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3. PREHISTORIC HUMAN BIOLOGICAL ADAPTATION

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CONTENTS

ABSTRACT

Skeletal remains from the prehistoric coast of Georgia are the basis of this study. The effects of agriculture on the human skeleton are examined and explained in the present paper. The region was chosen because (1) there is a large skeletal series representative of both an early preagricultural adaptation (2200 B.C.–A.D. 1150) and a later mixed agricultural and hunting-gathering adaptation (A.D. 1150–A.D. 1550); (2) the Georgia coast represents continuous *in situ* cultural development from at least 2200 B.C. to A.D. 1550, implying human biological continuity for at least 3500 years prior to European contact; and (3) the economic regime for the Georgia coast has been documented by a large body of archaeological and ethnohistoric data.

A series of skeletal and dental changes are viewed in light of an adaptational model encompassing disease and size of the hard tissues—skeletal and dental—and their respective responses to the behavioral shift from a hunting and gathering lifeway to one that incorporated corn agriculture after A.D. 1150. The model consists of two parts. First, with the introduction of an agriculture-based diet and consequent increase in population size and density, the pathology reflecting a general rise in occurrence of infectious disease due to an expansion in population size and a high dietary carbohydrate base should increase. Second, with the adoption of corn as a major dietary constituent, the softer foodstuffs and more sedentary lifeway associated with that adaptation should result in a respective decrease in functional demand on the masticatory complex in particular and on the body in general. In addition, the element of poor nutrition should come into play in an economy in which plant domesticates, and corn in particular, are the focus of diet.

The comparison and analysis of the pathology and metric data support the model. In addition, the detailed examination of these data by sex suggests that the behavioral alterations that occurred consequent to the change in lifeway differentially affected females.

INTRODUCTION

DAVID HURST THOMAS

The American Museum of Natural History began a long-term program of anthropological research on St. Catherines Island in the fall of 1974. This program is part of a larger research effort, established by agreement between the American Museum and the Edward John Noble Foundation. The overall St. Catherines Island Research Program has enabled literally hundreds of scientists and advanced students to conduct research on various aspects of the natural and cultural history of the island. This far-reaching program has dealt with vegetation, geology, avifauna, mammals, insect fauna, reptiles and amphibians, mollusks and other invertebrates. Thomas et al. (1978) provide an overview of the natural and cultural history of St. Catherines Island.

The initial objective of the St. Catherines Island Anthropological Project was to explore and define the early mortuary complex, which existed during the Refuge and Deptford phases, from about 1500 B.C. through A.D. 600. Crews from the American Museum of Natural History excavated nine such mounds between November 1974 and May 1977. To our knowledge, no mounds of comparable antiquity had been scientifically excavated and reported for the Georgia and Florida coast. Not only did the investigations clarify the temporal affiliations of these low sand mounds, but the fieldwork also provided the first real data regarding the religious and ritual practices of the period. These findings have been reported by Thomas and Larsen (1979).

The present volume, by Clark Spencer Larsen, is an outgrowth of that initial fieldwork on St. Catherines Island. The overall objective of this paper is to examine the biocultural nature of the prehistoric adaptation on St. Catherines Island. The methods employed are both cultural and biological, reflecting our belief that the ecological, cultural, and biological systems are interrelated and, in fact, inseparable. It became quickly apparent during the excavation of the Refuge-Deptford mortuary complex that the human biological and archaeological samples from St. Catherines Island provided an exemplary case study for examining the relationship between culture, biology, and related variables. Larsen has examined the problem of changing dietary adaptation, specifically the shift from a purely hunting and gathering mode of subsistence to one depending heavily on agricultural foodstuffs.

Although the focus of this study is clearly on the human biology of St. Catherines Island, it was necessary to supplement the early mortuary material from St. Catherines Island with later, more complete skeletal collections from throughout the Georgia coast. As it turned out, a number of previously unanalyzed skeletal populations were available, and Larsen has quite successfully integrated materials from a number of major institutions.

We are pleased to present Larsen's results as the third monograph in this series entitled *The Anthropology of St. Catherines Island.* Future volumes in this series will deal with diverse yet related topics including prehistoric settlement patterning and an examination of historic Guale social organization and economy in light of recent ethnohistorical findings.

ACKNOWLEDGMENTS

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Two individuals of the Department of Anthropology, of the American Museum of Natural History, provided invaluable services: Mr. Dennis O'Brien drew the maps which show the locations of the preagricultural and agricultural mortuary sites; Ms. Margot Dembo edited the final draft of the manuscript.

I thank my doctoral committee for their assistance in the development of the original draft of this monograph: Drs. Milford H. Wolpoff, David S. Carlson, Christopher S. Peebles, Nathaniel H. Rowe (all of the University of Michigan), David Hurst Thomas (American Museum of Natural History), and Douglas H. Ubelaker (National Museum of Natural History, Smithsonian Institution). Their individual and combined expertise and guidance is greatly appreciated.

CHAPTER 1. THE ARCHAEOLOGY OF THE GEORGIA COAST

BACKGROUND

The Georgia coast, historically known as Guale, has been the focus of a great deal of archaeological research. Beginning with the investigations of this region by C. C. Jones, Jr. and Clarence B. Moore in the mid- to late-nineteenth century, a large body of cultural and biological data has been acquired (for details of the history of anthropological research on the Georgia coast see Thomas et al., 1978; Thomas and Larsen, 1979; Larsen, 1980; DePratter and Howard, 1980; and others).

Much of the work on the Georgia coast has been directed toward establishing, defining, and explaining a chronological sequence that would be applicable to the area in general (DePratter, 1979, n.d.). The most recent revision of the Georgia coastal cultural sequence (summarized in table 1) consists of seven prehistoric periods and one historic period: St. Simons (2200 B.C.–1100 B.C.), Refuge (1100 B.C.–400 B.C.), Deptford (400 B.C.–A.D. 500), Wilmington (A.D. 500–A.D. 1000), St. Catherines (A.D. 1000–A.D. 1150), Savannah (A.D. 1150–A.D. 1300), Irene (A.D. 1300–A.D. 1550), and Altamaha (A.D. 1550–A.D. 1700). The importance of this sequence to the study of change in human biological adaptation is that it represents a picture of cultural continuity from at least 2200 B.C. to A.D. 1550 (cf. DePratter, 1977), thus, human genetic continuity as well.

In addition, much of the analysis of prehistoric behavior on the Georgia coast has been oriented toward the reconstruction of lifeways. The following discussion outlines these data, particularly in relation to subsistence, settlement patterning, and ethnohistoric interpretation.

LIFEWAY RECONSTRUCTION

SUBSISTENCE

Subsistence data from the prehistoric Georgia coast are available for most of the cultural sequence. The following represents a summary of prehistoric subsistence based on reported archaeologically recovered faunal remains and plant macrofossils from sites that are representative of the major cultural periods. These data are derived from the following localities: Cumberland Island (Milanich, 1971, 1973), St. Simons Island (F. Cook, 1976; Marrinan, 1975, 1976), Sapelo Island (Waring and Larson, 1968; Simpkins and McMichael, 1976), Black Island (DePratter, 1973), St. Catherines Island (Thomas and Larsen, 1979; Lee, 1970; Steed, n.d.; Smith, n.d.a, n.d.b), Ossabaw Island (Pearson, 1976, 1977, 1978, 1979; DePratter, 1974), and Skidaway Island (DePratter, 1975, 1976b), as well as from several isolated mortuary and habitation sites: Pine Harbor site (Larson, 1969), Norman Mound (Larson, unpubl. data), Irene Mound site (Caldwell, unpubl. data; Caldwell and McCann, 1941), Red Bird Creek site (Pearson, n.d.; Bates, n.d.), Kent Mound (Cook, 1976, 1978), and Wamassee Pond site (Woods, personal commun.; Caldwell, n.d.).

Analysis of St. Simons period (2200 B.C.–1100 B.C.) dietary remains has indicated that subsistence was oriented toward tidal creek and salt marsh biotopes. For example, Marrinan (1975, 1976) reported the presence of over two dozen molluscan species from the Cannons Point shell ring sites on St. Simons Island. The species offering the greatest subsistence potential were oyster, quahog clam, whelk, *Tagelus,* mussel, and numerous marine snails. Mammalian remains were represented by deer, raccoon, opossum, and dog. In addition, a predominance of fish species indicates their importance in the dietary regime. Plant items included hickory and acorn. Similarly, on Sapelo Island, Waring and Larson (1968) reported the presence of species of molluscan fauna (whelk, clam, oyster), and fish, as well as deer, raccoon, dog, and opossum. Finally, Simpkins and McMichael (1976) also reported the predominance of molluscs (oyster, quahog, periwinkles, whelk) in a St. Simons period refuse midden. A few mammalian, bird, fish, rep-

TABLE 1
Cultural Sequence for the Georgia Coast (After DePratter, 1979, n.d.)

Period	Ceramic Types	Dates
		A.D. 1700
Altamaha	Altamaha—Line Block, Incised, Plain, Check Stamped, Red Filmed	
		A.D. 1550
Irene	Irene—Incised, Complicated Stamped, Burnished Plain, Plain, Corn Cob Impressed	
		A.D. 1300
Savannah	Savannah—Complicated Stamped, Checked Stamped, Fine Cord Marked, Plain, Corn Cob Roughened	
		A.D. 1150
St. Catherines	St. Catherines—Plain, Net Marked, Fine Cord Marked, Burnished Plain	
		A.D. 1000
Wilmington	Wilmington—Plain, Burnished, Heavy Cord Marked, Check Stamped, Complicated Stamped	
		A.D. 500
Deptford	Deptford—Complicated Stamped, Cord Marked, Check Stamped, Refuge Simple Stamped, Refuge Plain	
		400 B.C.
Refuge	Deptford—Linear Checked Stamped, Checked Stamped; Refuge—Plain, Simple Stamped, Dentate Stamped, Punctated, Incised	
		1100 B.C.
St. Simons	St. Simons—Incised and Punctated, Incised, Punctated, Plain	
		2200 B.C.

tile, crustacean, and possible amphibian remains were also recovered.

Until recently, the succeeding period in the Georgia coastal cultural sequence, the Refuge period (1100 B.C.–400 B.C.), was relatively unknown. In contrast to earlier interpretations, recent research has shown a widespread distribution of Refuge period sites (cf. DePratter, 1976a). The Refuge occupation has been difficult to delineate, in part due to the apparent lack of shell midden or other evidence of occupation. Furthermore, many of these sites are located beneath mean high tide, thus hampering their identification.

DePratter and Howard (1977, 1978) have suggested that Refuge sites represent a time period during which there had been a significant change in sea level and concomitant shift in dietary adaptation. These authors demonstrated that during the earlier St. Simons period (*ca.* 2200 B.C.) sea level was approximately 1.5 to 2 m. below present sea level. Compared with the Refuge period sites, St. Simons period sites are common and contain large amounts of shellfish remains, including oyster, clam, whelk, and mussels indicating that St. Simons human populations were dependent upon a diet consisting of marsh and estuary resources, primarily molluscs and fish, supplemented by land fauna (discussed above). However, by 800 B.C. to 700 B.C., a lowering of sea level had taken place and mean sea level was probably about 3 to 4 m. below the present levels. These data suggest that by the middle of the Refuge period, shellfish resources had declined and no longer were important to the overall subsistence economy. Furthermore, by the end of the Refuge period (*ca.* 600 B.C.), sea level rose and reached modern levels. These suggestions by DePratter and

Howard (1977, 1978) explain the depauperate nature of shell in Refuge period sites relative to the earlier St. Simons period, as well as to the succeeding Deptford period.

Hunting may have been important during Refuge times because projectile points and associated lithics became common (Marrinan, 1975). Deer, raccoon, rabbit, opossum, and alligator were hunted (Marrinan, 1975). Recent excavations at the Second Refuge site, however, have indicated that collecting shellfish, though infrequent, was done during the Refuge period (Lepionka, 1980). Investigation of this deeply stratified site demonstrates some use of both riverine and estuarine resources: oysters, whelk, clams, freshwater mussels, and freshwater snails. In addition to these food remains, fragments of hickory nuts, as well as deer, bird, opossum, raccoon, rabbit, rodent, turtle, and fish bones were recovered from this site (Lepionka, 1980).

Although mortuary sites generally offer little information pertinent to subsistence, recently reported data from nine Refuge-Deptford burial mounds on St. Catherines Island support the aforementioned DePratter-Howard model for Refuge period diet (cf. DePratter and Howard, 1977, 1978). At these sites, shell was found to be generally associated with only pre-mound pits in the St. Catherines Island Cunningham Mound group (Cunningham Mounds A, B, C, D, E, McLeod Mound, South New Ground Mound) and Seaside Mound group (Seaside Mounds I and II). Shell was not distributed throughout the fill of these mounds (cf. Thomas and Larsen, 1979). Inferential evidence from these sites suggests that much of the respective mound fill is comprised of reworked residue of previous Refuge period habitation sites. If this is true, then it can be concluded that the Refuge period sites on St. Catherines Island were not shell middens. Indeed, in a large series of preliminary test excavations on St. Catherines Island, a number of the Refuge period habitation sites located show little, if any, shell (Thomas, personal commun.). These data, then, suggest that shellfish contributed relatively little to Refuge period diet.

Documentation of Deptford period (400 B.C.–A.D. 500) subsistence has been attempted for three localities on the Georgia coast: Cumberland Island (Milanich, 1971, 1973), Skidaway Island (DePratter, 1976b), and St. Catherines Island (Smith, n.d.a). Based on the evidence from these islands, the prehistoric subsistence economy during this period appears to have the same characteristics as that of the preceding St. Simons period. For example, Milanich (1971, 1973) reported the presence of numerous species of molluscs (oyster, mussel, *Tagelus,* and whelk), fish (shark, ray, catfish, drum, channel bass, sheepshead, snook, snapper, jack, trout, flounder, mullet, toadfish, and blowfish), terrapin, and several species of sea mammals (otter, porpoise, seal, whale). Land animals included a predominance of deer, and in descending order of frequency: raccoon, opossum, rabbit, pocket gopher, bear, bobcat, tortoise, box turtle, Florida panther, and several genera of avifauna (red-breasted merganser, lesser scaup, and loon). Edible plant remains included hickory nuts and acorns. Similarly, on St. Catherines Island, B. Smith (n.d.a) reported a strong predominance of molluscan fauna (oyster, clam, whelk) and fish, as well as some deer, raccoon, and turtle in a large Deptford site.

Relatively little data exist in publication describing Wilmington period (A.D. 500–A.D. 1000) subsistence remains, faunal or floral. The only reported faunal remains are from a single refuse midden on St. Catherines Island (cf. Lee, 1970) and from a survey on Skidaway Island (cf. DePratter, 1976b). Included were a large quantity of shellfish (oyster, clam, whelk) as well as some animal bone (deer, fish). DePratter (personal commun.), however, has archaeologically tested a large number of Wilmington period habitation localities on Ossabaw, Wassau, Blackbeard, and Little St. Simons islands. This work indicates little divergence from food item inventories reported for the previous Deptford period. That is, preliminary identification of the animal and plant remains from these islands include the following: molluscs, fish, a few land animals and reptiles, as well as hickory nuts and acorns.

The St. Catherines period (A.D. 1000–

A.D. 1150) has also been scantily reported with regard to archaeologically recovered animal and plant remains. University of Georgia investigations of a number of middens in King New Ground Field on St. Catherines Island, however, resulted in some subsistence-related information. At Midden II in King New Ground Field, most of the animal remains consisted of molluscs (oyster, clam, mussel). Non-molluscan animal remains were rare. They included deer with a few remains of turtle, squirrel, opossum, and fish (Steed, n.d.). Preliminary analysis of recovered animal remains from other St. Catherines period sites on St. Catherines Island indicates nearly identical assemblages of faunal and floral remains (Larsen and Thomas, in press).

There is at present a much more comprehensive picture of Savannah (A.D. 1150–A.D. 1300) and Irene (A.D. 1300–A.D. 1550) period diet, perhaps because there are so many more Savannah-Irene sites than sites of the earlier periods (see discussion below). Pearson (1979) investigated two major Savannah period refuse middens on Ossabaw Island. Shellfish remains, especially oyster, comprised the bulk of the recovered faunal remains. Other molluscan remains included clam, mussel, whelk, and periwinkle. Mammals constituted the majority of non-molluscan fauna: deer, raccoon, and rabbit. Other fauna recovered included fish (gar, catfish, mullet, sea trout, bass, drum, flounder), reptiles (turtle, rattlesnake), avifauna, and crab. Plant remains were comprised of hickory nut, acorn, and cabbage palm berry.

Other Savannah period sites that have yielded information regarding prehistoric diet include a pre-mound refuse midden excavated at the Kent Mound site on St. Simons Island (Cook, 1976, 1978) and a midden at the Norman Mound site in McIntosh County (Larson, unpubl. data). At the Kent Mound site, excavation of the pre-mound midden resulted in the recovery almost exclusively of oyster shell. Non-molluscan fauna consisted of deer, raccoon, rabbit, opossum, and several species of fish. Plant remains consisted of two domesticates: corn and mustard. Likewise, the Norman Mound excavations resulted in the recovery of a cache of burned corn kernels and cupules. No other floral or faunal remains have been reported from this site (Larson, unpubl. data).

Knowledge of subsistence during the final prehistoric period, the Irene period (A.D. 1300–A.D. 1550), is based on a series of archaeological test excavations on Ossabaw Island (Pearson, 1976, 1977, 1978, 1979), as well as at the Pine Harbor site (Larson, 1969), the Irene Mound site (Caldwell and McCann, 1941; Caldwell, unpubl. data), the Red Bird Creek site (Pearson, n.d.; Bates, n.d.), and Wamassee Pond (Woods, personal commun.; Caldwell, n.d.). In a series of refuse middens on Ossabaw Island, the inventory of recovered plant and animal remains from the Irene period was identical with that of the earlier Savannah period (Pearson, 1979): shellfish (oyster, whelk, clam, periwinkle), fish, deer, raccoon, rabbit, reptiles, avifauna, and crab. Plant remains included hickory, acorns, and one domesticate—corn. Larson (1969) has provided excellent archaeological documentation of Irene period subsistence that is derived from excavations of the Pine Harbor site. Most of the food remains consisted of molluscan fauna (mussel, snail, oyster, clam, whelk, periwinkle), fish, and crab. Non-molluscan faunal remains consisted of deer, raccoon, bobcat, opossum, and rabbit. Wild plant remains consisted only of acorns and hickory nuts. The remains of a plant domesticate—corn—and possibly a second—beans—were also recovered.

At the Irene Mound site, a major ceremonial-habitation center on the Georgia coast during the Savannah and Irene periods, a diverse composite of fauna was recovered (Caldwell and McCann, 1941; McCann, 1939a, 1939b), including a predominance of shellfish (clam, oyster, mussel, cockle, quahog, razor shell, periwinkle, whelk) and fish (shad, sturgeon, gar, triggerfish, houndfish, drumfish). In addition, the remains of a number of land mammals (deer, bear, opossum, raccoon, squirrel, rabbit, bobcat, beaver, skunk, dog, bison [?]), birds (turkey, goose, duck, teal), reptiles (alligator, turtle, tortoise), and miscellaneous invertebrates (primarily crab) were recovered. Although Caldwell and McCann (1941) did not publish the data on plant remains recovered from the Irene Mound site, it is known that at least one large cache of burned corn (kernels and cupules) was excavated (Caldwell, unpubl. data).

In addition to the Irene Mound site, three other habitation sites containing Irene period components—the Red Bird Creek site, the Wamassee Pond site, and the Seven Mile Bend site—have yielded some information with regard to prehistoric subsistence. Only the ethnobotanical data are available from these localities. At the Red Bird Creek site, the remains of corn (burned cobs and kernels) were found in association with an Irene period house structure (Pearson, n.d.; Bates, n.d.). Likewise, excavations by Larson at Wamassee Pond on St. Catherines Island, resulted in the collection of the remains of burned corn (Woods, personal commun.). A later series of archaeological excavations at the same area by J. R. Caldwell produced additional specimens of burned corn (Caldwell, n.d.). Finally, in a recent series of excavations at the Seven Mile Bend site, F. C. Cook (1971) recovered a cache of carbonized corn cobs in association with an Irene period village.

In summary, it appears that subsistence for the entire cultural sequence on the prehistoric Georgia coast can be characterized as being based on the exploitation of local wild plant and animal resources: hunting, gathering, and fishing. Furthermore, the prehistoric diet appears to be focused on local estuary and marsh biotopes. It appears that only during the Refuge period was there a decrease in use of shellfish resources due, at least in part, to a temporary regression in sea level. Finally, a major shift in subsistence occurred at some point during the Savannah period. That is, during the Savannah period, there was the addition of plant domesticates, and in particular, corn, to the dietary regime. Most certainly, the fact that the remains of corn have not been found in pre-Savannah period contexts does not preclude the existence of corn as a dietary foodstuff in earlier periods because, as is obvious, the sample of ethnobotanical remains is quite limited. However, based on the available archaeologically recovered dietary remains, the subsistence reconstruction presented here seems to be the most parsimonious.

SETTLEMENT PATTERNING

Interest in prehistoric settlement patterning on the Georgia coast is relatively recent; therefore only a few studies of this type exist in either published or manuscript form. However, a number of preliminary investigations as well as analyses by Pearson (1979), Milanich (1971, 1973), DePratter (1975, 1976b) and others have provided some evidence with regard to settlement patterning on the prehistoric Georgia coast. The following discussion presents observations on habitation site size, location, and density, and draws upon archaeological investigations of three major localities: Cumberland Island (Milanich, 1971, 1973), Skidaway Island (DePratter, 1975, 1976b), and Ossabaw Island (DePratter, 1974; Pearson, 1976, 1977, 1978, 1979).

In an examination of Deptford period settlement patterning on Cumberland Island, Milanich (1971, 1973) observed that habitation sites, as demarcated by refuse middens, were small and showed little horizontal or vertical dimension. Few sites exceeded 600 square m. in overall area. Furthermore, all habitation sites were widely spaced and located only at peripheral areas of the island. DePratter (1975, 1976b) similarly noted that the majority of habitation sites from the St. Simons through the Deptford periods on Skidaway Island consisted of small isolated concentrations of shellfish remains and were at the periphery of the island. Furthermore, like the sites examined by Milanich (1971, 1973), the Skidaway Island habitation localities were found to consist of very small, isolated, and generally scattered surface deposits of refuse midden (cf. DePratter, 1975: especially figs. 19, 20, 21, and 22). Unlike the earlier periods, later Wilmington and St. Catherines period sites on Skidaway Island, however, are situated both on marginal areas of the island and in the interior. During these two periods, sites became more clustered;

that is, groups of sites often appeared in close proximity to each other. However, as in the previous periods, sites remained generally small, widely dispersed localities (DePratter, 1976b).

In marked contrast to the distribution and size of St. Simons, Refuge, Deptford, Wilmington, and St. Catherines period habitation sites, Savannah and Irene period sites are relatively larger and less scattered. During the Savannah period, in particular, although the number of habitation sites decreased in the absolute sense, there is a dramatic increase in number of inhabitants occupying major communities (DePratter and Howard, 1980). In the Irene period, large towns continue to exist (DePratter and Howard, 1980). Moreover, habitation sites during these periods are not restricted to the island peripheries. For example, on Ossabaw Island, a significant proportion of major habitation areas are in the interior of the island (Pearson, 1976, 1977, 1978, 1979). More specifically, with regard to the Savannah-Irene occupation of Ossabaw Island, Pearson (1978, 1979) observed that 57 percent of the habitation sites investigated were from 119,000 to 412,000 square m. in area, and most of the sites were related to the island interior.

In summary, these data suggest that prior to A.D. 1150, habitation localities on the prehistoric Georgia coast were small, widely dispersed, and given their thin depositional context, most likely represent isolated short-term occupations. Milanich (1971) suggested that the small settlement areas that constitute the bulk of the earlier habitations may represent nuclear family occupation of small seasonally occupied settlements. In contrast to the pattern of the earlier periods, Pearson (1978, 1979) suggested that the larger, generally more concentrated sites of the later Savannah and Irene periods reflect a marked increase in both size of population and length of occupation as well as permanent year-round village settlement. That is to say, prior to A.D. 1150, human populations were widely dispersed and located in small short-term settlements, and following A.D. 1150, human populations increased, became less mobile, and inhabited villages for lengthier periods of time.

Other data from archaeological surveys on the Georgia coast support these interpretations (cf. DePratter, 1973, 1974; Hally, Zurel and Gresham, 1975; Zurel, 1975, 1976; Simpkins and McMichael, 1976). In particular, Thomas (personal commun.) has completed a systematic archaeological survey of St. Catherines Island. Although the analysis is at present in progress, Thomas and co-workers have found nothing so far that conflicts with the above interpretation. That is, most of the pre-Savannah period sites are small and widely dispersed; the later occupations, in contrast, tend to be large, both in the vertical and horizontal dimensions.

ETHNOHISTORY

In addition to the archaeological evidence for subsistence and settlement distribution, the ethnohistoric record for the Georgia coast has provided excellent corroborative documentation of lifeway. Larson (1969, 1978) has drawn a number of conclusions based on his interpretation of the prehistoric-historic transition on the Georgia coast. With regard to subsistence, Larson (1969) suggested that unlike most interior mainland groups who practiced intensive alluvial bottomland cultivation, the Guale, the historic period Amerinds that inhabited the Georgia coast, practiced shifting cultivation in scattered areas of tillage. Fields were cultivated by widely separated and isolated families and were only worked for a few seasons. Settlement, according to Larson (1969), appears to have been highly dispersed and mobile. Furthermore, only enough corn was grown for part of the year and hickory nuts and acorns made up the non-animal source of diet. These factors contributed to an adaptation requiring high mobility, dispersed settlement, and small living groups. Jones (1978, 1979), however, has pointed out that Larson's interpretation of the ethnohistory of the Georgia coast relies almost entirely on the Jesuit records, records that are clearly not to be taken at face value. Jones (1978) suggests that more reliable evidence can be found in the records that predate and postdate the Jesuit mission period.

To summarize, Jones (1978) has provided evidence that suggests that the Jesuit documents simply do not conform to the more reliable early French reports or to subsequent documentation. Moreover, Jones (1978, 1979, 1980) concluded that the Guale can be characterized as having a chiefdom level of social organization in which a central figure exercised primary economic authority in the form of controlling food distribution from central localities. This reinterpretation of the early European records indicates a major utilization of food crops, specifically corn, with a centralization of both its production and distribution around large permanently occupied towns.

Diet appears to have been diverse and in addition to corn included beans and squash. Melons were seasonally planted and harvested. Apparently, corn production was sufficient to last in storage from the harvest in late summer to April, when planting was resumed. In addition to these foodstuffs, oysters were of major importance. Deer, bears, and wild turkeys were hunted; fishing was an important source of supplemental subsistence.

CONCLUSIONS

From the above discussion, I suggest the following: (1) the Georgia coast is represented by a continuous *in situ* cultural development, thereby representing a temporal continuum of human populations; and (2) prior to the Savannah period (pre-A.D. 1150), the Georgia coastal economy was based primarily on a hunting and gathering mode of subsistence, and after that date, agricultural food production increased, thus playing a major role in the dietary regime of Georgia coastal populations. The former conclusion is supported by detailed analysis of ceramics in stratigraphic context (cf. DePratter, 1979). Several forms of evidence support the latter conclusion. First, although limited, all ethnobotanical data show that corn is only present in post-St. Catherines period contexts. Second, following the St. Catherines period, there is a marked increase in habitation site density and area of distribution. This settlement change most likely resulted from the increased utilization of plant domesticates which support more concentrated, larger human populations. Conditions were thereby created in which more and larger settlements could exist on foodstuffs whose increased yields were at least roughly predictable. Thus, the dramatic demographic and settlement changes on the prehistoric Georgia coast are probably best viewed in light of a shift in mode of subsistence to one that included a greater agricultural-based component relative to the earlier periods. Finally, the ethnohistoric record supports this viewpoint in that large, centrally located, permanent villages were occupied on the Georgia coast at historic European contact. Furthermore, at historic contact, corn agriculture appeared to represent a major constituent of diet.

This does not mean to say, however, that prior to A.D. 1150, the Georgia coast was occupied by people employing a purely hunting and gathering subsistence economy, and that after A.D. 1150 the adaptation was totally switched to the raising of plant domesticates. Such an all-or-nothing dichotomy is not supported by the evidence discussed above. Most certainly, Pearson (1979), Larson (1969, 1978), and Jones (1978, 1979) have amply demonstrated, to one degree or another, that the agricultural systems of the prehistoric Georgia coast were very different from those in the interior of the southeastern United States. Therefore, the standard "Mississippian" analogue is not strictly applicable to this area (see Ford, 1974, 1977; Griffin, 1967; Peebles, 1977; B. D. Smith, 1975, 1978a, 1978b for discussion of interior Mississippian subsistence strategy). The archaeological and ethnohistoric data suggest that the subsistence round in the last of the two prehistoric periods, the Savannah and Irene, was comprised of a mixture of agriculture, hunting, and gathering.

Since this study represents an analysis of human skeletal remains representing populations differing only in pattern of subsistence mode, the cultural periods are combined into two groups. The earlier pre-A.D. 1150 periods constitute a *preagricultural group* that consists of skeletal remains from the Refuge (1100 B.C.–400 B.C.), Deptford (400 B.C.–A.D. 500), Wilmington (A.D. 500–A.D. 1000) and St. Catherines (A.D. 1000–A.D. 1150) periods. The later post-A.D. 1150 periods constitute an *agricultural group*. The latter group consists of human skeletal remains from the Savannah (A.D. 1150–A.D. 1300) and Irene (A.D. 1300–A.D. 1550) periods. This separation of the skeletal remains into two groups is not meant to represent an all-or-nothing subsistence dichotomy for either of the groups. Rather, it is done to facilitate the analysis procedure reflecting the economic shift on the prehistoric Georgia coast.

CHAPTER 2. MATERIALS

The human skeletal remains from 19 preagricultural and 14 agricultural period mortuary sites from the Georgia coast were studied. They included 269 individuals from the preagricultural group and 342 individuals from the agricultural group. Table 2 (preagricultural group) and table 3 (agricultural group) summarize each site by site name, number of individuals observed, appropriate references for the archaeological provenience of the skeletal remains, cultural affiliation, and present location of the skeletal remains. With the exception of two individuals from Lewis Creek Mound E, the author made all observations on the original specimens. The postcranial, cranial, and dental measurements and pathology observations for these two individuals were kindly provided by Dr. Ted A. Rathbun of the University of South Carolina. The locations of all mortuary sites used in this study are shown in figure 1 (preagricultural group) and figure 2 (agricultural group).

The following discussion contains a description of each mortuary site from which human skeletal remains were observed for this study. Because a number of the mortuary localities from St. Catherines Island have been described in detail in an earlier volume of this series (cf. Thomas and Larsen, 1979; see also Larsen, 1980), they are not included in the site descriptions below. The sites excluded from this discussion are South New Ground Mound, Cunningham Mounds C, D, and E, McLeod Mound, and Seaside Mounds I and II.

Varying levels of competence and reporting have characterized the history of mortuary archaeology on the Georgia coast. On the one hand, a number of archaeological sites have received extensive attention in method of excavation and analysis as well as in subsequent publication of the results (e.g., Caldwell and McCann, 1941; Thomas and Larsen, 1979). On the other hand, several of the mortuary sites are known to the present author on the basis of personal communication alone (e.g., Red Knoll site), thus inhibiting thorough description below.

Chronological assessment of the archaeological localities varies. For the purposes of this study, radiocarbon chronometrics used in conjunction with typological-temporal analysis of ceramics provide the best means of cultural-temporal positioning of the associated skeletal remains. However, many of the descriptions of the archaeological localities presented in the following discussion are based solely on association of ceramic types because the site excavations, for the most part, pre-date the technology of radiocarbon dating.

THE PREAGRICULTURAL MORTUARY SITES

EVELYN PLANTATION SITE

The Evelyn Plantation site (9 Gn 6A, 91–94) is situated on a bluff overlooking the Altamaha River in Glynn County directly across from Darien, Georgia. The site is a mound site that contains one platform mound and four small conical burial mounds (Waring and Holder, 1968). The four burial mounds were investigated by Preston Holder for the Works Progress Administration (W.P.A.) in 1936. This work yielded six burials from Mound A, two burials from Mound B, four burials from Mound C, and one burial from Mound D (Holder, 1936–1937, 1939). In 1968, during archaeological salvage operations, C. B. DePratter recovered cranial fragments and teeth from an additional human burial at the site (DePratter, personal commun.). Because most of the pottery recovered is representative of the Deptford series, the burial mounds were probably constructed during the Deptford period (Waring and Holder, 1968). No radiocarbon dates are available and both cultural remains and skeletal remains from this site are unpublished. However, a preliminary description of the W.P.A. investigations at the site has been reprinted (cf. Waring and Holder, 1968).

AIRPORT SITE

The Airport site (9 Gn 1) is near the south end of St. Simons Island. It was first exca-

TABLE 2
Preagricultural Mortuary Sites

Site	N[a]	Reference(s)	Cultural Affiliation	Location[b]
South New Ground Mound	1	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Cunningham Mound C	4	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Cunningham Mound D	2	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Cunningham Mound E	1	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
McLeod Mound	14	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Seaside Mound I	16	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Seaside Mound II	8	Thomas and Larsen, 1979	Refuge-Deptford	AMNH-SCI
Evelyn Plantation	3	Holder, 1936–1937, 1939, n.d.; Waring and Holder, 1968; Willey, n.d.	Deptford	NMNH-SI; UGA
Airport	52	Holder, 1936–1937, 1938, 1939; Milanich, 1977	Wilmington	NMNH-SI
Deptford	43	Caldwell and McCann, n.d.a; Caldwell et al., 1941; Hulse, n.d.; Waring and Holder, 1968	Wilmington	NMNH-SI
Walthour	2	Caldwell and McCann, 1940b; DePratter, n.d.	Wilmington	NMNH-SI
Cannons Point	18	Holder, 1936–1937, 1938, 1939	St. Catherines	NMNH-SI
Cedar Grove Mound A	1	Caldwell and McCann, n.d.b; Caldwell et al., 1941; DePratter, n.d.	Wilmington-St. Catherines	NMNH-SI
Cedar Grove Mound B	2	Caldwell and McCann, n.d.b; Caldwell et al., 1941; DePratter, n.d.	Wilmington-St. Catherines	NMNH-SI
Cedar Grove Mound C	7	Caldwell and McCann, n.d.b; Caldwell et al., 1941; DePratter, n.d.	Wilmington-St. Catherines	NMNH-SI
Sea Island Mound	28	Holder, 1936–1937, 1938, 1939	St. Catherines	NMNH-SI
Johns Mound	49	Caldwell, 1971; Larsen and Thomas, in press; Butler, n.d.	St. Catherines	AMNH-SCI
Marys Mound	5	Caldwell, 1971; Larsen and Thomas, in press	St. Catherines	AMNH-SCI
Charlie King Mound	13	Holder, 1936–1937, 1938, 1939; Willey, n.d.	St. Catherines	NMNH-SI
TOTAL	269			

[a] Number of individuals.

[b] AMNH-SCI = American Museum of Natural History, St. Catherines Island Archaeology Laboratory. NMNH-SI = National Museum of Natural History, Smithsonian Institution. UGA = University of Georgia, Department of Anthropology.

vated by Frank M. Setzler of the United States National Museum, Smithsonian Institution, in the winter of 1936 (Holder, 1936–1937). During Setzler's investigation, he discovered that the Airport site consisted of an extensive shell midden overlying a large premidden cemetery. Four human burials were recovered in this archaeological test excavation. Several months after this initial work, Setzler arranged for Preston Holder, through the W.P.A., to continue work on the midden and associated cemetery during 1936 and 1937. In addition to the four individuals recovered by Setzler, a minimum of 147 in-

TABLE 3
Agricultural Mortuary Sites

Site	N[a]	Reference(s)	Cultural Affiliation	Location[b]
North End Mound	1	Moore, 1897	Irene	NMNH-SI
Shell Bluff, Low Mound	1	Moore, 1897	Irene	NMNH-SI
Townsend Mound	2	Moore, 1897; Cook, 1970	Irene	NMNH-SI; UGA
Deptford Mound	5	Caldwell and McCann, 1940b, n.d.a; Caldwell et al., 1941; DePratter, n.d.	Savannah	NMNH-SI
Norman Mound	28	Larson, 1957	Savannah-Irene	UGA
Kent Mound	25	Cook, 1976, 1978	Savannah-Irene	UGA
Lewis Creek Mound A	7	Cook, 1966	Savannah-Irene	UGA
Lewis Creek Mound B	10	Cook, 1966	Savannah-Irene	UGA
Lewis Creek Mound E	4	Cook, 1966; Neighbors and Rathbun, 1973; Sexton and Rathbun, 1977	Savannah-Irene	UGA; USC
Red Knoll	6	Pearson (personal commun.)	Irene	UGA
Seven Mile Bend Mound	1	Cook, 1971	Irene	UGA
Oatland Mound	2	Cook and Pearson, 1973	Savannah	UGA
Seaside Mound II (Burial 8)	2	Thomas and Larsen, 1979	Savannah-Irene	AMNH-SCI
Irene Mound	248	Moore, 1898; Caldwell, 1939, 1940; Caldwell and McCann, 1940a, 1940b, 1941; Caldwell et al., 1941; Fewkes, 1938a, 1938b, 1938c; Hulse, 1939a, 1939b, 1941 (personal commun.); Shaeffer, 1939	Savannah-Irene	NMNH-SI
TOTAL	342			

[a] Number of individuals.

[b] UGA = University of Georgia, Department of Anthropology. AMNH-SCI = American Museum of Natural History, St. Catherines Island Archaeology Laboratory. NMNH-SI = National Museum of Natural History, Smithsonian Institution. USC = University of South Carolina, Department of Anthropology.

dividuals from 85 single and multiple interments were excavated from this site (Holder, n.d.). The site is complicated by a dense concentration of shell and non-shell refuse as well as by postmold patterns that were apparently associated with the later village occupation overlying the cemetery. However, most of the ceramics from both the cemetery and village components are representative of the Wilmington series (Milanich, 1977). No radiocarbon dates are available from the site and most of the work remains unpublished.

