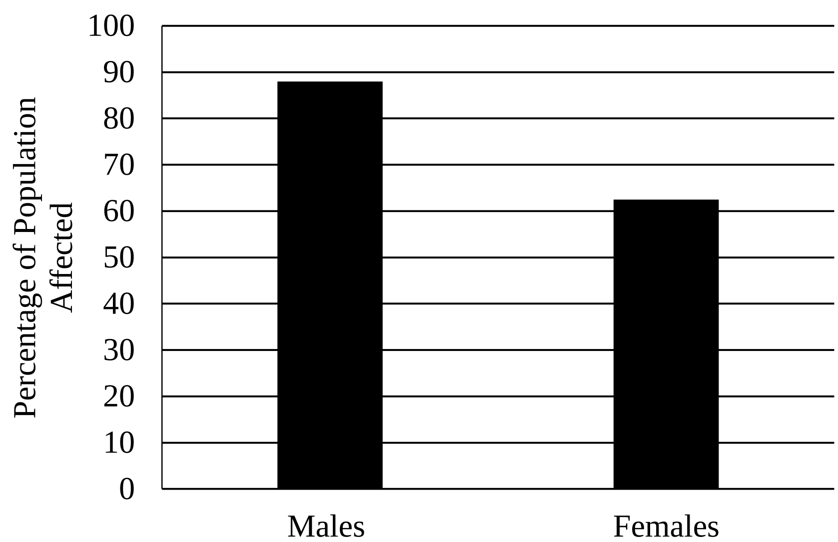

Figure 15. Percentage of individuals displaying periosteal reactions of the tibia at Shady Grove by sex.

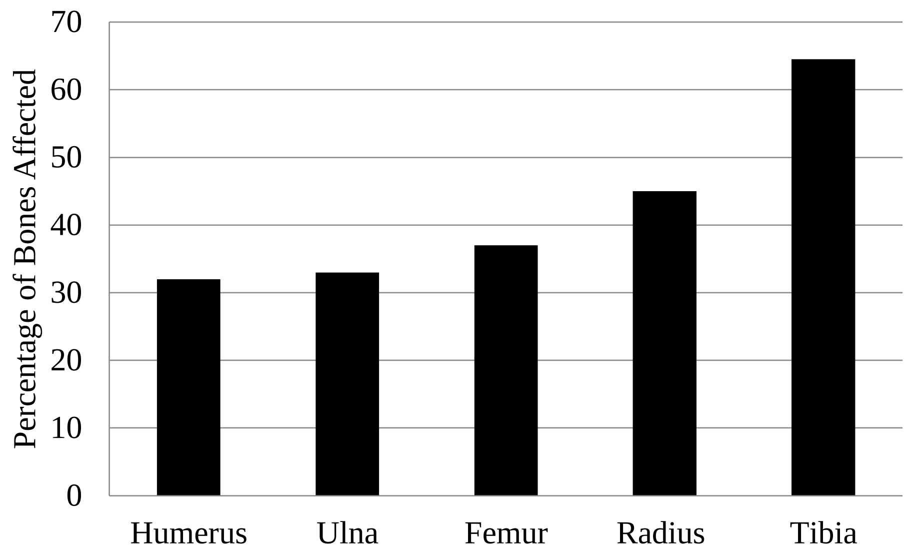

Figure 16. Percentage of individual long bone elements displaying periosteal reactions at Shady Grove.

Generalized periosteal reactions of non-specific origin in the form of mild plaque like lesions found on long bone diaphyses, usually healed or in the process of healing, was the most prominent periosteal reaction identified with examples observed on each type of long bone analyzed. Lesions along muscle attachment lines suggesting muscle tears were the second most frequent pathology found. These were most commonly in association with the soleus muscle located on the posterior tibia and muscles in the posterior thigh which attach to the linea aspera of the femur. No differences in lesion location were observed in regards to sex.

Among the reconstructed individuals, there were few cases of specific infection. Differential diagnosis was applied to two burials, and based on lesion type, location, and severity, a determination was made. One individual, burial 5, a young adult male, was diagnosed with tuberculosis. Burial 5 exhibited lesions on the vertebrae consistent with severe Pott's disease as well as lesions on the clavicle, radius, ulna, crania, and sacrum (Figure 17-18). Burial 5 was not complete, missing many elements commonly affected by tuberculosis including tarsals and metatarsals, carpals and metacarpals, ribs, and some long bones. While lesions associated with tuberculosis can manifest similar to systemic infection and other infectious diseases, locations of lesions and the particular bones affected aid in differential diagnosis. Alfer (1892) lists distribution and frequency of tuberculous lesions by bone from a large clinical series of 1752 cases. Considering that burial 5 is incomplete but all bones exhibiting lesions were found on Alfer's list, tuberculosis is the most probable infection. Furthermore, burial 5 was a young adult. Ortner (2003) states cranial lesions associated with tuberculosis are more common on sub adult and juvenile skeletons; however it can manifest in adults.

Burial 6, a young adult female, was diagnosed with treponemal disease. While no cranial lesions (caries sicca) were observed on burial 6, pathologies on the post-cranial skeleton were severe and consistent with treponematosis. The most diagnostic lesions were saber shins and bilateral periosteal lesions on the distal femora. Destructive lesions were also observed on the distal right humerus and proximal right ulna. One isolated crania, burial 66, an age indeterminate probable female, showed cranial lesions associated with treponemal disease (Figure 19). Early stage caries sicca is characterized by often roundish or irregular gummatous lesion, creating a characteristically lumpy appearance on vault bones. Osteomyelitis was also seen in two individuals: burial 49 in association with a healed left humeral fracture (Figure 20), and burial 64b on the distal third of the radius.

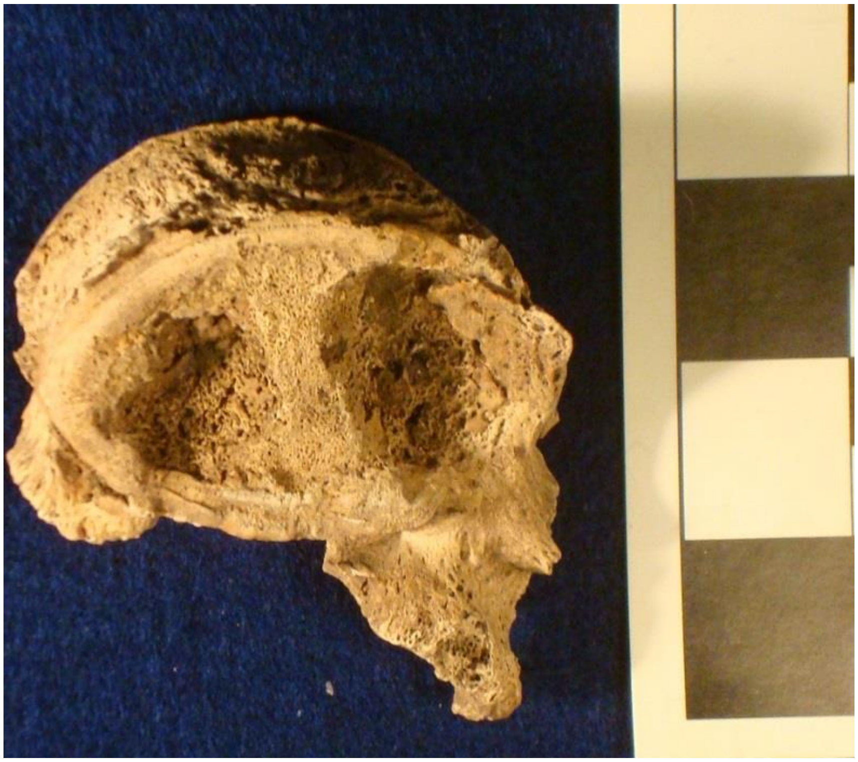

Figure 17. Burial 5 displaying Pott's disease on a lumbar vertebra (photography by Brady Davis).

