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Infant/Weanling Mortality in Tennessee's Prehistory: A Comparative Approach

Rick R. Richardson
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To the Graduate Council:

I am submitting herewith a thesis written by Rick R. Richardson entitled "Infant/Weanling Mortality in Tennessee's Prehistory: A Comparative Approach." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Charles H. Faulkner, Major Professor

We have read this thesis and recommend its acceptance:

Jefferson Chapman, Maria Smith

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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INFANT/WEANLING MORTALITY IN TENNESSEE'S PREHISTORY: A COMPARATIVE APPROACH

A Thesis
Presented for the
Master of Arts
Degree
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Rick R. Richardson

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ABSTRACT

Although there is general agreement among many researchers concerning the decline in health and nutrition which accompanied the shift from hunting and gathering to agriculture, few studies have directly addressed the differences in infant\weanling mortality between these two distinct cultural adaptational strategies. This research focuses on infant mortality as an indicator of general health and nutritional status. Results from the present study, which utilizes more than 1,200 skeletal samples from eight sites, indicate a significant difference in infant mortality between prehistoric hunter-gatherers and agriculturalists in Tennessee.

Demographic comparisons were made between six Archaic sites and two Mississippian sites using the mortality profile method. Non-statistically significant differences in infant\weanling mortality were noted between the Archaic sites having shell middens and those without. These differences, while not significant, are believed to be due to a combination of better bone preservation in shell middens and density dependant diseases affecting individuals in the 0-5 year age intervals at Archaic summer base camps.

Statistically significant differences in infant\weanling mortality were found between the Archaic and

Mississippian sites. This difference suggests a better health and nutritional status for the Archaic hunter-gatherers than for the later Mississippian agriculturalists. The higher infant\weanling mortality among the Mississippian peoples is believed to result from an intensive reliance on a high carbohydrate, low protein maize diet and density dependant diseases brought about by population increase and sedentism.

Results from a paleopathological analysis of the remains utilized in the study show a statistically significant difference in frequencies of porotic hyperostosis between the Archaic and Mississippian periods. This pathology is used as and indicator of nutritional stress and is the result of iron deficiency anemia. Previous research has shown a correlation between porotic hyperostosis and maize reliance. The results show a much higher frequency of porotic hyperostosis in the Mississippian sample compared to the Archaic series analyzed. These findings support the conclusions drawn from the paleodemographic results.

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CHAPTER I

INTRODUCTION

The holistic nature of anthropology is perhaps most evident in the sub-disciplinary approach to research found under the label of bioarchaeology. According to Robert Blakely, anthropologists have too often "dichotomize(d) human biology and culture, treating each as if it were an independent variable shaping and being shaped by the human experience" (Blakely 1977: 1). Human skeletal remains can be used in conjunction with ethnographic data to test hypotheses regarding prehistoric dietary and nutritional strategies. This study examines a particular biological consequence of two distinct cultural adaptational strategies. Specifically, infant\weanling mortality is utilized as an indicator of the general health and nutritional status of prehistoric hunter-gatherers and early agriculturalists in Tennessee.

Differences in dietary and health patterns between archaeological populations can be examined through demographic profiles and stress related changes in bone growth and development. Numerous studies support the view that a major decline in health and nutrition accompanied the shift from a hunter-gathering way of life to an agricultural subsistence strategy (Allison 1984; Buikstra 1984; Cook 1984; Cassidy 1984; Goodman et al. 1984; Palkovich 1984;

Perzigian et al. 1984; Rose et al. 1984; and Ubelaker 1984). While many researchers focus primarily on the health of prehistoric agriculturalists, some have made comparisons with earlier hunter-gatherers (Blakely 1971; Cassidy 1972; 1980a; and 1984). One avenue of investigation is the demographic and health related variability both within and between populations, which is critical for a better understanding of human adaptational processes. The present research focuses specifically on variability in infant\weanling mortality among Archaic hunter-gatherers and Mississippian agriculturalists in Tennessee.

Some authors contend (McElroy and Townsend 1979; Brennan 1983) that infant\weanling mortality is the most sensitive indicator of health. If so, then much more emphasis should be placed on this measure . An extremely high infant mortality rate was observed among the contemporary Zulu during the 1940s. This was partly attributed to a reliance on maize introduced by Western settlers (McElroy and Townsend 1985). Other developing countries share a similar pattern. In 1960 more than 45% of all deaths recorded in Mexico were those of infants and children less than 5 years of age (Gwatkin and Brandel 1982: 62).

Although the relatively poor health and high infant mortality among prehistoric agriculturalists is widely recognized by researchers, any in-depth synchronic and

diachronic analysis of infant mortality in prehistory has yet to be published. In this aspect, at least, the present study represents a pivotal point for investigating and interpreting infant\weanling mortality in the archaeological record. Hopefully, this thesis will illustrate the utility of such data for biocultural interpretations. Additionally, the traditional use of adult longevity as an indicator of overall health as well as the "problem" of infant underrepresentation in paleodemographic studies will be addressed.

Information concerning Archaic and Mississippian culture as well as archaeological site background is presented in Chapter II. Chapter III addresses the demographic methodology and materials utilized for the study. The problems of infant underenumeration in the archaeological record and adult age estimations are also discussed in Chapter III. The paleodemographic results are presented and discussed in Chapter IV. Paleopathological indicators of stress are discussed in Chapter V along with the results of analysis. Chapter VI discusses the demographic and pathologic results in terms of general interpretations. The final chapter presents a summary and conclusion of this research.

CHAPTER II

ARCHAEOLOGICAL BACKGROUND

I. Introduction

Archaeological background information is necessary for any complete bio-cultural analysis of archaeological populations. This chapter discusses cultural adaptational strategies as well as relevant site background information for the populations under study (see Figure 1 and Table 1 for site locations). The total population consists of Archaic and Mississippian samples from Tennessee.

II. Culture and Site Descriptions

The Archaic Period

The Archaic period in Tennessee is generally described in terms of seasonal movement of bands based on the availability of a wide variety of resources. In Tennessee, this period began about 8000 B.C. and lasted until 1000 B.C. (Hofman 1984). Archaic period base camps tend to be small settlements located near permanent streams. It has been suggested that the presence of large shell middens at some Archaic sites is indicative of increasing population pressure and resource stress during the latter part of the period (Cohen 1975; Osborn 1977). Others (Klippel and Morey 1986; Parmalee and Klippel 1974) believe that shellfish

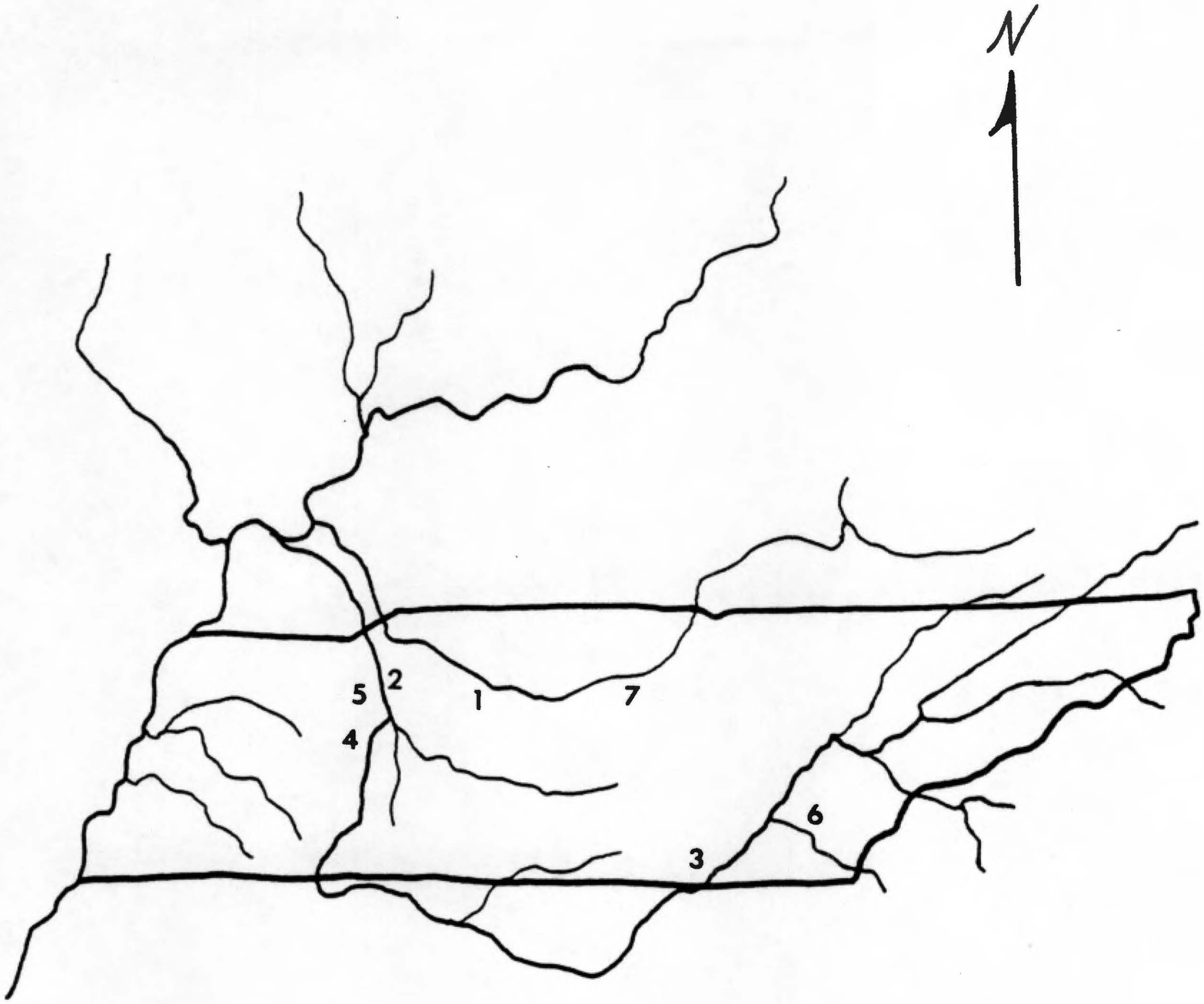

FIGURE 1. Location of Selected Sites in Tennessee. Sites indicated by map numbers are indentified in Table 2.

TABLE 1. Location of Selected Sites. Map numbers refer to Figure 1.

Map #	Site Name
1	Anderson
2	Cherry
3	Dallas
4	Eva
5	Ledbetter Landing
6	Ledford Island
7	Robinson

were probably supplemental to the main diet. The presence of shell middens at some sites has also been used as an indicator of summer and\or fall base camp occupation based on the seasonal availability of freshwater mussels and gastropods (Hofman 1986; Klippel and Morey 1986; Joerschke 1983; Magennis 1977; Bowen 1975).

Zooarchaeological evidence indicates that a wide variety of animal foods other than mussels were also utilized. Although white-tailed deer seems to have been the most important meat resource utilized on Archaic sites (Bogan 1982; Robinson 1982; and Parmalee 1973), other faunal remains such as wild turkey, elk, bear, rabbit, wolf, fish, and beaver are well represented (Lewis and Kneberg 1959; Chapman 1976; Faulkner 1977). A variety of floral remains such as seeds, nuts, fruits, and roots has also been recovered from such sites (Lewis and Kneberg 1959; Chapman 1976; Faulkner 1977).

The broad spectrum subsistence strategy of Archaic populations based on diverse quantities of meat, nuts, seeds, and aquatic resources provided adequate protein, minerals and vitamins to the diet (Buikstra 1984; Dunn 1978). Evidence for this can be found in paleopathological comparisons between prehistoric farmers and hunter-gatherers. Cohen found that prehistoric farmers "seem fairly commonly to have suffered more infection and more chronic malnutrition than their forebears living on wild

resources, and they seem to have suffered as many or more episodes of growth disrupting stresses..." (1987: 275). The population size was apparently sufficiently small enough to not allow infectious diseases on an endemic level (Cockburn 1967). Jablonski (1983) has also hypothesized a limited exposure to pathogens among Archaic peoples due to the small population size as well as a decreased likelihood of environmental pressures on food resources.