DEPTFORD SITE

Most of the Deptford site (9 Ch 2), like the Airport site, represents a large village midden (Caldwell and McCann, n.d.a). It is on the southwest side of the Savannah River, 3.2 km. from Savannah. During the fall of 1937, Preston Holder and Antonio J. Waring, under the auspices of the W.P.A., made an initial test excavation of the site. In 1940, Catherine McCann excavated several hundred square feet in the same area. From this later series of excavations, 42 human burials were removed. Most of the skeletal remains have been described in a brief unpublished report by Frederick S. Hulse (n.d.).

The majority of the ceramics from this site are from the Deptford and Wilmington series. Based on this information, Caldwell and McCann (n.d.a) concluded that the burials represent Deptford-Wilmington period inter-

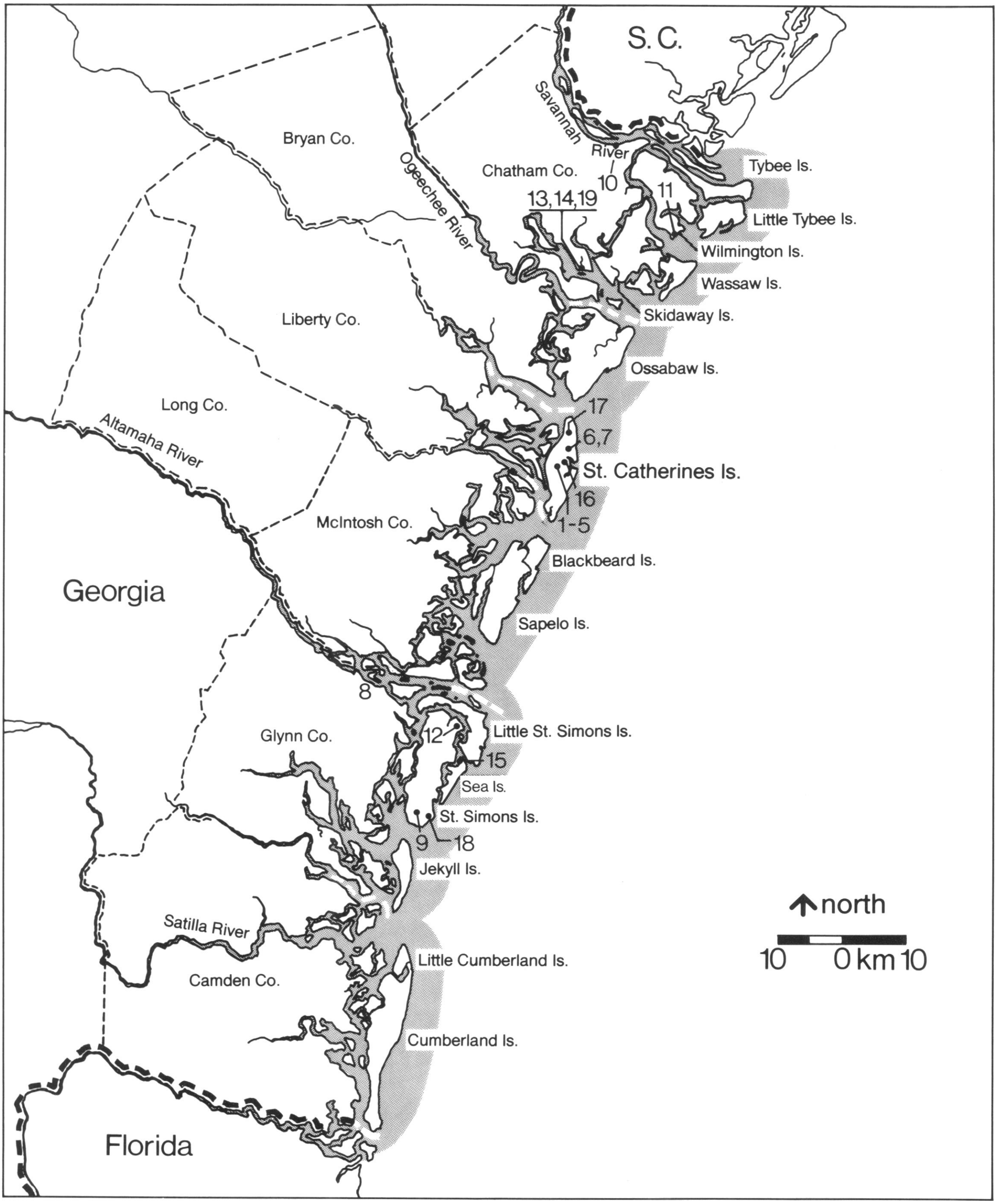


FIG. 1. Map of Georgia coast showing locations of preagricultural mortuary sites (1 = South New Ground Mound; 2 = Cunningham Mound C; 3 = Cunningham Mound D; 4 = Cunningham Mound E; 5 = McLeod Mound; 6 = Seaside Mound I; 7 = Seaside Mound II; 8 = Evelyn Plantation; 9 = Airport; 10 = Deptford; 11 = Walthour; 12 = Cannons Point; 13 = Cedar Grove Mound A; 14 = Cedar Grove Mound B; 15 = Sea Island Mound; 16 = Johns Mound; 17 = Marys Mound; 18 = Charlie King Mound; 19 = Cedar Grove Mound C).

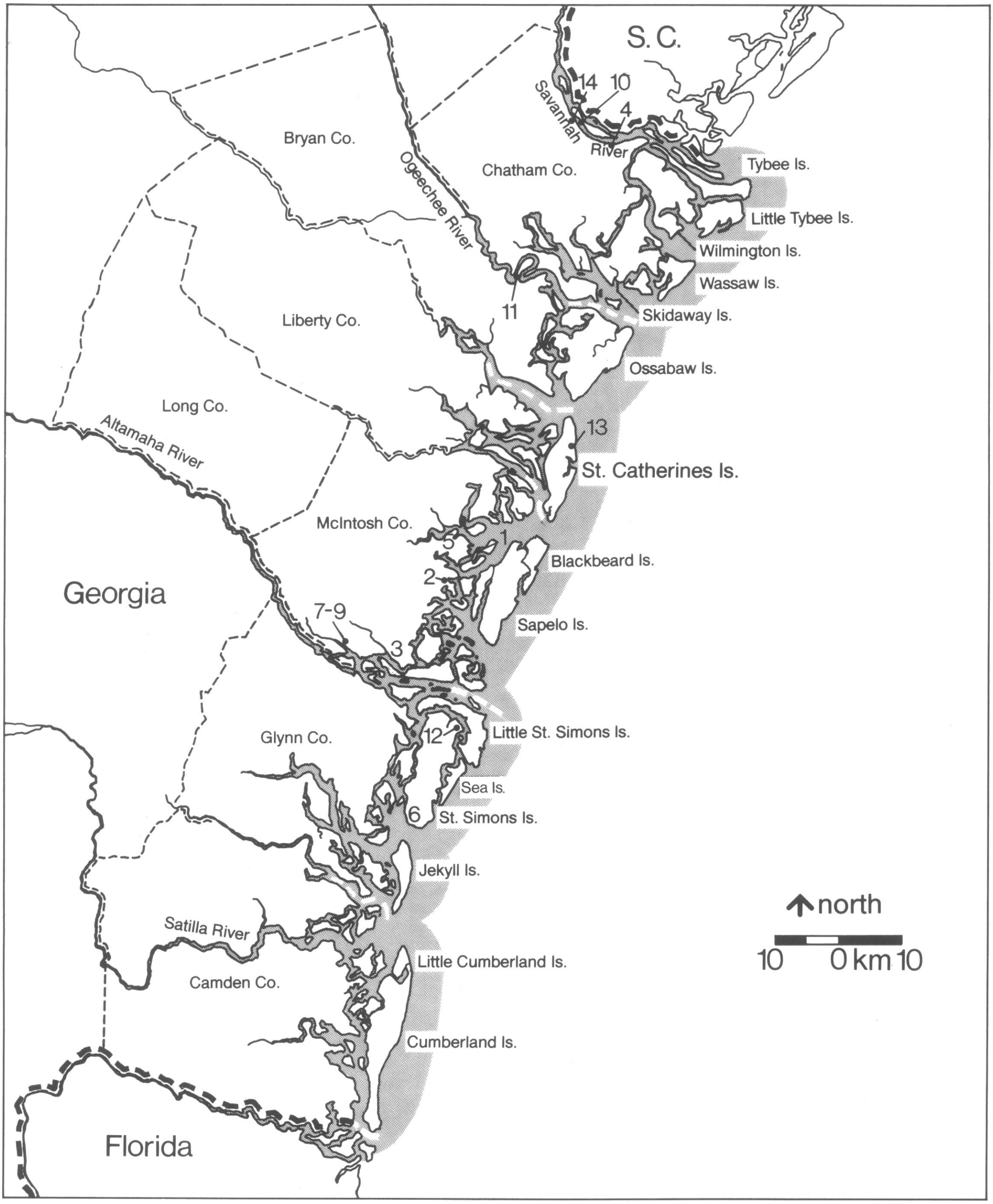


FIG. 2. Map of Georgia coast showing locations of agricultural mortuary sites (1 = North End Mound; 2 = Low Mound, Shell Bluff; 3 = Townsend Mound; 4 = Deptford Mound; 5 = Norman Mound; 6 = Kent Mound; 7 = Lewis Creek Mound A; 8 = Lewis Creek Mound B; 9 = Lewis Creek Mound E; 10 = Red Knoll; 11 = Seven Mile Bend Mound; 12 = Oatland Mound; 13 = Seaside Mound II (Burial 8); 14 = Irene Mound).

ments. No radiocarbon dates are available from the Deptford site.

WALTHOUR SITE

The Walthour site (9 Ch 11) is situated on Half Moon Creek, near the southern end of Wilmington Island. This site consists of two parts, a large clearing containing three shell mounds and a shell midden about 137 m. in length along the creek bank (Caldwell and McCann, 1940b). This site was excavated in 1940 under the direction of Joseph R. Caldwell and Catherine McCann with support from the W.P.A. Three human burials were recovered in the midden area located on the creek bank. They were briefly described in an unpublished progress report to the W.P.A. (cf. Caldwell and McCann, 1940b). Although no radiocarbon dates are available from the site, the pottery is predominantly representative of the Wilmington series.

CANNONS POINT SITE

The Cannons Point site (9 Gn 5) represents an extensive series of refuse middens that are located on the northern extremity of St. Simons Island. The area was excavated by the W.P.A. under the direction of Preston Holder during the summer of 1936 (Holder, 1936–1937, n.d.). Within the fill of one of the five midden areas, three individual human burials were excavated. A large series of isolated human bones from a number of disturbed burials were recovered from other areas of the site. Most of the cultural and human skeletal materials remain unpublished. However, in a series of letters to A. R. Kelly (cf. Holder, 1936–1937), Holder provided a preliminary description of the pottery from the site. This description indicates that most of the pottery appears to represent St. Catherines period types. No radiocarbon determinations are available from the site.

CEDAR GROVE MOUND SITE

The Cedar Grove Mound site consists of three burial sites: Mound A (9 Ch 13), Mound B (9 Ch 18), and Mound C (9 Ch 19). The site is in an area called the Cedar Grove Tract, approximately 5 km. southwest of Savannah. The three mounds were excavated by the W.P.A. under the direction of Joseph R. Caldwell and Catherine McCann in 1940 (Caldwell, McCann and Griffin, 1941; DePratter, n.d.). The mounds are small burial mounds that consist mostly of sand fill. Within the fill of the individual mounds, one burial was recovered from Mound A, six burials from Mound B, and three burials from Mound C. In addition, skeletal remains that represented several disturbed burials were removed from Mound C. The contents of the site, cultural and skeletal, have been described in a brief progress report to the W.P.A. (cf. Caldwell, McCann and Griffin, 1941). Most of the pottery is representative of Deptford through St. Catherines period types (DePratter, n.d.).

SEA ISLAND MOUND

Sea Island Mound (9 Gn 2) is on the north end of St. Simons Island and consists of a natural sand dune on which was superimposed a shell and sand lamina that functioned as a burial locality. The site was excavated by the W.P.A. under the supervision of Preston Holder during the summer of 1936 (Holder, n.d., 1936–1937). The apex of the mound stood approximately 9.5 m. high and was 15.2 m. in diameter at the widest point of the mound base. Thirty-six human burials were recovered in a sand layer beneath the shell cap of the mound. None of the cultural or skeletal materials has been described in publication.

Although no radiocarbon dates are available from this site, a large sample of ceramics was recovered in the excavation, thus providing knowledge of cultural affiliation for the site. The predominant pottery types are from the St. Catherines series (Holder, 1939).

JOHNS MOUND

Johns Mound (9 Li 18) is a large burial mound located in an antebellum field near the eastern periphery of St. Catherines Island. Prior to archaeological excavation, the mound stood about 1.5 m. high and had a diameter of about 15 m. (Caldwell, 1971; Larsen and Thomas, in press; Anon., n.d.). The site was virtually completely excavated by a series of field schools from the University of Georgia under the direction of Joseph R. Caldwell in 1969 and 1970. A total of 65 burials representing single and multiple interments were encountered. These burials represent an estimated 75 to 80 individuals (Larsen and Thomas, in press). Unfortunately, the exact number of individuals will never be known because approximately 20 percent of the recovered individuals were lost following excavation. A preliminary discussion of the site in published form was given by J. R. Caldwell (1971). A cursory description of the skeletal remains has also been provided (cf. Butler, n.d.). A detailed description of the site is currently in preparation by the present author with D. H. Thomas (cf. Larsen and Thomas, in press).

Two groups of burials were recovered from Johns Mound: (1) pre-mound interments in or on the original primary humus, and (2) burials in the mound fill. Thirty-seven burials of the former type were encountered, and the remainder were of the latter type. It appears likely that the burials from both sections of the mound are associated with the St. Catherines period because the predominant pottery types that are present at this site are representative of the St. Catherines series. In addition, two radiocarbon determinations are available: A.D. 1053 ± 60 from charcoal in a pre-mound feature associated with the initial activity of mound construction, and A.D. 1119 ± 60 from a shell feature in the mound fill above the original humic zone.

MARYS MOUND

Marys Mound (9 Li 20) is a low burial mound comprised of sand with a central shell core. It is situated in a large open field at the northern end of St. Catherines Island (Larsen and Thomas, in press). The original height of the mound cannot be estimated due to many years of disturbance by relic collectors. In addition, the site had been extensively ploughed over during historic times. The mound is approximately 20 m. in diameter at its base. According to local tradition, this mound represents the burial locality of Mary Musgrove, Amerindian friend and interpreter to General Oglethorpe, the first English colonial governor of Georgia (cf. Thomas et al., 1978).

During the summer of 1970, the University of Georgia placed two bisecting trenches through the center of the mound. Four prehistoric interments were located in, and recovered from, a pre-mound pit. During the spring of both 1977 and 1978, the American Museum of Natural History, under the direction of David Hurst Thomas, expanded upon the University of Georgia excavations by excavating the entire western half of the mound. In this later excavation, one undisturbed burial and one partially disturbed burial were exposed.

A single radiocarbon date is available from charcoal found in the original pre-mound humus: A.D. 700 ± 70. Because the pottery types represent primarily St. Catherines period wares, the radiocarbon determination from this mound most likely is associated with activity several hundreds of years prior to the mortuary-related behavior at this site. The ceramic associations within the mound indicate that the mound was constructed during the St. Catherines period.

CHARLIE KING MOUND

Charlie King Mound (9 Gn 3) is a low sand-filled burial mound located on the southern end of St. Simons Island. The site was excavated by the W.P.A. under the direction of Preston Holder during the fall of 1936 (Holder, n.d., 1936–1937). According to Holder (1936–1937, 1939), the site had been badly disturbed by relic collectors at the turn of the twentieth century, by road-building crews seeking fill during the 1930s, and most recently, by the presence of a hog pen on the summit of the mound. However, in a series of excavations at the periphery of the mound, Holder was able to expose and recover the human skeletal remains of eight undisturbed burials. These burials represented a minimum of 21 individuals. With the exception of one burial, all interments were beneath a central shell covering. Both skeletal and cultural materials remain unpublished. No radiocarbon dates are available from Charlie King Mound; however, a large ceramic sample was recovered that represented primarily St. Catherines period pottery types.

THE AGRICULTURAL MORTUARY SITES

NORTH END MOUND

A large burial mound on the north end of Creighton Island was excavated by Clarence B. Moore in either the late fall or early winter of 1896–1897 (Moore, 1897). According to Moore's description, the mound stood 1 m. in height and 30.5 m. in maximum diameter. Despite the fact that the mound had been subjected to many years of intensive cultivation, over 200 well-preserved human burials as well as a large array of elaborate grave goods were found: ground stone celts, chisels, discoidal stones, projectile points, shell gorgets, pearls, bone implements, pottery vessels, pipes, and copper chisels. Furthermore, Moore (1897) indicated that this mound was the largest of more than 50 that he investigated during his expedition up the Georgia coast.

Much to the misfortune of physical anthropology, however, Moore saved but a few human skeletal specimens from his excavations. From this site, Moore kept one particularly well-preserved skull and donated it to the now defunct Army Medical Museum. It was later given to the Smithsonian Institution.

Although at the time of Moore's work on the Georgia coast, the present cultural chronology was nonexistent, his careful description of the cultural materials from this burial mound provide sufficient data for an assessment of cultural affiliation. The pottery that Moore describes (Moore, 1897, pp. 39–41) clearly represents Irene period ceramic types. In addition, a shell gorget from this mound shows the classic rattlesnake motif (head with forked eye) that is representative of the so-called "Southeastern Ceremonial Complex" or "Southern Cult" (cf. Waring and Holder, 1945; Peebles, 1971; Brown, 1976). On the Georgia coast, this pattern is restricted to the Savannah and Irene periods (Waring and Holder, 1945; Larson, 1958). In sum, based on the presence of predominantly Irene series pottery as well as cultural paraphernalia that is restricted to post-A.D. 1150 contexts, it seems reasonable to conclude that the skull recovered by Moore from the North End Mound is from the Irene period.

SHELL BLUFF, LOW MOUND

A low, rather unspectacular mound located on Shell Bluff Creek, 5 km. southeast of Crescent, Georgia, was excavated by Clarence B. Moore as part of the same project described in the above site (cf. Moore, 1897, pp. 26–28). Moore did not report the dimensions of this mound. Like the burial mound on Creighton Island, the surface of this mound had been greatly altered by many years of cultivation and excavation by the owner of the land upon which the mound stood. Thirty-one individual interments were encountered by Moore at this mound. Among the six burials described, there was included the following description:

> Burial 14. Sixteen feet E. by W., on the base of a pit containing numerous oyster shells, 16 inches from the surface, was the skeleton of a male flexed on the right side, heading S. by W. The cranium, an exception to the almost universal rule in this mound, was well preserved and showed a marked artificial flattening of the frontal bone. It was sent to the Army Medical Museum, Washington, D.C.

The skull was subsequently donated to the Smithsonian Institution.

As is generally typical of Moore's publications, the cultural and structural aspects of the Low Mound at Shell Bluff were carefully described. In the description of the contents of this mound, a number of burials are designated as urn burials. This burial type is restricted to the Savannah and Irene periods (cf. Caldwell and McCann, 1941; Cook, 1965, 1966, unpubl. data). In addition, the remainder of the ceramic sample recovered by Moore appears to be related to the Savannah-Irene series. Thus, based on the cultural associations, as well as the particularly well-preserved nature of the burial, it seems most likely that the skull recovered by Moore is from an individual interred during the Savannah-Irene period.

TOWNSEND MOUND

Another of the burial mounds excavated by C. B. Moore in the late 1890s was the Townsend Mound (9 McI 4). This mound, located 1.5 km. east of Darien, Georgia, was reported by Moore as not having been subject to intentional excavation prior to his work on the site. However, because the mound is in an antebellum field, it undoubtedly had been plowed over prior to the Civil War. Moore reported that the mound stood nearly 1.2 m. high and about 13 m. wide at its base. Fifty-nine burials were encountered in the mound as well as a large number of artifacts. The only ceramic artifacts included as mortuary items were eight pipes. Associated with one of the burials was a large cache of historic period glass trade beads.

Three well-preserved human crania were saved in the excavation: two of the skulls were placed in the collections of the Academy of Natural Sciences of Philadelphia and one was sent to the Army Medical Museum. The latter skull was later donated to the Smithsonian Institution.

Because Moore either recovered no pottery or simply did not describe the pottery that he did recover, little can be said with regard to cultural affiliation of this site based on his excavations. Fortunately, however, Fred C. Cook resumed excavation of the site during the fall of 1970 in order to define the cultural-temporal position of the site (Cook, 1970). In addition to exposing the skeletal remains representing one individual, a large sample of ceramics was recovered. Of the 108 potsherds recovered by Cook from the Townsend Mound, only one was found to represent a pre-Savannah period type. Most of the pottery was, in fact, representative of the Irene series. Associated with the burial removed by Cook were two perforated, engraved bone pins that represented a combination of two Southern Cult motifs. The upper part of each pin was engraved with the form of a rattlesnake rattle. The rattle motifs are further superimposed on baton-shaped motifs. As discussed above, Southern Cult symbolization is restricted to post-A.D. 1150 contexts. Thus, the data provided by Cook (1970) and Moore (1897) are highly suggestive of a relatively late cultural affiliation for the Townsend Mound. Most likely, the context of the skeletal remains represents a Savannah-Irene affiliation.

DEPTFORD MOUND

The Deptford Mound (9 Ch 2A) was excavated by the W.P.A. under the direction of H. Thomas Cain in the fall of 1939 in conjunction with the excavation of the nearby Deptford site (Caldwell and McCann, n.d.a). At its center, the Deptford Mound stood 1.5 m. high. The mound is roughly circular, and, at its base, measured approximately 23.2 m. across. The fill of the mound consisted of sand with some mixture of whelk, oyster, and clam shell. Six poorly preserved burials were encountered in the excavation of the site. The skeletal remains were described with the Deptford site materials by Frederick S. Hulse (n.d.).

Radiocarbon dates are not available for this mortuary site. However, a large pottery sample was recovered. The predominant types were representative of the Savannah series. The fact that the latest and most common pottery type found is from that series led Caldwell and McCann (n.d.a) to conclude that the mound was most likely constructed during the Savannah period.

NORMAN MOUND

Norman Mound (9 McI 64) is a small conically shaped burial mound measuring 1 m. in height and 15 m. in diameter. This mound, located on the Sapelo River in McIntosh County, was excavated during the winter of

1953–1954 by the Georgia Historical Commission (present Office of Site Planning, Georgia Department of Natural Resources) under the direction of Lewis H. Larson, Jr. (Larson, 1957). The mound consisted of sand fill overlying a central shell core. A large series of human burials was recovered representing a total of 36 individuals. All interments were found either on top of or around the central shell core. The site appeared to have rested on a Deptford period refuse midden.

No radiocarbon dates are available from the Norman Mound. However, from the high percentage of Savannah period pottery that was associated with individual burials as well as with the mound fill, Larson (1957) concluded that the mound was constructed during the Savannah period.

KENT MOUND

Kent Mound (9 Gn 51) is a large burial mound that is at the southern end of St. Simons Island (Cook, 1965, 1976, 1978). Prior to archaeological excavation, parts of the mound had been destroyed by road grading operations, the presence of a trailer park around the site, and the placement of a sewer ditch. The mound was archaeologically tested in 1965 and 1975 by Fred C. Cook (1978). It was found to consist primarily of sand and shell fill overlying a central core comprised of whelk, clam, and oyster shell. In the process of excavation, approximately 30 human burials were exposed (Cook, 1978). The skeletal remains have since been described in a detailed report (cf. Cook, 1976).

Several of the burials from this site appear to represent historic period intrusion: one individual was associated with European glass trade beads, another with an iron knife, and two others with historic period (Altamaha) pottery vessels (Cook, 1978). The skeletal remains from these burials were excluded from the analysis since they represent intrusive interments that occurred well after the construction of the mound.

Most of the pottery found in association with the remainder of the burials, as well as with the mound fill in general, is almost exclusively representative of the Irene period. This led Cook (1978) to conclude that the mound had been constructed during the Irene period. No radiocarbon dates are available from the Kent Mound.

LEWIS CREEK MOUNDS

The Lewis Creek Mounds (9 McI 88) represent a group of five sites—burial mounds—that had been badly disturbed prior to investigation. A large prehistoric village refuse midden is associated with the mounds (Cook, 1966). The site is situated on Lewis Creek, a tributary of the Altamaha River, approximately 5 km. west of Darien, Georgia. Several professional and semi-professional archaeologists have worked at the site since 1960. In the fall of 1963, Clements DeBaillou (Augusta Museum) placed several large archaeological test units into Mounds A and B of the site. Approximately 20 individual skeletons were recovered from these two mounds. During the summer of 1966, a series of excavations were carried out by Fred C. Cook at Mound E (Cook, 1966). Cook exposed the remains of 30 poorly preserved burials. Two of these individuals were saved and subsequently sent to Ted A. Rathbun at the University of South Carolina for analysis (cf. Sexton and Rathbun, 1977; Neighbors and Rathbun, 1973). Finally, in 1971 C. H. Wharton (Georgia State University) salvaged two burials from an eroding shell midden at the site (Carnes, personal commun.).

DeBaillou made a large collection of ceramics from Lewis Creek Mounds A and B, most of which appears to represent Savannah period wares (DePratter, personal commun.). The majority of typable pottery from Mound E, including 17 complete vessels, is also representative of the Savannah series (Cook, 1966). No radiocarbon determinations are available from Lewis Creek Mounds A, B, or E.

RED KNOLL SITE

The Red Knoll site (9 Ch 115) is a prehistoric village midden located at the confluence of Little Back River and Middle River at the western end of Argyll Island several kilometers from Savannah (Pearson, personal commun.). In an archaeological test of this site, six individual human skeletons were recovered by Fred C. Cook during the summer of 1971. Although a report has not been prepared by the excavator, preliminary analysis of the associated pottery suggests that the occupation of the site and related interments are most likely related to the Irene period (Pearson, personal commun.). No radiocarbon dates are available from this site.

SEVEN MILE BEND MOUND

During the spring and summer of 1971, Fred C. Cook excavated a mound located on a narrow, eroding peninsula formed by an oxbow bend in the Ogeechee River. This mound, the Seven Mile Bend Mound (9 Bry 6), rests directly on the site of the colonial town of Hardwicke, 11.2 km. east of the present town of Richmond Hill, Georgia. Cook estimated that prior to erosion by the Ogeechee River, the mound stood about 60 cm. high and had a diameter of 9.1 m. at its base. Through the course of this erosion, one human burial was exposed and later salvaged by Cook.

In an attempt to ascertain the cultural affiliation of the site, a small archaeological test unit was placed in the southeastern region of the mound. This test revealed that the mound consisted of two distinct strata: a lower midden zone that contained only Savannah period ceramics and an upper clay mantle that contained only Irene period ceramics (Cook, 1971). Thus, the excavator of the site concluded that the mound and its contents, skeletal and cultural, are related to the Savannah and Irene periods.

OATLAND MOUND

Oatland Mound (9 Gn 56) is a prehistoric burial mound located on the northeastern side of St. Simons Island on the tract of land known as the Oatland Plantation (Cook and Pearson, 1973). The mound was described as having stood about 1 m. in height prior to excavation. Due to its location in an open, wooded area of the island, the surface of the mound has suffered a considerable amount of damage from local relic collectors. Excavation of the mound by Fred C. Cook and Charles E. Pearson revealed that the mound consisted of sand overlying a central shell core. Three burials associated with the shell core were excavated and subsequently described in an unpublished preliminary report (cf. Cook and Pearson, 1973).

Although little pottery was recovered from this site, typable sherds were related exclusively to the Savannah series, thus leading Cook and Pearson (1973) to conclude that the mound had been constructed during the Savannah period. Radiocarbon determinations have not been made available from this locality.

IRENE MOUND SITE

The Irene Mound site (9 Ch 1) is a large ceremonial-habitation locality that is situated on the western bluff of the Savannah River, immediately south of its juncture with Pipemakers Creek near the city of Savannah (Caldwell and McCann, 1941). The site has a long history of excavation activity, professional and otherwise, having been known since the founding of the colony of Georgia. A Moravian mission was built on the site in 1736 for the purpose of converting a nearby group of Yamacraw Indians to Christianity. In 1897, Clarence B. Moore excavated parts of two mounds on the site, a large mound and an adjoining burial mound (Moore, 1898). Ten years later, nearly the entire north side of the large mound was removed as land fill for a local engineering project. Finally, in the fall of 1937 the W.P.A. under the direction of four successive field directors—Preston Holder, Vladimir J. Fewkes, Claude E. Shaeffer, and Joseph R. Caldwell—initiated and completed a massive two-year archaeological excavation of the site (Caldwell and McCann, 1941).

The Irene Mound site is comprised of several parts: a large mound, from which the site derived its name, a burial mound, a mortuary feature, a rotunda, and a number of minor architectural features. The large mound is a circular structure measuring 4.7 m. in height and approximately 48 m. in diameter at its base. Excavation revealed that this mound consisted of eight superimposed mounds, several of which had well-defined occupation zones on their summits. Each of the successive mounds was pentagonally shaped with ascending ramps and summit structures. Thirteen human burials were located in the large mound. The burial mound was made up of a central shell core with overlying layers of sand and shell fill. This mound is low and circular, measuring 16.8 m. in diameter and less than 1 m. in height. A total of 106 interments were excavated in the burial mound by the W.P.A., including the 10 burials that C. B. Moore had earlier exposed and redeposited at the site.

The mortuary structure, marked only by a slight elevation prior to excavation, was found to consist of a semi-subterranean wattle and daub construction that was square with rounded corners and a projecting entrance passage. After the structure had been used, it was burned and a sand fill was subsequently placed over the structure and used as a cemetery. This later cemetery consisted of two successive stages, each marked by palisade enclosures. Eighty-one human burials were recovered by W.P.A. archaeological crews from the floor of the initial structure, the fill above the ruin, and in the immediate area of the mortuary. The rotunda consisted of an architectural feature with six concentric circles of wall trenches and postmolds. This structure evidently represented a building that measured approximately 36.5 m. in diameter. Seven human burials were excavated near the center of this part of the site. In addition to the burials that were found in association with the above features, 40 isolated interments were also exposed by W.P.A. field crews. In all, 265 human burials were recovered from the Irene Mound site.

Following excavation, the human skeletal materials were carefully cleaned, reconstructed, preserved, and catalogued by W.P.A. laboratory personnel under the supervision of Frederick S. Hulse and Virginia Griffin (Hulse, personal commun.). These materials were then described in detail by Hulse in a paper published as an appendix to the monograph describing the Irene Mound site cultural and architectural associations (cf. Caldwell and McCann, 1941).

Based on an extremely large sample of ceramics from all parts of the site, it was determined that the site was used during the Savannah and subsequent Irene periods, particularly during the latter (Caldwell and McCann, 1940a, 1940b, 1941; Caldwell, McCann and Griffin, 1941; Caldwell, 1939, 1940, 1952; Fewkes, 1938a, 1938b, 1938c; Shaeffer, 1939). Radiocarbon dates are not available from this locality.

SUMMARY

The human skeletal remains used in this study are derived from a large series from 33 mortuary sites. Most of these remains were collected from Glynn County and Chatham County, Georgia, as well as from St. Catherines Island.

The use of the skeletal materials from the sites discussed in this monograph as being representative of the human populations from which they came is warranted for two reasons. First, a large skeletal sample is used, thereby reducing the probability of error due to small sample size. Second, the nature of interment is relatively uniform through time. That is, with few exceptions, the basic burial pattern is that associated with mound burial. Moreover, burial did not seem to vary in pattern with regard to sex, age, or status. This suggests, then, that at no time did the behavioral aspects of prehistoric Georgia coastal societies skew one sample of burials in one direction, and, at another point in time, skew them in another direction.

CHAPTER 3. RESEARCH OBJECTIVES AND METHODS

PREVIOUS RESEARCH

The human skeleton is an exceedingly complex system, both as a tissue and as an organ, in that it is continuously responsive to a wide range of interrelated variables, including age (Kerley, 1965, 1970; Tappen, 1977; Enlow, 1977; Garn, 1977; Ortner, 1975), mechanical stress (Evans, 1973, 1977; Frankel and Burstein, 1970; Lovejoy, Burstein and Heiple, 1976; Moss, 1972; Ruff, 1980; Burstein, Reilly and Martens, 1976; Plato and Norris, 1980; Plato, Wood and Norris, 1980), and disease (McLean and Urist, 1968). The observation, measurement, and analysis of these factors have been treated in the archaeological record, particularly with reference to age (Ubelaker, 1974; Carlson, Armelagos and Van Gerven, 1976; Armelagos et al., 1972; Perzigian, 1973), and mechanical function (Carlson and Van Gerven, 1977, 1979; Van Gerven, Armelagos and Rohr, 1977; Hylander, 1977), as well as diet and nutrition (Hengen, 1971; El-Najjar, 1977; El-Najjar, Lozoff and Ryan, 1975; El-Najjar et al., 1976; Mensforth et al., 1978; Buikstra, 1977; Cook, 1972; Cook and Buikstra, 1973, 1979; Lambert, Szpunar and Buikstra, 1979; Schoeninger, 1980; Wing and Brown, 1979; Goodman, Armelagos and Rose, 1980; Yesner, 1980).

Many investigators dealing with archaeologically recovered human skeletal remains have viewed morphological changes associated with the variables listed above as being related directly to the subsistence shift from hunting-gathering to agricultural lifeways. Two general research areas—response of hard tissue to disease and functional demand, and skeletal and dental size—form the foci of these investigations.

Observation of hard tissue response has received increasing attention in recent years in part due to the interest in the relationship between subsistence and health of prehistoric human populations (Armelagos, 1969). A number of investigators have demonstrated a series of trends regarding the response of the skeleton to infectious disease that accompanies the adoption of agriculture. For example, Lallo and co-workers (Lallo, Armelagos and Mensforth, 1977; Lallo, Armelagos and Rose, 1978; Lallo and Rose, 1979) found that a marked increase in frequency of periosteal reactions occurred in later agricultural populations from the eastern United States. Robbins (1971), Cook (1972), Cassidy (1972), and Ubelaker (1980) noted similar skeletal changes in samples from other prehistoric localities in the New World. These investigators concluded that the increased frequency of periosteal lesions represented an increase in infectious disease that probably arose consequent to an increase in population size and density during the later periods involving the intensification of agricultural subsistence.

It has long been observed that a marked increase in dental pathology—in particular, dental caries—has occurred with an increase in carbohydrate consumption in diverse human populations (Armelagos, 1969; Armelagos and Rose, 1972; Corbett and Moore, 1976; Moore and Corbett, 1971, 1973, 1975, 1978; Hillson, 1979; Colyer, 1922; Mummery, 1870; Hardwick, 1960; Brinch and Møller-Christensen, 1949; Angel, 1944, 1971, 1974; and others). In North and South America, increase in frequency and severity of dental caries appears to be related to the adoption of a diet based at least in part on corn agriculture (Anderson, 1965, 1967; Goldstein, 1948; Hooton, 1930; Newman and Snow, 1942; Wachtel, n.d.; Buikstra, 1977; Cook and Buikstra, 1973, 1979; Leigh, 1925; Stewart, 1931, 1943, 1976; Thomas and Larsen, 1979; Behrend, 1978; Sarnäs, 1964; Saul, 1972; Ubelaker, 1981; Turner, 1978, 1979; Scott and DeWalt, 1980). Although the cause of dental caries has been much debated, there is widespread agreement that the increase in consumption of corn, a carbohydrate with a high sucrose component, had led to an increase in dental decay in the prehistoric past (Coykendall, 1976; Turner, 1979).

Functional demand, or response of skeletal tissue to its mechanical load, has received attention with relation to subsistence change and its effects on bone. Evidence for mechanical stress exists in a number of forms, including pathological response as well as size and shape alterations of both the cranium and postcranium. Pathological response to mechanical stress usually occurs in the form of osteoarthritis, more properly called degenerative joint disease (Duncan, 1979; Jurmain, 1977b). Generally, the disease is expressed as either a breakdown of bone on the joint articular surface (pitting, eburnation) or build-up of bone along the articular margin (lipping). After a comprehensive review of the clinical literature, Jurmain (1977b) indicated that investigators have proposed two sets of factors that underlie the occurrence of degenerative joint disease in human beings: systemic-predisposing (age, sex, metabolism, nutrition, hormones, heredity) and mechanical-functional (chronic or acute trauma, obesity). Although no single factor should be considered as the sole focus in the etiology of degenerative joint disease, Jurmain has suggested that external mechanical factors seem to be the most important in interpreting the variation in frequency of the disease in humans. Specifically, this investigator pointed out that "the most convincing etiological argument relates directly to the kind and amount of environmental stress typical of the varying life styles of . . . populations . . ." (1977b, p. 363; see also Tainter, 1980). Jurmain found in the samples he studied that hunter-gatherers (Eskimo) exhibit the greatest degree of osteoarthritis, urban populations (Terry Collection) an intermediate degree, and prehistoric agriculturalists (Pecos Pueblo) the least occurrence of the disease. Other investigators have similarly demonstrated that populations representative of a hunting-gathering mode of subsistence exhibit higher frequencies of degenerative joint changes than do those groups practicing an agricultural lifeway (cf. Angel, 1971; Cassidy, 1972; Anderson, 1976; Pfeiffer, 1977).

Through remodeling during growth and development and adulthood, bone is adapted to respond to mechanical demand. In reflection of this, for example, a number of postcranial indices have been shown to exhibit change with mode of subsistence as a consequence of change in mechanical demand. Bennett (1973) found an increase in the platymeric and platycnemic indices in a time-successive prehistoric series of femora and tibiae from Point of Pines, Arizona. The rounder femoral subtrochanteric and tibial nutrient foramina shaft regions were thought to reflect an increase in mechanical stress due to a possible increase in body weight that accompanied the intensification of agriculture. Lovejoy, Burstein and Heiple (1976) and Lovejoy and Trinkaus (1980), however, have provided convincing evidence that tibiae with rounder shafts at both the nutrient foramen and midshaft regions appear to be associated with generally *less* mechanically stressful lifeways. Specifically, these investigators pointed out that both the elliptical cross-sectional form and posterior pilaster represent adaptations of the tibia to very marked torsional and anterior-posterior bending loads.

