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Culinary confusion: using osteological and stable isotopic evidence to reconstruct paleodiet for the Ocmulgee/Blackshear cordmarked people of south central Georgia

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CULINARY CONFUSION: USING OSTEOLOGICAL AND STABLE ISOTOPIC EVIDENCE TO RECONSTRUCT PALEODIET FOR THE OCMULGEE/BLACKSHEAR CORDMARKED PEOPLE OF SOUTH CENTRAL GEORGIA

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ABSTRACT

The Ocmulgee Big Bend and Lake Blackshear regions of Georgia have diverse uplands and lowlands, rich in different types of food. Archaeological investigations have shown Late Woodland-style ceramics and artifacts extending up to the Middle Mississippian Period in these regions. Archaeologists have proposed the people of this region did not adopt maize agriculture or a Mississippian subsistence or cultural pattern during the Early Mississippian Period. This study tests this hypothesis with osteological and isotopic data from burials recovered from the Cannon site (9Cp52) and osteological data from the Telfair Mound site (9Tf2). Isotopic data demonstrate clearly that these people were not consuming maize, but were consuming some food high in carbohydrates. Potential sources of carbohydrates are discussed, as are possible models to explain the dental and isotopic data, including one based upon starchy seed agriculture. Finally, future lines of research, stemming from questions in this research, are outlined.

CHAPTER 1:

INTRODUCTION

South-central Georgia is a sparsely populated region that has come under intensive archaeological scrutiny only in the last 30 years. During the last three decades, research has shown considerable cultural differences between this region and the surrounding regions of Georgia in the Late Woodland and Early Mississippian Periods. From roughly A.D. 800 to A.D. 1300, sweeping changes were taking place throughout what is now the southeastern United States. Late Woodland Period cultures relying on hunting and gathering, supplemented with small-scale squash, bean, and native seed agriculture, were becoming integrated into Mississippian Period chiefdoms in which population density and social hierarchy were supported by large-scale maize agriculture. Unlike their neighbors, the people in the Lake Blackshear and Ocmulgee Big Bend regions of Georgia did not adopt large-scale agriculture during the Early Mississippian Period (Crook 1987; Schnell 1975; Snow 1977; Stephenson et al. 1996).

Research in the Lake Blackshear and Ocmulgee Big Bend regions have shown that a culture producing a Woodland-style artifact assemblage including cord marked pottery, Woodland-style pipes, and small triangular projectile points continued into the 13th century with little influence from Mississippianized neighbors (Schnell 1975, Snow 1977; Crook 1987; Stephenson et al. 1996). (Though Lake Blackshear is approximately 35 miles west of the Ocmulgee Big Bend region and minor ceramic differences are noted in the cord marked assemblages from each region, the overall similarities between the two cultures are such that they can be treated as a single cultural region in this research.) The continued use of a purely Woodland-style artifact assemblage well into the early Mississippian Period suggests that the people of this region, either passively or actively, resisted the flow of Mississippian cultural influence into the region for several centuries.

This study was designed to verify the absence of maize agriculture in the Lake Blackshear area. The abundance of cord marked pottery coupled with the paucity of Mississippian cultural materials in the Lake Blackshear area prompted Schnell (1975) to suggest that Woodland forms of social and economic organization persisted into the Mississippian period, possibly because the soils in the Lake Blackshear area were poorly suited for intensive maize agriculture. This work tests this hypothesis with isotopic and bioarchaeological data. An analysis of stable carbon and nitrogen isotopes in the bone of the human remains from the Cannon site, coupled with osteological data from the Cannon and Telfair Mound sites, provides information about the diet of these individuals. As social organization is often tied to subsistence strategies, the biocultural markers of diet will either support or challenge the existence of a Woodland-style enclave in the Ocmulgee Big Bend region during the 13th century. In addition to hypothesis testing, this work has provided an opportunity for the researcher to gain knowledge and experience of isotopic assay as it applies to paleodietary reconstruction.

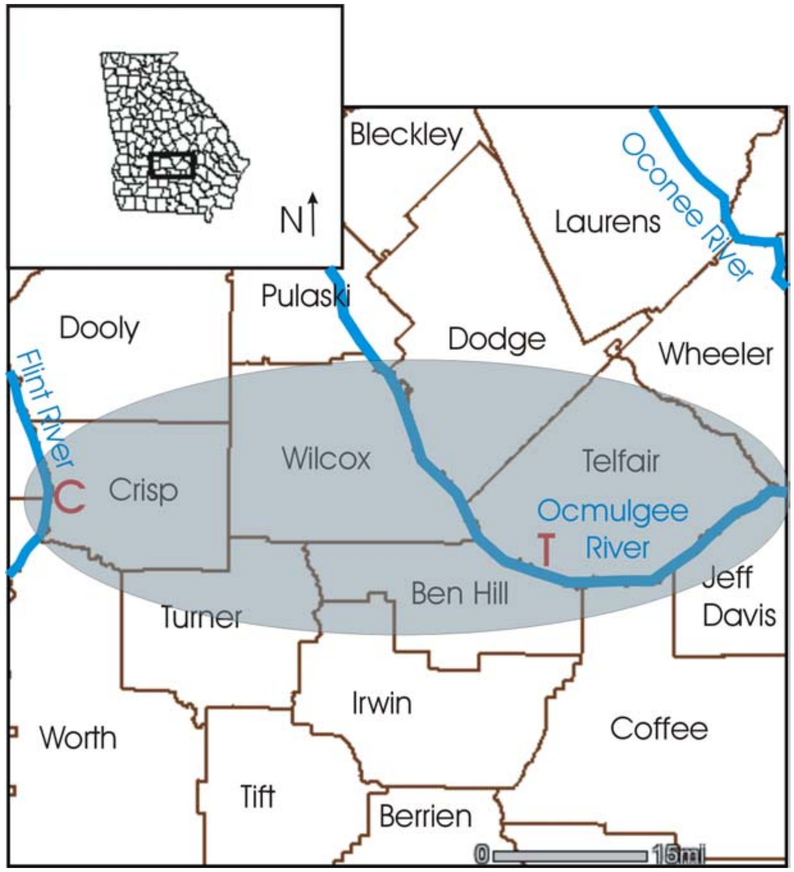
This research is presented in the following format. First, background material is presented, with a discussion of the geographic and environmental features of the region. Next, a discussion of the ceramic evidence for a Late Woodland Period-style subsistence pattern during the Early Mississippian Period will be presented. The environmental, geographic, and ceramic evidence are followed by a summary of the Cannon (9Cp52) and Telfair Mound (9Tf2) sites (Chapter 2). After the site summaries, a general review of stable isotopes, bone composition, and dietary routing is presented (Chapter 3). Next the methodology for the osteological evaluation and the isotopic assay are outlined (Chapter 4). Following the methodology, the results of the osteological and isotope analyses are presented (Chapter 5) and then discussed (Chapter 6). Finally, a summary of the project will be presented with closing comments on directions for future research (Chapter 7).

CHAPTER 2:

GEOGRAPHIC AND ENVIRONMENTAL FACTORS, CERAMIC EVIDENCE, AND SUMMARIES OF OCMULGEE/BLACKSHEAR SITES WITH HUMAN REMAINS

The Ocmulgee Big Bend region is located in the Vidalia Upland portion of the Tifton Upland physiographic division of the Georgia Coastal Plain (Wharton 1978). The Ocmulgee River originates in the Piedmont and flows across the Fall Line at Macon and onto the Coastal Plain. In Dodge County, the river starts an eastward swing to form a long crescent that terminates when it joins the Oconee River to form the Altamaha River. This crescent is known as the Ocmulgee Big Bend region (Stephenson 1990) (Figure 1).

The Big Bend region has two environmental zones: the Ocmulgee River floodplain and its bordering uplands (Stephenson et al. 1996). The floodplain is an extensive, nutrient rich, alluvial swamp that extends 3 to 4 km from the river (Wharton 1978). A natural levee runs along the margin of the river, behind which lies a well-developed natural bottomland (Wharton 1978). The bottomland is poorly drained and is subjected to river overflow throughout the winter and spring. Flooding, however, can occur during any month in accordance with the amount of rainfall that occurs on the Piedmont component of the river basin (Larson 1980). Throughout the bottomlands are elevated areas such as sand knolls, the remnants of old river levees, and sand hammocks (Wharton 1978). These elevated areas support diverse micro-environments and served as locations for prehistoric settlements (Snow 1977; Stephenson 1990; Wharton 1978). The upland area has gently rolling, sandy hills with rounded summits, drained by numerous small streams (Cooke 1925). The uplands contain extensive riverside sand ridges with sand hill ponds and large sandstone outcroppings (Wharton 1978).



C = Location of Cannon site T = Location of Telfair Mound site

Figure 1. Map of Georgia with Ocmulgee/Blackshear Cord Marked Region Shaded.

The Big Bend region is poorly suited to large-scale agriculture—prehistoric or modern. The upland soils are sandy, acidic, leach rapidly, and have poor moisture retention (Larsen 1980). While the floodplain is rich in nutrients, frequent flooding makes it impractical for cultivation (Schnell and Wright 1993). Despite its unsuitability for agricultural development, the Ocmulgee Big Bend region is rich in other resources that allowed prehistoric groups to inhabit the region for millennia (Stephenson 1990). Early non-sedentary groups who practiced hunting and gathering regimes were particularly well suited to the local environment (Stephenson et al. 1996). However, later Mississippian groups, who were more dependent on agriculture, appear to have been much less successful in their attempts to adapt to the region (Stephenson et al. 1996). It is still unclear if these were new people practicing new subsistence techniques or the native inhabitants adopting a new subsistence strategy. In either event, the Mississippian agricultural adaptation in the Ocmulgee Big Bend was short-lived, lasting ca. 75 years (Stephenson 1990). This proposed relationship between the local environment and the subsistence strategies of Woodland and Mississippian groups is supported by the ceramic sequences of the region.

Ceramic Evidence

Cord marked ceramics are associated with the people of the Late Woodland Period in Georgia. However, in the Big Bend Region and Lake Blackshear Basin, these ceramics appear to persist through the early Mississippi Period until they were finally replaced by a short occupation of a Middle Mississippian culture, represented by Late Etowah and Late Savannah ceramic complexes, several centuries later than the rest of Georgia. As noted above, environmental evidence suggests the groups practicing Woodland-style hunting and gathering subsistence strategies were well adapted to the local environment. As such, these groups may have lacked an impetus to adopt Mississippian Period style subsistence.

Prior to 1965, little archaeological work had been conducted in the region. In 1955, Caldwell (1955) investigated 9Dg8, a sand ridge site near Abbeville; the majority of the sherds recovered were either cord marked or plain. Nielson (1966) conducted the first extensive archaeological survey of the Ocmulgee Big Bend region in 1965. Nielson surveyed a nine county area that began with Pulaski and Wilcox counties west of the Ocmulgee and extended eastward beyond the Oconee River into Truetlan and Montgomery counties. Nielson located over 70 archaeological sites and conducted excavations at three of them.

Nielson determined that the most common ceramic type for the region was Savannah Fine Cord Marked, a type commonly found on the upper and central Georgia coast, even though the sherds failed to conform strictly to the Savannah Fine Cord Marked type description (Neilson 1966). The presence of fiber-tempered, Deptford Check Stamped, Wilmington Heavy Cord Marked, and Savannah Fine Cord Marked convinced Neilson that the source of ceramic influence for central Georgia was the Georgia coast (Neilson 1966).

In 1977, Snow published a report that covered nine years of survey in the Ocmulgee Big Bend Region (Snow 1977). Snow established a cultural historical framework (one not related to the existing framework for the coast) for the region based upon 320 sites he located along the lower Ocmulgee. Fifty-eight percent, or 187, of these sites had a cord marked component and on most of these sites, Ocmulgee Cord Marked appeared to be the primary decorative motif (Snow 1977). Snow distinguished three spatially contiguous varieties of cord marked ceramics specific to the region. Ocmulgee I is found in the northern portion of the cord marked region in and south of Dodge County (Crook 1987; Snow 1977). Ocmulgee I sherds are described as usually having folded rims with cord marking oriented vertically and parallel on the vessel's exterior surface (Crook 1987; Snow 1977). Ocmulgee II, which is found between the northern and eastern potions of the cord marked region (actually in the "bend" of the Big Bend) is intermediate between Ocmulgee I and III and has the attributes of both types (Crook 1987; Snow 1977). Ocmulgee III is found in the eastern portion of the region along the lower Ocmulgee and upper Altamaha Rivers, and usually has non-folded (plain) rims with cord marking placed in a crisscross manner on the vessel (Crook 1987; Snow 1977).

The total distribution of Ocmulgee cord marked ceramics is not yet known; however, the majority of the sites bearing large amounts of these sherds appear to be largely confined to the Ocmulgee Big Bend region. A survey of the Upper Satilla Basin, an area just south of the Big Bend region, yielded cord marked ceramics at 28% of the sites (Blanton 1979). Blanton reported that these ceramics resemble the Ocmulgee II style defined by Snow (1977).