The preceding observations provide an interpretive framework for the present study. It was predicted that increased stress from the Archaic period to the Mississippian period would be reflected by an increase in infant\weanling mortality. The following site descriptions provide a background for the Archaic samples chosen to test for evidence of stress by use of demographic and pathological indicators.

Archaic Sites

Anderson (40WM9). The Anderson site is a Middle Archaic shell midden site located on the Harpeth River in Williamson County, Tennessee, in the western part of the Nashville Basin. According to Joerschke (1983: 21), the site "represents a base camp occupied over several generations by a homogenous population of Middle Archaic hunter-gatherers." Radiocarbon dates from the site place the occupation between approximately 6000 to 7000 B.P.

(Joerschke 1983: Table 1). According to Joerschke (1983), approximately 15% of the total site was excavated . It is assumed that the burials recovered from the site are representative of the Anderson population. Joerschke states that "Although different areas of the site, i.e., the periphery, were not excavated, it appears that many biases often associated with the procedures of burial recovery are not a major problem with the Anderson skeletal sample" (1983: 28). A total of 73 burials was recovered from the site.

Eva (6BN12). The Eva site was located on a floodplain of the Tennessee River in Benton County, Tennessee, in the western Tennessee Valley. Artifacts recovered from the site indicate an Early, two Middle (Eva I and Eva II), and one Late Archaic (Eva III) occupations. For the purpose of this study, only the Middle and Late Archaic components are of interest. Due to the small sample size of the earlier Middle Archaic occupation, the skeletal remains from the Eva I component (N=17) were combined with the Eva II sample (N=100).

Although no chronometric dates exist for the Eva II component, radiocarbon dates from other Middle Archaic components in the region yield dates of approximately 5000 - 7000 B.P. This component has been assigned to the Sykes-Benton phase of the Middle Archaic (Hofman 1986). Based on projectile point types and radiocarbon comparisons with

other Late Archaic sites, the Eva III component has been assigned to the Ledbetter Phase of the Late Archaic period which dates from approximately 3200 to 4500 B.P.(Hofman 1986). The abundance of shell associated with the Eva II component contrasts sharply with the relative absence of shell during the Late Archaic occupation (Lewis and Lewis 1961). The Eva site (component II and III) is believed to represent a base and transient camp (Magennis 1977). Only 9.14% of the site was excavated. A total of 117 Middle Archaic and 57 Late Archaic remains was recovered.

Cherry (84BN74). The Cherry site was located in Benton County, Tennessee, about one mile from the Big Sandy River. It was an upland site situated between two tributary streams. The Cherry site has been described as a "fall, winter, early spring occupation" (Bowen 1975: 32). Although no chronometric dates exist for the site, it has been assigned to the Ledbetter phase of the Late Archaic period dating to approximately 3200 to 4500 B.P.(Bowen 1975). It has been suggested that the Eva and Cherry sites differed in a functional sense based on differences in location and numbers of features and structures (Magennis 1977). Only 9.79% of the site was excavated. A total of 76 individuals was recovered from the site.

Ledbetter Landing (9BN25). The Ledbetter Landing site was also located in Benton County, Tennessee, between the Tennessee River and Morgan Creek. The site is believed to

have been a summer base camp and is associated with the Late Archaic Ledbetter phase (Lewis and Kneberg 1959). Bowen (1975) found no significant functional difference between Ledbetter Landing and the Cherry site other than season of occupation. While shell was present in Stratum I at Ledbetter Landing, the site is not believed to represent a "classic" Shell Mound Archaic site (Bowen 1975). Although a portion of the site is believed to have been eroded by river action, the majority of the site was intact at the time of excavation based on artifacts, features, and the number of burials recovered (Bowen 1975: 62). Approximately 16% of the remainder of the site was excavated. A total of 119 individuals was recovered from the site.

Robinson (40SM4). The Robinson site was an eastern Nashville Basin shell midden site located along the Cumberland River in Smith County, Tennessee. The site has been classified as a Shell Mound Archaic site based on artifact types recovered from the midden as well as a series of radiocarbon dates. Three clusters of dates from the site indicate three separate occupations ranging from approximately 2500 to 3500 B.P. (Morse 1967). According to Morse (1967), more than 3100 square feet over the major portion of the site was excavated. Sixty-two individuals were recovered from the site.

The Mississippian Period

The Mississippian period in Tennessee corresponds to the time period between approximately 800 A.D. to 1650 A.D. (Smith 1978). This cultural period is divided into an early and late component. The Mississippian period is generally characterized by maize agriculture and permanent villages. Besides the large, fortified, village\mound centers located along major river valleys, there is considerable evidence for smaller, short-term, upland farmsteads (Morse and Morse 1983; Smith 1978). Several types of change occurred during the Mississippian period. Some of these changes include an increase in population, increased population nucleation, increased defensive structures, increased evidence of violence, an increase in hierarchical organization of sites, and an increase in agricultural implements over those used for hunting (Morse and Morse 1983).

While Mississippian peoples relied predominantly on maize for subsistence, hunting and gathering of wild animals and plants also played a role (Smith 1978). This is evident by the presence of the largest settlements in broad, fertile river bottoms suitable for intensive agriculture as well as diverse wild resources. Maize, beans, and squash are the primary cultigens that have been recovered from Mississippian sites, while faunal evidence indicates the presence of deer, turkey, fish, and bear (Smith 1978).

1978).

Archaeological evidence indicates a chiefdom level of social organization for the Mississippian period (Morse and Morse 1983). However, elements of both chiefdom and egalitarian socio-political organization seem to have been in operation at some Mississippian sites (Blakely 1977). Nevertheless, differential access to important resources, such as food, certainly occurred throughout the Mississippian period (Hatch 1976; Morse and Morse 1983).

According to Jablonski (1983), a combination of increased population density (and the accompanying increase in human waste), increased reliance on a high carbohydrate maize diet, decreased intake of animal protein, and the resulting increase in malnutrition all provided a mechanism for the spread of disease. The following site descriptions provide a background for the Mississippian samples utilized to test for increased stress by means of demographic and pathological indicators.

Mississippian Sites

Dallas (7HA1 village and 8HA1 mound). The Dallas site was located on the east bank of the Tennessee River near Harrison, Tennessee, in the eastern Tennnessee River Valley. The site is represented by a village-mound complex and dates from approximately 1300 A.D. - 1550 A.D.(Schroedl 1988: personal communication). Radiocarbon dates from other

possibly as late as 1650 A.D.(Hatch 1974). The entire mound and a significant portion of the village was excavated. A total of 282 individuals was recovered from the mound and village.

Ledford Island (16BY13). The Ledford Island site is located on Ledford's Island in the Hiwassee River in Bradley County, Tennessee. This site has been assigned to a Late Mississippian complex called the Mouse Creek Phase with a tentative date of 1500 A.D. to 1650 A.D. (Boyd 1984). Less than 12% (1.75 acres) of the total site was excavated (Boyd 1984). A total of 469 individuals was recovered from the site.

CHAPTER III

DEMOGRAPHIC METHODS AND MATERIALS

I. Aging and Sexing Techniques

Aging Techniques

Any demographic comparison of burial populations requires accuracy in age determinations and care in sample selection. In determining the age at death for the skeletal material utilized for this study, several criteria were used. Dental eruption patterns provide the most accurate means for determining age in children 12 years and under (Thoma and Goldman 1960). Ages obtained from dental eruption patterns were arrived at through comparison with Schour and Massler's (1941) dental eruption chart. During the adolescent and young adult stage epiphyseal union (McKern and Stewart 1957), long bone measurements (Bass 1971) and eruption of the third molar are adequate for age determination.

The aging of adult remains over 27 years is considered to be much less reliable than for younger individuals. Methods such as pubic symphyseal changes (McKern and Stewart 1957), cranial suture closure (Todd and Lyon 1925), and dental attrition were used for age estimations in older adults. Because observations regarding degenerative changes in adults are subjective, the potential exists for intra-

observer differences in age estimations. For this reason and because the focus of the study is the subadult data, all adults were placed in the 18+ age interval (for a more detailed discussion of skeletal aging techniques see Ubelaker 1978).

Problems With Aging Adults

The use of chronological age intervals for adult remains is common practice in paleodemographic analysis. However, our ability to accurately place adults in a specific chronological interval is questionable. This is particularly true when one attempts to narrow the results down to the too commonly used five year age intervals.

Although many studies have pointed out the unreliability of such methods as cranial suture closure and dental wear, more recent studies have shown even the most trusted adult aging techniques to be questionable. In an assessment of adult aging techniques, Meindl et al. found that both the "aging of the pubis and the aging of the auricular surface of the innominate demonstrated anticipated error, which increased on the average with the actual age of the specimen" (1983: 80). According to Bocquet-Appel and Masset (1982: 321) :

> Aging is based upon a good correlation between biological features (cranial sutures, pubic symphysis, humeral and femoral heads, osteons) and age. However, it is not possible to estimate the structure of deaths of skeletal populations if the correlation coefficient (r or multiple-R) between biological characteristics and age is lower than

> 0.9. None of the published age indicators, whether they are used together or separately, reach this required level (about 0.83 for males and 0.8 for females).

Paleodemographers also tend to assume that the osseous evolution of adults has remained unchanged from prehistory to the present (Masset et al. 1981) and often overlook age related sexual dimorphic differences (Bocquet-Appel and Masset 1982).

Superimposing age structures on prehistoric populations based on techniques derived from modern populations is, at most, inexact. Making statements about past bio-cultural phenomenon based on questionable age structures is a more critical error. One good example of this type of error concerns the use of adult longevity as a measure of prehistoric health status. Lawrence Angel states that "for overall health, the simplest indicator is adult longevity" (Angel 1984: 52). This may be true under ideal circumstances. However, if present techniques do not allow for accurate adult age determinations, then any assessment of health based only on longevity may be inaccurate.

Bocquet-Appel and Masset (1982) contend that paleodemographic analyses are seriously flawed because of problems with aging adult skeletons. As Alan Goodman understates, "Age at death stands as perhaps the most important single indicator of stress" (1984: 17). So then does accuracy in age determinations stand as the most

important criteria for paleodemographic analysis. Since developmental criteria used for aging infants provides more accuracy than does degenerative changes in adults, infant mortality may perhaps be a better indicator of general health for prehistoric populations.

Sexing Techniques

Although determinations of sex for the adult skeletal remains were made, that information was deemed unnecessary for the focus of this study. Accordingly, sexes were pooled for the adult age category. Methods used for sexing the adult remains follow those outlined in Bass (1971).

II. Demographic Methods

The demographic methodological approach utilized in this study follows the mortality profile method which has been used to characterize the population structure of New World skeletal samples (Blakely 1971; Blakely 1977; Blakely and Matthews 1975; Snow 1948; Johnston and Snow 1961). This method allows for inter- and intra- site comparisons of mortality distributions in specified age intervals.

The mortality profile method was chosen over the commonly used life table approach (for a detailed description of the life table approach see: Ascadi and Nemeskeri 1970) for two important reasons. Primarily, life tables require specific age intervals for the entire

skeletal sample. As stated previously, the adults from the skeletal samples utilized were placed in general biological categories rather than chronological age intervals. This was largely due to intra-observer differences and the questionable techniques used for placing adults over 30 years in five and ten year age intervals.

The second purpose for choosing the mortality profile method over life tables concerns the prerequisites and assumptions involved in paleodemographic analysis with particular reference to the use of life tables. According to Ubelaker (1974: 5), the following prerequisites are necessary for demographic analysis:

(1) a knowledge of the completeness of the sample;

(2) information about the archaeological associations of the skeletons;

(3) a determination of the length of time the sample represents;

(4) an adequate assessment of sex and age at death;

(5) a proper selection of demographic methodology.