Figure 18. Burial 5 displaying cranial lesions consistent with tuberculosis (photography by Brady Davis).

Figure 19. Cranium associated with burial 66a displaying lesions consistent with treponemal disease (photography by Brady Davis).

Figure 20. Burial 49 displaying osteomyelitis in association with a healed left humeral fracture (photography by Brady Davis).

When assessing Shady Grove's nonspecific infection with the comparative samples, only the tibia was used since it is the most commonly affected long bone (Larsen, 1997). Shady Grove shows the second highest frequency of periosteal reactions, indicating the population was under considerably more environmental stress than all of the other populations with the exception of the Upper Nodena, the protohistoric sample (Figure 21). Larsen (1997) suggests as populations engage in intensive agriculture and populations increase, the frequency of periosteal reactions will also increase.

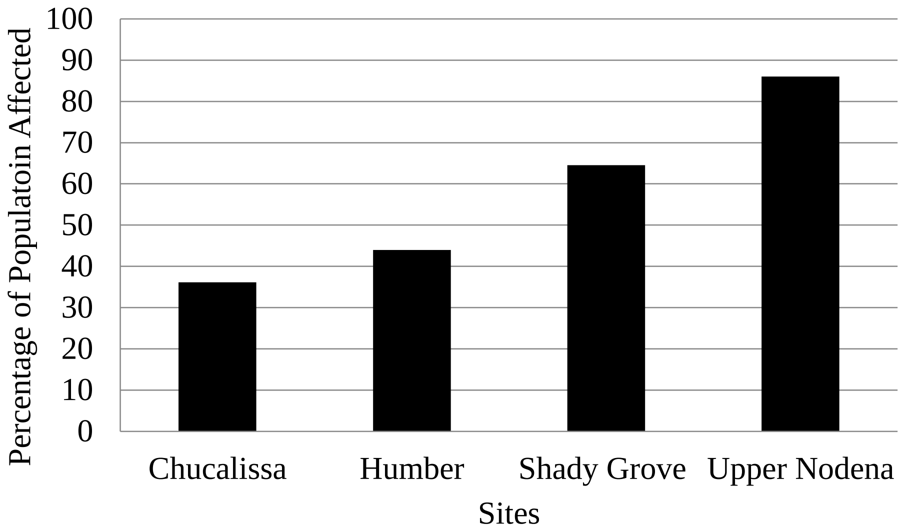

Figure 21. Percentage of Shady Grove population displaying periosteal reactions relative to the comparative samples.

Specific Infectious Diseases

Among the isolated bones, there did not seem to be any observable pattern in the distribution of the infectious lesions in regards to bone affected, age, or sex, but of course, a pattern would be potentially challenging to identify due to the Shady Grove population being mostly a comingled ossuary with limited reconstruction of individuals. Examples of active moderate and severe lesions, along with healed lesions or ones in the process of healing, were located on all isolated long bones and crania, specifically the tibia, femur, and ulna. However, some suggestions of treponemal disease were seen. Some 27% (N=22) of isolated tibia with pathologies were affected with saber shins. Treponemal disease can often affect the distal portion of the femur, and 17% (N=23) of isolated femora in the ossuary showed periosteal reactions in this region of the bone. Osteomyelitis was also present, affecting the femur of burial 50A. The example was severe and possibly associated with treponemal disease, referred to as syphilitic osteomyelitis (Figure 22).

Figure 22. Burial 50a displaying severe active osteomyelitis possibly associated with treponemal disease (photography by Brady Davis).

In summary, analysis of the health status of in the Shady Grove series suggests the adult population was under an intense amount of stress. Frequencies of all pathologies observed were high, especially periosteal lesions. Males and females were similarly affected, with the exception of PH and CO in which the males showed a markedly higher frequency, but not severity, of the markers. The Shady Grove population ranks high in frequencies of environmental stress indicators relative to the comparative samples. Stature was the only inter-site variable compared by sex, and Shady Grove males showed the shortest stature among all the comparative sites and the Shady Grove females were only slightly taller than the Chucalissa females. When the other health indicators are considered, overall Shady Grove consistently exhibited the second highest frequency of LEH, porotic hyperostosis, and nonspecific infection relative to the comparative samples, and never did the same comparative site exceed Shady Grove in one of these categories twice. It must be considered that the sample sizes from the Shady Grove ossuary were small, possibly skewing the results. However, the strength of the consistency of the pattern in the comparative analysis of Shady Grove with the other sites in the region must be given great weight.

CHAPTER VI

DISCUSSION

The purpose of this study was to examine the adult health status of the Shady Grove population from a bioarchaeological perspective. Primarily, this investigation centered on childhood indicators of stress and non-specific infection. The Shady Grove site likely dates to the Middle Mississippian period, shortly after the region had adopted agriculture, which co-occurred with a variety of sociopolitical changes; thus this analysis focused on the consequences of these transformations.

Placing Shady Grove in a Temporal Framework

Bioarchaeological and mortuary data brings a unique perspective to our understanding of these transitions. More information can be gained from a human burial than any other archaeological feature (Peebles, 1979, p. 124). When studying individual burials and ossuaries, it is important to understand them within a temporal context. Among the artifacts recovered in the Shady Grove ossuary was a badly deteriorated copper plate with a forked eye motif. Also found were two Tippet Bean pots. Artifacts associated with the Southeastern Ceremonial Complex are often relatively good temporal markers beginning around A.D 1250, and the forked eye is a major iconographic motif (Muller, 1989). Therefore, the ossuary appears to date to the Middle Mississippian period. It is possible that the artifact was an heirloom and the ossuary is from a later date, possibly post-AD 1300 or as late as AD 1450 according to C-14 samples collected in 1975 (Scott, 2009). The Tippet bean pots at Shady Grove are local reproductions, which also could suggest a later date, as local reproduction of trade items occurred more often once trade networks began to falter. However, there was no specific evidence that conclusively pointed to a later date for the ossuary.

Considering the Shady Grove ossuary probably dates to the Middle Mississippian period, the population was likely engaged in maize agriculture, which has been associated with many negative health consequences (Larsen, 1997). Agriculture, especially the reliance on one primary crop such as maize, has nutritional disadvantages. This does not mean the group would only have been subsisting on food derived from maize, but that it was the primary staple. The population undoubtedly continued to fish, hunt, and collect wild fruit, vegetables, and nuts. Even if these foods were minor additions, they still added some variation to the diet when available. Nevertheless, a maize based diet would have lacked adequate protein and also essential vitamins, minerals, fats, and amino acids. Other potential problems with the primary reliance on agriculture included a stationary lifestyle, population aggregation, and the creation of surplus. The creation of surplus allowed the population to increase and begin to practice craft specialization, which in turn led to increased rates of infection. Furthermore, surplus and specialization fostered the development of stratified societies. As population levels grew, this resulted in potentially harmful effects on the environment and unhealthy outcomes for the population.

