6-1981

# The Averbuch Skeletal Series: A Study of Biological and Social Stress at a Late Mississippian Period Site from Middle Tennessee

Hugh Edward Berryman
*University of Tennessee - Knoxville*

To the Graduate Council:

I am submitting herewith a dissertation written by Hugh Edward Berryman entitled "The Averbuch Skeletal Series: A Study of Biological and Social Stress at a Late Mississippian Period Site from Middle Tennessee." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

William M. Bass, Major Professor

We have read this dissertation and recommend its acceptance:

Richard Jantz, Francis Jones, Wlater Klippel, Fred Smith, Charles Faulkner

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

# THE AVERBUCH SKELETAL SERIES: A STUDY OF BIOLOGICAL AND SOCIAL STRESS AT A LATE MISSISSIPPIAN PERIOD SITE FROM MIDDLE TENNESSEE

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Hugh Edward Berryman

June 1981

ACKNOWLEDGMENTS

Completion of this dissertation was accomplished only with the aid and encouragement of numerous individuals to whom I am truly grateful. I wish to thank Dr. William M. Bass, my committee chairman, for the assistance he gave me in this project and also throughout my academic career. Other committee members, Dr. Charles Faulkner, Dr. Richard Jantz, Dr. Francis Jones, Dr. Walter Klippel and Dr. Fred Smith, provided invaluable assistance for which I am most appreciative. Each committee member demonstrated outstanding ability in leading me through this educational pursuit.

The author is indebted to those people who worked diligently in the osteology lab during the course of the Averbuch project. Specifically, I wish to acknowledge the conscientious effort of Mr. Clifford Boyd, Ms. Katherine Douglass, Ms. Audrey Grubb, Ms. Ann Hawkins and Mr. Terry Zobeck. Their dependability and loyalty to the project as well as the high quality of their work was exemplary and most appreciated. I also wish to thank Mr. Bill Baden, Ms. Cleone Hawkinson, Dr. Douglas Owsley, Ms. Ann Reed and Mr. P. Willey for their support and suggestions which have been of great help.

Without the financial support of the Interagency Archeological Services of Atlanta, through contracts 3-5556(78) and C-5943(79), this research would have been impossible.

Finally, I wish to thank my wife, Treva, for her assistance, patience, and understanding. It is to her that this work is dedicated.

# ABSTRACT

The purpose of this study was to examine the biological and social evidence of stress at the Averbuch site (40DV60), a late Mississippian Period Middle Cumberland Culture village from the Nashville Basin in Middle Tennessee. Recent excavation of this site produced one of the largest systematically excavated skeletal series from Tennessee. The majority of burials were recovered from three cemeteries which could be aligned temporally. It was hoped that analysis of this skeletal series would illuminate conditions which contributed to the late prehistoric decline and ultimate disappearance of the Middle Cumberland people from the Nashville area.

A general investigation of stress was accomplished with a life table approach assuming a stationary population model. The vital statistics produced by this analysis includes data on mortality, survivorship, age-specific probability of death, life expectancy and crude mortality rates. These data are compared to that of other populations. Crude mortality rate was used to estimate Averbuch population size. The life table approach was also used to examine stress between the cemeteries and the sexes. Evidence of biological (i.e., short stature, Harris lines and enamel hypoplasia) and social (i.e., scalping) stress was examined. Frequencies and means are presented and the differences between the cemeteries and sexes are subjected to an analysis of variance. Evidence for scalping was also examined.

The results of the demography indicate that the Averbuch infants experienced a high mortality rate, the adolescents were the least stressed, and adult males and females were most stressed during the 20 to 25 year age interval. The crude mortality rate of 60 per thousand per year was among the highest noted in the literature. Male crude mortality rate increases temporally while the female mortality remains relatively constant. The age specific distribution of death between the sexes and the cemeteries are examined. The only significant differences (p > .005) was between Cemetery 3 males and females and Cemetery 3 females and Cemetery 1 males. This difference was produced by elevated mortality for the Cemetery 3 females during the 20 to 25 year age interval. The crude mortality rate (60), number of years the village was occupied (15 to 25 years) and the estimated total number of dead (n = 1,232) were used to calculate an Averbuch population size of between 800 and 1,400 individuals.

With the exception of stature between the sexes, analysis of variance tests produced no significant differences when the proposed stress indicators are examined in respect to sex or cemetery. However, the interaction of sex and cemetery for enamel hypoplasia was significant. The mean number of stress episodes is greater for Cemetery 1 females than males whereas this relationship is reversed for the males and females from Cemetery 2 and 3. Social stress was evident in the form of scalping which appeared on six crania, three from Cemetery 1 and three from Cemetery 3. Both sexes and a variety of adult ages were among the victims.