To the west, along the Chattahoochee and Flint River drainages, cord marked ceramics appear only as a minority ware with one notable exception—the Lake Blackshear basin of the Flint River drainage. Schnell designated this ceramic type as Lake Blackshear cord marked (Figure 2). Stephenson (1990) believed Lake Blackshear may be near both the geographic (western) and temporal (terminal) boundary of cord marked pottery in the Southeast. Supporting evidence comes from the Mill Creek site (9Su6), approximately 20 km west of the Cannon Site, where cord marked ceramics were a minority ware (Gresham et al. 1989). In comparison to the Ocmulgee cord marked types, the Cannon site cord marked sherds have a much lower incidence of folded rims and the cord markings are closely spaced and frequently overlap. These three attributes clearly distinguish the Cannon site assemblage from sherds from the Ocmulgee I series (Price and Tucker n.d.). In most respects, the Cannon site assemblage compares more favorably with the Ocmulgee II series, which occurs along the lower reaches of the Ocmulgee River (Price and Tucker n.d.). Additionally, Snow (1977) reported that small triangular projectile points, like the ones at the Cannon site, are associated with all three Ocmulgee varieties.

Figure 2. Blackshear Cord Marked Ceramics.

Stephenson, in his 1990 Master's thesis, attempted to further refine the chronology of the Ocmulgee Cord Marked ceramic assemblage. Using stratigraphic data, Stephenson (1990) showed that Ocmulgee Cord Marked pottery began after the late Swift Creek (Middle Woodland) period and likely extended past A.D. 1000, as indicated by cord marked pottery in a level above Napier, a Late Woodland ceramic. Radiocarbon dates support this stratigraphic interpretation. Radiocarbon dates of A.D. 885 and A.D. 1160 (Crook 1987) correlate with the emergence of Ocmulgee Cord Marked just after Late Swift Creek (Table 1).

The latest date obtained for an Ocmulgee component, A.D. 1279 ± 65 (Schnell 1975), supports the continued use of Ocmulgee Cord Marked past A.D. 1000. A site in Pulaski County, 9Pu10, has a cord marked component and a Late Etowah/Savannah component that are spatially restricted, occurring in separate areas of the site (Stephenson 1990). The mutually exclusive and discreet distribution of cord marked and Late Etowah/Savannah ceramics indicate they were not being made at the same time (Stephenson 1990). A radiocarbon date of A.D. 1281 ± 47 was obtained from the Etowah/Savannah component of the site (Stephenson 1989). If the ceramics were not in use at the same time, the production of cord marked ceramics must have ceased at this site prior to A.D. 1281± 47. Therefore, Stephenson et al. (1996) believe the stratigraphic and radiocarbon dates combine to support a time range for the Ocmulgee Cord Marked ceramics of around A.D. 850 – 1250.

Ocmulgee Cord Marked ceramics and the associated people and subsistence style were replaced by the Pulaski phase around A.D. 1275 (Stephenson et al. 1996). The Pulaski phase represents a Middle Mississippian occupation and the end of the Late Woodland-style subsistence in the Ocmulgee Big Bend Region (Stephenson et al. 1996). The Pulaski phase is marked by the introduction of Etowah Complicated Stamped ceramics and the termination of

Table 1. Ocmulgee and Blackshear Sites with Corrected and Calibrated ^{13}C dates (Data supplied by Keith Stephenson [personal communication. 2002]).

Site	Name	Lab #	Conventional Radiocarbon Age, B.P.	Calibrated Age, One Sigma	Reference
9Tf139	Lowe	Beta 16013	-	A.D. 885 (981) 1024	Crook 1987
9Wl11	Fishing Bank Tillmans Bluff	Beta 165346	980±40	A.D. 1018 (1025) 1152	None
9Jd38	None	Beta 159212	980±40	A.D. 1024 (1040, 1100, 1141) 1160	None
9Jd81	Bloodroot	OxA 220299	940±60	A.D. 1021 (1040, 1100, 1141) 1183	Stephenson 1990
9Tf139	Lowe	Beta 16014	-	A.D. 1020 (1160) 1259	Crook 1987
9Jd10	Rocky Hammock	Beta 145809	920±40	A.D. 1033 (1061, 1123, 1156) 1184	None
9Wl27	Bridges Home Place-West	Beta 165347	900±40	A.D. 1040 (1160) 1209	None
9Tf65	China Hill 2	Beta 165344	900±40	A.D. 1040 (1160) 1209	None
9Tf49	Point Hill @ McRaes Landing	Beta 165342	890±40	A.D. 1042 (1161) 1213	None
9Tf49	Point Hill	Beta 165343	860±40	A.D. 1160 (1192, 1208) 1221	None
9Cp52	Cannon	UGA 668	-	A.D. 1220 (1279) 1297	Schnell 1975

cord marked ceramics in the region (Stephenson et al. 1996). Additionally, the presence of corncob-impressed ceramics marks the introduction of maize into the area, evidence of a change in the subsistence base of the people. Apparently the Late Woodland groups in the Ocmulgee River area either adopted a Mississippian sociopolitical organization with the accompanying ceramic types, or were pushed out, possibly to the Lake Blackshear area (Price and Tucker n.d.; Schnell 1975)

To date, no mature Mississippian material has been recovered from the Lake Blackshear area (Schnell and Wright 1993), supporting Schnell's (1975) original proposition that the Blackshear phase represents a Late Woodland enclave retreating into, or as Stephenson (1996) suggested, remaining in, an area poorly suited for a subsistence regime based upon agriculture but well suited for hunting and gathering.

Summaries of Ocmulgee/Blackshear Sites with Human Remains

Only a handful of Ocmulgee cord marked sites containing human remains have been found. The Bars Bluff/Sand Lake Burial site (9Cf29) had a burial exposed by earth moving equipment. A small triangular point of soft chert, a type known to be associated with Ocmulgee III cord marked pottery, was found on the surface of the site (Snow 1992). However, due to the disturbance from the heavy equipment, a cultural affiliation for the burial could not be determined (Snow 1992). The Evergreen site (9Dg8) consisted of two mounds and contained Ocmulgee I ceramics. Burials at the Evergreen site were also exposed by earth moving equipment and looters are reported to have collected multiple skeletons from this these mounds. No archaeological recovery of human remains has been conducted at the site. The Sandridge site (9Cf17) is suspected to be an Ocmulgee III site. A single burial was found in a logging company road. The long bones were moved and re-interred nearby while the cranial remains were transported offsite for examination (Snow 1992). Substantial human remains have only been recovered from two sites in the region: the Telfair Mound site (9Tf2) and the Cannon site (9Cp52). The Cannon site is the only site to have human remains discovered and excavated by trained archaeologists.

The Cannon site was excavated in 1974 as part of an archaeological survey of Lake Blackshear conducted by the Columbus Museum under the direction of Frank Schnell. In 1974, the water level in Lake Blackshear was lowered temporarily, which allowed Schnell to investigate the effects of long-term inundation on archaeological sites. Schnell (1975) found that inundation had badly damaged the sites within the lake boundaries. The Cannon site was surveyed as a control for the flooded sites because the Cannon site was located on a terrace above the Flint River and had escaped flood damage. The site was remarkable because of the high percentage of cord marked pottery recovered during the pedestrian survey. Until the Cannon site, cord marked pottery had been recovered only as a minority type in both the Flint and Chattahoochee drainages. Testing was undertaken at the Cannon site to secure a radiocarbon date and collect more information. Charcoal recovered from the Cannon Site had a calibrated intercept of A.D.1279 (Table 2).

Limited test excavations were conducted in an area of the site that had numerous flecks of mussel shell on the surface. The plowzone was removed, exposing a large rectangular feature (273 x 182 cm) oriented north to south; the feature was 120 cm in depth. The pit contained the remains of four adults and one child (Figure 3). The child and an adult female were the central burials in the pit. The northeastern portion of the pit contained the remains of a second adult, a tightly flexed male. The southeastern portion of the pit contained

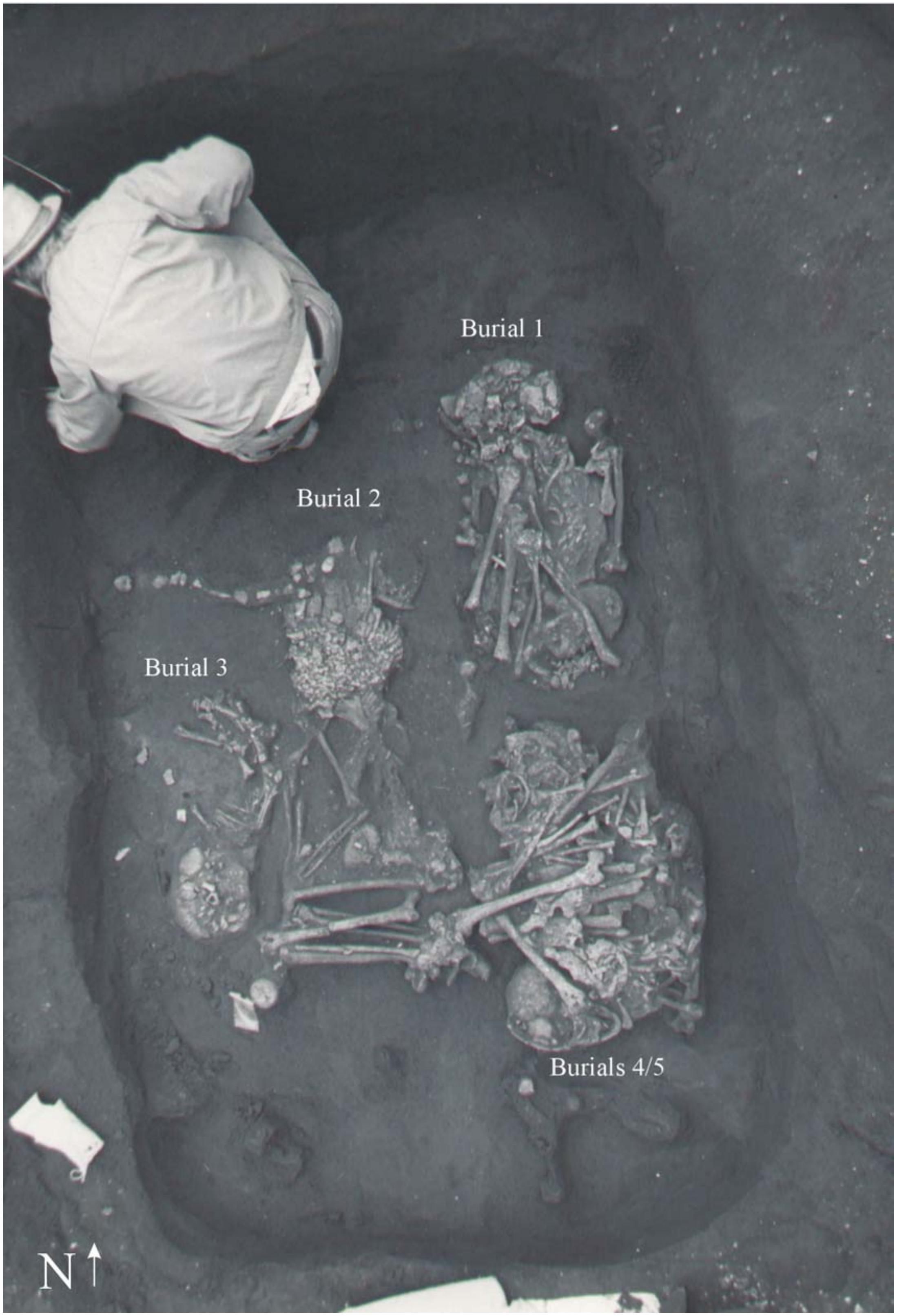


Figure 3. The Cannon Site, Entire Burial Pit, Burials 1 to 5.

Table 2. Results of Radiocarbon date from 9Cp52*.

Laboratory No.	Material Dated	Radiocarbon Age B.P.	Calibrated Age Range (one sigma	Calibrated Age Range (two sigma)
UGA-668	Charred wood	747 +/-65	A.D. 1220 (1279) 1297	A.D. 1160 (1279) 1395

*measured radiocarbon age adjusted for isotopic fractionation [delta 13^c -25.0 ± 2.5] and calibrated using Calib 4.1.2.

the commingled remains of the two remaining adults, one male and one female (Figure 4). The pit had been filled with occupational midden, which contained much crushed mussel shell, which resulted in good bone preservation.