Climate change also affected the environment. The transition to cooler and drier conditions during the "Little Ice Age" that began around AD 1250-1300 would have caused repeated crop failure, a long term drought, and a change in how people utilized resources (Anderson, 2001). Using dendrochronology, Cook, Seager, Heim, Vose, Herweijer and Woodhouse (2009) have shown evidence of extended droughts along the Mississippi River valley and surrounding areas during the Mississippian Period, specifically a prolonged dry spell lasting from AD 1122-1299 and a severe drought lasting from roughly AD 1340-1400.

Larsen (1987, p. 357) states the human skeleton carries with it the memory of past metabolic disturbances from pre-adult years, including the sort undoubtedly caused by these cultural and environmental changes. These markers are often observed as childhood indicators of stress including stature, linear enamel hypoplasias, and porotic hyperostosis and cribra orbitalia. Furthermore, individuals who maintain compromised immune systems during childhood are often more prone to health disruptions as adults (Larsen, 1997). According to Stini (1976), Stinson (1985), and Buikstra and Cook (1980), males often exhibit a weaker immune system during development providing less buffering against health related stress, and hence will often show higher frequencies childhood indicators of stress and nonspecific indicators of stress as adults. The negative effects of maize agriculture along with the extended dry spell and severe drought would have further reduced both botanical and animal subsistence resources, and thus amplified the nutritional stress on the Shady Grove population.

Given these circumstances, two research questions were explored in this thesis. The first looked at the intensification of agriculture of in the Yazoo Basin, and how this potentially affected nutritional strain at Shady Grove. Population-wide levels of stress in adults were the focus. It was hypothesized that levels of most health markers would be relatively high. Sex differences were also considered, and it was anticipated that males would exhibit evidence of more health disruptions than their counterparts. The second question examined the findings at Shady Grove in a regional context. Shady Grove adults were placed in a diachronic framework comparing their results with those of both earlier and later populations from in and around the Yazoo Basin. It was hypothesized that as dependence on agriculture increased, lower stature, higher frequencies of childhood indicators of stress and nonspecific infection would be observed increasingly in later populations.

Indicators of Childhood Stress and Nonspecific Infection

The analysis of the health indicators assessed were able to provide valuable insight into the health of the residents of Shady Grove from a variety of perspectives.

Intrasite Comparisons

In general, high frequencies of childhood indicators of stress as well as nonspecific indicators of stress were found in the adult Shady Grove population. However, there were only modest differences between frequencies observed in males and females with exception of stature, for which the level of sexual dimorphism was moderate. Although it was surprising that there was no overlap in stature between male and females, both male and female stature was markedly low, suggesting stunted growth due to poor health. Males showed a trend exhibiting higher frequencies and severity of porotic hyperostosis and cribra orbitalia, as well as a higher percentage of periosteal reactions on the tibia. Frequencies of linear enamel hypoplasias were considerably more similar, but this may very well be due to the extremely small sample size available for male and female comparison. According to Powell (1991, p. 46), the lack of differences in stress indicators between the sexes could suggest a population well adapted to their surroundings, and thus individuals in generally good health. The level of sexual dimorphism was high at Shady Grove, which Goodman et al. (1984) (cf. Larsen, 1997) state is usually associated with a decrease in population stress.

Therefore, analysis involving the first hypothesis of this study, which focused on the difference of male and female childhood indicators and nonspecific indicators of stress, showed that the differences seen were only slight at best. Although this trend does exist in the data, it must remembered that the sample sizes were small. However, Shady Grove cannot be viewed in a vacuum. While the adult population being under extreme duress does not seem at all apparent, the findings must be viewed in regards to other regional populations through time.

Intersite Comparisons

Stature. Comparing the adults at Shady Grove to other populations in the region revealed potentially high levels of nutritional stress. Based on the comparative data, there seems to be a general increase in stature through time, with the exception of the possible high status population of Humber. Pre-agricultural populations are often taller than their agricultural counterparts (Larsen, 1997). Although there is obviously considerable variation based on region, Shady Grove would not be expected to be the shortest population in this study. According to Larsen’s argument, Lake George should be the tallest population followed by the terminal Woodland Austin village group. Shady Grove, Chucalissa, and the Upper Nodena should be the shortest populations, but this is not the case. Upper Nodena actually shows the highest stature. The short stature seen at Shady Grove indicates considerable stress on the population, keeping them from reaching their potential height. The other populations were not as stressed and likely maintained more varied well balanced diet. Those close to multiple ecological zones such as large rivers, lakes, swamps, and forests may have had access to adequate resources when not bound by environmental and/or population issues. Lake George was situated on a large body of water and the Upper Nodena sites were on the Mississippi River, indicating they likely had access to adequate resources. Shady Grove was located on the banks of the

Coldwater River, placing it in an area for a potentially wide array of resources, yet it was still one of the shortest groups in the study.

Linear enamel hypoplasias. A general trend exists for an increase in episodes during the development and expansion of maize agriculture in the southeastern United States (Larsen, 1997). Shady Grove showed the highest frequency of linear enamel hypoplasias with the exception to the Late Mississippian/Protohistoric site of Upper Nodena. Other than the potential high status Humber sample, the data in the present study seemed to fit this trend. The Shady Grove sample likely dates to the Late Middle Mississippian or Early Late Mississippian period, and therefore should, and does, show higher frequencies than Lake George, Austin, and Humber, respectively.

Porotic hyperostosis. Intersite comparisons of porotic hyperostosis showed a surprising pattern. Usually there is an increase in this indicator as maize agriculture becomes more prevalent (Cohen, 1977; Cohen, 1984; Goodman et al., 1984; Larsen, 1997; 2006). However, almost the opposite is seen with the exception of Shady Grove, which showed the second highest frequency of the indicator. It is possible that the results are skewed due to differences in individual scoring techniques by researchers. A more liberal approach may have been taken with Shady Grove, and possibly Lake George, while it seems likely that a much more conservative scoring system was used by Mary Powell with the Upper Nodena based on her description of the method she used in analyzing Moundville (Powell, 1988). The exceptionally low frequencies of porotic hyperostosis seen at Upper Nodena likely reflect this.

Other reasons to explain why the Shady Grove, Lake George, and Humber frequencies of PH are higher than those of the Chucalissa and Upper Nodena samples may result from the fact that the causes are more complex than simply iron deficiency anemia spawned from poor nutrition. It could very well be a natural biologic response to protect the body from specific parasites caused by a dense population and poor sanitary conditions. Many types of parasites require iron as a primary energy source to maintain themselves in the body; without this energy source they cannot survive; the anemia could be protecting them from types of parasitic infection. Lake George was earlier than the other populations, but it was a very large mound site and was likely densely populated. Aggregated sedentary populations create a less sanitary environment than smaller or spread out groups causing higher incidences of infectious and communicable diseases. The anemia is possibly protecting the population from types of parasitic infections that become more frequent once groups are living in these conditions.

