12-1993

White-Tailed Deer Crown Height Measurements and Mortality Profiles from the Hayes Site, Middle Tennessee

Renee Beauchamp
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Renee Beauchamp entitled "White-Tailed Deer Crown Height Measurements and Mortality Profiles from the Hayes Site, Middle Tennessee." 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.

Walter E. Klippel, Major Professor

We have read this thesis and recommend its acceptance:

Paul Parmalee, Lyle Konigsberg

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

To the Graduate School:

I am submitting herewith a thesis written by Renee Beauchamp entitled "White-Tailed Deer Crown Height Measurements and Mortality Profiles from the Hayes Site, Middle Tennessee." I have examined the final 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.

Walter E. Klippel, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor
and Dean of the Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at The University of Tennessee, Knoxville, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Renee Beauchamp

Date 12-2-93

WHITE-TAILED DEER CROWN HEIGHT MEASUREMENTS
AND MORTALITY PROFILES
FROM THE HAYES SITE, MIDDLE TENNESSEE

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Renee Beauchamp

December 1993

Dedication

This thesis is dedicated, in loving memory, to my grandfather James V. Kane. He taught me that education is the key to success and to always strive to reach my goals.

Acknowledgments

I would like to thank all of my committee members for supporting me in this endeavor, as well as in my graduate education. In particular, I would like to thank Dr. Walter Klippel for prompting me to begin this study, it has been a great experience. Dr. Klippel took me aside my first semester of graduate school and encouraged me to pursue white-tailed deer crown height measurements, and even though it has taken three years it has been well worth it. Dr. Paul Parmalee has shared his vast experience with me through two wonderful faunal identification courses, and has certainly given me a great start as a zooarchaeologist. Dr. Lyle Konigsberg has spent endless hours explaining the mysteries of statistics to me. I truly appreciate all the time he worked on running programs and calculating data for my thesis research.

I could never have come this far without the support of the graduate students in the UT Anthropology Department. It has become clear to me that UT has one of the best student-to-student support networks. Fellow graduate students have always been ready to discuss ideas and problems with my research, as well as edit drafts and listen to presentations. In particular, Sean Coughlin and Katherine Park have taken the brunt of my complaining and

I am endlessly grateful. Phil Carr has always been eager to hear the latest results or edit a paper. Darcy Morey has been a wonderful source of information about the Hayes site. In addition, Amy Lynn Young, Justin Lev-Tov, Sara Sherwood, Maureen Hays, Amy Young, and Susan Andrews have always been available to distract me from the "TH" word.

This research would not have been possible without the help of people outside the Department. Dr. Sara W. Neusius has always been a source of encouragement and I have been thankful that I followed in her footsteps. Dr. Harry Jacobson has proved an endless source of information about white-tailed deer. I learned more about white-tailed deer in the three days I spent at the Mississippi State University than I did in three years of reading about white-tailed deer. Dr. Rick Purdue had been most generous and helpful while I was gathering data at the Illinois State Museum.

My family has always been supportive of my efforts, and for that I am eternally grateful. Despite the long years of schooling, and the many moves from one school to another, they have always been there for me. My mother has been my greatest source of inspiration through her efforts to educate herself and her daughters at the same time. My sister Michele has been supportive and encouraging. My Aunt Joan, cousin Christopher and grandmother Helen have always made visits home and

holidays special. In addition, my fiance Charles, has been an endless source of support and solace. I could not have been successful without the support and encouragement of all of these people.

Finally, Hayes site investigations were made possible with the support of the Tennessee Valley Authority. Much thanks to the archaeologists in the Cultural Resources Division at TVA.

Abstract

Previous research at the Hayes Site (40ML139) prompted an investigation of white-tailed deer remains from the site. An evaluation of aging techniques revealed that the dental crown height measurement technique is the best method for aging white-tailed deer. A regression formula was developed with a known-age sample of Mississippi white-tailed deer. An investigation of mortality profile interpretations defines attritional, living-structure, and prime-dominated mortality profiles. The mortality profile interpretations are used to define seasonality and hunting intensity for the white-tailed deer from the Hayes site. A modified iterated age length key is used to derive mortality profiles. Results for hunting intensity indicate the mortality profiles consisted primarily of sub-adults, with no differences between early Middle, late Middle and Late Archaic period occupations. Results for seasonality indicate sub-adult deer were killed primarily in the Fall and Winter for the late Middle and Late Archaic periods, and in the Fall for the early Middle Archaic period. These results suggest seasonal culling of deer, with special selection of sub-adult white-tailed deer, was the hunting adaptation utilized at the Hayes site.

Table of Contents

List of Tables

List of Figures

Chapter I: Introduction

Shell middens accumulate from years of prehistoric human occupation, and the archaeological record from these middens can become quite complicated. The Hayes site, an Archaic period site located in Middle Tennessee, is one such midden. Resulting from over 2,000 years of intermittent occupation, this site has supplied thesis and dissertation material for half a dozen University of Tennessee graduate students. This thesis attempts to explain the hunting patterns of prehistoric hunter-gatherers occupying the Hayes site by using white-tailed deer (Odocoileus virginianus) mortality profiles.

This thesis focuses on white-tailed deer due to its importance as a protein source for prehistoric Eastern North American Indians (McDonald 1984). However, despite the importance of white-tailed deer in hunter-gatherer economies, little research has been conducted on their mortality profiles. It is generally assumed that hunter-gatherers produce patterns in white-tailed deer mortality with a predominance of prime-aged adults (Stiner 1991). Therefore, it is important to determine the ages of deer actually being hunted in prehistoric economies.

In order to do this properly, this thesis places the Hayes site into context through several literature reviews. First, aging techniques are examined to

determine the most reliable and replicable method. Second, interpretations of animal mortality profiles are examined. Third, trends and traditions in shell midden excavations are evaluated to understand how the Hayes site fits in with other shell midden research. These three topics lead to results from constructing mortality profiles for the Hayes site occupations, and a discussion of what these results indicate.

Chapter II of this thesis develops an aging technique to be used with the white-tailed deer remains from the Hayes site. In particular, an attempt has been made to age the white-tailed deer with dental aging criteria. Dental aging criteria have been a major part of zooarchaeological studies and are used to age a variety of animals such as pigs, cattle, goats, sheep, horses, gazelles and deer (Klein and Cruz-Uribe 1984). Several techniques for aging these animals have been developed, and there is often great debate over which is the best method for aging (see Klein et al. 1981). Ages from teeth can be derived from tooth wear and eruption patterns, cementum annuli analysis, and crown height measurements.

Developing an aging technique for prehistoric white-tailed deer required the examination of a modern population of known-age deer to determine the accuracy of the technique. Preliminary studies were conducted with modern white-tailed deer aged with tooth wear and

replacement. A known-age sample of Mississippi white-tailed deer was used as the reference sample for this study. The Mississippi sample consisted of over 100 individuals, of both captive and wild deer.

Chapter III examines mortality profile interpretations in wildlife biology and zooarchaeology literature. Mortality profiles have been used in wildlife management to determine the viability of a population. Techniques used in wildlife biology can also be used to interpret mortality profiles of prehistoric white-tailed deer. In zooarchaeology, deciphering the mortality profile can lead to conclusions about prehistoric behavior such as the hunting practices of prehistoric humans and site seasonality (Bourque et al. 1978; Caughley 1966, 1977; Stiner 1990; 1991).

Many people have developed models of mortality profiles and used ethnographic data to interpret their meanings (see Alvard and Kaplan 1991; Blumenschine 1991). For example, a mortality profile similar to the natural mortality of a population suggests either scavenging or a hunting technique that selects for young or old individuals. A mortality profile containing many prime adults is unnatural and indicates selective hunting pressure for these animals. Through observation of these mortality profiles, an idea can be formed about prehistoric human hunting behavior.

The fourth chapter reviews studies of shell middens and how these studies approached the many problems in dealing with accumulations of shells in archaeological sites. Some researchers tend to focus on shellfish and their role in diet, and the environment (Claasen 1986). Other researchers have focused on the increase in shell middens during the Holocene and what this means with reference to climatic changes (Delcourt and Delcourt 1983). Still others have focused on human burials which often seem to be associated with shell middens (Webb and DeJarnette 1942).

The Hayes site is a shell midden from the Nashville Basin in Middle Tennessee. Instead of focusing primarily on shells or burials, research at the Hayes site emphasized lithic analysis, stratigraphic interpretations, pollen studies, and faunal analyses (Carr 1991; Crites 1987; Morey 1986; Turner et al. 1982). Conclusions drawn from the research do not always fit neatly into models and interpretations that are commonplace in shell midden research in general, such as the notion of shell- fish as the primary food resource.

Chapter V uses information gleaned from mortality profile interpretations to conduct a study on mortality of white-tailed deer from the Hayes site. Hypotheses generated by previous investigations at the Hayes site were used to determine if the occupants during the early

Middle, late Middle, and Late Archaic periods were hunting white-tailed deer differently from one period to the next, or the same. Testing these hypotheses required the aging of the white-tailed deer teeth and constructing mortality profiles for all periods.

A sample of teeth was recovered and ages were derived for the archaeological specimens. The number of individual specimens was used for both the first molar and the fourth deciduous premolar. These numbers were used with a modified iterated age length key to develop mortality profiles for the Hayes site occupations.

Chapter VI describes the results for the mortality profiles from the Hayes site material. These results are presented as percentages of archaeological white-tailed deer in each age category, and bar chart figures illustrate these percentages. In addition, the seasonal age group percentages are presented as percentages as well as in bar chart figures. Finally, the results of chi square tests for differences between the three occupations of the site are presented for the mortality profiles and the seasonality profiles.

A discussion of mortality profiles from Hayes attempts to explain changes in percentages of each age group throughout the occupations of the site. A chi-square test indicates the differences are not significant between the three occupations, but differences between

seasonal use of the site are significant. There are slight differences in percentages of yearling, sub-adult, prime-adult and aged-adult white-tailed deer. Changes in mortality profiles, along with changes in lithic technology, indicate different hunting adaptations or changes in seasonal occupations of the Hayes site.

In summary, this thesis examines aging techniques for white-tailed deer, mortality profiles, and analysis of white-tailed deer remains from an Archaic period shell midden. An aging technique is developed for modern white-tailed deer as a means of aging prehistoric white-tailed deer from the Hayes site. Mortality profile interpretations are examined to better explain the resulting mortality of white-tailed deer from the Hayes site. The Hayes site, an Archaic period shell midden, is researched to outline conclusions for the site based on previous investigations. All of this information, in addition to results from this thesis, is discussed to interpret white-tailed deer hunting patterns for the Archaic period at the Hayes site.

Chapter II:
Aging Technique Reliability

Introduction

Zooarchaeology attempts to understand the complex relationship between humans and fauna from the past. Zooarchaeologists study this relationship by applying special identification and analysis techniques to samples of animal remains. One means of interpreting past cultural adaptations to animal exploitation is by determining the age at death of individuals of certain species. The ages of animals recovered in the archaeological record can reveal the strategy of species exploitation utilized by past cultures (Davis 1987; Klein et al. 1981; Klein 1982a, 1982b; Morris 1972; Maltby 1982; Nimmo 1971; Stiner 1990).

There are a variety of methods used to age faunal material using both axial and cranial elements of an animal (Harlow and DeFoor 1962). Epiphyseal fusion is used on appendicular elements, such as fore- and hind-limb bones, as an indicator of age (Ericson et al. 1970; Purdue 1983). Cranial elements, such as mandibles, often involve dental criteria for determining the age of animals (Spinage 1973). The pros and cons are evaluated for each of these methods to determine the best technique for aging white-tailed deer.

Aging techniques

Purdue (1983) evaluated the variation in the timing of epiphyseal fusion in white-tailed deer from Illinois, Missouri, and South Carolina. The sequence of fusion for white-tailed deer was established as follows: the vertebral centrum, proximal end of the radius and distal end of the humerus, phalanges, distal tibia, and finally the proximal humerus (Purdue 1983). No variation in this sequence was noted for the geographic location of the deer specimens, but epiphyses in the female skeleton often fused earlier than in the males.

Problems with aging deer with this method in an archaeological setting stem from the destruction of fragile juvenile long bones and epiphyses at prehistoric sites (Davis 1983). The ends of long bones are often subject to carnivore damage, and this can eliminate the evidence of fusion. The major difficulty in using the fusion of epiphyses to age animals is that most epiphyses fuse while the animals are still relatively young, usually by the third year. Thus, this method is not very reliable for determining the ages of a complete animal population.

Methods of evaluating age at death that involve dental criteria are valuable for several reasons. First, teeth are made of extremely dense material and

consequently preserve well in archaeological contexts (Bourque *et al*. 1978; Roseberry 1980). Second, teeth are usually identifiable to species (Hillson 1986). Third, teeth erupt at certain intervals and wear throughout an animals' life (Klein *et al*. 1981).

There are three methods for aging ungulates by their teeth. These methods include tooth wear and replacement, cementum annuli counts, and crown height measurements. The tooth wear and replacement method involves a comparison of a mandible of unknown age with mandibles of known ages (Gilbert and Stolt 1970). These mandibles are aged according to the sequence of tooth eruption for a species, and also according to the wear of teeth for older specimens.

Many studies have been conducted of known-age animals to determine the ages at which certain teeth erupt and begin to wear (Severinghaus 1949; Schwartz and Schwartz 1964; Hillson 1986; Deniz and Payne 1982; Rees *et al*. 1966). Severinghaus (1949) established the most widely used tooth wear and replacement criteria. These criteria were based on the tooth eruption and wear of deer from fall to fall for hunting seasons. White-tailed deer (*Odocoileus virginianus*), for example, have full permanent dentition by two and a half years of age (third fall).

Other studies utilize tooth wear and replacement patterns to separate animals of different ages into age

groups, or cohorts, rather than identify age from year to year. Nimmo (1971) identified seven age groups for pronghorn antelope (*Antilocapra americana*). The scoring system used by Hillson (1986) records the eruption sequence of red deer (*Cervus elaphus*) teeth. This sequence continues from birth, when all teeth are absent, to 27 months, when all permanent teeth are erupted. A study by Turner (1985) defined five age classes with descriptions of tooth wear and replacement for extinct springbok (*Antidorcas bondi*).

The tooth wear and replacement method can be problematic for several reasons. First, most criteria were developed for wildlife management programs, and ages were established from hunting season to hunting season (Severinghaus 1949; Schwartz and Schwartz 1964). Second, as far as archaeological specimens are concerned, it is rare to find an assemblage with many whole mandibular elements (Klein *et al*. 1981:2). Third, poor nutrition can delay tooth eruption in some populations, and the type of food consumed by an animal directly influences wear (Grant 1978). Fourth, there is variation in the hardness of enamel and dentine in teeth due to the amounts of strontium, phosphorous, and fluorine available in food and water (Robinette *et al*. 1957:140). Finally, variation in the process of mastication will affect tooth wear (Gilbert and Stolt 1970). Therefore, it is difficult to use the

matching method for an archaeological sample when the objective is to determine age profiles of an animal population.

A second method, dental annuli counting, involves thin sectioning teeth and counting cementum growth rings deposited throughout an animals lifespan (Ericson and Seliger 1969; Gilbert 1966; Gordon 1982; Kay 1974; Lieberman *et al*. 1990; Low and Cowan 1963; Ransom 1966; Sergeant 1967; Spiess 1990). Mitchell (1967) conducted an analysis of the growth layers in approximately 3,000 Scottish red deer (*Cervus elaphus*), and the first molar gave results with very high accuracy. In 1972, Lockard studied the cementum annuli method for aging white-tailed deer from Ohio. Lockard (1972) sectioned the incisors of deer and found lines in 95% of the specimens, and estimated ages had only a 26% discrepancy from known ages. Mitchell (1989) tested the accuracy of the tooth wear and replacement technique against cementum annuli for aging white-tailed deer. The results of her analysis showed that the cementum annuli method (using the second premolar) was more accurate and consistent.

The identification of cementum annuli is also useful for determining seasonality. Bernstein (1990) defined three categories: the dark, winter annulus; the short, light summer annulus; and the long, light summer annulus. Spiess (1990) used the cementum annuli to determine

seasonality of prehistoric deer hunting in Maine. The study revealed that early people (4,500 B.P.) relied on intense hunting from November to May, while later occupations (4,000-3,800 B.P.) switched to hunting deer during all seasons.

Unfortunately, there are many problems with the cementum annulation method as well. First, there is a tendency for cementum annuli counts to severely underage or overage some animals. Second, animals from warm climates may not have a well defined separation between winter and summer growth lines (Roseberry 1980). Third, the rates of deposit are not always constant, and the layers will vary in thickness and color. Fourth, split annuli may occur from the sectioning technique, and false annuli can result from seasonal fluctuations in nutrition, such as during the rut (Spiess 1990). Finally, dental annuli counts are time consuming, destructive, and the process is not well understood (Klein and Cruz-Uribe 1984:46). Although dental annuli counting is a more objective method of aging animals, it is still somewhat problematic for archaeological samples.

