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# The agriculturalists of the Poole-Rose ossuary: a study of the femora and tibiae

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THE AGRICULTURALISTS OF THE POOLE-ROSE OSSUARY: A STUDY OF THE  
FEMORA AND TIBIAE

A Thesis

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
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in

The Department of Geography and Anthropology

by  
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## **ABSTRACT**

Dr. Heather McKillop of Louisiana State University was asked by the Alderville First Nation of Ontario in 1990 to excavate the Poole-Rose ossuary in 1990. This mass burial consisted of hundreds of mixed disarticulated and de-fleshed individuals as well as three articulated individuals laid in flexed positions. No artifacts were discovered with the bodies. Due to the absence of stratified soil layers from different periods, McKillop estimated the ossuary occurred during one burial event- "The Feast of the Dead." Radiocarbon dating found the ossuary to be from A.D. 1550  $\pm$  50 years (McKillop and Jackson 1991).

I estimated sex according to measurements that fall below or rise above the means of femoral and tibial midshaft anteroposterior and mediolateral diameters (Dap and Dml; Dmax and Dmin, respectively), circumferences, and external breadth index (Dap/Dml). I also calculated sexual dimorphism of the Poole-Rose samples from those femoral and tibial midshaft measurements and measurements of the nutrient foramina anteroposterior/mediolateral ratio (Dmax/Dmin). I compared Poole-Rose sample means to Christopher Ruff's (1987) similar reports of measurements in hunter-gatherer, agriculturalist, and industrialist samples. I also compared Poole-Rose means to Patricia Bridges's (1989) study of femoral and tibial midshaft circumferences of agriculturalists and hunter-gatherers.

This study tests the hypothesis that agricultural populations have lower sexual dimorphisms of the femur and tibia when compared with hunter-gatherer populations. I studied 325 tibiae and 281 femora. I assigned sex to 293 tibiae (146 females and 147 males) and 229 femora (113 females and 116 males). The Poole-Rose sexual dimorphism of femoral midshaft external breadth index was lower than Ruff's (1987) hunter-gatherer samples and fell within the range of Ruff's agricultural sample sexual dimorphisms. Poole-Rose tibial midshaft and nutrient

foramina external breadth indices are higher than Ruff's (1987) hunter-gatherers and agriculturalists. Poole-Rose femoral midshaft external breadth indices almost equal to Ruff's (1987) Georgia Coast sample mean of agriculturalists. Poole-Rose femoral and tibial midshaft circumference means are also higher than Bridges's (1989) hunter-gatherers and agriculturalists.



## **CHAPTER 1. ETHNOGRAPHIC LITERATURE REVIEW OF THE LATE WOODLAND PEOPLE**

Much information is written about the historic Huron Indians, so they provide a useful comparison for the life ways of prehistoric Late Woodland people such as the native peoples interred in the Poole-Rose ossuary. The Poole-Rose ossuary is located outside Huron territory and is not a Huron burial (Heather McKillop, personal communication 2007). Huron Indians, who shared the unified language of Iroquoian, descended from early hunter-gatherers in southern Ontario during the Archaic and Early/Middle Woodland periods (Spence 1986; Trigger 1969). Huron tribes hunted, gathered, fished, and grew crops for subsistence. An estimated 10,000 Huron Indians lived in the Great Lakes region at the time that Columbus reached America in the late 15<sup>th</sup> century (Ritzenthaler and Ritzenthaler 1983).

Individual Huron tribes had their own territories in which to hunt in separately from the other tribes. Tribes came together in the spring and summer with the abundance of resources, and then they dispersed in the winter due to scarce resources. Alliances between tribes, who lived together in large villages, also aided in protection from enemies during warfare. Eventually, migrations among Huron populations and village growth caused the different tribes to establish the Huron Confederacy around A.D. 1500 as a shared hunting territory for all Huron tribes (Ramsden 1990; Trigger 1969).

The land occupied by the Huron Confederacy, called “Huronian,” allowed separate tribes to live in close vicinity to one another. Huronia was “the area between Georgian Bay and Lake Simcoe in what is now the northern part of Simcoe County, Ontario” (Dickason 1996; Johnston and Jackson 1980:173; Leitch 1979). Originally, there were four tribes; yet by the late 1630s, there were five, according to the Jesuit missionaries (Heidenreich 1978). From 1634 to 1650, Jesuit missionaries worked to convert the souls of the Indians in Huronia and kept descriptive

field records of their progress (Johnston and Jackson 1980). Recent analyses show 20,000 people lived in Huronia by the mid-17<sup>th</sup> century (Johnston and Jackson 1980).

Huronia consisted of both small and large villages (surrounded by wooden palisades) built on high ground and close to water sources. Huron villages consisted of numerous longhouses. The larger villages accommodated 1500 to 2000 people in 40 or more longhouses (Melbye 1985; Trigger 1969).

The Huron had an egalitarian society with chiefs and shamans. Civil leadership was not a great necessity, although leadership was essential for warfare against European invaders (Ritzenthaler and Ritzenthaler 1983). Chiefs gained their hereditary positions by selection from the “child-bearing women in each family” (Leitch 1979:186). Chiefs of the Woodlands may not have held as much prestige as shamans, however.

Great shamans may have held esteemed roles in religious communities as well as political circles. “Generally speaking, in contrast to a priest, a shaman receives his or her power directly from the spirit world and acquires status and the ability to do things, such as cure, through personal communication with the supernatural,” unlike priests who selected to study and learn from others in the religious community (Stein and Stein 2005:127). Shamans trained with older shamans to enhance their spiritual and mystical knowledge (Stein and Stein 2005).

Huron neighbors lived in close proximity to each other in the community. The Huron utilized the largest longhouse, which was the head chief’s residence, for councils, celebrations, and feasts (Trigger 1969). Also distinct from the numerous neighboring Algonkin tribes who passed descent patrilineally, the Huron clans and other Iroquois clans passed descent matrilineally (Leitch 1979; Ritzenthaler and Ritzenthaler 1983). Longhouses, built near each other, were necessary for extended matrilineal family residences (Dickason 1996; Leitch 1979).

During most activities such as cooking, eating, playing, and socializing, the Huron chose to spend their time together outside the home as weather permitted.