Angel (1969: 428) criticizes the use of life tables in that they rest on the following false assumptions:

1. That the cemetery represents a single generation cohort.

2. That death rates are even at all ages after infancy and hence directly reflected in cemetery age frequencies.

3. That the population is virtually stable biologically and socially over the period of cemetery use.

These prerequisites and assumptions also apply to the use of

mortality profiles, but to a much lesser degree.

Mortality profiles make no assumptions about survivorship, probability of dying, mean age at death, and life expectancy at birth. When these types of data are produced from life tables, the probability for error is greatly increased if all prerequisites for analysis are not fully adhered to. Also, mortality profiles in paleodemographic studies are most often used for general interpretations regarding mortality patterns in the archaeological record. With this method the chances of overinterpretation are reduced.

Age Intervals

The age intervals utilized were devised to best address the scope of the problem. For the purpose of this study, infant\weanling mortality refers to individuals dying before the fifth year as indicated by the skeletal remains recovered from each site. Infant and weanling are general age terms not easily definable. According to McElroy and Townsend, " weaning from the breast takes place at two to three years, occasionally even four years" (1979: 229).

Discussions of infant health and mortality in many paleodemographic and paleopathological studies often refer to individuals in the 0-5 year age interval (Blakely 1971 and 1977; Boyd 1984; Parham 1982). Paleodemographic profiles have shown a drastic reduction in childhood

mortality beginning at age five. One reason for this is that "by the age of five children grow less rapidly and therefore need fewer of the nutrients that had previously been essential" (Farb and Armelagos 1980: 80).

The infant\weanling category represents those individuals in the fetal to 4.9 year age interval. Ages 5 to 17.9 years were divided into three age intervals (5 to 9.9, 10 to 14.9, and 15 to 17.9). All adults were placed in the 18+ category.

The Sample

The Archaic sample consists of 495 individuals and the Mississippian sample is represented by a total of 747 individuals. Of these 1242 individuals, the infant\weanling category is represented by a total of 428 (Archaic N=123; Mississippian N=305). Because of the fragmentary nature of some of the remains, 7 Archaic and 4 Mississippian subadults could not be placed in a specific age interval. These were omitted from the samples. All burial information is on file at the Frank H. McClung Museum, Knoxville, Tennessee.

The Archaic sites chosen for this study (Anderson, Cherry, Eva II, Eva III, Ledbetter Landing, and Robinson) represent seasonally variable hunter-gatherer base camps. The Mississippian sites (Ledford Island and Dallas) represent Late Mississippian agricultural village and village mound complex sites. Furthermore, all sites were

chosen based on the preservational qualities of the skeletal remains.

<u>Sampling Problems</u>

Sample selection is as critical to archaeological demographics as is the proper use of aging techniques. Sample selection should take into account such things as differential preservation of bone, differing mortuary practices, and intersite variation. Since a variety of Archaic sites as well as Mississippian village and mound burials are represented in this study, sampling problems resulting in infant underrepresentation due to differing mortuary practices and intersite variation have been minimized. A more critical problem concerning the present study involves infant underenumeration resulting from differential preservation of bone.

Over 5000 human remains were examined during a National Science Foundation funded collections improvement project. During the course of inventorying and aging the skeletal remains utilized, a pattern of relatively good preservational condition and completeness for infant remains was noted by a team of nine skeletal analysis technicians. This pattern seems to indicate that the often cited underenumeration of infants due to differential preservation of bone may have been over emphasized.

Most paleodemographic research makes reference to only one, if any, study concerning the underrepresentation of infants in the archaeological record. Gordon and Buikstra's (1981) unprecedented study appears to be the only quantitative or qualitative analysis of biologic age related bone preservation. The authors found a correlation between soil acidity, bone preservation, and the biologic age of remains. However, it should be noted that all samples utilized for that study represent mound interments from two Late Woodland sites in the same biogeographic zone.

Since soil acidity and water percolation are interrelated due to changes in pH resulting from mineral leaching (U.S. Bureau of Plant Industry, Soils, and Agricultural Engineering 1962), skeletal remains recovered from mounds are more susceptible to the adverse affects of water percolation than non-mound burials. Furthermore, Gordon and Buikstra's study did not address the relationship between depth of burials in mounds and erosion due to such factors as plant and animal activity. Another factor overlooked in the study concerns the added problem of cultural underrepresentation of infants in mounds. Results from other studies involving Mississippian sites (Blakely 1977; Blakely and Mathews 1975), including the present, indicate that less than 3% of the mound burials are represented by individuals in the 0 - 5 year age interval. Although Mississippian and Woodland mounds may differ in a

functional sense, cultural determinants of mortuary placement were probably operating at both. It is uncertain what role differential preservation has in this distribution, but the social status of infants certainly had an effect.

Clearly, a more detailed analysis of the problem of infant underrepresentation is warranted before any conclusive statements can be made regarding the sampling and preservational quality of infant remains in the archaeological record. Although the present study was not designed as an empirical test of the representativeness of infant remains, the paleodemographic patterns that emerge for the infant age interval distribution should provide some insight into the utility of the sample. If infants are underrepresented due to differential preservation, treatment, or recovery of remains, then significant differences in the distribution of infants should occur between sites.

Statistical Method

The Kolmogrov-Smirnov two-sample test was chosen as the most appropriate statistical method for the paleodemographic comparisons. This test is applicable for two samples of statistically valid size, two samples which have been measured into ordinal categories, and for data which have been arranged into sets of cumulative proportions (Thomas

1976: 322-326). The data from this study meet each of these criteria.

The cumulative proportion of individuals for each age interval represented at each site was computed. The Kolmogorov-Smirnov test compares the difference between the cumulative proportion of all age intervals for each sample (site). The largest observed difference (D) between age intervals from two sites is chosen and compared to the Kolmogorov-Smirnov critical value table (Thomas 1976: Table A.8(b), p.505). When the observed difference (D) does not exceed the critical value for the appropriate level of significance, the null hypothesis of no significant difference between the samples is accepted. If the computed D value exceeds the critical value, the null hypothesis is rejected. The formula for the Kolmogorov-Smirnov test at the 0.05 level is: $1.36\sqrt{\frac{n_1+n_2}{n_1n_2}}$

For statistical comparison each Archaic site was independently tested against all others at the 0.05 level of significance. The Archaic sites were then combined into shell and non-shell midden categories for further comparison since preservation at shell midden sites should be better. The two Mississippian samples were also tested against each other. Finally, the Archaic shell midden and non-shell midden categories were compared both separately and combined to the Mississippian samples. It was expected that there

would be no statistical differences within the Archaic samples and within the Mississippian samples. However, a statistically significant difference should occur between the Archaic and Mississippian samples due to differing subsistence and settlement strategies.

CHAPTER IV

RESULTS

I. Site Comparisons

Archaic Non-Shell Midden Sites

The results in Tables 2 and 3 show the percentage of individuals dying before the fifth year at the Late Archaic Cherry (12.5%) and Ledbetter sites (15.79%). Tables 4 and 5 show the percentage of individuals dying by age five during the Late Archaic component at Eva (14.04%) as well as a percentage from the three Archaic non-shell midden sites combined (14.41%). There appears to be only a relatively minor difference between the three sites in terms of infant\weanling mortality.

A Kolmogorov-Smirnov two-sample test was conducted comparing each site against all others. In each case the observed difference did not exceed the critical value required for rejection of the null hypothesis. No significant differences exist between the sites at the 0.05 level. The mortality curves in Figure 2 illustrate the comparability of the results for the Archaic non-shell midden samples.

Archaic Shell Midden Sites

The results from Tables 6 and 7 show the percentage of individuals dying before the fifth year at the Middle

TABLE 2. Frequencies & Percentages of Death at the Cherry Site

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	9	9	12.50	12.50
5 - 9.9	7	16	9.72	22.22
10 - 14.9	4	20	5.56	27.78
15 - 17.9	4	24	5.56	33.34
18 +	48	72	66.66	100.00

N = 72, sexes combined

TABLE 3. Frequencies & Percentages of Death at the Ledbetter Landing

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	18	18	15.79	15.79
5 - 9.9	10	28	8.78	24.57
10 - 14.9	3	31	2.63	27.70
15 - 17.9	7	38	6.14	33.34
18 +	76	114	66.66	100.00

N = 114, sexes combined

TABLE 4. Frequencies & Percentages of Death at the Eva III Site

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	8	8	14.04	14.04
5 - 9.9	1	9	1.75	15.79
10 - 14.9	0	9	0.00	15.79
15 - 17.9	0	9	0.00	15.79
18 +	48	57	84.21	100.00

N = 57, sexes combined

TABLE 5. Frequencies & Percentages of Death for Archaic Non-Shell Midden Sites

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	35	35	14.41	14.41
5 - 9.9	18	53	7.41	21.82
10 - 14.9	7	60	2.88	24.70
15 - 17.9	11	71	4.52	29.22
18 +	172	243	70.78	100.00

N = 243, sexes combined

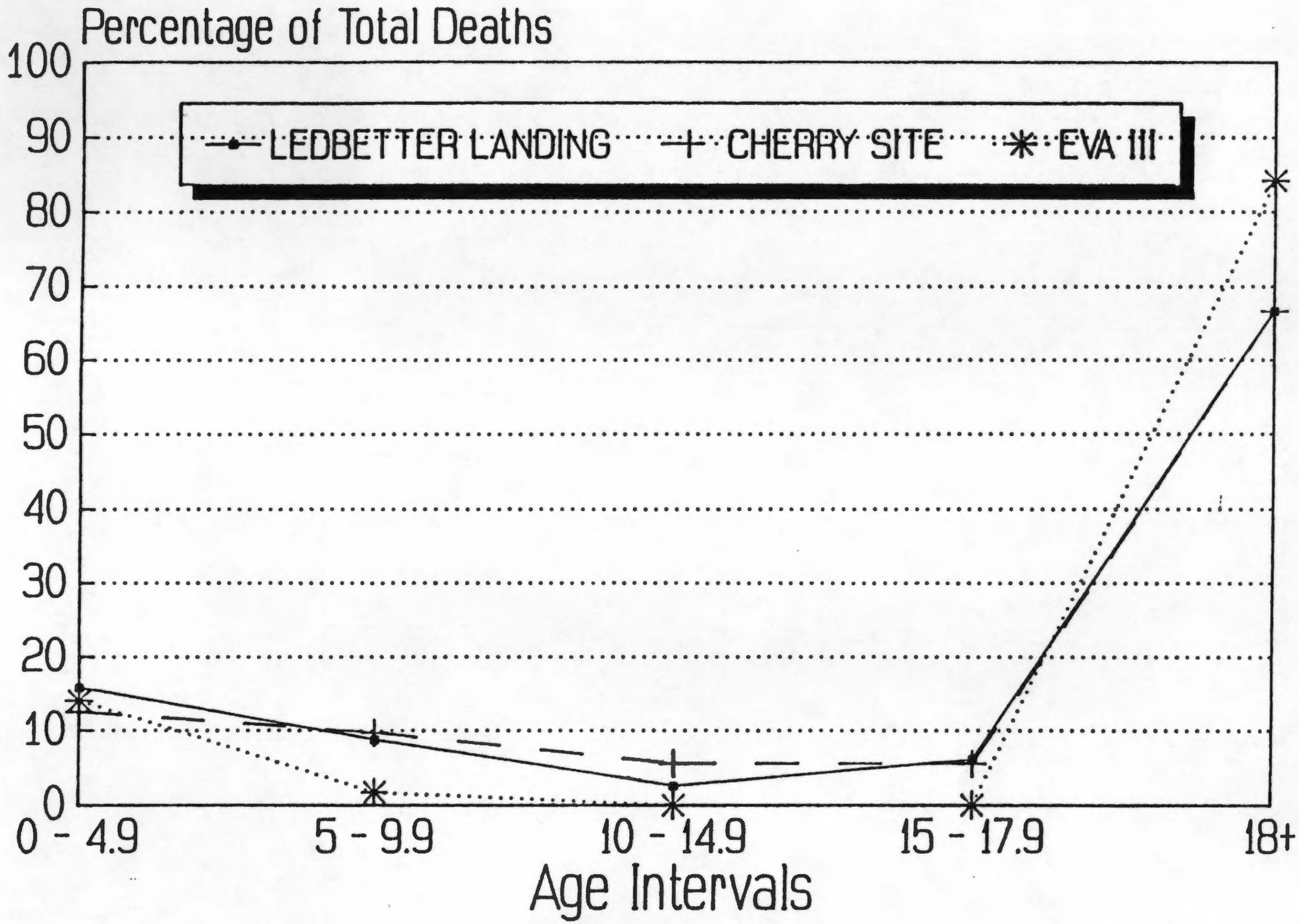

FIGURE 2. Comparison of Mortality Distributions Between the Archaic Non-Shell Midden Sites. A Kolmogorov-Smirnov test indicates no significant difference at the 0.05 level of confidence.