The last method involving the use of dental material for determining age is dental crown height measurements. The crown height measurement technique measures "a given tooth ... from the occlusal surface to the crown-root junction down one side of the tooth: this is for the

buccal (external) side of mandibular teeth and the lingual (internal) side of maxillary teeth" (Davis 1987:43). Crown height measurements provide easily replicable results, can be applied to isolated teeth, and are very objective (Klein et al. 1981). High-crowned ungulate teeth wear gradually throughout the life of an animal, but there is some rapid wear early in the attrition process (Gifford-Gonzales 1991). Crown height measurements can also be obtained without destroying valuable archaeological specimens (Levine 1982). The age classes developed from crown height measurements can provide an accurate age profile of the population being evaluated and reveal important information regarding human/animal interaction.

In a recent study, Klein et al. (1981) determined the feasibility of predicting age of red deer from crown height measurements on the deciduous fourth lower premolar and the permanent first and second lower molars of a known-age sample. Two assumptions were made: the reduction of tooth height is relatively constant through time, and tooth replacement occurs when deciduous teeth are completely worn. However, teeth do have variable rates of wear, first wearing quickly and then slowing (Klein 1982a).

Klein et al. (1981) define three steps to develop the formula for predicting age. The first step takes the

measurements from the crown heights and plots them against the known ages (Klein _et al_. 1981:9). Second, the mathematical relationship between age and crown height is determined through a regression of age against crown height (Klein _et al_. 1981:12). Finally, this relationship is utilized to make age estimations from crown heights. The resulting formula can be used to assess age and construct age profiles of archaeological samples.

Davis (1983) utilized crown height measurements to determine differential exploitation of gazelles in Israel. The teeth utilized include the fourth deciduous premolar and the permanent third molar. His correlation coefficient for the fourth deciduous premolar is -.673, which indicates a fairly good correlation between crown height and age. Another study by Koike and Ohtaishi (1985, 1987) utilized crown height measurements to estimate the age of sika deer. Crown height measurements were used in conjunction with appearance of cervical line, wear patterns, and epiphyseal fusion to determine age (Koike and Ohtaishi 1985).

Some problems with this method are similar to problems found with tooth eruption and wear patterns, such as variability of diet (Gifford-Gonzales 1991). The genetic relationship and nutritional background in prehistoric animal populations are also difficult to isolate. One way to overcome some of these problems is to

use crown heights for determining the age of an animal within a class, such as 10% of an animals potential ecological longevity, in order to decrease the effects of variability (Klein et al. 1981:4). Factors of diet can be isolated by examining regional variation in animal populations, and the size of animals can be recorded and accounted for in modern samples (Maltby 1982). Utilizing crown height measurements for estimating the age of high-crowned ungulates can prove more valuable by taking variability of individuals within populations into consideration.

The above review of epiphyseal fusion, tooth wear and replacement, cementum annuli, and crown height measurement aging techniques provides some pros and cons for each method. Although epiphyseal fusion is a valuable technique, taphonomic processes render it a less useful method for determining age of white-tailed deer than methods based on teeth. Tooth wear and replacement is too subjective to be of use in archaeological samples, and the cementum annuli method is destructive and time consuming. Thus, dental crown height measurements may be regarded as the best method for determining ages of white-tailed deer.

Methods

Klein et al. (1981) argued that the crown height measurement technique can be used for high-crowned

ungulate species that are similar to red deer. This argument can be put to good use in the southeastern United States with white-tailed deer. Two studies were conducted with crown height measurements to determine age of white-tailed deer by utilizing criteria developed by Klein _et al_. (1981) and Koike and Ohtaishi (1985, 1987). A preliminary study examined criteria by Klein _et al_. (1981), and an expanded study compared aging criteria developed by both Klein _et al_. (1981) and Koike and Ohtaishi (1985, 1987).

The preliminary sample consisted of 25 individuals collected primarily in eastern Tennessee, with 9 males and 16 females from different seasons. Determining the relationship between the white-tailed deer observations and the original formula from Klein _et al_. (1981) required regression and correlation coefficient analysis. The results of the statistical analysis of the white-tailed deer sample revealed a poor correlation for the deciduous fourth lower premolar. An evaluation of the formula for the permanent second lower molar is slightly better than the deciduous tooth. The most outstanding results involve the permanent first lower molar, with a slope significantly differently different from 0 at an alpha level of 0.05.

After evaluating crown height measurements with the small sample, an expanded study was conducted with a

sample of 92 white-tailed deer housed in the University of Tennessee and Illinois State Museum comparative collections. A total of 34 were collected from Illinois, 31 from Tennessee, 17 from Texas, 7 from Wyoming and 1 each from Washington, Missouri, and Ohio. These specimens were aged with tooth wear and replacement in the mandibular tooth row. The dental matching technique, correlated with a birth date of June 1 and date of death, was used to provide the age at death for the specimens (Chapman and Feldhamer, 1982). The specific information (Appendix 1) recorded for the white-tailed deer included dental matching (Schwartz and Schwartz 1964), cervical line appearance (Koike and Ohtaishi 1985), crown height measurements (Klein et al. 1981; Koike and Ohtaishi 1985), and crown width and breadth measurements. All measurements were obtained to the nearest one-hundredth of a millimeter using digital calipers.

In the expanded study, two crown height measurement techniques are compared, one by Klein et al. (1981) and another by Koike and Ohtaishi (1985). The measurement in the preliminary study, by Klein et al. (1981), is the minimum distance from the occlusal surface to the cervical line on the anterior cusp, labial side of the tooth (Figure 2.1). Best results were reached using the lower deciduous fourth premolar and the lower permanent first, second, and third molars.

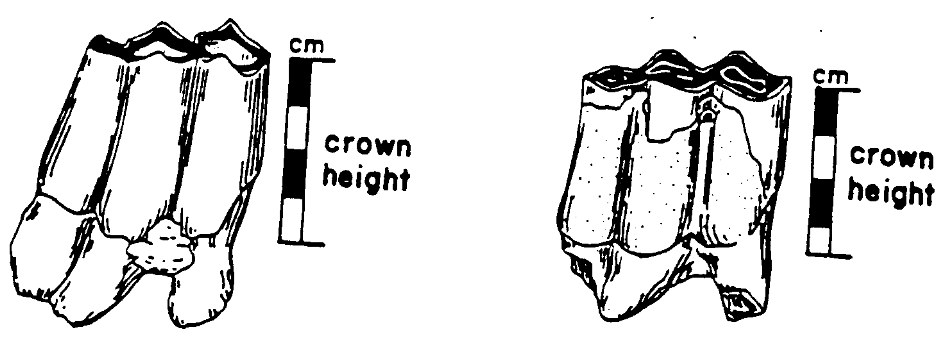


Figure 2.1: Crown Height Measurements on the Labial Side of the Third Molar(after Klein and Cruz-Uribe 1983)

In addition to the technique reported by Klein et al. (1981), a technique developed by Koike and Ohtaishi (1985) was employed in the expanded study. The second crown height measurement technique measures the distance from the cervical line to the top of the highest cusp of each molar (Figure 2.2). The posterior cusp of the lower fourth deciduous premolar, lower first and second permanent molars, and the anterior cusp of the lower third permanent molar are recommended (Koike and Ohtaishi 1985, 1987).

The results of the age data for white-tailed deer were obtained using correlation coefficients, and linear and quadratic regressions. The measurements for each tooth were plotted against age to determine the relationship. Plots for the crown widths and breadths were very poorly correlated; most of the teeth showed no relationship of crown width or breadth to age. The crown heights were very highly correlated, although some differences between the two measurements were evident. Correlation coefficients for the Klein et al. (1981) measurements were slightly less correlated with age than the Koike and Ohtaishi (1985) measurements (Figure 2.3). For example, the correlation coefficient for the deciduous fourth premolar with the Klein et al. (1981) measurements was -.62, while the Koike and Ohtaishi (1985) measurements produced a correlation of -.75.

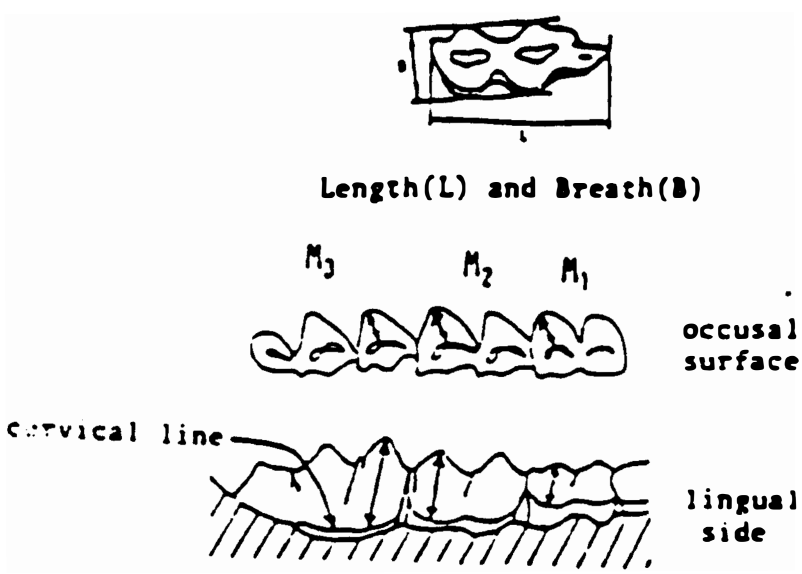


Figure 2.2: Crown Height Measurements on the Lingual Side of the Lower Mandibular Teeth (after Koike and Ohtaishi, 1985)

Tooth	Klein *et al*. (1981) r-value	Koike and Ohtaishi (1985) r-value
dP4	-.62	-.75
P4	-.87	-.91
M1	-.86	-.95
M2	-.87	-.95
M3	-.87	-.91

Figure 2.3: Correlation Coefficients Showing Differences Between Klein *et al*. (1981) and Koike and Ohtaishi (1985) Measurements

Plots for the crown height measurements against age suggested slight nonlinearity for some of the teeth, so quadratic regressions were also computed for the teeth (Figure 2.4). All of the permanent teeth measured with the Klein et al. (1981) method suggested a curved relationship. The Koike and Ohtaishi (1985) measurements showed less of a relationship with the curved regression, except for the M1 which had a p-value of .0002.

The results of the correlation coefficient suggest crown height measurements are highly correlated with age, and the Koike and Ohtaishi (1985) measurements have higher correlations than the Klein et al. (1981) measurements. Thus, the correlation coefficients and the high p-values for quadratic regression suggest that the Koike and Ohtaishi (1985) measurements may be more useful for aging white-tailed deer.

Materials

The methodology developed with the preliminary studies was then applied to a known-age population of white-tailed deer mandibles. The known-age population is part of the Wildlife Management Program at the Mississippi State University, conducted by Jacobson and Reiner (1989). The mandibles were collected from both wild tagged deer, and captive deer which are part of the deer breeding program at the University. Wild deer were tagged soon

Tooth	Klein *et al*. (1981) p-value	Koike and Ohtaishi(1985) p-value
dP4	.1846	.7695
P4	.0001	.0125
M1	.0003	.0002
M2	.0004	.0088
M3	.0006	.0845

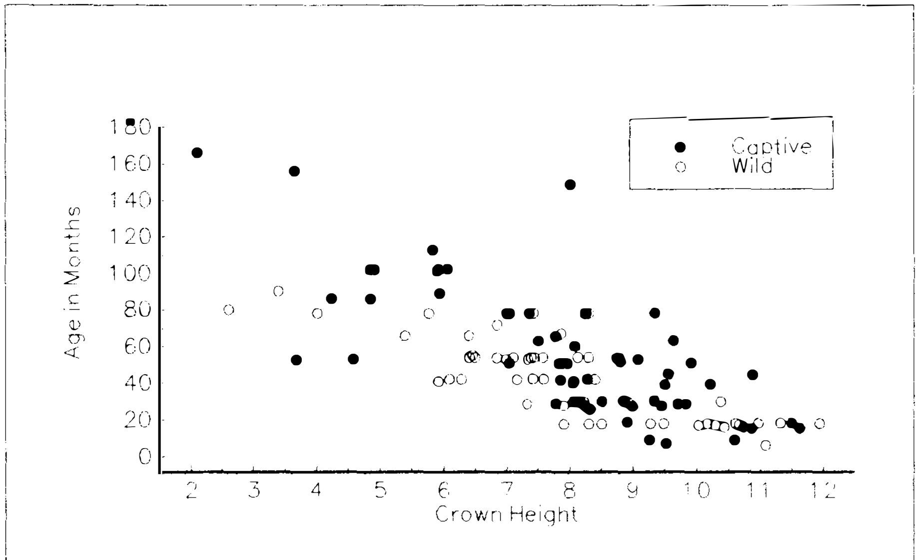
Figure 2.4: Quadratic Regression P-values for Klein *et al*. (1981) and Koike and Ohtaishi (1985) Measurements

after birth and reported at death; most animals were recovered during the hunting season. Some of the wild deer were born at the Mississippi State University facility and released into the wild. Captive deer were kept in a series of pens, and fed a mixture of dairy rations, corn and free-range grass.

Plots of the captive and wild deer, and females and males were obtained to determine if habitat or sexual variability exists with crown heights (see Figure 2.5). The plot of captive and wild deer shows little difference with crown height of the first permanent molar. Also, the plot of females and males illustrates a high degree of similarity for the crown heights of the first permanent molar. Plots of the crown heights for captive and wild, and male and female white-tailed deer present evidence supporting little difference between these groups.

All mandibles have associated data that includes catalog number, state, sex, age, month of death, side, and whether the animal was wild or captive. Aging data recorded at the Mississippi State University facilities includes tooth wear and replacement, and cementum annuli for some of the white-tailed deer (see Appendix 2). In addition, Appendix 2 contains the ages of deer based on crown height measurements recorded for lower mandibular teeth.

A)



B)

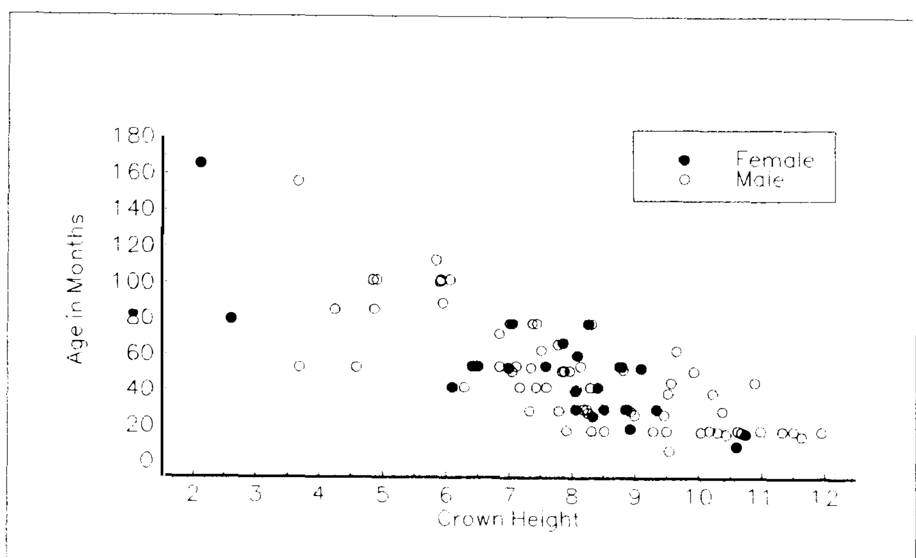


Figure 2.5: Scatter Plots for A)Captive and Wild and B)Female and Male White-tailed Deer

Results

The measurement used to generate ages for the known-age deer was the height of the crown on the lingual surface of the posterior cusp, based on the Koike and Ohtaishi (1985,1987) method. These measurements were then regressed against the ages for the white-tailed deer using a quadratic regression equation (Figure 2.6). This equation can be used for estimating ages of white-tailed deer based on crown height measurements.

The quadratic regression of age on crown height for the known-age sample resulted in a p-value of .001 for the first permanent molar. As shown in Figure 2.6, the crown height measurements are very close to the regression line. Correlation coefficients indicate a high degree of correlation of age and crown height measurements. Although this is not surprising, considering the results of the preliminary studies, it is important to consider with a known-age sample.