Nonspecific infection. Nonspecific infection, such as periosteal lesion, also shows a general tendency to increase over time with the reliance on maize agriculture throughout the world (Larsen, 1997). The data in this study seemed to fit this model with the exception of Humber. Upper Nodena, the sample with the latest dates, exhibited the highest levels of nonspecific infection; however, Chucalissa showed the lowest, followed by Humber, and they are also associated with the Late Mississippian period. In contrast, the rates of periosteal lesions at Shady Grove surpassed those of Chucalissa and Humber. Humber, the potential high status population, should exhibit lower frequencies of stress indicators relative the other samples. However, Powell's analysis of Moundville showed no difference in periosteal lesions between high and low status populations (Powell, 1991). Based on potential access to resources, Chucalissa and Upper Nodena could have enjoyed the lowest frequencies due to their location close to the Mississippi River, which allowed access to a more varied diet, especially in aquatic protein resources, and therefore stronger immunities compared to those living on smaller waterways (Larsen, 1997, p. 95). The high levels of nonspecific infection in the Shady Grove in association with the other indicators again suggest a high level of nutritional stress for those recovered from the ossuary.

In summary, the results of the analysis of health at the site potentially indicate that less nutritional stress was being placed on the population based on high levels of sexual dimorphism and similar results of childhood stress indicators and nonspecific infection. However, when assessing Shady Grove in relation to the comparative samples, the site showed the lowest stature and high levels of childhood stress indicators and nonspecific infection relative to them. While the results do not fit perfectly within the parameters of the hypotheses, there is a general trend, with the exception of stature, toward increased health related stress through prehistory in the Yazoo Basin and surrounding areas based on data from the ossuary and the populations used for comparison. This pattern also suggests that the residents of Shady Grove may have been under considerably more nutritional stress than the other comparative populations regardless of temporal position in the study. This in turn begs the question as to why this variation in health pattern existed.

The Role of Cultural Systems and Political Organization

Cultural systems are one factor affecting health. Cultural systems dictate how a society interacts and attempts to utilize resources from the environment. Political and social organization as well as general responses to the environment can act as a buffer, helping protect populations. For example, Goodman and Armelagos (1989) point out that clothing and shelter are responses to a cold environment, but not all potential stressors are buffered. Cultural systems can also create detrimental stressors. In many, but not all, regions, intensive maize agriculture was mostly detrimental to the societies regarding physical stress and long term health (Bridges, 1989; Cohen & Armelagos, 1984).

Sociopolitical organization was undoubtedly a major influence on health patterns at the site. Shady Grove was a moderately sized mound center that arose out of a large Late Woodland component. With only one documented Mississippian platform mound, the polity was most likely a simple chiefdom where often less strict social stratification system was in place (Blitz, 1999). King (2003, p. 7) states that the use of political authority during the Mississippian period can be divided into two general categories: network and corporate. It is possible Shady Grove elites grew and maintained political power utilizing corporate rather than network based strategies. Polities utilizing a network strategy will often become engulfed in access to esoteric knowledge and prestige goods, which are important characteristics of social reproduction and exchange between populations (King, 2003, p. 8). Often at sites practicing this network strategy, there are distinct differences in status and class reflected in material culture. Elites control important resources, knowledge, and prestige goods, and use them as a means of control over the non-elite population. In contrast, the corporate approach emphasizes the importance of the social group at the expense of individual wealth and status; thus it is more inclusive (King, 2003, p. 9). Polities whose elite practice a corporate strategy can still be politically complex and create large earthworks relative to the polities who practice a network strategy, but the focus is more group-oriented. With this different focus, important clans or individuals will be less visible in the archaeological record

(King, 2003, p. 9). King (2003) also notes that corporate polities, while being more stable politically than network polities, are more susceptible to destabilization by lack of adequate subsistence, environmental fluctuations, or overburdened by a population too large to feed.

If the Shady Grove were a simple chiefdom or practiced a corporate strategy, there would have been more equal access to available resources. The data supported this as males and females at the site showed very similar frequencies of both childhood indicators of stress and nonspecific infection. Also, the relative paucity of grave goods suggested a less stratified society. However, one artifact, a copper plate with a forked eye motif, was present, which is indicative of a potentially high status individual buried in the ossuary. Nevertheless, it is possible the esoteric item was not owned individually, but rather by a clan or lineage. Evidence, such as green staining on bones in the ossuary, does indicate that other copper artifacts may have been present, but were destroyed by taphonomic processes.

The Role of Climate Change

The role of the environment must also be considered in interpreting health patterns at Shady Grove. According to Goodman and Armelagos (1989, p. 226), "The environment is the source of both the resources necessary for survival and potential stressors that are adversely affecting the population." Goodman et al. (1984) also note that environmental constraints include both limiting resources and stressors. Climate directly affects the environment which dictates the outcome of agricultural practices and affects how people utilize resources. As noted, the medieval warming period, or the Medieval Climate Optimum, that occurred from AD 950 to 1250 set the stage for the expansion of agriculture in the southeastern North America, allowing it to flourish along with the Mississippian settlements associated with it. However, Cook et al. (2009) observed a prolonged dry period in the later portion of the Medieval Climate Optimum (Figure 23). The Little Ice Age followed the medieval warming period, bringing cooler drier conditions and the potential for drought across the Southeast beginning in the late 1200s (Anderson, 1995, 2001). With this change in climate, agriculture would have become much more difficult; this could have caused political upheaval, decreased long distance trade, and potentially famine (Anderson, 1995; 2001; Muller, 1989). Using tree ring data from the *Living Blended Drought Atlas*, Cook et al. (2009) provide examples of three significant drought periods in and surrounding the Mississippi River Valley (Figure 23).

The Yazoo Basin where Shady Grove is located was not the only region to be affected by drought. Much of the Mississippi River Valley experienced these conditions including the paramount chiefdom of Cahokia, which by the end of the Sterling Phase (AD 1200) has seen a decrease in population. By AD 1350, Cahokia had lost 50% of its population (Benson, Pauketat, & Cook, 2009). Benson et al. (2009) attribute the depopulation of Cahokia to dramatic decrease in maize yields, the potential drop in the water table, and the decrease in aquatic resources supported by a decline in fish and shellfish remains associated with Sterling Phase sites. Evan Peacock (2005) argues for a decline in shellfish around the advent of agriculture, citing climate change as a possible cause. However, with significant population growth during the Mississippian period, it is likely that shellfish numbers stayed low, and if the Yazoo Basin was affected similar to how the Central Mississippi River Valley was, other aquatic resources would have also declined during the drought periods. Figure 23 shows the geographical extent of the extended drought periods. It seems a similar situation may have been seen at Shady Grove during this period.

The Shady Grove ossuary dates to roughly around AD 1250-1400, which is a large span of time. Therefore the individuals in the ossuary may have been affected by this environmental constraint, potentially limiting resources. The Middle Mississippian cultural system had significant health disadvantages for the majority of its inhabitants. These problems, compounded by the changing environment, may have taken a dramatic toll on host resistance. Even though the mortuary data suggest the Shady Grove ossuary lacked significant status differences regarding gender or social standing, it does not mean it was not present. It was a staple of these societies.