TABLE 6. Frequencies & Percentages of Death at the Anderson Site

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	18	18	24.66	24.66
5 - 9.9	3	21	4.11	28.77
10 - 14.9	7	28	9.59	38.36
15 - 17.9	2	30	2.74	41.10
18 +	43	73	58.90	100.00

N = 73, sexes combined

TABLE 7. Frequencies & Percentages of Death at the Eva II Site

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	29	29	24.79	24.79
5 - 9.9	4	33	3.42	28.21
10 - 14.9	4	37	3.42	31.63
15 - 17.9	5	42	4.27	35.90
18 +	75	117	64.10	100.00

N = 117, sexes combined

Archaic shell midden Anderson (24.66%) and Eva II (24.79%) sites. Table 8 shows the percentage of individuals dying in the 0 - 5 year age interval at the Late Archaic Robinson (22.58%) shell midden site. Table 9 shows the percentage of individuals dead by age 5 in the combined Archaic shell midden sample. As before, a Kolmogorov-Smirnov test was conducted between all of the shell midden sites with no significant differences at the 0.05 level. Figure 3 illustrates the comparability of the mortality profiles for the shell midden sites.

Shell and Non-Shell Midden Sites

A Kolmogorov-Smirnov test was conducted comparing each of the six Archaic sites against all others independant of their respective shell and non-shell categories. No significant differences at the 0.05 level were found. The non-shell midden and shell midden groups were then compared with no significant difference occurring. Figure 4 represents the mortality profiles for the two groups based on the distributions from Tables 5 and 9. Since no significant difference exists between the non-shell and shell midden samples in terms of infant\weanling mortality, both groups were combined into one Archaic sample (Table 10) for a later comparison with the Mississippian sample.

TABLE 8. Frequencies & Percentages of Death at the Robinson Site

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	14	14	22.58	22.58
5 - 9.9	2	16	3.22	25.80
10 - 14.9	3	19	4.84	30.64
15 - 17.9	3	22	4.84	35.48
18 +	40	62	64.52	100.00

N = 62, sexes combined

TABLE 9. Frequencies & Percentages of Death for Combined Archaic Shell Midden Sites

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	61	61	24.21	24.21
5 - 9.9	9	70	3.57	27.78
10 - 14.9	14	84	5.55	33.33
15 - 17.9	10	94	3.97	37.30
18 +	158	252	62.70	100.00

N = 252, sexes combined

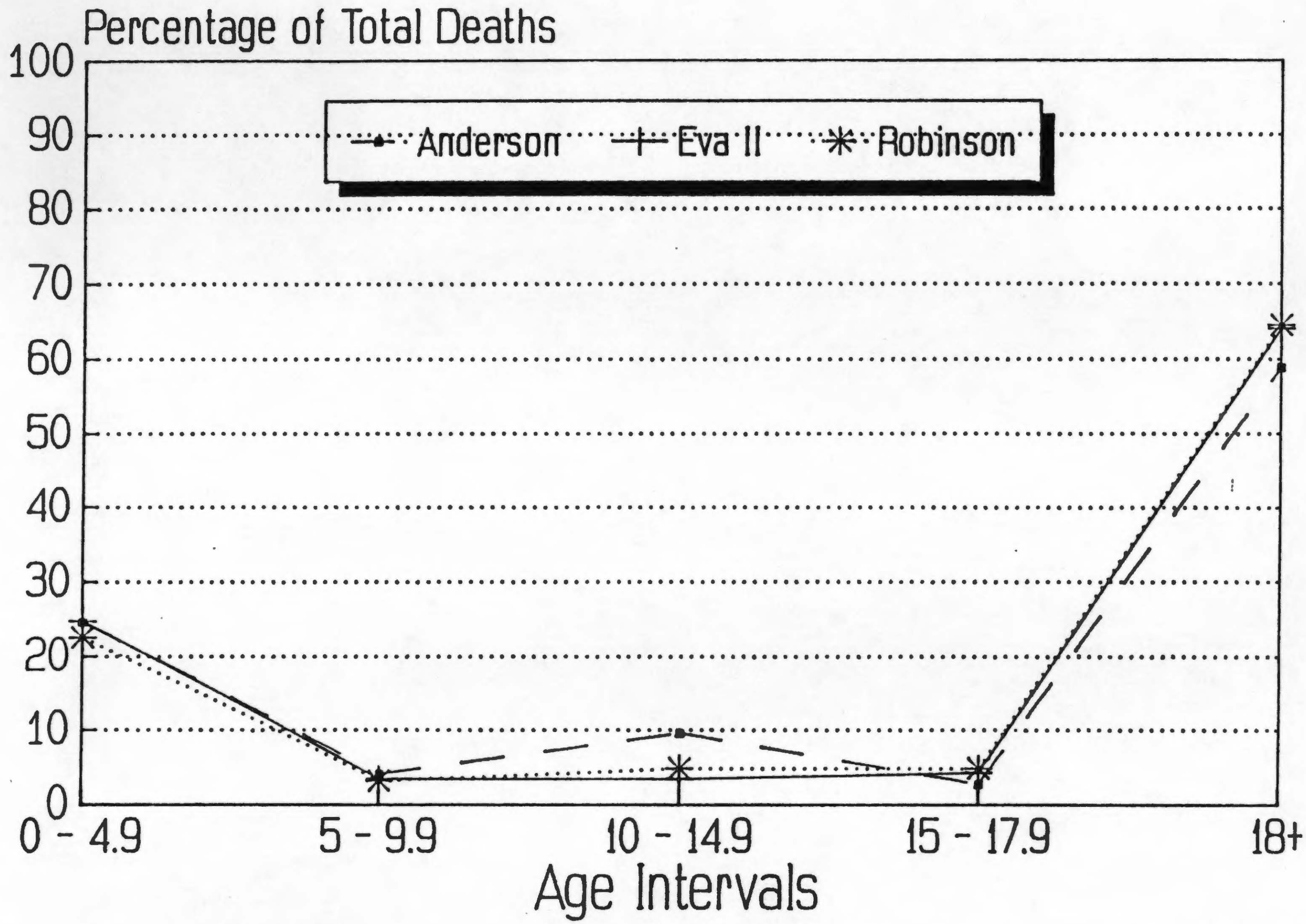

FIGURE 3. Comparison of Mortality Distributions Between the Archaic Shell Midden Sites. A Kolmogorov-Smirnov test indicates no significant difference at the 0.05 level of confidence.

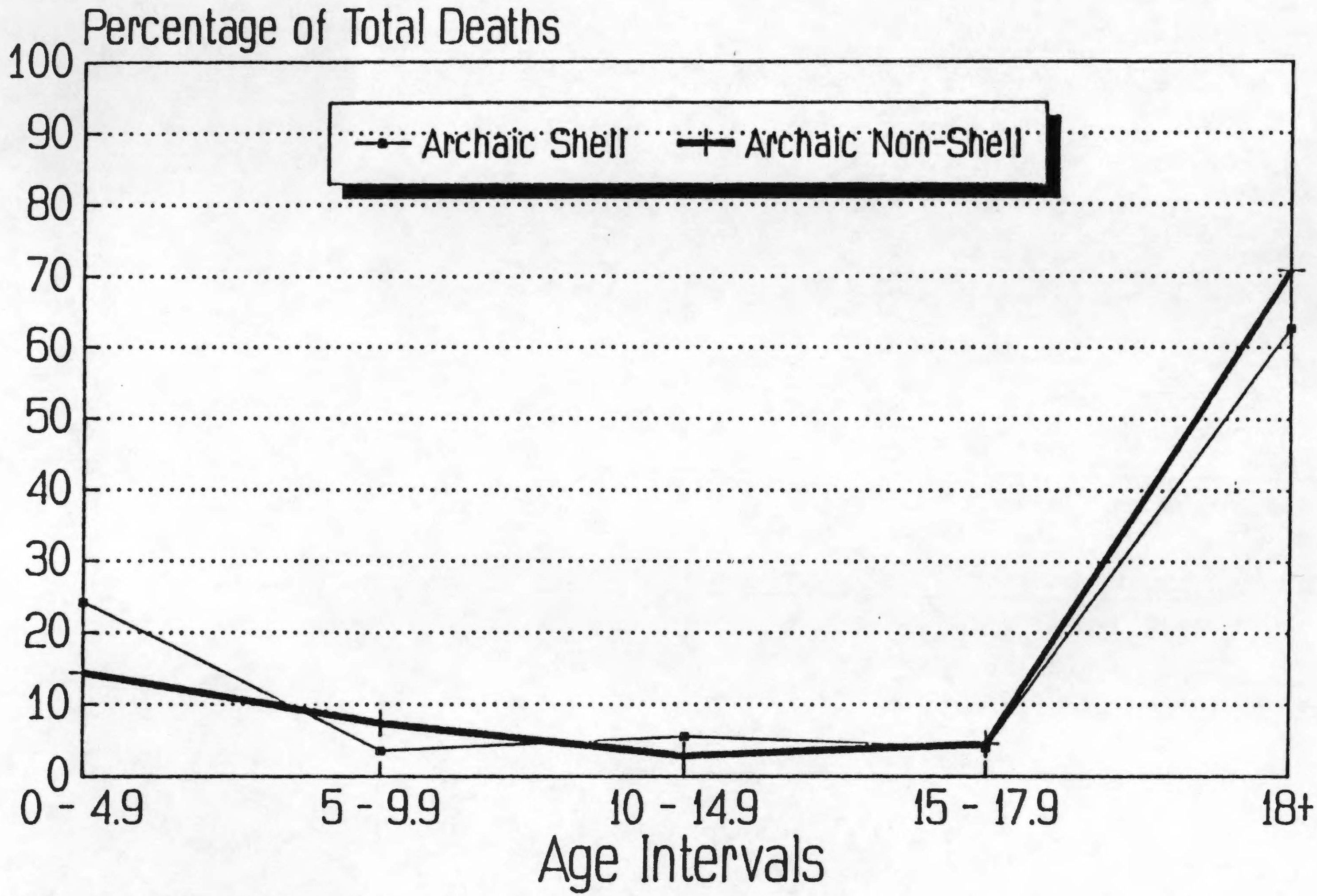

FIGURE 4. Comparison of Mortality Distributions Between the Archaic Shell and Non-Shell Midden Sites. A Kolmogorov-Smirnov test indicates no significant difference at the 0.05 level of confidence.

TABLE 10. Frequencies & Percentages of Death for Archaic Combined

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	96	96	19.40	19.40
5 - 9.9	27	123	5.45	24.85
10 - 14.9	21	144	4.24	29.09
15 - 17.9	21	165	4.24	33.33
18 +	330	495	66.67	100.00

N = 495, sexes combined

Mississippian Sites

Tables 11 and 12 show the percentage of individuals dying before the fifth year at the two Mississippian sites. The results indicate that 39.36% of the individuals from the Dallas site died before the age of five while 28.60% from Ledford Island died by age five. Although the difference between Dallas and Ledford Island is larger than expected (but not significant at the 0.05 level), the combined average (Table 13) is 32.66% which compares very well with results for early agriculturalists from Illinois [31% (Blakely 1971; Table 2, p.48)], Kentucky [33% (Cassidy 1984; Table 12.5, p.320)], Georgia [32% (Blakely 1977; Figure 2, p.49)] and Tennessee [35% (Parham 1982: 35)]. Figure 5 is a comparison of the mortality curves for the Mississippian sites. Figure 6 provides a graphic display of the difference in infant\weanling mortality between the Archaic and Mississippian samples.