An equation for estimating ages of white-tailed deer was developed based on the quadratic regression:

$$Y=\alpha+\beta_1(X)+\beta_2(X)^2$$

where the X is the predictor variable, Y is the predicted variable, α is the Y-intercept, and β is the slope of the

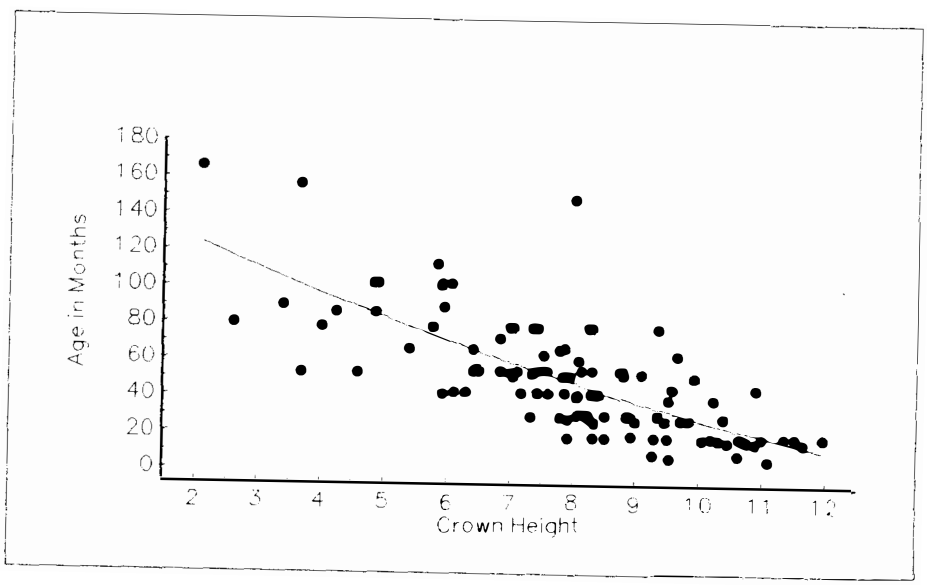


Figure 2.6: Quadratic Regression of Age on Crown Height for Mississippi Known-Age White-tailed Deer Sample

line (Thomas 1976). Figure 2.7 represents the Y-intercepts and slopes for the fourth deciduous premolar, fourth permanent molar and first, second and third permanent molars.

A blind test conducted with 40 white-tailed deer mandibles provided comparable results with crown height measurements. The mandibles were aged with tooth wear and replacement for the mandibular row and given a specimen number. Measurements were taken on all mandibular teeth with no previous knowledge of specimen age. Crown height ages derived with the regression formula provided a 97% correlation with known age of the white-tailed deer.

Conclusion

The purpose of this chapter was to evaluate several aging techniques and determine the best method for aging white-tailed deer. Epiphyseal fusion, tooth wear and replacement, cementum annuli, and crown height measurements were evaluated. Crown height measurements were found to be the best method because they are objective, easy to replicate, and can be used on isolated teeth.

Subsequently, crown height measurements were evaluated with a preliminary and an expanded sample of white-tailed deer mandibles. The preliminary and expanded samples were aged with tooth wear and replacement of the

Tooth	Y-intercept	Slopes	
dP4	18.52	.73	-.30
P4	184.83	-33.16	1.90
M1	157.04	-16.55	.36
M2	153.10	-10.67	.01
M3	185.26	-15.64	.28

Figure 2.7: Statistics for the Regression Equation for Calculating Age of Unknown White-tailed Deer

mandibular row, and two measurement techniques were evaluated. The crown height measurements included those by Klein et al. (1981) and Koike and Ohtaishi (1985, 1987). Based on correlation coefficients, the Koike and Ohtaishi (1985, 1987) measurement was chosen as the best technique.

A known-age sample was investigated to determine the accuracy of the technique and to develop a regression equation for determining age of white-tailed deer. The known-age sample consisted of over 100 mandibles from the Mississippi State University, and accuracy for predicting age was very high. The equation can be used, with the slope and constant information gathered from the known-age sample, to determine age of a sample of white-tailed deer.

Chapter III: Mortality Profile Interpretations

Introduction

Wildlife biologists use life tables to take a census of living populations and reconstruct the number of individuals in various age classes (Deevey 1947). These reconstructions are utilized by wildlife managers for estimating the rate of population increase, effects of predation, potential ecological longevity, and overall well-being of a population (Causey 1989; Sadlier 1987). Collecting data for life tables requires calculating the survivorship of certain age classes, or taking a census of live animals. However, the life table information is difficult to obtain in a modern setting and impossible for prehistoric populations (Klein 1982a).

Mortality profiles are better suited to studying prehistoric animal species. Death assemblages from archaeological sites are used to reconstruct past environments and infer human behavior (Klein 1982; Klein et al. 1981; Davis 1983; Koike and Ohtaishi 1987; Stiner 1990). Studies of mortality profiles have been very useful in determining whether early hominids used a scavenging or hunting strategy (Blumenschine 1991; Stiner 1990, 1991). Also, site seasonality can be determined from constructing mortality profiles (Davis 1983; Todd 1991). This information is useful in interpreting the

faunal material from archaeological sites.

Mortality Profiles

Mortality profiles estimate the number of individuals at certain ages and compare these numbers to determine if the population resembles a u-shaped, living-structure, or prime-dominated distribution (Davis 1987; Deevey 1947; Frison 1984; Klein 1982b; Lyman 1984; Savelle and McCartney 1991; Spinage 1972; Stiner 1991). Mortality patterns must assume that the archaeological sample is representative of the bone material originally deposited at a site and representative of the hunting selection of the prehistoric population (Maltby 1982; Speth 1991).

A u-shaped, or attritional, distribution describes the age structure for animal species bearing one young per year (see Figure 3.1). These profiles are bimodal, with more deaths occurring in the very young and very old age classes (Monks 1981). Attritional mortality profiles resemble natural deaths of animals, with peak deaths in the very young and very old individuals (Caughley 1966, 1977). Remains of animal populations with attritional mortality profiles resemble the natural deaths with the weaker individuals more likely to be killed. Research on early hominids suggests scavengers and non-human predators generally produced attritional mortality profiles (Blumenschine 1991).

Living-structure, or stepped, mortality profiles are similar to the live age structure of populations with numerous young individuals, some prime aged individuals, and few aged individuals (see Figure 3.1). Living structure mortality profiles are characterized as the result of catastrophic death, since natural disasters such as floods and volcano eruptions kill most of the members of animal populations and leave death structures similar to the natural population (Caughley 1966, 1977). In addition, deaths from animal drives, such as herding bison over cliffs, can result in living structure mortality profiles (Frison 1984). The living structure profiles are non-selective and result from intensive, massive kills. Living-structure mortality profiles represent a census of all age categories (living structure of a population) and are found in death assemblages through natural catastrophes and some hunting techniques (Caughley 1966).

A prime-dominated mortality profile represents an age structure with mostly prime-aged adults, and few young and old adults (see Figure 3.1). In addition, a prime-dominated mortality profile has been characterized as having an abundance of prime-aged adults (Stiner 1990, 1991). Prime-dominated profiles are the result of selective culling of prime-aged adults from an animal population. The prime-aged adults are the healthiest of the herd, usually at or near their maximum weights.

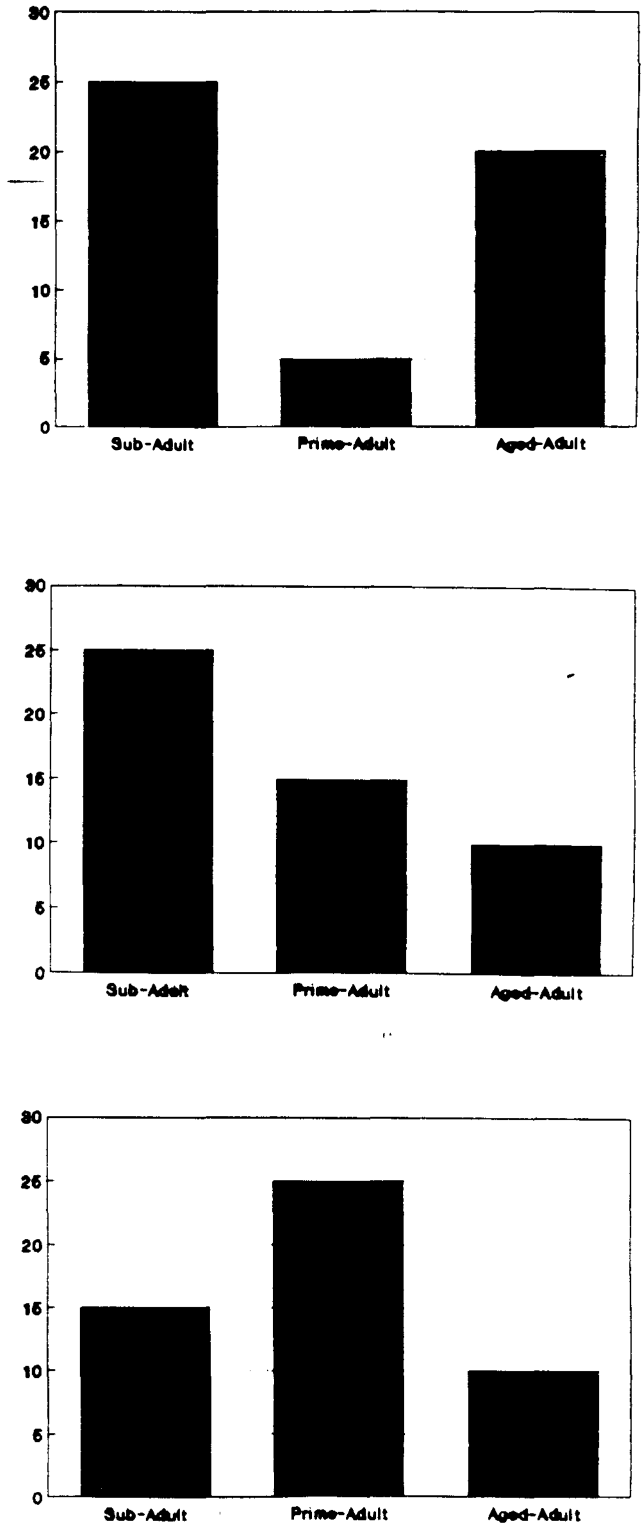


Figure 3.1: A) Attritional, B) Living-Structure (after Caughley 1966, 1977) and C) Prime-Dominated (after Stiner 1990, 1991) Mortality Profiles.

Mortality Profile Studies

Analyses of age profiles for animal populations are used to determine seasonality and hunting intensity. Seasonality can be determined from the variation in the younger age groups of a population. Age and sex within populations varies seasonally, and this information can be used to make inferences about the season of an archaeological assemblage (Monks 1981). Hunting intensity can be examined from the percentages of animals present in certain age groups (Coe *et al*. 1980; Lyman 1987). Both of these investigations are important for deciphering past hunting adaptations.

Davis (1983) examined the death assemblage for gazelles (*Gazella*) from Mousterian, Aurignacian, and Natufian sites in Israel to determine whether the percentage of juveniles at the different sites represented seasonal hunting, or hunting throughout the year. Gazelles bear young in the Spring, and age classes based on young juveniles (1-5 months), average juveniles (6-10 months), and old juveniles (11-15 months) revealed that Mousterian and Aurignacian period sites had higher proportions of gazelles in the middle age category, suggesting a winter hunting season. The Natufian period site was quite different; all juvenile age classes were present in high proportions, which indicated a more sedentary, all-season hunting strategy.

Turner (1985) examined an age profile of extinct springbok (Antidorcas bondi) from the Swartkrans Hominid site to determine if these animals were being hunted seasonally. After assuming an October birth date for springbok, Turner (1985) determined that Swartkrans Member 2 was deposited during the summer months. These studies indicate that utilizing age profiles for determining seasonality of archaeological sites can prove valuable.

Age profiles can also be useful for determining the hunting intensity on animal populations. Hunting pressure can produce variable age distributions within populations, either directly (through age-specific culling), or indirectly (through changes in the population structure from hunting) (Coe et al. 1980; Mitchell 1989). Koike and Ohtaishi (1987) examined the shift in hunting intensity on sika deer (Cervus nippon) for three cultural periods in a Japanese shell midden. The age profiles for the earliest period suggest a predominance of adult sika deer, with a hunting rate of five percent. The middle period shows a markedly increased hunting rate of fifteen percent, and an age profile with a predominance of fawns. Finally, the latest period indicates a slight decrease in hunting intensity to ten percent and an age profile with abundant juveniles.

Mitchell (1989) conducted a study on a modern death assemblage of white-tailed deer in Tennessee to determine

the influence of hunting on a previously protected population. The resulting age and sex profiles for 2,506 deer harvested from 1985 to 1988 revealed that the proportion of yearlings steadily increased during this four year period, while the proportion of adults decreased. Estimates were based on the median ecological longevity, which is the relative cumulative frequency of deer regressed against age. The median ecological longevity of harvested deer decreased from two and a half to one and a half years. Harvest of yearling bucks increased, while frequencies of adult bucks decreased; and yearling doe harvest increased, while adult doe frequencies decreased. Mitchell (1989) concluded that hunting affects the age and sex composition of a population. For example, even when hunters have a bias towards adult bucks, all ages and sexes are affected, and hunters lose selectivity as availability of preferred animals decreases.

A study conducted by Stiner (1990) utilized mortality patterns to determine the importance of ungulates in hominid adaptations. Stiner (1990:307) argued that it is necessary to understand the variables affecting mortality patterns, such as variance in the ecology of predators and prey. Differences between different predators and naturally-induced mortality patterns indicate that humans are the only predator that

generally produce mortality patterns with more prime-aged adults (Stiner 1990:316-317). This phenomenon can be applied to determine the agency of accumulation for assemblages of ungulates. For example, old and young-biased age profiles suggest scavenging, while prime-dominated profiles indicate ambush hunting.

Population Biology

Several areas of white-tailed deer biology are important to understand for constructing mortality profiles. First, the reproductive cycle of female deer begins with the first ovulation around 12 months of age (Woolf and Harder 1979). Second, white-tailed deer ovulate in November and December, have a gestation period of 199 to 207 days, and usually give birth to one or two fawns in the Spring (Sadlier 1987). Third, Chapman and Feldhamer (1982) document that fawns are born predominantly in May and June in North America. Some variability does exist and fawns from Alabama, Louisiana, and Mississippi, for example, have been documented as being born as late as October (Causey 1989). A study of juvenile deer from Alabama showed that the differences in weight and development of fawns born before July and after July were slight (Causey 1989:7-8). In other words, the fawns born later in the year were able to 'catch up' to fawns born earlier in the year. Finally, white-tailed

deer are classified as polytocous browsers, and give birth to fawns weighing 2.5 to 4.0 kilograms (Bunnel 1987).

The tooth eruption and replacement schedules for white-tailed deer were based on Severinghaus (1949) and Schwartz and Schwartz (1964). Loss of the deciduous fourth lower premolar take place at approximately 17 months. The eruption ages for the permanent first and second lower molars are 5 months and 8 months respectively. The average longevity of white-tailed deer is estimated as 150 months in the wild, although they can live up to 180 months in captivity.

Determining the age of individuals at death in a population of white-tailed deer associated with a prehistoric site has important implications. Knowing the age profile of the deer population would allow archaeologists to understand how the prehistoric population exploited deer herds. For instance, an attritional age profile would show that the prehistoric population exploited the weaker young and very old animals rather than the strong, mature animals. Perhaps this would be the case if the prehistoric population did not have the technological or organizational capacity to successfully hunt down animals in their prime. Broad studies such as this would be of great use to regional archaeological studies.

Conclusion

Mortality profiles are useful to Zooarchaeologists for understanding animal population changes. Studies of prehistoric animal populations use mortality profiles to discover changes in seasonality and hunting intensity in the archaeological record. Determining ages of young animals for mortality profiles can lead to conclusions about seasonal use of animals. Finally, mortality profiles developed for hunting intensity can answer questions about hunting techniques and animal selection.

Mortality profiles are interpreted as either u-shaped, living-structure, or prime-dominated. The shape of the profile can then be used, in conjunction with population biology information, to determine whether the mortality is natural or cultural, and if cultural, then what types of hunting pressure are being applied. Once mortality profiles of a prehistoric animal population are understood, researchers can draw conclusions about the people subsisting on these prey species.

Chapter IV: Shell Middens Investigations

Introduction

Shell midden deposits are important areas for archaeological investigation due to their world-wide occurrence in both coastal and riverine environments, throughout a long period of human cultural development. Shell middens have been documented in both the New and Old World in places such as Australia, New Zealand, Spain, Japan, the Pacific Islands, and Coastal and Interior North and South America (Brennan 1977; Ceci 1977; Foster 1975; Sanger 1981; Koloseike 1970; Waselkov 1982). The earliest known shell midden is Terra Armata, Spain, dating to 300,000 B.P.; others include the Good Hope rockshelters (70,000-60,000 B.P.), and the Mousterian period shell deposits (45,000-41,000 B.P.) (Waselkov 1982).