From this study it may be concluded that the Averbuch people were severely stressed by both biological and social forces, and the biological stress was widespread among the population. Demographically, there is no evidence of an epidemic. The stress was chronic and did not result from seasonal, or patterned, episodes of starvation or malnutrition. Temporally, there is no statistically significant increase or decrease in the occurrence of stress (i.e., Harris lines or lines of enamel hypoplasia) in the skeletal series. The occurrence of scalping is evident of the extreme social stress experienced by the inhabitants of Averbuch.

The significance of these findings in reference to late Mississippian Period populations who lived in the Nashville Basin is discussed. A hypothesis concerning the late prehistoric disappearance of these people is presented for future testing.

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# CHAPTER I

## THE BIOCULTURAL APPROACH TO THE ANALYSIS OF THE AVERBUCH SKELETAL SERIES

During the last few decades, physical anthropology has experienced a shift from a basic descriptive approach, often centered on the unique, to a more general, population approach in which specific problems are addressed. A population orientation coupled with the more complete recognition of the interrelationship of biology and culture has produced the biocultural approach to the study of skeletal remains. This approach is presently accepted as one of the more appropriate treatments in the osteological study of human biology and behavior (Blakely 1977). Peebles (1977:124) states that

> A human burial contains more anthropological information per cubic meter of deposit than any other type of archeological feature. A burial represents the latent images of a biological and cultural person frozen in a clearly delimited segment of space and time.

In recent years, skeletal demography has been an important tool of the biological anthropologist in the study of the interrelationship of prehistoric populations and their environment. Paleopathological indicators of stress represent an additional facet of the biological approach which has received much attention in studies of the social and biological adaptation of prehistoric populations. Biological phenomena such as Harris lines, enamel hypoplasia, and variation in stature reflect the differential experiences of individuals and

ultimately skeletal populations to environmentally induced stress (i.e., malnutrition and disease). Stress resulting from social interactions, such as warefare, may also be recorded on the skeleton in the form of fracture patterns, projectile points embedded in bone, and cuts from scalping.

The present study proposed to employ these techniques to examine the biological and environmental interactions at the Averbuch site (40DV60)—a late Mississippian village located in a transitional zone between the Nashville Basin and the Highland Rim of Middle Tennessee.

Little is known concerning the archaeology of the Nashville Basin and far less is known of the skeletal biology. The Averbuch site is situated in north Davidson County, and consists of a stockaded village with three separate cemeteries. These three cemeteries provide the largest, systematically excavated skeletal series ever obtained from the Middle Tennessee area. Archaeologically, Averbuch belongs to the Mississippian Period "stone box" phenomenon termed the Middle Cumberland culture by Ferguson (1972), and was occupied between the thirteenth and fifteenth centuries A.D. Care in excavation was such that many of the sampling biases discussed by Buikstra (1977:72) may be avoided or addressed.

The Nashville area was densely populated throughout the Mississippian Period as is evident from the large number of stone lined graves excavated since the nineteenth century. Thruston (1897:2) excavated over 3,000 burials from the Noel Farm site in what is now Nashville and discovered at least 1,000 more on adjoining farms. Thruston (1897:28) notes that:

> The burial grounds on Brown's Creek, near Nashville, recently discovered, contain three or four thousand graves and smaller cemeteries have been found on nearly all the adjoining farms. Prof. Putnam and his assistants explored about six thousand graves, the majority of them in the vicinity of Nashville. Dr. Jones examined a large number, in some fifteen different cemeteries. Dr. Troost, the learned geologist of Tennessee, reports six very large cemeteries near Nashville.

Twentieth century urban expansion, intensive agricultural practices and looting by relic hunters have destroyed many other sites and thousands of burials.

The Middle Cumberland people vanished prior to the eighteenth century when the first settlers came into Middle Tennessee. In the early 1770's companies of hunters and explorers began to move into this area. Clayton (1880:16) notes that "The camps of the hunters at this time were the only habitations in Middle Tennessee, there being no Indian lodges anywhere in the country visited by the explorers." The last known Indian inhabitants of the Nashville area were the Shawnee who mainly occupied the lower Cumberland river valley in Kentucky. Tradition suggests that they migrated into this area during the mid-seventeenth century from Florida and Georgia. During the first decade of the eighteenth century the Shawnee were expelled from the Cumberland Valley by the allied forces of the Cherokee and Chickasaw (Ramsey 1926:78-80).