II. Discussion

Archaic Results

The 10% increase (Figure 4) in the distribution of individuals less than 5 years of age from the Archaic non-shell midden sample to the shell midden sample may be the result of several factors. This difference could reflect a slightly better preservational quality of bone at the

TABLE 11. Frequencies & Percentages of Death at Dallas

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	111	111	39.36	39.36
5 - 9.9	27	138	9.57	48.94
10 - 14.9	13	151	4.61	53.55
15 - 17.9	10	161	3.55	57.09
18 +	121	282	42.91	100.00

N = 282, sexes combined

TABLE 12. Frequencies & Percentages of Death at Ledford Island

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	133	133	28.60	28.60
5 - 9.9	34	167	7.31	35.91
10 - 14.9	17	184	3.66	39.57
15 - 17.9	7	191	1.51	41.08
18 +	274	465	58.92	100.00

N = 465, sexes combined

TABLE 13. Frequencies & Percentages of Death for Combined Mississippian Sites

Age Intervals	Frequencies	Cumulative Frequencies	%	Cumulative %
Fetal - 4.9	244	244	32.66	32.66
5 - 9.9	61	305	8.17	40.83
10 - 14.9	30	335	4.02	44.85
15 - 17.9	17	352	2.28	47.12
18 +	395	747	52.88	100.00

N = 747, sexes combined

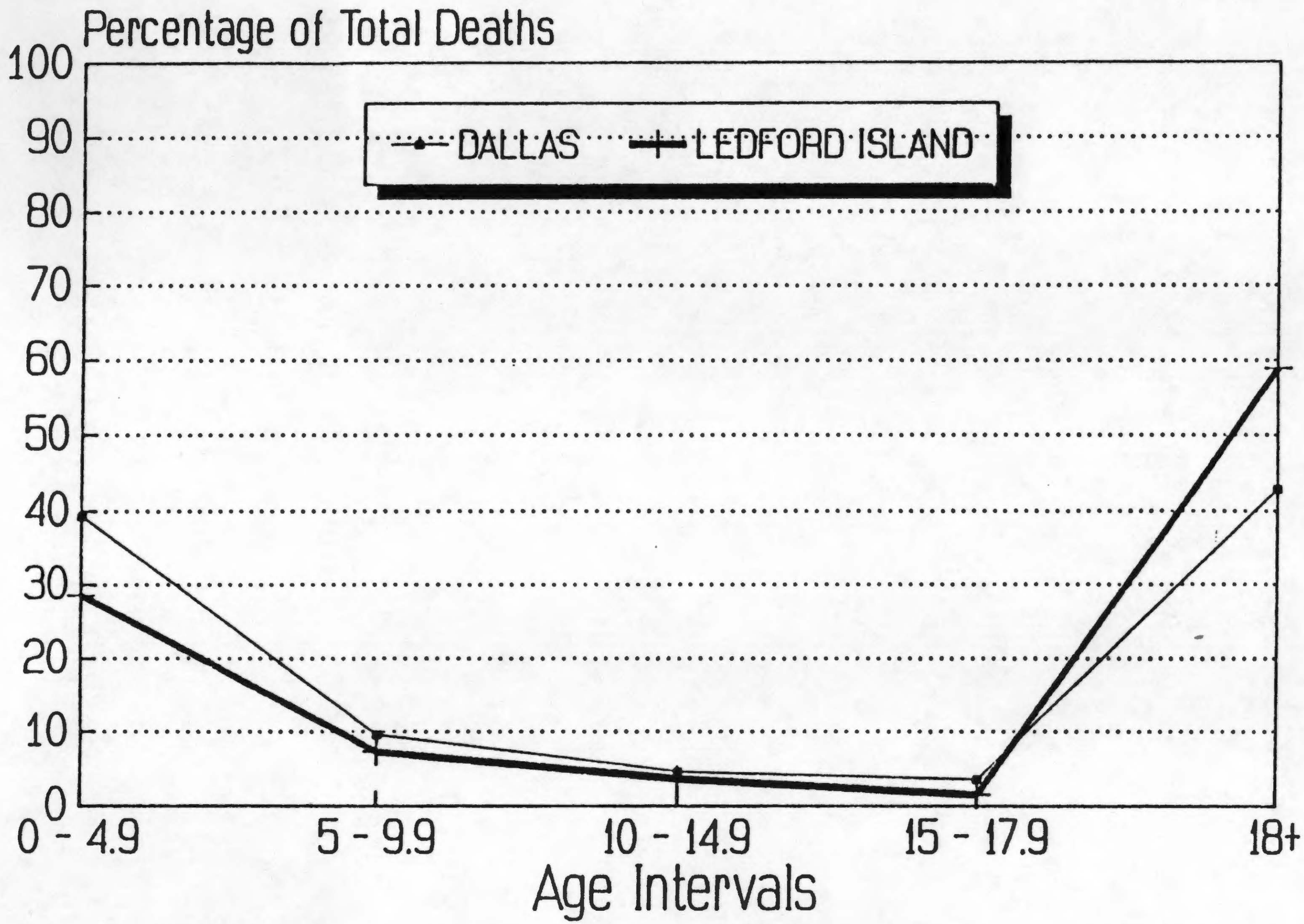

FIGURE 5. Comparison of Mortality Distributions for the Two Mississippian Sites. A Kolmogorov-Smirnov test indicates no significant difference at the 0.05 level of confidence.

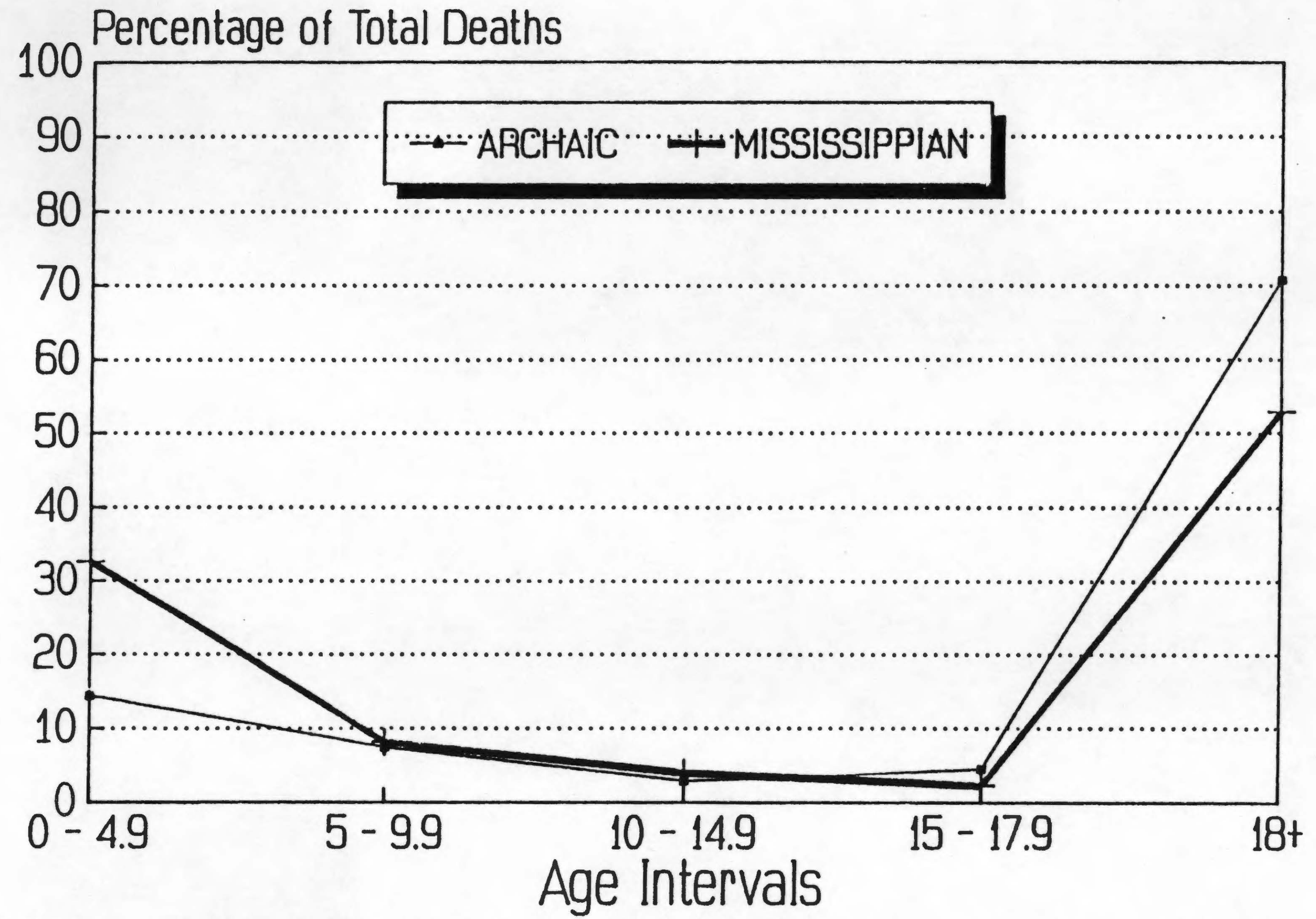

FIGURE 6. Comparison of Mortality Distributions Between the Combined Archaic and Combined Mississippian Samples. A Kolmogorov-Smirnov test indicates a significant difference between the two at the 0.05 level of confidence.

Anderson, Eva II, and Robinson sites due to the proximity of shell. The high concentrations of calcium in the middens would certainly have some effect on bone preservation. However, the preservational difference for infants between the two groups of sites does not appear to be statistically significant.

Another possibility concerning the disparity in infant representation between the Archaic shell and non-shell midden sites is that the difference reflects an elevated mortality due to subsistence related factors. The presence of large quantities of shellfish at some Archaic sites has been used as an indicator of population and resource stress (Osborn 1977; Cohen 1975). Currently, there is little evidence to suggest a difference in nutritional stress between the two groups. Klippel and Morey (1986) propose that:

> stress among Archaic hunter-gatherers in the Midsouth would have been greatest during late winter and early spring, precisely the period when gastropods would be most difficult to collect on a regular basis. Alternatively, summer and fall are more likely as periods of gastropod procurement on purely practical grounds but, outside their relatively rich mineral composition, it is difficult to imagine their dietary role as anything but an easily obtained supplement.

If dietary stress among Archaic populations was in fact greater during the winter and spring months, then a higher infant mortality rate should be reflected in the Cherry and Eva III non-shell midden samples. The results from this

study suggest that nutritional stress was not a major factor affecting the differences in infant\weanling mortality between the Archaic shell and non-shell midden sites.

A third likelihood regarding the difference in infant representation between the two Archaic groups concerns settlement related factors. Hofman's (1986) study of hunter-gatherer mortuary variability in the Middle South found that:

> hunter-gatherer societies relying upon resources which are seasonally variable in productivity and place of occurrence will typically exhibit cyclical variation in group organization, including periods of aggregation (maxiband or reproductive group) and periods of fission or dispersal (miniband or subsistence group). (1986: 55).

Hofman further proposes that Archaic shell middens in the Middle South represent "aggregation" sites (1986: 4).

As with the present study, Hofman also noted a higher frequency of infant remains present at Archaic shell midden sites (1986: 183). Hofman attributes this pattern to the correlation between fetal\infant deaths and seasonal peak birth periods which, according to the author, "may well have been between late spring and early fall, or the period of least inclement weather and when aggregation site occupation was most likely" (1986: 183-184). This proposal is plausible given the susceptibility of infants to density dependant health problems that might occur when population density increases during aggregation.