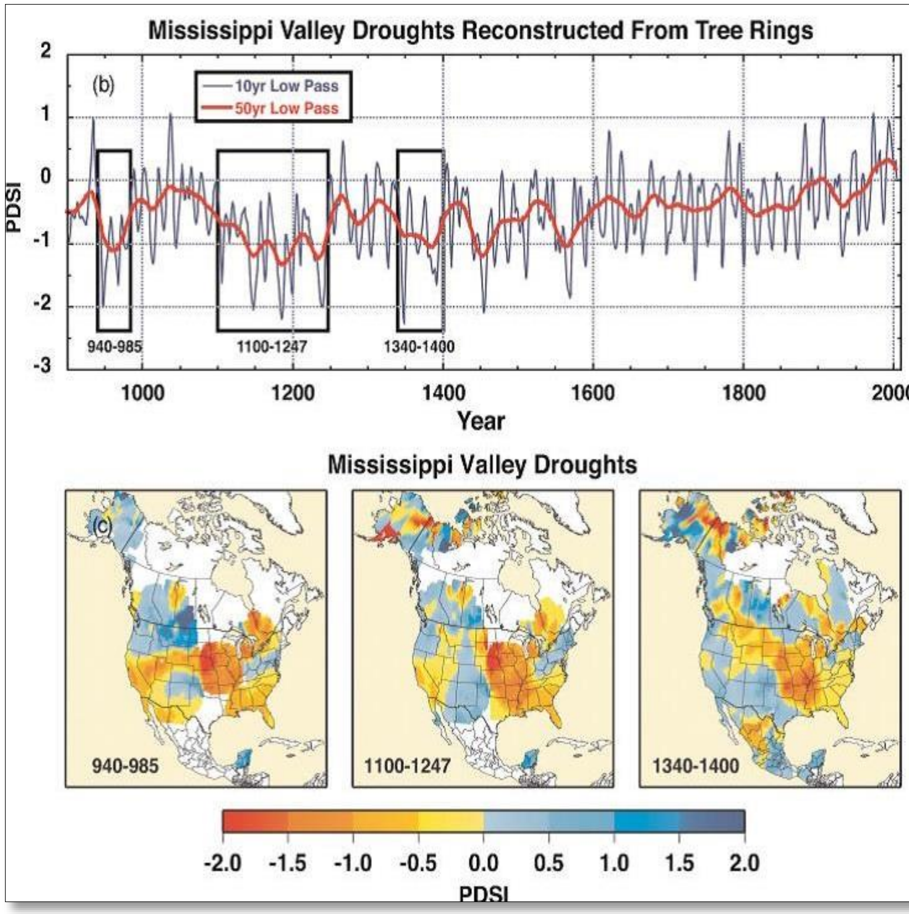

Figure 23. Mississippi Valley drought as reconstructed from tree rings in the new Living Bend Drought Atlas. Taken from Cook et al. (2009, p. 57).

Summary

Both cultural systems and the environment play an important role in understanding why the Shady Grove population exhibits high levels of population stress. More specific factors allowing an explanation to why Shady Grove was so stressed can be found in the type of subsistence strategy, namely intensive agriculture, during the Middle Mississippian. The cultural system and the environment work synergistically with each other. The actions of populations affect the environment, yet climatic changes will affect the environment which in turn will affect the population. In other words, each can act on the other in specific ways.

During the Middle Mississippian, maize agriculture was becoming more prominent in the Upper Yazoo basin; this transition to a single primary crop had its disadvantages, which is possibly one of the many reasons Shady Grove showed considerably more evidence of childhood stress and infection relative to the comparative samples. Maize, as a primary food staple, does meet caloric requirements, but it is deficient in the essential amino acids lysine, isoleucine, and tryptophan. The crop needs to be supplemented with other high protein vegetables, such as wild or domesticated beans, and nuts such as hickory, pecan, or acorn (Larsen, 1997). With no botanical evidence from Shady Grove, it is possible that the population accepted maize agriculture and had a less varied diet. However, the population was still likely exploiting native crops, nuts, and other wild fruits and vegetables, but not in sufficient quantities to counteract the negative consequences of maize agriculture.

Another explanation working alongside the subsistence stress and susceptibility to disease involves the high population density of Mississippian mound centers. With possibly up to five mounds present, it was a medium-sized center. High population density in mound centers often created unsanitary living condition, furthering the physical stress on the population. However, it is important to note that ceramic collections from Shady Grove show low frequencies of Mississippian sherds relative to Late Woodland ceramics, which does not suggest a large resident population. This could indicate that the population density of Shady Grove was rather low, with only elites and their kin groups living there, and that Mississippian populations utilizing the site could have resided in the surrounding area. Frequencies of stress makers in males at females at Shady Grove were similar; this often evidences relatively good health in a population.

However, when weighed against the comparative populations, as a whole those in the ossuary exhibited high levels of population stress, suggesting a combination of the Mississippian cultural system along with potential changes in climate had a detrimental effects on the Shady Grove population.

CHAPTER VII

CONCLUSIONS

During the Mississippian Period, maize agriculture expanded throughout the southeastern U.S. Along with the transition to this subsistence strategy, other elements of Mississippian culture also emerged. Agriculture permitted populations to become more sedentary, and construct permanent villages. Populations increased, surplus of food allowed for specialization, control of resources became more important, and ranked societies developed. However, the transition to agriculture did not emerge without negative impacts. In many regions, overall health declined during this period. Population studies have shown decreases in stature and elevated frequencies of childhood indicators of stress, non-specific infection, and infectious disease. This study focused on rates of childhood indicators of stress and nonspecific infection within the adult Mississippian period Shady Grove ossuary in the Yazoo Valley of Mississippi in order to explore health patterns at the site.

Studying an ossuary population comes with its own unique set of challenges, and this investigation attempted to go beyond the standard ossuary analysis for the purpose of using the data to compare levels of stress with those seen in more complete bioarchaeological samples from the general region. The fragmented and commingled, yet well preserved, skeletal material in the Shady Grove ossuary proved difficult to evaluate. Crania could not be assigned to sets of long bones; thus isolated crania were used for the porotic hyperostosis and cribra orbitalia comparisons. The dental sample sizes were also quite small, hindering intersite comparison between males and females. Also, along with the extensive elemental analysis, reconstruction of individuals was attempted to create a sample to compare with the individual burial populations of other samples, and while many confident reconstructions did occur providing useful data, it caused the Shady Grove intrasite nonspecific infection comparative sample to be relatively small. The limited sample sizes may have resulted in unreliable data. At times, they made various comparisons nearly impossible, such as with the linear enamel hypoplasias. Also, long bones used to calculate stature were often fragmentary, and lengths of long bones had to be estimated; although always done with care, this may have caused inconsistencies with the stature data. In addition, the Shady Grove ossuary was intrusive into a Late Woodland period shell midden. While this provided excellent preservation relative to many skeletal populations in the region, many of the bones were still fragmentary. Another limitation likely culminating in the lower sample sizes for the intersite analysis was the rather expedited excavation of the ossuary. Fieldwork was conducted in less than ideal conditions during the middle of the winter, leading to gaps in the documentation. This as well as other potential problems with the excavation resulted in more problems than solutions once in the laboratory.

Variations in scoring methodologies must also be taken into consideration when comparing variables among different groups. While *Standards for Data Collection of Human Remains* (Buikstra & Ubelaker, 1994) does provide a framework for data collection and analysis, it was published in 1994. Many of the comparative samples were analyzed well before this time, but even today researchers will employ their own methods for collecting and assessing data. Differences in scoring systems can sometimes cause the data to be skewed, such as the concern with the scoring of porotic hyperostosis at Upper Nodena as discussed in the previous chapter. There have been many attempts in the past to better standardize scoring procedures for pathologies on human remains, but it seems researchers will always use what they feel works best for them.