Cranial, postcranial, and dental metric changes have been observed following the adoption of agricultural lifeways in many geographic areas. Carlson (1974, 1976a, 1976b), Carlson and Van Gerven (1977, 1979) and Van Gerven, Armelagos and Rohr (1977) have observed that a trend toward a more globular cranial vault accompanied a reduction and relocation of masseter and temporalis muscles in prehistoric Nubian crania. Similarly, y'Edynak (1978, 1980) has reported reductions in facial robusticity in a series of skeletal remains from the Iron Gates site of Vlasac in Yugoslavia that span the end of the Pleistocene up to the origin of agricultural food production. The investigators working with both the Nubian and Yugoslavian materials suggested that dependence on softer agricultural foodstuffs in the later populations places less functional demand on the masticatory apparatus during growth and development, thus resulting in the changes observed.

Few postcranial metric trends have been noted. With agricultural intensification, stature, as estimated from long bone lengths, has been observed to decrease. Cook (1972) noted that a reduction in stature consequent to overall reduction in postcranial size followed the adoption of agriculture in the lower Illinois Valley, perhaps reflecting an increase in nutritional stress (malnutrition) with the change in economic base. Angel (1946, 1971, 1975) has observed similar trends of postcranial-stature reduction with the adoption of agriculture in Greece. In the Maya area, Haviland at Tikal (1967), Stewart at Zaculeu and other sites (1949, 1953), and most recently, Saul at Altar de Sacrificios (1972), found a marked stature reduction from the Preclassic to Postclassic periods (see also Nickens, 1976). Saul (1972) concluded that nutritional stress, coupled with an increase in population size and infectious disease, had resulted in an overall reduction in body size, hence, stature.

Unlike cranial and postcranial size, tooth size has been the focus of a great deal of attention in the bioanthropological literature. It has long been observed that a trend in dental reduction with respect to size has occurred in human beings from the Lower Paleolithic to the Upper Paleolithic (Brace, 1967; Bailet and Friedlander, 1966; Wolpoff, 1971c; Smith, 1977; Frayer, 1978). It has been suggested that dental size reduction has continued during subsequent prehistory (Brace and Mahler, 1971; Frayer, 1978). This has been documented for North America (Brace and Mahler, 1971; Ryan and Posner, 1975; Ryan, 1977; Sciulli, 1979; Smith, Smith and Hinton, 1980; Hinton, Smith and Smith, 1980), Europe (Brace, 1978; y'Edynak, 1978, 1980), the Middle East and Asia (Brace, 1978), the Pacific (Brace and Hinton, 1981), Nubia (Greene, Ewing and Armelagos, 1967; Greene, 1972; Greene and Scott, 1973), and Greece and Turkey (LeBlanc and Black, 1974). Those populations involved in agricultural food production for the longest period of time appear to have the smallest dentitions (Brace and Ryan, 1980).

Several explanations have been offered for the observed post-Pleistocene dental size reductions. Greene and co-workers (Greene, 1972; Greene, Ewing and Armelagos, 1967; Greene and Scott, 1973) suggested two factors for tooth size reduction in prehistoric Nubia: (1) selection for less complex, caries-resistant teeth, and (2) relaxed selection due to the adoption of less abrasive softer foodstuffs. Sofaer (1973), Sofaer, Bailet and MacLean (1971), Carlson and Van Gerven (1977), and Frayer (1978) indicated that dental reduction may have been the result of a decrease in space allowed for developing teeth because of reduction in the growth of the maxillary–mandibular complex in response to decreased oral functional demand. Hylander (1977) suggested that the evolution of tooth size is perhaps best related to tooth wear—those populations experiencing high attrition would seem to be subject to a great deal of selection for a large amount of tooth material, i.e., large tooth size. Indeed, although the Eskimo dentitions examined by Hylander (Canadian Thule) exhibited a great deal of dental attrition, it appears that the *rate* of attrition is markedly less for these individuals when compared to prehistoric Amerindians. Hylander concluded that the lower attrition rates in the Eskimo dentitions had resulted in a relaxation of selection for large tooth size.

Finally, Brace and Mahler (1971), Brace (1978), and Brace and Hinton (1981) have suggested that since the role of the human dentition is to process food, differences in tooth size between human groups should reflect differences in food processing requirements. Brace pointed out that human groups associated with an agricultural lifeway utilize pottery for cooking. This "enables the users to reduce their food to a mushy or liquid consistency where the larger size or even the existence of teeth is no longer absolutely necessary for survival" (1978, p. 204). Thus, Brace has suggested that the important factor in relating tooth size to diet is not so much the food type, but rather how the food is prepared. Furthermore, with the change in preparation technology associated with agricultural food production, the selective pressures that maintained larger tooth size were relaxed, setting up the conditions necessary for the operation of the Probable Mutation Effect (Brace, 1963; see also Brace and Mahler, 1971; Brace, 1964; Brace and

Ryan, 1980; Wolpoff, 1969, 1971c, 1975b, 1975c).

EXPECTATIONS

It is the purpose of this study to examine and explain the effects that the adoption of agriculture has had on the human skeleton and dentition through the study of a large human skeletal and dental sample from the Georgia coast (see Chapter 2). Based on the above analyses, there are two expectations that are tested in this study. First, the status of health, both skeletal and dental, is expected to decrease with the increased utilization of agricultural foodstuffs in the overall subsistence pattern. It has long been understood that the adoption of agriculture in human groups leads to a more sedentary lifeway supporting larger numbers of people and consequently higher frequency of infectious disease (Armelagos, 1967; Armelagos and Dewey, 1970). Therefore, the number of osseous lesions, particularly periosteal reactions, should increase, reflecting an increase in infectious disease in general.

If, indeed, corn agriculture became an important dietary component in the post-A.D. 1150 subsistence regime on the prehistoric Georgia coast, then a marked increase in both frequency and severity of dental caries should result. In a recent survey of average percentage of teeth affected by dental caries covering a large number of diverse human skeletal and living populations, Turner (1979) found that the average numbers of carious teeth for different subsistence economies are: hunting and gathering, 1.7 percent; mixed (agriculture plus hunting, gathering, or fishing), 4.4 percent; and agricultural, 8.6 percent. From these data, it appears that the greater the reliance on agricultural foodstuffs, and, in particular, carbohydrates, the greater the incidence of dental caries. Consequently, the later post-A.D. 1150 Georgia coastal dental sample should exhibit frequencies of caries at least as great as the 4.4 percent threshold reported by Turner (1979) for mixed agricultural and hunting-gathering economies.

Second, it can be expected that given the highly plastic nature of skeletal tissue, an alteration in size of the skeleton should occur with the adoption of agriculture. For instance, Carlson (1976a, 1976b) and Carlson and Van Gerven (1977, 1979) suggest that foodstuffs associated with the adoption of agriculture in prehistoric Nubia exerted less functional demand on the masticatory apparatus during oral preparation and led to a reduction in facial size. If this is true, then the face should reduce in size on the Georgia coast as well. With respect to the postcranial skeleton, a number of investigators have demonstrated that a lifeway based on hunting and gathering appears to involve more functional demand on the body than one in which agriculture represents the primary mode of subsistence. This finding has been made particularly apparent in those studies that show a disparity in frequency of degenerative joint disease between hunter-gatherers and agriculturalists (e.g., Jurmain, 1977b, 1980), as well as those that show differences in the indices related to the femoral subtrochanteric area (platymeric index), the tibial nutrient foramen area (platycnemic index), and the tibial midshaft area (tibia midshaft index) (e.g., Lovejoy, Burstein and Heiple, 1976; Lovejoy and Trinkaus, 1980). These data suggest that a lifeway involving production of plant domesticates lends itself to generally less mechanically stressful or functionally demanding activity. If this contention holds true, then there should be a corresponding change in both the frequency of degenerative joint disease and the postcranial indices with the increased utilization of agricultural foodstuffs on the prehistoric Georgia coast. Furthermore, in keeping with the general phenomenon that in the presence of functional demand bone is deposited and in its absence is resorbed (Wolff's Law), the overall size of the postcranial skeleton should reduce with the shift in lifeway. Thus, consequent to the change in lifeway and economic focus on the Georgia coast, three changes involving the postcranial skeleton should occur due to a decrease in level of functional demand: (1) decrease in frequency of degenerative joint disease; (2) increase in platymeric, platycnemic and tibial midshaft indices; and (3) decrease in size of the postcranial skeleton.

Two additional factors may influence skeletal size reduction following the adoption of agriculture. First, if corn consumption does increase and the protein resources are reduced, the consequent nutritional stress may contribute to reduction in overall skeletal size. Recent studies utilizing modern human populations of known diet show that a significant reduction in body size occurs under conditions of nutritional stress, particularly protein and/or caloric malnutrition (Stini, 1969, 1971; Frisancho, Garn and Ascoli, 1970a, 1970b; Frisancho et al., 1973; Martorell et al., 1979; Garn and Frisancho, 1971; Garn and Clark, 1975; Garn, Nagy and Sandusky, 1972). This is particularly true for populations that utilize corn as a major dietary item (Albanese and Orto, 1964). Second, corn appears to have an inhibitory effect on bone growth due to its lack of two essential amino acids. This factor precludes proper growth and metabolic functions of body tissues (Stini, 1971), thus contributing to a reduction in overall skeletal size.

In accordance with an expected reduction in overall skeletal size, there should be a decrease in tooth size. A number of statistical correlations have been reported in the literature demonstrating a strong relationship between tooth size and various measures of body size in a number of extant primates, including *Homo*. For example, Gingerich (1977) demonstrated that a high correlation exists between second molar length and body weight in a sample of living hominoids (*Hylobates, Symphalangus, Pan, Pongo, Gorilla, Homo*). Likewise, Kay (1975), Gould (1975), and Johnson (1978) reported additional high correlations between other measures of body size and tooth size in similar primate taxa (see also Gingerich and Schoeninger, 1979; Gingerich, Smith and Rosenberg, 1980). Specifically, in human beings, Garn, Lewis and Walenga (1968) reported strong body size/tooth size relationships for all classes of teeth, maxillary and mandibular, in a group of known families of western European origin. Most certainly, these studies tend to suggest that if skeletal size is to reduce with the adoption of agriculture on the Georgia coast, then there should be a concomitant reduction in dental size for this region.

METHODS

As outlined above, this study focuses on the comparisons of two major types of data: pathology and size of both skeletal and dental elements. Given the diversity of data utilized in this investigation, it is imperative that observational techniques relating to these variables be clearly understood in reference to this and related analyses. Furthermore, because the human skeleton and dentition represent a dynamic system, it is also important that pathology and size variables be examined in light of the age structures of the skeletal groups used here. For example, since degenerative joint disease is an age-progressive phenomenon, it is necessary that comparisons between groups be age-controlled. That is, if one group is older than the other in overall structure, then any differences in frequency of degenerative joint disease may simply reflect a disparity in the respective age distributions of the populations. Likewise, sex must be considered with respect to the variables to be examined in this study. With regard to degenerative joint disease, it has been shown in human beings, prehistoric and historic, that sexual division of labor and related activity is an important factor in the expression of the disease (cf. Jurmain, 1977b; Rathbun, 1980; Angel, 1979; Pickering, 1979; and others). Thus, age and sex of all individual skeletons were determined where possible for this study. Methods of age and sex estimation, observation of pathology, and skeletal and dental measurement are summarized below.

DETERMINATION OF AGE

Preadult age determinations for this study were based on a combination of the following: epiphyseal union, dental calcification, and dental eruption. Epiphyseal union standards utilized were those summarized by Krogman (1962, pp. 32–33). Age estimations based on dental calcification and eruption followed Ubelaker's study of Amerindian preadult dental age changes (1978, pp. 46–47). Adult ages at death were estimated, for the most part, using the method of age assessment based on degree of functional occlusal wear developed by A. E. W. Miles (1962, 1963, 1978), a method which utilizes incompletely erupted preadult dentitions to estimate the number of years that individual teeth have been in functional occlusion (see applications by Mann, 1975; Nowell, 1978; Wolpoff, 1979; Ruff, 1980; Black, 1979; Meindl, Lovejoy and Mensforth, 1980).

It was possible to estimate age for a few individuals by observing age-related changes of the symphyseal face of the pubis (cf. Todd, 1920). As a check on the dental wear method, ages determined by both dental wear and pubic symphyseal face metamorphosis were compared. Table 4 lists those individuals that were aged by both methods. Because the two aging methods were applied independently, the similarity in age estimation verifies their applicability for use in this study.

Finally, if none of the above age criteria could be utilized due to either the fragmentary or incomplete condition of a skeleton, then general indicators of age, such as overall size and development of skeletal elements as well as suture closure, were utilized. Age estimation was possible for 113 individuals in the preagricultural group and 110 individuals in the agricultural group.

TABLE 4

Comparison of Ages Based on Dental Wear (Miles, 1963) and Pubic Metamorphosis (Todd, 1920) for Individuals with Both Components

Site-Burial	Dental Age	Pubic Age
Sea Island Mound-7	17–19	18–19
Johns Mound-2	45+	45–50
Johns Mound-22	45+	45–50
Irene Mound-5	19–21	18–19
Irene Mound-20	18–20	18–19
Irene Mound-24	20–22	20–24
Irene Mound-105	20–22	22–24
Irene Mound-107	33–37	35–39
Irene Mound-127	21–23	20–21
Irene Mound-143	34–38	35–39
Irene Mound-149	38–42	35–39
Irene Mound-152	20–22	20–21
Irene Mound-153	18–20	18–19
Irene Mound-169	18–20	18–19
Irene Mound-248	18–20	18–19

DETERMINATION OF SEX

Sex determinations were attempted only for the adult sample of both the preagricultural group and the agricultural group since methods for preadults have questionable accuracy (cf. Black, 1978). Determination of adult sex was based, in order of reliability, on the Phenice (1969) method for the pubis (ventral arc, subpubic concavity, and medial aspect of the ischiopubic ramus morphology), overall pelvic morphology (sciatic notch, subpubic angle, orientation of the symphysis, size of the obturator foramen and acetabulum, morphology and type of preauricular sulcus, presence-absence of the preauricular and pubic parturition scars). In addition, general gracility or robusticity of the cranial and postcranial skeleton was considered for each individual. In general, the female skeleton exhibits a much more gracile skeleton than do males. The sex differences for each of these morphological variates are listed in table 5.

PATHOLOGY

Three pathological conditions are considered. They include periosteal reactions, dental caries, and degenerative joint disease. Periosteal reactions represent a type of nonspecific skeletal lesion that occurs with a wide variety of disease conditions affecting bone (Greenfield, 1975). This pathology usually appears as smooth or irregular new layers of bone giving an elevated appearance to the periosteum. The reactions usually result from an expansion of the outer fibrous layer of the periosteum because of stretching and compressing blood vessels (Jaffe, 1972). Diverse agents such as neoplasm, trauma, pus, or granulation tissue may lead to the reaction restricting normal bone metabolism. The result of the reactive process is necrosis. Should the periosteum not be entirely de-

TABLE 5
Sex Differences in Morphological Features of the Human Skeleton

Feature	Female	Male
PELVIS		
Pubic ventral arc	Present	Absent
Subpubic concavity	Present	Absent
Ischio-pubic ramus (medial aspect)	Sharp ridge	Flat
Sciatic notch	Wide	Narrow
Subpubic angle	Wide	Narrow
Pubic symphysis	Wide (medio-lateral)	Narrow (medio-lateral)
Obturator foramen	Small	Large
Acetabulum	Small	Large
Posterior pubis and preauricular sulcus	Parturition scars sometimes present	Parturition scars absent
SKULL		
Mastoid processes	Small	Large
Supraorbital tori	Small	Large
Nuchal region	Smooth	Rugose

stroyed, the outer fibrous layer will resume its integrity and production of new bone in the osteogenic subperiosteal layer will continue (Mensforth et al., 1978).

Although a great deal of literature documents reactive processes involving the periosteum of bone (cf. Armelagos, Mielke and Winter, 1971), for the most part, the paleopathology literature emphasizes an approach based on individual diagnosis (Armelagos, 1969). The current bioanthropological approach to disease in prehistoric human populations involves the application of epidemiological techniques of study. That is, the study of disease and its relationship to the population rather than to specific individuals is stressed (Mensforth et al., 1978).

Unfortunately, the Georgia coastal skeletal remains are generally fragmentary and incomplete and preadult individuals are poorly represented (see Chapter 4). Therefore, for this study, periosteal reactions for only the adult sample were recorded for the clavicles, humeri, ulnae, radii, femora, tibiae, and fibulae. Presence of periosteal reactions was recorded if there was any degree of healed or unhealed inflammation of these skeletal elements.

Dental caries is a disease process that is characterized by focal demineralization of dental hard tissues by acids which result from bacterial fermentation of dietary carbohydrates, especially sugars. The causative factors are multiple and complex. Briefly, these factors are divided into two main groups, essential and modifying (Rowe, 1975). The essential factors include: teeth with susceptible surfaces exposed to the oral environment, dental plaque, and oral ingestion of food, particularly carbohydrates. Modifying factors include, in part: some systemic diseases, race, sex, heredity, salivary flow and chemistry, tooth substance and structure, nutrition, and finally, the presence or absence of fluorides (Rowe, 1975; see also Rowe et al., 1976; Jenkins, 1978; Gray, 1977; Volker and Pinkerton, 1974; Gibbons and van Houte, 1973; Dreizen, 1977; Hardie et al., 1977; Silverstone, 1977; and others). With respect to the Georgia coast, however, the single most important influence in cariogenesis was the increased consumption of dietary carbohydrates that was associated with the adoption or at least the marked increase in the use of corn, a food staple containing a high component of sugar (cf. Hardinge et al., 1965).

Most studies dealing with dental caries, particularly those that compare hunter-gatherer with agriculturalist dentitions, utilize the technique of recording carious lesions by indicating presence or absence of the pathology for each tooth. Usually, dental samples are characterized in terms of percentage of teeth affected by dental caries (e.g., Angel, 1971, 1974; Turner, 1978, 1979; Armelagos, 1969). In a recent series of studies utilizing a large well-documented time-successive sample of dentitions from the British Isles, Moore and Corbett (1971) demonstrated the importance of observation of not only presence of caries, but also lesion size and crown location (see also Moore and Corbett, 1973, 1975, 1978; Corbett and Moore, 1976). This additional information is important in establishing population differences for *both* frequency and severity of the disease; differences have been found to be masked by comparing only frequency of teeth or individuals affected by dental caries (cf. Moore and Corbett, 1971).

Caries observations for the present study included size and location of carious lesions on each permanent and deciduous tooth. Lesion size was divided into three categories: (1) incipient (small pit); (2) medium (pit not extending to the pulp chamber); and (3) gross (pit involving the pulp chamber at minimum and total crown destruction at maximum). Four types of lesion locations were observed for each carious tooth: (1) occlusal (grooves and/or cusps); (2) buccal (pit and/or groove); (3) interproximal (tooth contact area); and (4) cervical (enamel-root junction). If cariogenesis had produced nearly total crown destruction, its location on the tooth was recorded as unknown because the place of origin of the lesion on the tooth had long since been obliterated by the decalcification process.

Degenerative joint disease is an age-related disease involving the weight-bearing articular joints as well as the shoulder, elbow, wrist, and hand joints (Jurmain, 1977b, 1980; Steinbock, 1976). Although the skeletal changes that are associated with the disease appear to be caused by a number of factors, mechanical stress appears to be the most important (Jurmain, 1977b; Ortner, 1968; Stewart, 1979). Two types of joints are involved—synovial joints (e.g., shoulder and knee) and intervertebral joints. Two major skeletal articular changes are associated with the disease (Stewart, 1979; Jurmain, 1977b; Ortner, 1968; Tobin and Stewart, 1953). First, loss of subchondral bone on the articular surfaces is due to mechanical erosion and breakdown of the surrounding articular cartilage. The loss of bone appears in the form of areas of rarefaction on the articular surfaces. In the extreme condition, eburnation can occur due to the rubbing of one bone surface against another. Second, stress on articular joints can result in hypertrophic osteogenesis or formation of new bone at the edge of the articular cartilage.

Methods of recording degenerative joint disease are quite diverse, ranging from the minimum of simply noting the presence or absence of degenerative change for articular joints (e.g., Angel, 1971; Pickering, 1979) to the maximum of recording it by degree or grade of affection (e.g., Jurmain, 1977a, 1977b, 1978, 1980; Martin, Armelagos and King, 1979; Stewart, 1958; Clark and Delmond, 1979). The purpose of the present study, however, is to observe differences in *frequency* rather than differences in *severity* of degenerative joint disease. Therefore, only presence of degenerative joint disease was recorded, thereby not involving differing grades of the pathology. Presence of degenerative joint disease was observed for each major adult postcranial articular joint: vertebral, shoulder, elbow, wrist, hand, hip, knee, ankle, and foot. Table 6 includes a list of the specific joint articular surfaces and margins that were observed. The characteristic degenerative changes include joint surface pitting, eburnation, and general surface destruction, as well as the presence of osteophytes (marginal lipping) on the articular margins (cf. Jurmain, 1977b; Ortner, 1968; Stewart, 1979; Ubelaker, 1978). The presence of degenerative joint disease was recorded even if only one element of a joint was affected. For example, if the articular surface of a patella exhibited marginal exostoses, the presence of degenerative joint disease for the knee joint was recorded. Similarly, if the femur head showed both erosional pitting of the articular surfaces as well

TABLE 6
Articular Surfaces and Margins of Major Adult Articular Joints

Joint	Skeletal Element(s)
Vertebra	Cervical, thoracic, lumbar, sacrum (twelfth thoracic–first sacral segment)
Shoulder	Proximal humerus (head) Scapula (glenoid fossa)
Elbow	Distal humerus (trochlea, capitulum) Proximal radius (head, radial notch) Proximal ulna (semilunar notch)
Wrist	Distal ulna (head, styloid process) Distal radius (lunate-scaphoid articular surfaces) Carpals Proximal metacarpals
Hand	Distal metacarpals Proximal and distal phalanges
Hip	Proximal femur (head) Innominate (acetabulum)
Knee	Patella (condylar surfaces) Distal femur (condyles) Proximal tibia (condyles)
Ankle	Distal tibia (talar articular surfaces) Tarsals Proximal metatarsals
Foot	Distal metatarsals Proximal and distal phalanges

as marginal exostoses, then the hip joint was recorded as having degenerative joint disease.

MEASUREMENT

As discussed above, there has been a recent interest in the study of skeletal and dental size in relation to the shift from a lifeway involving solely hunting and gathering to one in which agricultural products form a major focus of diet. Techniques for measurement of cranial, postcranial, and dental size are nearly as diverse as the number of studies that have been generated. With regard to cranial size, the more notable investigations include those that have attempted to understand changes in craniofacial anatomy in the context of shift in lifeway (see especially Carlson, 1974, 1976a, 1976b; Carlson and Van Gerven, 1977, 1979; Hinton and Carlson, 1979).

The present investigation utilizes traditional osteometric techniques of measurement that emphasize variation for the face in particular as well as the cranium in general. That is, the analysis of the Georgia coastal skull is based on a battery of facial as well as vault dimensions. For example, a number of cranial dimensions in the present study are compared in order to document function-related differences both within and between the subsistence group—preagricultural and agricultural—on the Georgia coast. Masseter origin length, zygomatic arch thickness, and cheek height can be expected to be influenced by the masseter muscle because it is attached in this region of the craniofacial complex. Likewise, infratemporal fossa depth, infratemporal fossa length, temporalis length, and temporalis height, as measured from the cranial vault, reflect the size of the temporalis muscle. By adopting these measurements for the present study, a better understanding of the relationship between the use of the masticatory muscles as they relate to oral function (i.e., food preparation) and shift in dietary base will be accomplished. Table 7 includes a list of all cranial dimensions used in this study. Bilateral cranial dimensions were taken only on the left side of the cranium so that each individual is represented by one measurement per dimension. If the left dimension could not be measured, the right was substituted if available.

Little attention has been given in the literature to postcranial size and its relationship to shift in mode of subsistence from hunting and gathering to the use of agriculture as a dietary focus. With the exception of studies relating to stature (e.g., Cook, 1972; Bennett, 1973; Saul, 1972; Stewart, 1949, 1953; Angel, 1975) and postcranial indices (e.g., Bennett, 1973; Lovejoy, Burstein and Heiple, 1976; Lovejoy and Trinkaus, 1980), to my knowledge, the present investigation represents the first attempt to analyze size change on a large scale in the postcranial skeleton in relation to change in lifeway.

For the present investigation, a large series of postcranial dimensions were taken in order that an accurate assessment of the size of each skeletal element as well as their segments be made. For example, the femur consists of a number of segments: head and neck, shaft, and condyles. In order to assess size of the head and neck, head diameter as well as vertical and horizontal diameters of the neck were taken. An approximation of femoral shaft size was ascertained by measurement of anterior-posterior diameter, transverse diameter, and circumference of the midshaft, as well as anterior-posterior diameter and transverse diameter of the subtrochanteric region. The size of the condylar region was approximated by the measurement of maximum bicondylar breadth. In a similar fashion, the size of the tibia (length, midshaft circumference, anterior-posterior diameter, transverse diameter of the midshaft), fibula (length), clavicle (length), ulna (length), radius (length, head diameter, interosseous crest maximum and minimum diameters), and humerus (length, head diameter, midshaft circumference, maximum and minimum midshaft diameters, epicondylar breadth) were measured in order to provide a means of assessing size of the postcranium. All postcranial dimensions and their definitions are presented in table 8.

A number of postcranial dimensions were taken for two purposes: (1) lengths of the femora and tibiae were recorded as part of the complex as an estimate of size of these bones; and (2) lengths of the femora and tibiae were recorded for the purpose of estimation of stature (see below). In addition, several postcranial dimensions were included for the purpose of calculating indices (see table 9 and discussion below). These indices include: femoral platymeric, midshaft (or pilastric) and robusticity indices, tibial midshaft and robusticity indices, and humeral midshaft and robusticity indices. These indices were chosen for analysis because inferential evidence indicates that long bone shaft shapes and proportions reflect relative degree of functional demand (cf. Lovejoy, Burstein and Heiple, 1976; Lovejoy and Trinkaus, 1980). For example, anterior-posterior flattening of the femoral subtrochanteric region (platymeria) appears to be associated with human populations that are undergoing more strenuous lifeways (Brothwell, 1972). Similarly, Lovejoy, Burstein and Heiple (1976) and Lovejoy and Trinkaus (1980) have demonstrated that greater degrees of medial-lateral flattening of the tibial midshaft and nutrient foramen regions are associated with human groups generally having more functionally demanding adaptations. These authors suggested that relatively flattened tibial midshaft and nutrient foramina regions represent a response to acute torsional strains that occur in active locomotion. Although the platycnemic (or cnemic) index appears to be greatly influenced by functionally mediated factors, it was not included in the present investigation because of the apparent variability in the way different investigators have measured this index at the nutrient foramen. In a recent investigation of 104 tibiae from the Dickson Mounds skeletal collection, Andermann (1976) showed that the range of variation of the nutrient foramen position on the tibial diaphysis is over 10 percent of the tibial length. He suggested that this variation is too extreme to warrant continued use of the index. Hrdlička (1898) and Vallois (1912, 1938), who made a similar observation with regard to the variability of the position of the nutrient foramen, indicated that the tibia midshaft index represents a more appropriate index for measurement of medio-lateral flattening of the tibia shaft. Thus, the postcranial index chosen for this study involving the tibial shaft shape is the tibia midshaft index.

Stature approximations were calculated by use of regression formulae provided by Genovés (1967) for the adult female and male femur and tibia. These formulae were utilized because they are based on a native Amerindian sample that undoubtedly represents a closer biological affinity to the Geor-

TABLE 7
Cranial Measurements

Measurement	Definition	Instrument
FACE-MASTICATORY COMPLEX		
Masseter origin length	Midpoint of zygomaxillary tubercle to most inferior aspect of zygotemporal suture	Vernier calipers
Zygomatic arch thickness	Jugale to most inferior aspect of zygomaxillary suture	Vernier calipers
Cheek height	Orbitale to most inferior aspect of zygomaxillary suture	Vernier calipers
Upper facial height	Nasion to alveolare	Vernier calipers
Biorbital breadth	Frontomalare anterior to frontomalare anterior	Vernier calipers
Orbital breadth	Dacryon to ectoconchion	Vernier calipers
Orbital height	Perpendicular to orbital breadth	Vernier calipers
Infratemporal fossa depth	Maximum horizontal distance from jugale to greater wing of sphenoid perpendicular to the sagittal plane	Vernier calipers
Infratemporal fossa length	Maximum anterior-posterior distance measured perpendicular to infratemporal fossa depth	Vernier calipers
Temporalis length	Maximum distance from anterior aspect of temporal line on the frontal to the most posterior aspect of the temporal line; usually on the posterior-inferior parietal	Vernier calipers
Temporalis height	Vertical distance from auricular point to most superior aspect of temporal line on parietal	Vernier calipers
Palate length	Staphylion to orale	Vernier calipers
Palate breadth	Maximum internal breadth of alveoli at roots of maxillary second molars	Vernier calipers
Bizygomatic breadth	Greatest breadth between most lateral aspects of zygomatic arches	Spreading calipers
Minimum frontal breadth	Minimum distance between frontal temporal lines	Vernier calipers
Frontal chord	Nasion to bregma	Vernier calipers
Frontal arc	Nasion to bregma	Tape
Bicondylar breadth	Maximum distance between lateral surfaces of condyles	Vernier calipers
Condylar breadth	Maximum medial-lateral breadth of condyle	Vernier calipers
Bigonial breadth	Maximum external distance on mandibular angles	Vernier calipers
Ascending ramus height, coronoid process	Vertical distance from tip of coronoid process to surface on which mandible is resting	Vernier calipers
Ascending ramus height, condyle	Vertical distance from superior surface of condyle to surface on which mandible is resting	Vernier calipers
Ascending ramus, minimum breadth	Minimum anterior-posterior distance	Vernier calipers
Symphysis height	Infradentale to gnathion	Vernier calipers
Symphysis thickness	Maximum anterior-posterior distance parallel to base of mandibular corpi	Vernier calipers
Mandibular length	Maximum distance from a tangent across both mandibular condyles to the most anterior point of the mental process	Osteometric board

TABLE 7—(*Continued*)

Measurement	Definition	Instrument
VAULT		
Prosthion-opisthion	—	Vernier calipers
Prosthion-basion	—	Vernier calipers
Opisthion-nasospinale	—	Spreading calipers
Parietal chord	Bregma to lambda	Vernier calipers
Occipital chord	Lambda to opisthion	Vernier calipers
Lambda-inion chord	—	Vernier calipers
Inion-opisthion chord	—	Vernier calipers
Biasterionic chord	Asterion to asterion	Vernier calipers
Parietal arc	Bregma to lambda	Tape
Occipital arc	Lambda to opisthion	Tape
Lambda-inion arc	—	Tape
Inion-opisthion arc	—	Tape
Biasterionic arc	Asterion to asterion	Tape
Bregma-inion	—	Spreading calipers
Bregma-opisthion	—	Spreading calipers
Lambda-basion	—	Vernier calipers
Nasion-lambda	—	Spreading calipers
Basion-nasospinale	—	Spreading calipers
Nasion-opisthion	—	Spreading calipers
Cranial height	Basion to bregma	Spreading calipers
Auricular height	Midpoint of biauricular breadth to bregma	Head spanner
Maximum cranial length	Glabella to opistocranion	Spreading calipers
Maximum cranial breadth	Maximum breadth measured perpendicular to midline on sagittal plane	Spreading calipers
Biauricular breadth	Auricular point to auricular point	Spreading calipers

gia coastal skeletal sample used herein than any other provided in the extant literature. Traditionally, stature estimations for prehistoric Amerindians have utilized the regression formulae published by Trotter and Gleser (1958) because these formulae are also based, in part, on native Americans. However, as Genovés (1967) pointed out, in addition to Amerindians, the Trotter and Gleser (1958) skeletal sample includes a mixture of Filipinos, Hawaiians, Japanese, and others, thereby making the regressions less than reliable for application to Amerindian skeletal series. Furthermore, the Trotter and Gleser (1958) regression formulae are based only on a male sample of skeletons; the Genovés (1967) regression formulae are specific to both males and females. Finally, other researchers have found the Genovés (1967) regressions most useful in the determination of stature for Amerindian skeletal specimens (cf. Rogers, 1977).

In sum, a total of 27 postcranial dimensions were taken following standard techniques of measurement. Except for stature calculation, only the left postcranial dimensions were analyzed for this study. This was chosen as the preferred side for the evaluation of postcranial skeletal size for the following reasons: (1) representation of one individual by one dimension; (2) this side appears to be least affected by age-dependent factors such as subperiosteal apposition (Pfeiffer, 1980); (3) control for bilateral asymmetry (Ruff and Jones, 1981); and (4) this side is apparently better correlated with other regions of the skeleton in overall size (Ruff and Jones, 1981).

An extensive literature exists on tooth size and related techniques of measurement. For

TABLE 8
Postcranial Measurements

Measurement	Definition	Instrument
FEMUR		
Head diameter	Maximum diameter of head	Vernier calipers
Neck vertical diameter	Maximum vertical diameter at midpoint of neck	Vernier calipers
Neck horizontal diameter	Maximum horizontal diameter at midpoint of neck	Vernier calipers
Maximum length	Maximum distance from proximal surface of femur head to distal surface of medial condyle	Osteometric board
Midshaft anterior-posterior diameter	Maximum anterior-posterior distance at midpoint of femur length	Vernier calipers
Midshaft transverse diameter	Distance taken perpendicular to midshaft anterior-posterior diameter	Vernier calipers
Midshaft circumference	Maximum circumference at midpoint of femur length	Tape
Subtrochanteric anterior-posterior diameter	Maximum anterior-posterior distance immediately inferior to lesser trochanter	Vernier calipers
Subtrochanteric transverse diameter	Distance taken perpendicular to subtrochanteric anterior-posterior diameter	Vernier calipers
Bicondylar breadth	Maximum distance from medial epicondyle to lateral epicondyle	Vernier calipers
TIBIA		
Maximum length	Maximum distance from lateral condyle to tip of medial malleolus (does not include inter-condylar eminence)	Osteometric board
Midshaft anterior-posterior diameter	Maximum anterior-posterior distance at midpoint of tibia length	Vernier calipers
Midshaft transverse diameter	Distance taken perpendicular to midshaft anterior-posterior diameter	Vernier calipers
Midshaft circumference	Maximum circumference taken at midpoint of tibia length	Tape
FIBULA		
Maximum length	Maximum distance from most proximal aspect to most distal aspect	Osteometric board
CLAVICLE		
Maximum length	Maximum distance from most medial aspect of surface of head (sternal end) to most lateral aspect (acromial end)	Osteometric board
ULNA		
Maximum length	Maximum distance from tip of styloid process to proximal surface of olecranon process	Osteometric board

TABLE 8—(*Continued*)

Measurement	Definition	Instrument
RADIUS		
Maximum length	Maximum distance from head to styloid process	Osteometric board
Head diameter	Maximum diameter of head	Vernier calipers
Interosseous crest, maximum diameter	Maximum diameter of interosseous crest	Vernier calipers
Interosseous crest, minimum diameter	Minimum diameter of interosseous crest taken at same position on the diaphysis as the maximum diameter of the interosseous crest	Vernier calipers
HUMERUS		
Maximum length	Maximum distance from proximal surface of head to distal aspect of trochlea	Osteometric board
Midshaft maximum diameter	Maximum diameter taken at midpoint of humerus length	Vernier calipers
Midshaft minimum diameter	Minimum diameter taken at midpoint of humerus length	Vernier calipers
Midshaft circumference	Maximum circumference taken at midpoint of humerus length	Tape
Head diameter	Maximum diameter of head	Vernier calipers
Biepicondylar breadth	Maximum distance taken from medial epicondyle to lateral epicondyle	Vernier calipers

the present study, two dental dimensions were taken as measures of tooth size: crown length (mesiodistal diameter) and crown breadth (buccolingual or labiolingual diameter). Following procedures outlined by Goose (1963), Wolpoff (1971a), Schuman and Brace (1954), Johanson (1974), and others, the crown length dimension was taken at the area of greatest length at the midpoint of the contact points between teeth in normal tooth position, thereby representing neither a maximum nor a minimum measure of tooth size. This method was used so as not to overestimate tooth length, especially with regard to non-rectangular teeth such as maxillary molars. In addition, the interproximal contact points generally give a more definite reference point for measurement. This method of measurement also seems to represent the average length dimension regardless of tooth orientation or shape (Wolpoff, 1971a). If any tooth measured showed abnormal position or no interproximal wear for unsocketed teeth, the respective normal position of the tooth in the socket or the interproximal contact points were approximated; the tooth was then measured accordingly.

Crown breadth was always taken perpendicular to crown length and represents an excellent measure of tooth size because the technique of measurement is more standardized relative to measurement of mesiodistal dimensions (cf. Hrdlička, 1924; Dahlberg, 1963; Mahler, 1973; Pedersen, 1949; Schuman and Brace, 1954; Weidenreich, 1937; Wolpoff, 1971a, 1971b; Frayer, 1978; Black, 1978) and it is relatively unaffected by dental wear, except in the extreme expression of occlusal wear.