Research on shell middens has changed over the past 200 years. In the 1700s, shell middens were thought to be natural accumulations of molluscs, but by the 1800s it was accepted that shell middens were cultural deposits (Waselkov 1982). Most researchers in the late 1800s, such as Jeffries Wyman and C.B. Moore, were concerned with bisecting and describing the stratigraphy of the shell middens they encountered (Cumbaa 1976). During the early 1900s, archaeologists' primary interest was to excavate the well-preserved human skeletal remains and associated

artifacts often found in shell middens.

Later, an interest grew in shellfish quantification following the "California" school of archaeology (Claasen 1986). Archaeology in the mid-1900s played a role in paleoenvironmental reconstruction with shell midden research (Matteson 1960; Morrison 1942). During the 1970s and 1980s researchers examined shellfish in prehistoric economies by determining its dietary importance in terms of calories, protein, and carbohydrate contribution (Anderson 1981; Brose 1972; Claasen 1986; Erlandson, 1988; and Parmalee and Klippel 1974). Seasonality and paleoenvironmental reconstruction were also a major part of shell midden investigations (Bernstein 1990; Killingley 1981; Koike 1979; Warren 1991). Currently, other areas of investigation such as geoarchaeology, paleoethnobotany, lithic analyses, and zooarchaeology are used to decipher the complicated patterns present in prehistoric shell middens.

This chapter will investigate regional studies of shell middens from the Mid-south. In addition, research at the Hayes site, a Mid-south shell midden with predominantly Archaic period occupations, will be investigated. Research at this site has incorporated a broad scale of analyses to interpret the prehistoric behaviors associated with the occupation.

Regional Studies from the Mid-South

Shell midden investigations in the Mid-south have been established since 1915, with the work of C.B. Moore, and have continued to be of interest in the 1990s. The focus on Archaic period shell middens has shifted from burial excavations and descriptions to understanding the relationship between Archaic period shell midden dwellers and their environment. This shift can be seen in the reports, articles, and books published on shell midden excavations. Some of these sites include: Pickwick Basin shell middens (Webb and DeJarnette 1942), McLean County, Kentucky archaic sites (Webb and Haag 1947), Indian Knoll (Webb 1974), Carlson Annis (Webb 1950),Eva (Lewis and Lewis 1961), Ervin (Hofman 1984), and Hayes (Hofman 1985; Morey 1988).

The Pickwick Basin sites were some of the first systematically excavated Archaic period shell middens in the Mid-south. The work in the basin progressed along the Tennessee River and uncovered approximately nine shell heaps. These shell heaps were thought to be unusual, and interest increased as large numbers of burials were found within the shell middens. The McKelvey mound, located along the Tennessee River, was said to be erected on an old village layer and contained much shell, bone artifacts, burials, and clay-grit pottery (Webb and DeJarnette 1942). Smithsonia Landing was an extensive

shell midden near present-day Florence, Alabama. This midden extended for 250 feet in length, 125 feet in width, and 12 feet in depth. Several burials were uncovered from the midden units, as well as 141 limestone potsherds. The Perry site, even larger than the Smithsonia Landing site, was approximately 300 feet long, 200 feet wide and 10 feet high. The emphasis in excavating this deposit was on defining the stratigraphy, so a trench was excavated through the midden and several layers were defined. Predominantly, the layers consisted of dark clay/loam layers between layers of many shellfish remains, bone and stone artifacts and burials. Over 180 burials were removed from the site, including 20 dog burials.

The commonalities among all of the shell middens prompted Webb and DeJarnette (1942) to define the "Shell Mound Complex." General traits of this complex include shell mounds as habitation sites, fire hearths on clay floors, scattered postmolds, river pebbles broken by heat, and fire basins lined with river cobbles. Burial traits were defined as burials within the mounds, burials without artifacts, and partially and fully flexed burials. Technological traits included circular hammerstones, flint blades, wide-stemmed projectile points, flint drills, antler drifts, turkey bone awls, and cylindrical bone needles.

The material from the Pickwick Basin was utilized in

some analyses to gain a better understanding of the newly defined shell mound complex. Morrison (1942) analyzed a sample of molluscs recovered from the shell midden sites. He concluded that the mounds were contemporaneous, contained a variety of pelecypod and gastropod species, were located near shoals in the river, and surrounded by forested floodplains.

The Green River area of Kentucky is also known for a predominance of shell midden sites. Webb and Haag (1947) undertook research of McLean County, and located four sites in a close radius. Two of these sites were large shell middens. The Barrett site was located on Pond River, approximately 12 miles from the Green River. This site was circular, approximately 300 feet in diameter, and three to eight feet deep. The technique used for excavating this midden entailed staking the area in ten-foot squares and excavating in one-foot levels. Features discovered in the midden include fireplaces, caches of artifacts, refuse pits, and clay floors. Over 400 burials were recovered from a two foot layer of deposit, and contained 237 adults, 41 children, and 101 infants. Most of the burials were flexed within round graves, but a few were partially flexed or extended, disturbed, incomplete, or skulls only.

The second shell midden site, the Butterfield site, was also of interest to the investigators. This site was

1200 feet long and 150 feet wide, and contained vast amounts of shell in addition to some burials and features. The artifacts recovered from the site were described as "the usual types found in the shell-mound complex" (Webb and Haag 1947:34). In sharp contrast to the shell midden sites, the Smith site was a small rockshelter site located one-half mile from the Green River. This site contained a few remains of animal bone, flakes, and shells. Another small site, the Reynerson site, was defined as a small campsite, occupied for a short amount of time.

These four sites led the investigators to draw some conclusions about the settlement pattern of the shell mound complex people in McLean County. Webb and Haag (1947) concluded that all four sites are from occupation of a single group of people, and their culture complex was non-pottery and non-agricultural. The shell mounds were occupied most of the year, and in times of high water the inhabitants were driven to the rockshelters to camp periodically. The material associated with these groups was of the Archaic period.

Carlson Annis mound, located in Butler County, Kentucky along the Green River, is a large deposit investigated by Webb (1950). This site was approximately 350 feet long, 300 feet wide, and seven and a half feet deep. Excavations were conducted by trenching the site with an east-west trench, and then staking the rest of the

site into five foot squares and removing the material in half foot levels. A variety of features were uncovered, such as fire hearths, rock lined fire basins, burned clay floors, storage and refuse pits, and caches of pestles, hammerstones, deer antlers, chert blades, shells, and sandstone tablets. Three hundred and ninety human burials and twenty-eight dog burials were recovered from the midden, but the preservation was poor so only burials with artifacts associated with them were cleaned and measured.

Interest in artifacts such as fish hooks and atlatls led Webb (1950) to develop chronologies for these remains. Fish hooks appear first as manufactured from deer phalanges, then drilled fish hooks take precedence, only to be replaced by bodkin fish hooks in later occupations of the site. The deer phalanx fish hooks are not as common at Carlson Annis as they are from shell midden sites in Alabama. Atlatls first appear, then stone and prismoidal weights are added to the shaft, finally the all wooden shaft is found with prismoidal stone weights with hooks. The chronologies of fish hooks and atlatls were developed from the location of the artifacts within the stratigraphy of the site.

Webb (1950) was also interested in 'medicine bags' owned by prehistoric inhabitants of the shell midden sites. Carlson Annis mound excavations recovered a number of small mammal jaws that had been cut, and it was thought

that these represented the medicine bags first recorded by Catlin in 1841. Catlin noted that the Indians he encountered carried medicine bags containing the jaw bones of animals such as bobcat, mink, martens, dogs, groundhogs, and rabbits. Webb (1950) concluded that the jaws of similar animals found at Carlson Annis, often associated with burials, were representative of medicine bags.

Indian Knoll was a shell mound located along the Green River in Kentucky. This mound contained a large number of human burials, excavated by both C.B. Moore and W.S. Webb (Webb 1974). Almost 1200 burials were removed from Indian Knoll, an area only 450 feet long, 220 feet wide and 5 feet deep. In 1915, C.B. Moore managed to remove 298 burials in 22 days with a crew of eight men. It was expected that much of the mound would have been destroyed by the removal of so many burials, but trenching by Webb's crew revealed only a small portion had been damaged. Most of the burials were round grave burials containing flexed individuals.

The trait lists were also accompanied by a listing of some of the refuse animal bone recovered from the units. White-tailed deer was by far the most abundant species; about 23,756 specimens were identified as deer out of a total of 25,756 remains, but this may be reflect recovery techniques. Other species represented include raccoon,

opossum, dog, groundhog, squirrel, fox, beaver, bear, skunk, chipmunk, mink, rabbit, turkey, goose, and drumfish. The identifications were made by Opal Skaggs, an anatomy graduate student, who also conducted an analysis of the dogs recovered from the site. Bone measurements were taken on 17 dog burials and compared to coyote and wolf specimens. It was concluded that the dogs were more similar to the coyotes and were probably descended from them.

Lewis and Lewis (1961) investigated the Eva site in Benton County, Tennessee. This site was located in the upper west-central region of Tennessee, on the Tennessee river floodplain. The landscape was characterized as swell and swale topography with swampy vegetation (Lewis and Lewis 1961). The stratigraphy of the site was composed of five strata. The first (top) stratum was approximately two and a half feet deep with heavy black soil and no mussel shells. Defined as the Big Sandy Phase and dated to 3,500 to 2,500 years ago, this stratum coincides with the Medithermal, a period of a higher precipitation and increased river depths. According to Lewis and Lewis (1960:9), the climate may account for the lack of shells in this layer. Stratum two was designated the Three Mile Phase, dating approximately from 6,000 to 3,500 years ago. This layer was characterized by heavy shell and ash content with little animal bone. The next

stratum was determined to be a flood deposit, containing mostly sand and silt. Stratum four contained abundant chert flakes, animal bone, ash, dog coprolites and shell. This stratum was termed the Eva Phase and dates from 8,000 to 6,000 years ago. The fifth stratum was another flood deposit with some intrusive Eva Phase pits.

Emphasis on material recovered from the Eva site shifted from the previous interest on burials seen in the Webb reports (1942, 1947, 1950, and 1974) to subsistence, stratigraphy and technology. Subsistence is of primary interest, and a total assemblage of 18,089 specimens is examined for differences between the occupation periods. Mammal remains were the most numerous for all phases, making up 83% of the Big Sandy and Three Mile occupations, and 94% of the Eva occupation. Birds, turtles and fish were slightly more abundant in the Big Sandy and Three Mile phases (17%). Lewis and Lewis (1961:20) argued that a subsistence change occurred between the Eva and Three Mile periods, because the Eva occupation contained five times as much bone as the Three Mile occupation; the Three Mile occupation contained vast amounts of mussel shell.

The investigations of subsistence, stratigraphy and technology at the Eva site allow several conclusions about the lifeways of the prehistoric occupants. Lewis and Lewis (1961) concluded the site was a single habitation area for several thousand years, probably by the same

group of people and their descendants. The Eva phase was the earliest at the site (8,000 to 6,000 B.P.), characterized by heavy reliance on white-tailed deer as a source of food and tools. The Three Mile stratum was occupied by people with an economy based on fishing and exploiting riverine resources from 6,000 to 3,500 years ago. Finally, the Big Sandy phase was occupied from 3,500 to 2,500 years ago, and the people decreased their reliance on mussels but may have increased participation in the trade network.

Hayes Site (40ML139)

A shell midden located on the Duck River in Middle Tennessee was excavated as part of the Columbia Archaeological Project during the late 1970s by the University of Tennessee (Figure 4.1). The Hayes site was occupied from 6,000 to 4,200 years ago, and corresponds to the Three Mile phase at Eva. Hayes differs from other shell middens because of the greater quantity of gastropods in the midden compared to pelecypods. Carbon-14 dates for the site range from 6,000 to 4,200 B.P., and much of the deposit contains early Middle Archaic to Late Archaic occupations (Turner et al. 1982). A review of this research attempts to place the Hayes site in context with the environment, as well as the cultural characteristics that define the Archaic (Amick 1987;

Figure 4.1: Contour Map of the Hayes Site (40ML139), with arrow indicating vicinity of site (after Klippel and Morey, 1988)

Brackenridge 1984; Hofman 1984; Juchniewcz 1991). In addition, previous investigations of material from the Hayes site offer some explanations for site adaptations (Carr 1991; Morey 1988).

Environmental and Cultural Context

The environmental context of the Hayes site shell midden is based on climatic change with the onset of the Hypsithermal between 8,000 and 5,000 B.P. This mid-Holocene period is classified as a warming and drying trend that replaced much of the boreal forest in the Southeast (Delcourt and Delcourt 1981). Smith (1986:23) correlates the Hypsithermal with a change in atmospheric flow and a shift from flooding rivers to stable rivers. Because the floodplains were much more stable, this warming and drying trend left the upland areas with much less precipitation and may have caused an increased human dependence on aquatic resources (Smith 1986:24-25). The Hypsithermal also caused an increase in riverine swamps (Anderson and Hanson, 1988). These environmental factors set the stage for understanding the adaptations possible during a period of great climatic change.

Prior to the Hypsithermal, from 12,500 to 8,000 B.P., the environment was much cooler and forests were temporally and spatially heterogenous (Smith 1986). During the Hypsithermal, the Laurentide ice sheet

retreated and caused a slight warming trend from earlier periods (Delcourt and Delcourt 1981). Post-Hypsithermal times were characterized by mixed hardwood forests with climate and precipitation similar to the modern environment (Delcourt and Delcourt 1981). The mid-Holocene Hypsithermal is of great interest in southeastern archaeology because the obvious environmental changes are not completely understood in terms of human adaptation strategies.

The cultural context for Archaic period populations in the Mid-south is also important for explaining shell midden occupations (Anderson and Hanson 1988; Caldwell 1958; Chapman et al. 1982; Ford 1941; Lewis and Kneburg 1959; Nance 1987; Smith 1986). Lewis and Kneberg (1959) defined regions, phases and traditions for the Mid-south. Basically, four regions are differentiated: the Kentucky, Tennessee, Alabama, and Georgia regions. Typical sites of these regions are large shell middens varying in depth from several to 20 feet deep, located close to streams, and usually inhabited for long periods of time (Lewis and Kneberg 1959:161). Phases in the Mid-south include the Eva Phase (6,000-4,000 B.P.), Three-mile Phase (4,000-1,500 B.P.), and the Big Sandy Phase (1,500-500 B.P.), and all of these phases are of the Midcontinent Tradition (Lewis and Kneberg 1959). Ford and Willey (1941:332) characterize the Archaic period as having no horticulture

or pottery, but being the foundation for later cultural developments. Sites were usually located in close proximity of abundant shellfish, with no associated structures and "simple" burials (Ford and Willey 1941).

Later interpretations of Archaic period culture acknowledge the complexity of hunter-gatherer interactions with the environment and other groups. Evidently, a broad spectrum of cultural change occurred from Paleoindian subsistence utilizing a fluted-point technology and following large mammal herds to semi-sedentary Late Archaic groups practicing small-scale horticulture. Early Archaic groups are characterized by brief, non-intensive site occupation with deer as the primary food source (Nance 1987). Anderson and Hanson (1988) developed a model of Early Archaic settlement patterns as aggregated in the winter, and dispersed for the remaining seasons. Smith (1986) characterized the cultural context of Middle Archaic people as a period of increased sedentism due to the abundance of aquatic resources and stabile floodplains. Middle Archaic sites often contain dense, organic middens representing intensive, multiple occupations (Nance 1987). Sites dating to the Middle Archaic in the Mid-south are not always associated with shell middens, but the intensity of site use may also occur with other localized resources such as oak-hickory forests. Nance (1987) investigated the Archaic in the

Lower Tennessee-Cumberland-Ohio region and concluded that shellfish are not a feasible resource in this area.

As the environment stabilized during the Late Archaic, mobility may have increased slightly, but people began to adopt plant domestication (squash and gourds) between 4,400 and 3,300 years B.P. (Chapman et al. 1982, Crites 1987). The changes in Archaic period cultures suggest that the Middle Archaic may have played an important role in the evolution of southeastern prehistoric populations. Thus, it is important to discover and explain the subsistence and settlement patterns present during the Middle Archaic to understand how they affected future cultures.

Hayes Site Investigations

Several areas of research were undertaken with the material recovered from the Hayes site: site formation processes, vertebrate and invertebrate faunal analyses, and lithic analyses (Klippel and Turner 1991; and Morey 1988; Morey and Klippel 1991). The analyses intended to answer questions about the relationships between the various Hayes site occupations, and included paleoenvironmental reconstruction and settlement and subsistence patterns.