Another potential problem with the interpretation is the Shady Grove ossuary's placement in time. Local reproductions of such items commonly suggest a later date. The fragmentary copper forked-eye ornament suggest a date more consistent with the rise of the Southeastern Ceremonial Complex during the Middle Mississippian period. Radiocarbon dates taken in 1975 of another ossuary at the site by MDAH archaeologist John Connaway suggest a continuous occupation from AD 600 to 1450 (Connaway, 1981). While the specific time period is unknown, artifacts associated with the ossuary analyzed in this thesis suggest the Middle Mississippian period.

With these issues in mind, specific explanations for these health patterns at the site are difficult to pinpoint; however, there are likely multiple factors working together placing a high level of stress on the Shady Grove population. The site sits along the Coldwater River, which provided easy access to water transportation and an abundance of aquatic life including abundant mussels and other wildlife attracted to the river. During the Baytown period, aquatic resources were exploited quite heavily, but it is unclear as to whether these resources were as abundant during the Middle Mississippian period (Connaway, 1981). Evidence suggests resource availability may have changed during this time due to a regional climatic shift toward cooler drier conditions. Tree rings suggest a severe drought in the central and lower Mississippi River valley in the 13th and 14th centuries that could have placed significant stress on populations such as crop failure and fewer exploitable natural resources (Anderson, 1995; 2001; Benson et al. 2009; Cook, 2009; Muller, 1989). Peacock (2005) shows evidence of a decline in freshwater mussels associated with the advent of agriculture in the eastern woodlands. It is very likely the shellfish populations in the Coldwater River would have also declined. Along with mussels, fish and other aquatic resources could have become less plentiful as Benson et al. (2009) suggest for the Central Mississippi River Valley. Also, the population increase and climate associated with the introduction of intensive agriculture would have kept these numbers down. Although many studies have shown that intensive maize agriculture had negative effects on population health, it would seem that exploitation of the abundant local resources, if available, would have been able to mitigate some of the harmful consequences. However, they evidently did not.

Little in terms of archaeological investigation has taken place at Shady Grove, and most of the work conducted has focused on the Late Woodland Baytown component, specifically the large shell ring midden which cuts through the Mississippian plaza area. Further archaeological and bioarchaeological evaluations are needed to better clarify the role and identity of the site in the region, specifically its Mississippian component. This data should be added to the analysis of the juvenile population of the ossuary, which was conducted by Jamie Ide for her recently completed master's thesis (Ide, 2015). Using both data sets a comparison of the Shady Grove ossuary to other skeletal populations in the region dating to the same time period would provide more comprehensive results regarding how nutritionally stressed Shady Grove was. The majority of fieldwork relating to the Mississippian period at the site has been the ossuary excavations. Further fieldwork should be conducted on Mound A, the plaza, and the other smaller potential mounds. Research should focus on more effectively documenting the extent and length of the Mississippian occupation, village organization, and its connection to the larger

Mississippian world. Other projects focusing on diet and status will provide us more information relative to the present study and provide a clearer picture as to why the Shady Grove population exhibits such poor health, and if cultural systems and environmental changes played a major role as suggested in this thesis.

Reliance on maize agriculture did not have a singular effect on the adults in the Shady Grove ossuary. Multiple variables were likely affecting the population causing the extremely low stature and the high frequencies of pathological indicators suggestive of significant nutritional stress. Other factors must be taken into consideration, such as how the Mississippian component of the Shady Grove site was organized politically as well as temporal variation in the local environment, including in comparison to that of other sites. Furthermore, climatic shifts through time must also be acknowledged. Research has shown evidence of prolonged dry spells and severe droughts in the Eastern Woodlands. More evidence on how this affected populations in the Upper Yazoo Basin is needed. However, this bioarchaeological evaluation of one of the largest ossuaries recovered in the southeastern U.S. provides great insight into our understanding of prehistoric life in the Upper Yazoo Basin, potentially one of the richest environments in the eastern woodlands, and how it compares to other areas of the Mississippi River Valley.

REFERENCES

Alfer, C. (1892). Die Haufigkeit der Knochen und Gelektuberkulose in Beziehung aug Alter, Geschlecht, Stand aun Eblichkeit. *Beitrage zur Klinischen Chirurgie*, *8*, 277-290.

Anderson, D. G. (1995). Paleoclimate and the Potential Food Reserves of Mississippian Societies: A Case Study from the Savannah River Valley. *American Antiquity, 60*(2), 258-286.

Anderson, D. G. (2001). Climate and Culture Change in Prehistoric and Early Historic Eastern North America. *Archaeology of Eastern North America*, *29*, 143-186.

Angel, J. L. (1966). Porotic Hyperostosis, Anemias, Malarias, and Marshes in the Prehistoric Eastern Mediterranean. *Science, 153*, 760-763.

Aufderheide, A. C. & Rodriguez-Martin, C. (1998). *The Cambridge Encyclopedia of Human Paleopathology*. New York, NY: Cambridge University Press.

Bense, J. A. (1996). Overview of the Mississippian Stage in the Southeastern United States. *Revista de Arqueología Americana, 10*, 53-71.

Benson, L., Pauketat, T. R., & Cook, E. R. (2009). Cahokia's Boom and Bust in the Context of Climate Change. *American Antiquity, 74*(3), 467-483.

Blitz, J. H. (1999). Mississippian Chiefdoms and the Fission-Fusion Process. *American Antiquity, 64*(4), 577-592.

Bridges, P. S. (1989). Changes in Activities with the Shift to Agriculture in the Southeastern United States. *Current Anthropology, 30*(3), 385-394.

Buikstra, J. E., & Cook, D. C. (1980). Paleopathology: An American Account. *Annual Review of Anthropology, 9*, 433-470.

Buikstra, J. E., & Ubelaker, D. H. (1994). *Standards for Data Collection from Human Skeletal Remains*. Research Series No. 44. Fayetteville, AR: Arkansas Archaeological Survey.

Claassen, C. (1998). *Shells.* Cambridge, UK, Cambridge University Press.

Cohen, M. N. (1977). *Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture.* New Haven, CT: Yale University Press.

Cohen, M. N. (1984). Introduction to the Symposium. In M. N. Cohen & G. J. Armelagos (eds.), *Paleopathology at the Origins of Agriculture.* (pp 1-12). Gainesville, FL: University Press of Florida.

Condon, K., & Rose, J. C. (1992). Intertooth and Intratooth Variability in the Occurrence of Developmental Enamel Defects. *Journal of Paleopathology, 2*, 61-77.

Connaway, J. (1981). *Archaeological Investigations in Mississippi 1969-1977.* Jackson, MS: Mississippi Department of Archives and History.

Connaway, J. (1983). *National Register of Historic Places Inventory- Nomination Form: Shady Grove (22QU525).* Washington, DC: U.S. National Park Service.

Connaway, J. Personal Communication. May 24, 2012.

Cook, R. E., Seager, R., Heim, R. R., Vose, R. S., Herweijer, C.,& Woodhouse, C. (2009). Megadroughts in North America: Placing IPCC Projections of Hydroclimatic Change in a Long-Term Palaeoclimate Context. *Journal of Quaternary Science*, 25, 48-61.

Corruccini, R. S., Handler, J. S., & Jacobi, K. P. (1985). Chronological Distribution of Enamel Hypoplasias and Weaning in a Caribbean Slave Population. *Human Biology*, *57*(4), 699-711.

Cucina, A. (2002). Brief Communication: Diachronic Investigation of Linear Enamel Hypoplasia in Prehistoric Skeletal Samples from Trentino, Italy. *American Journal of Physical Anthropology, 119*, 283-287.