If this is true, the comparatively brief occupation of Middle Tennessee by the Shawnee cannot be used to explain the demise of the Middle Cumberland people. Pressure from epidemic disease introduced by Spanish and French exploration to the south, or Iroquois conquest

from the north are two factors which may have led to their seemingly sudden disappearance (Ferguson 1972:45). The Iroquois were known to raid as far south as northern Alabama; and, at the 1768 Treaty of Fort Stanwix, claimed by right of conquest the land north of the Tennessee River. In addition, a population density such as that of the Nashville Basin would have certainly taxed the environment. Decreased food availability with increased morbidity may represent factors that contributed to the Middle Cumberland disappearance.

The temporal and geographic location of the Averbuch site offers a rare opportunity to examine environmental and social influences that may have contributed to the demise of the Middle Cumberland people in the Nashville area. The present study investigates the biological and social adaptations of the Averbuch people to their environment and represents one of the first such studies of this magnitude in the Southeast. After a thorough description of the history and archaeology of the site, Averbuch demography will be presented and compared to that of other skeletal series. The demography of each of the three Averbuch cemeteries will be examined in an attempt to determine the temporal nature of stress at the site. The demographic analysis will provide the basis for the examination of more direct evidence of biological (i.e., Harris lines, enamel hypoplasia and stature) and social (violent trauma) stress.

CHAPTER II

# THE AVERBUCH SITE

## I. EXCAVATION HISTORY OF THE SITE

The Averbuch site (40DV60) is located on the property of Mr. Sidney Averbuch in the Bordeaux area of north Davidson County, Tennessee. The site is situated on the south slope of a hill approximately 300 meters east of Drake Branch in a transitional zone between the Nashville Basin and Highland Rim (Figure 1). Culturally, the Averbuch site belongs to the Middle Cumberland culture of the Mississippian Period. Although most Mississippian sites in the Nashville Basin are found along the major river systems, the Averbuch site is approximately four kilometers from the Cumberland River and over two kilometers from White Creek, a secondary tributary of the Cumberland.

The site was reported to the Tennessee Division of Archaeology after burials were uncovered during the expansion of the Royal Hills Subdivision. Joseph Benthall, Director of the Division of Archaeology, with the aid of coinvestigators Patricia Coats and Donald P. Rapp, initiated test excavations in 1975. The majority of the field crew consisted of volunteers from the Tennessee Archaeological Society, the Volunteer State Archaeological Society and students from McGavock High School (Rapp 1976). Excavation and survey revealed a cemetery located on lots No. 53 and No. 54 and a village 600 feet by 1,000 feet