Huron Indians had physical traits comparable to other Woodland Indians. According to Ritzenthaler and Ritzenthaler, Woodland Indians “reflected such Mongoloid traits as brownish skin color; straight, black hair; sparse facial and body hair; dark eyes; wide malars (cheek bones); a trace of the epicanthic fold, which is most apparent in infants; and the Mongolian spot, a bluish-black spot at the base of the spine, also observable mostly in infants” (1983:15). The majority of Woodland Indians were medium to tall in height (men averaged 5’7” and women averaged 5’2”) with slender to medium body builds (Ritzenthaler and Ritzenthaler 1983). Older women tended to be physically stocky (Ritzenthaler and Ritzenthaler 1983). However, while most Indians of the northeastern U.S. had appearances of “longheadedness” (dolichocephaly), the Iroquois and Hurons had “roundheadedness” (Ritzenthaler and Ritzenthaler 1983). Scientists refer to roundheadedness as “brachycephaly” (Bass 2005:70).

### **1.1. Subsistence Economy**

Hunting and trapping, gathering, and fishing provided some resources for the Huron and other Late Woodland Indians. The Huron diet consisted of food trapped or hunted (on foot, by canoe, by toboggan, or by sled) by men with wooden bows and arrows and domesticated dogs (Heidenreich 1978; Ritzenthaler and Ritzenthaler 1983). Men hunted game such as deer, moose, fox, a variety of fowl, and bear (not without special ceremonial requests for forgiveness, for bears were highly important to Native American Indian cultures). Utilization of pitfalls, deadfalls, nets, and nooses enabled men to trap a variety of animals in the winter, such as otter, beaver, mink, and partridge (Ritzenthaler and Ritzenthaler 1983). Snowshoes (invented by North American Indians) made treading in the snow easier (Ritzenthaler and Ritzenthaler 1983).

Year-round fishing mainly by men yielded trout, pike, sturgeon, and turtles from local streams and lakes (Heidenreich 1978; Trigger 1969). In the spring, men used nets, spears, bait on hooks made of deer bone and native copper, and V-traps (Ritzenthaler and Ritzenthaler 1983). V-traps built with timber or rocks allowed fish to swim into the apex of the V, where the Huron clubbed them. Also, men ice fished on frozen lakes during the winter (Ritzenthaler and Ritzenthaler 1983).

Women and children collected wild foods such as berries (cranberries, blueberries), plants such as herbs for medicines and rituals, sunflower seeds, nuts (acorns, hazelnuts, butternuts), and vegetables (potatoes and onions) (Hudson 1999; Ritzenthaler and Ritzenthaler 1983). Women attached buckets made of birchbark to their waists in order to fill them with gathered food. “At the beginning of each season, everyone was so hungry for the fresh fruits or berries that much of the crop was eaten immediately, but they gathered enough to cook, make into preserves or jams, or dry to be eaten as a seasoning with dried meat” (Ritzenthaler and Ritzenthaler 1983:21).

Varieties of gardening allowed the Huron to depend on not only hunting, gathering, and fishing. The Huron grew crops of maize, beans, and squash. The Huron economy was 80% agriculture (Dickason 1996). “They operated out of fairly permanent villages and within a radius of perhaps a hundred miles, but their seasonal cycle kept them on the move much of the time” (Ritzenthaler and Ritzenthaler 1983:19). Women cultivated, harvested, and stored maize (corn), beans, and squash seasonally with wooden hoes and digging tools (Heidenreich 1978; Ramsden 1990; Ritzenthaler and Ritzenthaler 1983; Trigger 1969).

Maize, beans, and squash complement each other as they can all be grown in the same field; for this reason, the Huron cultivated them by A.D. 1500 and called them the “three sisters”

(Dickason 1996; Hudson 1999). Eastern flint corn reached the eastern United States between A.D. 800 and 1000. The Plains and Northeast Indians later developed this corn into “a hard northern flint corn which was especially adapted to a short growing season” (Hudson 1999:292; Dickason 1996). “Huron women produced about 1.3 pounds of corn for each family member’s daily allotment” (Hurt 1987). As early as A.D. 800 to 1000, eastern United States Indians began to grow many varieties of beans (i.e. kidney, snap, and pole beans) (Hudson 1999). Beans needed to grow on bushy plants or vines; therefore, corn stalks and poles served as excellent spots for bean growth that usually takes up to ten weeks (Hudson 1999). Indians have been cultivating squash (pumpkins and summer squashes) since the Early Woodland Period around 1000 B.C. (Hudson 1999). Squash grows effortlessly and plentifully (Hudson 1999). Indian women also found squash to be easily stored and well preserved in winter months (Hudson 1999).

The benefits of cultivating the “three sisters” together are great. “While corn removes nitrogen from the soil, beans replace nitrogen, and the soil is therefore exhausted more slowly” (Hudson 1999:294). Since the land’s minerals did not deplete in just a few years, the Huron could stay in one settlement from eight to thirty years without having to move to the next settlement (Heidenreich 1978; Ramsden 1990; Trigger 1969). Even though the Huron practiced slash-and-burn techniques and weeded the fields and gardens, eventually the Huron villages had to move to new pieces of land to cultivate their crops (Heidenreich 1978; Melbye 1985; Ramsden 1990; Trigger 1969).

Nutritionally, agricultural diets included many essential vitamins and nutrients. Maize, beans, and meat supply protein, but corn lacks the vital amino acid lysine that is “relatively abundant in beans” (Hudson 1999:294). The three sisters have rich vitamins as well. However,

Pfeiffer and King (1983) found evidence of Huron adults from the Kleinburg and Uxbridge ossuaries (west of the Poole-Rose ossuary) with thin cortical bones. Nutrient deficiencies associated with maize agriculture in the Kleinburg and Uxbridge populations were the suggested causes (Pfeiffer and King 1983).

Trade was also important to the Huron people. “Corn, fish, tobacco, and hemp were obtained from the Neutral and Petun and traded to northern Algonquian tribes for furs, principally beaver, which the Huron in turn traded to the French for various goods” (Leitch 1979:187). For protection of resources, the Huron did not allow the French to trade with the Neutral or Petun Indians (Leitch 1979). Huron men left their villages to trade from June to September (Leitch 1979).

### **1.2. Cultural Importance of the Feast of the Dead**

Cultural anthropology is “the study of specific contemporary cultures (ethnography) and the more general underlying patterns of human culture derived through cultural comparisons (ethnology)” (Ferraro 2006:11). Ethnography allows emic (an insider’s view, i.e. a member of the culture studied) and etic (an outsider’s view, i.e. the anthropologist) approaches to describe and classify cultures. Ethnographic descriptions show the Feast of the Dead served to enable religious afterlife, social adherence, and future economic stability.