For the present study, both dimensions—

TABLE 9
Postcranial Indices

Index	Calculation
FEMUR	
Platymeric	$\frac{\text{subtrochanteric anterior-posterior diameter} \times 100}{\text{subtrochanteric transverse diameter}}$
Midshaft	$\frac{\text{midshaft transverse diameter} \times 100}{\text{midshaft anterior-posterior diameter}}$
Robusticity	$\frac{\text{midshaft circumference} \times 100}{\text{maximum length}}$
TIBIA	
Midshaft	$\frac{\text{midshaft transverse diameter} \times 100}{\text{midshaft anterior-posterior diameter}}$
Robusticity	$\frac{\text{midshaft circumference} \times 100}{\text{maximum length}}$
HUMERUS	
Midshaft	$\frac{\text{minimum diameter midshaft} \times 100}{\text{maximum diameter}}$
Robusticity	$\frac{\text{midshaft circumference} \times 100}{\text{maximum length}}$

mesiodistal and buccolingual (or labiolingual)—were measured for each left adult tooth except for the mesiodistal dimension of the maxillary and mandibular first and second incisors since virtually any occlusal wear on these teeth significantly reduces the mesiodistal dimension. Specimens that exhibited a large degree of tooth length or crown height reduction due to wear were not included in the analysis. Both dimensions, length and breadth, were recorded to the nearest 0.1 mm.

As an additional measure of tooth size, tooth areas were calculated for each tooth by multiplying crown length by crown breadth as a measure of the total occlusal area (cf. Wolpoff, 1971b). Most certainly, the product of tooth length and breadth is not an exact measure of tooth area since teeth rarely have parallel sides. However, it appears to be the best approximation due to the ease of replicability (Brace and Mahler, 1971). Tooth area was not calculated for the maxillary and mandibular central and lateral incisors because, for reasons discussed above, lengths of these teeth were not recorded for the present analysis.

For all dimensions—cranial, postcranial, and dental—standard anthropometric instruments were used where appropriate (see tables 7 and 8 for cranial and postcranial dimensions, respectively; all dental dimensions were taken by use of vernier scale sliding calipers). These instruments included: linen measurement tape (GPM), vernier scale sliding calipers (Mitutoyo), spreading calipers (GPM), osteometric board (Bass), and head spanner (GPM). All dimensions are expressed in millimeters. With the exception of the dimensions that required measurement by use of vernier scale sliding calipers (e.g., teeth, see also tables 7 and 8), measurements were recorded to the nearest millimeter. All other dimensions were recorded to the nearest 0.1 mm.

A more detailed treatment of methodology and a list of individual sex and age estimates as well as individual pathologies—periosteal reactions, dental caries, and degenerative joint disease—and all individual dimensions—cranial, postcranial, and dental—are presented by the author elsewhere (Larsen, 1980).

Chapters 4 and 5 present the findings of this investigation. These chapters include a respective presentation of the dental and skeletal pathology and metric data. Each data presentation is then followed by a discussion which assesses the implications for human biological adaptation in relation to the shift from hunting and gathering to a dietary regime based at least in part on corn agriculture on the prehistoric Georgia coast.

CHAPTER 4. PATHOLOGY TRENDS

Throughout this chapter a number of percentage differences for each pathology—periosteal reactions, dental caries, and degenerative joint disease—are calculated as measures of preagricultural-agricultural frequency change or female-male differences. These differences are simply calculated by the following procedure:

(1) For the preagricultural-agricultural pathology frequency change:

$$\%_A - \%_P$$

where A = the agricultural group, and
P = the preagricultural group.

(2) For the female-male differences:

$$\%_M - \%_F$$

where M = the males, and
F = the females.

Because the observations discussed are all representative of nominal data and the sample sizes for each variable are generally greater than 40, the nonparametric test statistic utilized for all comparisons is the chi-square test (cf. Thomas, 1976). The results are considered significant if the probability of the same result occurring by chance is $p \leq 0.05$ (Simpson, Roe and Lewontin, 1960). In order to minimize the observed and expected tallies in the computation of chi-square values, the Yates' Correction for Continuity was considered for use in this analysis as it has often been applied to nonparametric data such as these (cf. Thomas, 1976). However, Fleiss (1973) and Grizzle (1967) have shown that the Yates' Correction for Continuity should not be used because its application lowers actual significance levels. This results in a *power* reduction of the test statistic; that is, a reduction in the probability of detecting a real difference in frequencies. Therefore, this test statistic was not adapted for use in the analysis.

Because periosteal reactions, dental caries, and degenerative joint disease are representative of age-progressive processes, any differences in frequency of these conditions between the preagricultural and agricultural groups may, in fact, simply represent differences in age structure of the two subsistence groups. That is, if the agricultural group consists of a younger adult population at death than the preagricultural group, then the result might suggest that the preagricultural group had a higher frequency of pathology when this was not necessarily the case. Thus, it is important that the age structures of the two groups be clearly understood prior to discussing the comparisons of the pathology data.

Unfortunately, the preagricultural and agricultural groups contain a number of adult individuals of unknown age at death. However, assuming that these individuals follow the same age distribution as the adult individuals of known age, the individuals of unknown age at death were distributed into the respective age intervals: 16.1–20.0, 20.1–25.0, 25.1–30.0, 30.1–35.0, 35.1–40.0, 40.1–45.0, 45.1+. The distribution of adults of unknown age at death was accomplished by the following procedure. For the *preagricultural group,* a weight factor of 2.03 was calculated by dividing the preagricultural total number of adults (n = 229) by the preagricultural number of adults of known age (n = 113). By multiplying the known number of individuals in each adult age group by the weight factor, a corrected number of individuals in each adult age interval for the age distribution is derived (table 10). For the *agricultural group,* a weight factor was similarly calculated by dividing the total number of adults (n = 281) by the total number of adults of known age at death (n = 110). The resulting weight factor (2.60) multiplied by the known number of individuals at death for each adult age interval in the agricultural group, results in a corrected age distribution (table 11). These corrected age distributions represent a more realistic reconstruction of age profiles.

The above age distribution corrections for the preagricultural and agricultural groups are listed in tables 10 and 11, respectively.

TABLE 10
Preagricultural Age Distribution

Age Interval	Median Age	N[a]	Corrected N[b]	% Represented
0.0–2	1.0	7	7.0	2.6
2.1–12	7.0	19	19.0	7.1
12.1–16	14.0	13	13.0	4.8
16.1–20	18.0	22	44.7	16.6
20.1–25	22.5	27	54.8	20.4
25.1–30	27.5	14	28.4	10.6
30.1–35	32.5	6	12.2	4.5
35.1–40	37.5	14	28.4	10.6
40.1–45	42.5	11	22.3	8.3
45.1+	47.5	19	38.6	14.3
Unaged	—	116	—	—

[a] Number of actual individuals represented per age interval (representing skeletons that could be aged; see Larsen, 1980, Appendix A).

[b] Corrected number of individuals; see text for detailed explanation.

TABLE 11
Agricultural Age Distribution

Age Interval	Median Age	N[a]	Corrected N[b]	% Represented
0.0–2	1.0	12	12.0	3.5
2.1–12	7.0	30	30.0	8.8
12.1–16	14.0	25	25.0	7.3
16.1–20	18.0	33	85.8	25.1
20.1–25	22.5	38	98.8	28.9
25.1–30	27.5	11	28.6	8.4
30.1–35	32.5	8	20.8	6.1
35.1–40	37.5	9	23.4	6.8
40.1–45	42.5	6	15.6	4.6
45.1+	47.5	5	13.0	3.8
Unaged	—	171	—	—

[a] Number of actual individuals represented per age interval (representing skeletons that could be aged; see Larsen, 1980, Appendix A).

[b] Corrected number of individuals; see text for detailed explanation.

In order to compare these distributions, the most appropriate means is by use of survivorship curves since these curves represent an approximation of the frequency of those individuals surviving at the end of each age interval (cf. Weiss, 1973; Ubelaker, 1974, 1978). Figure 3 shows the survivorship curves for both the preagricultural and agricultural groups. Close inspection of these profiles suggests several conclusions regarding the preagricultural and agricultural age distributions. First, neither survivorship curve is likely to be a very good characterization of the actual age composition of the two groups. For example, well over 80 percent of individuals in both the preagricultural and agricultural groups appear to survive to age 16. Lovejoy et al. (1977) have shown in the prehistoric Libben site skeletal sample, perhaps the most comprehensively censused North American prehistoric cemetery, a survivorship to age 15 of approximately 50 percent. These investigators indicated that the Libben sample represented a "robust, successful population" (1977, p. 291). Most certainly, the discrepancy between the preadult Georgia coastal and Libben survivorship curves reveals a major under-representation in at least this part of the reconstructed age profiles for the former skeletal sample.

However, and more important for the present investigation, the comparison of the age profiles of the Georgia coastal preagricultural and agricultural groups shows that the preagricultural group is clearly represented by an older skeletal sample than the agricultural group. The difference in the age distributions is statistically significant at p = 0.05 (Kolmogorov-Smirnov, chi-square). In addition, both the sample (adults and preadults combined) and adult mean ages at death for the preagricultural group are significantly greater than the respective sample

TABLE 12
Comparison of Preagricultural and Agricultural Sample (Preadults and Adults Combined) and Adult Mean Ages at Death

	Mean Age at Death	
	Sample	Adult
Preagricultural	27.5	31.1
Agricultural	23.4	25.8
Chi-square (p)	0.05	0.05

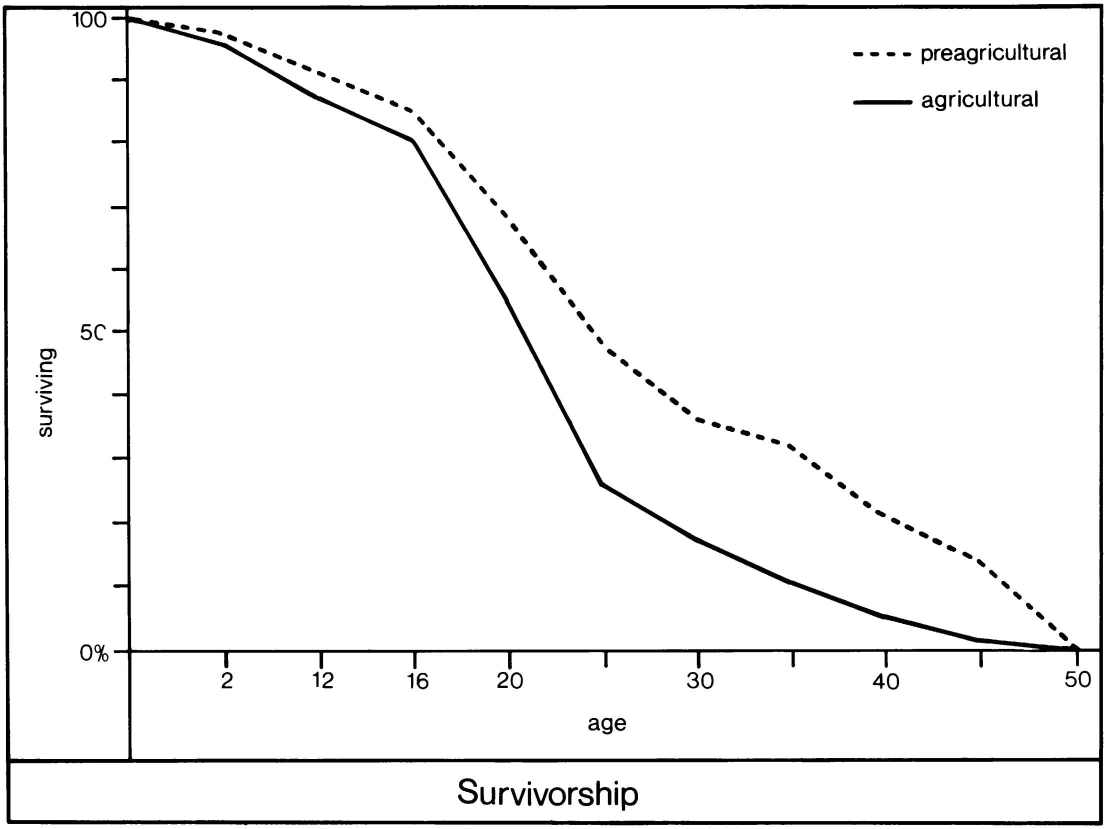


FIG. 3. Comparison of Georgia coastal preagricultural and agricultural survivorship curves.

and adult mean ages at death for the agricultural group (table 12) (p = 0.05: chi-square). In sum, although the skeletal samples probably do not reflect actual population profiles, their comparison reveals one important consideration: the preagricultural sample is a decidedly older skeletal sample than the agricultural sample.

PERIOSTEAL REACTIONS

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

The frequency of adult (females, males, indeterminate sex combined) preagricultural and agricultural skeletal elements affected by periosteal reactions, preagricultural-agricultural percent changes, and significance levels are shown in table 13 and figure 4. In general, the agricultural adults have significantly greater frequencies of bones affected by periosteal reactions than the preagricultural adults. The significant frequency increases for reactive bones include those for the humerus (2.7%), radius (3.8%), femur (4.7%), tibia (10.5%), and fibula (6.6%).

FEMALE-MALE COMPARISONS

Similar statistical treatment of the frequency of reactive bones by sex reveals that the females have significant increases for the tibia (13.6%) and fibula (8.5%) (table 14) and the males have significant frequency increase for the tibia only (11.8%) (table 15). With the exception of the male clavicle (−0.3%), all other bones (humerus, ulna, radius, femur, tibia, fibula) show increase in frequency of

TABLE 13
Frequency of Preagricultural-Agricultural Periosteal Reactions: Adult (Females, Males, Indeterminate Sex Combined) Comparisons

	Preagricultural		Agricultural			
Bone	%	N[a]	%	N[a]	Change of %[b]	Chi-square (p)
Clavicle	1.9	107	4.7	274	+2.8	n.s.[c]
Humerus	0.5	190	3.2	273	+2.7	.05
Ulna	0.7	147	3.7	327	+3.0	n.s.
Radius	0.7	136	4.5	335	+3.8	.05
Femur	2.1	193	6.8	410	+4.7	.05
Tibia	4.5	156	15.0	374	+10.5	.001
Fibula	1.7	116	8.3	289	+6.6	.05

[a] Number of bones observed for presence or absence of periosteal reactions.
[b] Computed by the formula: % Agricultural − % Preagricultural.
[c] Not significant.

periosteal reactions in the agricultural group that is not significant. There were no significant differences between the sexes in either group (tables 16 and 17).

DENTAL CARIES

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

The frequency of noncarious and carious individuals (individuals with at least one carious lesion) and significance levels for the preagricultural-agricultural comparisons are shown in table 18 and figure 5. In general, the agricultural group is characterized by a dramatic increase in frequency of carious individuals over the preagricultural group. For the total sample (adults and preadults combined), 49.9 percent more of the agricultural individuals are affected by the disease. Similarly, the increase in dental caries, preagricultural to agricultural, is 58.7 percent for the females, 52.6 percent for the males, and 48.2 percent for the preadults. Although all preagricultural to agricultural increases in frequency of dental caries are significant, the increase for the females is the largest, males intermediate, and preadults the least.

Table 19 and figure 6 show the total sample (adults and preadults combined) increase in frequency for individual teeth affected by dental caries. Most teeth show increases in frequency of carious lesions. In the permanent dentition, all maxillary post-incisor teeth and all mandibular post-canine teeth show significant increases: maxillary canine (8.3%), third premolar (17.3%), fourth premolar (11.6%), first molar (14.3%), second molar (11.5%), third molar (8.7%), mandibular third premolar (5.1%), fourth premolar (10.9%), first molar (21.2%), second molar (21.0%), and third molar (22.1%). One deciduous tooth showed a significant increase in frequency of dental caries, the maxillary first molar (19.1%). In sum, for all tooth categories combined (I1 + I2 + C+ . . . M3), the preagricultural group shows that 1.3 percent of all teeth are carious (36/2429); whereas the agricultural group shows 11.6 percent carious teeth (486/4189). This represents a 10.3 percent frequency increase in the agricultural group relative to the preagricultural group.

Comparisons of the preagricultural and agricultural females, males, and preadults show the same pattern of frequency increase for individual tooth categories affected by dental caries. The females show significant increases for teeth affected by dental caries for the maxillary canine (17.0%), third premolar (21.0%), fourth premolar (14.4%), first molar (16.7%), second molar (18.3%), third molar (17.4%), and the mandibular third premolar (8.1%), fourth premolar (13.9%), first molar (25.8%), second molar (30.3%), and third molar (25.0%) (table 20). The female

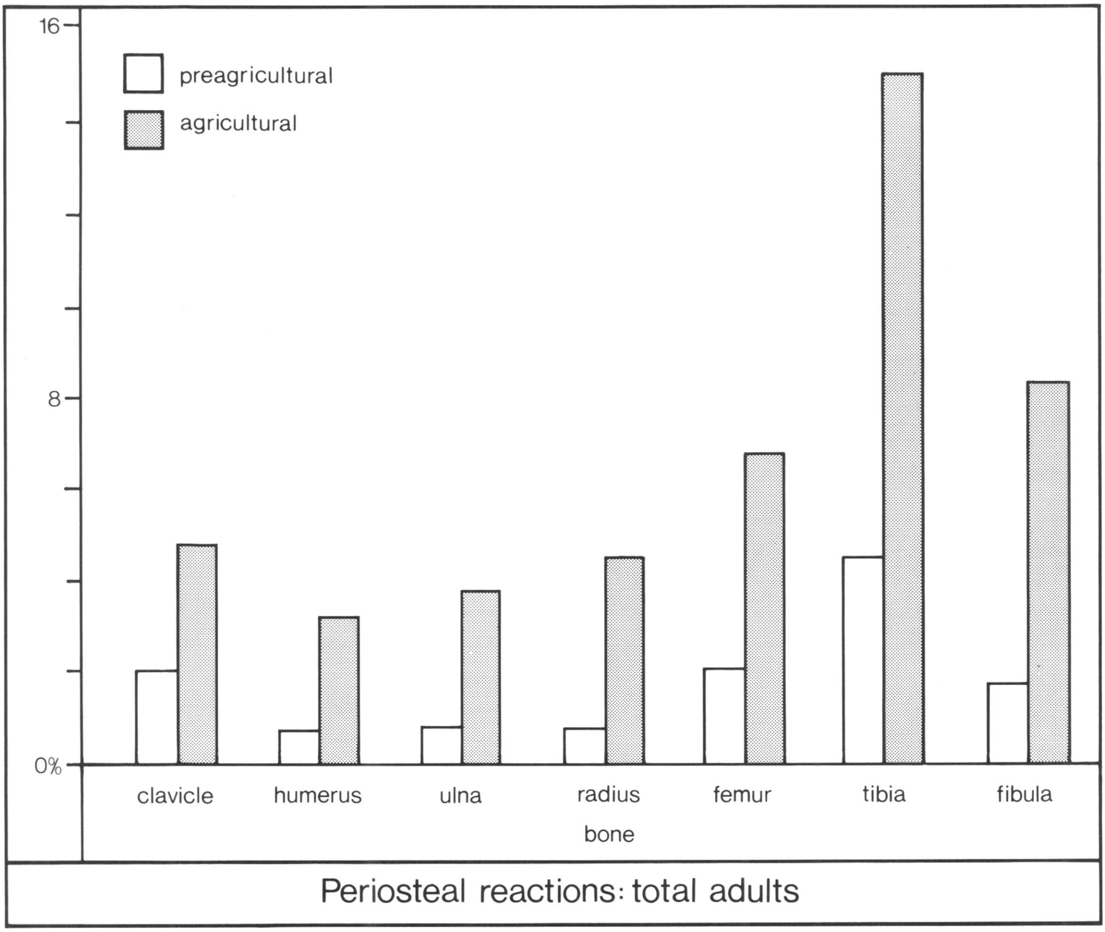


FIG. 4. Bar graph showing comparison of preagricultural and agricultural adult skeletal elements affected by periosteal reactions.

dentition, for all tooth categories combined, shows a 14.4 percent increase in frequency of teeth affected by dental caries. Most of the frequency increase apparently is oriented toward the posterior dentition.

Table 21 shows the male dental caries frequencies for the preagricultural and agricultural groups. Although there is a percent increase in frequency of dental caries for all teeth, with the exception of the maxillary first incisor (2.1% decrease), there are fewer significant increases than in either the total sample (adults and preadults combined) or females. The significant increases in carious teeth are restricted to the maxillary post-canine and the mandibular post-third premolar dentitions. The significant percentage increases for teeth affected by dental caries occur for the maxillary third premolar (27.6%), fourth premolar (13.4%), first molar (18.5%), third molar (16.1%), and the mandibular first molar (20.3%), second molar (10.8%), and third molar (20.8%). For all tooth categories combined, the male dentition shows a 10.6 percent increase in frequency of teeth affected by dental caries.

The preadults show an expected percent increase in frequency of carious teeth in the agricultural group relative to the preagricultural group (table 22). Although there is a

TABLE 14
Frequency of Preagricultural-Agricultural Periosteal Reactions: Female Comparisons

Bone	Preagricultural %	Preagricultural N[a]	Agricultural %	Agricultural N[a]	Change of %[b]	Chi-square (p)
Clavicle	0.0	61	2.9	140	+2.9	n.s.[c]
Humerus	0.0	106	3.7	190	+3.7	n.s.
Ulna	1.2	82	3.6	167	+2.4	n.s.
Radius	0.0	77	4.0	173	+4.0	n.s.
Femur	1.8	110	7.2	207	+5.4	n.s.
Tibia	2.4	84	16.0	187	+13.6	.005
Fibula	1.4	74	9.9	152	+8.5	.05

[a] Number of bones observed for presence or absence of periosteal reactions.
[b] Computed by the formula: % Agricultural − % Preagricultural.
[c] Not significant.

significant increase in dental caries for all tooth categories combined (3.0%), none of the individual tooth category increases are significant. Thus, the percentage of preadult carious teeth shows notably less significant increase than either the total sample (adults and preadults combined), female, or male percentage increases. The differences between the preadults and the remainder of the sample is made even more apparent by comparison of the preadult sample with the female and male samples combined. Whereas the increase in frequency of preadult carious teeth is 3.0 percent (preagricultural group, 0.9%; agricultural group, 3.9%), the female-male sample shows nearly a 13 percent increase in percentage of carious teeth (preagricultural group, 0.9%; agricultural group, 13.7%).

CARIOUS LESION SIZE

Table 23 shows the frequencies of teeth affected by incipient, medium, and gross lesions in the preagricultural and agricultural groups. Generally, each tooth category shows percentage increases in teeth affected by dental caries for all three lesion sizes in the agricultural group relative to the preagricultural group. For example, the preagricultural maxillary third premolar shows no teeth affected by gross carious lesions, whereas

TABLE 15
Frequency of Preagricultural-Agricultural Periosteal Reactions: Male Comparisons

Bone	Preagricultural %	Preagricultural N[a]	Agricultural %	Agricultural N[a]	Change of %[b]	Chi-square (p)
Clavicle	5.6	36	5.3	114	−0.3	n.s.[c]
Humerus	2.0	51	3.6	140	+1.6	n.s.
Ulna	0.0	42	2.3	130	+2.3	n.s.
Radius	0.0	43	2.9	140	+2.9	n.s.
Femur	2.0	49	6.4	156	+4.4	n.s.
Tibia	4.0	50	15.8	146	+11.8	.05
Fibula	0.0	37	5.3	114	+5.3	n.s.

[a] Number of bones observed for presence or absence of periosteal reactions.
[b] Computed by the formula: % Agricultural − % Preagricultural.
[c] Not significant.

TABLE 16
Frequency of Preagricultural Periosteal Reactions: Female-Male Comparisons

	Female		Male			
Bone	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
Clavicle	0.0	61	5.6	36	+5.6	n.s.[c]
Humerus	0.0	106	2.0	51	+2.0	n.s.
Ulna	1.2	82	0.0	42	−1.2	n.s.
Radius	0.0	77	0.0	43	0.0	n.s.
Femur	1.8	110	2.0	49	+0.2	n.s.
Tibia	2.4	84	4.0	50	+1.6	n.s.
Fibula	1.4	74	0.0	37	−1.4	n.s.

[a] Number of bones observed for presence or absence of periosteal reactions.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

the agricultural maxillary third premolar has 13.0 percent of teeth affected by gross lesions.

The frequency change in preagricultural-agricultural percentages for carious lesion size is more clearly demonstrated, however, by combining all tooth categories (table 24). For the total sample (adults and preadults combined), females, males, and preadults, nearly all carious lesion size categories show significant percentage increases. The total sample shows percentage increases for incipient (2.0%), medium (2.2%), and gross (5.7%) lesions; the females show percentage increases for incipient (3.3%), medium (0.9%), and gross (8.8%) lesions; and the preadults show percentage increases for incipient (1.5%), medium (0.3%), and gross (1.5%) lesions. The preadult medium lesion category is the only carious lesion size category that does not show a significant preagricultural-agricultural percentage increase. Although the total sample, female, male, and preadult groups shows percentage increases in all carious lesion size categories, the group most affected by the frequency increases in teeth affected by dental caries is the female group. That is, over 8 percent more agricultural female teeth have gross carious lesions than those of the preagricultural female group. Furthermore, although marked frequency increases occur for each lesion size

TABLE 17
Frequency of Agricultural Periosteal Reactions: Female-Male Comparisons

	Female		Male			
Bone	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
Clavicle	2.9	140	5.3	114	+2.4	n.s.[c]
Humerus	3.7	190	3.6	140	−0.1	n.s.
Ulna	3.6	167	2.3	130	−1.3	n.s.
Radius	4.0	173	2.9	140	−1.1	n.s.
Femur	7.2	207	6.4	156	−0.8	n.s.
Tibia	16.0	187	15.8	146	−0.2	n.s.
Fibula	9.9	152	5.3	114	−4.5	n.s.

[a] Number of bones observed for presence or absence of periosteal reactions.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

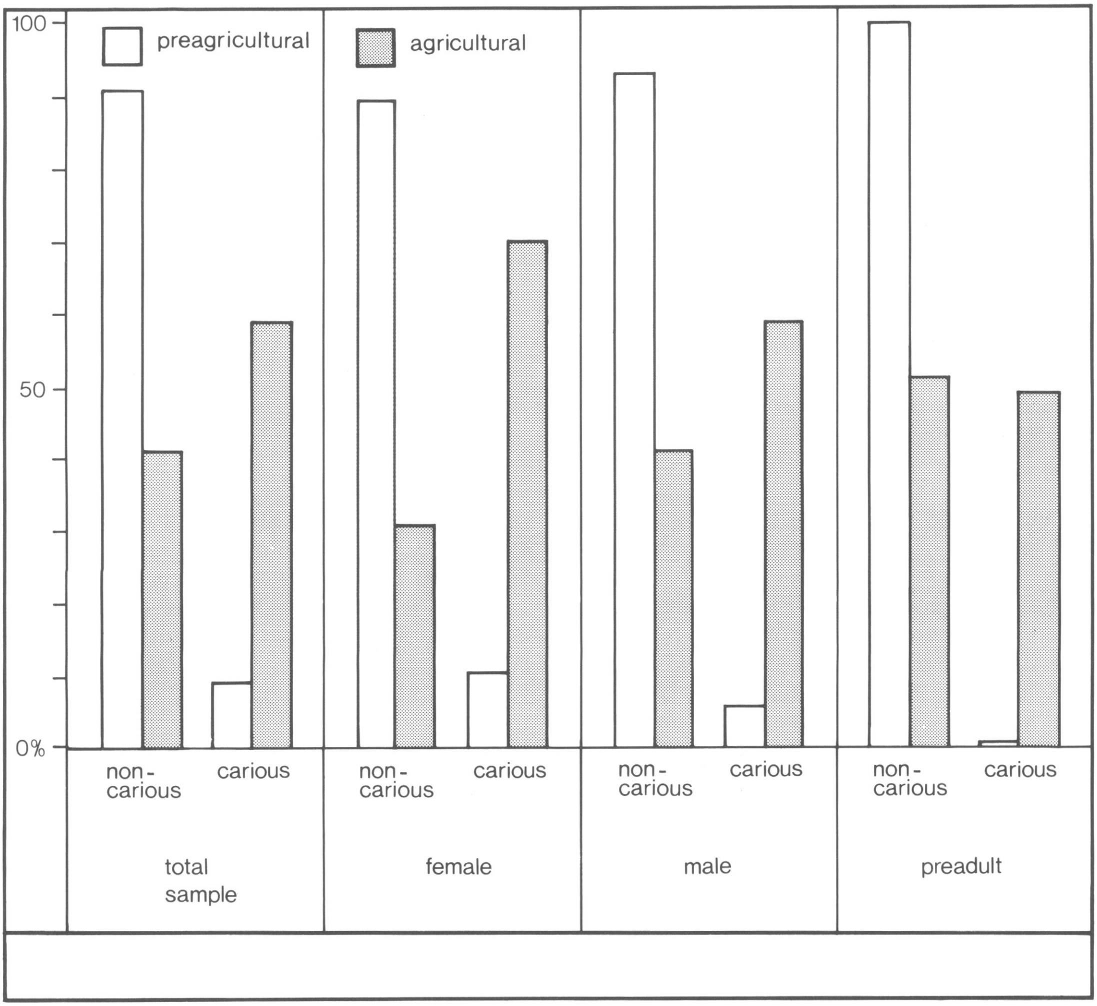


FIG. 5. Bar graph showing comparison of preagricultural and agricultural total sample (adults and preadults combined), females, males, and preadults affected by dental caries.

category, the most notable increases occur for teeth affected by gross carious lesions. While in the preagricultural group few of the carious lesions are gross, the agricultural group shows many more teeth affected by the advanced form of dental caries involving the pulp chambers of teeth.

CARIOUS LESION CROWN LOCATION

Analysis of frequencies of preagricultural and agricultural carious lesion location (occlusal, buccal, interproximal, cervical) shows similar trends of percentage increases in frequency of the dental caries in the agricultural group. Table 25 shows the frequencies of teeth affected by occlusal, buccal, interproximal, and cervical dental caries for the preagricultural and agricultural groups by tooth category. As in the carious lesion size category, the pattern of preagricultural-agricultural percentage change is demonstrated most clearly by combining the tooth categories.

Table 26 shows the frequencies of teeth

affected by dental caries for each lesion location category for the total sample (adults and preadults combined), females, males, and preadults, percentage changes, and significance levels. These data show that most preagricultural-agricultural percentage changes represent significant increases in frequency of carious lesion location. Only the preadult interproximal and cervical caries show little or no frequency increases in dental caries. For the total sample, the preagricultural-agricultural frequency increases include occlusal (3.3%), buccal-labial (1.2%), interproximal (0.3%), and cervical (4.7%) lesions; males show frequency increases for the occlusal (2.8%), buccal-labial (0.6%), interproximal (0.5%), and cervical (3.5%) lesions; and the preadult increases in location categories show occlusal (1.5%), buccal-labial (1.5%), interproximal (0.0%), and cervical (0.5%) lesions. Thus, the females show the most, males intermediate, and preadults the least percentage increases in teeth affected by dental caries for nearly all lesion location categories.

FEMALE-MALE COMPARISONS

Tables 27 and 28 contain the frequencies of teeth affected in females and males by dental caries for the preagricultural and agricultural groups, the percentage differences, and significance levels. The comparison of the preagricultural females and males affected by dental caries shows that there are no significant differences between the two sexes in frequency of the dental caries present. Both females and males are minimally affected by the disease process. However, in the agricultural group, most tooth categories show fewer teeth affected by dental caries in males than in females. Two of the percentage differences, those for the maxillary second incisor (3.7%) and the mandibular second molar (18.6%), are significant. For all teeth combined, the agricultural males have 4.4 percent fewer carious teeth than the females. This difference is also significant.

Subdividing these data by carious lesion size and location, categories for the preagricultural female-male and the agricultural female-male comparisons show similar trends (tables 29 and 30). In the preagricultural group, no significant female-male percent differences are present due to the fact that neither sex group in the preagricultural group is affected to any extent by dental caries. In the agricultural group, all lesion size and location categories, with the exception of interproximal lesions, show fewer teeth affected by dental caries in the males than in the females. The significant differences in percentages of caries between agricultural males and females include gross (3.2%), occlusal (2.8%), and cervical (1.5%) lesions.

TABLE 18

Frequency of Individuals Affected by Dental Caries (Includes Individuals with at Least One Carious Lesion)

	Preagricultural (%)	Agricultural (%)	Chi-square (p)
TOTAL SAMPLE	(N = 201)[a]	(N = 275)[a]	
Noncarious	91.0	41.1	.001
Carious	9.0	58.9	.001
FEMALE	(N = 75)	(N = 108)	
Noncarious	89.3	30.6	.001
Carious	10.7	69.4	.001
MALE	(N = 49)	(N = 80)	
Noncarious	93.9	41.3	.001
Carious	6.1	58.7	.001
PREADULT	(N = 36)	(N = 56)	
Noncarious	100.0	51.8	.001
Carious	0.0	48.2	.001

[a] Number of individuals observed with at least one tooth present in the maxillary and mandibular dentitions combined.

PREADULT-ADULT COMPARISONS

The preagricultural-agricultural preadult and adult percentage changes and the preagricultural preadult-adult percentage differences for teeth affected by dental caries are presented in table 31. Both the preadults and adults show significant preagricultural-agricultural percentage increases in teeth affected by dental caries. As discussed above, most of the increase is due to larger numbers

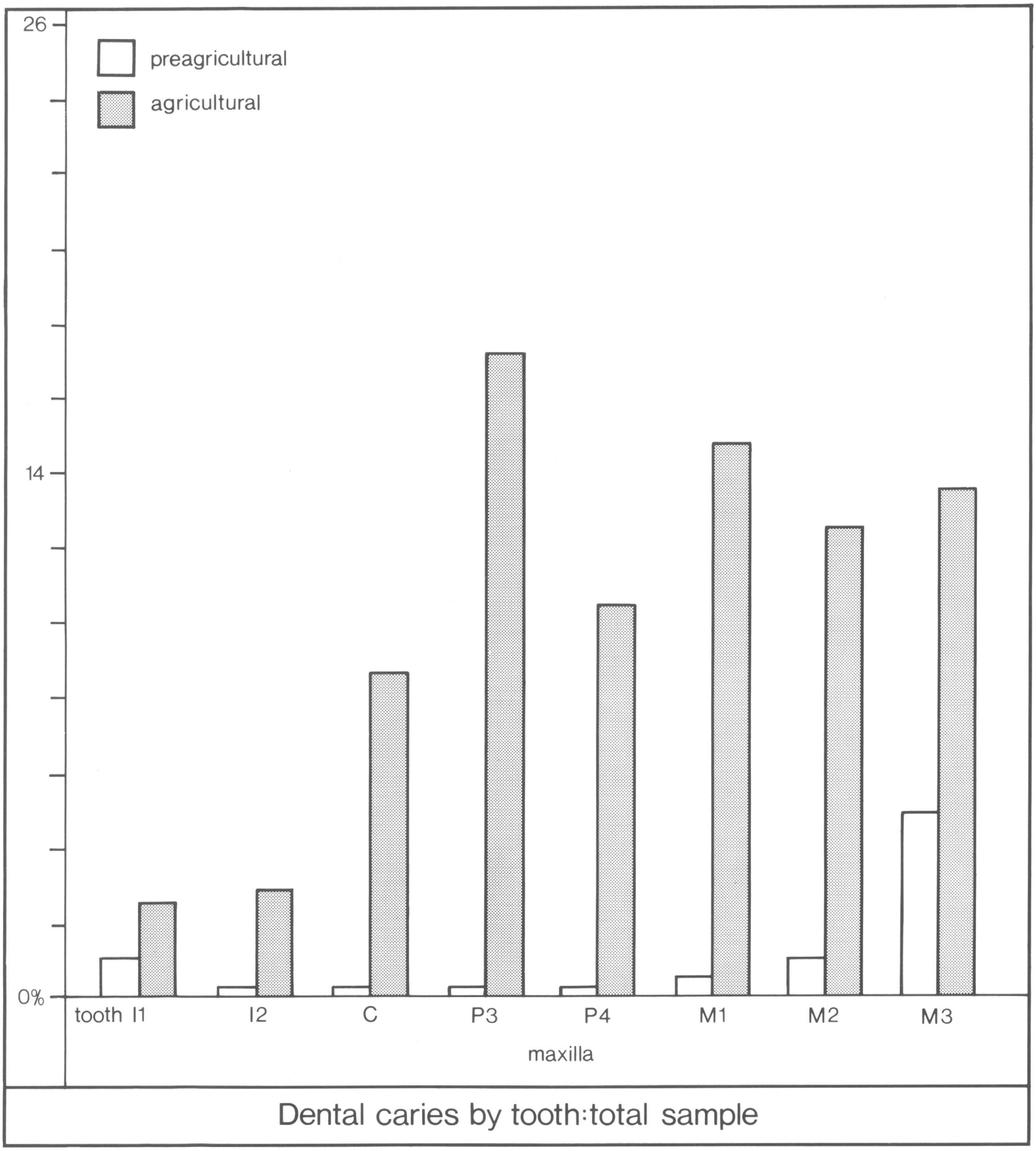
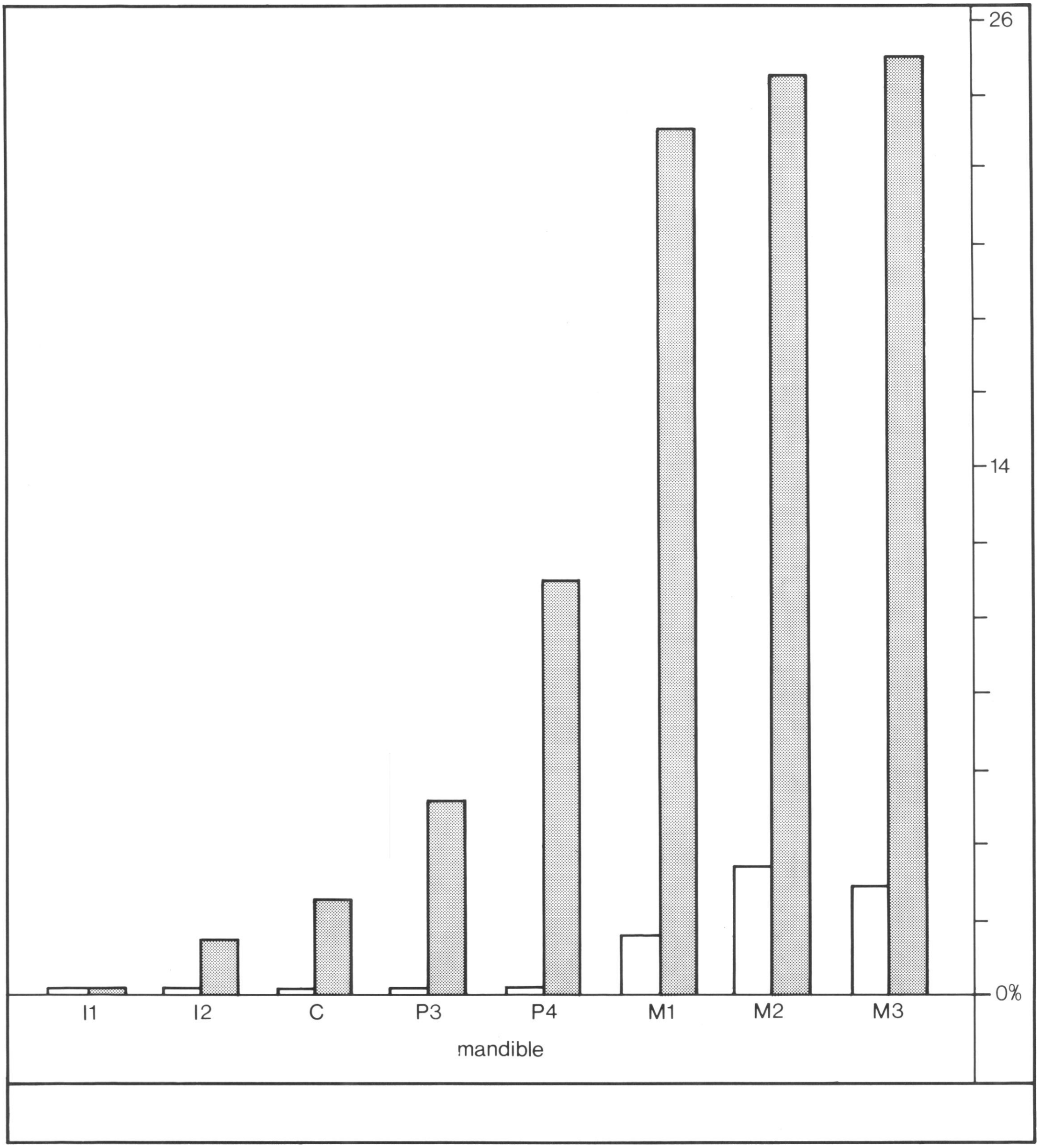


FIG. 6. (On two consecutive pages.) Bar graph showing comparison of preagricultural and agricultural total sample (adults and preadults combined) dental caries by tooth (permanent dentition only).

and severity of carious lesions, particularly with regard to the posterior dentition (postcanine teeth). Moreover, most of the percentage increases in frequency of carious teeth are restricted to the adults (12.5%). Within the preagricultural group, there are no significant preadult-adult differences in percentage of teeth affected by dental caries.