Flotation samples from this pit revealed two hickory nut fragments (less than .2g), one pine nut (less than .01 g), and one unidentified tree seed (less than .1g). Yarborough et al. (1976) identified 11 species of locally occurring freshwater bivalves and one species of gastropod from the fill. Also noted in the tomb fill were small pieces of animal bone, charcoal, small triangular projectile points, and cord marked sherds. Schnell (1975) has briefly described the artifact assemblage and a more extensive description is forthcoming (Price and Tucker n.d.) Various artifacts were found in association with the burials themselves. A thirteen strand necklace with over 2200 shell disc beads, a bone knife, bobcat claws, a shallow whelk shell cup, a turtle shell rattle, a flint knapper's kit, and a fragment of a probable antler headdress were found in association with the central burial (Burial 2). The two individuals (Burials 4 and 5) in the disarticulated, commingled bundle burial had

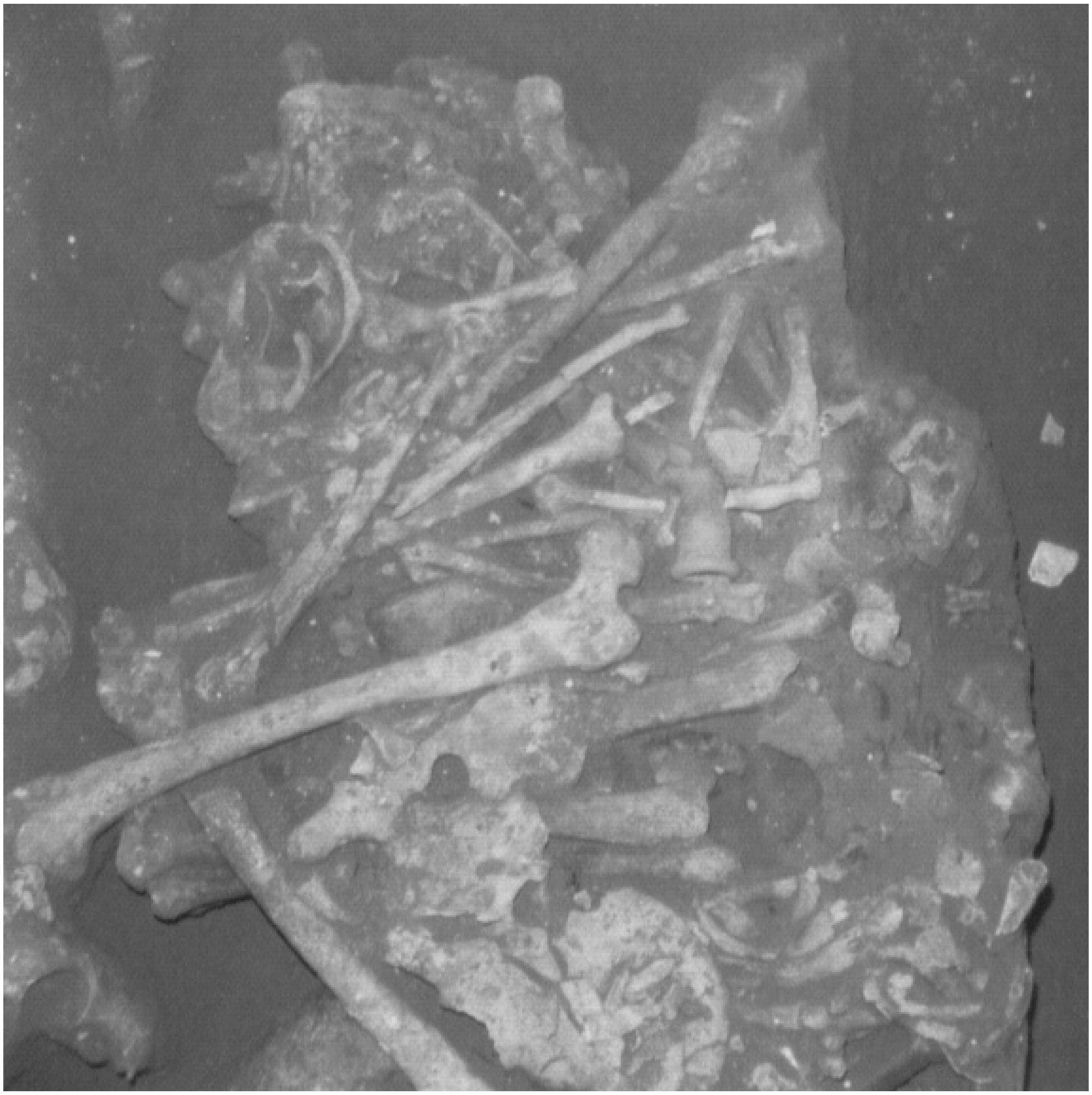


Figure 4. Burials 4 and 5.

associated marginella beads, a flint knapper's kit, and a Woodland-style ceramic pipe. The tightly flexed individual (Burial 1) was buried with a shell disc bead necklace, a flint knapping kit, a raccoon baculum, cut wolf jaws, a broken shell pendant, and a broken sandstone abrader (Schnell and Wright 1993).

The Telfair Mound site overlooks the Ocmulgee River. Contrary to its name, the Telfair Mound site is not an artificial mound but rather a naturally occurring sand ridge (Stephenson 1989). Three archaeological investigations have been conducted at the site. In 1972, Frankie Snow excavated four test units at the site. In one 3 x 6 foot unit, Snow found cord marked ceramics above Weeden Island and Swift Creek types (Bracken et al. 1986). Triangular (Hamilton) points were found in association with the cord marked ceramics. In 1985, a field crew under the direction of Nancy White, from the University of South Florida, excavated four 2 x 2m test units. Forty-one percent of the ceramic assemblage recovered was cord marked (Bracken et al. 1986). In 1989, an artifact collector uncovered a mass burial at the Telfair Mound site. The collector gave the remains to Frankie Snow at South Georgia College. Snow transferred the bones to the University of Georgia Laboratory of Archaeology for examination and curation. Later that year, a team including Frankie Snow and Keith Stephenson conducted a salvage excavation at the site of the burial (Stephenson 1989). The goals of the salvage excavation were to determine the extent of looting activity, salvage the burial, establish the cultural and temporal affiliation of the burial, and to gather any information possible about mortuary behavior. Unfortunately, the collector had largely destroyed the burial feature and little additional information concerning mortuary behavior was recovered (Stephenson 1989).

Floral material was recovered from a feature associated with the cord marked occupation at the Telfair Mound site. The feature contained pinewood, hickory nutshell fragments, an acorn, and a fruit skin (Schnell and Wright 1993). Faunal remains found in association with the cord marked occupation were limited to whitetail deer, but squirrel and rabbits which are common on sites in the region, are expected to have been utilized as as well.

Other features of unknown cultural affiliation contained pigweed (*Chenopodium album*) and pokeweed (*Phytolacca americana*) seeds, indicating that these plants had been utilized at some time by the sites inhabitants (Schnell and Wright 1993).

A culture similar to the Ocmulgee/Blackshear culture developed in an environmentally similar niche in north central Florida. The Hickory Pond phase of the Alachua Tradition appeared as early as A.D. 600-700. There are several similarities between the Blackshear/Ocmulgee people and the Hickory Pond Alachua people. Hickory Pond Alachua sites have cord marked pottery, Prairie Cord Marked, as the majority type (Kohler 1991). Alachua sites are concentrated on the Central Florida Ridge where, much like in the Blackshear Basin and the Ocmulgee Big Bend, soils are sandy and nutrients leach out of soils under cultivation rapidly (Kohler 1991). No evidence of maize agriculture is present until the late Hickory Pond phase (A.D. 1250), when cob marked sherds increase at the expense of cord marked ceramics.

Floral and faunal remains recovered from Alachua sites resemble the remains found at the Cannon and Telfair sites. Fauna included deer (*Odocoileus virginianus*), squirrel (*Sciurus spp*.), and fresh water fish including catfish (*Ictaluridae*), gar (*Lepisosteus sp*.), bowfin (*Amia calva*), and sunfish (*Lepomis sp*.) (Milanich 1994:338-339). Floral remains were limited to palm berries (*Sabal palmetto*), hickory nuts (*Carya sp*.), and acorns (*Quercus sp*.) (Milanich 1994:339). The ceramic evidence for the late introduction of maize and the floral and faunal remains indicating a hunting and gathering subsistence system are further supported by isotopic data, which show “little consumption of maize and a mixed dietary regime with an emphasis on terrestrial animal resources combined with C_3 plants” (Hutchinson et al. 1998:406).

The emergence of maize agriculture in the late Hickory Pond phase corresponds closely with the introduction of maize at the beginning of the Pulaski phase in the Ocmulgee Big Bend/Blackshear region. Additionally, excavations at Hickory Pond burial mounds show a high percentage of female burials. Though the Ocmulgee/Blackshear samples are not large enough to estimate the percentage of females burials, but females burials were at least present at both sites. Some of these similarities led Milanich et al. (1976; Milanich 1994) to suggest that the Alachua Tradition is derived from south-central Georgia. Milanich (1977; 1994) reported the immigration of people using a Wilmington-like ceramic complex into northern Florida from the lower Ocmulgee River as a result of population expansion around A.D. 600. While cultural and chronological continuities exist between the Ocmulgee/Blackshear and the Alachua people, their relationship remains unclear.

CHAPTER 3:

STABLE ISOTOPES, COMPOSITION OF BONE, AND DIETARY ROUTING

Isotopes are forms of the same element that differ in their number of neutrons and thus have different nuclear masses (Faure 1986). Isotopes are either stable or radioactive. A radioactive isotope decays over time while stable isotopes do not. For instance, carbon has eight isotopes, ^{9}C to ^{16}C. However, archaeologists and anthropologists are generally concerned with only three of the carbon isotopes: ^{12}C, ^{13}C, and ^{14}C. ^{12}C and ^{13}C are stable and do not decay overtime. ^{14}C is radioactive and is a useful tool for carbon dating because it does decay over time, while ^{12}C and ^{13}C are used to reconstruct paleodiets and environments. Stable nitrogen isotopes are also useful for clarifying aspects of prehistoric diet. While there are seven nitrogen isotopes, only two are stable and thus of use in reconstructing paleodiet: ^{14}N and ^{15}N.

The heavier an isotope, the less abundant it is in natural systems. Carbon, for example, before the addition of considerable ^{14}C to the atmosphere due nuclear weapons testing, occurred in proportions of approximately 100(^{12}C) to 1.1 (^{13}C) to $1x10^{-12}$ (^{14}C). The small amounts of the heavier isotopes complicate absolute measurements, but relative abundances are determined by mass spectrometry and expressed in delta (δ) notation. A δ value expresses the ratio of heavy to light isotopes in a sample compared to a standard measure in part per thousand (per mil or ‰). Delta values are designated in terms of the heavier isotope, for example, $\delta^{13}C$. Delta^{13}C values are expressed in terms of the PeeDee Belemnite standard and $\delta^{14}N$ is expressed in term of an atmospheric nitrogen standard AIR.

The variation in $\delta^{13}C$ values in skeletal material was discovered while carbon isotopic fractionation was being studied for radiocarbon dating (Schober 1998). Vogel and van der Merwe (1977:239) recognized that "since both animals and humans ultimately derive their carbon from plants, the carbon isotope ratio can be used to determine the relative intake of C_3 and C_4 plants at the beginning of their food chain." C_3 plants are designated as such because they use the Calvin-Benson photosynthetic cycle. In this photosynthetic pathway, CO_2 initially reacts with ribulose, 1,5-diphosphate (RuDP) to produce two, three-carbon molecules of phosphoglyceric acid (PGA). C_4 plants use the Hatch-Slack photosynthetic pathway (Hatch and Slack 1966; Hatch et al. 1967). In the Hatch-Slack pathway, atmospheric CO_2 is fixed with phospho-enol-pyruvate (PEP) in the mesophyll of the plant to produce two, four-carbon molecules, malic and aspartic acid (Bjorkman and Berry 1973). The PEP carboxylase enzyme produced by C4 plants is more reactive than the RuDP produced by C3 plants, especially where the ratio of O_2/CO_2 is high (Bjorkman and Berry 1973). As a result, C4 plants discriminate less against ^{13}C than C3 plants, producing a higher or more enriched $^{13}C/^{12}C$ ratio. C_3 plants have ^{13}C ratios from –35 to –20‰ with an average of –26.5‰ (Smith 1972; Smith and Epstein 1971). C_4 plants have ^{13}C values that range from –15 to –7‰ with a mean of 12.5‰ (Smith 1972; Smith and Epstein 1971). There is a third photosynthetic pathway, the Crassulacean Acid Metabolism pathway (CAM). Edible CAM plants are largely limited to succulents in arid areas with low summer rainfall. Generally, CAM plants are not a concern in the Eastern Woodlands, though prickly pear, a CAM succulent, does grow along the eastern coast.

C_3 plants are generally found in more temperate regions. Several C_3 plants found in the southeastern U.S. are of dietary significance; these include temperate grasses, root crops, fruits, nuts, and seed crops including the Chenopods. C_4 plants thrive in arid climates with intense sunlight and high temperatures. C_4 plants include some forms of millet, sorghum, sugarcane, and other tropical grasses and, most germane to this discussion, maize. Though various hybrids of corn now thrive in less arid environments, maize appears to have developed in the arid environments of Central America where a Hatch-Slack pathway was advantageous. Later, when maize spread to less arid environments it appears to have retained its C_4 pathway and the resulting isotopic signature.

While carbon isotopes clearly distinguish terrestrial C_4 from terrestrial C_3 resources, the addition of nitrogen isotopes greatly expands the explanatory power of isotopic reconstruction. Though $\delta^{13}C$ values can be used to discriminate between trophic levels, $\delta^{13}C$ are only slightly enriched per level, around 1‰ (Schoeninger and Moore 1992). This small amount of enrichment limits the use of carbon values for the study of trophic level in all but the most controlled systems (Schoeninger and Moore 1992). Nitrogen isotopes exhibit a much larger enrichment factor and allow for an improved understanding of terrestrial food chains and trophic levels, identifies the presence of legumes and other N_2 fixing plants in a terrestrial diet, and distinguishes between terrestrial and marine diets (Norr 1995).

Nitrogen comprises approximately 78% of the earth's atmosphere but most biological organisms cannot use it in its natural state. To be utilized, nitrogen gas must be converted to nitrate in a process known as nitrogen fixation. Terrestrial plants obtain fixed nitrogen in one of two ways. The plant may enter a symbiotic relationship with organisms that fix nitrogen residing on their roots or plants may derive it from the soil after bacteria that reside there have fixed it. Plants that enter a symbiotic relationship with organisms are known as N_2 fixing plants. Legumes, including beans and peas, are an example of N_2 fixing plants. When bacteria fix nitrogen utilized by the non- N_2 fixing plants, fractionation of the nitrogen occurs, resulting in more positive values than those found in the atmosphere. As a result of this fractionation, non- N_2 fixing plants are expected to exhibit $\delta^{15}N$ values of around 8.8‰ (Rennie et al. 1976). Since N_2 fixing plants derive their nitrates directly from the bacteria in their root nodules, they only slightly discriminate against ^{15}N (Virginia and Delwiche 1982). Therefore, nitrogen-fixing plants should have an isotope ratio for N_2 at or around the atmospheric level, 0‰.