The Huron culture was first written about by Samuel de Champlain when he met a Huron war party in New York in 1608 and later visited Huronia from 1615 to 1616 (Johnston and Jackson 1980; Kidd 1953). Gabriel Sagard, who visited the Huron from 1623 to 1624, also wrote of them (Kidd 1953; Johnston and Jackson 1980). Father Jean de Brébeuf, a Jesuit missionary, best described and ethnographically recorded the Hurons of the village Ihonatiria and their religious ceremonies in 1636. Reuben G. Thwaites published Brébeuf’s accounts in

The Jesuit Relations and Allied Documents, Volume X, pages 279-305 (Kidd 1953; Ubelaker 1978).

According to Johnston (1979), large ossuaries are an “Ontario phenomenon” that the Huron, Neutral, and Petun Indians practiced in North America. When a large Huron village exhausted its land of resources (timber, maize, beans, squash), the Feast of the Dead took place. However, other factors such as population growth and readily available resources for the Feast also affected when the Feast of the Dead would take place. The village invited other smaller villages to join in gathering all of their dead, who died after the last Feast, for reburial in a communal pit called an ossuary (“kettle” was the term used by the Huron, according to Father Brébeuf) (Kidd 1953:372). Strengthening social relations among different clans, tribes, and guests was through sharing the wealth of Huron goods and available resources.

The number of years between each Feast of the Dead varies among different ethnohistories. According to Father Brébeuf, the Feast occurred every ten to twelve years (Kidd 1953; Ubelaker 1978). Today, ten to twelve years is the most widely agreed amount of time between the Feasts (Johnston and Jackson 1980; Kapches 1976; Kidd 1953; Leitch 1979; McKillop and Jackson 1991; Trigger 1969; Ubelaker 1978).

Because of a great belief in the afterlife, the Hurons thought the souls chosen for reburial would go to the afterlife. There, the dead could live as they once did on Earth. Those Huron who drowned, died in battle, committed suicide, or had violent deaths were not included in reburial. The Huron allowed only the recently deceased and people who were neither infants nor elderly for burial in the pit (Heidenreich 1978; Ramsden 1990; Trigger 1969). Hurons believed infants, buried along a road or path, would reincarnate by entering the womb of a woman passing by (Kapches 1976; Trigger 1969). However, the Huron, like many other cultures around the

world, buried most infants and young children in the walls or floors of houses and in or around the village, perhaps to keep the dead nearby (Kapches 1976; Stein and Stein 2005). Vessels and copper kettles also entombed children. The Huron believed the elderly souls could not make their way to the afterlife since they lacked the strength to endure the long journey (Trigger 1969).

The Feast of the Dead lasted ten days and included social events and games. After the large banquet to honor the deceased loved-ones, the first eight days began with gathering the dead bodies. After retrieving the bodies, women of the village disarticulated and scraped the bones clean of flesh and muscle. Then women washed and wrapped the bones in fur skins. “Since all those who died since the last ceremony were included, however, some were less completely decomposed” (Ubelaker 1978:19). The Huron buried recently deceased individuals in a grave or placed them high above the ground on top of wooden scaffolds. The Huron women did not de-flesh these people, but they did wrap the bodies in new robes, according to Father Brébeuf (Kidd 1953; Ubelaker 1978). The people then gathered and burned the belongings primarily buried with the deceased (Trigger 1969).

The last two days of the Feast of the Dead were spent depositing the mass of bones inside the fur-lined ossuary (usually circular-shaped) with the articulated bodies of recently deceased people placed at the bottom and in flexed positions (Kidd 1953). Men stirred the bones with long wooden poles symbolically to unite the Huron tribes together politically and socially. The complete randomness of distribution of the stirred bones is best stated by Kidd’s description of the Huron ossuary: “The bones lay in extreme miscegenation, perhaps best exemplified by crania lying inside pelvic cavities, ribs perforating eye sockets” (1953:363) and vertebrae in unexplainable positions. This description is most likely the same one also described by Father Brébeuf in 1636 due the general location of the Ossossané site and the artifacts found by Kidd



and described by Brébeuf (Kidd 1953). Finally, the village viewed the bodies and later covered the pit with more fur skins.

At the end of the ceremony, the people filled the pit with food and gifts. Dirt surrounded the ossuary for eternity. By Father Brébeuf's account, the rich Indians could afford to give many valuable items. Yet the middle-class and poor people brought whatever gifts were most valuable "in order not to appear less liberal than the others in this celebration. Everyone makes it a point of honor" (Kidd 1953:375). Droughts, as in 1628 and 1635, could have affected food supplies of the Huron (Heidenreich 1971). Twice every ten years famines occurred with summer droughts (Heidenreich 1978). The Poole-Rose ossuary did not contain any artifacts (McKillop and Jackson 1991).

Fur trading caused the expansion of Iroquois tribes south of the Huron (Dickason 1996; Leitch 1979). The Iroquois of the Five Nations (Senecas, Oneidas, Mohawks, Cayugas, and Onondagas) massacred Huron villages between 1648 and 1651. Most Hurons abandoned their villages. The Iroquois killed or imprisoned the remaining Huron people. The Huron Confederacy and ossuary burials discontinued by the end of the 17<sup>th</sup> century. According to Elliott (1887), the only massacre-surviving Huron village to remain into the late 19<sup>th</sup> century was that of Lorette, located near Quebec, Canada.

### **1.3. Archaeological Finds of the Poole-Rose Ossuary and Other Ossuaries**

Building contractors discovered the Poole-Rose site in the summer of 1990. They uncovered human skeletal remains behind a 19<sup>th</sup> century farmhouse. Dr. Heather McKillop, an archaeologist now with Louisiana State University, excavated the Poole-Rose ossuary. The site was 2.5 meters below the ground surface and extended 1.5 meters deep. It stretched approximately 2.5 meters in diameter. Several hundred male and female individuals of varying

ages filled the ossuary, but archaeologists recovered no artifacts. Radiocarbon testing dated the Poole-Rose ossuary to A.D. 1550 ± 50 years, within the Late Woodland period (McKillop and Jackson 1991).