Both of the age groups, preadult and adult, are minimally affected by dental caries. However, in the agricultural group, there is a significant percentage difference in frequency of teeth affected by dental caries between the preadults and adults. The agricultural adults have 10.0 percent more carious teeth than the agricultural preadults. Of course, this is not surprising given that the adult teeth represent tooth surfaces that had been exposed to cariogenic activity for relatively longer periods of time than preadult teeth.

TABLE 19

Frequency of Carious Teeth by Tooth: Preagricultural and Agricultural Total Sample (Adults and Preadults Combined)

	Preagricultural			Agricultural				
Tooth	%	N[a]	N[b]	%	N[a]	N[b]	Change of %[c]	Chi-square (p)
MAXILLA								
I1	1.0	103	53	2.3	177	95	+1.3	n.s.[d]
I2	0.0	95	49	2.8	178	92	+2.8	n.s.
C	0.0	126	65	8.3	241	124	+8.3	.005
P3	0.0	149	76	17.3	231	121	+17.3	.001
P4	0.0	149	75	11.6	242	131	+11.6	.001
M1	0.5	188	95	14.8	317	163	+14.3	.001
M2	1.0	193	102	12.5	303	154	+11.5	.001
M3	4.9	163	82	13.6	228	122	+8.7	.005
dI1	0.0	12	7	10.5	19	10	+10.5	n.s.
dI2	0.0	10	6	11.5	18	9	+11.1	n.s.
dC	0.0	18	10	0.0	28	15	0.0	n.s.
dM1	0.0	26	16	19.1	47	24	+19.1	.05
dM2	0.0	20	12	8.2	49	25	+8.2	n.s.
MANDIBLE								
I1	0.0	64	34	0.0	164	87	0.0	n.s.
I2	0.0	84	44	1.5	196	100	+1.5	n.s.
C	0.0	126	66	2.6	232	119	+2.6	n.s.
P3	0.0	136	70	5.1	276	140	+5.1	.01
P4	0.0	151	83	10.9	248	124	+10.9	.001
M1	1.7	174	88	22.9	315	159	+21.2	.001
M2	3.5	174	89	24.5	274	138	+21.0	.001
M3	2.9	173	87	25.0	244	125	+22.1	.001
dI1	0.0	7	5	0.0	9	5	0.0	n.s.
dI2	0.0	11	6	0.0	15	8	0.0	n.s.
dC	0.0	19	12	0.0	26	16	0.0	n.s.
dM1	0.0	28	15	5.4	56	30	+5.4	n.s.
dM2	0.0	29	15	5.4	56	29	+5.4	n.s.
TOTAL	1.3	2429	201	11.6	4189	275	+10.3	.001

[a] Number of teeth observed for presence or absence of dental caries.

[b] Number indicates minimum number of individuals represented.

[c] Computed by the formula: % Agricultural − % Preagricultural.

[d] Not significant.

REGION COMPARISONS

As discussed above, little significant increase in frequency of teeth affected by dental caries occurs for the anterior teeth in the agricultural group relative to the preagricultural group. The largest preagricultural-agricultural frequency increases appear to be restricted to posterior teeth. This dichotomy is made clearer by comparison of frequencies of teeth affected by dental caries within each group, preagricultural and agricultural, for the individual tooth types (incisors, canines, premolars, molars). In order to delineate more specifically the exact region of the dentition most affected by the caries process, the frequencies of the anterior and posterior teeth affected by dental caries and the nonmolar and molar teeth affected by dental caries for the preagricultural and agricultural

TABLE 20
Frequency of Preagricultural and Agricultural Female Teeth Affected by Dental Caries

	Preagricultural			Agricultural				
Tooth	%	N[a]	N[b]	%	N[a]	N[b]	Change of %[c]	Chi-square (p)
MAXILLA								
I1	0.0	48	26	3.7	82	42	+3.7	n.s.[d]
I2	0.0	39	21	6.0	66	35	+6.0	n.s.
C	0.0	52	26	17.0	100	53	+17.0	.005
P3	0.0	60	31	21.0	95	50	+21.0	.001
P4	0.0	61	31	14.4	111	58	+14.4	.005
M1	0.0	73	37	16.7	138	73	+16.7	.001
M2	0.0	77	41	18.3	126	68	+18.3	.001
M3	0.0	73	37	17.4	109	58	+17.4	.001
MANDIBLE								
I1	0.0	33	17	0.0	58	33	0.0	n.s.
I2	0.0	42	23	2.4	84	43	+2.4	n.s.
C	0.0	60	31	5.1	97	52	+5.1	n.s.
P3	0.0	65	33	8.1	123	65	+8.1	.05
P4	0.0	76	43	13.9	130	67	+13.9	.001
M1	1.3	79	41	26.8	127	65	+25.8	.001
M2	1.2	86	43	31.5	127	66	+30.3	.001
M3	1.1	92	47	26.1	115	60	+25.0	.001
TOTAL	1.2	1016	75	15.6	1688	108	+14.4	.001

[a] Number of teeth observed for presence or absence of dental caries.
[b] Number indicates minimum number of individuals represented.
[c] Computed by the formula: % Agricultural − % Preagricultural.
[d] Not significant.

groups are shown in tables 32, 33, and 34 for all adults (females, males, and indeterminate sex combined), females, and males, respectively. These data show that, for the most part, the posterior teeth have significantly higher caries frequency than the anterior teeth in both the preagricultural and agricultural groups. More specifically, the molars have significantly more carious teeth than the nonmolar teeth for all comparisons. The only exceptions to the anterior-posterior and nonmolar-molar dichotomies are the preagricultural male dentitions. That is, there appear to be no significant differences between the frequency of carious teeth for the male anterior-posterior teeth or the nonmolar-molar teeth in the preagricultural group.

The comparisons of percentage differences for the preagricultural-agricultural incisors, canines, premolars, and molars are shown in figures 7, 8, and 9 for the adults (females, males, indeterminate sex combined), females, and males, respectively. These graphs show, in more detail than the anterior-posterior or nonmolar-molar comparisons, the nature of caries distribution in the adult, female, and male preagricultural-agricultural dentitions. In the preagricultural adults, less than 1 percent of the incisors are carious, whereas nearly 3 percent of the molars are affected by dental caries. None of the preagricultural adult canines or premolars show evidence of cavitation. In the agricultural adults, the following percentages of tooth types are carious: incisors, 2 percent; canines, 6 percent; premolars, 11 percent; and molars, nearly 20 percent. The preagricultural and agricultural females and males follow roughly the same percent distribution for tooth types affected by the disease.

TABLE 21
Frequency of Preagricultural and Agricultural Male Teeth Affected by Dental Caries

	Preagricultural			Agricultural				
Tooth	%	N[a]	N[b]	%	N[a]	N[b]	Change of %[c]	Chi-square (p)
MAXILLA								
I1	2.1	37	19	0.0	63	35	−2.1	n.s.[d]
I2	0.0	31	16	1.7	58	30	+1.7	n.s.
C	0.0	35	18	4.9	82	41	+4.9	n.s.
P3	0.0	39	20	27.6	76	40	+27.6	.001
P4	0.0	38	20	13.4	82	42	+13.4	.05
M1	0.0	46	23	18.5	92	48	+18.5	.005
M2	0.0	47	25	13.5	89	46	+13.5	n.s.
M3	0.0	40	20	16.1	81	42	+16.1	.01
MANDIBLE								
I1	0.0	15	8	0.0	58	30	0.0	n.s.
I2	0.0	24	13	1.4	69	35	+1.4	n.s.
C	0.0	42	25	0.0	85	44	0.0	n.s.
P3	0.0	43	22	3.2	93	49	+3.2	n.s.
P4	0.0	41	21	8.0	88	48	+8.0	n.s.
M1	2.1	47	24	22.4	98	51	+20.3	.001
M2	2.1	47	24	12.9	85	45	+10.8	.05
M3	2.1	45	23	22.9	96	50	+20.8	.001
TOTAL	0.6	617	49	11.2	1295	80	+10.6	.001

[a] Number of teeth observed for presence or absence of dental caries.
[b] Number indicates minimum number of individuals represented.
[c] Computed by the formula: % Agricultural − % Preagricultural.
[d] Not significant.

In sum, dental caries is a disease process that has had little effect on the preagricultural dentition. Due to the low frequency of the disease in the preagricultural group, there appears to be little or no difference in individuals affected regardless of age or sex. In the agricultural group, however, the frequency of this disease affecting all individuals increases markedly. Unlike the preagricultural group, the agricultural group shows females affected more by cariogenesis than either males or preadults. Adults, in turn, appear to be more affected by caries than preadults. Finally, within each group, preagricultural and agricultural, the disease process is most severe in the posterior teeth.

DEGENERATIVE JOINT DISEASE

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

The preagricultural-agricultural frequency differences, percent changes, and significance levels by articular joint for the adults (females, males, indeterminate sex combined) are shown in table 35 and figure 10. In general, there is a marked frequency reduction in degenerative change for each joint in the agricultural sample. The significant percentage reduction in degenerative change occurs for the intervertebral lumbar (26.2%), elbow (6.8%), wrist (4.5%), hip (3.8%), knee (7.2%), and ankle (4.0%) joints.

Table 36 represents the female preagricultural-agricultural percentage changes for the frequency of degenerative joint disease. Significantly fewer articular joints of agricultural females are affected by degenerative joint disease for the cervical (15.8%), lumbar (19.6%), elbow (9.6%), hip (4.3%), knee (11.6%), and ankle (4.5%) joints. Similarly, the males show significant preagricultural-agricultural reduction in frequency of degenerative joint changes (table 37). The most

TABLE 22

Frequency of Preagricultural and Agricultural Preadult Teeth Affected by Dental Caries

Tooth	Preagricultural %	Preagricultural N[a]	Preagricultural N[b]	Agricultural %	Agricultural N[a]	Agricultural N[b]	Change of %[c]	Chi-square (p)
MAXILLA								
I1	0.0	13	7	0.0	38	20	0.0	n.s.[d]
I2	0.0	14	7	0.0	35	18	0.0	n.s.
C	0.0	16	9	0.0	40	18	0.0	n.s.
P3	0.0	18	10	0.0	45	19	0.0	n.s.
P4	0.0	16	10	0.0	32	16	0.0	n.s.
M1	0.0	30	17	2.9	70	34	+2.9	n.s.
M2	0.0	21	11	2.0	49	24	+2.0	n.s.
M3	0.0	14	8	0.0	29	14	0.0	n.s.
dI1	0.0	13	7	10.5	19	10	+10.5	n.s.
dI2	0.0	10	6	11.1	18	9	+11.1	n.s.
dC	0.0	18	10	0.0	28	15	0.0	n.s.
dM1	0.0	26	16	19.1	47	24	+19.1	n.s.
dM2	0.0	20	12	8.2	49	25	+8.2	n.s.
MANDIBLE								
I1	0.0	11	6	0.0	28	14	0.0	n.s.
I2	0.0	15	8	0.0	49	25	0.0	n.s.
C	0.0	12	6	0.0	47	25	0.0	n.s.
P3	0.0	19	10	0.0	51	26	0.0	n.s.
P4	0.0	17	10	0.0	31	17	0.0	n.s.
M1	0.0	33	17	12.7	71	38	+12.7	n.s.
M2	16.0	25	13	6.0	50	25	−10.0	n.s.
M3	0.0	10	6	5.6	18	10	+5.6	n.s.
dI1	0.0	7	5	0.0	9	5	0.0	n.s.
dI2	0.0	11	6	0.0	15	6	0.0	n.s.
dC	0.0	19	12	0.0	26	12	0.0	n.s.
dM1	0.0	28	15	5.4	56	25	+5.4	n.s.
dM2	0.0	29	15	5.4	56	25	+5.4	n.s.
TOTAL	0.9	465	36	3.9	996	56	+3.0	.005

[a] Number of teeth observed for presence or absence of dental caries.

[b] Number indicates minimum number of individuals represented.

[c] Computed by the formula: % Agricultural − % Preagricultural.

[d] Not significant.

notable significant reduction in frequency of degenerative joint changes for the males is in the lumbar vertebra. Nearly two-thirds of the preagricultural male lumbar vertebrae are affected by some form of degenerative change involving this joint. Only one-third of the agricultural males show degenerative change associated with the lumbar region. Two other preagricultural-agricultural male joints show significant percentage reduction in frequency of degenerative joint disease: the shoulder (8.8%) and the wrist (1.7%).

FEMALE-MALE COMPARISONS

Table 38 and table 39 show the female-male comparisons for the preagricultural and agricultural groups, respectively, for articular joints affected by degenerative joint disease. In general, males of both groups, preagricultural and agricultural, tend to have greater frequencies of joints affected by degenerative joint disease than females. The significant differences between the preagricultural females and males occur for the lum-

TABLE 23
Frequency (%) of Incipient (I), Medium (M), and Gross (G) Carious Lesions for the Preagricultural and Agricultural Groups (Adults and Preadults Combined)

	Preagricultural				Agricultural			
Tooth	N[a]	I	M	G	N[a]	I	M	G
MAXILLA								
I1	103	0.0	0.0	0.0	177	0.0	1.1	1.1
I2	95	0.0	0.0	0.0	178	0.6	0.0	2.3
C	126	0.0	0.0	0.0	241	2.1	1.7	4.6
P3	149	0.0	0.0	0.0	231	1.3	3.0	13.0
P4	149	0.0	0.0	0.0	242	0.4	2.1	9.1
M1	188	0.0	0.0	0.5	317	3.2	1.6	10.1
M2	193	0.5	0.0	0.5	303	3.6	2.3	6.6
M3	163	4.3	0.6	0.0	228	4.4	2.6	6.6
dI1	13	0.0	0.0	0.0	19	10.5	0.0	0.0
dI2	10	0.0	0.0	0.0	18	11.1	0.0	0.0
dC	18	0.0	0.0	0.0	28	0.0	0.0	0.0
dM1	26	0.0	0.0	0.0	47	0.0	2.1	17.0
dM2	20	0.0	0.0	0.0	49	2.0	0.0	6.1
MANDIBLE								
I1	64	0.0	0.0	0.0	164	0.0	0.0	0.0
I2	84	0.0	0.0	0.0	196	0.0	0.0	1.5
C	126	0.0	0.0	0.0	232	0.0	0.9	1.7
P3	136	0.0	0.0	0.0	276	1.5	1.5	2.2
P4	151	0.0	0.0	0.0	248	0.4	2.8	7.7
M1	174	0.0	1.7	0.0	315	6.0	7.3	9.5
M2	174	0.6	0.6	2.3	274	8.8	5.5	10.2
M3	173	2.9	0.0	0.0	244	14.3	3.7	7.0
dI1	7	0.0	0.0	0.0	9	0.0	0.0	0.0
dI2	11	0.0	0.0	0.0	15	0.0	0.0	0.0
dC	19	0.0	0.0	0.0	26	0.0	0.0	0.0
dM1	28	0.0	0.0	0.0	56	0.0	0.0	5.6
dM2	29	0.0	0.0	0.0	56	1.8	3.6	0.0
TOTAL	2429	0.7	0.2	0.4	4189	2.7	2.4	6.1

[a] Number of teeth observed for carious lesion size.

bar (37.1%) and shoulder (8.1%) joints (table 38), whereas the significant differences between the agricultural females and males occur for the cervical (9.9%), thoracic (10.4%), lumbar (15.2%), elbow (6.1%), and knee (9.2%) joints (table 39).

DISCUSSION

From the results of the above comparisons of preagricultural and agricultural frequencies of periosteal reactions, dental caries, and degenerative joint disease, two primary conclusions can be drawn with regard to the relationship of pathology and subsistence change of groups inhabiting the prehistoric Georgia coast. First, status of health, both skeletal and dental, deteriorates as indicated by a respective increase in frequency of postcranial periosteal reactions and dental caries. Second, there is a commensurate reduction in mechanical stress placed on the postcranial skeleton as indicated by a reduction in frequency of degenerative articular joint changes. Both of these trends are most likely

TABLE 24
Frequency of Carious Lesions for All Tooth Categories

Lesion Size	Preagricultural %	Preagricultural N[a]	Agricultural %	Agricultural N[a]	Change of %[b]	Chi-square (p)
TOTAL SAMPLE						
Incipient	0.7	2429	2.7	4189	+2.0	.001
Medium	0.2	2429	2.4	4189	+2.2	.001
Gross	0.4	2429	6.1	4189	+5.7	.001
FEMALES						
Incipient	0.7	1016	4.0	1688	+3.3	.001
Medium	2.0	1016	2.9	1688	+0.9	.001
Gross	0.3	1016	8.8	1688	+8.5	.001
MALES						
Incipient	0.2	617	3.1	1295	+2.9	.001
Medium	0.2	617	2.5	1295	+2.3	.001
Gross	0.3	617	5.6	1295	+5.3	.001
PREADULT						
Incipient	0.2	465	1.7	996	+1.5	.05
Medium	0.4	465	0.7	996	+0.3	n.s.[c]
Gross	0.2	465	1.7	996	+1.5	.05

[a] Number of teeth observed for carious lesion size.

[b] Computed by the formula: % Agricultural − % Preagricultural.

[c] Not significant.

related to the change in lifeway from that of a hunting and gathering economy to that based at least in part on corn agriculture following A.D. 1150.

STATUS OF HEALTH: SKELETAL EVIDENCE

The increase in frequency of periosteal reactions among inhabitants of the Georgia coast can be explained in a number of ways. The differences in frequency of skeletal elements affected by periosteal reactions may be related to the age structure of the two groups. However, as pointed out previously, it is the preagricultural group that is represented by an older adult skeletal sample relative to the agricultural group. Therefore, the fact that the agricultural adults exhibit a greater frequency of periosteal reactions cannot be explained by differences in age structure between the preagricultural and agricultural skeletal samples.

Alternatively, the increase in the pathology may be related to the introduction of a new disease such as one or more treponema infections (e.g., syphilis, bejel, yaws) at the time of the adoption of a lifeway based, in part, on agricultural food production. However, nearly all the periosteal reactions occur on localized areas of single bones or skeletal elements of single limbs of affected individuals. Further, with the exception of the tibia, the increase in frequency of periosteal reactions is distributed in relative uniformity throughout the skeleton. For example, the statistically significant percentage increases for the adults (females, males, indeterminate sex combined) range from 2.7 percent in the humerus to 6.6 percent in the fibula. If a new disease were present in the agricultural group, the pattern of skeletal infections would appear as involving multiple bones or skeletal elements of limbs, particularly in paired situations of left and right elements (Steinbock, 1976).

Another possibility that could explain an increase in periosteal reactions would be an

TABLE 25
Frequency of Occlusal (O), Buccal-Labial (B), Interproximal (I), and Cervical (C) Carious Lesions for the Preagricultural and Agricultural Groups

	Preagricultural					Agricultural				
Tooth	N[a]	O	B	I	C	N[a]	O	B	I	C
MAXILLA										
I1	103	1.0	0.0	0.0	0.0	177	1.1	0.0	0.0	1.1
I2	95	0.0	0.0	0.0	0.0	178	1.7	0.0	0.0	1.1
C	126	0.0	0.0	0.0	0.0	241	2.0	0.0	0.4	3.7
P3	149	0.0	0.0	0.0	0.0	231	4.8	0.9	1.3	5.2
P4	149	0.0	0.0	0.0	0.0	242	1.7	0.0	0.8	4.1
M1	188	0.5	0.0	0.0	0.0	317	3.5	0.0	0.0	5.4
M2	193	2.6	0.0	0.0	1.0	303	4.6	0.7	0.0	3.6
M3	163	4.3	0.0	0.0	0.6	228	7.5	0.0	0.0	5.7
dI1	13	0.0	0.0	0.0	0.0	19	0.0	10.5	0.0	0.0
dI2	10	0.0	0.0	0.0	0.0	18	0.0	11.1	0.0	0.0
dC	18	0.0	0.0	0.0	0.0	28	0.0	0.0	0.0	0.0
dM1	26	0.0	0.0	0.0	0.0	47	12.8	0.0	0.0	4.3
dM2	20	0.0	0.0	0.0	0.0	49	4.1	2.0	0.0	2.0
MANDIBLE										
I1	64	0.0	0.0	0.0	0.0	164	0.0	0.0	0.0	0.0
I2	84	0.0	0.0	0.0	0.0	196	0.0	0.0	0.0	0.5
C	126	0.0	0.0	0.0	0.0	232	1.3	0.0	0.0	0.9
P3	136	0.0	0.0	0.0	0.0	276	0.0	1.1	2.2	1.5
P4	151	0.0	0.0	0.0	0.0	248	3.2	0.0	0.0	5.7
M1	174	0.6	0.0	0.0	0.0	315	8.6	4.4	0.0	7.0
M2	174	1.5	0.0	0.0	0.0	274	11.3	7.0	0.7	3.7
M3	173	2.9	0.0	0.0	0.0	244	13.9	4.5	0.8	1.2
dI1	7	0.0	0.0	0.0	0.0	9	0.0	0.0	0.0	0.0
dI2	11	0.0	0.0	0.0	0.0	15	0.0	0.0	0.0	0.0
dC	19	0.0	0.0	0.0	0.0	26	0.0	0.0	0.0	0.0
dM1	28	0.0	0.0	0.0	0.0	56	3.6	0.0	0.0	1.8
dM2	29	0.0	0.0	0.0	0.0	56	3.6	1.8	0.0	0.0
TOTAL	2429	1.1	0.1	0.0	0.1	4189	4.4	1.3	0.3	3.3

[a] Number of teeth observed for carious lesion location.

increase in frequency of fractures. As pointed out by Steinbock (1976), fractures are the major cause of direct infection of bone. However, the number of fractures in both the preagricultural and agricultural groups is minimal: only seven fractures are present in each group (table 40). Hence, fractures as a factor leading to a general increase in skeletal infections can be ruled out.

Because the skeletal lesions are restricted to localized areas of periosteal surfaces, most of the pathology can probably be attributed to localized soft tissue infections due to pus-producing organisms such as staphylococci or streptococci (Steinbock, 1976). The most likely explanation for the increase in the frequency of this pathological condition in the agricultural period can be traced to the probable shift in living conditions associated with the change in lifeway from a hunting-gathering, seasonally occupied, small village system to permanent villages with larger population size and density after A.D. 1150 (discussed in Chapter 1). Prior to the adoption of agriculture, the hunting-gathering Georgia coastal settlements

TABLE 26
Frequency of Carious Lesions for All Tooth Categories Combined

Lesion Location	Preagricultural		Agricultural		Change of %[b]	Chi-square (p)
	%	N[a]	%	N[a]		
TOTAL SAMPLE						
Occlusal	1.1	2429	4.4	4189	+3.3	.001
Buccal-labial	0.1	2429	1.3	4189	+1.2	.001
Interproximal	0.0	2429	0.3	4189	+0.3	.05
Cervical	0.1	2429	3.3	4189	+3.2	.001
FEMALES						
Occlusal	0.9	1016	6.3	1688	+5.4	.001
Buccal-labial	0.0	1016	1.1	1688	+1.1	.05
Interproximal	0.0	1016	0.3	1688	+0.3	.05
Cervical	0.3	1016	5.0	1688	+4.7	.001
MALES						
Occlusal	0.7	617	3.5	1295	+2.8	.001
Buccal-labial	0.0	617	0.6	1295	+0.6	.05
Interproximal	0.0	617	0.5	1295	+0.5	.05
Cervical	0.0	617	3.5	1295	+3.5	.001
PREADULTS						
Occlusal	0.4	465	1.9	996	+1.5	.05
Buccal-labial	0.4	465	1.9	996	+1.5	.05
Interproximal	0.0	465	0.0	996	0.0	n.s.
Cervical	0.0	465	0.5	996	+0.5	n.s.

[a] Number of teeth observed for carious lesion location.
[b] Computed by the formula: % Agricultural − % Preagricultural.
[c] Not significant.

were relatively small, isolated and transitory, thus restricting the transmission of infection. With the adoption of agriculture, however, villages became larger, more densely and more permanently occupied. The larger size and higher density of village populations associated with the agricultural lifeway represent important factors contributing to poor sanitary conditions, and thus providing the necessary habitat for the increase and continual presence of infectious disease.

Epidemiological analysis of disease in human populations indicates that increase in population size and density has resulted in the concomitant increase in infectious disease throughout the post-Pleistocene world (Haldane, 1932; Cockburn, 1963; Newman, 1975). For example, Livingstone (1958) suggested that the conditions whereby the Bantu spread in Africa seem to have been dependent on the adaptation of agriculture to the equatorial forests. This adaptation was made possible by the adoption of iron tools to replace stone tools, thus facilitating the clearing of these forests. Ultimately, the later adoption of root crops as opposed to grains produced higher and more nutritional yields. It seems that conditions that made it possible for humans to adapt to tropical forests also enhanced the multiplication of anopheline mosquitoes that spread the malarial parasite, *Plasmodium falciparum*. Once the forests were cut down, the soils rapidly lost the humus which absorbed water and the shade provided by the tropical overstory. This situation created ideal conditions for rain-fed pools, the primary areas of mosquito breeding. Moreover, human refuse within the cleared areas probably provided additional mosquito breeding grounds. In contrast to

TABLE 27

Frequency of Preagricultural Female and Male Carious Teeth

	Female		Male			
Tooth	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
MAXILLA						
I1	0.0	48	2.1	37	+2.1	n.s.[c]
I2	0.0	39	0.0	31	0.0	n.s.
C	0.0	52	0.0	35	0.0	n.s.
P3	0.0	60	0.0	39	0.0	n.s.
P4	0.0	61	0.0	38	0.0	n.s.
M1	0.0	73	0.0	46	0.0	n.s.
M2	0.0	77	0.0	47	0.0	n.s.
M3	0.0	73	0.0	40	0.0	n.s.
MANDIBLE						
I1	0.0	33	0.0	15	0.0	n.s.
I2	0.0	42	0.0	24	0.0	n.s.
C	0.0	60	0.0	42	0.0	n.s.
P3	0.0	65	0.0	43	0.0	n.s.
P4	0.0	76	0.0	41	0.0	n.s.
M1	1.3	79	2.1	47	+0.8	n.s.
M2	1.2	86	2.1	47	+0.9	n.s.
M3	1.1	92	2.1	45	+1.0	n.s.
TOTAL	1.2	1016	0.6	617	−0.6	n.s.

[a] Number of teeth observed for presence or absence of dental caries.

[b] Computed by the formula: % Male − % Female.

[c] Not significant.

this, the earlier peoples, hunter-gatherers, did not clear the forests and thus did not provide mosquito breeding grounds. Furthermore, their populations were dispersed, constantly moving, and low in density thus not promoting the disease conditions described above. Although malaria has no relevance to disease conditions in the prehistoric New World, the history of this particular disease serves to show the general importance and interrelationship of the disease host, pathogen, and population size and distribution in creating the optimal conditions necessary for the support of infectious disease in general.

This relationship has been strongly implicated for the prehistoric record as well. For example, Buikstra and Cook (1978) have analyzed a large series of human skeletal remains (n = 1357 individuals) spanning over 1000 years of prehistory (100 B.C.–A.D. 1300) in the Illinois River Valley and adjacent uplands extending to and including the east side of the Mississippi River Valley. In light of several biocultural factors—intensification of corn agriculture, regional increase in population density, and increase in interregional interaction and communication—Buikstra and Cook (1978) argue that the aggregation of human population in later prehistory provided a reservoir conducive to the development and maintenance of infectious disease. Indeed, in their study, these investigators show a marked increase in skeletal lesions that are suggestive of tuberculosis and/or blastomycosis. Similarly, Lallo, Armelagos and Rose (1978) have examined skeletal remains dating from A.D. 950 to A.D. 1300 from the Dickson Mounds site located near the confluence of the Illinois and Spoon rivers. On the basis of gross macroscopic examination of each burial (n = 572), it was shown that the frequency of infectious bone lesions doubled. These authors suggested that the increase in frequency of this gener-

TABLE 28
Frequency of Agricultural Female and Male Carious Teeth

	Female		Male			
Tooth	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
MAXILLA						
I1	3.7	82	0.0	63	−3.7	n.s.[c]
I2	6.0	66	1.7	58	−4.3	n.s.
C	17.0	100	4.9	82	−12.7	.05
P3	21.0	95	27.6	76	+6.6	n.s.
P4	14.4	111	13.4	82	−1.0	n.s.
M1	16.7	138	18.5	92	+1.8	n.s.
M2	18.3	126	13.5	89	−4.8	n.s.
M3	17.4	109	16.1	81	−1.3	n.s.
MANDIBLE						
I1	0.0	58	0.0	58	0.0	n.s.
I2	2.4	84	1.4	69	−1.0	n.s.
C	5.1	97	0.0	85	−5.0	n.s.
P3	8.1	123	3.2	93	−4.9	n.s.
P4	13.9	130	8.0	88	−5.9	n.s.
M1	26.8	127	22.4	98	−4.1	n.s.
M2	31.5	127	12.9	85	−18.6	.05
M3	26.1	115	22.9	96	−3.2	n.s.
TOTAL	15.6	1688	11.2	1295	−4.4	.001

[a] Number of teeth observed for presence or absence of dental caries.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

TABLE 29
Frequency of Carious Teeth by Lesion Size and Location—Preagricultural Group

Category	% Female (N = 1016)[a]	% Male (N = 617)[a]	Difference in %[b]	Chi-square (p)
SIZE				
Incipient	0.7	0.2	−0.5	n.s.[c]
Medium	2.0	0.2	−1.8	n.s.
Gross	0.3	0.3	0.0	n.s.
LOCATION				
Occlusal	0.9	0.7	−0.2	n.s.
Buccal-labial	0.0	0.0	0.0	n.s.
Interproximal	0.0	0.0	0.0	n.s.
Cervical	0.3	0.0	−0.3	n.s

[a] Number of teeth observed for carious lesion size and location.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

TABLE 30
Frequency of Carious Teeth by Lesion Size and Location—Agricultural Group

Category	% Female (N = 1688)[a]	% Male (N = 295)[a]	Difference in %[b]	Chi-square (p)
SIZE				
Incipient	4.0	3.1	−0.9	n.s.[c]
Medium	2.9	2.5	−0.4	n.s.
Gross	8.8	5.6	−3.2	.001
LOCATION				
Occlusal	6.3	3.5	−2.8	.001
Buccal-labial	1.1	0.6	−0.5	n.s.
Interproximal	0.3	0.5	+0.2	n.s.
Cervical	5.0	3.5	−1.5	.05

[a] Number of teeth observed for carious lesion size and location.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

TABLE 31
Frequency Comparison of the Preadult and Adult Teeth Affected by Dental Caries Within the Preagricultural and Agricultural Groups

	Preagricultural		Agricultural		Change of %[b]	Chi-square (p)
	%	N[a]	%	N[a]		
Preadult	0.9	465	3.9	996	+3.0	.005
Adult	1.4	1964	13.9	3193	+12.5	.001
% Difference[c]	0.05	—	10.0	—	—	—
Chi-square (p)	—	—	.001	—	—	—

[a] Number of teeth observed for presence or absence of dental caries.
[b] Computed by the formula: % Agricultural – % Preagricultural.
[c] Computed by the formula: % Adult – % Preadult.

alized condition can best be interpreted as a result of an increased reliance upon corn agriculture, an increase in population density and settlement, and an extension of trade networks and social contacts.

As pointed out in Chapter 1, there is a marked increase in size, number, and density of archaeological habitation sites on the Georgia coast which probably reflects an overall increase in population size and density that is associated with an increased utilization of plant domesticates following A.D. 1150. Therefore, it seems most likely that the increase in frequency of reactive bone reflects a general increase in infectious disease brought about by closer, more crowded living conditions. This increase in population, then, has acted to increase the frequency of potential disease hosts thus contributing to the efficiency of disease transmission commensurate with the shift in economic focus.

Status of Health: Dental Evidence

The increase in frequency and severity of dental caries can be explained in a number of ways. As with the increase in periosteal reactions, if the agricultural group had been shown to be representative of an older, longer surviving population than the preagricultural group, then the fact that the agricultural adults had more carious teeth might simply

TABLE 32
Frequency Comparison of Preagricultural and Agricultural Adult[a] Dental Regions Affected by Caries

	Preagricultural		Agricultural	
Dental Region	%	N[b]	%	N[b]
Anterior (I1–C)	0.2	598	3.2	1188
Posterior (P3–M3)	1.8	1650	15.9	2678
Chi-square (p)	.005	—	.001	—
Nonmolar (I1–P4)	0.1	1183	6.7	2185
Molar (M1–M3)	2.8	2248	18.8	1681
Chi-square (p)	.001	—	.001	—

[a] Female, Male, Indeterminate Sex combined.
[b] Number of teeth observed for presence or absence of dental caries.

TABLE 33
Frequency Comparison of Preagricultural and Agricultural Female Dental Regions Affected by Dental Caries

	Preagricultural		Agricultural	
Dental Region	%	N[a]	%	N[a]
Anterior (I1–C)	0.0	274	6.4	487
Posterior (P3–M3)	1.6	742	19.4	1201
Chi-square (p)	.05	—	.001	—
Nonmolar (I1–P4)	0.0	536	10.0	946
Molar (M1–M3)	2.5	480	22.8	742
Chi-square (p)	.01	—	.001	—

[a] Number of teeth observed for presence or absence of dental caries.

TABLE 34
Frequency Comparison of Preagricultural and Agricultural Male Dental Regions Affected by Dental Caries

	Pre-agricultural		Agricultural	
Dental Region	%	N[a]	%	N[a]
Anterior (I1–C)	0.5	184	1.5	415
Posterior (P3–M3)	0.7	433	15.8	880
Chi-square (p)	—	—	.001	—
Nonmolar (I1–P4)	0.3	345	6.1	794
Molar (M1–M3)	1.1	272	17.9	541
Chi-square (p)	—	—	.001	—

[a] Number of teeth observed for presence or absence of dental caries.

reflect longer life and consequently more time for individual oral environments to produce dental hard tissue cavitation. However, as demonstrated above, the preagricultural adults generally follow an older age profile than the agricultural adults. Therefore, an age-related interpretation of this pathology can be excluded.

Alternatively, the difference in frequency of carious teeth between the preagricultural group and the agricultural group might be related to the differences in the completeness of the respective dental samples. For instance, if the preagricultural dental sample is less complete than the agricultural dental sample, then the less complete preagricultural dental sample may be related to premortem tooth loss factors such as periodontal disease. The periodontal disease in turn might have been ultimately related to preagricultural dental caries. If this were true, then in reality the premortem loss of carious teeth could mask the actual frequency of dental caries in the preagricultural group.

Figure 11 illustrates the relative completeness of the adult dental sample by percentage of teeth present per tooth category relative to the number of observed individuals for the preagricultural and agricultural groups. For example, about 28 percent of the maxillary central incisors are represented in the 201 preagricultural group dentitions. For the same tooth, about 33 percent are represented in the 275 agricultural group dentitions. In general, the agricultural group is slightly better represented by frequency of teeth present per tooth category.