While results from the two studies relating to infant\weanling mortality are very similar, one difference exists which should be noted. Hofman's (1986) research utilized four of the six Archaic sites (Anderson, Cherry, Eva II, and Eva III) employed for the present study. Hofman's Kolmogorov-Smirnov results from the four sites were identical to the present study's except when comparing the Late Archaic non-shell midden Cherry and Eva III components. Hofman did find a significant difference between these two sites, but only in the 30-34 year age group (1986: 197). This difference has no affect on the overall results of either study and may only be due to the different age categories used for the adult remains.

Mississippian Results

When comparing the Mississippian samples the percentage of infants represented at the Dallas site is higher, though not significantly, than at Ledford Island (Figure 5). The lower infant representation at Ledford Island was also noted by Boyd (1984) along with a lower frequency of nutritional and infectious disease related pathologies compared to other Late Mississippian sites. One possibility mentioned for this difference concerns variation in the degree of maize reliance between Mississippian sites (Boyd 1984).

Results from the Mississippian sample show a significant increase over the Archaic sample in the 0-5 year

age distribution (Figure 6). This difference comes as no surprise due to subsistence and settlement related differences between the Archaic and Mississippian samples. The broad spectrum diet and relatively low population density during the Archaic period probably reduced the potential for nutritional stress and infectious diseases. The low protein, high carbohydrate diet, and increased population nucleation during the Mississippian period could result in an elevated mortality for infants and children due to the synergistic effects of malnourishment and disease. While the paleodemographic results suggest differences between the Tennessee Archaic and Mississippian populations in terms of overall health, paleopathological indicators of stress should also be considered before any conclusive statements can be made. The Kolmogorov-Smirnov results for the Archaic Shell Midden, Non-Shell Midden, and Mississippian comparisons are shown on Table 14.

TABLE 14. Kolmogorov-Smirnov Results from Comparison of Three Site Groups.

	Archaic Non-Shell Midden Sites Combined	Archaic Shell Midden Sites Combined	Mississippian Sites Combined
Archaic Non-Shell Sites	-	D=.098	D=.2015 *
Archaic Shell Sites	D=.098	-	D=.130 *
Mississippian Sites	D=.2015 *	D=.130 *	-

D = observed difference
* = denotes statistically significant difference

CHAPTER V

PALEOPATHOLOGY

I. Introduction

Although this is primarily a paleodemographic study, any discussion involving comparisons of overall health and nutrition between populations relying on different subsistence strategies should also take into consideration frequency variations of specific physiologic stress indicators. Mensforth et al. (1978: 2) state :

> The study of human paleopathology is concerned with disease process as a selective agent in the evolutionary history of our species. As an evolutionary biologist, the paleopathologist attempts to describe, to classify, and to interpret the epidemiological parameters of disease in human populations. The objectives of such studies should be twofold: first, to employ disease patterns to evaluate the relative fitness of a human population under stress; and second, to analyze the interactions among cultural, biological and environmental components of disease process as they contribute to the nature and scope of human variation.

According to Rathbun et al., "It is increasingly important to attempt to evaluate the general health/disease patterns of past populations rather than emphasizing single traits" (1980: 52). The following discussion will address a few indicators of physiologic stress evident on human skeletal remains which will shed light on health and nutritional differences between the hunter-gatherer and agricultural food economies.

Previous Research

Physiological stress is due to a "disruption in the biological homeostasis of an organism caused by a maladjustment to its environment..."(Jablonski 1983: 4). Abundant literature exists outlining specific and non-specific indicators of nutritional stress which are identifiable in human bone and dentition. In almost every study available there appears to be a clear trend of increasing frequencies of skeletal change and pathologies related to nutritional stress accompanying the transition from hunting-gathering to agriculture. This trend has been noted using such non-specific indicators as relative length-for-age of long bones and cortical thickness of bone (Buikstra and Cook 1984; Cassidy 1984; Goodman et al. 1984; Smith et al. 1984). Decreasing stature and reduced skeletal robusticity also seem to indicate a decline in the quality of nutrition among farming peoples (Angel 1984; Kennedy 1984; Larsen 1984; Meiklejohn 1984). Studies involving more specific and severe indicators of stress require a more detailed discussion.

Dental Stress

Disruptions in the enamel development of teeth due to poor nutrition and other stressors can result in several types of dental stress. Two of the most common dental stress measures used in nutritonal studies are pathological

enamel bands and enamel hypoplasias. A pathological band, or Striae of Retzius, "forms in the enamel of teeth which are developing during a stress episode suffered by an individual" (Jablonski 1983: 12-13). Enamel hypoplasias can be defined as compressed Striae of Retzius along with structureless surface enamel (Jablonski 1983). Several studies have shown an increase in these two stress indicators with the change from hunting-gathering to agriculture (Allison 1984; Angel 1984; Buikstra and Cook 1984; Cassidy 1984; Goodman et al. 1984; Kennedy 1984; Perzigian et al. 1984; Smith et al. 1984; and Ubelaker 1984). Jablonski (1983), utilizing samples from several Tennessee sites included in the present study, found an increase in the frequency of pathological enamel bands from the Archaic through the Mississippian time periods. Thus, the contention of increasing stress through time has been supported through previous research involving dental stress.

Porotic Hyperostosis

Porotic hyperostosis is a term referring to pathological lesions which are confined primarily to the cranial vault and eye orbits (Angel 1966). These lesions are typically displayed by a "widening of the diploe, thinning of the outer table, and the presence of small apertures, giving a coral or sieve - like appearance to the bone" (El-Najjar et al. 1976: 477). Porotic hyperostosis

can be broken down into three basic types: osteoporotic pitting, the more severe spongy hyperostosis, and the inner eye orbital manifestation called cribra orbitalia (Carlson et al. 1974). Figures 7,8, and 9 represent good examples of these types found at three Mississippian sites. In the Old World, porotic hyperostosis has been shown to result from iron deficiency anemia (Carlson et al. 1974; Sandford et al. 1983), malaria and other blood related diseases (Angel 1966). However, Angel (1966) indicates that malaria and other blood related pathologies were restricted to the Old World before European contact with New World populations.

There is a general consensus that the etiology of porotic hyperostosis in the New World can best be understood in terms of nutritional deficiencies, particularly iron deficiency resulting in anemia (El-Najar et al. 1976; Lallo et al. 1977; Palkovich 1987; Parham 1982). The manifestation of iron deficiency anemia in young children, porotic hyperostosis, results from insufficient hematopoetic marrow expansion due to the natural distribution of yellow marrow. In adults, the increased demand for red blood cells brought on by anemia is possible because of a higher yellow marrow content. In children, pathogenesis occurs when marrow is forced to grow outward (Stuart-Macadam 1985).

Several factors affect the bioavailability of iron in maize. The presence of phytic acid in maize as well as the deficiency of lysine and tryptophan results in a decrease in

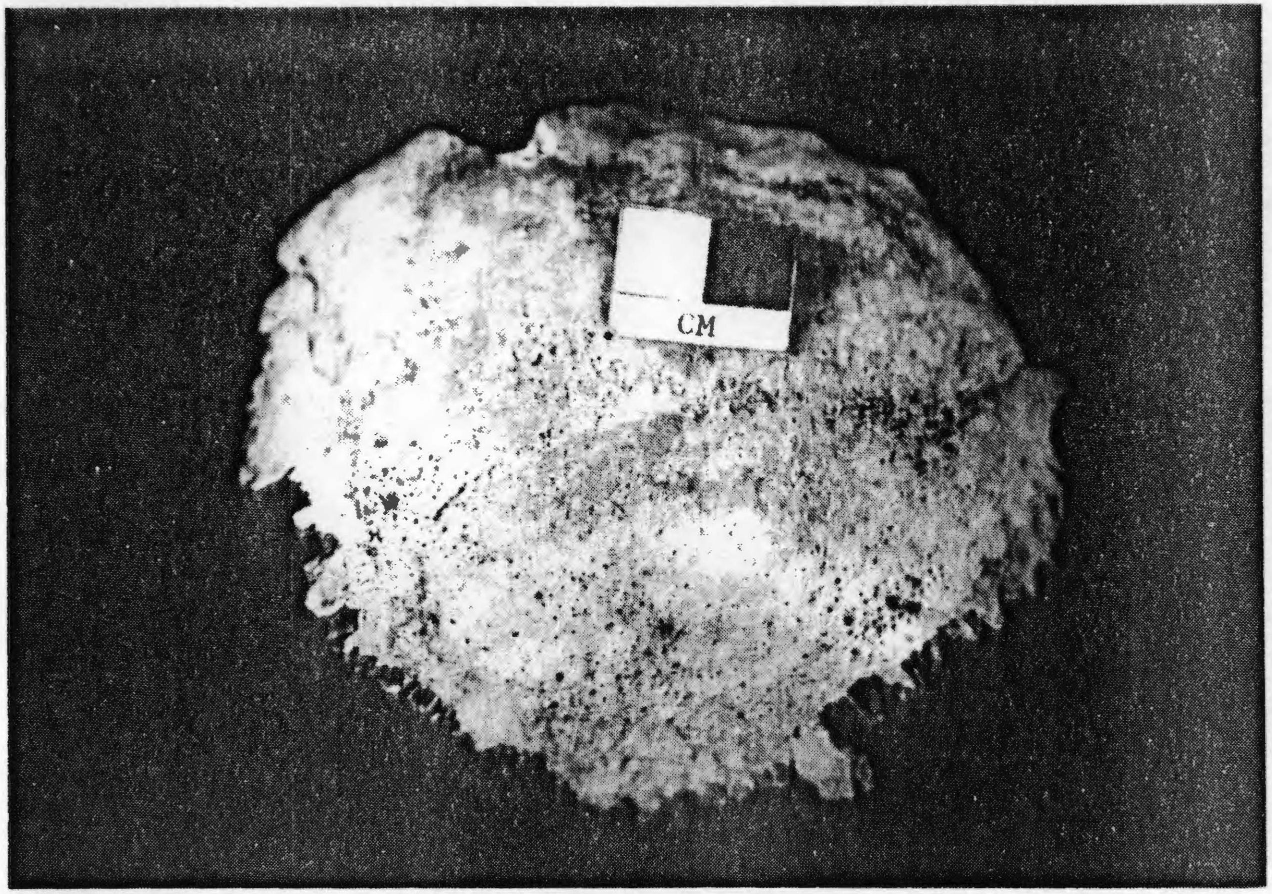

FIGURE 7. Infant Occipital from Dallas (8Hal) Burial - 113. Showing Calvarial Porosity.