Site formation at Hayes was interpreted through the excavation of two trenches and a stratigraphically

excavated block unit (Morey 1988). The occupation from 6,200 to 5,800 years ago was by early Middle Archaic people who utilized small quantities of shellfish. Later, from 5,800 to 5,600 B.P., flooding deposited alluvium sediment. Late Middle Archaic occupation of the site occurred for the next 1,200 years. Then, from 4,400 to 4,200 B.P., people classified as Late Archaic produced a Ledbetter type of projectile point. During this period, the use of the site apparently changed as indicated by the disappearance of aquatic gastropods from the midden deposits. Finally, around 2,000 years ago Woodland peoples occupied the site, leaving behind various pottery fragments.

Morey (1988) conducted extensive analysis of the faunal material from three block units excavated by natural strata. Over 24,290 grams of unmodified faunal material were excavated from the block unit. The predominant animal class by count was mammal (93.39%), followed by reptile (5.28%), bird (1.01), fish (.29%), and amphibian (.10%). Subsistence patterns identified for the early Middle Archaic occupation of the site were characterized by intensive use of mammal species, particularly deer. The late Middle Archaic period was characterized by a vast amount of invertebrate and vertebrate faunal remains. The vertebrate faunal remains were predominantly deer, supplemented by cottontail

rabbit, raccoon, turkey, turtles, and fish. The subsistence remained basically unchanged for almost 1,200 years. Finally, the Late Archaic period of occupation marked a change in the subsistence practices at the site. Late Archaic occupants utilized a variety of plant and animal foods but did not procure shellfish.

Klippel and Turner (1991) examined the terrestrial gastropods from Hayes and compared them to modern assemblages from Middle Tennessee. Terrestrial gastropods are good environmental indicators, sensitive to fluctuations in temperature. The comparison by Klippel and Turner (1991) revealed that regional changes in the environment occurred between the middle and late Holocene in the Nashville Basin.

A study was conducted on the white-tailed deer remains from Hayes (Morey and Klippel 1991). Approximately 940 deer bones were examined for the extent of canid ravaging that may have occurred at the site. The canid ravaging at the site was considered to be a factor in interpreting the skeletal remains, since 23.5% of the deer bone was modified by canids.

Lithic studies conducted by Amick (1987) and Carr (1991) have suggested a change in organizational strategy from the Middle to Late Archaic. Amick (1984) noted that changes in tool technology indicate a shift to logistical, permanent base camps during the Late Archaic. Carr (1991)

examined the debitage from several Hayes units and determined that site use may have changed from a forager to a collector strategy between the early Middle and late Middle Archaic, and the Late Archaic people may have used the site as a collector camp.

Hofman (1984) conducted a regional study into explanations for hunter-gatherer mobility in the Nashville Basin and interpretations were based on a variety of models for hunter-gatherer occupations (Caldwell 1958; Lewis and Lewis 1961). Hofman concluded that Fall occupations were characterized by harvesting nut crops in the uplands, and exploiting raccoons, turkeys, squirrels, and deer located in the area. The groups were organized with aggregated and residential occupations. Winter occupations were in sheltered sites, with stored resources, and groups were dispersed logistically in minibands. Spring groups harvested vast quantities of shellfish and other water resources, and were aggregated in maxibands. Summer groups became dispersed again and exploited patchy areas.

Conclusion

Regional southeastern shell midden studies have a long standing history. Early research by Webb (1950, 1974) and others focused on the burial practices of the shell mound culture. Later, Lewis and Lewis (1961) became

interested in the subsistence and chronological sequence of the shell midden occupants. Finally, work in the Nashville Basin prompted investigations about the change between Middle and Late Archaic occupations, and hunter-gatherer mobility patterns. Investigations of these changes have been attempted through environmental reconstruction, regional mobility patterning, and understanding subsistence change.

Research at the Hayes site provided an understanding of the complexities of life involving prehistoric shell middens. First, environment and climate affected how people adapted to their habitat. These analyses revealed a site occupied periodically over a two thousand year period. Evidence based on lithic analyses suggests that during this time a shift from foraging to collecting occurred. Faunal analysis suggests people began collecting aquatic gastropods as a dietary supplement, not as a major food resource. A regional study of Archaic hunting bands suggests the Hayes site may be characteristic of Spring groups gathering shellfish during the late Middle Archaic period (Hofman 1984). Early Middle and Late Archaic people may have been occupying the Hayes site during the Fall or Summer months.

Chapter V:
Materials and Methods

Introduction

This chapter describes the materials and methods used to construct mortality profiles for the Hayes site white-tailed deer. A regression formula for aging white-tailed deer has already been illustrated in Chapter II. This regression formula proved valuable for estimating ages during a blind test of white-tailed deer specimens. However, a modified iterated age-length key may be better suited to constructing mortality profiles for white-tailed deer. Consequently, mortality profiles are derived with a modified iterated age length key, similar to age length keys used in wildlife research (Kimura 1977; Konigsberg and Frankenberg 1992). In addition, maximum likelihood estimation is used to place archaeological specimens into age categories. The mortality profiles are developed to examine both hunting intensity and seasonality at the Hayes site.

Materials

The Hayes site sample consists of 268 lower mandibular teeth collected from 38 units excavated at the Hayes site, and spanning all periods of occupation (see Table 5.1). The first molar was selected because this tooth erupts early and provides a good indication of age.

Table 5.1: First Molars from the Hayes Site (40ML39) Archaic Components

Component	NISP	MNI
Early Middle Archaic	25	14
Late Middle Archaic	58	32
Late Archaic	17	11
Total	100	57

One hundred first molars were recovered from the site: of these, 25 were from the early Middle Archaic, 58 from the late Middle Archaic, and 17 were from the Late Archaic. The total MNI of deer for the site was 57, including 14 from the early Middle Archaic, 32 from the late Middle Archaic, and 11 from the Late Archaic.

In addition to the first molar, the fourth deciduous premolar was used to examine the distributions of young deer within the archaeological sample. A total of 23 fourth deciduous premolars were collected from the Hayes site units: 8 from the early Middle Archaic, 12 from the late Middle Archaic, and 3 from the Late Archaic (see Table 5.2). Although these numbers are low, this represents a 100% sample of all the deer teeth recovered from the site.

After collecting the white-tailed deer teeth from the Hayes site, it was important to consider the sequence of ages for the mortality profiles. The mortality profiles were separated into sub-adult, prime-adult and aged-adult

Table 5.2: Fourth Deciduous Premolars from the Hayes Site (40ML139) Archaic Components

Component	NISP	MNI
Early Middle Archaic	8	5
Late Middle Archaic	12	8
Late Archaic	3	2
Total	23	15

age categories. Sub-adult white-tailed deer range in age from 0 to 18 months and represent deer which are below maximum weights, reproduction, and antler development (Jacobson and Reiner 1989). Dentition of sub-adults reaches maturity when the third permanent molar comes into wear (Schwartz and Schwartz 1964; Severinghaus 1949). Prime-adult white-tailed deer are from 19 to 72 months old and have reached maximum weights, reproduction, lactation, antler development, and mature dentition. Aged-adults are over 73 months old and represent deer which have begun to decline in weight, reproduction, and antler development. Dentition of aged-adults is severely worn, with almost all of the dentine becoming exposed (Severinghaus 1949).

Methods

A regression formula is presented in Chapter II as a simpler approach to estimating ages of white-tailed deer.

The quadratic regression formula is presented as follows:

$$Y=\alpha+\beta_1(x)+\beta_2(x)^2$$

Individual ages can be derived by measuring the crown height of an unknown specimen (x) and by using the information in Figure 2.6 (see Chapter 2).

A modified iterated age length key (Konigsberg and Frankenberg 1992) was employed for developing mortality profiles for early Middle, late Middle and Late Archaic occupations at the Hayes site. The age length key utilizes a target, or archaeological, sample and a reference, or modern, sample to estimate age (Konigsberg and Frankenberg 1992).

Assuming a normal density within age classes, the modified iterated age length key is applied to a continuous age indicator such as crown height measurements. The normal density is:

$$P_{xa}=\frac{1}{\sqrt{2\sigma_a^2\pi}}\left(-\frac{1}{2}\,\frac{X-\mu_a^2}{\sigma_a^2}\right)$$

where μ_a and σ_a^2 are the mean and variance of crown height within age class "a" for the known age Mississippi deer (Konigsberg and Frankenberg 1992:247). P_{xa} is the

probability of observing a given crown height (x) conditional on the deer being in a particular age class (a).

An expectation maximization (or EM) algorithm is applied to the crown height measurements for determining age distributions (Dempster et al. 1977). The first step, or expectation step, finds the probability that any given deer is in a particular age class (a) conditional on its crown height measurement (x) (Konigsberg and Frankenberg 1992:240). This expectation is found using Bayes theorem:

$$\hat{P}_{ax} = \frac{P_{xa}\hat{d}_a}{\sum_{a=1}^{w} P_{xa}\hat{d}_a}$$

where $\hat{d}_a$ is an estimated age-at-death distribution for the target sample, w is the number of age classes (3) and P_{xa} is a function of the known age deer. On initialization , a uniform distribution is assumed for this step, and the three age categories are given distributions of .33, .33 and .34 respectively.

Finally, the actual age distributions are determined with the maximization step of the EM algorithm. This step finds the maximum likelihood estimate of the age distribution of the archaeological deer sample, based on the probabilities of each deer being in a particular age

class conditional on crown height (P_{ax}).

The maximization formula is represented as:

$$\hat{d}_a = \frac{\sum_{i=1}^{n} \hat{P}_{ax}}{n}$$

The results of this equation are then cycled back into the expectation equation for numerous cycles until the estimated age distributions stabilize between cycles (Konigsberg and Frankenberg 1992).

The maximum likelihood estimate for the age distribution is identified at the maximum probability of getting the observed distribution of crown heights in the target sample, conditional on the information from the reference sample. This equation is given as:

$$\sum_{i=1}^{n} \ln\left(\sum_{a=1}^{w} P_{xa}\hat{d}_a\right)$$

This represents the likelihood of an archaeological sample mortality structure based on the observed crown height measurements (Konigsberg and Frankenberg 1992). At this point, the distributions in each category can be defined as the mortality profile for the archaeological sample.

Chi-square statistical analysis is conducted on the estimate for the age categories to determine any differences between periods. The chi square takes the log-likelihood for each pooled and saturated distribution,

where the pooled distribution is the combined log-likelihoods for each period, and the saturated distribution combines two of the periods and then adds the third. The log-likelihoods from the saturated distribution are subtracted from the pooled distribution and multiplied by -2 to get a chi square estimate. The chi square is calculated as:

$$-2[lnL(\hat{d}_p|F_p)-lnL(\hat{d}_1|F_1)-lnL(\hat{d}_2|F_2)]$$

where $\hat{d}_p$ is the pooled maximum likelihood estimate, $\hat{d}_1$ and $\hat{d}_2$ are the first and second samples, and F is the information from the age indicators (Konigsberg and Frankenberg 1992:252).

Discussion

The modified iterated age length key equations for a continuous age indicator are more suited to estimating age structures of an unknown population than a simple regression equation. Iterated age length keys take into account variation within samples, and are not biased towards the known age population structure (Konigsberg and Frankenberg, 1992). Applying a simple regression equation for each specimen and then calculating the numbers within each age group may be simpler, but regression equations are too general to deal with the specific problem of developing age distributions.

Regression equations are unsuited to age estimates for several reasons. First, regression equations, rather than age measurements, may be the cause for skewed age distributions in animal populations (Gifford-Gonzales 1991). Second, the regression equation is based on the distribution from the reference sample, and information applied to the target sample may be biased to follow the pattern set by the reference sample. Finally, choosing a linear or quadratic regression equation may also bias age structures. These two types of equations may not account for all the variation in aging techniques.

Conclusion

A modified iterated age length key was used to develop age distributions for an archaeological sample of white-tailed deer teeth. The crown height measurement developed to age deer teeth is a continuous age indicator, similar to age length keys developed in wildlife biology. Four steps involving Bayesian and maximum likelihood formulas are necessary to derive the age distributions. First, the normal distribution probabilities of having a given crown height within a certain age are determined. Second, an expectation formula for the known age sample is used to determine the probability of having a given age in certain age categories. Third, a maximization step determines the distribution of deer in each of the age

groups. Fourth, the maximum likelihood estimate is the probability of getting an age distribution for a target sample based on information from the reference sample. All of these steps are central to deriving mortality profiles for an archaeological sample of white-tailed deer, and much more suited than regression formulas.

Chapter VI: Results

Introduction

White-tailed deer mortality profiles were analyzed to determine hunting intensity and seasonality during the early Middle, late Middle, and Late Archaic occupations of the Hayes site. Individual ages of the white-tailed deer were calculated with a quadratic regression formula. In addition, a modified iterated age length key was applied to the archaeological sample, utilizing information from a known age sample of white-tailed deer. Percentages calculated with the maximum likelihood method were applied to the sub-adult, prime-adult and aged-adult age categories. These percentages were then compared for all three Hayes site occupations for all ages categories and sub-adult seasonal categories.

Results

Information on individual age of the Hayes site white-tailed deer was obtained with a quadratic regression formula (see Appendix 3). However, these data are thought to be biased (for a discussion of biased age estimates see Konigsberg and Frankenberg 1992) and are not used to construct mortality of white-tailed deer remains from the Hayes site.

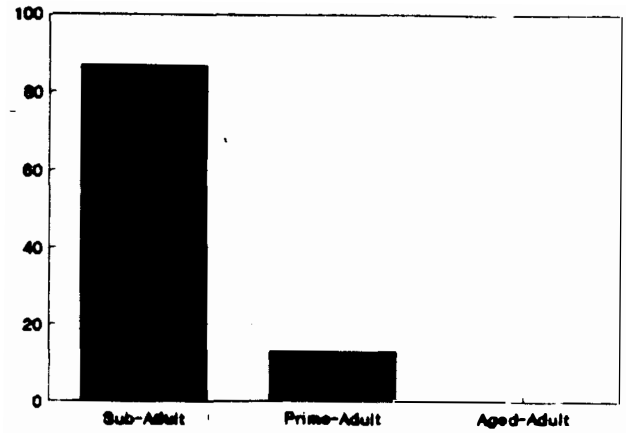
Instead, the modified iterated age length key was

applied to both first molars and fourth deciduous premolars. Age categories for the first molars were intended as large-scale indicators of hunting intensity. Age categories for fourth deciduous premolars were intended as indicators of seasonality, with young white-tailed deer separated into three month age intervals.

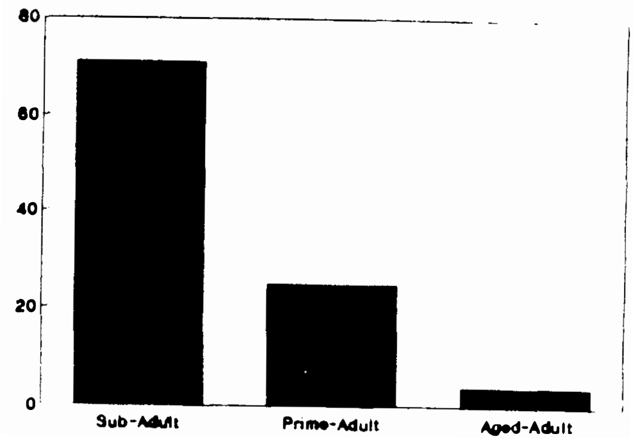
Percentages calculated from number of individual specimens for the first molar indicated that 87% of white-tailed deer from the early Middle Archaic were sub-adults, and 13% were prime-adults, with no aged-adults present (see Figure 6.1). Sub-adults represented 71% of Late Middle Archaic mortality profiles, prime-adults represented 25%, and aged-adults represented 4% (see Figure 6.1). Finally, Late Archaic percentages indicated 51% were sub-adults, and 49% were prime-adults (see Figure 6.1).

Percentages from number of individual specimens for the fourth deciduous premolar revealed that the young white-tailed deer were from the fall or winter seasonal intervals. In the early Middle Archaic, 100% were from the Fall age intervals (see Figure 6.2). During the late Middle Archaic, 54% of the young white-tailed deer were from the Fall age intervals, and 46% were from the Winter age intervals (see Figure 6.2). Finally, 65% of the Late Archaic sub-adult white-tailed deer were from the Fall age intervals, and 35% were from Winter age intervals.