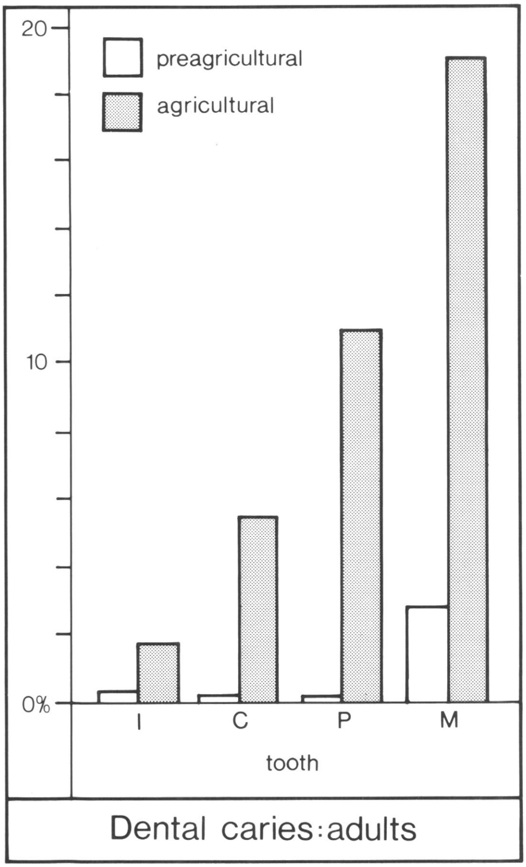


FIG. 7. Bar graph showing comparison of preagricultural and agricultural adult dental regions affected by dental caries.

It is doubtful, however, that the poorer representation of the preagricultural teeth is due to premortem factors. On the one hand, nearly all the carious lesions in the preagricultural group are very small occlusal lesions in unworn teeth. Most certainly, the disease occurrence in the preagricultural group did not contribute conditions favorable to premortem tooth loss. On the other hand, most of the disparity between the relative dental completeness of the two groups can be ex-

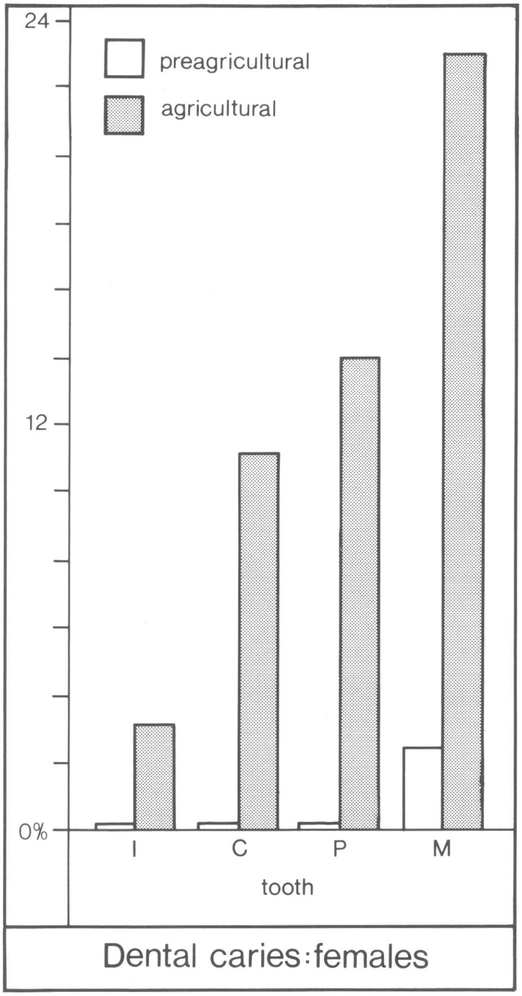


FIG. 8. Bar graph showing comparison of preagricultural and agricultural female dental regions affected by dental caries.

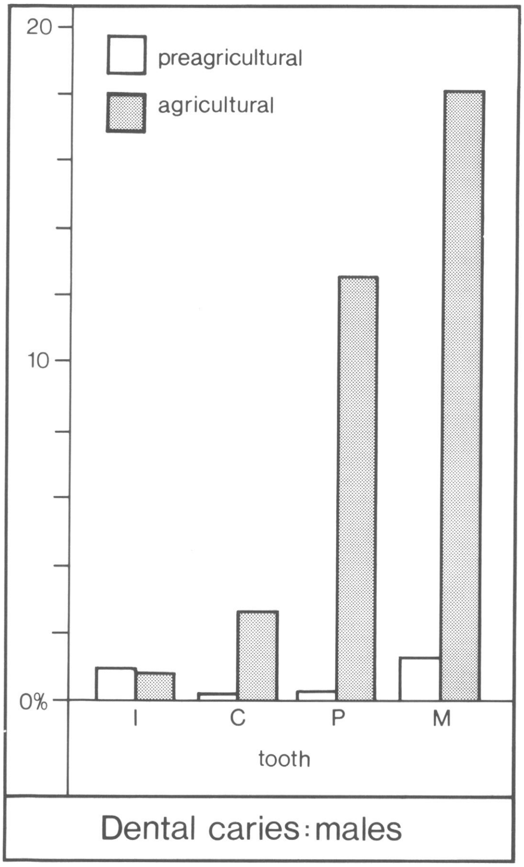


FIG. 9. Bar graph showing comparison of preagricultural and agricultural male dental regions affected by dental caries.

plained by one postmortem factor: archaeological preservation. Because all preagricultural teeth predate A.D. 1150, they had been exposed to the highly acidic Georgia coastal soils for a relatively longer period of time than the agricultural teeth. A number of the archaeological mortuary sites that were used in this study yielded dentitions in which only a few posterior teeth had remained preserved *in situ*. Furthermore, many of the preserved teeth consisted only of tooth enamel. In some instances, the excavators were unable to remove the tooth crowns intact since the enamel fragmented on contact (cf. Thomas and Larsen, 1979). Thus, the disparity in the dental completeness of the preagricultural and agricultural groups does not account for the increase in frequency of dental caries.

The single most likely explanation for the significant increase in dental caries on the prehistoric Georgia coast is related to the nature of the food staple forming the economic basis of the agricultural lifeway: corn. The progressive dependence on this dietary carbohydrate most likely promoted the growth of odontolytic organisms in the dental plaque of the agricultural group. Corn has a high sucrose component and it has been

TABLE 35

Frequency of Preagricultural and Agricultural Adult (Females, Males, Indeterminate Sex Combined) Articular Joints Affected by Degenerative Joint Disease

	Preagricultural		Agricultural			
Joint	%	N[a]	%	N[a]	Change of %[b]	Chi-square (p)
Cervical	26.4	53	5.3	132	−21.1	n.s.[c]
Thoracic	8.0	50	5.3	131	−2.7	n.s.
Lumbar	44.4	45	17.8	118	−26.6	.001
Sacrum	2.7	40	3.4	87	+0.7	n.s.
Shoulder	4.0	149	1.0	289	−3.0	n.s.
Elbow	9.1	176	2.3	307	−6.8	.001
Wrist	4.9	142	0.4	266	−4.5	.05
Hand	0.0	82	1.2	245	+1.2	n.s.
Hip	4.1	169	0.3	290	−3.8	.005
Knee	13.7	183	6.5	291	−7.2	.01
Ankle	4.4	158	0.4	285	−4.0	.005
Foot	0.0	81	0.4	232	+0.4	n.s.

[a] Number of articular joints observed for presence or absence of degenerative joint disease.

[b] Computed by the formula: % Agricultural − % Preagricultural.

[c] Not significant.

shown that low protein and high sucrose diets predispose teeth to the growth of cariogenic organisms (Rowe, 1975). This suggests that there may have been a decreased reliance on animal protein sources with the progressive increase in utilization of corn as a dietary staple. This most certainly would have created an ideal situation for the increase in cariogenesis. At any rate, the increase in ingested corn probably led to the

TABLE 36

Frequency of Preagricultural and Agricultural Female Articular Joints Affected by Degenerative Joint Disease

	Preagricultural		Agricultural			
Joint	%	N[a]	%	N[a]	Change of %[b]	Chi-square (p)
Cervical	17.2	29	1.4	73	−15.8	.005
Thoracic	6.7	30	1.4	72	−5.3	n.s.[c]
Lumbar	32.1	28	12.5	64	−19.6	.005
Sacrum	4.3	23	6.4	47	+2.1	n.s.
Shoulder	2.4	83	0.7	144	−1.7	n.s.
Elbow	9.6	94	0.0	167	−9.6	.001
Wrist	2.6	77	0.0	140	−2.6	n.s.
Hand	0.0	50	0.8	129	+0.8	n.s.
Hip	4.3	93	0.0	148	−4.3	.05
Knee	15.0	94	3.4	147	−11.6	.005
Ankle	4.5	88	0.0	139	−4.5	.05
Foot	0.0	48	0.0	120	0.0	n.s.

[a] Number of articular joints observed for presence or absence of degenerative joint disease.

[b] Computed by the formula: % Agricultural − % Preagricultural.

[c] Not significant.

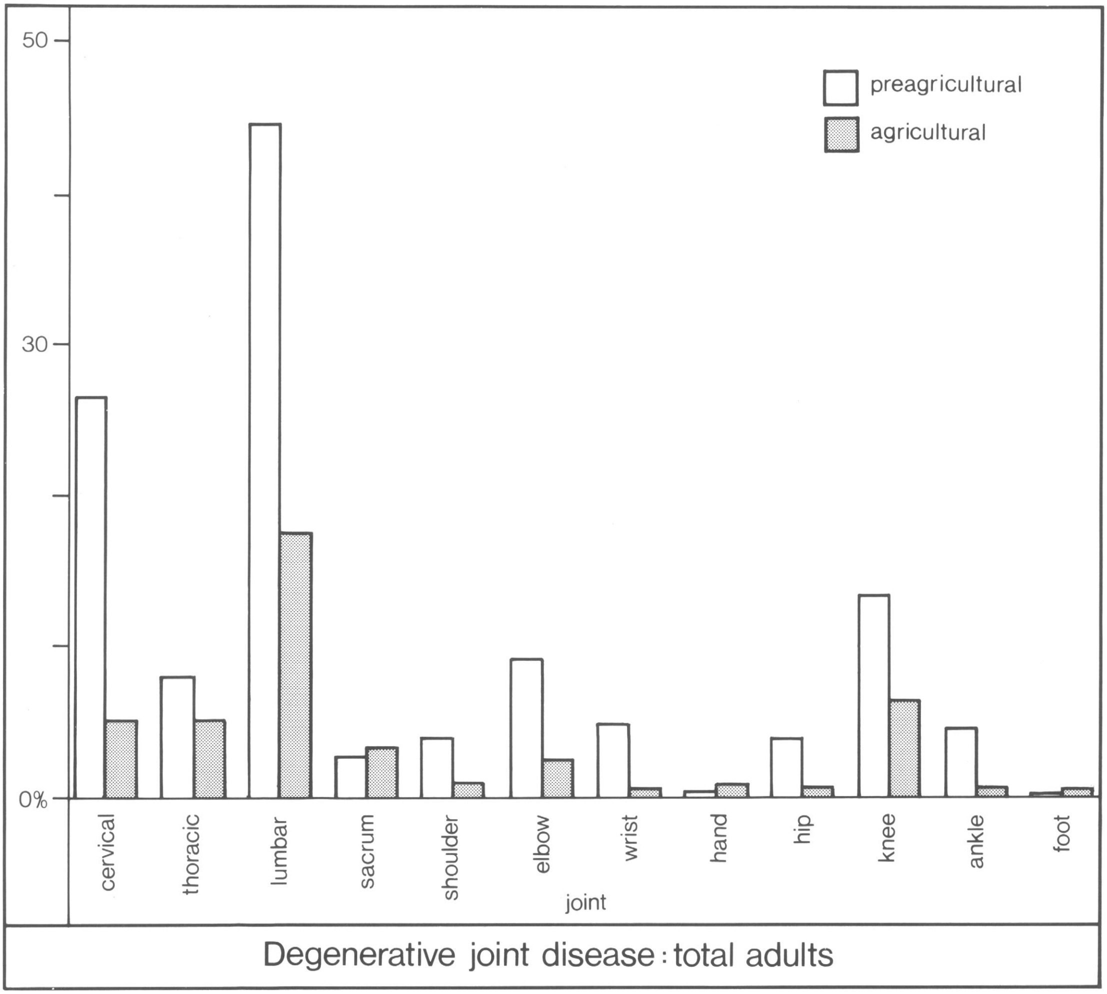


FIG. 10. Bar graph showing comparison of preagricultural and agricultural adult articular joints affected by degenerative joint disease.

increased frequency and severity of the disease following the adoption of a subsistence regime based at least in part on corn agriculture.

This argument is further supported by a recent survey of the averages of carious adult teeth reported by various workers (summarized in Turner, 1979). In this survey, Turner found that in hunting and gathering economies, an average of 1.3 percent of all teeth were carious, while mixed (agriculture plus hunting, gathering, or fishing) and agricultural economies had averages of 4.4 percent and 8.6 percent carious teeth, respectively. Assuming that the sources summarized by Turner (1979: see especially table 3) are representative and their respective inter-observer errors are minimal, then the 0.9 percent adult (female sample plus male sample) carious teeth for the Georgia coastal preagricultural group and the 13.7 percent adult (female sample plus male sample) carious teeth for the agricultural group are indeed in complete accordance with the eco-

TABLE 37
Frequency of Preagricultural and Agricultural Male Articular Joints Affected by Degenerative Joint Disease

	Preagricultural		Agricultural			
Joint	%	N[a]	%	N[a]	Change of %[b]	Chi-square (p)
Cervical	40.0	20	11.3	53	−28.7	n.s.[c]
Thoracic	12.5	16	11.8	51	−0.7	n.s.
Lumbar	69.2	13	27.7	47	−41.5	.01
Sacrum	0.0	10	0.0	33	0.0	n.s.
Shoulder	10.5	38	1.7	120	−8.8	.05
Elbow	13.7	51	6.1	114	−7.6	n.s.
Wrist	2.6	39	0.9	106	−1.7	.05
Hand	0.0	28	2.0	100	+2.0	n.s.
Hip	0.0	51	9.1	110	+9.1	n.s.
Knee	18.6	59	12.6	111	−6.0	n.s.
Ankle	4.1	49	9.2	109	+5.1	n.s.
Foot	0.0	26	1.1	93	+1.1	n.s.

[a] Number of articular joints observed for presence or absence of degenerative joint disease.
[b] Computed by the formula: % Agricultural − % Preagricultural.
[c] Not significant.

nomic reconstruction presented for the prehistoric Georgia coast in Chapter 1. Following from Turner's work, if the pre-Savannah period (pre-A.D. 1150) economic regime were to be reconstructed on the basis of frequency of carious teeth alone, then an economic subsistence strategy based solely on hunting and gathering would seem to be in keeping with the caries data reported in this monograph. Likewise, if the later post-A.D. 1150 prehistoric Georgia coastal economy were to be reconstructed on the basis of fre-

TABLE 38
Frequency of Preagricultural Female and Male Articular Joints Affected by Degenerative Joint Disease

	Female		Male			
Joint	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
Cervical	17.2	29	40.0	20	+22.8	n.s.[c]
Thoracic	6.7	30	12.5	16	+5.8	n.s.
Lumbar	32.1	28	69.2	13	+37.1	.01
Sacrum	4.3	23	0.0	10	−4.3	n.s.
Shoulder	2.4	83	10.5	38	+8.1	.05
Elbow	9.6	94	13.7	51	+4.1	n.s.
Wrist	2.6	77	2.6	39	0.0	n.s.
Hand	0.0	50	0.0	28	0.0	n.s.
Hip	4.3	93	0.0	51	−4.0	n.s.
Knee	15.0	94	18.6	59	+3.6	n.s.
Ankle	4.5	88	4.1	49	−0.4	n.s.
Foot	0.0	48	0.0	26	0.0	n.s.

[a] Number of articular joints observed for presence or absence of degenerative joint disease.
[b] Computed by the formula: % Male − % Female.
[c] Not significant.

TABLE 39

Frequency of Agricultural Female and Male Articular Joints Affected by Degenerative Joint Disease

	Female		Male			
Joint	%	N[a]	%	N[a]	Difference in %[b]	Chi-square (p)
Cervical	1.4	73	11.3	53	+9.9	.05
Thoracic	1.4	72	11.8	51	+10.4	.05
Lumbar	12.5	64	27.7	47	+15.2	.05
Sacrum	6.4	47	0.0	33	−6.4	n.s.
Shoulder	0.7	144	1.7	120	+1.0	n.s.
Elbow	0.0	167	6.1	114	+6.1	.005
Wrist	0.0	140	0.9	106	+0.9	n.s.
Hand	0.8	129	2.0	100	+1.2	n.s.
Hip	0.0	148	9.1	110	+9.1	n.s.
Knee	3.4	147	12.6	111	+9.2	.01
Ankle	0.0	139	9.2	109	+9.2	n.s.
Foot	0.0	120	1.1	93	+1.1	n.s.

[a] Number of articular joints observed for presence or absence of degenerative joint disease.

[b] Computed by the formula: % Male − % Female.

[c] Not significant.

quency of carious teeth alone, then a mode of subsistence based only on agricultural resources would seem likely. Indeed, the frequency of adult carious teeth in the Georgia coastal agricultural group exceeds all sample frequencies representative of "mixed" economies reported by Turner (1979). The archaeological and ethnohistoric evidence, however, demonstrates that hunting, gathering, and fishing provided important supplementary food items to agriculture in the Savannah-Irene economic regime on the Georgia coast.

The above analysis of the dental caries data hints at a disparity in percentage of agricultural female and male teeth affected by dental caries. Specifically, the agricultural females appear to be more affected by cariogenesis than the agricultural males. This difference may represent a disproportionate amount of ingested dietary carbohydrates between the agricultural females and males.

The ethnohistoric accounts of the Georgia coastal Amerindians, the Guale, and the southeastern Amerindians in general, indicate that there was a strict sexual division of most activities including those associated with subsistence. Females appear to have been primarily responsible for most of the plant gathering and agricultural activities including planting, harvesting, and food preparation. Males, on the other hand, were responsible for all hunting activities (Swanton, 1942, 1946; Hudson, 1976).

If one can generalize from the example of the !Kung San where the males, who are also responsible for hunting, differentially consume more animal protein acquired while on the hunt (Lee, 1968), then the difference in subsistence-related sex roles might provide a basis for explaining the disparity in agricultural female-male frequencies of dental caries on the prehistoric Georgia coast. If the Georgia coastal agricultural males were receiving more protein and less carbohydrates than the females, then those individuals ingesting more corn, the females, may have developed more carious teeth as a group than the males due to the cariogenic nature of dietary carbohydrates, especially sugar from corn.

MECHANICAL STRESS

Unlike periosteal reactions and dental caries, the third pathology observed, degenerative joint disease, markedly decreased in frequency in the agricultural group relative to the preagricultural group. Because degenerative joint disease is an age-progressive, functionally degradative process, the decrease in frequency of joints affected by degenerative change could simply reflect the disparity in age distributions of the preagricultural group and agricultural group. Indeed, the preagricultural group is represented by an older skeletal sample of adults than the agricultural group (see above). It seems plausible, then, that the disparity in age distributions could account for the difference in frequency of degenerative joint disease between the preagricultural and agricultural groups. However, statistical treatment (Kolmogorov-Smirnov and chi-square) of the age distributions of individuals affected by degenerative joint disease showed no significant differences between the preagricultural and agricultural groups at the $p = 0.05$ level. Therefore, the factor of age differences between the two groups does not explain the disparity in relative frequency of degenerative joint disease despite the fact that the preagricultural sample is representative of an older skeletal series than the agricultural sample.

The most probable explanation for the decrease in frequency of degenerative joint disease in the agricultural group can be related to the nature of the disease itself. Although degenerative joint disease is complex and influenced by both systemic and mechanical factors (cf. Jurmain, 1977a, 1977b, 1978, 1980), the differences between human populations can be best interpreted in light of mechanical stress associated with lifeway (cf. Stewart, 1979, pp. 175–178).

Assuming that level of mechanical stress is associated with level of difficulty of lifeway, and that the latter in turn can be measured by amount of time devoted to the food quest (cf. Lee, 1968, 1969, 1979), then a lifeway that is solely dependent on hunting and gathering can be seen as more demanding than one in which plant domesticates constitute an important component of diet. Ethnographic evidence suggests that groups dependent on hunting and gathering as the primary means of subsistence devote most of their time to food procurement or related activity. Although discussions in the literature relating to time spent on the food quest are rare, a number of cases are noteworthy. For example, among Australian aborigines, both sexes are fully involved in subsistence procurement with hunting done predominantly by males and plant gathering by females (Yengoyan, 1968). Observation of the Pitjantjatjara-speaking peoples and the Ngatatjara Australian aborigines in particular has revealed that the better part of the work day is devoted to subsistence (Gould, 1977, 1980; see also Meggitt, 1957, 1962). On the one hand, females spend the greater part of the day either collecting or preparing edible plants; and the males devote much of their time to hunting. Similarly, most Eskimo groups devote the better part of the work day to subsistence activity. Depending upon the season, the Netsilik, Copper, and Iglulik Eskimos spend the day either hunting seals or caribou or fishing (Balikci, 1968, 1971; Damas, 1968; and others). Finally, the Campa, a group occupying the eastern foothills of the central Andes, often spend two or three days or even several weeks of continuous work on a single hunting foray; the time and en-

TABLE 40
Preagricultural and Agricultural Fractures

Site-Burial	Skeletal Element Affected
PREAGRICULTURAL	
Airport-2	Midshaft l. ulna
Deptford-15A	Distal r. ulna
Deptford-15B	Distal l. radius
Deptford-17	Distal l. radius
Deptford-24	Distal r. radius
Sea Island Mound-16	Distal l. radius
Johns Mound-37	Midshaft r. fibula
AGRICULTURAL	
Irene Mound-23	Midshaft fibula
Irene Mound-154A	Midshaft l. clavicle
Irene Mound-161	Distal ulna
Irene Mound-164	Midshaft l. radius
Irene Mound-181	Midshaft l. clavicle
Irene Mound-206B	Midshaft r. clavicle
Irene Mound-209	Midshaft l. tibia[a]

[a] Associated with periosteal reaction.

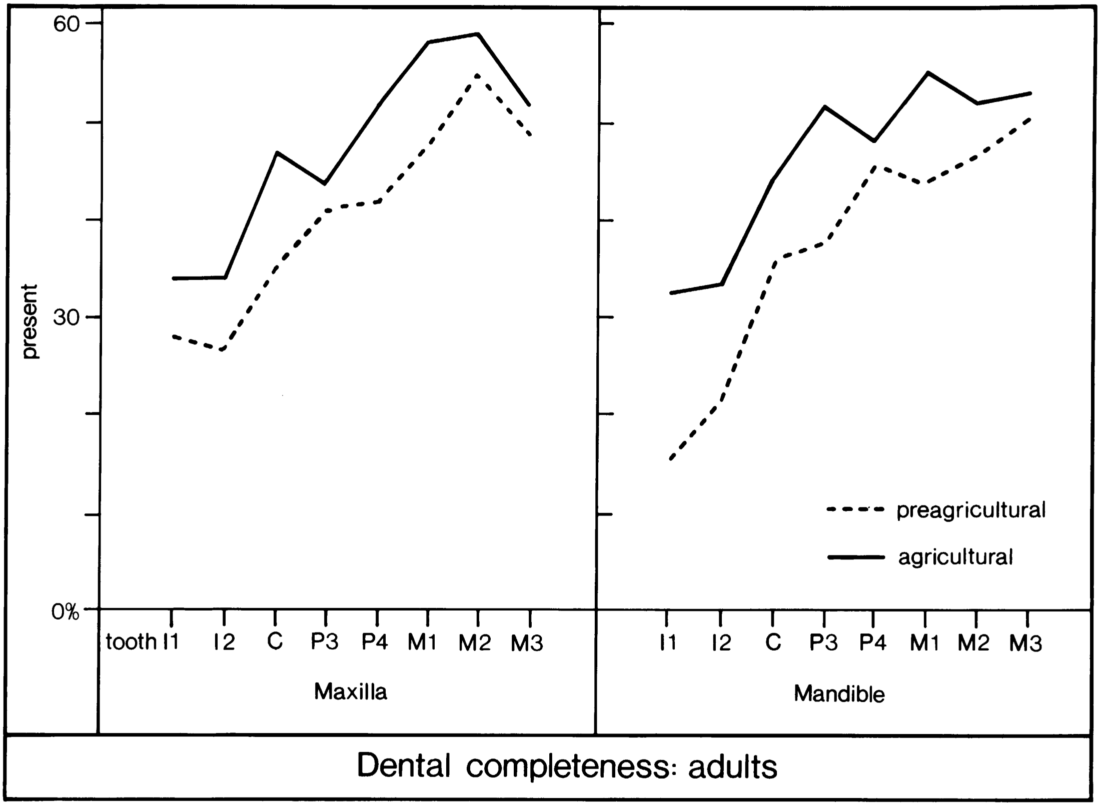


FIG. 11. Line graph showing relative completeness of preagricultural and agricultural dentitions as measured by percent of teeth present per tooth category.

ergy is expended not only in the hunt but in the subsequent trip back to the base-camp as well (Deneven, 1971). In all of these cases, the authors stated outright or strongly implied that time devoted to the food quest was continuous, unrelenting, and consequently demanding, both in terms of time and expenditure of energy.

In contrast to the above hunter-gatherers, human groups that employ agriculture as a major means of subsistence appear to devote relatively less time, and hence less work, to the acquisition of food. For example, the Kuikuru, a central Brazilian group that grows both corn and manioc, spend about three and a half hours per day on subsistence (two hours on care of crops; one and a half hours on fishing) and the remaining 10 to 12 hours of the day on some form of informal recreation and loafing (Carneiro, 1961). With regard to the eastern Timbira, another agriculturalist South American tropical forest group, Nimuendajú (1946) indicated that although a great deal of energy might be expended in felling trees and planting crops, little additional attention is paid to subsistence. Furthermore, like the Kuikuru, the Timbira lifeway is characterized as one involving a great deal of leisure time.

I suggest that differences in time devoted to subsistence-related work in fact reflect differences in degree of mechanical-functional demand to which the body is subjected. That is, those human groups spending more of their daily lives in work are subjected to relatively greater degrees of mechanical stress. This is *not* to say that hunters and gatherers have difficult lifeways, and agriculturalists have easy lifeways. One simply cannot categorize hunter-gatherer and agriculturalist human groups as two totally distinct lifeways. The hunter-gatherer !Kung San of the Kalahari Desert, for example, appear to have relatively greater amounts of leisure time than do many other hunting-gathering groups (Lee, 1968, 1979). A large number of variables involved in controlling level of activity are undoubtedly related to the overall characterization of their respective lifeways. However, the above cases serve to show that time devoted to the food quest, and hence, relative difficulty of lifeway, have some relation to mode of subsistence.

Most certainly, the data from the prehistoric Georgia coast suggest that there is in fact a decrease in degree of functional demand on the body resulting in less stress-related pathology. Controlling for age, there is a marked decrease in degenerative joint disease in the agricultural group. In conclusion, it appears that the later subsistence economy on the prehistoric Georgia coast represents a less mechanically stressful lifeway than the earlier hunting and gathering adaptation.

SUMMARY

The comparisons of the preagricultural and agricultural frequencies of periosteal reactions and dental caries are suggestive of a general decline in health with the adoption of an economy based at least in part on agricultural food production on the prehistoric Georgia coast. Evidence for this decline in health comes from an increase in frequency of periosteal reactive bone and dental caries which are respectively related health problems associated with an increase in population size and carbohydrate consumption accompanying the adoption of corn agriculture.

The preagricultural and agricultural frequency comparisons of degenerative joint disease suggest a reduction in functional stress with the shift to a more sedentary agricultural lifeway. The pathology evidence for this is a marked reduction in frequency of lesions that are related to mechanical stress at the weight-bearing and other articular joints in the agricultural group relative to the preagricultural group. Males of both the preagricultural and agricultural groups reflect male hunting responsibilities in that they exhibit more stress-related degenerative joint changes than do the females in either of the groups.

CHAPTER 5. SKELETAL AND DENTAL SIZE TRENDS

The results of a number of calculations summarizing postcranial dimensions and indices, stature, and cranial and dental dimensions are included in this chapter. Mean percentage differences were calculated to show relative change between the preagricultural and agricultural groups. In dimensions where the preagricultural mean is greater than the agricultural mean, the percentage change is expressed as:

$$-(1 - \bar{X}_A/\bar{X}_P)(100)$$

where A = the agricultural group, and
P = the preagricultural group.

If the preagricultural mean is less than the agricultural mean, the percentage change is expressed as:

$$+(1 - \bar{X}_P/\bar{X}_A)(100)$$

where P = the preagricultural group, and
A = the agricultural group.

Likewise, percent sexual dimorphism in mean postcranial, cranial, and dental dimensions, as well as stature in both the preagricultural and agricultural groups were calculated. This was done by use of the following formula:

$$+(1 - \bar{X}_F/\bar{X}_M)(100)$$

where F = the females, and
M = the males.

For the few instances in which the female mean exceeds the male mean, percent sexual dimorphism was calculated by use of the following formula:

$$-(1 - \bar{X}_M/\bar{X}_F)(100)$$

where F = the females, and
M = the males.

In order that level of significance be estimated, the test statistic utilized for all measurement comparisons is Student's *t*. Because the sample sizes for all variables are not large (not exceeding 100), the results are considered significant if the probability occurring by chance alone is $p \leq 0.05$ (cf. Thomas, 1976). This significance level is widely accepted as a meaningful rejection value (Simpson, Roe and Lewontin, 1960). The test used was that provided in SPSS (Statistical Package for the Social Sciences, Nie et al., 1975).

POSTCRANIAL SIZE

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

Tables 41 and 42 include the preagricultural-agricultural mean dimension comparisons for the femur, tibia, fibula, clavicle, ulna, radius, and humerus as well as the percentage changes and significance levels for females and males, respectively. This treatment of the data reveals that the earlier preagricultural group is characterized by larger postcranial size than the agricultural group.

The difference between preagricultural and agricultural females is significant for nearly all measures of postcranial size. There are no significant differences for only three of the 27 female postcranial dimensions: horizontal diameter of the femur neck, minimum diameter of the radius interosseous crest, and minimum diameter of the humerus midshaft. However, in the males, fewer of the postcranial dimensions show statistically significant changes than the females. Eleven of the 27 male postcranial dimensions show significant reduction in size. In addition, nearly all dimension reductions are greater in the females than in the males.

To summarize these data, in the females, the average of the percentage changes for each skeletal element shows the following reductions: femur, 5.9 percent; tibia, 6.3 percent; fibula, 11.8 percent; clavicle, 4.3 percent; ulna, 3.5 percent; radius, 4.6 percent; and humerus, 4.5 percent. In the males, the average percentage changes for each skeletal element show the following reductions: femur, 3.4 percent; tibia, 4.8 percent; fibula, 6.1 percent; calvicle, 0.7 percent; ulna, 1.5 percent; radius, 1.2 percent; and humerus, 4.3 percent.

TABLE 41

Comparison of Female Preagricultural and Agricultural Postcranial Dimensions (in Millimeters)

Variable	Preagricultural			Agricultural			%	t
	Mean	N	S.D.	Mean	N	S.D.	Change[a]	(p)
Femur								
Head diameter	41.1	31	2.41	39.0	61	1.98	−4.9	.001
Neck vertical diameter	27.2	29	1.82	25.8	64	2.79	−5.3	.05
Neck horizontal diameter	22.7	31	1.63	22.0	64	1.92	−3.0	n.s.[b]
Maximum length	434	19	24.30	416	54	19.25	−4.2	.01
Midshaft anterior-posterior	26.7	44	2.03	25.2	86	2.29	−5.8	.001
Midshaft transverse diameter	24.3	44	1.61	23.1	86	1.61	−5.9	.001
Midshaft circumference	80	44	4.70	76	86	5.44	−5.0	.001
Subtrochanteric anterior-posterior	23.9	47	1.89	21.9	91	1.62	−8.3	.001
Subtrochanteric transverse diameter	31.7	45	2.20	29.3	92	2.46	−7.4	.001
Bicondylar breadth	74.3	4	4.60	67.3	16	3.17	−9.4	.01
Tibia								
Maximum length	367	14	27.14	347	50	18.79	−5.5	.01
Midshaft anterior-posterior	28.4	52	1.59	26.6	72	2.20	−6.2	.001
Midshaft transverse diameter	19.5	33	1.71	18.1	73	1.75	−7.0	.001
Midshaft circumference	77	33	4.52	72	71	5.73	−6.5	.001
Fibula								
Maximum length	374	3	28.49	330	18	14.03	−11.8	.001
Clavicle								
Maximum length	141	12	8.84	135	39	6.49	−4.3	.01
Ulna								
Maximum length	256	15	17.59	247	33	13.11	−3.5	.05
Radius								
Maximum length	234	17	16.22	226	43	11.86	−3.4	.05
Head diameter	20.3	11	1.27	19.1	30	1.29	−5.8	.05
Interosseous crest maximum	15.0	27	1.53	14.2	61	1.29	−5.3	.05
Interosseous crest minimum	10.0	27	0.84	9.6	61	1.47	−3.8	n.s.
Humerus								
Maximum length	306	25	18.37	293	52	14.63	−4.3	.01
Midshaft maximum diameter	20.8	37	1.86	19.9	78	1.63	−4.3	.05
Midshaft minimum diameter	14.7	38	1.84	14.3	77	1.14	−2.3	n.s.
Midshaft circumference	60	37	5.91	57	77	5.10	−5.0	.01
Head diameter	40.1	13	1.66	37.9	42	1.88	−5.6	.001
Biepicondylar breadth	55.5	14	2.04	52.5	50	2.91	−5.3	.001

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

Female-Male Comparisons

Table 43 shows the percent sexual dimorphism within the preagricultural and agricultural groups. For the most part, percent sexual dimorphism is consistently greater in the agricultural group than in the preagricultural group. Twenty-four of the 27 postcranial dimensions show greater percent sexual dimorphism than the preagricultural group. In addition, 22 of the preagricultural dimen-

TABLE 42
Comparison of Male Preagricultural and Agricultural Postcranial Dimensions (in Millimeters)

	Preagricultural			Agricultural				
Variable	Mean	N	S.D.	Mean	N	S.D.	% Change[a]	t (p)
FEMUR								
Head diameter	45.5	14	2.31	43.8	58	2.58	−3.8	.05
Neck vertical diameter	30.7	12	2.71	29.7	60	2.31	−3.4	n.s.[b]
Neck horizontal diameter	25.9	13	2.71	25.0	58	2.26	−3.3	n.s.
Maximum length	449	9	23.80	448	47	20.90	−0.2	n.s.
Midshaft anterior-posterior	31.1	21	3.06	29.5	68	2.65	−5.0	.05
Midshaft transverse diameter	26.4	20	1.68	25.7	68	1.69	−2.4	n.s.
Midshaft circumference	90	21	6.12	86	68	6.02	−4.4	.05
Subtrochanteric anterior-posterior	25.4	19	2.47	25.1	70	2.14	−0.9	n.s.
Subtrochanteric transverse diameter	34.5	19	2.45	32.5	69	1.91	−5.6	.001
Bicondylar breadth	80.5	2	0.14	76.3	16	3.71	−5.2	n.s.
TIBIA								
Maximum length	396	10	30.40	376	39	21.87	−5.0	.05
Midshaft anterior-posterior	32.8	21	2.31	31.7	59	3.04	−3.2	n.s.
Midshaft transverse diameter	22.2	21	1.62	20.7	59	2.04	−6.5	.01
Midshaft circumference	88	21	6.00	84	57	6.58	−4.6	.05
FIBULA								
Maximum length	378	5	32.43	355	19	19.18	−6.1	.05
CLAVICLE								
Maximum length	146	7	8.72	147	28	7.94	+0.7	n.s.
ULNA								
Maximum length	272	8	13.53	276	27	12.44	+1.5	n.s.
RADIUS								
Maximum length	255	11	15.60	252	30	12.60	−1.2	n.s.
Head diameter	22.4	9	0.92	21.8	22	1.40	−2.8	n.s.
Interosseous crest maximum	16.2	20	1.60	16.1	49	2.00	−0.8	n.s.
Interosseous crest minimum	11.0	20	1.04	11.0	49	0.87	0.0	n.s.
HUMERUS								
Maximum length	324	14	17.50	317	42	12.35	−2.2	n.s.
Midshaft maximum diameter	23.2	24	2.42	22.4	59	1.56	−3.6	n.s.
Midshaft minimum diameter	17.5	24	2.62	16.4	58	1.29	−6.2	.05
Midshaft circumference	68	24	7.56	65	57	4.07	−4.4	.05
Head diameter	46.2	11	5.52	42.7	31	2.50	−7.6	.01
Biepicondylar breadth	60.0	16	2.82	58.9	42	3.45	−1.8	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

sions are statistically significant in dimorphism, whereas all 27 agricultural dimensions are significantly dimorphic (table 43).

These data, coupled with the greater number of significant postcranial dimension reductions in the females, indicate that although postcranial size reduction occurs for the adult populations as a whole, the reductions are greater in the females than in the males. That is, there is an increase in percentage of sexual dimorphism in the agricultural group relative to the preagricultural group for most measures of postcranial size.

POSTCRANIAL INDICES

COMPARISONS

Univariate statistical treatment of the postcranial index data implies some reduction in skeletal robusticity in the agricultural group relative to the preagricultural group (tables 44 and 45). This is not surprising given the overall reduction in postcranial size. In the females, one skeletal index of the seven analyzed—femoral robusticity—shows significant reduction (3.2%) (table 44). Since this index is a measure of the relationship of the femoral midshaft circumference to femoral maximum length, it is important to understand the change in both dimensions relative to each other. The female mean midshaft circumference reduces from 80 to 76 mm. (5.0% reduction), whereas the mean maximum length reduces from 434 to 416 mm. (4.2% reduction). In short, the reduction in the index of femoral robusticity represents a result of lesser reduction in the maximum femoral length than in the femoral midshaft circumference.

In the males, one skeletal index—platymeric—is significantly lower in the preagricultural group than in the agricultural group, indicating that the preagricultural subtrochanteric area is more anteroposteriorly flattened than the agricultural subtrochanteric area (table 45). This male index increases 4.8 percent in the agricultural group relative to the preagricultural group. The increase noted for the agricultural males appears to be the result of the relatively greater decrease in the mean subtrochanteric transverse diameter (5.6%) compared to the mean subtrochanteric antero-posterior diameter (0.9%).