In contrast to the Poole-Rose ossuary that contained no artifacts, Kidd (1953) excavated varying and numerous artifacts at Ossossané, perhaps the same ossuary described by Father Jean Brébeuf in 1636. They included shell beads, “stone projectile points, pigments, textile fabrics, and pipes” (Kidd 1953:364). Kidd (1953) added that only Huron body ornaments were made of shell, indigenous and exotic kinds. European goods included copper kettles, iron knives, table knives, metal awls, glass beads, and imported copper finger rings. Other items found at Ossossané were multiple beaver skins (preserved by copper salts) and a copper kettle that contained a birchbark basket (probably a Huron item). These mixed modern and indigenous items show how Europeans and Huron Indians could exist well together and borrow one another’s material cultures.

## **CHAPTER 2. BONE MORPHOLOGY LITERATURE REVIEW**

Wolff's Law states, "Every change in the function of a bone is followed by certain definite changes in its internal architecture and its external conformation" (Bacon 1990:363). Hydroxyapatite crystals and collagen that make up bone will orient to help bone resist external forces. Therefore, bone will remodel itself according to the amount and direction of the forces applied to bone. The orientation of these hydroxyapatite crystals and collagen will change variably throughout one's lifetime, depending on the type of physical work an individual chooses to do and how often one works (Bacon 1990). Bone will be deposited by osteoblasts where needed to compensate for the amount of external force that is put on the body; conversely, bone will be taken away by osteoclasts from areas of the body that do not bear external forces (Larsen 1995). As a result, the subperiosteum and endosteum of cortical bone will expand or become smaller in areas functionally significant or insignificant during one's growth (Larsen 1995).

### **2.1. Midshaft and Nutrient Foramina External Breadth Index Studies of Femora and Tibiae**

In the article "Sexual Dimorphism in Human Lower Limb Bone Structure: Relationships to Subsistence Strategy and Sexual Division of Labor," Ruff compared the sexual dimorphisms of hunter-gatherer, agricultural, and industrial societies temporally "because it was anticipated that subsistence technology and relative differences between the sexes in mobility and other behavioral patterns would be related" (1987:398). Ruff collaborated with Dr. Wilson C. Hayes in the Orthopaedic Biomechanics Laboratory to collect data on Pecos Pueblo Indians and modern U.S. Whites (Ruff and Hayes 1983). Ruff measured the external breadth index (the anteroposterior diameter divided by the mediolateral diameter-  $D_{ap}/D_{ml}$ ) of the femoral and tibial midshafts and nutrient foramina of 119 adult (59 males and 60 females) Pecos Pueblo Indian agriculturalists from New Mexico and 47 adult modern U.S. White industrialists (23

males and 24 females). U.S. White tibial measurements of external breadth indices of midshafts and nutrient foramina came from 42 tibiae (19 males and 23 females). The external breadth index of femoral midshafts also is the pilasteric index. He claimed, "Breadth measurements for the femoral midshaft, or pilasteric index, are more likely to be taken in or very close to the true A-P and M-L planes of the femur, because the linea aspera of the femur lies almost directly posterior and makes an obvious landmark for orientation" (Ruff 1987:400). Therefore, the pilasteric index is similar to the  $I_x/I_y$  ratio of the moment of inertia ("x"=A-P axis and "y"=M-L axis), although the values differ. When  $I_x/I_y=1.0$ , an equal distribution of bone is found. A ratio of greater or lesser size means more bone is distribution in either the x- or the y-axis, respectively, of the bone studied.

Ruff compared the  $I_x/I_y$  of the three categories of subsistence in his Table 3 (1987:398). In addition to the Pecos Pueblo and U.S. White industrialist samples, Ruff included separate populations (ten males and ten females from each) studied by other scientists. The femoral midshaft  $I_x/I_y$  of males was greater than females in all hunter-gatherer samples (8 to 36% sexual dimorphism in Georgia, New Mexico, Tennessee River Valley, and prehistoric Japan) and in most agricultural samples (2 to 9% sexual dimorphism in Georgia, New Mexico, and Pecos Pueblo) (Ruff 1987:398-399). The industrial samples (modern Japanese and U.S. White) showed no sexual dimorphism with only a range of -2 to 1% (Ruff 1987:399). Overall, however, samples decreased in sexual dimorphism from hunter-gatherers to industrialists. "Later, Ruff (1999) compared sex differences in  $I_x/I_y$  ratio between hunter-gatherers and horticulturalists in the Southeast, Southwest, and Great Plains, finding that nearly all hunter-gatherer groups exhibited greater sexual dimorphism in femur shape than horticultural populations" (Wescott 2006:202).

From Ruff's Table 4 (1987:401; Table 1 here) of the samples measured, Ruff (1987) concluded that sexual dimorphism at the femoral midshaft decreased, without overlapping, among populations with differences in subsistence technologies: "hunter-gatherers range from 7 to 15%, agriculturists from 3 to 6%, and industrial period groups from -1 to 1% sexual dimorphism" (1987:400-401). Hunter-gatherer samples included in Ruff's study of femoral midshaft external breadth indices were from Australia, two from the Ohio River area, one from the Tennessee River Valley, one from the Georgia Coast, one from New Mexico, and one from prehistoric Japan. Among the agriculturalist samples, two were from the Ohio River area, one from the Tennessee River Valley, one from the Georgia Coast, one from New Mexico, one Pecos Pueblo, and two from Great Britain. Ruff then added industrialist samples that included modern Japanese, two modern British, and two modern U.S. Whites.

Ruff's study of the tibial nutrient foramina external breadth index ( $D_{max}/D_{min}$ ; "platycnemic index") showed sexual dimorphism declined (1987:401, Table 4; Table 1 here). According to Bass, the platycnemic index "expresses the degree of mediolateral flatness of a tibia" (2005:247). Ruff listed two samples from Ohio River as "Ohio River 1" and Ohio River 2". Ruff also included two British samples called "British 1" and "British 3"; "British 2" did not pertain to this study. "U.S. White 1," "U.S. White 2," and "U.S. White 3" completed the three modern U.S. White samples. In Table 4 of Ruff (1987:401; Table 1 here), Ruff studied hunter-gatherer and agriculturalist samples from Ohio River 1 and Tennessee River, as well as an industrialized U.S. White sample 3. The Ohio River hunter-gatherer sample showed the greatest sexual dimorphism of 8% (male  $D_{max}/D_{min}=1.43$  and female  $D_{max}/D_{min}=1.32$ ). For the Ohio River agriculturalist sample, sexual dimorphism of the tibia at the nutrient foramen decreased to 4%, while the sample's external breadth indices at the nutrient foramen ( $D_{max}/D_{min}$ ) increased