A)



B)



C)

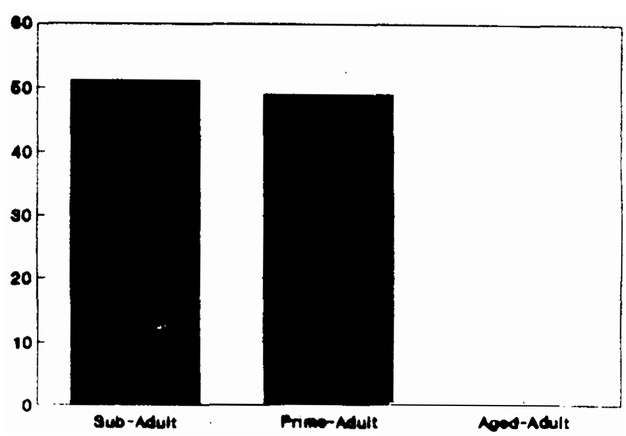


Figure 6.1: A) Early Middle, B) Late Middle and C) Late Archaic Mortality Profiles for the Hayes Site (40ML139) White-tailed Deer

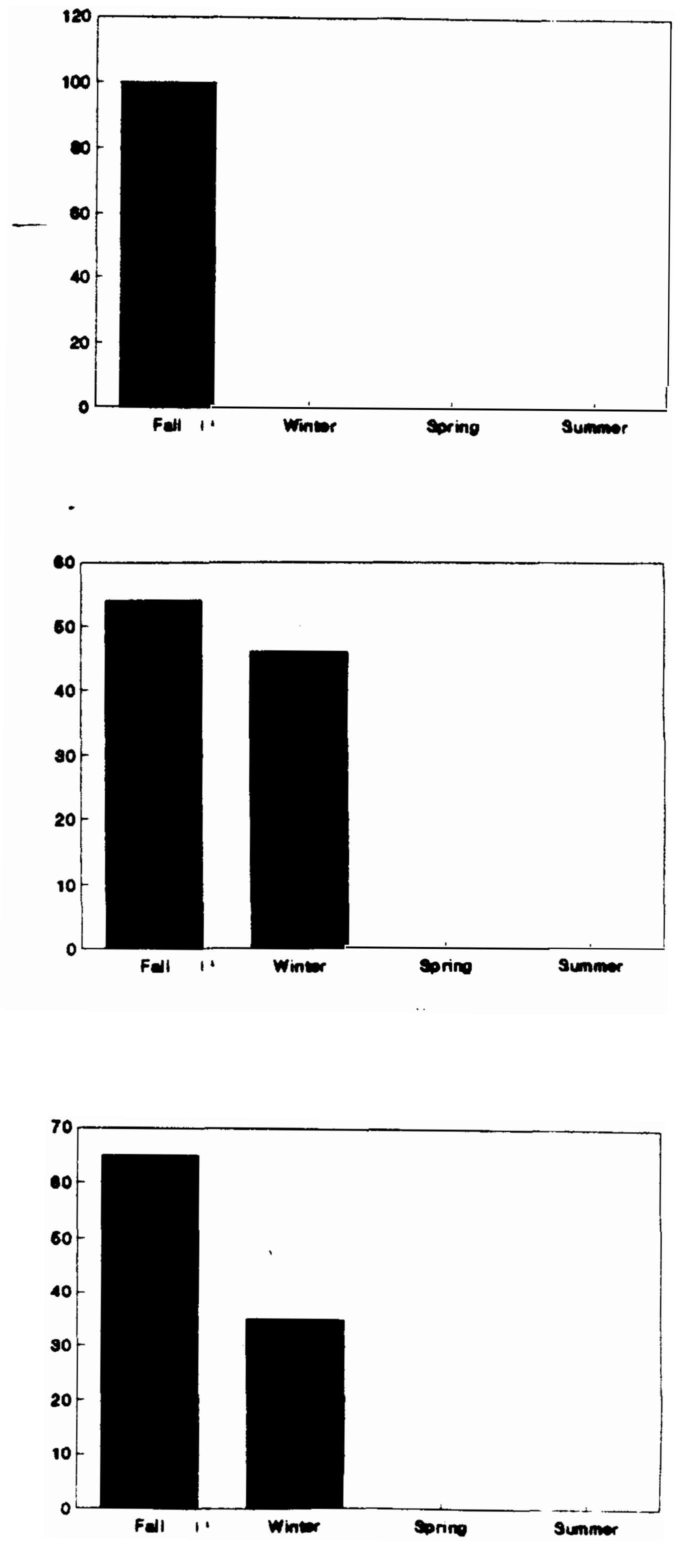


Figure 6.2: A) Early Middle, B) Late Middle and C) Late Archaic Seasonal Mortality Profiles for the Hayes Site (40ML139) White-tailed Deer

Chi-square statistical analyses were conducted to determine if the differences in percentages for the three periods are significant. A chi-square of the mortality profiles indicates no significant difference between the mortality profiles from the Middle Archaic occupations and the Late Archaic occupation of the Hayes site. However, a chi-square statistical analysis of the seasonal differences between the early Middle Archaic, and the late Middle and Late Archaic occupations shows a significant difference at an alpha level of 0.1.

Conclusions

Differences in Hayes site Archaic occupations were suggested by previous research on site organization, subsistence, and environment. White-tailed deer mortality profiles were investigated to determine if differences existed in hunting intensity and seasonality for the three Hayes site Archaic occupations. No significant differences were found in the mortality profiles between the sub-adult, prime-adult, and aged adult age categories. Although no differences in hunting intensity were found, a definite emphasis on sub-adult white-tailed deer was found for the Archaic period at the Hayes site.

Seasonal differences in sub-adult white-tailed deer were found significant with the chi-square statistical analysis. More specifically, seasonal differences were

noted between the early Middle Archaic and the later occupations of the site. Early Middle Archaic white-tailed deer hunting seems to be primarily in the Fall, from September to November. Late Middle and Late Archaic period hunting was in both the Fall and Winter seasons, from September to January.

Chapter VII: Discussion

Introduction

The results from the mortality profiles can be viewed with several different approaches. These approaches are methodological, ecological, taphonomic, seasonal and cultural. First, a methodological approach determines problems with the crown height aging technique. Second, ecological factors relate to white-tailed deer population biology, such as responses of deer populations to hunting pressure. Third, taphonomic factors, such as breakage of older, more worn deer teeth, affect animal age composition. Fourth, seasonal differences in the mortality profiles are factors to be considered. Finally, cultural approaches indicate human prey selection of certain animals. These approaches will shed light on the results from the white-tailed deer mortality profiles from the Hayes site.

Interpretations

Methodological factors may account for the large percentages of young animals at Hayes. Discrepancies may arise with the aging technique, such as several previously mentioned problems (see Chapter IV). First, teeth may have variable rates of wear due to the type of food and the age of the animal. Despite this, the technique

assumes that the teeth wear at a constant rate and that permanent teeth erupt after the deciduous tooth is completely worn. Second, the crown height measurement technique can skew the ages of animals. For example, bovines aged with crown height measurements leaned toward younger ages (Gifford-Gonzales 1991). However, Klein et al. (1981) argue that there are no directional biases in aging Cervidae teeth. Therefore, methodological problems with the technique are not likely the reason for the predominately sub-adult animals in the Hayes site mortality profiles.

Ecological factors may affect the structure of animal populations, such as the fluctuations in environmental conditions during the Hypsithermal. Animal populations respond to certain conditions by having more or fewer young (Sadlier 1987). In addition, females begin reproducing at a later age if conditions are poor or if the population has reached its carrying capacity (Sadlier 1987). However, if conditions are good and there are fewer older adults, females respond by producing more young (twinning) at a younger age (Mitchell 1989).

Ecological factors may not be the best explanation for the presence of young deer at the Hayes site. Environment fluctuated at the Hayes site, but this was spread out over many centuries and the deer population had ample time to adjust to the changes. Also, the presence

of acorns and hickory nuts at the site indicates an environment that may have been conducive to white-tailed deer reproduction. Thus, ecological factors probably did not cause the mortality profiles from the Hayes site to consist of predominantly young animals.

Taphonomic interpretations examine how artifacts survive in the archaeological record and come to be examined by archaeologists. In general, more robust elements are better represented in site contexts (Binford and Bertram 1977). Young deer teeth are unworn and stronger than older deer teeth. The crown of a young deer tooth is very high compared to older deer, and are much more likely to resist breakage. Very old deer teeth have extremely low crowns, sometimes almost meeting the cervical line, and much more likely to break. However, no dramatic proportions of old broken deer teeth were recovered from the Hayes site strata and taphonomic factors may not be the best interpretation for the large number of sub-adult white-tailed deer.

Seasonal differences in the sub-adult deer at the Hayes site reveal mobility strategies for the Archaic occupations of the site. Most of the sub-adults were killed from September to November, and all were killed from September to February. During these seasons, deer have acquired more weight from summer feeding, and have stored fats for the winter which becomes depleted by

Spring. The fall and winter seasons were perhaps the best time to acquire young deer, when they are most vulnerable from group segregation and had acquired their winter fat deposits.

In addition, the fall and early winter seasons provided access to two sub-adult age cohorts. Both the 4-6 month and 16-18 month sub-adult cohorts are present in great abundance during the fall. These young cohorts represent easy, plentiful game and an excellent source of protein. Thus, seasonal differences may be a major factor in the mortality profiles of predominately sub-adults.

Finally, cultural phenomena may account for young deer at the Hayes site. Plainly and simply, a cultural interpretation suggests that young white-tailed deer may have been selected by Archaic period hunters because they are easier to stalk and kill. This conflicts with hunter selection explanations by Stiner (1990), who suggests all modern hunters selected prime-aged animals. Prime-aged animals have the highest meat weights and fat deposits, as well as antlers from male adults for use as tools.

Occupants of the Hayes site were living at the site for part of the year. During the earliest period they practiced a foraging strategy, with more mobility and an easily maintained technology (Amick 1984; Carr 1991). Later periods of occupation practiced a foraging and collecting strategy, with slightly less mobility and a

more curated technology. Hayes site occupants also collected vast amounts of fresh-water gastropods during the late Middle Archaic period, while other subsistence strategies remained the same (Morey 1988).

Hunting young deer may have been a strategy which complimented other activities, such as mobility associated with foraging/collecting strategies. Young deer are easier to kill, due to a lack of experience and speed, than older deer (Coe et al. 1980). In addition, adolescent males go off on their own at an early age and are an easy target (Sadlier 1987). Finally, the smaller sub-adults are more easily transported whole back to the home site and the result is more cranial/tooth fragments of young deer in the archaeological record.

In particular, if a single hunter has killed a prime-aged male, weighing as much as 200 pounds (Jacobson and Reiner 1989), it would be very difficult to drag the whole animal a long distance back to the home site. Thus, he might elect to carry meat packages of the upper fore- and hind-limbs, leaving cranial and lower limb bones behind. A hunter in a similar situation who has just killed a sub-adult deer, weighing about 75 pounds (Jacobson and Reiner 1989), would have a much easier time getting this animal back to the site, thus resulting in a larger accumulation of cranial and lower limb bones of young animals at the home site. It is, therefore, not completely unexpected

for many young deer to be represented in the mortality profiles of the Hayes site.

Conclusion

In conclusion, Hayes site mortality profiles for white-tailed deer are predominantly sub-adults due to seasonal and cultural factors, rather than methodological, ecological or taphonomic reasons. Methodological biases are dismissed due to the proven accuracy of the crown height measurement technique. Ecological phenomena may be factors, but environmental fluctuations occurred over a long period of time and the white-tailed deer population around the site may have stabilized. Taphonomic factors may be related to the number of young deer in the mortality profiles, but the presence of few broken aged - adult deer teeth suggests this is not a problem. Seasonal factors offer a good explanation of the large numbers of sub-adults at the Hayes site during the Archaic period. Finally, an anthropological explanation, such as purposeful selection of sub-adult white-tailed deer, may be the cause of the high percentage of young in the mortality profiles.

Chapter VIII:
Summary

This thesis evaluated several topics in archaeological investigations. First, aging techniques were evaluated, and a crown height measurement technique developed, to investigate ages of white-tailed deer from the Hayes site. Second, mortality profile interpretations were reviewed to determine how to interpret mortality profiles for the Hayes site. Third, shell midden research was reviewed in an attempt to better understand the cultural complexities of the Hayes site in Middle Tennessee, including the many artifacts that offered insight into the Archaic occupations. Fourth, materials and methods were stated to illustrate the techniques used to develop mortality profiles. Finally, results from constructing mortality profiles were presented and discussed to determine hunting intensity and seasonality at the Hayes site shell midden.

Chapter II examined methods of estimating age of animals in order to derive a method for aging white-tailed deer. A reliable aging technique was developed with crown height measurements on a known-age population of white-tailed deer from the Mississippi State University Department of Wildlife Resources. The best measurement for aging white-tailed deer was the height of the crown from the cervical line to the occlusal surface on the

posterior cusp, lingual surface of the tooth. Statistical analysis indicated this measurement had a high degree of reliability, and the technique qualified to be used on an archaeological sample of white-tailed deer.

Chapter III provided a review of the interpretations of mortality profiles in wildlife and zooarchaeological literature. Mortality profiles are defined as either attritional, living-structure, or prime-dominated and are interpreted by researchers according to observations in modern populations (Lyman 1987; Stiner 1990, 1991). These observations generally stem from studies of hunting intensity on animal populations, and seasonal use of animals (Davis 1987). Hunting intensity can be investigated by determining percentages of animals in specific age categories. Seasonality is best studied by examining percentages of sub-adults within seasonal age categories.

Chapter IV consisted of a review of shell midden research; this review showed that during the early 1900s most interest was in the human burials often associated with shell middens. In the late 1900s, researchers found that investigating other areas, such as stratigraphy, lithics, faunal remains, and paleobotanical remains, was a necessary pursuit. Excavations at shell mounds such as the Carlson Annis mound near the Green River, Kentucky (Stein 1982), and the Eva site in Tennessee (Lewis and

Lewis 1961) benefitted from use of stratigraphic, lithic, faunal and botanical analyses.

Chapter IV also summarized previous investigations of the Hayes site, along the Duck River in Middle Tennessee. Investigations revealed early Middle, late Middle and Late Archaic occupations dating from 6,000-4,000 years ago (Morey 1988; Turner et al. 1982). Research at the Hayes site included stratigraphic, lithic, faunal and botanical analyses. Stratigraphic analyses shed light on the complicated, two-meter thick, deposits at the site (Morey 1988). Studies of lithic technology suggested a shift from a non-logistic, foraging organization to a logistic, foraging-collecting organization (Amick 1987; Carr 1991). Faunal analysis conducted by Morey (1988) contends subsistence remained the same for much of the Hayes site occupation, except for vast shellfish consumption during the late Middle Archaic. Paleobotanical research documented the first sunflower domesticate, as well as major consumption of hickory nuts (Crites 1987). These analyses depict a clear image of lifeways at the Hayes site.

Chapter V described the materials and methods used to derive mortality profiles for the Hayes site white-tailed deer remains. Materials for the mortality profile analysis include teeth collected from all the excavated units and levels at the Hayes site. Total number of

individual specimens is 268, and the first permanent molar was used to calculate mortality with a total of 100. Number of individual specimens for the early Middle Archaic is 25, late Middle Archaic is 58, and Late Archaic is 17.

The fourth deciduous premolar was also used to calculate seasonal differences in sub-adult mortality at the Hayes site. A total of 23 fourth deciduous Premolars were recovered from the Hayes units. The early Middle Archaic contained 8 fourth deciduous Premolars, the late Middle Archaic 12, and the Late Archaic contained 3. Although these numbers are small they represent a 100% sample of the fourth deciduous premolars recovered from the Hayes site excavations.

Age categories were determined by dentition, maximum weights and antler development, and reproduction. Sub-adults are classified as up to 18 months old, prime-adults are from 19 to 72 months old, and aged-adults are 73-156 months old. These broad age categories are used by other researchers such as Stiner (1990, 1991), since broader categories eliminate problems with aging technique variability.

A modified iterated age length key was used to construct the profiles. Based on means and variances for tooth crown height in a known-age population, this method calculates the likelihood of obtaining means and variances

for age groups in an unknown population (Konigsberg and Frankenberg 1992). Percentages for each age group were derived, and chi-squares were calculated to determine significance of the results.

Chapter VI described mortality profiles derived from both first molars and fourth deciduous premolars provided some interesting results. The results from the first molar indicate early Middle Archaic mortality profiles for white-tailed deer were 87% sub-adults, 13% prime-adults, and no aged adults were present. Late Middle Archaic profiles had 71% sub-adults, 25% prime-adults, and 4% aged-adults. Finally, Late Archaic white-tailed deer mortality included 51% sub-adults, and 49% prime-adults. The chi-square statistical analysis indicated no significant difference between the three strata.

Mortality profiles based on the fourth deciduous premolar were based on seasonal fluctuations in the sub-adult age category. The early Middle Archaic was characterized by all fall sub-adult white-tailed deer mortality. Late Middle and Late Archaic sub-adults were killed in the fall and winter seasons. A chi-square statistical analysis shows this significant at .10 with 3 degrees of freedom.