STATURE

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

Similar statistical treatment of preagricultural and agricultural stature shows significant size reduction in the agricultural group (table 46). Since stature is calculated from the lengths of the femur and tibia, and given the significant preagricultural-agricultural reductions of these measurements, this finding is to be expected. However, following the pattern of postcranial reduction in general, stature reduction for the females is greater than observed for the males. In the females, the range of stature reduction is 2.7 percent (right femur) to 3.4 percent (left tibia), whereas in the males, the reduction ranges from 0.2 percent (left femur) to 2.3 percent (left tibia). Additionally, all four stature estimates based on the lengths of the left femur, right femur, left tibia, and right tibia, show statistically significant reductions for the females. In the males, significant stature reduction occurs for only one of the stature estimates, that based on the left tibia. Although the other male estimates of stature based on the left femur, right femur, and right tibia decrease, the changes are not significant. In sum, the average of the four female estimates of stature reduction is 3.0 percent and the average for the males is 1.1 percent.

FEMALE-MALE COMPARISONS

In comparison of stature of the preagricultural females and males and the agricultural females and males, a pattern of increase in percent sexual dimorphism is revealed (table 47). That is, the percentage differences between the females and males are consistently greater in the agricultural group than in the preagricultural group. In the preagricultural group, the percentage of sexual dimorphism based on the four estimates of stature ranges from 3.4 percent (left femur) to 4.9 percent (right femur); whereas in the agricultural group, the values range from 5.6 percent (left tibia) to 6.4 percent (right femur). In the preagricultural group, the average of the percent sexual dimorphism based on stature is 4.1 percent; and in the agricultural group, the average is 6.2 percent.

TABLE 43
Preagricultural and Agricultural Postcranial Percent Sexual Dimorphism (in Millimeters)

Variable	Preagricultural			Agricultural		
	Female Mean	Male Mean	% Sex.[a] Dimorphism	Female Mean	Male Mean	% Sex.[a] Dimorphism
Femur						
Head diameter	41.1	45.5	+9.7*	39.0	43.8	+11.0*
Neck vertical diameter	27.2	30.7	+11.4*	25.8	29.7	+13.1*
Neck horizontal diameter	22.7	25.9	+12.4*	22.0	25.0	+12.0*
Maximum length	434	449	+3.3	416	448	+7.1*
Midshaft anterior-posterior	26.7	31.1	+14.2*	25.2	29.5	+14.6*
Midshaft transverse diameter	24.3	26.4	+8.0*	23.1	25.7	+10.1*
Midshaft circumference	80	90	+11.1*	76	86	+11.6*
Subtrochanteric anterior-posterior	23.9	25.4	+5.9*	21.9	25.1	+12.8*
Subtrochanteric transverse diameter	31.7	34.5	+8.1*	29.3	32.5	+9.9*
Bicondylar breadth	74.3	80.5	+7.7	67.3	76.3	+11.8*
Tibia						
Maximum length	367	396	+7.3*	347	376	+7.7*
Midshaft anterior-posterior	28.4	32.8	+13.4*	26.6	31.7	+16.1*
Midshaft transverse diameter	19.5	22.2	+12.2*	18.1	20.7	+12.6*
Midshaft circumference	77	88	+12.5*	72	84	+14.3*
Fibula						
Maximum length	374	378	+1.1	330	335	+7.0*
Clavicle						
Maximum length	141	146	+3.4	135	147	+8.2*
Ulna						
Maximum length	258	272	+5.2	247	276	+10.5*
Radius						
Maximum length	234	255	+8.2*	226	252	+10.3*
Head diameter	20.3	22.4	+9.4*	19.1	21.8	+12.4*
Interosseous crest maximum	15.0	16.2	+7.4	14.2	16.1	+11.8*
Interosseous crest minimum	10.0	11.0	+9.1*	9.6	11.0	+12.7*
Humerus						
Maximum length	306	324	+5.6*	293	317	+7.6*
Midshaft maximum diameter	20.8	23.2	+10.3*	19.9	22.4	+11.2*
Midshaft minimum diameter	14.7	17.5	+16.0*	14.3	16.4	+12.8*
Midshaft circumference	60	68	+11.8*	57	65	+12.3*
Head diameter	40.1	46.2	+13.2*	37.9	42.7	+11.2*
Biepicondylar breadth	55.5	60.0	+7.5*	52.5	58.9	+10.9*

[a] Computed by the formula: $(1 - \bar{X}_F/\bar{X}_M)(100)$; asterisk (*) indicates that percent sexual dimorphism statistically significant at the p = .05 level.

CRANIAL SIZE

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

The female preagricultural and agricultural mean dimensions, percentage changes, and significance levels are shown in table 48. The univariate statistical treatment of these data clearly reveals significant reduction in a number of cranial dimensions: cheek height (4.7%), biorbital breadth (2.4%), orbital breadth (3.8%), infratemporal fossa depth

TABLE 44

Comparison of Female Preagricultural and Agricultural Postcranial Indices

Index	Preagricultural Mean	Preagricultural N	Preagricultural S.D.	Agricultural Mean	Agricultural N	Agricultural S.D.	Change[a] %	t (p)
FEMUR								
Midshaft	91.3	44	6.69	92.1	86	7.44	+0.9	n.s.[b]
Platymeric	75.6	45	10.26	75.1	91	7.28	−0.7	n.s.
Robusticity	18.8	18	0.98	18.2	51	1.10	−3.2	.05
TIBIA								
Midshaft	68.8	32	5.22	68.3	72	5.21	−0.7	n.s.
Robusticity	21.4	13	1.16	20.8	43	1.77	−2.8	n.s.
HUMERUS								
Midshaft	70.4	37	5.88	71.9	77	3.88	+2.1	n.s.
Robusticity	19.7	25	1.78	19.2	52	1.74	−2.5	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

(8.7%), temporalis length (5.4%), temporalis height (5.8%), minimum frontal breadth (2.3%), parietal chord (3.0%), parietal arc (5.1%), lambda-inion chord (6.4%), bregma-inion (3.5%), bregma-opisthion (2.7%), bigonial breadth (3.4%), ascending ramus height at the condyle (5.1%), ascending ramus height at the coronoid process (5.0%), mandibular symphysis height (4.7%), mandibular symphysis thickness (4.1%), and mandibular length (2.8%). Most of the significant size reductions are facial dimensions or are in some other way associated with the masticatory complex (e.g., temporalis and masseter muscle attachments). There are no significant changes for all other cranial dimensions, most of which are related to vault dimensions.

Similar statistical treatment of the male preagricultural and agricultural cranial di-

TABLE 45

Comparison of Male Preagricultural and Agricultural Postcranial Indices

Index	Preagricultural Mean	Preagricultural N	Preagricultural S.D.	Agricultural Mean	Agricultural N	Agricultural S.D.	Change[a] %	t (p)
FEMUR								
Midshaft	85.7	20	6.67	87.7	68	6.98	+2.3	n.s.[b]
Platymeric	73.6	19	5.60	77.3	69	5.17	+4.8	.05
Robusticity	20.0	9	1.14	19.4	46	1.48	−3.0	n.s.
TIBIA								
Midshaft	67.8	21	4.53	65.7	59	6.90	−3.1	n.s.
Robusticity	22.5	10	1.32	22.1	34	1.93	−1.8	n.s.
HUMERUS								
Midshaft	75.1	24	6.00	73.3	58	5.54	−2.4	n.s.
Robusticity	20.4	14	2.09	20.3	41	1.67	−0.5	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

TABLE 46
Comparison of Preagricultural and Agricultural Stature for Females and Males (Based on Left Femur, Left Tibia, Right Femur, Right Tibia [in Centimeters])

		Preagricultural			Agricultural				
Sex	Bone	Mean	N	S.D.	Mean	N	S.D.	Change[a] %	*t* (p)
Female	L. femur	162.2	19	6.30	157.5	54	4.99	−2.9	.01
	L. tibia	163.7	14	7.38	158.1	50	5.11	−3.4	.01
	R. femur	160.7	21	7.74	156.4	52	4.09	−2.7	.01
	R. tibia	163.1	15	5.31	158.1	55	5.41	−3.1	.01
Male	L. femur	167.9	9	5.38	167.5	47	4.72	−0.2	n.s.[b]
	L. tibia	171.4	10	5.95	167.5	39	4.29	−2.3	.05
	R. femur	168.9	12	5.81	167.1	48	4.30	−1.1	n.s.
	R. tibia	169.4	17	5.42	167.9	45	4.57	−0.9	n.s.

[a] Computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$.

[b] Not significant.

mensions shows a size reduction trend (table 49). The significant reductions include: cheek height (7.6%), biorbital breadth (2.2%), orbital breadth (5.9%), lambda-inion chord (11.0%), lambda-inion arc (12.4%), mandibular symphysis thickness (4.8%), and mandibular length (3.6%). As in the females, there is a definite pattern exhibited with respect to reduction in cranial size. That is, the reductions are restricted, for the most part, to facial and related dimensions. With the exception of the lambda-inion arc, all the cranial dimensions that show significant reduction in the males, reduce in the females as well. In addition, the significant size change noted for the lambda-inion chord in the females and the lambda-inion chord and lambda-inion arc in the males is suggestive of an alteration in the nuchal musculature in the agricultural group relative to the preagricultural group. These size changes may be associated with the changes observed for the face and masticatory complex.

Female-Male Comparisons

Table 50 shows the percentage of sexual dimorphism for the preagricultural and agricultural groups. Although more significant female-male differences occur in the agricultural group, there is no clear pattern of increase or decrease in percentage change for the females and percentage change for the males. However, a trend for an increase in percent sexual dimorphism in the agricultural group relative to the preagricultural group

TABLE 47
Preagricultural and Agricultural Stature Percent Sexual Dimorphism (Based on Left Femur, Left Tibia, Right Femur, Right Tibia [in Centimeters])

	Preagricultural			Agricultural		
Bone	Female Mean	Male Mean	% Sex.[a] Dimorphism	Female Mean	Male Mean	% Sex.[a] Dimorphism
Left femur	162.2	167.9	+3.4	157.5	167.5	+6.0
Left tibia	163.7	171.4	+4.5	158.1	167.5	+5.6
Right femur	160.7	168.9	+4.9	156.4	167.1	+6.4
Right tibia	163.1	169.4	+3.7	158.1	167.9	+5.8

[a] Computed by the formula: $(1 - \bar{X}_F/\bar{X}_M)(100)$.

TABLE 48
Comparison of Female Preagricultural and Agricultural Cranial Dimensions (in Millimeters)

	Preagricultural			Agricultural				
Variable	Mean	N	S.D.	Mean	N	S.D.	% Change[a]	*t* (p)
FACE-MASTICATORY COMPLEX								
Masseter origin length	32.9	14	3.26	32.6	39	4.00	−0.9	n.s.[b]
Zygomatic arch thickness	27.5	22	2.65	26.9	47	2.55	−2.3	n.s.
Cheek height	25.5	22	2.35	24.3	53	2.37	−4.7	.05
Upper facial height	65.6	8	4.20	68.3	33	5.25	+4.0	n.s.
Biorbital breadth	95.0	22	3.68	92.6	49	3.15	−2.4	.05
Orbital breadth	40.1	14	2.79	38.6	34	1.99	−3.8	.05
Orbital height	35.6	14	3.87	34.6	33	2.15	−2.8	n.s.
Infratemporal fossa depth	23.5	11	2.84	21.4	24	2.69	−8.7	.05
Infratemporal fossa length	38.1	11	3.86	39.8	29	2.60	+4.4	n.s.
Temporalis length	129.5	29	7.48	122.5	55	9.12	−5.4	.001
Temporalis height	88.8	28	9.18	83.7	54	6.80	−5.8	.01
Palate length	45.2	8	4.12	45.7	15	2.66	+1.1	n.s.
Palate breadth	39.9	13	3.78	40.1	35	3.99	+0.4	n.s.
Bizygomatic breadth	129	3	5.20	130	17	4.00	+0.9	n.s.
Minimum frontal breadth	91.7	25	4.04	89.6	49	3.78	−2.3	.05
Frontal chord	109.7	33	0.47	108.0	63	4.72	−1.6	n.s.
Frontal arc	121	29	5.68	120	65	5.81	−0.8	n.s.
Bicondylar breadth	121.3	12	9.52	118.6	44	6.02	−2.2	n.s.
Condylar breadth	19.4	29	2.37	19.4	55	2.15	0.0	n.s.
Bigonial breadth	98.8	24	6.49	95.4	57	6.30	−3.4	.05
Asc. ramus height, coronoid	62.0	36	4.85	58.9	72	4.91	−5.0	.01
Asc. ramus height, condyle	53.4	29	5.13	50.7	62	6.00	−5.1	.05
Asc. ramus, minimum breadth	34.9	42	2.53	34.4	79	2.53	−1.4	n.s.
Symphysis height	34.1	30	3.54	32.5	56	2.81	−4.7	.05
Symphysis thickness	14.4	42	1.39	13.8	70	1.55	−4.1	.05
Mandibular length	106	22	5.25	103	54	4.34	−2.8	.05
VAULT								
Prosthion-opisthion	124.9	4	9.05	128.8	13	6.49	+3.0	n.s.
Prosthion-basion	90.1	3	2.57	95.7	11	4.32	+5.8	n.s.
Opisthion-nasospinale	125	5	9.15	124	13	11.74	−0.8	n.s.
Parietal chord	102.5	35	5.89	99.4	78	6.44	−3.0	.05
Occipital chord	95.9	19	10.52	94.3	39	9.88	−1.7	n.s.
Lambda-inion chord	70.9	40	11.11	66.4	72	9.94	−6.4	.05
Inion-opisthion chord	37.3	18	8.71	40.0	40	8.93	+6.6	n.s.
Biasterionic chord	104.9	29	5.63	106.2	54	5.07	+1.2	n.s.
Parietal arc	117	34	6.40	111	78	8.40	−5.1	.001
Occipital arc	116	18	10.87	111	38	8.13	−4.3	n.s.
Lambda-inion arc	75	36	12.46	71	72	11.14	−5.3	n.s.
Inion-opisthion arc	39	18	8.83	41	39	8.10	+4.9	n.s.
Biasterionic arc	123	26	5.93	122	52	5.84	−0.8	n.s.
Bregma-inion	145	32	7.82	140	63	5.93	−3.5	.001
Bregma-opisthion	150	16	5.79	146	35	4.80	−2.7	.05
Lambda-basion	112.7	8	7.23	113.5	20	3.39	+0.7	n.s.
Nasion-lambda	164	24	5.05	161	58	8.98	−1.8	n.s.
Basion-nasospinale	89	4	1.29	98.7	14	2.65	+9.2	n.s.
Nasion-opisthion	134	11	8.97	131	20	5.30	−2.2	n.s.
Cranial height	134	7	8.54	134	20	5.04	+0.7	n.s.

TABLE 48—(*Continued*)

Variable	Preagricultural Mean	N	S.D.	Agricultural Mean	N	S.D.	% Change[a]	*t* (p)
Auricular height	110	22	4.72	110	39	3.66	0.0	n.s.[b]
Maximum cranial length	168	28	6.39	166	63	7.13	−1.2	n.s.
Maximum cranial breadth	139	26	5.20	140	64	6.73	+0.7	n.s.
Biauricular breadth	130	17	5.63	128	42	6.13	−1.5	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

is suggested since nearly twice the number of cranial dimensions show significant reduction in the females as compared to the males (discussed above). In addition, 31 preagricultural cranial dimensions show significant sexual dimorphism, whereas 39 agricultural cranial dimensions are significantly dimorphic. These differences between the preagricultural and agricultural groups, as well as the differences between the females and males within each group, are suggestive of an increase in sexual dimorphism in the cranium.

DENTAL SIZE

PREAGRICULTURAL-AGRICULTURAL COMPARISONS

Tooth length and breadth means, percentage changes, and significance levels for the preagricultural-agricultural females and the preagricultural-agricultural males are shown in tables 51 and 52, respectively. Univariate statistical treatment of both groups shows very few significant tooth size differences between the preagricultural and agricultural groups. In the females, significant tooth size changes include reduction in lengths of the mandibular second molar (0.9%) and the mandibular third molar (2.7%). The preagricultural and agricultural comparisons of male tooth size show no significant changes in any dimensions, lengths or breadths.

Statistical treatment of tooth area (= length × breadth), perhaps a more functionally meaningful expression of tooth size (Wolpoff, 1971b), shows a complementary pattern of crown size reduction (tables 53 and 54). In the females, the significant changes include reduction of several posterior teeth: maxillary third molar (6.6%), mandibular first molar (3.7%), and mandibular third molar (5.4%) (table 53). As in the male preagricultural and agricultural comparisons of tooth lengths and breadths, there are no significant size differences between the male groups, preagricultural and agricultural, with respect to tooth areas (table 54). Thus, as in the measurements of body size (postcranial dimensions and stature), tooth size appears to show relatively little change in the agricultural group relative to the preagricultural group for the male dental sample. In the females, however, there is a greater degree of reduction in measurements of body size and tooth size relative to those exhibited in the males. These data, then, suggest a strong possibility of covariance between measures of tooth and body size.

FEMALE-MALE COMPARISONS

Percent sexual dimorphism for tooth lengths and breadths are shown in table 55 for the preagricultural and agricultural groups. This treatment of the data reveals that there are more statistically significant sexually dimorphic dental dimensions in the agricultural group than in the preagricultural group. Four dental dimensions are significantly dimorphic in the preagricultural group. These dimensions include the maxil-

TABLE 49

Comparison of Male Preagricultural and Agricultural Cranial Dimensions (in Millimeters)

	Preagricultural			Agricultural				
Variable	Mean	N	S.D.	Mean	N	S.D.	% Change[a]	t (p)
FACE-MASTICATORY COMPLEX								
Masseter origin length	37.2	12	2.44	36.6	32	5.49	−1.6	n.s.[b]
Zygomatic arch thickness	31.6	21	2.69	30.3	28	4.33	−4.1	n.s.
Cheek height	29.6	21	2.45	27.3	42	2.48	−7.6	.01
Upper facial height	74.2	6	6.15	72.1	21	5.02	−2.9	n.s.
Biorbital breadth	98.8	15	3.87	96.6	35	2.91	−2.2	.05
Orbital breadth	42.1	8	2.02	39.7	24	1.88	−5.9	.01
Orbital height	35.2	8	2.06	34.7	23	2.04	−1.4	n.s.
Infratemporal fossa depth	23.2	7	3.26	24.3	21	2.86	+4.6	n.s.
Infratemporal fossa length	39.3	8	3.25	40.8	22	3.83	+3.8	n.s.
Temporalis length	133.6	23	10.67	132.9	49	11.94	−0.5	n.s.
Temporalis height	93.1	22	7.19	94.5	45	9.19	+1.4	n.s.
Palate length	48.3	5	3.05	47.4	17	1.95	−1.7	n.s.
Palate breadth	43.7	9	3.10	42.2	29	3.27	−3.6	n.s.
Bizygomatic breadth	145	5	10.85	138	13	9.86	−4.8	n.s.
Minimum frontal breadth	96.6	16	5.22	93.7	37	5.09	−3.0	n.s.
Frontal chord	113.5	28	0.48	113.3	42	0.53	−0.1	n.s.
Frontal arc	126	27	6.31	125	42	7.46	−0.8	n.s.
Bicondylar breadth	130.0	10	7.90	127.7	33	6.34	−1.8	n.s.
Condylar breadth	21.8	20	2.58	21.7	45	2.55	−0.3	n.s.
Bigonial breadth	108.3	17	6.00	105.7	42	8.03	−2.4	n.s.
Asc. ramus height, coronoid	68.3	25	6.53	67.0	59	7.07	−2.0	n.s.
Asc. ramus height, condyle	58.8	21	5.32	58.9	49	5.49	+0.1	n.s.
Asc. ramus, minimum breadth	36.9	30	2.71	36.0	60	2.98	−1.2	n.s.
Symphysis height	35.7	22	2.81	35.6	51	4.34	−0.5	n.s.
Symphysis thickness	15.7	30	1.53	14.9	66	1.31	−4.8	.05
Mandibular length	110	18	5.94	106	46	5.50	−3.6	.05
VAULT								
Prosthion-opisthion	135.4	4	6.55	135.4	9	6.49	0.0	n.s.
Prosthion-basion	98.0	2	8.49	98.7	10	5.76	+0.8	n.s.
Opisthion-nasospinale	135	5	3.96	133	10	5.93	−1.5	n.s.
Parietal chord	104.6	27	7.20	104.3	57	7.13	−0.3	n.s.
Occipital chord	103.0	16	9.78	99.0	30	5.18	−3.9	n.s.
Lambda-inion chord	76.2	30	10.01	67.9	62	9.49	−11.0	.001
Inion-opisthion chord	38.5	17	5.60	42.2	30	8.72	+8.8	n.s.
Biasterionic chord	111.6	19	6.40	111.8	46	5.87	+0.2	n.s.
Parietal arc	118	26	8.94	118	56	9.35	0.0	n.s.
Occipital arc	120	17	13.06	115	32	10.68	−4.2	n.s.
Lambda-inion arc	81	28	14.14	71	63	11.15	−12.4	.01
Inion-opisthion arc	41	17	9.37	44	31	8.15	+6.8	n.s.
Biasterionic arc	131	19	5.71	128	44	6.65	−2.3	n.s.
Bregma-inion	150	24	9.38	147	52	6.56	−2.0	n.s.
Bregma-opisthion	155	13	8.01	151	26	5.40	−2.6	n.s.
Lambda-basion	120.0	5	5.15	115.3	19	6.06	−3.9	n.s.
Nasion-lambda	170	23	14.69	167	41	13.20	−1.8	n.s.
Basion-nasospinale	97	3	3.22	96	12	5.55	−1.0	n.s.
Nasion-opisthion	141	11	9.90	135	15	11.11	−4.3	n.s.
Cranial height	143	5	7.71	141	16	6.04	−1.4	n.s.

TABLE 49—(*Continued*)

	Preagricultural			Agricultural				
Variable	Mean	N	S.D.	Mean	N	S.D.	% Change[a]	*t* (p)
Auricular height	114	20	5.43	114	39	6.14	0.0	n.s.
Maximum cranial length	178	24	5.31	175	50	7.69	−1.7	n.s.
Maximum cranial breadth	144	23	6.82	145	47	6.34	+0.7	n.s.
Biauricular breadth	136	14	8.47	135	34	5.60	−0.7	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

lary second incisor breadth (5.9%), fourth premolar breadth (5.3%), first molar length (2.8%), and mandibular third premolar length (4.2%). Eleven dental dimensions are significantly dimorphic in the agricultural group: maxillary first incisor breadth (5.3%), canine breadth (3.5%), second molar breadth (3.3%), third molar length (3.2%), mandibular canine length (8.2%), canine breadth (5.1%), fourth premolar length (5.6%), first molar length (2.6%), first molar breadth (2.7%), and second molar breadth (2.8%).

Analysis of tooth area shows a similar preagricultural-agricultural increase in number of significant dimorphic tooth differences (table 56). The preagricultural group has three significant dimorphic tooth areas—maxillary first molar (6.2%), mandibular canine (8.8%), and third premolar (9.6%); whereas the agricultural group shows six significant dimorphic tooth areas—maxillary second molar (5.5%), third molar (8.0%), mandibular canine (13.0%), fourth premolar (6.8%), first molar (5.0%), and second molar (4.7%). It is noteworthy that the agricultural mandibular canine has the greatest degree of percent sexual dimorphism for any measure of tooth size, lengths, breadths, or areas (13.0%). This is particularly interesting in that it appears that the agricultural group shows, in general, more sexual dimorphism than the preagricultural group. Furthermore, this tooth has been shown to be the most dimorphic tooth for most human groups (Wolpoff, 1975a; Brace and Ryan, 1980; Garn et al., 1967).

In summary, the presence of significant tooth length and area reductions in the females but not in the males, as well as a greater number of significant sexually dimorphic tooth dimensions in the agricultural group than in the preagricultural group, provides suggestive evidence for a greater degree of sexual dimorphism in the agricultural group relative to the preagricultural group with regard to tooth size. Dimorphism in dental dimensions, then, follows the same pattern shown in the other metric skeletal traits analyzed.

DISCUSSION

These data reveal a consistent pattern of skeletal and tooth size change in a comparison of the earlier preagricultural group with the later agricultural group from the prehistoric Georgia coast. One primary trend is evident from the above analysis: there is a significant reduction in postcranial size, stature, facial and masticatory complex size and posterior tooth size. Although the size reductions occur for both males and females, the degree of reduction appears to be greatest in the females. Thus, concomitant with the reduction in skeletal and dental size, there is an increase in the percentage of sexual dimorphism which is most apparent for postcranial and cranial size. The female-male increase in dimorphism is only suggestive for tooth size alone given the small number of significant agricultural tooth size reductions as well as the small number of significant in-

TABLE 50
Preagricultural and Agricultural Cranial Percent Sexual Dimorphism (Measurements in Millimeters)

	Preagricultural			Agricultural		
Variable	Female Mean	Male Mean	% Sex.[a] Dimorphism	Female Mean	Male Mean	% Sex.[a] Dimorphism
FACE-MASTICATORY COMPLEX						
Masseter origin length	32.9	37.2	+11.6*	32.6	36.6	+10.9*
Zygomatic arch thickness	27.5	31.6	+13.0*	26.9	30.3	+11.2*
Cheek height	25.5	29.6	+13.9*	24.3	27.3	+11.0*
Upper facial height	65.6	74.2	+11.6*	68.3	72.1	+5.3*
Biorbital breadth	95.0	98.8	+3.9*	92.6	96.6	+4.2*
Orbital breadth	40.1	42.1	+4.8	38.6	39.7	+2.8
Orbital height	35.6	35.2	−1.1	34.6	34.7	+0.3
Infratemporal fossa depth	23.5	23.2	−1.3	21.4	24.3	+11.9*
Infratemporal fossa length	38.1	39.3	+3.6	39.8	40.8	+2.5
Temporalis length	129.5	133.6	+3.1	122.5	132.9	+7.8*
Temporalis height	88.8	93.1	+4.6	83.7	94.5	+11.4*
Palate length	45.2	48.3	+6.4	45.7	47.4	+3.6
Palate breadth	38.9	43.7	+8.7*	40.1	42.2	+5.0*
Bizygomatic breadth	129	145	+11.0*	130	138	+5.8*
Minimum frontal breadth	91.7	96.6	+5.1*	89.6	93.7	+4.4*
Frontal chord	109.7	113.5	+3.4*	108.0	113.3	+4.7*
Frontal arc	121	126	+4.0*	120	125	+4.0
Bicondylar breadth	121.3	130.0	+6.7*	118.6	127.7	+7.1*
Condylar breadth	19.4	21.8	+11.0*	19.4	21.7	+10.6*
Bigonial breadth	98.8	108.3	+8.8*	95.4	105.7	+9.7*
Asc. ramus height, coronoid	62.0	68.3	+9.2*	58.9	67.0	+12.1*
Asc. ramus height, condyle	53.4	58.8	+9.2*	50.7	58.9	+13.9*
Asc. ramus, minimum breadth	34.9	36.9	+5.4*	34.4	36.0	+4.4*
Symphysis height	34.1	35.7	+4.5	32.5	35.6	+8.7*
Symphysis thickness	14.4	15.7	+8.3*	13.8	14.9	+7.4*
Mandibular length	106	110	+3.6*	103	106	+2.8*
VAULT						
Prosthion-opisthion	124.9	135.4	+7.8	128.8	135.4	+4.9*
Prosthion-basion	90.1	98.0	+8.1	95.7	98.7	+3.0
Opisthion-nasospinale	125	135	+7.4*	124	133	+6.8
Parietal chord	102.5	104.6	+2.0	99.4	104.3	+4.7*
Occipital chord	95.9	103.0	+6.9*	94.3	94.3	+4.8*
Lambda-inion chord	70.9	76.2	+7.0*	66.4	67.9	+2.2
Inion-opisthion chord	37.3	38.5	+3.1	40.0	42.2	+5.2
Biasterionic chord	104.9	111.6	+6.0*	106.2	111.8	+5.0*
Parietal arc	117	118	+0.9	111	118	+5.9*
Occipital arc	116	120	+3.3	111	115	+3.5
Lambda-inion arc	75	81	+7.4	71	71	0.0
Inion-opisthion arc	39	41	+4.9	41	44	+6.8
Biasterionic arc	123	131	+6.1*	122	128	+4.7*
Bregma-inion	145	150	+3.3*	140	147	+4.8*
Bregma-opisthion	150	155	+3.2	146	151	+3.3*
Lambda-basion	112.7	120.0	+6.1	113.5	115.3	+1.6
Nasion-lambda	164	170	+3.5	161	167	+3.6*
Basion-nasospinale	89	97	+8.3*	98	96	−2.0
Nasion-opisthion	134	141	+5.0	131	135	+3.0

TABLE 50—(*Continued*)

Variable	Preagricultural			Agricultural		
	Female Mean	Male Mean	% Sex.[a] Dimorphism	Female Mean	Male Mean	% Sex.[a] Dimorphism
Cranial height	134	143	+6.3	135	141	+3.0
Auricular height	110	114	+3.5*	110	114	+3.5*
Maximum cranial length	168	178	+6.5	166	175	+5.1*
Maximum cranial breadth	139	144	+3.5*	140	145	+3.5*
Biauricular breadth	130	136	+4.4*	128	135	+5.2*

[a] Negative values computed by the formula: $-(1 - \bar{X}_M/\bar{X}_F)(100)$; positive values computed by the formula: $+(1 - \bar{X}_F/\bar{X}_M)(100)$; asterisk (*) indicates that percent sexual dimorphism statistically significant at the p = .05 level.

creases in sexually dimorphic teeth. However, this suite of alterations provides consistent evidence for a trend toward increased sexual dimorphism in the agricultural group relative to the preagricultural group. In essence, the preagricultural females and males appear to be more similar in skeletal and dental size than the agricultural females and males. Most of the increase in female-male size disparity occurs as a result of the proportionally greater degree of female size reduction.

SIZE REDUCTION: POSTCRANIAL EVIDENCE

The reduction in postcranial size and stature documented above must be examined in light of the adoption of an agricultural economy on the prehistoric Georgia coast following A.D. 1150. At least two variables should be considered: level of functional demand (mechanical stress) and protein malnutrition (nutritional stress).

As indicated in Chapter 4, the level of functional demand on the postcranial skeleton appears to become less with the adoption of an agricultural lifeway on the prehistoric Georgia coast as suggested by the significant decrease in mechanical stress-related pathology, degenerative joint disease. A postcranial reduction in mechanically related stress is further suggested by the significant decrease in the female femoral robusticity index as well as the significantly lower platymeric index in the preagricultural males relative to the agricultural males. Although low platymeric indices in human populations have been interpreted as representing a response to nutritional stress (Buxton, 1938), this interpretation is not supported by either the morphology associated with a low platymeric index (e.g., anteroposterior flattening) or by the calculation of area of bone present among groups with differing platymeric indices (cf. Buxton, 1938). Lower platymeric indices tend to be associated with the entire range of preagricultural hunter-gatherer Hominidae, fossil and extant; higher platymeric indices appear to be associated with agricultural and urban economies that are presumably associated with a less functionally demanding lifeway (Buxton, 1938; Pearson and Bell, 1917–1919; Townsley, 1946; Brothwell, 1972; Bennett, 1973). Thus, two independent forms of evidence suggest a decrease in functional demand on the postcranial skeleton with the adoption of an agricultural lifeway: (1) decrease in degenerative joint disease; and (2) change in diaphyseal form of the femur and tibia for the females and males, respectively.

It has been shown in both animals and humans that physical stress is directly related to bone development (Plato, Wood and Norris, 1980; Plato and Norris, 1980; Prives, 1960; E. L. Smith, 1973; Frisancho et al., 1970; Chamay and Tscantz, 1972; Watson, 1973; Saville and Smith, 1966; Buskirk, Andersen and Brozek, 1956; Smith and Reddan, 1976; and others). In instances of constant stress, skeletal elements increase the amount of bone tissue in order to resist efficiently ex-

TABLE 51
Comparison of Female Preagricultural and Agricultural Tooth Size: Lengths and Breadths

Tooth	Dimension	Preagricultural			Agricultural			%	*t*
		Mean	N	S.D.	Mean	N	S.D.	Change[a]	(p)
MAXILLA									
I1	Breadth	7.1	26	.457	7.1	40	.448	0.0	n.s.[b]
I2	Breadth	6.4	21	.518	6.5	31	.481	+1.5	n.s.
C	Length	7.9	25	.591	7.9	47	.543	0.0	n.s.
	Breadth	8.2	26	.619	8.2	47	.600	0.0	n.s.
P3	Length	7.0	28	.612	6.9	45	.679	−1.4	n.s.
	Breadth	9.3	31	.495	9.7	45	.571	+4.1	n.s.
P4	Length	6.6	31	.689	6.6	53	.783	0.0	n.s.
	Breadth	9.0	31	.614	9.5	53	.572	+5.3	n.s.
M1	Length	10.3	35	.652	10.4	65	.693	+1.0	n.s.
	Breadth	11.9	36	.566	11.8	65	.539	−0.8	n.s.
M2	Length	10.1	35	.510	9.9	58	.614	−2.0	n.s.
	Breadth	11.6	36	.701	11.6	58	.711	0.0	n.s.
M3	Length	9.4	37	.843	9.0	50	.859	−4.3	n.s.
	Breadth	11.0	37	.922	10.7	51	.765	−2.7	n.s.
MANDIBLE									
I1	Breadth	5.8	16	.465	5.9	23	.707	+1.7	n.s.
I2	Breadth	6.1	23	.325	6.1	43	.393	0.0	n.s.
C	Length	6.9	27	.562	6.7	45	.657	−2.9	n.s.
	Breadth	7.5	29	.623	7.5	45	.449	0.0	n.s.
P3	Length	6.8	32	.537	6.8	58	.827	0.0	n.s.
	Breadth	7.7	33	.531	8.0	57	.615	+3.8	n.s.
P4	Length	6.7	33	.539	6.8	63	.713	+1.5	n.s.
	Breadth	8.2	33	.564	8.3	63	.663	+1.0	n.s.
M1	Length	11.4	38	.804	11.2	65	.614	−1.8	n.s.
	Breadth	11.2	38	.535	11.0	64	.459	−1.8	n.s.
M2	Length	11.0	43	.794	10.9	61	.814	−0.9	.05
	Breadth	10.7	43	.645	10.5	61	.556	−1.9	n.s.
M3	Length	11.1	45	.802	10.8	55	.899	−2.7	.05
	Breadth	10.4	45	.704	10.2	55	.620	−1.9	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

ternal functional demands. Studies of dominant versus nondominant limbs of athletes such as in professional baseball pitchers (King, Brelsford and Tullos, 1969) and tennis players (Jones et al., 1977) have shown marked increases in humeral cortex thickness in the arm that receives most of the use in the sporting event. Similarly, Plato, Wood and Norris (1980) and Plato and Norris (1980) have provided data on grip strength and a series of radiographic-based measurements of the second metacarpal of living subjects. In these studies, it was found that grip strength was positively correlated with total width, cortical thickness, and cortical area of this skeletal element. Is was concluded that physical stress and bone size are clearly related. Amputation studies have provided corroborative data. For

TABLE 52
Comparison of Male Preagricultural and Agricultural Tooth Size: Lengths and Breadths (in Millimeters)

Tooth	Dimension	Preagricultural			Agricultural			% Change[a]	t (p)
		Mean	N	S.D.	Mean	N	S.D.		
MAXILLA									
I1	Breadth	7.3	18	.461	7.5	28	.592	+2.7	n.s.[b]
I2	Breadth	6.8	15	.461	6.6	28	.660	−2.9	n.s.
C	Length	8.2	17	.419	7.8	40	.820	−4.9	n.s.
	Breadth	8.4	17	.598	8.5	41	.812	+1.2	n.s.
P3	Length	7.3	18	.736	7.1	36	.598	−2.7	n.s.
	Breadth	9.5	19	.642	9.7	36	.652	+2.1	n.s.
P4	Length	6.9	18	.966	6.8	39	.654	−1.5	n.s.
	Breadth	9.5	17	.453	9.5	40	.766	0.0	n.s.
M1	Length	10.6	23	.657	10.6	44	.653	0.0	n.s.
	Breadth	12.2	22	.613	12.1	44	.942	−0.8	n.s.
M2	Length	10.3	22	.840	10.1	42	.711	−1.9	n.s.
	Breadth	11.9	22	.737	12.0	43	.761	+0.8	n.s.
M3	Length	9.7	20	.837	9.3	39	.963	−4.1	n.s.
	Breadth	11.2	20	.786	11.3	39	.878	+0.9	n.s.
MANDIBLE									
I1	Breadth	5.7	8	.183	5.9	30	.373	+3.4	n.s.
I2	Breadth	6.3	13	.341	6.2	34	.497	−1.6	n.s.
C	Length	7.2	24	.473	7.3	43	.548	+1.4	n.s.
	Breadth	7.8	25	.645	7.9	44	.536	+1.3	n.s.
P3	Length	7.1	21	.367	7.0	49	.596	−1.4	n.s.
	Breadth	8.1	22	.591	8.2	49	.658	+1.2	n.s.
P4	Length	7.0	20	.706	7.2	48	.634	+2.8	n.s.
	Breadth	8.4	20	.502	8.4	48	.633	0.0	n.s.
M1	Length	11.7	23	.803	11.5	51	.715	−1.7	n.s.
	Breadth	11.3	22	.303	11.3	49	.586	0.0	n.s.
M2	Length	11.2	24	.651	11.1	45	.753	−0.9	n.s.
	Breadth	10.9	23	.499	10.8	44	.558	−2.8	n.s.
M3	Length	10.9	23	.991	10.9	44	.902	0.0	n.s.
	Breadth	10.5	23	.689	10.4	46	.727	−1.0	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.
[b] Not significant.

example, Krogman (1962, 1972) has pointed out that in unilateral arm or leg amputations, the opposite, unamputated limb was subjected to a relatively greater mechanical burden. As a result, the amputated bone remnant was atrophied, and the unamputated side showed marked skeletal hypertrophy.