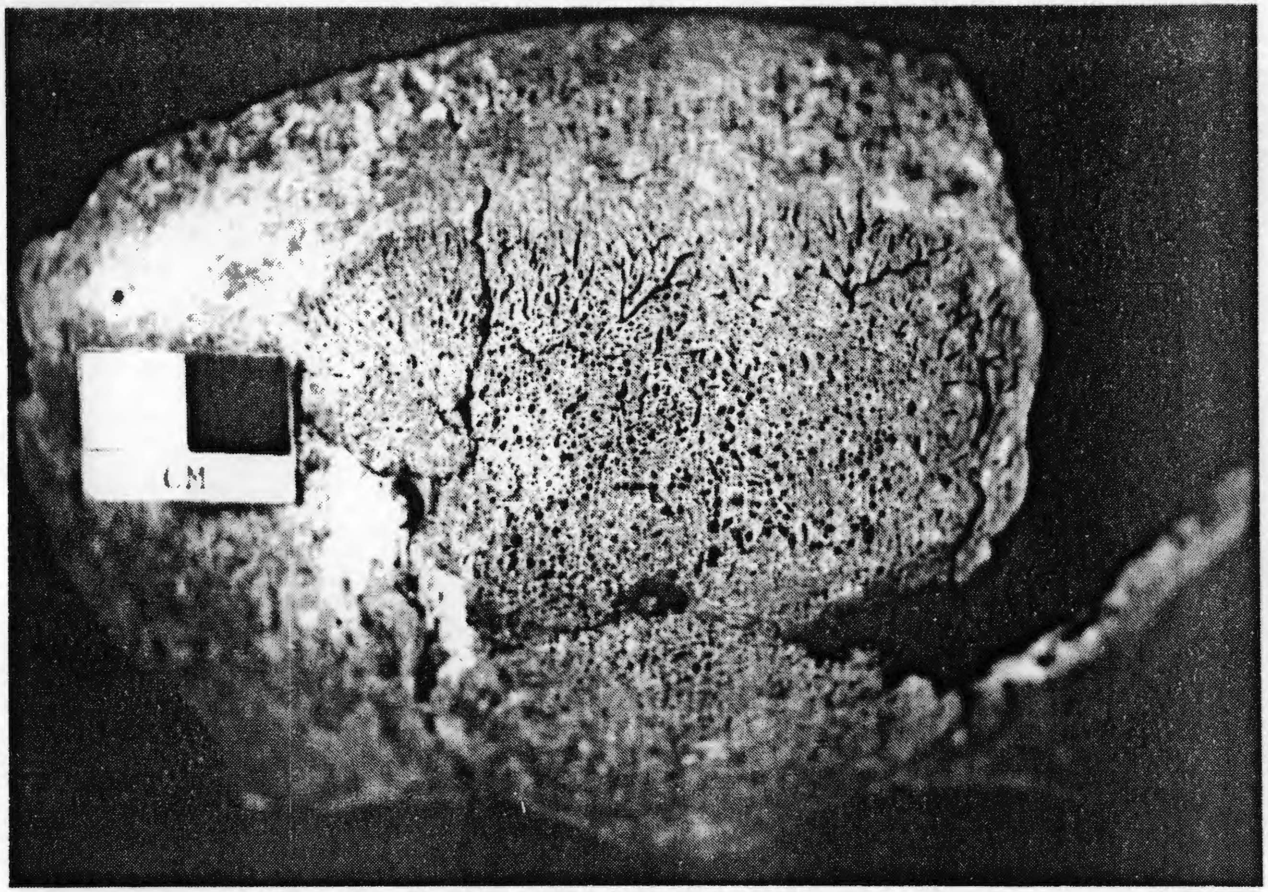

FIGURE 8. Child's Frontal from Hiwassee Island (38Mg31) Burial - 31 Showing Spongy Hyperostosis.

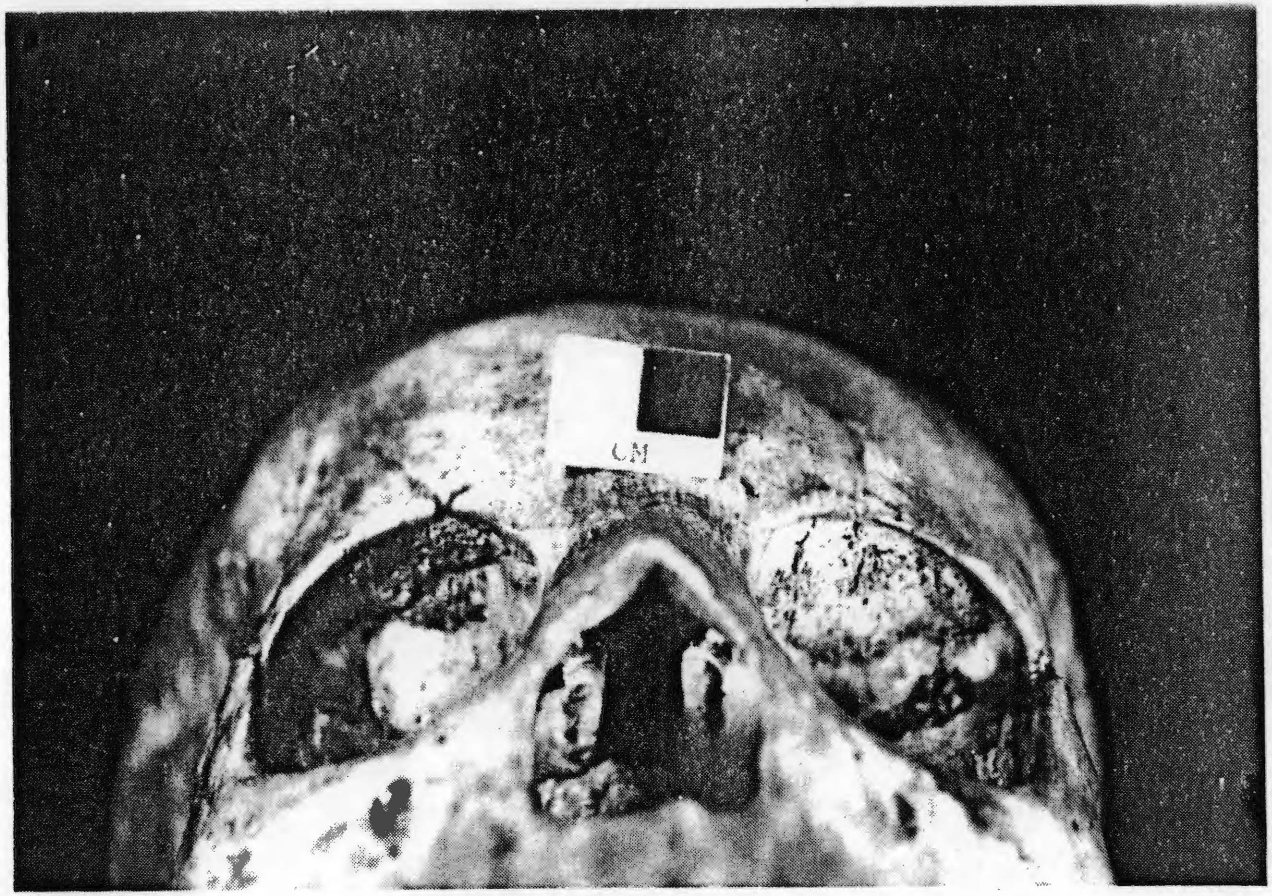

FIGURE 9. Infant from Sale Creek (65Ha32) Showing Cribra **Orbitalia** on Inner Eye Orbit Walls. Note: Nasal area reconstructed from clay.

iron absorbability (El-Najjar et al. 1976). Iron absorption can be further reduced by excessive calcium intake and high carbohydrate-low meat diets (El-Najjar et al. 1976). Infants and children of maize agriculturalists should be particularly succeptible to this condition due to their natural marrow distribution, high calcium ingestion from mother's milk, and an iron-poor diet during and after weaning. The increase in the frequency of this pathology coincides well with the increased reliance on maize among early farmers in the New World.

Adequate evidence from numerous studies (Boyd 1984; Carlson et al. 1974; El-Najjar et al. 1976; Allison 1984; Buikstra and Cook 1984; Cassidy 1984; Goodman et al. 1984; Parham 1982; Perzigian et al. 1984; Rose et al.1984; and Ubelaker 1984) conclude that a definite relationship exists between iron deficiency anemia, and increased reliance on maize agriculture. Cohen (1987: 270) notes that such studies suggest:

> that farming resulted in a decline in the overall quality of nutrition. The clearest indicator of this is provided by incidence of porotic hyperostosis and cribra orbitalia (porosity of the skull and orbits), considered indicative of anemia.

However, most of the studies cited involve comparisons of Woodland and Mississippian populations. One notable exception to this is Claire Cassidy's (1984) in-depth analysis and comparison of nutritional stress indicators

between Kentucky's Indian Knoll Archaic and Hardin Village Mississippian populations.

Cassidy's reevaluation of Indian Knoll contradicted earlier findings (Snow 1948) regarding the presence of nutritional related pathologies. For example, Snow cited frequent porotic hyperostosis in the Indian Knoll sample as "evidence of some kind of dietary deficiency" (1948: 498). However, Cassidy (1984: 325) found less frequent pitting of cranial vaults and orbits from which she concluded that:

> these changes were not classical osteoporosis symmetrica, and not pathological, and that anemia was not prevalent at Indian Knoll. Significantly, childen under five, the group most likely to suffer iron deficiency anemia, had the lowest frequencies of change.

These findings come as no surprise due to the extensive reliance on meat and the absence of maize in the diet of the Indian Knoll Archaic population. The availability of terrestrial animals as well as aquatic resources served as a good source of iron in the Archaic diet. According to Klippel and Morey (1986), aquatic shellfish meat contains high concentrations of iron and calcium as well as sufficient amounts of potassium, phosphorous, and sodium. The abundance of both terrestrial and aquatic faunal remains from Archaic sites as an important source of vitamins and minerals corresponds well with the paleopathological record.

In her analysis of the Hardin Village Misssippian population, Cassidy found that porotic hyperostosis "of

classical character affected individuals of all ages but was commonest in children under six and women aged 30 - 39 years, age groups commonly affected by iron deficiency anemia,..." (1984: 330). Cassidy also found a much higher frequency of other nutritional stress related pathologies at Hardin Village such as severe enamel hypoplasias, periosteal infections, and reduced cortical bone thickness.

Paleopathology of the Present Sample

Like Cassidy's study, although much more extensive in terms of number of sites and sample size, the present research involves a comparison of the nutritive health of Archaic hunter-gatherers to that of Mississippian agriculturalists. The pathological manifestation of iron deficiency anemia, porotic hyperostosis, is examined through a paleopidemeological approach. This approach "views disease in terms of population fitness and the interaction between biological, cultural, and environmental factors" (Parham 1982: 149).

Since infants and young children are more susceptible to iron deficiency anemia, and because the focus of this study is infant\weanling mortality, only those individuals in the 0 - 5 year age interval were analyzed for incidence of porotic hyperostosis. The cranial vault and orbital region of skeletal remains from five Archaic sites and one Mississippian site were examined for evidence of any stage

of porotic hyperostosis.

In many cases, due to the fragmentary nature of infant skulls and the thinness of the eye orbital walls, it was difficult to determine if both calvarial (cranial vault) porosity and cribra orbitalia were present. For this reason, both conditions were placed under the general heading of porotic hyperostosis which was scored if either were present. Individuals missing both the cranial vault and the orbital region were omitted from the sample. Between-site comparisons were made as well as further comparison with previous relevant research involving incidence of porotic hyperostosis at similar sites.

Statistical Method

The bivariate chi-square test of association was chosen for statistical comparisons of the frequency of porotic hyperostosis between Archaic and Mississippian sites. This method is appropriate for nominal data when total sample size is greater than 40 (Thomas 1979: 272 - 279). The bivariate chi-square requires the construction of a 2x2 contingency table which presents a two-way classification of variables. The calculated chi-square statistic is then compared to the tabled value (Thomas 1979: Table A.5, pp. 498-499). If the calculated statistic does not exceed the tabled value, the null hypothesis of no association is accepted. If the calculated value exceeds the table value,

the null hypothesis is rejected. Because of the almost complete absence of porotic hyperostosis among the Archaic samples, these were combined and then compared to the Dallas Mississippian sample.

II. Results

Comparison of Archaic Sites

In light of previous research involving hunter-gatherer health, a low frequency of porotic hyperostosis was expected for the Archaic sites. Results from the analysis of the remains from the Archaic sites are provided in Table 14. The only site not personally analyzed for pathologies was the Anderson site. According to Joerschke, some of the types of pathologies absent at the site are "bone pathologies generally associated with Vitamin D deficiency, i.e., rickets and osteomalacia, or those associated with iron deficiency anemia, i.e., cribra orbitalia and porotic hyperostosis" (1983: 87-88).

From the remaining five Archaic sites analyzed, only one case of porotic hyperostosis was observed. Burial 7 from the Robinson site contained the remains of a 3 to 4 year old child which exhibited slight calvarial porosity. However, the burial records from the site indicate that this burial was recovered from the plow zone (on file: McClung Museum). The association of Burial 7 with the Late Archaic component is questionable.