in males to 1.61 and in females to 1.54. The Tennessee River samples of hunter-gatherers' and agriculturalists' sexual dimorphisms at the nutrient foramen decreased from 6% to 5%, a 1% difference. Male external breadth index measurements from these Tennessee groups remained stable at 1.60. The industrial U.S. White sample had a negative 1% sexual dimorphism (male  $D_{max}/D_{min}=1.43$  and female  $D_{max}/D_{min}=1.44$ ). This dramatic drop from 8% sexual dimorphism of Ohio River Valley hunter-gatherers to negative 1% in U.S. White industrialists agreed with Ruff's hypothesis that sexual dimorphism does decrease in the mid- to proximal tibiae from hunter-gatherers into industrial times. Only the transition from agriculture to industry shows a dramatic decrease in external breadth index.

## **2.2. External Breadth Index and Circumference Comparisons of Femora and Tibiae**

In "Changes in Activities with the Shift to Agriculture in the Southeastern U.S.," Bridges found the circumferences of the femoral midshafts in Mississippian males and females (agriculturalists) to be bigger than Archaic males and females (hunter-gatherers) in Table 1 (1989:389) (see Table 3 here). Bridges gathered data from hunter-gatherers and agriculturalists from northwestern Alabama. According to the computation  $\{[1-(\text{mean of Agric.}/\text{mean of Pre-Agic.})] \times 100\}$  by Larsen (1981), left male Mississippian femoral midshaft circumference increased by 7% from the Archaic period (Bridges 1989). Right male Mississippian femoral midshaft circumference enlarged by 8% from the Archaic period (Bridges 1989). Left and right female Mississippian femoral midshafts also increased in size by 3% from the Archaic period (Bridges 1989).

In addition, the midshaft circumferences of the tibiae in both sexes in Bridges's (1989) study both increased in size from Archaic times to Mississippian times. Left male Archaic tibial midshaft circumferences became more robust by 5% into Mississippian times. Right male

Mississippian tibial midshaft circumference showed a 6% increase from the times of Archaic hunter-gatherers. Both left and right tibial midshaft circumferences of the Mississippian agriculturalist females had enhanced robusticity of 5%.

Ruff's (1987) and Bridges's (1989) studies differ with respect to sexual dimorphism of femoral midshafts and mid-proximal tibiae between hunter-gatherers to agriculturalists. Perhaps further studies can address the inconsistencies of these related articles.

### **2.3. Femoral Midshaft Robusticity**

Wescott (2006) researched North American groups of prehistoric, early historic, and modern peoples in his article "Effect of Mobility on Femur Midshaft External Shape and Robusticity." Wescott argued that not only do mechanical loads affect long bone morphology, but also do "cultural, environmental, and biological factors" (2006:202). Wescott compared for femoral midshaft sexual dimorphisms and dissimilarities between males and females in the femoral midshaft shape and robusticity. Wescott used various North American samples. Femoral midshaft structure can yield evidence to "detect the level of terrestrial logistic mobility (TLM; daily distance covered by an individual or group from the residence and back) within and between populations" (Wescott 2006:201). According to Wescott (2006:201) and others, use of the  $I_x/I_y$  ratio of the femoral midshaft, or "mobility index," can help to calculate the TLM (Holt 2003; Larsen 1997; Larsen et al. 1995; Ruff 1987, 1994, 1999; Stock and Pfeiffer 2001, 2004).

"Femoral external dimensional data were obtained from the University of Tennessee/Smithsonian Institution (UT/SI) Postcranial database (Wescott, 2001), the Terry Collection (Trotter, 1981), and the Forensic Data Bank (FDB) (Ousley and Jantz, 1998)" (Wescott 2006:202). The UT/SI collection comprised of prehistoric to historic Native

Americans from the United States. Nineteenth and 20<sup>th</sup> century American blacks and whites made up Wescott's data from the Terry collection and FDB.

The mobility index of hunter-gatherers is greater than "horticulturalists, since the former subsistence practice requires more long-distance travel, especially among males, than does the latter" (Wescott 2006:201; Larsen et al. 1996; Ruff 1987, 2000). In addition, horticulture requires less sexual division of labor than hunting and gathering and the result is less femoral midshaft sexual dimorphism among horticulturalists (Bridges 1995; Larsen 1997; Ruff 1987, 2000; Wescott 2006).

Wescott found studies that supported causes for "high anteroposterior (A-P) bending loads from the femur midshaft to the tibia midshaft" (2006:201). Morrison (1968, 1969, 1970) argued that running and climbing contract the hamstrings and quadriceps in the thigh, consequently "modeling modifies the femoral midshaft from its basic circular cross-section to one that is A-P elongated. Therefore, groups with low TLM should have lessened directional loading and thus greater femoral midshaft circularity than highly mobile populations. Likewise, females, who are generally less mobile than males, should have more circular femora than males, especially in hunter-gatherer populations" (Wescott 2006:201).

"Sex differences in mobility levels vary among hunter-gatherers, depending on environmental resources" (Wescott 2006:201; Stock and Pfeiffer 2004). Stock and Pfeiffer (2004) found Later Stone Age males and females in forest and coastal biomes of South Africa differed in long bone formation (Wescott 2006). "Males in both biomes were extremely mobile, but females in the forest biome were more mobile than coastal females" (Wescott 2006:201). Collier (1989) found Aboriginal males had a femoral A-P/M-L ratio (femur midshaft diaphyseal shape-FMS) similar to hunter-gatherers and less than industrialists (Wescott 2006).



### CHAPTER 3. MATERIALS AND METHODS

This study compares the Poole-Rose ossuary agricultural sample's femoral and tibial sexual dimorphisms, external breadth indices, and circumferences to those of other populations. Using the skeletal remains of the Poole-Rose ossuary, I measured the external breadth indices of the adult femoral midshafts ( $D_{ap}/D_{ml}$ ; Figs. 1 and 2), tibial midshafts ( $D_{max}/D_{min}$ ; Figs. 3 and 4), and midshaft circumferences. To find the midshafts of the femora and tibiae, I used an osteometric board. I utilized sliding calipers to measure anteroposterior (A-P) and mediolateral (M-L) diameters to the nearest 0.1 millimeter at the midshafts and nutrient foramina of the femora and tibiae. I also used a plastic tape to measure the circumferences to the nearest millimeter of the femoral and tibial midshafts.