Nitrogen levels are enriched in the tissues of animals that consume nitrates. Each successive step in the food chain is marked by a 3 to 4‰ increase. Therefore, primary consumers are 3 to 4‰ enriched relative to primary producers, secondary consumers are 3 to 4 ‰ enriched relative to primary consumers and so on. This increase is referred to as the trophic level effect, and has been well documented with strikingly similar results (Ambrose and DeNiro 1986; DeNiro 1985; DeNiro and Epstein 1981; Katzenberg 1989; Macko et al. 1982; Minagawa and Wada 1984; Nelson et al. 1986; Schoeninger 1985, 1989; Schoeninger and DeNiro 1984). Data suggest the ^{15}N range for herbivores is 1.0 to 12.7‰ with a mean of 5.28 +/- 2.6‰, while the range for carnivores is 5.3 to 18.8‰ with a mean of 10.2 +/- 2.9‰ (Schober 1998). These data support an enrichment factor of approximately 4‰ between contiguous trophic levels.

Composition of Bone

Preparation of bone for isotopic assay requires that bone be divided into its two components: the organic and inorganic. The organic portion comprises 35% of the dry weight of bone and the inorganic component comprises 65% of the dry weight of bone (Fawcett 1994). The organic component of bone is composed mainly (90%) of collagen. The collagen fibrils are 50-70nm in diameter. Bone collagen differs slightly from the collagen in soft tissue. In fact, one of the criteria that distinguishes bone collagen from soft tissue collagen is based upon differences exhibited in separating the collagen from the surrounding inorganic tissues. Bone collagen has a greater number of intermolecular crosslinks, which accounts for its lack of swelling in dilute acids and its insolubility in some solvents that are used to extract bone collagen from the surrounding tissues. In fully developed lamellar bone, the collagen fibers have a highly ordered arrangement. The fibers within each lamella of an osteon are parallel in their orientation, but the direction of the fibers changes in successive concentric lamella and run helically with respect to the axis of the Haversian canal (Fawcett 1994) (Figure 5).

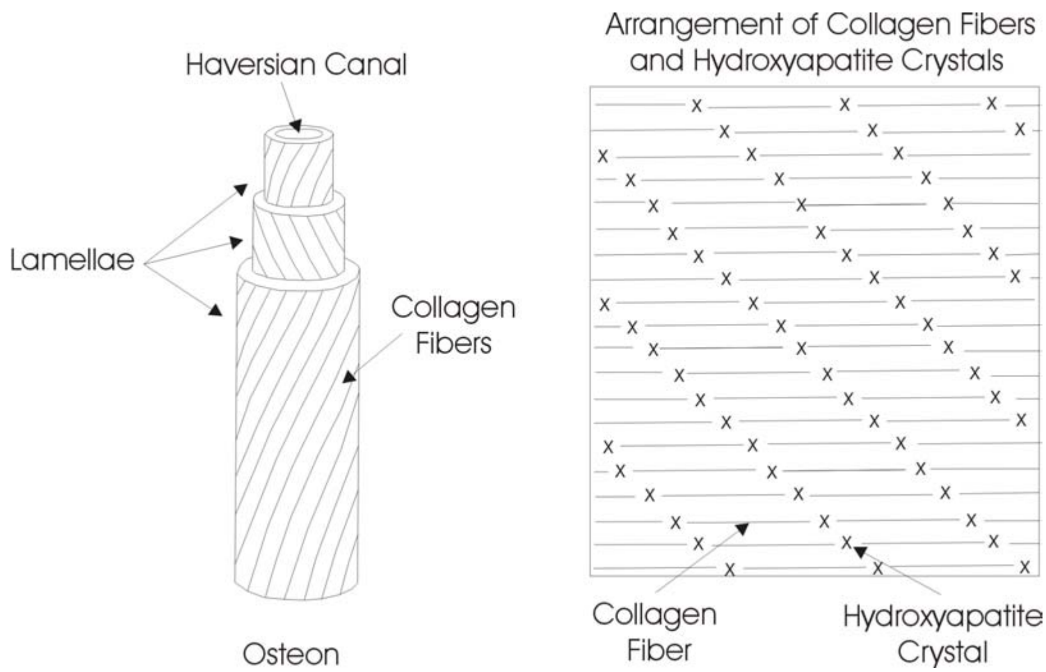


Figure 5. Microstructure of Bone. (Partially adapted from Marieb 1995)

The inorganic portion of bone consists of submicroscopic deposits of a form of calcium phosphate that is very similar, but not identical, to the mineral hydroxyapatite

($Ca_{10}[PO_4]_6[OH]_2$), henceforth referred to as bone apatite or as hydroxyapatite. According to Bloom and Fawcett (1994), opinion varies as to whether the bone mineral is initially deposited as amorphous calcium phosphate and is later reordered to form crystalline hydroxyapatite or if the calcium phosphate is crystalline from the outset. However, by the time the bone is mature, the mineral is in the form of slender, rod-like crystals around 40nm in length and 1.5-3nm in width. The crystals do not occur at random but are spaced throughout the collagen fibrils at a regular rate of about every 60-70nm (Figure 5). The disposition of the mineral follows the helical geometry of the collagen fibers in such a manner that crystals do not form lines longitudinal to the axis of the Haversian canals (or, macroscopically, the axis of a long bone), but rather spiral along the axis of the bone (Figure 5). This helical arrangement of resilient collagen fibers and rigid hydroxyapatite crystals provide bone with its strength.

Dietary Routing

That the natural isotopic values of producers will be integrated into consumer body tissues has been shown (DeNiro and Epstein 1978, 1981; Schoeninger et al. 1983). However, how these isotopic values are routed to different tissues in the consumer has been less clear; specifically, how the values are routed to the organic and inorganic portions of bone. One theoretical model, the linear mixing model, asserts that the carbon atoms of collagen have an equal chance of coming from any digestible portion of the diet, including proteins, carbohydrates, and lipids (Norr 1995). While this model may be appropriate for herbivores consuming some proportion of C_3 to C_4 grasses, or for reconstructions of C_3 woodland versus C_4 grasslands from soil, the model may be unsuitable for omnivores consuming protein, carbohydrates, and lipids that differ in their isotopic composition (Norr 1995). A different model, utilized by Chislom et al. (1982), Chislom (1989), and Krueger and Sullivan (1984), assumes that the carbon atoms of collagen come mainly from the protein sources in the diet. At the very least, the essential amino acids must come from dietary proteins since they cannot be synthesized by the body (Norr 1995). Only 12% of collagen is composed of amino acids, but those amino acids contain 18% of its carbon atoms (Ambrose and Norr 1993).

Building upon the model suggested by Krueger and Sullivan (1984), Ambrose and Norr (1993) performed controlled feeding experiments with rats. These experiments were designed to determine the degree to which dietary protein was routed to bone collagen and dietary energy, mainly carbohydrates, to bone apatite. The rats were raised on diets in which the isotopic composition of proteins, lipids, and carbohydrates were known and controlled. The bone collagen, bone apatite, muscle tissue, and hair from the rats were assayed for their stable carbon and nitrogen isotope values. The results from the controlled feeding experiments indicated that the ^{13}C value of rat bone collagen more heavily reflects the isotopic composition of dietary protein than that of the whole diet (Ambrose and Norr 1993). Therefore, the carbon isotope composition of bone collagen disproportionately reflects that of proteins in the diet. The bone apatite values differed from the collagen values in that they more closely reflected the composition of the entire diet.

Since the collagen values more closely represent the isotopic composition of the dietary protein and the apatite values more closely mirror the composition of the diet as a whole, the use of ^{13}C values from both fractions of bone can be used to estimate the isotopic composition of both proteins and carbohydrates in the diet. Ambrose and Norr (1993) used the spacing between the apatite values and the collagen values to distinguish the isotopic composition of each component of the diet. When the dietary protein and energy sources have similar isotopic values, the spacing between them is intermediate, around 5.7% +/- 0.4%.

When the $\delta^{13}C$ value of the dietary energy source is more negative than that of the dietary protein, for example a C_3 plant and marine fish diet, the spacing between the collagen and apatite values is quite small, from 1.2 % +/- 0.1% to 2.1% +/- 0.2%. If the $\delta^{13}C$ value of the dietary protein is more negative than the $\delta^{13}C$ value dietary energy source, for instance, in a terrestrial diet of C_3 protein with maize or other C_4 plants for dietary energy, the difference between the apatite and collagen values is large, 7.2% +/- 0.3% to 11.3% +/- 0.4%. Ambrose and Norr (1993) demonstrated that even a small amount of a C_4 energy source (21%) added to a C_3 diet would greatly affect the apatite values and thus the apatite-collagen spacing. A similar controlled diet study with rats conducted by Tieszen and Fagre (1993) produced results similar to those of Ambrose and Norr (1993), providing independent verification of their study.

Building on the collagen-apatite spacing results, Theresa Schober (1998:72) provided an excellent model for tracking the introduction of maize into a C_3 eastern woodland environment:

> "Prior to the incorporation of maize into the diets of Late Woodland peoples, ^{13}C values of bone collagen and [apatite] carbonate should differ only by the degree of fractionation from the diet in each of these tissues. Therefore, it is expected that the [apatite] carbonate-collagen spacing will be intermediate at approximately 5-6% (a monoisotopic diet). As maize is incorporated into the diet, the mix of a C_4 energy source with C_3 protein and energy will increase the difference between the ^{13}C ratios of bone [apatite] carbonate and collagen. In this instance, bone collagen will give a disproportional estimate of whole diet and reflect a pure or largely C_3 diet. Bone [apatite] carbonate-collagen spacing is expected to be larger than 5-6%. As maize becomes the dominant food resource for all or part of the population, bone collagen ^{13}C values will reflect a C_4 component to the diet and [the apatite-collagen spacing] will again approach 5 to 6%".

Studies that incorporate apatite-collagen spacing are better able to detect smaller amounts of maize in the diet than studies that rely solely on collagen. Most isotopic research conducted to date in the Southeast has relied solely upon isotope values from bone collagen. While the collagen-only studies will detect major shifts in subsistence, these studies are unable to detect the introduction of small amounts of maize into a region, as in the case of ritual foods. It is because of the increased sensitivity of the collagen-apatite spacing approach that this technique, coupled with Schober's interpretative model, will be utilized to assess the contribution of maize to the diets of the individuals from the Cannon site.

CHAPTER 4:

METHODS

Permission to undertake the analysis of the Cannon Site remains, both physical and chemical, was granted by W.A. McWilliams of J.W. Cannon Farms, Inc. Mr. McWilliams is the president of J.W. Cannon Farm, Inc., which owns the land where the Cannon Site is located. Since excavation, the material from the Cannon site has been on permanent loan to the Columbus Museum of Arts and Crafts in Columbus Georgia. The remains do not fall under the jurisdiction of NAGPRA because the Museum is not federally funded and the human remains were recovered on private land. In addition, the excavation date falls before the passing of state burial laws.

Physical analysis of the skeletal remains from the Cannon Site was conducted in May 2000. Bone preservation was generally good, though the weight of the pit fill had crushed the bones. The analysis was limited to an examination of the long bones and the cranial and pelvic remains from each burial. The approximate amount of tooth wear and the number of caries per individual were also recorded. Care was taken to note pathologies on all of the elements examined. *Standards for Data Collection from Human Skeletal Remains*, hereafter *Standards,* (Buikstra and Ubelaker 1994) provided a template for data collection, though some recommendations were modified due to time constraints.

Chemical analysis, specifically isotopic analysis, was performed in the spring of 2001 at the University of Florida. Samples were prepared for both bone collagen and bone apatite. Dr. Lynette Norr graciously provided access to the lab, as well as the necessary equipment and chemicals, and supervised the preparation of the samples.

The preferred bone samples for isotopic analysis (Table 3) are large pieces of cortical bone. Therefore, when selecting the elements to be sampled, pieces bearing large areas of intact cortical bone were chosen.

Table 3. Bone Samples for Isotopic Assay

Burial Number	Element Sampled	Weight of Sample Prior to Chemical Processing
Burial 1	Distal Left Tibia	~7.0g
Burial 2	Distal Left Fibula	5.5g
Burial 3	Femur Shaft	7.5g
Burial 4	Distal Right Tibia	6.1g
Burial 5	Distal Right Tibia	6.4g

Under the supervision of Norr's graduate assistant, Christopher King, the samples were prepared by the following techniques (These techniques are also outlined in Norr 1995). First, each sample was photographed with a digital camera to provide a visual record of the sample prior to its destruction (on file, L.S.U. M.N.S.) Then a sample of the bone weighing 5-7g was removed from the rest of the element. This sample was then brushed clean. After brushing, a scalpel was used to scrape off the outer and inner layers of cortical bone, removing any cancellous bone from the interior as well as surface contamination. A new scalpel blade was used to prepare each sample. The resulting piece of cleaned bone was weighed, then placed in an annealed 10ml beaker with distilled water. The beaker was placed in a sonic cleaner and cleaned for 10 minutes. Then the distilled water was drained, replaced, and the sample cleaned again. This process was repeated until the water was not cloudy after 10 minutes of cleaning. A fresh beaker was used for each sample.