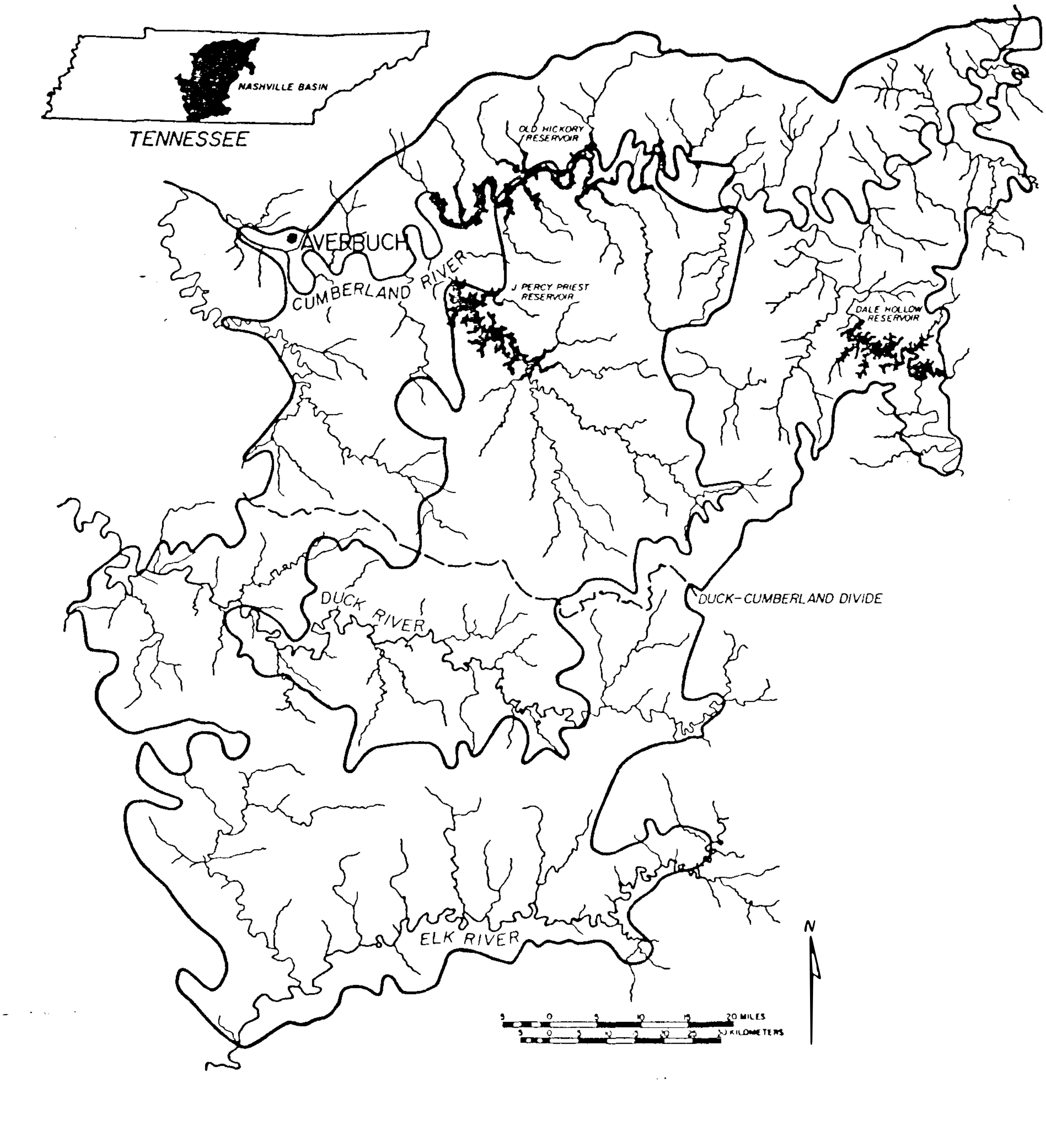



Figure 1. Map of the Nashville Basin and location of the Averbuch site.

along the north and east portion of the cemetery. Forty-nine stone lined graves were excavated and a number of post holes, two refuse pits and the possible remains of a prepared clay house floor were investigated (Rapp 1976). From these initial findings the Averbuch site was determined eligible for the National Register of Historic Places.

In September 1977, the Interagency Archaeological Service (IAS) of Atlanta contracted with the Department of Anthropology at The University of Tennessee, Knoxville, for further excavations at Averbuch. Two excavation programs were conducted with Dr. William M. Bass and Dr. Walter E. Klippel serving as coprincipal investigators. Dr. Klippel also served as Field Project Director while Ann Reed and Hugh E. Berryman were field supervisors. The first period of excavation began September 26, 1977, and was discontinued December 15, 1977. The results of this excavation established evidence of a much larger site than originally anticipated and demonstrated a need for further exploration. The second field season extended from March 20, 1978, through the first week of July 1978. Two crews were maintained during both field seasons, a weekly crew consisting of eight to fifteen members and weekend crew composed of approximately five to ten members.

Objectives of the fall field season were to ascertain site size, sufficiently sample the habitation areas, and totally excavate the cemetery to insure an adequate skeletal sample. Additional objectives were the determination of the temporal and spatial situation of the

site relative to other sites in the area, the subsistence pattern, intrasite structure and the cultural and biological aspects of social organization (Bass and Klippel n.d.:4-6).

Transects 90 centimeters wide and approximately 150 meters long were excavated with a backhoe at 10 meter intervals across the site from the 190E line to the 600E line. During the first field season, 226 graves (approximately 340 individuals) were excavated from the cemetery and investigations in the village area revealed two additional cemeteries. One structure was completely excavated and portions of two other structures were examined. During the second field season portions of a palisade and 74 structures were identified and 15 were excavated (Figure 2). Both charcoal and flotation samples were taken from each structure and the fill from the structures was waterscreened during removal. One hundred thirty graves (approximately 172 individuals) were excavated from Cemetery 1, 62 graves (approximately 72 individuals) from Cemetery 2, and 162 graves (190 individuals) from Cemetery 3. Thirty-five individuals were recovered in or near the 15 houses excavated (Klippel n.d.).

A total of 645 graves (887 individuals) was recovered from Averbuch by The University of Tennessee and the Tennessee Division of Archaeology. An additional 409 (estimated) individuals could not be collected due to destruction by cultivation or construction and lack of time to excavate the entire site.

It was estimated from backhoe testing that approximately 30 percent of the site had been destroyed by recent housing and road construction.