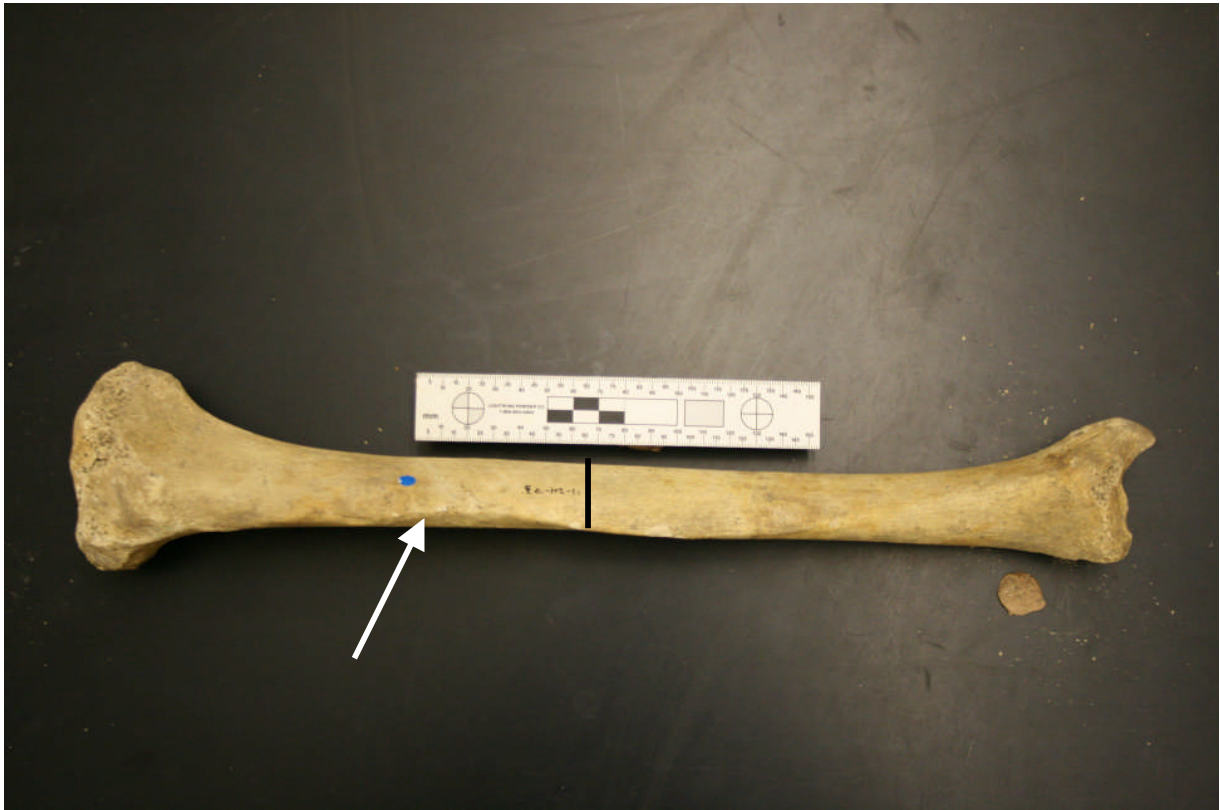


**Figure 1:** Left Femur, Specimen #3-23-783. Anterior/frontal view; left side is proximal end. The black line is the mediolateral diameter ( $D_{ml}$ ) of the midshaft.

I used Excel 2003 spreadsheets to record all diameters, external breadth indices, and circumferences. I assigned all measurements below the means and medians as “female” all measurements above the means and medians as “male.” For example, if more measurements of the midshaft circumference, midshaft diameters, midshaft external breadth index, and nutrient foramen diameters, and nutrient foramen external breadth index of a specimen were higher than the mean/median for each category, the sexual label was “male.” If more measurements in each category were lower than the calculated mean/median for those measurements, I labeled the specimen “female.” I labeled those measurements that yielded no definite determination of sex as “unknown” and omitted them from the final analyses. An “Unknown” individual was determined if even amounts of data that were both male and female means/medians occurred



**Figure 2:** Left Femur, Specimen #3-23-783. Lateral view; left side is proximal end. The black line is the anteroposterior diameter (Dap) of midshaft. The white arrow is the general area of nutrient foramen located on posterior distal side of the bone near the midshaft.



**Figure 3:** Right Tibia, Specimen #11-24-73. Anterior/frontal view; left side is proximal end. The black line is the mediolateral diameter (Dmin) of the midshaft. The white arrow points to the general area of the nutrient foramen located on the posterior lateral side of the proximal shaft.

across data categories or if more of an individual's means/medians equaled to the pre-calculated mean/median determinants.

Plavcan (1994) asserted that the mean method for assigning sexual dimorphism is reliable. Using SPSS 12, I calculated the means and standard deviations of both male and female samples separately for each bone and for right and left sides through one-sample t-tests. I calculated sexual dimorphism (% dif.) as  $[(\text{Male-Female})/\text{Female}] \times 100$  (Ruff 1987). I studied 325 left tibiae (154 left and 171 right) and 281 femora (140 left and 141 right). Sex was assigned to 293 tibiae (left- 71 females and 68 males; right- 75 females and 79 males) and 229 femora

(left-58 females and 58 males; right- 55 females and 58 males). I did not assign 32 tibiae and 52 femora as male or female.

I compared the Poole-Rose male and female external breadth index means and sexual dimorphisms to all of the studies concerned. Ruff's sexual dimorphisms and external breadth index measurements of the femoral and tibial midshafts of three subsistence categories (hunter-



**Figure 4:** Right Tibia, Specimen #11-24-73. Medial view; left side is proximal end. The black line is the anteroposterior diameter (Dmax) of the midshaft.

gatherer, agricultural, industrial) are employed for comparisons (1987). Measurements of the femoral midshaft circumferences in Bridges's (1989) study of males and females from the Mississippian period (agriculturalists) and from the Archaic period (hunter-gatherers) are compared to the Poole-Rose ossuary (1989). Finally, I used Wescott's mobility index to find the TLM of the femoral midshaft external breadth index of the Poole-Rose ossuary.