Once the cleaning was complete, the samples were allowed to air dry overnight. After drying, the sample was crushed with a clean, annealed mortar and pestle. A fresh mortar and pestle were used for each sample. The crushed bone was sieved into two sizes, 0.25-0.5mm and <0.25mm. These two sizes of crushed bone were placed in separate scintillation vials and labeled.

The larger fraction (0.25-.5mm) was used in the preparation of collagen samples. To begin the demineralization of the collagen samples, 0.8g of crushed bone from each sample was placed in a clean, annealed, labeled filter funnel on annealed Pyrex glass wool. Then ~50.0ml of 0.2m HCL was added to the funnel and the sample was stirred with a clean, annealed, glass rod. The funnel was covered with aluminum foil and checked twice daily. As demineralization occurred, the crushed bone effervesced until all minerals were removed and the pieces of bone became translucent collagen isomorphs. If the effervescing stopped prior to complete demineralization, the HCL was drained and replaced. After demineralization was complete, the HCL was drained and the sample was rinsed to neutral by filling and draining the funnel repeatedly with distilled water until the water draining out tested neutral on a pH strip.

Next, to remove any humic acids that may have contaminated the sample from the soil, ~50ml of 0.125m NaOH was added to the funnel and allowed to stand over night. The sample was again rinsed to neutral. Then, to reduce the isomorphs to collagen gelatin, ~50ml of 10^{-3} HCl (pH 3.0) was added to the funnel and the fill level marked with a Sharpie on the outside of the funnel. The funnel was covered tightly with aluminum foil and placed in a drying oven at 95C for 4-5 hours. Then 100 microliters of 1m HCl was added to the funnel and any evaporated liquid was replaced with 10^{-3} HCl to the fill line. The funnel was then returned to the oven for an additional 4-5 hours. The hot solution was then drained into a clean, annealed, side arm flask and placed into a 65C oven to condense the solution. When the solution was condensed to ~5ml or less it was transferred to a clean scintillation vial. The vial was returned to the oven and allowed to evaporate to ~2ml or less. The sample was then placed in a freezer and allowed to freeze overnight. Finally, the frozen sample was placed in a freeze-drier for 48 hours. The weight of the sample was then used to calculate the percent yield of the sample. An extremely low yield would indicate collagen degradation in the sample.

For the preparation of the apatite sample, all traces of collagen and other organic components of the bone must be removed. To begin, 100mg of the <.25mm bone powder was placed in an empty 15ml conical bottom centrifuge tube. Then ~12ml of a solution of 50% bleach (Clorox is preferred due to the lack of additives.) and 50% distilled water was added to the tube. The tube was then capped and agitated with a vortex machine. The tube was allowed to sit overnight and was vortexed occasionally. The following day, the tube was loaded into the centrifuge and spun until all the powder was compacted into the bottom, and the old Clorox solution was decanted and replaced. The tube was then vortexed again and allowed to sit. The solution was changed once per day until all organics were dissolved and the effervescence stopped. After the reaction had ceased, the sample was centrifuged and the solution decanted. The sample was rinsed to neutral by adding distilled water to the tube, vortexing the tube, then spinning it in the centrifuge to compact the sample to allow the water to be decanted. This procedure was repeated at least four times and then additional times as needed until the pH tested neutral and no Clorox odor remained in the sample. Next, ~12ml of 1m acetic acid was added the tube, the sample was vortexed and allowed to sit 24-36 hours until all bubbling had ceased. The sample was rinsed to neutral following the same procedure outlined above. Finally, the sample was freeze-dried and the percentage yield of apatite was calculated.

The freeze-dried samples were taken to Dr. Jason Curtis, the Stable Isotope Mass Spectrometry Laboratory Manager, in the Department of Geological Sciences at the University of Florida. Over the course of the Summer of 2001, Dr. Curtis performed the stable isotope measurements.

CHAPTER 5:

RESULTS

In this chapter, the results of the osteological analysis are presented, followed by the results of the isotopic testing. A short discussion of sample integrity and possible sources of error is also presented.

Physical Analysis

Details of the results of the osteological examination are presented in Table 4. The stature of Burials 1, 2, and 5 was calculated from maximum femur length. Due to a paucity of stature formulae specific to native North Americans, a formula developed by Genoves (1967) for Mesoamericans was used. While this formula may or may not accurately predict the actual height of the individuals, it should demonstrate the relationship of their heights to one another. The stature for Burial 4 was calculated from a fragmentary femur by first computing maximum femur length from a formula provided for Indian females by Steele and McKern (1969). This estimate was inserted into the same formula used for Burials 1, 3 and 5.

Table 4. Osteological Data from the Cannon Site.

Burial Number	Sex	Age	Height	Caries	Dental Attrition	Femur Length (cm)
1	Male	21-30	167.6 +/-3.4cm	5	Moderate	44.8
2	Female	20-24	161.6 +/-3.8cm	5	Light	43.2
3	Indeterminate	4-8	Indeterminate	0	-	-
4	Female	30+	158.4 +/-3.8cm	9	Extreme	22.5*
5	Male	20-35	161.3 +/-3.4cm	4	Heavy	42.0

*Length of segment two as defined by Steele and McKern (1969)

The presence of preservative and dirt on the teeth of all the remains, as well as the extreme wear in one case, confounded the examination of hypoplasias. As a result, no hypoplasias were noted on the dental remains. However, it is believed that, had any extreme cases of hypoplasia been present, they would have been detected on the remains. Additionally, no evidence of periostitis, osteomyelitis, porotic hyperostosis, or cribra orbitalia were found on the remains, though the fragmentary nature of the remains complicated this aspect of the study as well.

Burial 1.

Burial 1 was a tightly flexed young adult male, placed on his right side. The tightness of the flexing suggests that this was a secondary burial. Frank Schnell (personal communication, 2002) believes this individual was partially decomposed before being placed in the pit. The sex of the individual was derived from a qualitative assessment of the cranial morphology as outlined in *Standards*. In general, the cranial morphology was robust and the gonial angle acute, indicative of a male. In addition, the femur head measured 48 mm, placing this individual in the range of male diameters as indicated by Stewart (1979).

The age of the individual can only be loosely bracketed. The third molars were fully erupted, indicating an age of at least 21 years (Ubelaker 1989). The sagittal suture was open or active; it is generally agreed this suture closes sometime during the third decade of life (McKern and Stewart 1957). Therefore, a conservative estimate of this individual age is 21-30.

The individual had 12 dental caries, but most were quite small. These were concentrated on the occlusal surface of the right upper and lower first and second molars. Only one carious lesion had abscessed into the pulp cavity.

Burial 2.

Burial 2 was a young adult female. She was placed on her right side, partially flexed, in very close proximity to Burial 3 (a child). The lack of a pronounced glabella and nuchal crest, coupled with an obtuse gonial angle, indicated the adult individual was female. Her third molars were fully erupted. In Native Americans, this eruption takes place around age 21 (Ubelaker 1989). Her illiac crests were not yet fused to the illium, which often occurs as early as age 16 in females (Bass 1995). The auricular surface of her illium had youthful appearance with transverse billowing, which is indicative of a phase one surface and an age of 20-24 (Lovejoy et al. 1985). Therefore, she was likely in her late teens, between 18 and 21. Her teeth exhibited almost no wear, but she had experienced the antemortem loss of her lower left canine. The alveolar bone was remodeling to fill the socket at the time of death. There was no evidence that this loss resulted from a dental abscess. Five dental caries were present, all on the occlusal surfaces of her molars.

Burial 3.

Burial 3 was a child. The burial was contained within a partial ring of stones that extended from the legs of the central female (Burial 2) to her head. Children cannot be assigned a sex due to the lack of secondary sex characteristics that emerge during puberty. The child's age is indicated by the fused axis vertebra, which fuses between 4 and 6 years of age, as well as by the formation of the permanent canine (no root formation) and the near eruption of the second lower incisor, both of which indicate an age of around 6 years ± 24 months (Steele and Bramblett 1988; Ubelaker 1987). Thus the child was between 4 and 8 years of age.

Burials 4 and 5.

Burials 4 and 5 differed from 1 and 2 in that they were completely disarticulated and the bones were commingled. Frank Schnell (personal communication, 2002) believes that Burials 4 and 5 were in an advanced state of decay when interred with the primary burials. Despite being commingled, the bones had been field sorted into two individuals. My subsequent analysis found no discrepancies in the field sorting of the major elements.

Burial 4 was composed of the remains of a disarticulated adult female. Her overall cranial morphology, with an obtuse gonial angle and gracile zygomatic processes, indicated her sex. Her third molars had erupted, suggesting an age of at least 21 (Ubelaker 1989), and her sagittal suture had closed, which generally takes place in the third decade of life (McKern and Stewart 1957). The teeth belonging to Burial 4 show extreme attrition. Fifty to ninety percent of crown height was lost on all teeth, and her upper left second and third molars were lost antemortem. Due to the paucity of other markers of age associated with this burial, her age may be expressed conservatively as 30+, but the extreme wear suggests she was older. Nine caries were present. Three of the nine caries had abscessed into the pulp cavity, and two had abscessed into the maxilla. Burial 4 exhibited caries at and below the neck of the tooth, indicating the presence of periodontal disease.

Burial 5 was a disarticulated young adult male. The cranial morphology of Burial 5 was robust, with an extremely pronounced mental eminence. His pelvic remains exhibited a narrow, shallow, preauricular sulcus and a very narrow greater sciatic notch, both indicative of a male. His pubic symphysis showed the beginnings of the ossific nodules that indicate a Todd (1921) stage three and a Suchey-Brooks (Brooks and Suchey 1990) stage two. The Todd stage three has a corresponding age range of 22-24 while the Suchey-Brooks has a more conservative range that covers ca. 20 to 35 years of age, with a mean near 24. The auricular surface of illium of Burial 5 had a youthful appearance with a reduction in the billowing, which ranks the surface as a phase two (Lovejoy et al. 1985). A phase two auricular surface indicates an age from 25 to 29. Therefore, this individual was a young adult from 20-35 years old.

Burial 5 exhibited heavy dental attrition, with the loss of approximately 1/3 of the molar crown height and had 4 dental caries. The upper central incisors were worn from their mesial edges, demonstrating a cultural wear pattern perhaps associated with a ceramic pipe found with this burial. This individual also exhibited some remodeling of the left and right parietals near the sagittal suture. This activity obliterated the sagittal and coronal sutures and caused some thickening of the cranial bones. Additionally, this individual's right mandibular condyle was atrophied, but exhibited no porosity or eburnation. The accompanying mandibular fossa was not present for examination, but it is possible that the deformation was a result of a defect of the fossa itself.

Isotopic Assay and Sample Integrity

The results of the isotopic analysis are presented in chart form below (Table 5). Throughout this research, sample numbers correspond to the burial numbers; i.e. CO1 is a collagen value for burial 1. Before interpretations can be drawn from these data, sample quality must be assessed. The three most common methods of assessing sample quality for bone collagen are: atomic C:N ratio, % yield of collagen from bone, and % weight of carbon and nitrogen in the extracted collagen (Schober 1998). However, Schoeninger and Moore (1992) report that for bone that appears well preserved superficially, has been cleaned chemically and mechanically, and retains a percentage of organic residue equal to 50% or more of the original organic (organic residue >10% of the original dry bone weight), the C:N ratio is unnecessary. All five samples in this study meet those criteria, therefore only the % yield of collagen from bone and % weight of carbon in extracted collagen will be used to check collagen sample quality.

Modern human bone varies in collagen concentration from around 18 – 27%. In archaeological specimens, the division in collagen yields between an adequately preserved sample and an inadequately preserved sample is between 1.2 and 1.8% (Ambrose 1990). Ambrose (1990) recognized that samples with well-preserved bone collagen also had carbon and nitrogen concentrations greater than 13% and 4.8% respectively. The % weight carbon and nitrogen may be the best single indicator of sample integrity (Ambrose 1990).

All five samples more than surpassed the minimum criteria for % collagen yield and % C and N concentrations (Table 5). The % collagen yield for sample CO5 is anomalously low due to accidental loss of a portion of the final yield. Despite the accidental loss, the original sample yield was high enough that the sample still easily surpasses the minimum sample size. No single standard has been developed to assess the quality of bone apatite

Table 5. Collagen Yields and Values

Collagen Samples	% Collagen Yield	% weight C	% weight N	$\delta^{13}C$ value	$\delta^{15}N$ value
CO1	8.69	21.00	38.55	-20.04	9.47
CO2	12.64	19.78	41.81	-18.31	6.79
CO3	9.57	22.40	38.70	-17.13	10.46
CO4	14.04	22.45	43.82	-19.67	9.87
CO5	4.27	19.45	32.44	-19.46	11.90

samples. Ambrose (1993) proposed that the % weight carbon from bone apatite is useful. After apatite extraction procedures, the average % weight carbon in apatite is 0.9%. Ambrose (1993) suggested a range of 0.6 to 1.3% is an acceptable range for samples. Higher percentages can suggest diagenetic contamination while lower values may indicate a loss of structural apatite (Ambrose 1993).

Unfortunately, four of the five apatite samples fell out of the 0.6 to 1.3% range for an acceptable sample (Table 6). The higher percentages of carbon seem to indicate the presence of some diagenetic contamination.