The results of the mortality profile analysis were discussed in Chapter VII and indicated a predominance of young white-tailed deer from the site. This could be due

to methodological, ecological, taphonomic, seasonal or anthropological factors. Methodologically, the aging technique method may be skewed towards younger individuals, but analysis suggests the technique is reliable. Ecological factors such as environment and white-tailed deer population structure could play a role, but the occupation of the site is spread out over such a long period of time that stabilization can be assumed. Taphonomic factors, such as the survival of young white-tailed deer teeth in the archaeological record, may be important. Sub-adult deer teeth are unworn and have a better chance of preserving. However, few unbroken aged-adult deer teeth were recovered. Seasonal factors indicate white-tailed deer in the fall and winter seasons would have cold season fat deposits, and may have been an attractive source of food. In addition, two sub-adult cohorts are present in abundance during the fall and winter, presenting many hunting opportunities. Finally, an anthropological interpretation is that Hayes site hunters were selecting young, easier to kill, deer and bringing the whole carcass back to the site. This seems plausible since young deer are plentiful in most populations and less experienced at avoiding hunters. In addition, group hunting techniques such as ambushing or net-hunting could result in a predominantly young or living-structure mortality profile.

Chapter VIII concluded that investigating white-tailed deer mortality can add some insight into research at an Archaic period shell midden. White-tailed deer are an important part of the diet, and researchers cannot assume that all modern hunters produce prime-dominated mortality profiles. The balance of hunting intensity is very complicated and can only be understood through mortality profile investigations.

Results from the Hayes site indicate young deer were predominant in the Archaic period occupations, resulting in a living-structure mortality profiles for all three Archaic occupations. Seasonal occupation of the Hayes site was probably during the fall, particularly during the early Middle Archaic. Seasonal occupation extended into the winter during the later occupations of the site, which may coincide with the warming and drying trend postulated for this period.

Methods for aging white-tailed deer would be strengthened with statistical analysis of the variables in the Mississippi State University sample. In particular, differences between captive and wild, and male and female white-tailed deer. Although scatter plots illustrate the relationship between these variables, an in depth statistical analysis would strengthen information derived with the Mississippi State University sample.

Future research on white-tailed deer mortality should include investigations of long bone fusion to determine the proportions of young and prime deer at the Hayes site. This will help determine cultural phenomena affecting white-tailed deer deposition at the site. In addition, cementum annuli counts can be studied to discover more about seasonality of white-tailed deer from the site. Cementum annulation may not be the best method for determining age, but it is ideally suited for seasonal studies.

References Cited

References Cited

Alvard, M. and H. Kaplan
1991 Procurement Technology and Prey Mortality Among Indigenous Neotropical Hunters. In, Human Hunters and Prey Mortality, edited by M.C. Stiner, pp. 79-104.

Amick, D.S.
1987 Lithic raw material variability in the Central Duck River Basin: Reflections of Middle and Late Archaic Period Organizational Strategies. Tennessee Valley Authority Publications in Anthropology, 50, University of Tennessee, Department of Anthropology, Report of Investigations 46.

Anderson, A.J.
1981 A Model of Prehistoric Collecting on the Rocky Shore. Journal of Archaeological Science, 8:109-120.

Anderson, D.G. and G.T. Hanson
1988 Early Archaic Settlement in the Southeastern United States: A Case Study from the Savannah River Valley. American Antiquity, 53(2):262-286.

Bernstein, D.J.
1990 Prehistoric Seasonality Studies in Coastal Southern New England, American Anthropologist, 92:96-115.

Binford, L.R.
1981 Bones: Ancient Men and Modern Myths. Academic Press, New York.

Binford, L.R. and J.B. Bertram
1977 Bone Frequencies-And Attritional Processes. In For Theory Building in Archaeology, edited by L.R. Binford, pp. 77-153. Academic Press, New York.

Blumenschine, R.J.
1991 Prey Size and Age Models of Prehistoric Scavenging:Test Cases from the Serengeti. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp.121-147.

Bourque, B., P. Morris, and A.E. Spiess
1978 Determining the Season of Death of Mammal Teeth from Archaeological Sites: A New Sectioning Technique. Science, 199:530-531.

Brackenridge
1984 Alluvial Stratigraphy and Radiocarbon Dating Along the Duck River, Tennessee: Implications Regarding Floodplain Origins. Geological Society of America Bulletin, 95:9-25.

Brennan, L.A.
1977 Midden is the Message. Archaeology of Eastern North America, 5:122-137.

Brose, D.
1972 The Molluscan Fauna. In, The Schultz site at Green Point: A stratified occupation area in the Saginaw Valley of Michigan, edited by J.E. Fitting, Memoir No. 4, Museum of Anthropology, Ann Arbor: University of Michigan.

Bunnel, F.L.
1987 Reproductive Tactics of Cervidae and Their Relationship to Habitat. In, Biology and Management of the Cervidae, edited by C.M. Wemmer, Washington, D.C.: Smithsonian Institution Press.

Caldwell, J.R.
1958 Trend and Tradition in the Prehistory of the Eastern United States. Memoirs of the American Anthropological Association, 88.

Carr, P.J.
1991 Organization of Technology and Lithic Analysis: Prehistoric Hunter-Gatherer Occupation of the Hayes Site (40ML139). Unpublished M.A. Thesis, University of Tennessee, Department of Anthropology, Knoxville, TN.

Caughley, G.
1966 Mortality Patterns in Mammals. Ecology, 47:906-917.

1977 Analysis of Vertebrate Populations. John Wiley and Sons, London.

Causey, M.K.
1989 Growth and Antler Development of Alabama White-tailed Deer. University of Auburn Report, Alabama Fish and Game Division, Federal Aid in Wildlife Restoration.

Ceci, L.
1984 Shell Midden Deposits as Coastal Resources. World Archaeology, 16(1):62-73.

Chapman, J., P. Delcourt, P.A. Cridlebaugh, A.B. Shea, and H.R. Delcourt
1982 Man-Land Interaction:10,000 years of American Indian Impact on Native Ecosystems in the Lower Little Tennessee River Valley, Eastern Tennessee. Southeastern Archaeology, 1(2):115-121.

Chapman, J.A. and G.A. Feldhamer
1982 Wild Mammals of North America. Baltimore and London:Johns Hopkins University Press.

Claasen, C.
1986 Temporal patterns in Marine Shellfish: Species Use Along the Atlantic coast in the Southeastern United States. Southeastern Archaeology, 5(2):120-137.

Coe, R.J., R.L. Downing, and B.S. McGinnes
1980 Sex and Age Bias in Hunter-Killed White-tailed Deer. Journal of Wildlife Management, 44(1):245-249.

Cribb, R.L.D.
1987 The Logic of the Herd: A Computer Simulation of Archaeological Herd Structure. Journal of Anthropological Archaeology, 6:376-415.

Crites, G.D.
1987 Middle and Late Holocene Ehtnobotany of the Hayes Site (40ML139):Evidence from Unit 990N918E. Midcontinental Journal of Archaeology. 12(1):3-32.

Cumbaa, S.L.
1976 A Reconsideration of Freshwater Shellfish Exploitation in the Florida Archaic. Florida Anthropologist, 29(2):49-59.

Davis, S.J.M.
1983 The Age Profiles of Gazelles Predated by Ancient Man in Israel: Possible Evidence for a Shift from Seasonality to Sedentism. Paleorient, 9:55-62

1987 The Archaeology of Animals. New Haven and London: Yale University Press.

Deevey, E.S.
1947 Life Tables for Natural Populations of Animals. The Quarterly Review of Biology, 22:283-314.

DeGayner, E.J. and P.A. Jordan
1987 Skewed Fetal Sex Ratios in White-tailed Deer: Evidence and Evolutionary Speculations. In, Biology and Management of the Cervidae, edited by C.M. Wemmer, Smithsonian Institution Press, Washington, D.C.

Delcourt, P.A., and H.R. Delcourt
1981 Vegetation Maps for Eastern North America: 40,000 years B.P. to the Present. Geobotany II, edited by R.C. Romans, Plenum Publishing Corporation.

1983 Late Quaternary Vegetational Dynamics and Community Stability Reconsidered. Quaternary Research, 13:111-132.

Dempster, A.P., N.M. Laird, and D.B. Rubin
1977 Maximum Likelihood Estimation from Incomplete Data Via the EM Algorithm. Journal of Statistical Society Ser. B., 39:1-39.

Deniz, E. and S. Payne
1982 Eruption and Wear in the Mandibular Dentition as a Guide to Ageing Turkish Angora Goats. In, Ageing and Sexing Animal Bones from Archaeological Sites, edited by B. Wilson, C. Grigson, and S. Payne. Oxford, British Archaeological Reports Series 107, pp. 155-205.

Ericson, J.A., A.E. Anderson, D.E. Medin, and D.C. Bowden
1970 Estimating Ages of Mule Deer: An Evaluation of Technique Accuracy. Journal of Wildlife Management, 34:523-531.

Ericson, J.A., and W.G. Seliger
1969 Efficient Sectioning of Incisors for Estimating Ages of Mule Deer. Journal of Wildlife Management, 33(2):384-388.

Erlandson, J.M.
1988 The Role of Shellfish in Prehistoric Economies: A Protein Perspective. American Antiquity, 53(1):102-109.

Ford, J.A. and G.R. Willey
1941 An Interpretation of the Prehistory of the Eastern United States. American Anthropologist, 43(3):325-326.

Foster, J.W.
1975 Shell Middens, Paleoecology, and Prehistory: The Case from Estero Morura, Sonora, Mexico. The Kiva, 41(2):185-194.

Frison, G.C.
1991 Hunting Strategies, Prey Behavior, and Mortality Data. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 15-30.

Gifford-Gonzales, D.
1991 Examining and Refining the Quadratic Crown Height Method of Age Estimation. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 15-30.

Gilbert, F.F.
1966 Aging White-tailed Deer by Annuli in the Cementum of the First Incisor. Journal of Wildlife Management, 30(1):200-202.

Gilbert, F.F., and S.L.Stolt
1970 Variation and Aging White-tailed Deer by Tooth Wear Characteristics. Journal of Wildlife Management, 34(3):532-535.

Gordon, B.H.C.
1982 Tooth Sectioning as an Archaeological Tool. National Museum of Man, Canadian Studies Report, 14:1-4.

Grant, A.
1978 Variation in Dental Attrition in Mammals and its Relevance to Age Estimation, Research Problems in Zooarchaeology, edited by D.R. Brothwell, D.D. Thomas, and J. Clutton-Brock, Institute of Archaeology Occasional Publication, London.

Harlow, R. and M. DeFoor
1962 How to Age White-tailed Deer. Florida Wildlife, 18-21.

Hillson, S.
1986 Teeth. Cambridge: Cambridge University Press.

Hofman, J.L.
1984 Hunter-Gatherers in the Nashville Basin of Tennessee, 8,000-5,000 B.P. Tennessee Anthropologist, 9(2):129-192.

1985 Middle Archaic Ritual and Shell Midden Archaeology:Considering the Significance of Cremations. In, Exploring Tennessee Prehistory: A Dedication to A.K.Guthe, edited by T.Whyte, C.C. Boyd, and B. Riggs, University of Tennessee, Department of Anthropology, Report of Investigations, 42.

Hudson, J.
1991 Nonselective Small Game Hunting Strategies: An Ethnoarchaeological Study of Aka Pygmy Sites. In, Human Predators and Prey Mortality, edited by M.C. Stiner pp. 105-120.

Jacobson, H.A. and R.J. Reiner
1989 Estimating Age of White-tailed Deer: Tooth Wear Versus Cementum Annuli. Procedure of the Annual Conference of SEAFWA, 43:286-291.

Juchniewicz, J.M.
1991 Lithic Resource Procurement and Utilization Strategies Among Middle and Late Archaic Inhabitants of the Hayes Site: A Stratified Shell Midden in Middle Tennessee. Unpublished M.A. Thesis, University of Tennessee, Knoxville.

Kay, M.
1974 Dental Annuli Age Determination on White-tailed Deer from Archaeological Sites. Plains Anthropologist, 19:224-227.

Killingley, J.W.
1981 Seasonality of Mollusk Collecting Determined from 0-18 Profiles of Midden Shells. American Antiquity, 46(1):152-158.

Kimura, D.K.
1977 Statistical Assessment of the Age-Length Key. Journal of Fishery Resources Board Canada, 34:317-324.

Klein, R.G.
1982a Patterns of Ungulate Mortality and Ungulate Mortality Profiles from Langebaanweg (Early Pliocene) and Elandsfontein (Middle Pleistocene), South-western Cape Provence, South Africa. Annals of the South African Museum, 90:49-94.

1982b Age (Mortality) Profiles as a Means of Distinguishing Hunted Species from Scavenged Ones in Stone Age Archaeological Sites. Paleobiology, 8:151-158.

Klein, R.G. and K. Cruz-Uribe
1983 The Computation of Ungulate Age (Mortality) Profiles from Dental Crown Heights. Paleobiology, 9:70-78.

1984 The Analysis of Animal Bones from Archaeological Sites. Chicago: The University of Chicago Press.

Klein, R.G., C. Wolf, L.G. Freeman, and K. Allwarden
1981 The Use of Dental Crown Heights for Constructing Age Profiles of Red Deer and Similar Species in Archaeological Sites. Journal of Archaeological Science, 8:1-31.

Klippel, W.E., and D.F. Morey
1986 Contextual and Nutritional Analysis of Freshwater Gastropods from Middle Archaic Deposits at the Hayes Site, Middle Tennessee. American Antiquity, 51:799-813.

Klippel, W.E. and W.B. Turner
1991 Terrestrial Gastropods from Glade Sere and the Hayes Shell Midden in Middle Tennessee. In, Beamers, Bobwhites, and Bluepoints:Tributes to the Career of Paul W. Parmalee, edited by J.R. Purdue, B. Styles, and W.E. Klippel, Springfield:Illinois State Museum, 177-192.

Koike, H.
1979 Seasonal Dating and the Valve-pairing Technique in Shell Midden Analysis. Journal of Archaeological Science, 6:63-74.

Koike, H. and N. Ohtaishi
1985 Prehistoric Hunting Pressure Estimated by the Age Composition of Excavated Sika Deer (Cervus nippon) using the annual layer of tooth cement. Journal of Archaeological Science, 12:443-456.

1987 Estimation of Prehistoric Hunting Rates Based on the Age Composition of Sika Deer (Cervus nippon). Journal of Archaeological Science, 14:251-269.

Koloseike, A.
1970 Costs of Shell Analysis. American Antiquity, 35(4):475-480.

Konigsberg, L.W. and S.R. Frankenberg
1992 Estimation of Age Structure in Anthropological Demography. American Journal of Physical Anthropology, 89:235-256.

Levine, M.
1982 Crown Height Measurements and Eruption Wear Sequences to Age Horse Teeth. In, Ageing and Sexing Animal Bones from Archaeological Sites, 223-250.

Lewis, T.M.N. and M. Kneburg
1959 The Archaic Culture in the Middle South. American Antiquity, 25(2):161-183.

Lewis, T.M.N. and M. Lewis
1961 Eva: An Archaic Site. Knoxville: University of Tennessee Press.

Lieberman, D.E., T.W. Deacon, and R.H. Meadow
1990 Computer Image Enhancement and Analysis of Cementum Increments as Applied to Teeth of Gazella. Journal of Archaeological Science, 17:519-533.

Lockard, G.R.
1972 Further Studies of Dental Annuli for Aging White-tailed Deer. Journal of Wildlife Management, 36(1):46-55.

Low, W.A., and I.M. Cowan
1963 Age Determination of Deer by Annual Structures of Dental Cement. Journal of Wildlife Management, 27(3):466-471.

Lyman, R.L.
1987 On the Analysis of Vertebrate Mortality Profiles: Sample Size, Mortality Type, and Hunting Pressure. American Antiquity, 52:125-142.

1991 Subsistence Change and Pinniped Hunting. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 187-199.

Maltby, J.M.
1982 The Variability of Faunal Samples and Their Affects Upon Ageing Data. Ageing and Sexing Animal Bones from Archaeological Sites, 109:81-90.

Matson, G.
1978 The Preparation and Analysis of Tooth Section to Determine Age. Matson's Commercial Microtechnique Newsletter, October.

Matteson, M.R.
1960 Reconstruction of Prehistoric Environment Through the Analysis of Molluscan Collections from Shell Middens. American Antiquity, 26(1):117-120.

McDonald, J.N.
1984 Population Analysis of the Trigg Site Whitetail Deer. In, The Trigg Site: City of Radford, Virginia, The Archaeological Society of Virginia.