TABLE 15. Comparison of Frequencies and Percentages of Porotic Hyperostosis Observed at Archaic and Mississippian Sites

Archaic	n	Frequency	%
Anderson	18	0	0
Cherry	9	0	0
Eva II	29	0	0
Eva III	8	0	0
Ledbetter Landing	18	0	0
Robinson	14	1	7.14
Mississippian	**n**	**Frequency**	**%**
Dallas	101	42	41.58
Ledford Island	47	14	29.78

n = Number of individuals in 0 - 5 year age interval.

Nevertheless, in the absence of proof to the contrary, this sample is included in the pathological analysis.

Of the 96 individuals in the 0 - 5 year age interval utilized for the paleopathology comparison from six Archaic sites (including Anderson), only one exhibited any degree of porotic hyperostosis (Table 14). This translates to 1.04% of the total Archaic sample and 7.14% when viewing only the Robinson site from which the individual with porotic hyperostosis was recovered. The results are not significant at the 0.05 level.

Comparison of Mississippian Sites

A total of 117 individuals in the 0 - 5 year age interval from the Dallas site was analyzed for the presence of porotic hyperostosis. Of the 117 individuals, 16 were missing the cranial vault and eye orbit elements required for adequate observation. These were omitted from the sample. The presence of porotic hyperostosis was noted in 42 (41.58%) of the remaining 101 individuals (Table 14). A comparison with the previously analyzed Ledford Island site (Boyd 1984) indicates a similar, although slightly lower, pattern of iron deficiency anemia among Late Mississippians (Table 14). This difference is not significant at the 0.05 level (chi-square = 2.0697 < tabled value a= 3.84146).

Boyd's analysis of 47 individuals in the 0 - 5 year age interval from Ledford Island shows 14 (29.78%) exhibiting

evidence of porotic hyperostosis (1984: 144, Table 40). Boyd also notes a high frequency (47.93%) of the pathology at the Late Mississippian Averbuch site (1984: 163, Table 49). At Toqua, another Dallas phase Late Mississippian site, an extremely high frequency of porotic hyperostosis was present in the 0 - 5 year age interval. Parham (1982: 108) found that 90.3% of individuals in the 0 - 1 age interval and 69.2% in the 1 - 5 age interval exhibited some sign of the pathology. According to Parham, the high frequency of porotic hyperostosis at Toqua "attest to probable endemic proportions of iron-deficiency anemia at the site" (1982: 105).

Differences in the frequency of porotic hyperostosis between Mississippian sites are open to interpretation. As discussed earlier, Boyd (1984) indicates that one possible explanation may be that some type of differential maize consumption could be operating between the sites. Another possibility involves sampling. The frequency of porotic hyperostosis at Ledford Island (29.78%) is relatively low when compared to Dallas (41.58%), Averbuch (47.93%), and Toqua (90.3% and 69.2%). However, less than 12% of the Ledford Island site was excavated and most of the burials were recovered from the "status" areas of the site (Richard Polhemus: personal communication). Better control over sampling and more paleobotanical evidence are needed before such differences can be fully understood.

Comparison of Archaic and Mississippian Sites

Less ambiguous is the difference in frequencies of porotic hyperostosis between the Archaic sites (1.04%) and the Late Mississippian Dallas site (41.58%). Not surprisingly, these differences are significant at the .001 level (chi-square = 47.41 > tabled value a = 10.828). Evidence from other Mississippian sites shows a similar pattern of elevated frequencies of dietary stress. Although the frequencies of porotic hyperostosis at Indian Knoll and Hardin Village were not available, Cassidy (1984) concluded that the pathology was relatively absent at the Archaic site and significantly high at the Mississippian village. The present data and previous research involving porotic hyperostosis, as well as other indicators of dietary stress, indicate that Mississippian agriculturalists suffered from dietary insufficiencies not readily evident among the earlier Archaic hunter-gatherers.

CHAPTER VI

DISCUSSION

The results of this study indicate that infant\weanling mortality among the Mississippian agriculturalists was significantly higher than that of the Archaic hunter-gatherers. The difference in infant\weanling mortality is believed to be due to the combined effects of Mississippian reliance on maize agriculture and the high population density of Mississippian settlements.

According to Louise Robbins, "members of agricultural groups become targets for pathogens of epidemic proportions, food shortages, nutritional deficiencies, stresses of crowding and the intensifications of social interactions" (1977: 20). Cohen also notes a similar trend in deteriorating health in early farmers compared to hunter-gatherers which " resulted from increasing sedentism, larger population aggregates, and/or the well established synergism between infection and malnutrition" (Cohen 1987: 270). Rose et al. (1984) suggest that hunter-gatherers in the Mississippi Valley had a lower probability of dying as children or young adults than did later agriculturalists.

Compared to early agriculturalists, hunting-gathering societies probably experienced a healthier existence. The hunter-gatherer diet "may be said to be well balanced in the sense that minimal nutritional requirements are apparently

met" (Dunn 1978: 110). The diversity of the hunter-gathering diet and the relatively low population density contributes to their health status. Deficiency diseases prevalent among agriculturalists are probably the main cause of an elevated mortality rate among such groups. Chronic malnutrition and disease in infants and children among early agriculturalists was likely a result of the "poverty of the staple crops in most nutrients except calories...and periodic famines caused by the instability of the agricultural system..." (Roosevelt 1984: 573).

Robert Blakely has hypothesized that infant deaths among agricultural societies "may be due to malnutrition brought about by unsuccessful weaning..." (Blakely 1971: 63). Scrimshaw (1968) has noted the "synergistic" effects of malnutrition and nutritive diseases such as kwashiorkor and marasmus on infant mortality. Such diseases and malnutrition each magnifies the effects of the other.

Analyses of skeletal remains from Mississippian sites in Illinois and Kentucky (Blakely 1971; Cassidy 1984) Georgia (Blakely and Mathews 1975), and Tennessee (Boyd 1984; Parham 1982) agree with the findings from this study in several respects. All show a relatively high infant mortality rate for the Mississippian agricultural period accompanied by a low mortality rate for older children and adolescents. While a high Mississippian infant mortality rate was found in the present study, data from both the

Archaic and Mississippian sites show a dramatic decrease in mortality from ages five to fifteen years. Nevertheless, there are differences in results between the present study and Blakely (1971) and Cassidy's (1984) research which requires discussion.

The most significant difference between Blakely's, Cassidy's, and the present study concerns the disparity between the Archaic infant mortality data. Blakely's comparison of the Indian Knoll Archaic, Illinois Archaic, and Illinois Mississippian skeletal remains shows little difference in infant mortality between Archaic and Mississippian samples [31% for Indian Knoll Archaic, 34% for Illinois Archaic, and 31% for Illinois Mississippian (1971: Table 2, p.48)]. Cassidy's comparison of Indian Knoll Archaic and Hardin Village Mississippian also shows little difference in infant mortality [32.6% and 33.1%, respectively (1984: Table 12.5, p.320)]. These findings are somewhat disturbing in light of the differences in infant mortality between the Tennessee Archaic and Mississippian samples. There appears to be no regional environmental cause for an elevated mortality among the Illinois and Kentucky infants (Blakely: personal communication). This may suggest a problem with sample error resulting from such factors as differential preservation of bone, differential treatment of remains, or archaeological recovery techniques.

Four of the Tennessee Archaic sites utilized for this

study were excavated earlier this century at a time when archaeological sampling and recovery techniques were much less precise than today's methods. However, the comparable results from each of the sites do not seem to indicate sampling error due to incomplete recovery or differential preservation of infant remains. This does not rule out sample bias due to differential treatment of remains. If any differential mortuary treatment of infants is occurring at the Tennessee sites, it is surprisingly consistent.

The Indian Knoll Archaic site used by both Blakely and Cassidy was also excavated relatively early in terms of the development of archaeological sampling and recovery methods. In a reexamination of the archaeological literature and skeletal data from Indian Knoll, Robbins found the sampling and cultural\stratigraphical associations of the burials to be extremely problematic (1977: 14). Indian Knoll was a multi-component site occupied from the Archaic through the Mississippian periods. The potential for demographic skewing of the entire Indian Knoll sample is greatly increased if adequate chronological controls were not maintained. Site background information from Blakely's (1971) Illinois Archaic sample is not currently available. A closer look at Indian Knoll and the Tennessee Archaic sites used for this study is necessary before the difference in results can be fully understood.

A more recently recovered Illinois Archaic skeletal

series from the Carrier Mills site reveals an infant\weanling mortality pattern similar to the present data from Tennessee. A sample of 124 remains from the Middle Archaic component of the site indicates that approximately 24% of the individuals recovered fall in the 0-5 year age interval (Jefferies and Butler 1982: Figure 262, p.1046). This infant\weanling distribution is almost identical to the pattern noted at the Tennessee Archaic shell midden sites (Anderson, Eva II, and Robinson).

Although shell fish exploitation played a relatively minor subsistence role during the Middle Archaic period at Carrier Mills, analyses of paleobotanical and faunal remains indicate a middle to late summer occupation of the site (Jefferies and Butler 1982). This is precisely the season of occupation noted for the three Tennessee Archaic shell midden sites. As stated previously, density dependant health problems arising from population aggregation at summer base camps may result in an elevated infant\weanling mortality. While Blakely's (1971) Illinois data differs from the Tennessee Archaic data, evidence from the Illinois Carrier Mills site supports the results of the present study.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate the variability in infant\weanling mortality between Tennessee's Archaic and Mississippian archaeological populations in terms of health and nutritional related interpretations. It has been, and remains, common practice among paleodemographers to interpret the overall health of archaeological populations based primarily on adult longevity as reflected by age at death of adult skeletal remains. However, the accuracy of adult ages derived from current aging techniques is questionable. This is particularly problematic when biocultural interpretations are made based on such data.

The use of synchronic and diachronic variability in infant\weanling mortality distributions between archaeological populations has been offered here as an alternative indicator of overall health. The utility of infant remains has often been ignored in paleodemographic research based on the commonly held view that infant bones are more subject to destruction from natural transformation processes. The results from this study by no means suggest that sampling error does not occur in the representation of infant remains from archaeological sites. The data do indicate however, that references to infant underenumeration

in the literature may be exaggerated. Infant remains in the archaeological record can provide information related to the overall health and nutritional status of prehistoric populations and should not be underemphasized.

Comparisons of infant\weanling mortality distributions were made within and between six Archaic and two Mississippian sites from Tennessee. The mortality profile method indicated the existence of infant\weanling mortality variability between Archaic sites with shell middens and those without. The difference between these two types of sites was found to be statistically non-significant. The variability is believed to be the result of a combination of preservational differences and a seasonal settlement related pattern of infant mortality.

The mortality profile comparisons indicated that a statistically significant difference in infant mortality exists between Archaic and Mississippian populations. Based on extensive research conducted in the past concerning the decline in health which accompanied the adoption of agriculture in the New World, the variability between the Archaic and Mississippian samples was expected. The paleodemographic comparisons also indicated a not statistically significant difference within the Mississippian sample between the Dallas and Ledford Island sites.

A paleopathological analysis was conducted for

comparisons of dietary stress between the Archaic and Mississippian samples. Frequencies of porotic hyperostosis were noted from each site. This pathology was significantly absent at the Archaic sites. However, a relatively high frequency was found at the Late Mississippian Dallas site. As with the infant mortality rate, Ledford Island's Mississippian population seemed to be healthier in terms of less iron deficiency anemia than their Dallas counterparts. Interpreting health from a single physiologic stress indicator, such as porotic hyperostosis, is less conclusive than using several pathology classes. However, when combined with the paleodemographic results, it would be difficult to not conclude that Archaic hunter-gatherers were significantly healthier than later Mississippian agriculturalists.

In conclusion, a comparison of infant mortality between prehistoric hunter-gatherers and early agriculturalists in Tennessee indicates a decline in health and nutrition from the Archaic to the Mississippian period. When evaluating prehistoric health and nutrition through paleodemographic reconstruction, those individuals most susceptible to physiologic stress and which better reflect biologic reality should be considered. In addition to emphasizing the importance of infant samples to paleodemographic research, this study stresses the necessity of combining biological and cultural data into an integrated approach to prehistory.

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