Table 6. Apatite Yields and Values

Apatite Sample	% Weight Carbon	^{13}C Value
AP1	1.78	-14.84
AP2	2.67	-14.16
AP3	1.84	-13.48
AP4	1.80	-15.06
AP5	1.27	-15.55

However, with the exception of the child (AP3), the ^{13}C values (-14.84, -14.16, -15.06) of the apatite samples that fell outside the acceptable range of % weight carbon (0.6 to 1.3%) are close to the single acceptable ^{13}C value (-15.55). Furthermore, when the apatite samples are plotted (Figure 6), they mirror their respective collagen values, which is indicative of normal collagen-apatite spacing.

If these samples were contaminated, either the contamination is minimal or all five samples are contaminated very consistently. In light of the consistency of the apatite samples, tentative interpretations will be drawn from them. These apatite values should not be uncritically accepted however, and future verification will be required before definitive conclusions can be drawn from the apatite samples.

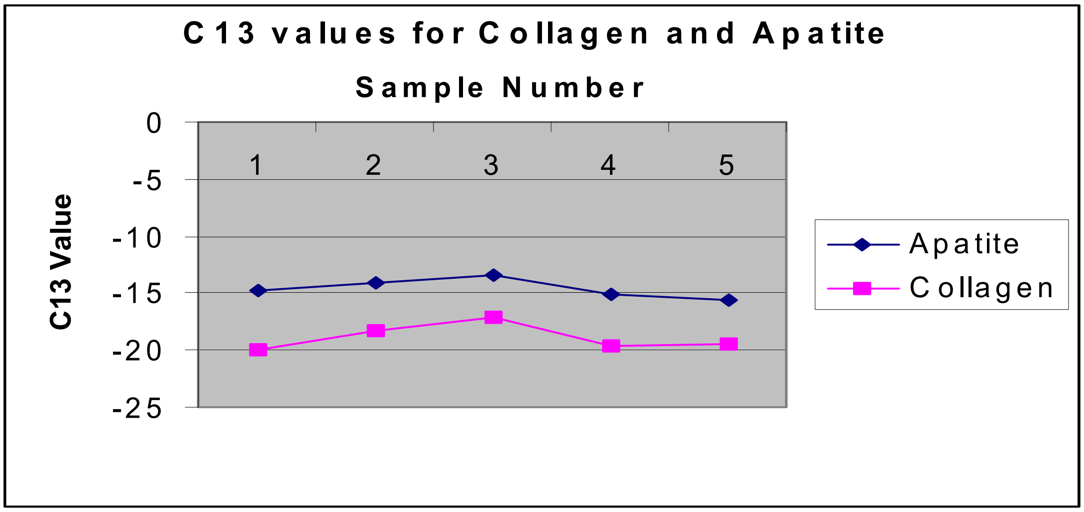


Figure 6. Collagen and Apatite ^{13}C Values.

Though the sample from the Cannon Site consists of just five individuals, only four of whom were adults, the sample may be adequate to generalize to the population as a whole. Studies have shown that there is little variation in isotopic values in large samples of human remains. Lovell et al. (1986a) found a standard deviation of 0.3% in 50 hunter-gathers from the northern plains and Bumsted (1984) found a standard deviation of 0.7% in 32 adults from a prehistoric horticultural site in South Dakota. Therefore, there should be little difference between these five individuals and the population they represent, unless status differentiation was reflected in the foods consumed. Variation is known to exist between high and low status individuals in more stratified societies in the Southeast (Welch 1991). The number and type of artifacts associated with the burials from the Cannon Site suggest these burials may have been high status individuals. However, since no other individuals have been recovered from this site, no comparisons can be made between high and low status individuals.

A final consideration in the quality of these samples is the possible contamination from preservatives placed on the skeletal material shortly after excavation. The exterior of the bones has a glossy, plastic-like appearance; clearly they have been treated with a preservative. Frank Schnell (personal communication, 2001) indicates this preservative was likely Alvar. Moore and colleagues (1989) specifically addressed the problem of Alvar contamination in isotopic analysis. Moore et al. (1989) prepared collagen samples from Alvar treated bone with three different techniques. They found that acetone effectively removed the consolidant from the bone while producing no negative effect on the sample over all. However, the results also indicated that in the case of Alvar, the acetone treatment is largely unnecessary. When applied, Alvar is largely confined to the external portions of bone and most of this is removed in the cleaning and preparation of the sample. Furthermore, Alvar is not soluble in the acids and base solutions used in the preparation of collagen samples and the mechanical effect of the filter removes any remaining Alvar from the sample. However, even in samples prepared with a non-filter method (the collagen "chunk" method), the presence of Alvar in the final sample does not appear to greatly affect the $\delta 13C$ ratio, as even these "contaminated" samples fell within the normal range of variation from the control. Therefore, the presence of Alvar on the remains from the Cannon site should not be considered a source of inaccuracy in this research.

CHAPTER 6:

DISCUSSION

Much bioarchaeological research has been conducted to investigate the diets of prehistoric peoples in the eastern United States (Bridges 1996; Buikstra 1992; Buikstra and Milner 1991; Buikstra et al. 1988; Driscoll and Weaver 2000; Larsen 1997; Lambert 2000). Studies that combine osteological and isotopic analysis have been successful in reconstructing paleodietary habits in several cases (Ezzo 1994; Rose et al. 1991; Schober 1998). In this chapter, I discuss the results of the osteological and isotopic investigations. Following the order of the results, the osteological evidence will be discussed first, followed by a discussion of the results of the isotopic assay. Note that, as discussed in Chapter 4, there were no pathologies observed in the cranial or postcranial remains with the exception of in the teeth. Therefore, the osteological discussion is limited to the dental remains.

Caries Rate

The rate of dental caries has been used to assess the contribution of maize to the diet throughout the Eastern Woodlands (Bridges 1996; Larsen 1995, 1997; Larsen et al. 1991; Rose and Marks 1985; Rose et al. 1991). In general, the rate of dental caries increases as the amount of maize in the diet increases (Larsen 1995, 1997). In his study of pre-agricultural (1000 B.C.-A.D. 1150) and agricultural (A.D. 1150-A.D. 1550) dentition from 31 burial contexts on the Georgia coast, Larsen (1984) found that caries increased by around 10% in all tooth types, and in both sexes, with the shift to agriculture. Larsen attributed this proliferation to a marked increase in the consumption of maize. Maize is high in sucrose, which is fermented by bacteria that occur on the teeth: *Lactobacillus acidophilus* and *Streptococcus mutans* (Roberts and Manchester 1997). This fermentation produces acids that demineralize the teeth and produce carious lesions.

Researchers in the Eastern Woodlands find caries rates of less than 8% in preagricultural populations and rates of 10-50% in agricultural populations (Table 7) (Larsen 1984). With regard to individuals, researchers have established the dividing line between high and low carbohydrate diets as 2 carious lesions per person (Rose et al. 1984; Turner 1979). The high rate of dental caries per person at the Cannon Site differs from what is expected in hunter-gatherer subsistence and makes a strong argument for the existence of a high carbohydrate diet. Twenty percent of the teeth (N=23) from the entire sample (N=113) have at least one carious lesion and the average rate of teeth with carious lesions per person is 5.9. Both of these rates far exceed the averages for a pre-agricultural subsistence.

Table 7. Comparison of Dental Trends.

Population	% of carious teeth per population.	Avg. # of carious teeth per individual.	References
Pre-agricultural	<8%	<2.0	Larsen 1984, Rose et al. 1984
Agricultural	10-50%	>2.0	Larsen 1984, Rose et al. 1984
Cannon Site	20%	5.9	Tucker n.d.
Telfair Mound Site	4%	0.7	Humph, personal com.
Cole's Creek	-	8.1	Rose et al. 1984

These results from the Cannon site can be compared with those from the Telfair Mound site (Table 7). Dr. Dorothy Humph examined the skeletal remains from the Telfair Mound site (Table 8). Observation revealed three individuals: one male, one female, and one individual of indeterminate sex (Humph, personal communication 2001). The age of the individuals was based upon cranial suture closure; the male was 30-40, the female 21-35, and the indeterminate individual was also 30-40.

Table 8. Results of the Skeletal Analysis of the Telfair Site (9Tf2)

Burial Number	Sex	Age	Caries	Dental Attrition
1	Male	30-40	1	Heavy
2	Female	21-35	1	Heavy
3	Indeterminate	30-40	0	Heavy

Humph's previously unpublished dental data indicated a low carbohydrate diet. Only four percent of the teeth from the Telfair Mound site (9Tf2) had carious lesions. The average rate of caries per individual is 0.7. However, closer inspection revealed that the small sample size, coupled with a high rate of antemortem tooth loss, skewed the results. Five premolars and six molars in the Telfair remains were lost antemortem. The average rate of antemortem tooth loss per individual at the Telfair Mound site was 3.6 teeth per person, compared to only 1.5 teeth per person at the Cannon Site (Table 9).

This loss increases the influence of the anterior dentition on the caries rate. The anterior dentition is much less likely to develop caries than the posterior (Larsen et al. 1991) and, as a result, the rate of carious lesions at the Telfair site appears quite low. However, if one assumes that most antemortem tooth loss in the posterior dental arcade is due to dental disease, likely resulting from carious lesions as opposed to breakage or trauma, then it is possible to combine the count of teeth lost antemortem and teeth with carious lesions (Reeves 2000). When the number of teeth lost antemortem and the number of teeth with carious lesions are combined as a count of diseased teeth, the populations are approximately equal (Table 9). The Cannon Site has 37.8% diseased teeth compared to 41.1% at the Telfair Mound site.

Table 9. Intersite Comparisons of Tooth Loss and Diseased Teeth.

Population	Avg. # of teeth lost antemortem per individual.	% of diseased teeth per population.	References
Cannon Site	1.5	37.8%	Tucker n.d.
Telfair Mound Site	3.6	41.1%	Humph, personal com.

Tooth Wear

Dental wear has been shown to be a better reflection of subsistence patterns than incomplete or fragmentary postcranial remains (Patterson 1984; Schmucker 1985). Tooth wear is a continuous process and therefore related to age; however, rates of dental wear are also heavily dependant on the type of food consumed and food preparation techniques (Gold 2000). A hunting and gathering subsistence regime is linked to higher amounts of dental attrition than an agricultural lifestyle (Molnar 1971; Schmucker 1985, Smith 1975). In the Eastern Woodlands, the amount of wear has been shown to decrease with the adoption of agriculture (Gold 2000). The switch to agriculture coincides with a decrease in the consumption of hard, abrasive foods and an increase in cooking time, which result in decreased dental attrition (Gold 2000). Despite this general trend, it is important to note that, in some cases, dental wear increases with the adoption of maize due to the use of grinding stones in maize preparation. The grit produced in the grinding increases dental wear (Hillson 1996; Larsen 1995).

The rate of tooth wear varies between the two sites. Wear on all three individuals from the Telfair site is described as "heavy." Sketches show obliteration of the cusps on the first molar and heavy wear on the second and third molars for each individual. At the Cannon site, tooth wear is more varied. As can be expected, the young female exhibits only light wear. The three older adults run the gamut from moderate, to heavy, to extreme wear. Combined, the dental attrition rates from the two sites point to a hunting and gathering subsistence, though the Cannon site is somewhat less convincing due to the more varied and lighter wear observed. This may be a result of the more variable age range and the average younger age of the Cannon site population.

While a sample size of seven adults is certainly too small to draw any definite conclusions, the caries and antemortem tooth loss data from each site suggest a diet rich in carbohydrates. Twenty percent of the teeth at the Cannon Site are carious, well within the range of maize agriculturalists (10-50%). While only 4% of the teeth at the Telfair Mound site were carious, a comparison of the rates of diseased teeth from both sites showed that they were approximately equal. The rate of diseased teeth at the Cannon Site was 37.8% compared to 41.1% at the Telfair Mound site. Taken together, these data indicate a high carbohydrate diet.

An explanation for both the high rate of caries and wear may be found in the results of dietary reconstructions for the Coles Creek culture of the Lower Mississippi

Valley. The Coles Creek period (A.D. 800-1200) is temporally equivalent to the Early Mississippian period of the southeastern United States, but the Coles Creek culture, like the Ocmulgee Big Bend/Lake Blackshear culture, eschewed maize agriculture. However, the human remains from various Coles Creek sites also yield a high rate of 8.1 carious teeth per person, well over the division between a high and a low carbohydrate diet (Garidino 1977; Rose and Marks 1985; Rose et al. 1984).

Despite the elevated rate of carious lesions, no evidence of maize agriculture has been found at a Coles Creek site (Byrd and Neuman 1978; House 1982; Neuman 1984; Rose and Harmon 1989). However, King (1985) found evidence of the cultivation of starchy seed plants, maygrass, knotweed, and goosefoot, in the Coles Creek occupation at the Alexander site (3Cn117). Rose et al. (1991) argued that the high starch content of these seeds could account for the high caries rate in Coles Creek remains and that the high rate of caries was paralleled by an increase in dental attrition. This increase in dental attrition was attributed to the preparation required to crush the starchy seeds (Rose et al. 1991). Rose and colleagues (1991) argued stone grinding implements were employed in the processing of these seeds (much like the aforementioned maize processing) and the resulting grit increased dental attrition. Therefore, it is possible that cultigens other than maize were being utilized at the Cannon site and the Telfair Mound site. The starchy seeds, and their preparation, could account for the high rate of caries at the Cannon site and the heavy rates of wear and antemortem tooth loss at the Telfair Mound site.