Cucina, A., & Iscan, M. Y. (1997). Assessment of Enamel Hypoplasia in High Status Burial Site. *American Journal of Human Biology, 9*, 213-222.

Danforth, M. E. (1999). Nutrition and Politics in Prehistory. *Annual Review of Anthropology, 28*, 1-25.

Danforth, M. E. (2012). A Compilation and Synthesis of Mississippi Bioarchaeology. *Mississippi Archaeology, 42*, 105-174. (Volume dated 2008).

Danforth, M. E., Jackson, H. E., & Funkhouser, J. L. (2011). Final Report on Analysis of Human Remains Produced by Archaeological Investigations by Moreau Chambers and James A. Ford in the State of Mississippi. Submitted to Mississippi Department of Archives and History, Jackson.

Danforth, M. E., Jacobi, K. P., Wrobel, G., & Glassman, S. (2007). Health and the Transition to Horticulture in the South-Central U.S. In M. N. Cohen & G. Kramer-Crane (eds.). *Ancient Health*. (pp. 299-338). New York, NY: Springer.

Egnatz, D. G. (1983). Appendix A: Analysis of Human Skeletal Material from Mound C. In S. Williams & J. Brain (eds.), *Excavations at the Lake George Site Yazoo County, MS 1958-1960.* (pp. 421-441). Cambridge, MA: Harvard University Press.

El-Najjar, M. Y., Andrews, J., Moore, J. G., & Bragg, D. G. (1982). Iron Deficiency Anemia in Two Prehistoric American Indian Skeletons: A Dietary Hypothesis. *Plains Anthropologist, 27, 205-9.*

El-Najjar, M. Y., & Lozoff, B. (1976). The Etiology of Porotic Hyperostosis Among the Prehistoric and Historic Anasazi Indians of Southwestern United States. *American Journal of Physical Anthropology, 44*, 477-88.

Flosenzier, D. B. (2010). *Mississippian Feasting Strategies in the Lower Mississippi Valley: Archaeobotanical Analysis of Two Features from Winterville Mounds (22WS500).* Master's thesis. University of Southern Mississippi, Hattiesburg.

Goodman, A. H., Armelagos, G. J. & Rose, J. C. (1980). Enamel Hypoplasias as Indicators of Stress in Three Prehistoric Populations from Illinois. *Human Biology, 52*(3), 515-528.

Goodman, A. H., & Armelagos, G. J. (1989). Infant and Childhood Morbidity and Mortality Risks in Archaeological Populations. *World Archaeology*, *21*(2), 225-243.

Goodman, A. H., Lallo, J., Armelagos, G. J., & Rose, J. C. (1984). Health Changes at Dickson Mounds, Illinois (AD 950-1300). In M. N. Cohen & G. J. Armelagos (eds.), *Paleopathology at the Origins of Agriculture.* (pp. 271-306). Gainesville, FL: University Press of Florida.

Handler, J. S., & Corruccini, R. S. (1986). Weaning among West Indian Slaves: Historical and Bioanthropological Evidence from Barbados. *The William and Mary Quarterly, 3rd Series, 43*(1), 111-117.

Hillson, S. (2005). *Teeth*. Cambridge, UK: Cambridge University Press.

Hrdlička, A. (1940). *Catalog of Human Crania in the United States National Museum Collections: Indians of the Gulf States.* Washington, DC: Smithsonian Institution Press.

Hogue, H. S. (2008). Bioarchaeology in the Mississippi Delta. In J. Rafferty & E. Peacock (eds.), *Time's River*: *Archaeological Synthesis from the Lower Mississippi River Valley*. (pp. 182-200). Tuscaloosa, AL: University of Alabama Press.

Ide, J. I. (2015). *One Big Puzzle, Two Thousand Tiny Pieces: An Analysis of the Juvenile Remains from the Shady Grove Ossuary.* Master's thesis. University of Southern Mississippi, Hattiesburg.

Kennedy, A. R. (1984). Growth, Nutrition, and Pathology in Changing Paleodemographic Settings in South Asia. In M. N. Cohen & G. J. Armelagos (eds.), *Paleopathology at the Origins of Agriculture.* (pp. 165-192). Gainesville, FL: University Press of Florida.

King, A. (2003). *Etowah: The Political History of a Chiefdom Capital*. Tuscaloosa, AL: University of Alabama Press.

Kondo, S., & Eto, M. (1975). Physical Growth Studies on Japanese-American Children in Comparison with Native Japanese. *Human Adaptability, 1*, 13-45.

Larsen, C. S. (1997). *Bioarchaeology: Interpreting Behavior from the Human Skeleton*. Cambridge, UK: Cambridge University Press.

Larsen, C. S. (2006). The Agricultural Revolution as Environmental Catastrophe: Implications for Health and lifestyle in the Holocene. *Quaternary International*, *150*(1), 12-20.

Larsen, C. S., & Sering, L. E. (2000). Inferring Iron-Deficiency Anemia from Human Skeletal Remains: The Case of the Georgia Bight. In P. Lambert (ed.), *Bioarchaeological Studies of Life in the Age of Agriculture: A View from*

Southeast. (pp.116-133). Tuscaloosa, AL: University of Alabama Press.

Larsen, C. S., & Thomas, D. H. (1982). *The Anthropology of St. Catherines Island: 4. The St. Catherines Period Mortuary Complex.* Anthropological Papers of the American Museum of Natural History, 57, part 4. New York.

Listi, G. (2007). *Bioarchaeological Analysis of Diet and Nutrition During the Coles Creek Period in the Lower Mississippi Valley.* Doctoral dissertation. Tulane University, New Orleans.

Listi, G. (2011). Bioarchaeological Analysis of Diet During the Coles Creek Period in the Southern Lower Mississippi Valley. *American Journal of Physical Anthropology, 144*, 30-40.

McNutt, C. H. (1996). The Upper Yazoo Basin in Northwest Mississippi. In C. McNutt (ed.), *Prehistory of the Central Mississippi Valley,* (pp.155-186). Tuscaloosa, AL: University of Alabama Press.

Mitchell, N. R. (1977). *Paleopathology in Archaeology: The Humber Site (22CO601) as a Case Study*. Master's thesis. University of Mississippi, Oxford.

Moore, C. B. (1908). Certain Mounds of Arkansas and Mississippi. *Journal of the Academy of Natural Science of Philadelphia, 2nd series, 14*, 367-478.

Muller, J. (1997). *Mississippian Political Economy*. New York, NY: Plenum Press.

Ortner, D. J. (2003). *Identification of Pathological Conditions in Human Skeletal Remains, 2nd ed.* New York, NY: Academic Press.

Peacock, E., Hagg, W. R., & Warren, M. L. Jr. (2005) Prehistoric Decline in Freshwater Mussels Coincident with the Advent of Maize Agriculture. *Conservation Biology, 19*(2), 547-551.

Peebles, C. S. (1979). Biocultural Adaptation in Prehistoric America: An Archaeologist's Perspective. In R. Blakely (ed.), *Biocultural Adaptation in Prehistoric America,* (pp. 115-130). Athens, GA: University of Georgia Press.

Phillips, P., Ford, J. A., & Griffin, J. B. (1951). *Archaeological Survey in the Lower Yazoo Basin, Mississippi 1949-1955*. Peabody Museum of Archaeology and Ethnology, v. 60. Cambridge, MA: Harvard University Press.