## CHAPTER 4. RESULTS

The tibial midshaft external breadth indices of the Poole-Rose ossuary (males=1.72 and females=1.56) are higher than Ruff's (1987:401; Table 4) industrial U.S. White sample 3 (males=1.41 and females 1.39) and Ruff's Tennessee River samples of hunter-gatherers (males=1.53 and females=1.47) and agriculturalists (males=1.57 and females=1.49) in Table 1. The sexual dimorphism of the Poole-Rose ossuary tibial midshaft external breadth index of 10% is less than Japanese hunter-gatherers of 15% and is greater than the Ohio River Valley sample 1 hunter-gatherers at 6% (Ruff 1987:401; Table 1 here). Tibial nutrient foramina external breadth indices of the Poole-Rose ossuary (males=1.77 and females=1.58) are also greater than Ruff's reported measurements in Table 4 (1987:401; Table 1 here) of Tennessee River samples of hunter-gatherers (males=1.60 and females=1.51) and agriculturalists (males=1.60 and females=1.53). Tibial nutrient foramina external breadth index sexual dimorphism of the Poole-Rose ossuary is 12%, greater than Ruff's Table 4 (1987:401; Table 1 here) hunter-gatherer samples.

Poole-Rose sexual dimorphism of the femoral midshaft external breadth index of 6% is less than hunter-gatherer samples in Ruff's Table 4 (1987:401; Table 1 here), but is in the range of Ruff's agricultural samples' sexual dimorphisms. The male femoral midshaft external breadth index of the Poole-Rose ossuary is equal to Ruff's Table 4 (1987:401; Table 1 here) male sample of Georgia Coast male agriculturalists at 1.14. The Poole-Rose ossuary's female femoral midshaft external breadth index of 1.08 is equal to some females' indices in Ruff's Table 4 (1987:401; Table 1 here) hunter-gatherer samples (Australian sample, Ohio River Valley sample 1, and Japanese sample) and his agriculturalist sample of the Ohio River Valley 2 at 1.08. The Poole-Rose sexual dimorphism of femoral nutrient foramina external breadth index is 5%.

**Table 1: Ruff's Table 4 (1987:401) - Sex differences in external breadth ratios of femoral and tibial diaphyses in autopsy and archaeological samples; including Poole-Rose sample.**

Section <sup>1</sup>	Property <sup>2</sup>	Sample <sup>3</sup>	Subsistence Technology								
			Hunter-gatherers			Agricultural			Industrial		
			M	F	%dif.*	M	F	%dif.*	M	F	%dif.*
Tibia mid.	Dmax/	Ohio River (1)	1.37	1.29	6	1.48	1.47	1			
	Dmin	Tennessee River	1.53	1.47	4	1.57	1.49	5			
		Georgia	1.47	1.45	2	1.52	1.46	4			
		Japanese	1.24	1.08	15				1.37	1.33	3
		U.S. White (3)							1.41	1.39	3
	Poole-Rose				1.72	1.56	10				
Tibia nut.	Dmax/	Ohio River (1)	1.43	1.32	8	1.61	1.54	4			
	Dmin	Tennessee River	1.60	1.51	6	1.60	1.53	5			
		U.S. White (3)							1.43	1.44	-1
		Poole-Rose				1.77	1.58	12			
Femur mid.	Dap/	Australian	1.17	1.08	8						
	Dml	Ohio River (1)	1.18	1.08	9	1.17	1.13	4			
		Ohio River (2)	1.20	1.11	8	1.11	1.08	3			
		Tennessee River	1.17	1.04	13	1.10	1.05	5			
		Georgia	1.17	1.09	7	1.14	1.09	5			
		New Mexico	1.18	1.09	8	1.10	1.04	6			
		Japanese	1.24	1.08	15				1.06	1.06	0
		Pecos				1.10	1.06	4			
		British (1,3)				1.02	1.00	3	1.09	1.08	1
		U.S. White (1)							1.11	1.12	-1
		U.S. White (2)							1.04	1.04	0
		Poole-Rose				1.14	1.08	6			

<sup>1</sup>Tibia and femur mid.: midshaft or 50% level; tibia nut.: at nutrient foramen (approx. 65-70%).

<sup>2</sup>Dmax/Dmin: maximum/minimum external diameter; Dap/Dml: anteroposterior/mediolateral external diameter <sup>3</sup>Ohio R. (1): Webb and Snow (1945); Ohio R. (2): Perzigian et al. (1984); British (1): Kennedy (1985); British (3): Holtby (1917); U.S. White (1): Ruff et al. (1986); U.S. White (2): present study, Terry collection; U.S. White (3): Hrdlička (1898).

\*[(Male-Female)/Female] X 100.

**Table 2: Femoral and tibial midshafts and nutrient foramina sexual dimorphisms of the Poole-Rose ossuary's adult samples; measurements in mm.**

Variable	MALE			FEMALE			% dif.*
	N	X	s.d.	N	X	s.d.	
<b>FEMUR</b>							
Circumf.-Mid.	72	92	4.29	82	80	4.51	15
Dap	72	30.7	2.03	82	26.0	1.6	18
Dml	72	27.0	1.46	82	24.1	1.95	12
Dap/Dml	72	1.14	0.09	82	1.08	0.08	6
Nut. For.- Dmax	109	30.8	1.67	119	26.5	1.6	16
Nut. For.- Dmin	109	27.5	2.31	119	24.8	2.15	11
Dmax/Dmin	109	1.13	0.11	119	1.08	0.08	5
<b>TIBIA</b>							
Circumf.-Mid.	33	90	3.07	26	79	4.79	14
Dmax	33	35.4	1.41	26	30.0	2.42	18
Dmin	33	20.7	1.37	26	19.4	1.51	7
Dmax/Dmin	33	1.72	0.13	26	1.56	0.15	10
Nut. For.- Dmax	149	38.8	1.8	155	32.2	2.47	21
Nut. For.- Dmin	149	22.1	2.19	155	20.4	1.8	8
Dmax/Dmin	149	1.77	0.15	155	1.58	0.14	12

\*[(Male-Female)/Female] X 100.

Results from Table 2 show that Poole-Rose males had higher measurements than females in femoral and tibial midshaft and nutrient foramina external breadth indices and in midshaft circumferences. The greatest sexual dimorphism occurred in the Dmax (Dap) of the tibial nutrient foramen (21%) and the lowest sexual dimorphism was in the femoral external breadth index (5%). A-P diameters were also greater than M-L diameters in the Poole-Rose ossuary tibiae and femoral samples in Table 2.