Using the Cole's Creek culture as a model, an argument can be made for a horticultural component of the diet utilizing starchy seeds. According to Gremillion

(2002), starchy seed crops were not extensively utilized in the deep south of the United States. In *The Development and Dispersal of Agricultural Systems in the Woodland Period Southeast* Gremillion (2002) reviewed several current arguments concerning the absence of starchy seed agriculture prior to the introduction of maize in the Southeast. Gremillion divided the eastern U.S. into three zones based upon seed counts recovered from Woodland Period sites. The "developed pre-maize agriculture" zone was limited mainly to the mid-west. The "limited pre-maize agriculture" zone encompassed what is now northern Mississippi, northern Alabama and northern Georgia, most of Tennessee, and western South and North Carolina. Finally, the "no pre-maize agriculture" zone included southern Mississippi, southern Alabama, and southern Georgia, all of Florida, and eastern South and North Carolina. The coastal plain of Georgia is squarely in the "no pre-maize agriculture" zone as indicated by Gremillion.

Another aspect of Gremillion's explanation for the absence of seed production in the southernmost eastern U.S. appeals to the degree of seasonal variation from region to region. On the basis of the seasonality of seeds and pollen found at sites, coupled with archaeological evidence of storage features, many researchers suggest that seed crops were stored and acted as a buffer against seasonal food shortages, especially during the winter months (e.g., Cowan 1978, 1985; Gremillion 1993; Gremillion and Sobolik 1996; Yarnell 1974a, 1974b). Gremillion (2002) proposed that if seasonal variation was a key causal factor in the development of food production, then there would be a relationship between the timing, spread, and importance of cultivated plants and environmental variables such as length of the growing season. To test this hypothesis, she plotted isotherms representing the average number of days per year the temperature drops below

32 degrees Fahrenheit. This map was overlaid on the three zones derived from seed counts. The line dividing the no pre-maize agricultural zone from the limited pre-maize agricultural zone fell almost perfectly between 40 and 50 days a year with below 32 degrees (Gremillion 2002). Fritz (1990) reported that south of the 50-day line is a zone lacking virtually all evidence for Woodland pre-maize farming. The Ocmulgee Big Bend region and the Lake Blackshear region both fall under the 30-day a year line, again firmly in the no-premaize agriculture area. Therefore, though a native seed crop production model fits the isotopic and dental data, the climatic data fail to support it. In addition, no remains of starchy seed plants have been recovered from either the Cannon site or the Telfair Mound site (Schnell and Wright 1993).

An alternative explanation for the high rates of dental wear and antemortem tooth loss is environmentally based. The Telfair Mound site and Cannon Site are both located on sandy soils (Calhoun 1981; Stephenson 1989). The high rates of wear could result from the coarse foods traditionally associated with a hunting and gathering subsistence coupled with sand and grit inadvertently included in the diet from the surrounding soils. In addition, abrasives could have been added during the grinding of foods such as acorns and may have contributed to an even higher rate of attrition. Acorns, a plentiful, seasonally abundant resource, could also have added significant quantities of starch to the diet (see below).

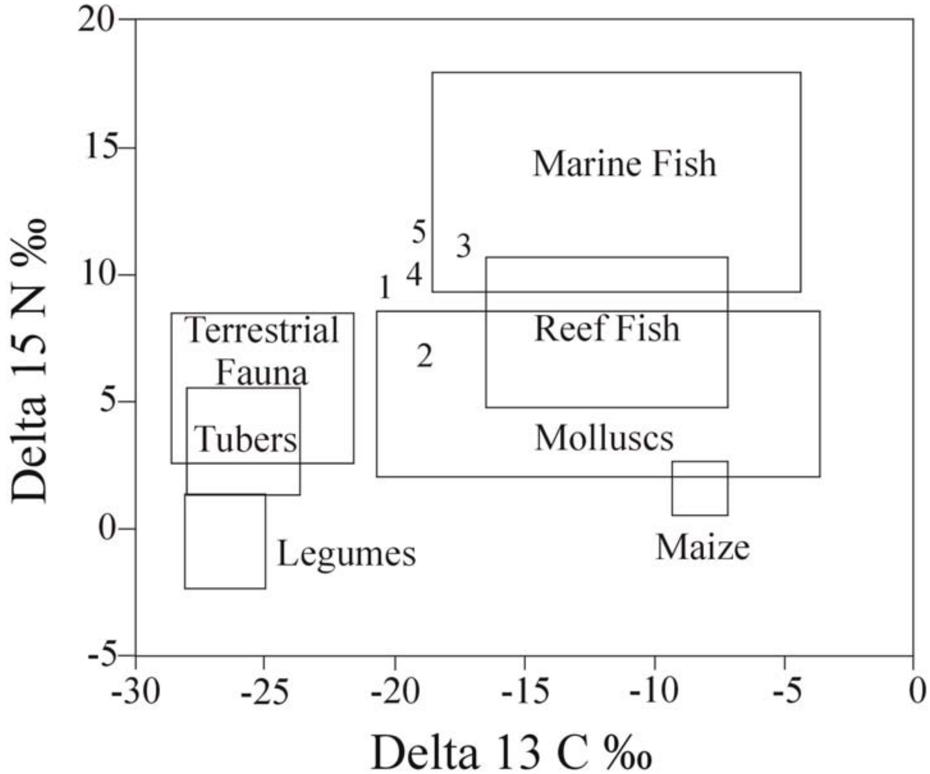
In any case, high rates of antemortem tooth loss may result from advanced dental attrition. The antemortem tooth loss at the Telfair Site could result from the teeth being worn away or from advanced caries. Heavy attrition exposes large areas of dentin, which is more susceptible to decay, and may lead to dental caries and eventual tooth loss.

(However, heavy dental attrition also wears away crevasses that trap food particles and facilitate caries formation. Hence, the effect of heavy attrition on rates of caries formation is not necessarily positive.) The antemortem tooth loss *may* be due to advanced attrition from an extremely abrasive diet rather than carious lesions from a high starch diet. While this explanation accounts for the high rates of antemortem tooth loss coupled with heavy attrition at the Telfair Site, it does not explain the high rate of caries coupled with the more varied dental wear found in the remains from the Cannon Site.

Isotopic Evidence

Despite the high rate of caries, the results of the isotopic assay show the people of the Blackshear region were not practicing maize agriculture. The consumption of a C_4 plant in an environment where the local resources are predominantly C_3 is a fairly straightforward application of isotopic assay to the reconstruction of paleodiet (Norr 1995). The native terrestrial fauna of the eastern U.S. are in a C_3 food chain and do not contribute high $^{13}C/^{12}C$ ratios to prehistoric diets (Katzenberg 1989; Land et al. 1980). C_3 plants have ratios that range from –35‰ to –20‰ with an average of –26.5‰, while C_4 plants have a range of –15 to –7‰ with an average of –12.5‰ (Smith 1972, Smith and Epstein 1971). Inland lacustrine and riverine environments also have a C_3 food web and, as with terrestrial fauna, do not contribute high $^{13}C/^{12}C$ ratios to prehistoric diets (Norr 1995). Nitrogen values for inland lacustrine and riverine environments, though generally lower than marine values, may vary greatly in freshwater environments (Norr 1995). Assuming a direct relationship between the carbon isotope ratio in bone collagen and the quantity of maize consumed, Vogel and van der Merwe (1977) established values for a traditional (C_3) and a pure maize (C_4) diet of -20 and –7‰ respectively.

The ${}^{13}C$ values from the bone collagen from the Cannon Site ranged from –17.13 to –20.04‰, with a mean of 18.92 ‰, the nitrogen values ranged from 9.47 to 11.90 (Figure 7.). These values are clearly out of the range of maize agriculturalists in the



*Individuals are represented by Burial number.
Figure 7. $\delta^{15}N$ and $\delta^{13}C$ Values from Bone Collagen for the Cannon Site (Adapted from Norr 1995).

Early, Middle and Late Mississippian populations shown in Table 10. The child's collagen sample had the highest $\delta^{13}C$ value for the population—a value of -17.13‰ as compared to the adult average of –19.37‰. This lower value seems to indicate the child was consuming a different diet than the adults. If the child is dropped from the analysis, the mean $\delta^{13}C$ from collagen lowers to 19.37‰.

Table 10. ^{13}C Collagen Values by Period

Period	Sample Size	$\delta^{13}C$ from Collagen	Location	Source
Late Archaic	13	-20.2	Illinois River Valley	Schober 1998
Middle Woodland	20	-20.6	Illinois River Valley	Schober 1998
Late Woodland	20	-19.7	Illinois River Valley	Schober 1998
Early Mississippian	14	-13.5	Illinois River Valley	Schober 1998
Middle Mississippian	5	-14.2	Ozark Highlands and Central Mississipian Valley	Rose et al.1991
Late Mississippian	3	-12.3	Ozark Highlands and Central Mississipian Valley	Rose et al.1991

The isotopic value of the whole diet can be calculated by subtracting 9.5‰ from the value of the bone apatite. If the ^{13}C values from bone apatite are adjusted for the average diet-apatite spacing (Ambrose and Norr 1993), then the ^{13}C values range from -22.98 to –25.05‰ placing the average of the whole diet well within a pure C_3 environment (Table 11). The adjusted apatite value of –22.98‰ for the Burial 3 (the child) indicates that the child's overall diet was still strongly C_3 in composition. When taken in conjunction with the child's lower collagen $\delta^{13}C$ value of –17.13‰, it appears as though more of the child's protein was of a C_4 origin than was the adults, though the researcher cannot suggest a possible source for the protein at this time. The values from the Cannon site may be interpreted via a model presented by Schober (1998), which examined apatite-collagen spacing. If people of the Cannon site were subsisting purely on C_3 resources in a C_3 environment, then their collagen-apatite values would reflect

Table 11. δ13C Values from Collagen and Apatite at the Cannon Site.

Sample Number	^{13}C Collagen Value	^{13}C Apatite Value	^{13}C – 9.5 for diet-apatite spacing
1	-20.04	-14.84	-24.34
2	-18.31	-14.16	-23.66
3	-17.13	-13.48	-22.98
4	-19.67	-15.06	-24.56
5	-19.46	-15.55	-25.05

a monoisotopic diet, experimentally shown to have a collagen-apatite spacing of 5-6‰ (Schober 1998) or 5.7‰ ± 0.4 (Ambrose and Norr 1993). The apatite-collagen spacing from the Cannon site ranged from 3.91 to 5.20‰ (Table 12). The average spacing for the sample was 4.3‰, about 1.0‰ less than the average spacing for a monoisotopic diet

Table 12. Difference in Collagen and Apatite ^{13}C Values.

Burial Number	^{13}C Collagen Value	^{13}C Apatite Value	Difference in Collagen-Apatite Spacing
1	-20.04	-14.84	5.20
2	-18.31	-14.16	4.15
3	-17.13	-13.48	3.65
4	-19.67	-15.06	4.61
5	-19.46	-15.55	3.91

as cited by Schober (1998). If the child is dropped from the analysis, the mean rises to 4.5‰ which, when rounded, is consistent (albeit on the low end) with the 5-6‰ cited by Schober and slightly smaller than the 5.7‰ +/- 0.4‰ shown by Ambrose and Norr (1993). If the dietary energy source for the people at the Cannon site was slightly more negative than that of the dietary protein then one could expect a smaller apatite-collagen spacing. However, the 4.3‰ or 4.5‰ found in this sample is much greater than the 2.1‰ ± 0.2‰ shown for a diet with 70% C_4 protein with a C_3 energy source or the 1.2‰ produced by a diet with 5% C_4 protein with a C_3 energy source. Therefore, it is doubtful the diet at the Cannon site had much isotopic variation. If a dietary energy source was more negative (C_3), it was only slightly so, or they consumed very little of it.

Apatite-collagen spacing has also been used to establish the relative amount of meat consumed (Lee-Thorp et al. 1989, Krueger and Sullivan 1984). Herbivore collagen-apatite spacing is reported as ca. 7‰, omnivore ca. 5‰, and carnivore spacing ca. 4-3‰. (Though these data were drawn exclusively from faunal material, their applicability to humans has been demonstrated by Roksandic et al. 1988.) The average apatite-collagen spacing at the Cannon site, 4.3‰ or 4.5‰, shows an omnivore diet as expected. However, the average leans toward the spacing typical of carnivores indicating heavy meat consumption by these people. These results mesh well with the nitrogen values.

The nitrogen values for the Cannon Site ranged from 6.79 to 11.90‰ with a mean of 9.7‰ (Table 13). These values are within expected limits for a terrestrial inland population. Males averaged 10.7‰ while females averaged 8.3‰. Assuming an average fractionation of 3-4‰ per trophic level, this indicates males may have been consuming more fauna from a higher trophic level than the females. Schober (1998) reported similar numbers for an Archaic population from the Klunk site. At that site, males had a mean $\delta^{15}N$ of 10.1‰ while females exhibited a mean $\delta^{15}N$ of only 8.7‰. Schober (1998:113) cautioned that this discrepancy in $\delta^{15}N$ values does not necessarily imply dietary discrimination against females. Males may consume more meat in an expedient fashion, such as during transport of hunted animals from the kill site to a habitation site (Schober 1998).

Table 13. $\delta^{15}N$ Values from the Cannon Site.