Mitchell, B.
1967 Growth Layers in Dental Cement for Determining the Age of Red Deer (Cervus elaphus L.). Journal of Animal Ecology, 36:279-293.

Mitchell, C.
1989 Influence of Either-sex Harvest on the Age and Sex Structure of White-tailed Deer on Oak Ridge Wildlife Management Area, Tennessee. M.S. Thesis in Biology, Tennessee Technical University, Cookeville.

Monks, G.
1981 Seasonality Studies. In, Advances in Archaeological Method and Theory (Vol.4), edited by M.B. Schiffer,pp. 177-240. Academic Press, New York.

Morey, D.
1988 Unmodified Vertebrate Faunal Remains from Stratified Archaic Deposits at the Hayes site, Middle Tennessee. Tennessee Valley Authority Report of Investigations, Department of Anthropology, University of Tennessee.

Morey, D. and W.E. Klippel
1991 Canid Scavenging and Deer Bone Survivorship at an Archaic Period Site in Tennessee. Archaeozoologia, vol.4, pp. 11-28.

Morris, P.
1972 A Review of Mammalian Age Determination Methods. Mammal Review, 2:69-104.

Morrison, J.P.E.
1942 Preliminary Report on Mollusks Found in Shell Mounds of Pickwick Landing Basin in the Tennessee River Valley. Bureau of American Ethnology, 29.

Nance, J.D.
1987 Research into the Prehistory of the Lower Tennessee-Cumberland-Ohio Region. Southeastern Archaeology, 6(2):93-100.

Nimmo, B.W.
1971 Population Dynamics of a Wyoming Pronghorn Cohort from the Eden-Farson Site, 48SW304. Plains Anthropologist, 16(54):285-288.

Parmalee, P.W. and W.E. Klippel
1974 Mussels as a Prehistoric Food Resource. American Antiquity, 39:421-434.

Purdue, J.R.
1983 Methods of Determining Sex and Body Size in Prehistoric Samples of White-tailed Deer (Odocoileus virginianus). Transactions of the Illinois State Academy of Science. 76:351-357.

Ransom, A.B.
1966 Determining Age of White-tailed Deer from Layers of Cementum in Molars. Journal of Wildlife Management,30(1):197-199.

Rees, J.W., R.A. Kainer, and R.W. Davis
1966 Chronology of Mineralization and Eruption of Mandibular Teeth in Mule Deer. Journal of Wildlife Management,30(3):629-631.

Robinette, W.L., D.A. Jones, and G.S. Gashwiler
1957 Notes on Tooth Development and Wear for Rocky Mountain Mule Deer. Journal of Wildlife Management, 21:134-153.

Roseberry, J.L.
1980 Age Determination of White-tailed Deer in the Midwest: Methods and Problems. In, White-tailed deer population management in the north central states, edited by R.L Hine and S. Nehls, Symposium of the Central Section Wildlife Society, 73-82.

Sadlier, R.M.F.
1987 Reproduction of Female Cervids. In, Biology and Management of the Cervidae, edited by C.M. Wemmer, Washington, D.C.: Smithsonian Institution Press.

Sanger, D.
1981 Unscrambling Messages in a Midden. Archaeology of Eastern North America, 9:37-42.

Savelle, J.M. and A.P. McCartney
1991 Thule Eskimo Subsistence and Bowhead Whale Procurement. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 201-216.

Schwartz, C.W., and E.R. Schwartz
1964 The Wild Mammals of Missouri. Kansas City: University of Missouri Press.

Sergeant, D.E.
1967 Age Determination of Land Mammals from Annuli. Zeitschrift Fur Saugetierkunde, 32(5):297-301.

Severinghaus, C.W.
1949 Tooth Development and Wear as Criteria of Age in White-tailed Deer. Journal of Wildlife Management,13:195-216.

Smith, B.D.
1986 The Archaeology of the Southeastern United States: From Dalton to de Soto, 10,500-500 B.P. In, Advances in World Archaeology, Volume 5, Academic Press, London.

Speth, J.D.
1991 Taphonomy and Early Hominid Behavior: Problems in Distinguishing Cultural and Noncultural Agents. In,Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 31-40.

Spiess, A.E.
1990 Deer Tooth Sectioning, Eruption and Seasonality of Deer Hunting in Prehistoric Maine. Man in the Northeast, 39:29-44.

Spinage, C.A.
1973 A Review of the Age Determination of Mammals by Means of Teeth with Special Reference to Africa. East African Wildlife Journal, 11:165-187.

Stein, J.
1982 Geologic Analysis of the Green River Shell Midden. Southeastern Archaeology, 1(1):22-38.

Stiner, M.
1990 The Use of Mortality Patterns in Archaeological Studies of Hominid Predatory Adaptations. Journal of Anthropological Archaeology, 9:305-351.

1991 Human Predators and Prey Mortality. Westview, Boulder.

Thomas, D.H.
1976 Figuring Anthropology:First Principles of Probability and Statistics. Holt, Rinehart and Winston, New York.

Todd, L.C.
1991 Seasonality Studies and Paleoindian Subsistence Strategies. In, Human Predators and Prey Mortality, edited by M.C. Stiner, pp. 217-238.

Turner, W.B., J.L. Hofman, and G.R. Brackenridge
1982 Technique to Aid in Recording and Field Interpretation of Stratigraphic Sections in Archaeological Deposits. Journal of Field Archaeology, 9:133-136.

Warren, R.E.
1991 Freshwater Mussels as Paleoenvironmental Indicators:A Quantitative Approach to Assemblage Analysis. In, Beamers, Bobwhites, and Bluepoints: Tributes to the Career of Paul W. Parmalee, edited by J.R. Purdue, B.W.Styles, and W.E. Klippel, Springfield: ISM, pp. 23-66.

Waselkov, G.A.
1982 Shellfish Gathering and Shell Midden Archaeology. PhD Dissertation, University of North Carolina, Chapel Hill.

Webb, W.S.
1950 The Carlson Annis Mound; Site 5, Butler County, Kentucky. University of Kentucky, Reports in Anthropology, No. 7.

1974 Indian Knoll. University of Tennessee Press, Knoxville.

Webb, W.S. and D.L. DeJarnette
1942 An Archaeological Survey of Pickwick Basin in the Adjacent Portions of the States of Alabama, Mississippi, and Tennessee. Smithsonian Institution,Bureau of American Ethnology Bulletin, No. 129.

Webb, W.S. and W.G. Haag
1947 Archaic Sites in McLean County, Kentucky. University of Kentucky, Reports in Anthropology 7(1).

Woolf, A. and J.D. Harder
1979 Population Dynamics of a Captive White-tailed Deer Herd with Emphasis on Reproduction and Mortality. Wildlife Monographs, No. 67.

Appendices

Appendix 1: White-tailed Deer Coding Format

1. **Specimen Number**

2. **Locality** (State, County)

3. **Date of Death** (Month)

4. **Sex** (M-Male, F-Female, U-Unknown)

5. **Weight** (Kilograms, or Pounds)

6. **Epiphyseal Fusion Age**

7. **Dental Annuli Count** (# of annuli, age)

8. **Mandible Side**

9. **Dental Matching Age**
-Schwartz and Schwartz, 1964; Severinghaus, 1949.

10. **Cervical Line**
P4\M1\M2
1-Below
2-Partly
3-Above
M3
3-Cusp 1,2 Above
4-Cusp 1,2,3 Above

11. **Wear Index** (0-7)
-Koike and Ohtaishi, 1985.

12a. **Crown Height** (dP4, P4, M1, M2, M3)
-Klein et al., 1981: Minimum distance from anterior, occlusal surface to cervical line, on the buccal surface.

12b. **Crown Height** (dP4, P4, M1, M2, M3)
-Koike and Ohtaishi, 1985: Cervical line to top of cusps, on the lingual surface (dP4,P4,M1/M2:Posterior Cusp, M3:Anterior Cusp).

13. **Crown Width**
-Width of cusps at occlusal surface, calipers lined up with both the cusps (anterior to posterior), same angle as tooth in jaw.

14. **Crown Breadth**
-Breadth of cusps at occlusal surface, calipers lined up with both cusps (lingual to labial), same angle as tooth in jaw.

Appendix 2: Mississippi White-tailed Deer Information

Catalog Number	Age	Wear & Replace	Cementum Annuli	Crown Height	DP4CH	P4CH	M1CH
001	63	30		41		8.03	9.65
003	66	66		61		5.38	5.39
004	55	66	66	57		5.67	6.46
006	54	42	42	50		6.96	8.30
007	90	102	114	100		3.11	3.40
010	28	30	30	38		7.24	8.25
011	45	42	36	45		7.03	9.56
014	9	6		13	5.38		10.60
015	78	66	78	72		6.49	7.36
016	30	30		36		7.46	8.23
018	30	30		33		5.80	9.34
020	78	54		63		6.08	8.30
022	86	78	90	84		4.30	4.24
023	78	66	78	73		7.36	5.77
027	41	42	54	42		7.73	5.92
028	78	90	102	83		3.93	4.01
031	51	42		50		7.43	7.96
036	18	18	18	15	6.11		11.33
037	54	54		50		6.38	8.13
038	53	66		73		4.53	4.58
039	51	42	54	52		4.50	7.87
040	42	42		50		5.64	6.28
042	54	42		57		6.99	7.10
043	30	30	30	38		6.24	8.51
046	27	30	30	35		7.40	8.99
047	42	54		49		6.49	7.16
048	39	30	30	42		7.70	10.22
049	18	30	30	12		6.96	7.91
050	18	18		12		4.67	11.95
051	51			49		6.48	7.04
052	26	30		35		7.30	8.33
055	15	18		15	4.85		11.63
056	30	30	30	30		7.07	8.88
059	54	54		60		8.54	6.84
060	29	30	30	33		8.24	10.38
064	42	42	42	45		5.42	7.59
065	40	42	42	46		6.27	8.05
066	28	42	42	37		6.19	7.91
068	54	42	42	53		6.24	7.44
072	54	66	66	54		6.65	6.41
076	10	6		10	6.61		
078	42	42	54	54		5.99	7.42
080	18	18		17	6.05		8.31
085	29	30	42	45		7.12	7.32
088	54	42	42	53		6.11	6.50
095	66	54	78	65		6.01	6.40

Catalog Number	Age	Wear & Replace	Cementum Annuli	Crown Height	DP4CH	P4CH	M1CH
097	54	42		54		6.66	7.39
100	19	18	18	38		5.84	8.92
101	42	30	30	42		5.74	8.40
102	6	6	6	6	7.79		
105	54	42	42	54		5.72	7.58
111	10	6	6	12	6.01		
112	4	6	6	11	6.27		
113	78	66	78	72		6.44	7.00
114	30	30	54	38		6.54	8.06
115	42	42	42	50		4.00	6.09
116	67	42	66	57		6.55	7.86
124	78	42	54	57		6.23	7.43
125	86	78	90	85		5.69	4.86
127	16	18	18	16	4.39		10.75
128	29	30	30	34		8.67	8.93
129	41	42	54	47		5.63	8.07
131	51	42	54	49		7.30	7.84
132	166	126	126	162		.72	2.10
133	45	42	42	40		8.36	10.89
137	18	18	6	19	6.11		11.50
139	18	18	18	15	4.93		9.49
140	18	18	18	17			10.62
144	80	90	102	100		3.10	2.60
145	17	18	18	18	5.63		10.30
146	18	18	18	17	3.75		10.17
148	30	30	30	39		6.98	8.85
149	51	42	54	47		7.60	9.92
150	17	18	18	16	4.50		10.04
151	9	18		14	4.86		9.26
152	18	18	18	22			9.28
153	18	18	6	18	3.22		8.51
155	29	30	30	38		7.71	7.79
156	6	6	6	13	5.76		11.09
159	53	54	48	72		4.61	3.68
161	16			14	5.39		10.44
163	18	18	18	19	4.33		10.98
164	27	30	30	33		6.66	9.45
165	54	42	54	53		7.82	8.79
167	5	6		7	7.52		
169	52	42		40		9.11	8.81
171	7	6		14	5.11		9.53
172	39	42	42	41		7.73	9.51
173	17	18		14	5.10		10.68
174	53	54	42	55		6.44	7.34
176	53	42		56		5.83	6.99
179	42	42	42	42		6.15	8.28
180	72	54		66		5.67	6.84

Catalog Number	Age	Wear & Replace	Cementum Annuli	Crown Height	DP4CH	P4CH	M1CH
181	88	90	102	104		2.93	
183	30	30		32		8.13	8.18
185	60	54		56		6.29	8.09
186	63	54		55		5.96	7.51
187	42	30		44		7.26	7.86
189	28	30		29		7.91	9.83
190	78	78		51		6.39	9.35
191	28	30		30		6.78	9.71
192	149			79		6.26	8.01
195	15			16	4.11		10.88
197	53			45		3.97	9.09
198	78	54		58		5.69	8.25
ABB	101			72		4.64	5.90
ANT	102			91		3.91	4.84
DON	156			106		3.24	3.65
GON	102			96		3.31	5.91
JOE	102			84		4.12	6.06
KEN	89			88		3.69	5.94
NAP	102			85		4.36	4.90
ROM	54			62		6.67	8.75
SAM	66			61		6.02	7.78
TEX	113			105		4.72	5.83
WIS	78			64		5.39	7.04

Appendix 3: Hayes White-tailed Deer Individual Age

Strata	Crown Height	Crown Height Sq	Age
2	11.89	141.37	11
2	11.64	135.49	13
2	11.13	123.88	17
2	10.88	118.37	20
2	10.83	117.29	20
2	10.12	102.41	26
2	9.90	98.01	28
2	8.49	72.08	42
2	8.33	69.39	44
2	8.24	67.90	45
2	8.19	67.08	46
2	7.43	55.20	54
2	6.31	39.82	67
2	6.30	39.69	67
2	6.18	38.19	69
2	6.11	37.33	69
2	5.87	34.46	72
3	12.64	159.77	5
3	12.16	147.87	9
3	11.90	141.61	11
3	11.77	138.53	12
3	11.37	129.28	15
3	11.36	129.05	15
3	11.12	123.65	18
3	11.11	123.43	18
3	11.07	122.54	18
3	11.02	121.44	18
3	11.02	121.44	18
3	10.89	118.59	20
3	10.88	118.37	20
3	10.87	118.16	20
3	10.77	115.99	21
3	10.65	113.42	22
3	10.53	110.88	23
3	10.44	108.99	23
3	10.44	108.99	23
3	10.44	108.99	23
3	10.41	108.37	24
3	10.38	107.74	24
3	10.38	107.74	24
3	10.36	107.33	24
3	10.31	106.30	25
3	10.25	105.06	25
3	10.08	101.61	27
3	9.87	97.42	29
3	9.83	96.63	29

Strata	Crown Height	Crown Height Sq	Age
3	9.80	96.04	29
3	9.68	93.70	31
3	9.54	91.01	32
3	9.35	87.42	34
3	9.15	83.72	36
3	8.99	80.82	37
3	8.64	74.65	41
3	8.61	74.13	41
3	8.41	70.73	43
3	8.10	65.61	47
3	8.03	64.48	47
3	7.93	62.88	48
3	7.70	59.29	51
3	7.39	54.61	54
3	7.37	54.32	55
3	7.32	53.58	55
3	7.22	52.13	56
3	7.19	51.70	57
3	7.19	51.70	57
3	6.94	48.16	60
3	6.66	44.36	63
3	6.34	40.20	67
3	6.31	39.82	67
3	5.49	30.14	77
3	5.46	29.81	77
3	5.28	27.88	80
3	5.15	26.52	81
3	4.50	20.25	90
3	4.33	18.75	92
4	12.94	167.44	3
4	11.13	123.88	17
4	10.77	115.99	21
4	10.73	115.13	21
4	10.70	114.49	21
4	10.53	110.88	23
4	10.24	104.86	25
4	9.84	96.83	29
4	9.54	91.01	32
4	9.52	90.63	32
4	9.50	90.25	32
4	9.49	90.06	32
4	9.05	81.90	37
4	9.04	81.72	37
4	8.81	77.62	39
4	8.74	76.39	40
4	8.68	75.34	41
4	8.47	71.74	43

Strata	Crown Height	Crown Height Sq	Age
4	8.12	65.93	46
4	7.86	61.78	49
4	7.84	61.47	49
4	7.52	56.55	53
4	7.47	55.80	53
4	7.27	52.85	56
4	6.34	40.20	67

Vita

Renee Beauchamp was born April 30, 1968 in Allentown, Pennsylvania. She attended Blue Mountain Elementary School and graduated from Blue Mountain High School in May of 1986. She earned her B.A. in Anthropology from Indiana University of Pennsylvania in May of 1990. She began her graduate studies at the University of Tennessee Anthropology Department in August of 1990 and received her M.A. in Anthropology in December of 1993.