Powell, M. L. (1988). *Status and Health in Prehistory: A Case Study of the Moundville Chiefdom.* Washington, DC: Smithsonian Institution Press.

Powell, M. L. (1989). The Nodena People. In D. Morse (ed.), *Nodena, An Account of 90 Years of Archaeological Investigation in Southeast Mississippi County, Arkansas.* (pp. 65-95, 127-150). Research Series No. 30. Fayetteville, AR: Arkansas Archaeological Survey.

Powell, M. L. (1991). Ranked Status and Health in the Mississippian Chiefdom at Moundville. In M. L. Powell, P. S. Bridges, & A. M. Mires (eds.). *What Mean These Bones? Studies in Southeastern Bioarchaeology*. Tuscaloosa, AL: University of Alabama Press.

Roberts, C., & Manchester, K. (2005). *The Archaeology of Disease*. Ithaca, NY: Cornell University Press.

Robinson, R. K. (1976). *Social Status, Stature, and Pathology at Chucalissa (40SY1), Shelby County, Tennessee.* Master's thesis. University of Tennessee, Knoxville.

Rose, J. C., Burnett, B. A., Blaeuer, M. W., & Nassaney, M. S. (1984). Paleopathology and the Origins of Maize Agriculture in the Lower Mississippi Valley and Caddoan Culture Areas. In In M. N. Cohen & G. J. Armelagos (eds.), *Paleopathology at the Origins of Agriculture.* (pp. 393-424). Gainesville, FL: University Press of Florida.

Rose, J. C., Condon, K. W., & Goodman, A. H. (1985). Diet and Dentition: Developmental Disturbances, In R. I. Gilbert & J. H. Mielke (eds.), *The Analysis of Prehistoric Diets.* (pp. 281-305). Orlando, FL: Academic Press.

Rose, J. C., Marks, M. K., & Tieszen, L. L. (1991). Bioarchaeology and Subsistence in the Central and Lower Portions of the Mississippi Valley. In M. L. Powell, P. S. Bridges, and A. M. Mires (eds.), *What Mean These Bones? Studies in Southeastern Bioarchaeolgy,* (pp. 7-21). Tuscaloosa, AL: University of Alabama Press.

Ross-Stallings, N. A. (1988). Phase I Report. Report submitted to Mississippi Department of Archives and History, Jackson.

Ross-Stallings, N. A. (1989a). Phase II Report. Report submitted to Mississippi Department of Archives and History, Jackson.

Ross-Stallings, N. A. (1989b). Treponemal Syndrome at the Austin Site (22TU549): A Preliminary Report. *Mississippi Archaeology*, *24*(2), 1-16

Ross-Stallings, N. A. (1991). Phase IV Report to MDAH. Report submitted to Mississippi Department of Archives and History, Jackson.

Ross-Stallings, N. A. (1997). Treponemal Syndrome in the Mississippi Delta: A Case from the Barner Site (22CO542) and a Probable Case of Congenital Treponemal Syndrome from the Austin Site (22TU549). In C. McNutt (ed), *Results of Recent Archaeological Investigations in the Greater Mid-South.* (pp. 95-110).

Anthropological Research Center Occasional Paper No. 18, University of Memphis, Memphis.

Ross-Stallings, N. A. (2007). Trophy Taking in the Central and Lower Mississippi Valley. In R. Chacon & D. Dye (eds.), *The Taking and Displaying of Human Body Parts as Trophies by Amerindians.* (pp. 339-369). New York, NY: Springer.

Sciulli, P. W., & Giesen, M. J. (1993). Brief Communication: An Update on Stature Estimation in Prehistoric Native Americans of Ohio. *American Journal of Physical Anthropology*, 92, 395-399.

Scott, S. (2009). Shady Grove Site: An Analysis of Health and Mortuary Patterns. Paper presented at the 66th Annual Meeting of the Southeastern Archaeological Conference, Mobile.

Scott, S. (2011). *Shady Grove Site (22QU525) Quitman County, Mississippi: Analysis of Demographics and Mortuary Practices*. Master's thesis. University of Southern Mississippi, Hattiesburg.

Smith, G. P., McNutt, C., & Barnes, M. R. (1993). National Register of Historic Places Inventory-Nomination: Chucalissa Site (40SY1). (PDF). National Park Service, retrieved 2009-06-22

Steckel, R. H., & Rose, J. C. (2002). *The Backbone of History: Health and Nutrition in the Western Hemisphere.* New York, NY: Cambridge University Press.

Steinbock, R. T. (1976). *Paleopathological Diagnosis and Interpretation.* Springfield, IL: C. C. Thomas.

Steponaitis, V. P. (1986). Prehistoric Archaeology in the Southeastern United States. *Annual Review of Anthropology*, *15*, 363-404.

Steponaitis, V. P., Williams, S. R., Davis, S. P, Brown, I. W., Kidder, T. R., & Salvanish (eds.). (2002). *LMS Archives Online*. Site Files: 16-P-2, p. 6, http://rla.unc.edu/archives/lms1/ (9/9/2015).

Stini, W. A. (1976). Evolutionary Implications of Changing Nutritional Patterns in Human Populations. *American Anthropologist, 73*(5), 1019-1030.

Stinson, S. (1985). Sex Differences in Environmental Sensitivity during Growth and Development. *Yearbook of Physical Anthropology*, *28*, 123-147.

Stuart-Macadam, P. (1992). Porotic Hyperostosis: A New Perspective. *American Journal of Physical Anthropology, 87*, 39-47.

Tesar, L. D. (1976). *The Humber-McWilliams, A Pre-Columbian Burial Ground, Coahoma Co, Mississippi: Exploration and Analysis, 1975-1976.* Marshall, TX: Port Caddo.

Thompson, A. R. (2008). *Reconstructing Life in the Protohistoric Southeast: A Bioarchaeological Analysis of the Oliver Site (22CO503), Coahoma County, Mississippi*. Master's thesis. University of Southern Mississippi, Hattiesburg.

Waldron, T. (2009). *Palaeopathology*. New York, NY: Cambridge University Press.

Wallings, R., & Chapman, S. (1999). *Archaeological Data Recovery at the McKnight Site (22CO500), Coahoma County, Mississippi.* Panamerican Consultants, Inc., Memphis. Submitted to Environmental Division, Mississippi Department of Transportation, Jackson.

Walker, P. L., Johnson, J. R., & Lambert, P. (1988). Age and Sex Biases in the Preservation of Human Skeletal Remains. *American Journal of Physical Anthropology*, *76*, 183-188.

Walker, P., L., Bathurst, R., Richman, R., Gjerdrum, T., & Andrushko, V. (2009). The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anemia Hypothesis. *American Journal of Physical Anthropology, 139*, 109-125.

Williams, S., & Brain, J. P. (1983). *Excavations at the Lake George Site, Yazoo County, Mississippi, 1958-1960.* Peabody Museum of Archaeology and Ethnology, vol. 1 Cambridge, MA: Harvard University Press.

Wood, J. W., Milner, G. R., Harpending, H. C., & Weiss, K., (1992). The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples [and Comments and Reply]. *Current Anthropology*, *33*(4), 343-370.

Wright, L. E., & Yoder, C. J. (2003). Recent Progress in Bioarchaeology: Approaches to the Osteological Paradox. *Journal of Archaeological Research*, *11*(1), 43-70.