Burial Number	$\delta^{15}N$ Value
Burial 1	9.47
Burial 2	6.79
Burial 3	10.46
Burial 4	9.87
Burial 5	11.90

Tuross and coworkers (1989) studied the ^{15}N ratios of nursing infants and their mothers. The infants were found to have ^{15}N values approximately 3% higher than their mothers. Infant levels fell to adult levels shortly after weaning. These results have been validated in an archaeological context from a historic cemetery with the bones of a mother and her infant. The $\delta^{15}N$ ratio for the infant was enriched 2.2‰ relative to the mother's $\delta^{15}N$ (Katzenberg 1991). In modern preindustrial societies, breastfeeding may continue until the child is around three years of age (Wood 1994). Despite the fact that the child at the Cannon site sample is between 4 and 8 years old, the $\delta^{15}N$ ratios of the child and its possible mother were compared. Interestingly, the $\delta^{15}N$ of the child was 10.46‰ while the mother's was only 6.79‰, a difference of 3.67‰. These results may indicate the child was younger than its fragmentary remains seem to indicate or that this culture had a longer period of breastfeeding.

Prior to this study, no isotopic data existed for the interior of south central Georgia during the Late Woodland and Early Mississippian periods, though there were stable isotope values for a scattering of sites on or near the Georgia coast and in northern Florida (Table 14). Isotopic data in Table 14 indicate that foraging gave way to horticulture as early as the 11th century, with significant C_4 plant use in Georgia by the 12th century (Hutchinson et al. 1998, 2000). The results from the Cannon site differ greatly from the sites on or near the coast. The $\delta^{13}C$ values from the Cannon site are more negative (C_3) than the sites along the coast while the $\delta^{15}N$ values are more positive. Compared to the coastal populations, the inhabitants of the Cannon site appear to have been subsisting on a more pure C_3 terrestrial diet while consuming less ^{15}N rich foodstuffs (in this case, marine resources). The $\delta^{13}C$ values from the Cannon site are more similar to the people of central and southern Florida than to the values from the Georgia coast (Hutchinson and Norr 1994; Hutchinson et al. 2000; Newsom 1987). Specifically, as noted in Chapter 2, the Alachua culture existed in an environment similar to that of the Ocmulgee/Blackshear people and also produced a cordmarked pottery into the Mississippian period. Though the $\delta^{13}C$ values from the Henderson Mound site (Table 14), an Alachua culture site, are still more positive than the results from the Cannon site, the values demonstrate another culture existing in a similar environment that also eschewed maize consumption in favor of C_3 resources (Hutchinson et al 1998).

The isotopic assay of the Cannon site supports the non-agricultural subsistence strategy suggested by the Woodland-style artifact assemblage. The carbon and nitrogen isotopes from the collagen show clearly that these people were subsisting on local C_3 resources and, if the apatite values can be trusted, not consuming even small amounts of maize. While the $\delta^{13}C$ values both from the collagen and apatite make it abundantly clear that these people were not eating maize, the values do not help to illuminate what C_3

resources they were consuming. Unfortunately, the isotopic data cannot differentiate the consumption of starchy seed crops; if the Lake Blackshear people were exploiting starchy seeds there is no way to distinguish them from other C_3 resources. All of the species utilized in the Southeast, notably sumpweed, sunflower, knotweed, maygrass, and various species of chenopodium, are C_3 plants. (The only C_4 seed crops, the Amaranths, were not utilized extensively outside of the southwest [Fritz 1994].)

These results align nicely with the heavy dental wear exhibited by the populations at the Cannon and Telfair sites. Heavy tooth wear is often associated with hunter-gather subsistence. However, the high rate of caries at the Cannon site and the high prevalence of antemortem tooth loss at the Telfair Mound site confound the view of these people as Woodland-style hunter-gathers. The rates of caries and tooth loss at these two sites are much closer to what one would expect from an agricultural, as opposed to a hunter-gather subsistence. While high rates of caries and antemortem tooth loss are often associated with starchy foods such as maize, they may also be the result of an abrasive diet, the explanation that is favored here; heavy use of acorns may also have added significant quantities of starch to the diet. It has been suggested that the slow development and limited importance of native seed crops in the lower Southeast might be due to the availability of acorns as a source of carbohydrates (Scarry 1993). Though acorns require much preparation to leach the tannic acids out, their overall abundance in the deep south may have made them preferable to starchy seeds, which, while present, were not naturally as abundant as acorns (Scarry 1993). Gremillion (2002) concluded that starchy seeds may have been an improvement over acorns in some parts of the south, but decidedly less cost effective in others. As has already been suggested, acorns and their preparation, if

Table 14. Isotope Values from Georgia and Florida (adapted from Hutchinson 2000).

Georgia Early Prehistoric 400 B.C.- A.D. 1000	**Coastal or Inland**	**N**	**$\delta^{13}C$**	**$\delta^{15}N$**	**References**
McLeod Mound	Coastal	4	-15.8	12.8	Thomas and Larsen 1979; Larsen 1982
Seaside Mound I	Coastal	1	-15.0	-	Thomas and Larsen 1979; Larsen 1982
Seaside Mound II	Coastal	3	-14.3	11.9	Thomas and Larsen 1979; Larsen 1982
Cunningham Mound C	Coastal	2	-15.4	14.4	Thomas and Larsen 1979; Larsen 1982
Cunningham Mound D	Coastal	1	-13.9	12.9	Thomas and Larsen 1979; Larsen 1982
Deptford Site	Inland	11	-16.0	11.1	Thomas and Larsen 1979; Larsen 1982
Florida Early Prehistoric A.D. 600-1200					
Henderson Mound	Inland	4	-15.9	10.3	Loucks 1976
Georgia Late Prehistoric A.D. 1000-1450					
John’s Mound	Coastal	10	-14.1	12.9	Larsen and Thomas 1982; Larsen 1982
Mary’s Mound	Coastal	2	-14.5	12.4	Larsen and Thomas 1982; Larsen 1982
Southend Mound I	Coastal	5	-13.0	12.1	Larsen and Thomas 1986
Irene Burial Mound	Inland	9	-13.0	10.7	Caldwell and McCann 1941; Hulse 1941; Larsen 1982; Anderson 1990
Irene Mortuary	Inland	13	-16.7	9.9	Caldwell and McCann 1941; Hulse 1941; Larsen 1982; Anderson 1990
Martinez B	Coastal	2	-13.1	13.9	Martinez 1975
Indian Field	Coastal	2	-14.8	14.0	Wallace 1975; Zahler 1976
Taylor Mound	Coastal	9	-12.1	12.3	Wallace 1975; Zahler 1976
Couper Field	Coastal	7	-13.8	12.3	Wallace 1975; Zahler 1976

ground into meal by stone implements, could account for the dental patterns found in both the Telfair and Cannon site remains. In fact, populations in California who consumed large amounts of acorns have caries rates from 44% to 84%, clearly demonstrating the high starch content of acorns (Kennedy 1960; Newman 1957). Additionally, some acorn shell was found in a feature containing cord marked sherds at the Telfair Mound site, suggesting that the inhabitants were utilizing acorns, though in what abundance is not known. Finally, though not living on the coast, the people of the Cannon site certainly utilized freshwater shellfish as a food source. Freshwater shellfish are a dependable source of protein available throughout much of the year.

Schnell and Wright (1993) have suggested that the Ocmulgee/Blackshear region may be an excellent test of Caldwell's Primary Forest Efficiency model. Caldwell (1958) proposed that the persistence of a foraging adaptation into the Woodland period on the coast, despite the presumed availability of crop plants, occurred because crop cultivation was not a cost-effective activity to hunter-gatherers who had access to diverse, seasonally predictable resources. Caldwell suggested that plant cultivation was less efficient and unable to compete "with hunting, with new economic balances based on the acorn, and with older coastal adjustments still relying heavily upon shellfish" (Caldwell 1958:72). The people at the inland Cannon site may have extended this foraging subsistence pattern beyond the Woodland period by utilizing all three of the strategies suggested by Caldwell, though with freshwater as opposed to marine shellfish. The faunal remains from the burial pit fill and the isotopic values from the site indicated a generalized C_3 diet which, judging by the nitrogen values, included a hunting component. The ubiquitous small triangular projectile points found throughout the Ocmulgee Big Bend region further support the importance of the hunting component of the diet.

Ultimately, Caldwell's model can account for the existence of a hunting and gathering lifestyle well into the Mississippian period. The people of the Ocmulgee Big Bend and Lake Blackshear region appear to have had little impetus to adopt either starchy seed cultivation or maize agriculture. The soils in the uplands are sandy, acidic, leach rapidly, and have poor moisture retention. The floodplains, though rich in nutrients, often flood, making large-scale agriculture unfeasible. However, both the uplands and lowlands contain diverse microenvironments with seasonally abundant flora and fauna. Though not able to be differentiated in the isotopic analysis, the presence of several species of freshwater mussel shell in the fill of the burial pit at the Cannon site attests to the exploitation of the lacustrine environment as well. The overall lack of dietary deficiency related pathology supports the assertion that these populations were well-nourished. The local terrestrial resources were more than adequate to meet dietary needs and the local environment was unsuited for maize agriculture.

CHAPTER 7:

CONCLUSION

Bioarchaeological research can be used to inform and clarify questions resulting from traditional archaeological research. The analysis of human skeletal remains, when coupled with the analysis of artifact assemblages and patterns, at both the site and regional level, is a powerful tool for understanding past people and their cultures. Much archaeological and biological anthropological research would benefit from increased cooperation between researchers, but more importantly, from increased cross training by both biological anthropologists and archaeologists in each other's subdisciplines.

This research has attempted to incorporate information from many sources including: osteological analysis, isotopic analysis, ceramic data, floral and faunal data, and environmental and climatic data. These data are used to reconstruct the subsistence strategies of the people of this region during the Late Woodland and Early Mississippian Periods. A brief summary of this project, and how these data are employed follows.

The upland soils of the Ocmulgee Big Bend region and the Lake Blackshear basin are sandy and leach rapidly and the lowlands are subject to frequent flooding, making both poor choices for agricultural cultivation. Both regions support a myriad of local micro-environments that are rich in seasonably abundant resources, which when combined can provide subsistence year round. A style of cordmarked ceramics developed in the Ocmulgee/Blackshear regions during the Late Woodland Period and persisted well in the Early Mississippian Period. These ceramics are common on sites within the Big Bend region and the Blackshear basin, but rare elsewhere. Based on environmental and ceramic evidence, it has been suggested that a Woodland period adaptation persisted into the Mississippian period in this area. This study was designed to test this proposition with osteological and stable isotope analysis of burials from the region.

Two sites from which human remains have been recovered exist within this region. The first of the sites is the Cannon site overlooking what is now Lake Blackshear. Excavations at the Cannon site revealed a multiple interment burial associated with cordmarked ceramics. The second site, the Telfair Mound site, is located in the Ocmulgee Big Bend region. The Telfair Mound site also contained burials found in association with cordmarked ceramics. The human remains from these sites were examined by osteological and isotopic assay. Stable isotope analysis is based upon the presence of differing amount of ^{12}C and ^{13}C, as well as, ^{14}N and ^{15}N in different foods. The different ratios of these isotopes in different components of bone can be used to help reconstruct what past populations were consuming. The osteological analysis was performed according to the recommendations in *Standards*, modified due to time constraints. The samples for isotopic analysis were prepared according to the procedures used by Dr. Lynette Norr in the stable isotope laboratory at the University of Florida.

The results of the isotopic assay show that the people at the Cannon site were not consuming maize. The dentition from both sites show heavy wear, which is consistent with a hunter-gatherer subsistence pattern. However, the high rate of caries is not consistent with a hunter-gatherer subsistence, and indicates the consumption of an unknown carbohydrate. Starchy seed cultivation could be responsible for the dental patterns found in the remains, and though unable to be supported by the isotope analysis, does not conflict with the isotope results. However, the climatic data and data from floral remains do not support the presence of starchy seed cultivation by the people of the Telfair Mound or Cannon sites.

The isotopic analysis of the skeletal remains, augmented by the osteological study, has supported the archaeologically based hypothesis that the Ocmulgee/Blackshear people were not practicing maize agriculture. The artifact assemblage from the region shows little change from the Late Woodland until the Middle Mississippian. This culture did not accept the influence of its Mississippian neighbors, though the presence of marine shell artifacts demonstrates they were in contact with the surrounding cultures. These were not a people cut off from their neighbors in isolation, rather they were a people well adapted to their environment through their culture, material and social.

While it is now clear that maize cultivation was not responsible for the high rates of diseased teeth, what was responsible is still unknown. Other questions remain as topics for future research. Though the Blackshear people and the Ocmulgee Big Bend cultures appear to have shared many cultural attributes, several aspects of their relationship remain unclear. Did they exist contemporaneously in two different river drainages? Did the Ocmulgee Big Bend people finally accept the Mississippian lifestyle or did Mississippian people push them out? If the latter were the case, then were the Blackshear people the remnants of the Ocmulgee people pushed west by encroaching Pulaski phase Mississippians? Certainly the late date from the Blackshear region could indicate this. Or were the Blackshear people the last adherents to the old lifeway after the Big Bend finally gave in? Whether the Pulaski phase people were new people or old people with new ideas is not clear, but what is clear is that the Mississippian society they created did not last long in the Ocmulgee Big Bend. The Pulaski phase and its Mississippian subsistence endured from A.D. 1275- 1350, only 75 years. Who replaced the people of the Blackshear region is not clear; two major Etowah sites were found in the Blackshear survey demonstrating the presence of Middle Mississippian people in the basin (Schnell, 2002, personal communication). Late Mississippian cultures are found to the north and south of the Blackshear basin (Worth 1988), but little evidence of Late Mississippian occupations was found within the Blackshear basin itself (Schnell, 2002, personal communication). Hopefully future research will reveal if the Blackshear people were replaced by a Middle or Late Mississippian group, as were the Ocmulgee people, or if they persisted until contact, perhaps as a northern branch of the Alachua tradition (Price and Tucker n.d.).

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