Both male and female measurements of femora and tibiae midshaft circumferences are greater than Bridges's Table 1 calculations (1989:389; Table 3 here). The people of the Poole-Rose ossuary show only a small increase of male left and right tibiae from Bridges's Mississippian agriculturalists (left=86.4 and right=87.4) though (1989:389). Female left and

right tibial midshaft circumferences of the Poole-Rose sample are higher than Bridges's Table 1 (1989:389; Table 3 here) Archaic (hunter-gatherer) and Mississippian females. Femoral midshaft circumferences of the Poole-Rose males and females are also higher than Bridges's study of pre-agriculturalists and agriculturalists (1989:389).

**Table 3: Bridges's Table 1 (1989:389) - Long bone midshaft circumferences (mm); including Poole-Rose agriculturalist sample.**

Bone	Archaic				Poole-Rose				Mississippian			
	L		R		L		R		L		R	
	X	N	X	N	X	N	X	N	X	N	X	N
<b>Males</b>												
Femur	82.2	48	81.8	49	92.0	36	91.0	36	88.2	43	88.3	44
Tibia	82.4	35	82.1	35	90.0	20	90.0	13	86.4	33	87.4	35
<b>Females</b>												
Femur	74.5	28	73.8	20	81.0	41	79.0	41	77.2	55	75.9	53
Tibia	69.5	17	71.1	16	79.0	15	81.0	11	73.5	36	74.8	31

Assessment of mobility level of the Poole-Rose population has mixed results as well.

The femur midshaft diaphyseal shape (FMS) (Dap/Dml) of Poole-Rose males equals 1.14.

Wescott's closest ratio calculations (2006:205) were 1.12 of two different mobility groups, three and five. Group three is of "mixed strategy of incipient horticulturalists (IHH) that require less mobility than seen in hunter-gatherers, but greater mobility compared to equestrian nomads or sedentary maize dependent horticulturalists" (Wescott 2006:204). Group five exhibits the highest mobility of five groups (0 is the lowest mobility) and consists nomadic hunter-gatherers that "exploited numerous ecological zones and traveled great distances to procure food and raw materials for tool production (Wescott 2006:203). Poole-Rose females have an FMS of 1.08 that is equal to group three (Wescott 2006:203). Therefore, I cannot conclude that the Poole-Rose people were agriculturalists or incipient horticulturalists from Wescott's mobility index.



## CHAPTER 5. CONCLUSION

Results show that similarities and dissimilarities exist among hunter-gatherers, the Poole-Rose people, and other agriculturalists. Poole-Rose femoral midshaft external breadth index sexual dimorphism was in the same range of Ruff's (1987:401) agricultural samples' sexual dimorphisms. Tibial and femoral midshaft external breadth indices and circumferences are higher in Poole-Rose than hunter-gatherers and agriculturalists; however, Poole-Rose female femoral midshaft circumference does fall between hunter-gatherers and agriculturalists.

The results of Ruff's (1987) analyses show there was a definite reduction in A-P/M-L bending strength in the mid- to proximal tibiae (around the nutrient foramen located 65-70% away from the distal end) and the mid- to distal femora and in sexual dimorphism through successive stages of subsistence patterns. Ruff stated, "The more populations differ with regard to culturally prescribed and/or economically necessary differences in mobility between the sexes, the more they should differ with regard to lower limb structure, particularly around the knee" (1987:397).

Ruff (1987) found that sexual dimorphism of femoral and tibial midshafts decreased from hunter-gatherer societies to industrial societies. Ruff (1987) explained that hunter-gatherer societies required more mobility in order to find and chase down game. Agricultural societies began to lead more sedentary lives as less long-distance travel was necessary to acquire resources. A-P/M-L bending strength and sexual dimorphism were greatly reduced, but still apparent, between these two economies. Little to no change in A-P/M-L bending strength occurred from agricultural to industrial economies. Consequently, sedentary lifestyles and less stress on bones have reduced the external breadth indices of femora and tibiae and the sexual dimorphism in contemporary industrial societies.

Larsen (1981:494) claimed, “The shift in economic focus with the size differential is due primarily to a relatively greater reduction in size and robusticity of the female postcranium.” Women in hunter-gatherer societies were very mobile as they collected nut, berries, and wild fruits and vegetables. Men traveled long distances to fish and hunt mobile animals such as squirrel, beaver, and deer. Agriculturalist societies’ women cultivated and harvested fields and produced food and goods. Agricultural men also began to share in the more sedentary activities such as making tools, homes, pottery, and other goods.

Changes in division of labor during the intensification of agriculture affect the “differing patterns of change in males and females” (Bridges 1989:389). Bridges (1989) found that sexual dimorphism increased from a hunter-gatherer to an agricultural society. Bridges (1989:389) suggested, “Mississippian males have thicker and stronger femoral diaphyses than do Archaic males. This suggests greater changes occurring in forces operating on the legs.” Amplified strength in Mississippian females’ arms and legs shows “a greater range of changing activities for the females” (Bridges 1989:389). Agricultural women took care of agricultural duties as well as “the same gathering and household duties as their Archaic forebears” (Bridges 1989:389). Perhaps men were affected less by the new agricultural activities. Differences in my study compared to Ruff’s (1987) and Bridges’s (1989) conclusions may be due to varied culturally prescribed duties among different Indian groups in North America.

With this study on bone distribution of the femoral midshafts in the Poole-Rose sample, I hope to show a generalized trend of bone mechanics among agricultural societies. Differences in sexual dimorphisms among hunter-gatherers, agriculturalists, and industrialists may encourage future archaeologists and physical anthropologists to study divisions and types of labor that evolved our cultural and physical backgrounds.

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## VITA

Melissa Louise Moreno was born on August 29, 1980, in Oklahoma City, Oklahoma. She began her undergraduate studies in petroleum engineering at Louisiana State University in August 1999. She transferred to Northwestern State University in January 2001 and was graduated with a Bachelor of Arts degree in Anthropology. During her time at Northwestern State University, Melissa worked as a field and lab assistant for the University's Cultural Resource Office, surveying and cataloguing artifacts from various archaeological sites in central Louisiana. After graduation, she decided to specialize in physical anthropology, again at Louisiana State University, in August 2004. After graduation, she plans for employment preferably in an anthropological or other scientific field. She will receive a Master of Arts degree in May 2007.