The above studies, then, point to the fact that growth of local bone tissue (e.g., sites of muscle attachment, cortical thickness, and mineralization) and bone in general are enhanced by increased mechanical-functional demand placed on the musculo-skeletal system. Therefore, it is suggested here that with a *decrease* in functional demand associated with a sedentary agricultural adaptation on the Georgia coast, the skeletal postcranial tissue had responded in such a way

TABLE 53
Comparison of Female Preagricultural and Agricultural Tooth Size: Areas (in Square Millimeters)

	Preagricultural			Agricultural			%	t
Tooth	Mean	N	S.D.	Mean	N	S.D.	Change[a]	(p)
MAXILLA								
C	65.3	25	7.77	65.1	45	7.97	−0.3	n.s.[b]
P3	65.2	28	7.80	67.5	44	9.82	−3.4	n.s.
P4	59.4	30	9.43	62.8	53	10.14	+5.4	n.s.
M1	121.8	35	11.45	122.7	65	11.84	+0.7	n.s.
M2	117.0	35	11.79	114.4	58	12.19	−2.2	n.s.
M3	104.1	37	17.05	97.2	50	13.72	−6.6	.05
MANDIBLE								
C	51.9	27	6.83	50.4	45	6.30	−2.9	n.s.
P3	52.7	31	6.29	54.0	57	9.01	+2.4	n.s.
P4	53.4	32	7.05	56.4	63	9.30	+3.2	n.s.
M1	128.4	37	11.73	123.6	64	10.24	−3.7	.05
M2	118.0	43	14.37	114.7	61	13.28	−2.8	n.s.
M3	116.4	45	13.61	110.1	55	13.84	−5.4	.05

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

that individuals were generally smaller and less robust. This suggestion is in keeping with the phenomenon called Wolff's Law: bone is deposited in the presence of functional demand and in its absence is resorbed.

Another plausible explanation for the ob-

TABLE 54
Comparison of Male Preagricultural and Agricultural Tooth Size: Areas (in Square Millimeters)

	Preagricultural			Agricultural			%	t
Tooth	Mean	N	S.D.	Mean	N	S.D.	Change[a]	(p)
MAXILLA								
C	68.7	17	6.20	67.1	40	9.61	−2.3	n.s.[b]
P3	69.6	18	8.92	68.7	36	9.53	−1.3	n.s.
P4	65.4	17	11.12	64.8	39	11.05	−0.9	n.s.
M1	129.9	22	11.78	127.7	43	14.81	−1.7	n.s.
M2	122.9	22	12.49	121.1	42	13.77	−1.5	n.s.
M3	108.7	20	14.29	105.6	39	17.66	−2.9	n.s.
MANDIBLE								
C	56.9	24	6.71	57.9	43	5.82	+1.7	n.s.
P3	58.3	21	5.51	57.2	49	8.77	−1.9	n.s.
P4	58.3	19	8.14	60.5	48	8.23	+3.6	n.s.
M1	133.0	22	13.69	130.1	49	12.81	−2.2	n.s.
M2	122.4	23	11.68	120.3	44	12.85	−1.7	n.s.
M3	113.4	23	16.50	112.8	44	15.45	−0.5	n.s.

[a] Negative values computed by the formula: $-(1 - \bar{X}_A/\bar{X}_P)(100)$; positive values computed by the formula: $+(1 - \bar{X}_P/\bar{X}_A)(100)$.

[b] Not significant.

TABLE 55

Preagricultural and Agricultural Dental Percent Sexual Dimorphism: Lengths and Breadths (in Millimeters)

		Preagricultural			Agricultural		
Tooth	Dimension	Female Mean	Male Mean	% Sex.[a] Dimorphism	Female Mean	Male Mean	% Sex.[a] Dimorphism
MAXILLA							
I1	Breadth	7.1	7.3	+2.7	7.1	7.5	+5.3*
I2	Breadth	6.4	6.8	+5.9*	6.5	6.6	+1.5
C	Length	7.9	8.2	+3.7	7.9	7.8	−1.3
	Breadth	8.2	8.4	+2.4	8.2	8.5	+3.5*
P3	Length	7.0	7.3	+4.1	6.9	7.1	+2.8
	Breadth	9.3	9.5	+2.1	9.7	9.7	0.0
P4	Length	6.6	6.9	+4.4	6.6	6.8	+2.9
	Breadth	9.0	9.5	+5.3*	9.5	9.5	0.0
M1	Length	10.3	10.6	+2.8*	10.4	10.6	+1.9
	Breadth	11.9	12.2	+2.5	11.8	12.1	+2.5*
M2	Length	10.1	10.3	+1.9	9.9	10.1	+2.0
	Breadth	11.6	11.9	+2.5	11.6	12.0	+3.3*
M3	Length	9.4	9.7	+3.1	9.0	9.3	+3.2*
	Breadth	11.0	11.2	+1.8	10.7	11.3	+5.3
MANDIBLE							
I1	Breadth	5.8	5.7	−1.8	5.9	5.9	0.0
I2	Breadth	6.1	6.3	+3.2	6.1	6.2	+1.6
C	Length	6.9	7.2	+4.2	6.7	7.3	+8.2
	Breadth	7.5	7.8	+3.9	7.5	7.9	+5.1*
P3	Length	6.8	7.1	+4.2*	6.8	7.0	+2.9
	Breadth	7.7	8.1	+4.9	8.0	8.2	+2.4
P4	Length	6.7	7.0	+4.3	6.8	7.2	+5.6*
	Breadth	8.2	8.4	+2.4	8.3	8.4	+1.2
M1	Length	11.4	11.7	+2.6	11.2	11.5	+2.6*
	Breadth	11.2	11.3	+0.9	11.0	11.3	+2.7*
M2	Length	11.0	11.2	+1.8	10.9	11.1	+1.8
	Breadth	10.7	10.9	+1.8	10.5	10.8	+2.8*
M3	Length	11.1	10.9	−1.8	10.8	10.9	+0.9
	Breadth	10.4	10.5	+1.0	10.2	10.4	+1.9

[a] Negative values computed by the formula: $-(1 - \bar{X}_M/\bar{X}_F)(100)$; positive values computed by the formula: $+(1 - \bar{X}_F/\bar{X}_M)(100)$; asterisk (*) indicates that percent sexual dimorphism statistically significant at the $p = .05$ level.

served decrease in postcranial size and stature is related to the possibility that with progressive increase in dietary carbohydrates a concomitant decrease in consumption of animal protein resulted in a reduction of overall skeletal size and stature. Protein has been shown to be an important dietary component that is essential to proper bone metabolism and growth (McLean and Urist, 1968). Most certainly, if there was a deficiency of protein with the adoption of corn agriculture as a dietary staple, then an overall reduction in skeletal growth would be expected.

A decrease in protein is suggested from analysis of dental caries data in the previous chapter. As pointed out, the oral environ-

TABLE 56
Preagricultural and Agricultural Dental Percent Sexual Dimorphism: Areas (in Millimeters)

Tooth	Preagricultural Female Mean	Preagricultural Male Mean	Preagricultural % Sex.[a] Dimorphism	Agricultural Female Mean	Agricultural Male Mean	Agricultural % Sex.[a] Dimorphism
MAXILLA						
C	65.3	68.7	+5.0	65.1	67.1	+2.9
P3	65.2	69.6	+6.3	67.5	68.7	+1.8
P4	59.4	65.4	+9.2	62.8	64.8	+3.1
M1	121.8	129.9	+6.2*	122.7	127.7	+3.9
M2	117.0	122.9	+4.8	114.4	121.1	+5.5*
M3	104.1	108.7	+4.2	97.2	105.6	+8.0*
MANDIBLE						
C	51.9	56.9	+8.8*	50.4	57.9	+13.0*
P3	52.7	58.3	+9.6*	54.0	57.2	+5.6
P4	53.4	58.3	+8.4	56.4	60.5	+6.8*
M1	128.4	133.0	+3.5	123.6	130.1	+5.0*
M2	118.0	122.4	+3.6	114.7	120.3	+4.7*
M3	116.4	113.4	−2.6	110.1	112.8	+2.4

[a] Negative values computed by the formula: $-(1 - \bar{X}_M/\bar{X}_F)(100)$; positive values computed by the formula: $+(1 - \bar{X}_F/\bar{X}_M)(100)$; asterisk (*) indicates that percent sexual dimorphism statistically significant at the p = .05 level.

ment ideal for the support of odontolytic organisms in dental plaque is created by a dietary regime low in protein and high in carbohydrates (cf. Rowe, 1975). The marked increase in dental caries on the prehistoric Georgia coast is suggestive of just such a nutritive combination.

In addition, Garn and Frisancho (1971), Garn and Clark (1975), Frisancho, Garn and Ascoli (1970a, 1970b), Frisancho et al. (1973), Stini (1969, 1971), Newman (1975), and others have shown that human populations undergoing protein malnutrition have relatively smaller body size and stature than populations with adequate nutrition. Although Frisancho et al. (1973) suggest that small body size may reflect an adaptive response to poor socioeconomic conditions in that parents with small body size have greater offspring survival than parents with larger body size in Latin American groups with low socioeconomic status, the universal response to protein malnutrition remains the same: reduction of body size.

The reduced postcranial size and stature in the agricultural group on the prehistoric Georgia coast would then seem to support the likelihood of some form of nutritional stress like protein malnutrition. Although animal protein, as represented for the most part by meat, contains all 20-odd amino acids necessary for growth in the approximate proportions needed, corn is very low in two essential amino acids, amino acids that are not produced by the body: lysine and tryptophan (Orr and Watt, 1957). Albanese and Orto (1964) and Stini (1971) point out that a reliance on one or a combination of foods that contain insufficient quantities of even one amino acid precludes the utilization of the rest of the amino acid group. The final result is an over-excretion of nitrogen without a compensatory intake and a restriction on body tissue metabolism and growth, including metabolism and growth of skeletal tissue.

A biological response to imbalance in amino acid intake is the secretion of proteins into the intestinal lumen where nutrients can be recovered. However, in situations where the individual is experiencing an infection, the immune response is activated and diverts available amino acids to the production of antibodies, thus resulting in a reduction of the amount of labile protein available for growth of the skeleton and other tissues (Stini, 1971). As indicated in Chapter 4, infections increased with the adoption of agriculture on the Georgia coast due to increase in population size and density. Hence, the probable restriction of ingested lysine and tryptophan is likely aggravated further by the overall increase in infections in the agricultural group. Indeed, in a recent series of studies of the health status of contemporary underdeveloped areas of Latin America, the relationship of infection to nutritional stress has been demonstrated to be an important consideration. Summarizing these data, Scrimshaw stated: "neither malnutrition nor infection can be considered separately; the interaction between the two is synergistic. Infection precipitates nutritional disease in the malnourished and malnutrition worsens the consequences of infections" (1967, p. 7; see also Scrimshaw, 1964; Scrimshaw, Taylor and Gordon, 1968; Scrimshaw et al., 1969; Scrimshaw and Tejada, 1970; Frisancho, 1979).

In sum, two distinct and independent types of stress are probably occurring with respect to biological adaptation involving the increased importance of agricultural, and, in particular, corn foodstuffs in the later prehistoric periods on the Georgia coast. First, the later lifeway that is associated with plant domesticates is seen as representing one that involves a decrease in mechanical stress. Second, the later lifeway most likely represents a dietary adaptation resulting in an increase in nutritional stress. It would be difficult, if not impossible, to pinpoint which of the two factors is the more important for an understanding of the observed postcranial and stature changes associated with the increased utilization of corn agriculture. In reality, both stress factors—decrease in functional demand and increase in nutritional stress—probably act concurrently, thus resulting in the observed preagricultural-agricultural postcranial size and stature reductions.

Size Reduction: Cranial Evidence

The cranial size changes observed on the prehistoric Georgia coast, reduction in facial and masticatory complex size, can be best explained with relation to dietary factors. A large body of experimental and related work utilizing laboratory animals has shown the interactive nature of muscle and bone in the growth and development of the skull and mandible (Dunn, 1937; Moss, 1968; Moss and Simon, 1968; Michejda and Weinstein, 1971; Warner, 1969; Avis, 1959, 1961; Boyd, Castelli and Huelke, 1967; Horowitz and Shapiro, 1951, 1955; Scott, 1954; Washburn, 1946a, 1946b, 1947a, 1947b; Spyropoulos, 1976; Moore, 1967, 1973; and others). Moreover, experimental work utilizing laboratory rats has shown that those animals fed a diet with a tough consistency had a larger, more robust maxillary-mandibular structure (Watt and Williams, 1951; Barber, Green and Fox, 1963; Moore and Lavelle, 1974). The greater degree of muscle stress on the face led to larger faces in those rats ingesting tougher foods. Although the relationships between form and function are not as yet clearly defined, the results of these studies clearly show that size and form of the facial and related skeletal tissues can be understood best when considered in the contextual framework of *function*. That is to say, ultimate form and size seem to be related, for the most part, to the influence of extrinsic functionally mediated factors (cf. Michejda and Weinstein, 1971 and references cited above).

The adoption of corn as a major component of diet on the prehistoric Georgia coast resulted in a probable decrease in masticatory stress. The food consistency associated with prepared corn-based foodstuffs was characterized by soft combinations as documented by early ethnohistoric records (e.g., tortas, bread, mush) (cf. Jones, 1978). It seems most likely, then, that the shift to a diet heavily utilizing softer, prepared foodstuffs associated with corn agriculture has led to a reduction in functional demand placed on the masticatory apparatus and consequently a reduction in skeletal dimensions that reflect facial and associated muscle size (e.g., masseter and temporalis) due to an alteration in growth and development in the agricultural group. The results of the analysis of preagricultural-agricultural cranial dimensions support the hypothesis originally proposed by Carlson and co-workers (Carlson, 1976a, 1976b; Carlson and Van Gerven, 1977, 1979; Hinton and Carlson, 1979) that the change in dietary-related oral function from a preagricultural hunting-gathering lifeway to agriculture has led to a decrease in size and robusticity of the craniofacial complex in prehistoric Nubian skulls, a change that arose consequent to a decrease in functional demand placed on the muscles of mastication.

Another possible explanation for the decreases observed in the facial-masticatory complex on the prehistoric Georgia coast might be due to an *overall* reduction in skull size. However, the measures of overall skull size (e.g., maximum cranial length, maximum cranial breadth, maximum cranial height, auricular height) remain unchanged from the Georgia coastal preagricultural to agricultural periods (see tables 48 and 49), whereas measures of facial size and masticatory muscles undergo statistically significant size reductions: cheek height, biorbital breadth, infratemporal fossa depth, temporalis length, temporalis height, bigonial breadth, ascending ramus height, mandibular symphysis height, mandibular symphysis thickness, and mandibular length in the females; and cheek height, orbital breadth, biorbital breadth, mandibular symphysis thickness, and mandibular length in the males. If the measures of facial and masticatory apparatus size were strongly influenced by skull size as a whole, then the size of the cranium, in general, should reduce in the agricultural group compared with the preagricultural group. This, in fact, is not the case. The size of the cranial vault, for the most part, has remained unchanged with the shift in adaptation.

SIZE REDUCTION: DENTAL EVIDENCE

The comparisons of the preagricultural and agricultural dental dimensions show some reduction in the size of the posterior teeth; specifically, reduction in length of the mandibular second and third molars and areas of the maxillary third molar and the mandibular first and third molars in the females. No significant dental size reductions occurred in the males. The size reductions involving the lengths of teeth could simply be related to an age structure difference between the preagricultural group and the agricultural group. Since the mesiodistal dimension of a tooth is influenced by interproximal tooth wear (cf. Goose, 1963; Wolpoff, 1971a, 1971b; Black, 1978; Biggerstaff, 1979; Brown and Townsend, 1980), an older population may appear to have reduced crown lengths in comparison with a younger population. Indeed, Black (1978) has demonstrated via the analysis of a large dental series from the southwestern prehistoric United States that older individuals tend to have reduced mesiodistal dental dimensions. However, as pointed out in the previous chapter, it is the *preagricultural* group that consists of an older skeletal sample than the agricultural group. Comparison of the age structure of the two groups, then, nullifies any age-related explanation for the reductions observed in the mesiodistal crown dimensions in the agricultural group relative to the preagricultural group.

The size changes observed in the prehistoric Georgia coastal dentitions support a number of accounts in the literature for reduction in tooth size, particularly in North America (cf. Brace and Mahler, 1971; Ryan and Posner, 1975; Ryan, 1977; Brace and Ryan, 1980; Hinton, Smith and Smith, 1980; Smith, Smith and Hinton, 1980). For example, Brace and Mahler (1971) reported tooth areas for several human dental samples that are representative of human populations utilizing agricultural foodstuffs. With respect to samples from North America, these authors provided values for tooth areas from two skeletal series: San Juan Teotihuacan and

Dickson Mounds. In the comparison of the former sample with the latter sample, the San Juan Teotihuacan mandibular molar areas were notably smaller than the Dickson Mounds mandibular molar areas. The differences were 11.5 percent, 11.2 percent, and 19.0 percent for the respective first, second, and third mandibular molars. Brace and Mahler (1971) suggested that the sample with the smaller teeth (San Juan Teotihuacan) simply represented populations in which food producing had been a factor for a longer period of time than in the populations with larger teeth (Dickson Mounds).

The mechanism underlying tooth size reduction remains unclear. Most studies dealing with tooth size changes have failed to take into account the relationship of tooth size to the cranium and postcranium. That is, most studies dealing with prehistoric human remains have viewed tooth size as completely autonomous without consideration of influences related to formation and growth (cf. Brown and Townsend, 1980). One series of investigations, however, has attempted to view dental and craniofacial size as interrelated phenomena rather than as separate entities operating under independent controls. This series of investigations, dealing with the above discussed time-successive series of human skeletal remains from prehistoric Nubia, suggested that change in mechanical forces operating on the maxillary-mandibular complex has resulted in compensatory reductions in tooth size (cf. Carlson and Van Gerven, 1977). That is, with the decrease in functional demand on the masticatory complex with the adoption of agriculture, there was a decrease in growth of the maxillary-mandibular complex resulting in a decrease in tooth size.

Following from this argument, the changes in tooth size on the prehistoric Georgia coast might similarly reflect a decrease in growth of the face and masticatory apparatus due to an alteration of the growth and development process in the agricultural group. Indeed, the size of the craniofacial skeleton in the agricultural group markedly reduces, particularly in females. However, unlike the Nubian skeletal series (cf. Hinton and Carlson, 1979; Masali, 1972), the Georgia coastal skeletal series shows a general decrease in overall postcranial size and stature reflecting a decrease in body size in the Georgia coastal agricultural group relative to the preagricultural group. Perhaps, then, the Georgia coastal dental size reductions might be best interpreted in light of the general relationship that is known to exist between tooth size and body size.

Recent investigations have demonstrated positive correlations between tooth size and body size within a number of primate taxa, including *Homo sapiens*. For example, Gould (1975) assessed the relationship between tooth area and skull length for male lemuroid, ceboid, and cercopithecoid primates. All correlation coefficients exceeded values of .93. Similarly, Kay (1975), Johnson (1978), and Gingerich and Schoeninger (1979) reported equally strong relationships between tooth size and various measures of body size. Specifically, in human beings, Garn, Lewis and Walenga (1968) found in a sample of dentitions of known familial relationships that taller parents have children with larger tooth length and breadth dimensions. Furthermore, these investigators found this phenomenon to hold true for all classes of teeth, both maxillary and mandibular. Following this evidence for a relationship between tooth size and body size, it seems most likely that the size changes observed in the Georgia coastal dentitions simply reflect the overall decrease in body size in the agricultural group with, perhaps, a secondary developmental influence related to the decrease in the size of the craniofacial complex.

SEXUAL DIMORPHISM

Although the importance of understanding sexual dimorphism to the study of prehistoric human adaptation has been clearly established (cf. Brace, 1973; Armelagos and Van Gerven, 1980), little has been accomplished in this area of investigation. This problem has been alleviated somewhat by the publication of a series of papers summarized and commented on by Armelagos and Van Gerven (1980). It is unfortunate, however, that the only samples that are large enough for meaningful comparisons are from Upper Paleolithic and later populations, thus limiting a broader context for this monograph. The present study offers data for later Holocene human evolution.

Increase in sexual dimorphism—the later agricultural group more dimorphic than the earlier preagricultural group—can probably be best understood in relation to the dietary and cultural factors operating in the prehistoric southeastern U.S. As pointed out in the previous chapter, Swanton (1942, 1946) and Hudson (1976) indicate that marked sexual divisions occurred for most activities, including those associated with subsistence, among southeastern Amerindians. Given the female-male disparity in frequency of functionally related mechanical stress pathology (degenerative joint disease) for both of the prehistoric Georgia coastal economies, preagricultural and agricultural, this pattern of subsistence-related sex role differentiation can probably be extended for the entire prehistoric period on the Georgia coast. If there is a proportional sex difference in diet and functional demand due to subsistence role differentiation in the Georgia coastal agricultural females and males, then it is reasonable to postulate a commensurate sex difference in the developmental effects on skeletal and dental tissues.

As indicated above, two factors are probably influencing postcranial size and stature with the adoption of an agricultural lifeway: mechanical stress and nutritional stress. In the agricultural adaptation, if the females are indeed ingesting proportionally more corn than the males, as is suggested by the difference in dental caries frequencies in the agricultural females and males (see Chapter 4), and if the males do indeed maintain the hunting-gathering responsibilities in the agricultural period, as is suggested by the ethnohistoric record, then the change observed—increase in sexual dimorphism—is the likely result. In the agricultural adaptation, if the males preserve the more stressful activity associated with a hunting-gathering adaptation as well as differentially consume more protein, then not only would the inhibitory effects of corn on bone growth be less for the males, but the intensity of activity would be maintained to the extent of maximizing bone growth and development.

The ethnographic literature demonstrates that in a number of societies males have differential access to protein that is acquired from animal sources on the hunt. For example, among the Hadza, a small group of hunters and gatherers living near Lake Eyasi, Tanzania, hunting is done exclusively by males, both preadult and adult (Woodburn, 1968). Woodburn (1968) pointed out:

> When a man goes off into the bush with his bow and arrows, his main interest is usually to satisfy his hunger. Once he has satisfied his hunger by eating berries or by shooting and catching some small animal, he is unlikely to make much effort to shoot a large animal. Of course, if he sees an animal close by which can easily be hunted, he will almost always take the opportunity. Men most often return from the bush empty-handed but with their hunger satisfied.

With regard to the Anbara, an Arnhem Land Australian aborigine group, a large portion of meat is prepared and consumed by males on the hunt and only leftovers are brought back to camp (Meehan, 1977a, 1977b). Similarly, Lee (1968) has made the observation that Dobe Bushmen males are also totally responsible for acquiring protein sources derived from hunting. Furthermore, those individuals that participate in the hunt consume the better, higher quality protein. The remainder of the Bushmen population, the individuals more closely associated with home-base activities (females, young preadults, senile, sick), receive proportionally less protein. In fact, Tobias (1962) noted a secular trend for increase in Bushmen male body size and stature, whereas females showed less change through time relative to the males (see also Key, 1980). In sum, these ethnographic accounts suffice to show that there is a good likelihood that differential access to protein may be, in part, behind the increase in disparity between female and male body size and stature on the prehistoric Georgia coast.

Superficially, the trend of increase in sexual dimorphism, as indicated by the preagricultural-agricultural postcranial, cranial, and dental size changes and increasing difference between the sexes, seems contradictory to a theme in human evolution—decrease in sexual dimorphism. Most studies have shown that until quite recently in human evolution, measurements of postcranial, cranial, and dental size have exhibited a greater degree of sexual dimorphism (cf. Wolpoff, 1975a, 1975b, 1976, 1980; Brace, 1973, 1979; Brace and Ryan, 1980; F. H. Smith, 1980; Armelagos and Van Gerven, 1980). The trend for a decrease in sexual dimorphism has continued in modern *Homo sapiens*. For example, this has been documented for cranial robusticity in the Neanderthal–Upper Paleolithic transition (Wolpoff, 1975b; F. H. Smith, 1980) and for measures of masticatory muscle size as well as temporo-mandibular joint size in the prehistoric Nubian shift from hunting and gathering to agricultural economies (Hinton and Carlson, 1979). With respect to the human dentition, Brace and Ryan (1980) have summarized trends in sexual dimorphism of tooth size (area) in a large series of dental remains that are representative of post-Middle Paleolithic human evolution. These authors found that by and large there has been a reduction in degree of sexual dimorphism from the Upper Paleolithic to the present. Plotting percent sexual dimorphism for the mandibular canine and mandibular second molar, the greatest degree of sexual dimorphism occurred in the European Upper Paleolithic and the least degree in Hong Kong Chinese. Percent sexual dimorphism for the Upper Paleolithic mandibular canine and mandibular second molar is 17 percent and 15 percent, respectively; whereas, in the same teeth in the Hong Kong Chinese, sexual dimorphism is 6 percent and 2 percent. Between these two extremes, percent sexual dimorphism for other populations analyzed by Brace and Ryan (1980), in descending order, was noted for the Mesolithic, Ann Arbor Americans (of European origin), Murray Basin, Walbiri, Java, Thai, Libben site, and Hawaiians. In these samples, the change in sexual dimorphism was due primarily to size reductions in the males.

A number of models have been offered for observed decreases in sexual dimorphism in later human evolution. Brace and Ryan (1980) have shown that the smallest average percent sexual dimorphism in dental size occurs in populations that have been separated for the greatest amount of time from a Pleistocene big-game hunting adaptation. Wolpoff (1975b) suggested that the decrease in sexual dimorphism arose as a consequence of increasingly similar demand for strength and endurance involving roles of both males and females. Frayer (1978, 1980) posited that in hunting-gathering groups, the differing economic responsibilities based on sex may be responsible for the large degree of sexual dimorphism in these groups. He suggested that, generally, males require a considerable amount of body robusticity necessary for procuring meat while females are involved in gathering of plants and small game. Thus, the males would be under selectional forces to maintain the size and robusticity necessary to fulfill required economic functions, whereas the females are subject to less selectional force to maintain large size. The result is a marked degree of sexual dimorphism. Frayer (1978, 1980) further suggested that subsequent to the increase in complexity of culture associated with the agricultural revolution, occupational division of labor became less important and both sexes took on increasingly similar roles; and as the selectional forces became more similar on both males and females, sexual dimorphism reduced.

On the surface, then, it would seem that with the adoption of an agricultural lifeway on the prehistoric Georgia coast, and following the aforementioned examples, females and males would take on similar adaptive roles. However, as pointed out above, the males probably maintained the hunting responsibilities, while the females were subject to most of the change in activity associated with the shift to an agricultural adaptation. That is, the sedentary nature of an agricultural adaptation had a disproportionate effect on the females. This is strongly suggested by the ethnohistoric accounts by the French and Spanish who first made contact with southeastern Amerindians (Swanton, 1942, 1946; Hudson, 1976). Thus, with regard to the prehistoric Georgia coast, the activity responsibilities appear to differ, effecting not only change in functional demand, but also nutrition. Most of the increasing size disparity between the sexes, then, can be accounted for by behavioral and nutritive factors associated with an increased dependence on corn agriculture.

SUMMARY

Statistical comparisons of preagricultural and agricultural postcranial, cranial, and dental dimensions as well as stature show significant skeletal and tooth size reductions that are associated with the change in adaptation on the prehistoric Georgia coast following A.D. 1150. In the female postcranial skeleton, nearly all measures of size show significant reduction: femur size (head diameter, neck vertical diameter, maximum length, midshaft anterior-posterior diameter, midshaft transverse diameter, midshaft circumference, subtrochanteric anterior-posterior and transverse diameters, bicondylar breadth), tibia size (maximum length, midshaft anterior-posterior and transverse diameters, midshaft circumference), fibula size (maximum length), clavicle size (maximum length), ulna size (maximum length), radius size (maximum length, head diameter, interosseous crest maximum diameter), and humerus size (maximum length, midshaft maximum diameter, midshaft circumference, head diameter, biepicondylar breadth). In the males, postcranial size reduces to a lesser extent than that demonstrated in the females. But, significant male postcranial size reductions occur for the femur (head diameter, midshaft anterior-posterior diameter, midshaft circumference, subtrochanteric transverse diameter, midshaft circumference), fibula (maximum length), and humerus (midshaft minimum diameter, midshaft circumference, head diameter). These size changes probably reflect a combination of a decrease in functional demand and an increase in nutritional stress associated with the agricultural lifeway. Cranially, measures of facial and masticatory muscle size significantly reduce, while for the most part, the remainder of cranial vault dimensions show no change with shift in subsistence economy.

As in the postcranial skeleton, there appears to be a greater degree of size reduction in the female cranium than in the male cranium. With regard to the females, the significant cranial size reductions include: cheek height, biorbital breadth, orbital breadth, infratemporal fossa depth, temporalis length, temporalis height, minimum frontal breadth, bigonial breadth, ascending ramus height (coronoid and condyle), symphysis height, symphysis thickness, mandibular length, parietal chord, lambda-inion chord, parietal arc, biasterionic arc, and bregma-opisthion. In the males, significant cranial size reductions include: cheek height, biorbital breadth, orbital breadth, symphysis thickness, mandibular length, lambda-inion chord, and lambda-inion arc. The craniofacial size changes documented probably reflect a decrease in functional demand on the masticatory apparatus, particularly masseter and temporalis, with the increased reliance on softer prepared foodstuffs derived from plant domesticates, especially corn.

Concomitant to the above postcranial and cranial size reductions, there is a decrease in several measures of posterior tooth size. Significant dental size reduction is restricted to the females (lengths of mandibular second and third molars; areas of maxillary third molar and mandibular first and third molars). Although the mechanism leading to dental size reduction is unclear, it seems likely that the changes observed might have arisen as a consequence to the overall reduction in body size as reflected by the distinct reduction observed for measurements of postcranial size and stature. Finally, comparison of females and males in the preagricultural group relative to the agricultural group for the above size dimensions shows an increase in sexual dimorphism which may have occurred as a result of the differential impact that corn agriculture seems to have had on the females as opposed to the males. On the one hand, males appear to have retained some of the hunting responsibilities with the shift in lifeway, thus maintaining some of the activity levels and nutritional base from the preagricultural to agricultural adaptations. On the other hand, the females took on the responsibilities associated with agricultural food production and were differentially affected by the adaptational shift.

CHAPTER 6. CONCLUSIONS

The purpose of this study has been to observe and explain the human skeletal and dental hard tissue responses to the shift from a hunting-gathering lifeway to one that has incorporated corn agriculture as an integral part of the dietary regime after A.D. 1150. The Georgia coast is particularly well suited to a study like this because the cultural, biological, and dietary controls are documented by a combination of archaeological and ethnohistoric data.

The model used in the present study is straightforward: on the one hand, with the increase in population size and density and the concomitant use of corn as a food staple, the pathology reflecting an increase in infectious disease due to increase in population density and size and a high carbohydrate diet should increase; on the other hand, the adoption of corn as a major dietary consituent, and the more sedentary lifeway associated with that adaptation should result in a decrease in functional demand both on the masticatory apparatus and the body. In addition, the element of malnutrition should come to play in an economy in which plant domesticates are an important food item in the overall dietary regime.

The data fit well with the model. Indeed, with the increase in population size and density following A.D. 1150 on the prehistoric Georgia coast, there is an increase in pathology probably related to infection-born disease in general (Chapter 4). Since most of the infectious instances (periosteal reactions) occur on localized areas of single skeletal elements or skeletal elements of single limbs in the affected individuals, this suggests that most of the reactions were caused by local bacterial infections. The increase in infections was probably due to crowded conditions associated with permanent occupation of large, densely populated sedentary villages during the later Savannah and Irene periods.

It has long been known that ingestion of dietary carbohydrates—especially sugars—results in cariogenesis. It seems likely that the increase in dietary sugar in the form of corn probably led to the observed increases in the frequency of dental caries. Furthermore, since the females had significantly more dental caries than the males, it appears that females may have been ingesting more corn than the males.

Along with the dietary changes, it appears that there was a concomitant decrease in functional demand on the skeleton with adoption of an agricultural lifeway. Two forms of evidence suggest this with respect to the postcranial skeleton. First, the frequency of pathology related to mechanical stress (degenerative joint disease) significantly reduces. Second, two skeletal indices that inferentially reflect stress show change: the female femoral robusticity index decreases and the male platymeric index increases. The latter increase is reflective of a rounder femoral subtrochanteric area indicative of a decrease in functional demand involving that postcranial region. Following Wolff's Law, with a decrease in functional demand on the postcrania, the size reductions demonstrated in Chapter 5 support this part of the model.

Following Carlson's model of alteration in craniofacial architecture (cf. Carlson and Van Gerven, 1977) as well as experimental work done on laboratory animals, the size and robusticity of the facial and masticatory apparatus do indeed reduce with the shift to agriculture as a subsistence mode on the prehistoric Georgia coast. Along with the reduction of facial and masticatory complex as well as stature and measures of postcranial size, there appears to be a reduction of posterior tooth size. Given the relationship between tooth size and body size, the tooth size reductions observed probably occur as a result of the reduction of overall body size.

Comparisons of the pathology of females and males and size data within each group, preagricultural and agricultural, show interesting results. With regard to skeletal health, both sexes appear to be equally affected by periosteal reactions, thus indicating uniformity in population distribution of infectious disease in the agricultural group. In contrast to this, however, it appears that females are more affected by dental caries than the males in that females have significantly more carious lesions than do males in the agricultural group. If the males were receiving more protein and less carbohydrates, then this would explain the disparity between the sexes for this disease process.

Reflecting the differences in sex roles, males of both the preagricultural and agricultural groups are significantly more affected by degenerative joint disease than are the females. This is in keeping with the early ethnohistoric accounts of males being totally responsible for hunting and females for agriculture-related activity: field preparation, planting, harvesting, and food preparation. Although both sexes show a decline in degenerative joint disease, it seems likely that the differences between the sexes in frequency of the disease probably can be accounted for by the male-female differences in subsistence-related activity.

Finally, although measurements of postcranial, cranial, and dental size as well as stature decrease in both sexes with the shift in economy, most of the size changes occur in the females. These size difference changes are most dramatic in the measurements of postcranial size. It appears then that there is a size reduction for measurements of skeletal and dental size, with the gracilization and tooth size reduction differentially affecting the females.

Since the sexes are differentially affected by the adoption of an agricultural lifeway, with the females participating in the village area subsistence procurement (agriculture) and males maintaining the preagricultural male roles (hunting), then it stands to reason that the females might be differentially affected by the shift in adaptive lifeway. First, the level of activity would be less for the females than the males. Second, if the females ingested more corn than the males, as suggested by the significantly higher frequency of dental caries, then the inhibitory effects of corn on bone growth as well as an accompanying restriction on protein resources would differentially affect the females, resulting in more pronounced reduction in postcranial size, craniofacial size, and tooth size. As is shown in Chapter 5, the data appear to support this contention since the skeletal and dental size changes apparently affect the females relatively more than the males. In sum, although the later population responds as a whole to change in economic lifeway, the females experienced more dramatic changes than the males following the adoption of agriculture.

Two problems remain: first, in this study, the female-male differences in diet have been speculative *in part*. The ethnohistoric record suggests that females are more involved in the agriculture-related activities of food procurement than the males. In addition, the females have been shown to have more dental caries than the males which may have resulted from the postulated differences in diet. These differences in frequencies of carious lesions between the females and males suggest that females are ingesting relatively less protein and more carbohydrates than the males. This type of nutritive combination in the females is particularly well suited for the maintenance of odontolytic organisms in dental plaque. In addition, the postcranial and stature reductions could have resulted in part from protein malnutrition in general and in combination with the inhibition of growth due to the ingestion of corn. From these environmental factors, we can only *infer* dietary differences between the females and males within the agricultural group.

What is known about subsistence on the Georgia coast is that after *ca.* A.D. 1150 there was a progressive shift to a diet based at least in part on the cultivation of storable food crops, particularly corn. With the adoption of this lifeway, there was, by definition, an increase in carbohydrate consumption. However, it cannot be said specifically what differences in diet there were within the agricultural group itself. It can only be suggested that the differences in the female and male skeletal morphology and size were due to differential access to protein on the one hand, and a dichotomy in level of functional demand that is associated with subsistence procurement on the other.

A second problem arises whenever fossil

or skeletal series are used to test hypotheses relating to biological change, particularly with regard to the postcranial, cranial, and dental size changes that have been documented in this study for the prehistoric Georgia coast. That is, is the causative agent for these changes secular or evolutionary? Carlson and Van Gerven (1977) have pointed out that morphological modification is "the direct result of alteration of patterns of both growth and development." However, Dahlberg (1965) noted: "It is not possible to discuss growth and development of fossil skulls or collections of skeletal materials, in the accepted sense . . . Past elements of change leave records in bones and teeth, but do not afford the opportunity to observe ongoing process" (quoted by Carlson and Van Gerven, 1977, p. 504). Thus, primarily due to this limitation, it is not possible to offer a statement here regarding the probability for either of the two alternatives, secular or evolutionary.

However, it is noteworthy that agricultural female stature reduction, 3.0 percent, and agricultural male stature reduction, 1.1 percent, represent relatively rapid change after A.D. 1150. These statural changes probably occurred within 10 to 15 generations (at least by A.D. 1550). This suggests that forces that have influenced phenotypic variation as it relates to stature have not been involved in the prehistoric Georgia coastal Amerinds for enough generations to have resulted in significant change in gene frequency. Moreover, it has clearly been shown that in most developed Western nations, in the last century the increase in stature represents secular change due to improved diet and public health (Newman, 1975; Tanner, 1968; Chamla, 1964; Harrison et al., 1977; and others). As discussed in the previous chapters, it seems quite likely that just the opposite trend—deterioration of diet and health—occurred on the Georgia coast. Given these factors, the possibility remains that the skeletal size alterations discussed in this study represent secular and not evolutionary change.

In summary, it has been my goal in this monograph to specifically demonstrate the responses of the human skeleton to shift in mode of subsistence and associated lifeway, and to provide a better understanding of human biological adaptation in general. This study does not intend to offer the final solution to the problem of prehistoric dietary adaptation, but rather, to provide stimulus for future hypothesis testing of related research.

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