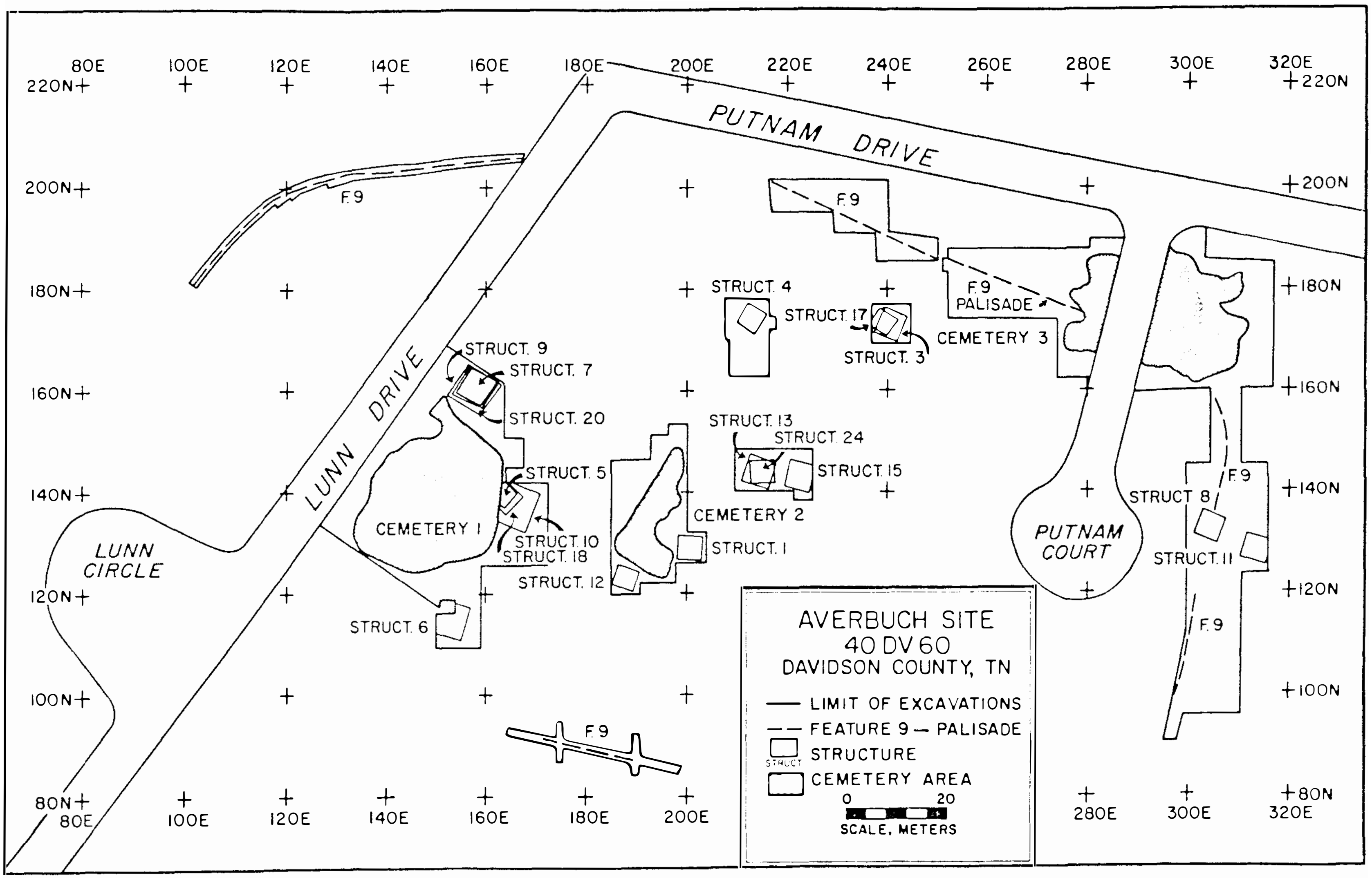



Figure 2. Map of the Averbuch site.

The portions of the site most affected were the village west and north of Cemetery 1 and the western periphery of Cemetery 1. Erosion has modified the southern portion of the site. In consideration of such disturbances, the Averbuch site apparently encompassed an area 330 meters east to west by 200 meters north to south (Reed 1978).

Two uncorrected $C_{14}$ dates were obtained from wood charcoal samples from one of the structures (UGa-2004 AD 1425 or 525 ± 55 BP; UGa-2005 AD 1255 or 695 ± 50 BP). These dates suggest that the site was occupied as late as the fifteenth century A.D. This date is further substantiated by several temporally diagnostic artifacts present at the site (e.g., filleted-rim bowls, strap-handled jars, small stone discoidals, deer and elk astragalus dice, etc.).

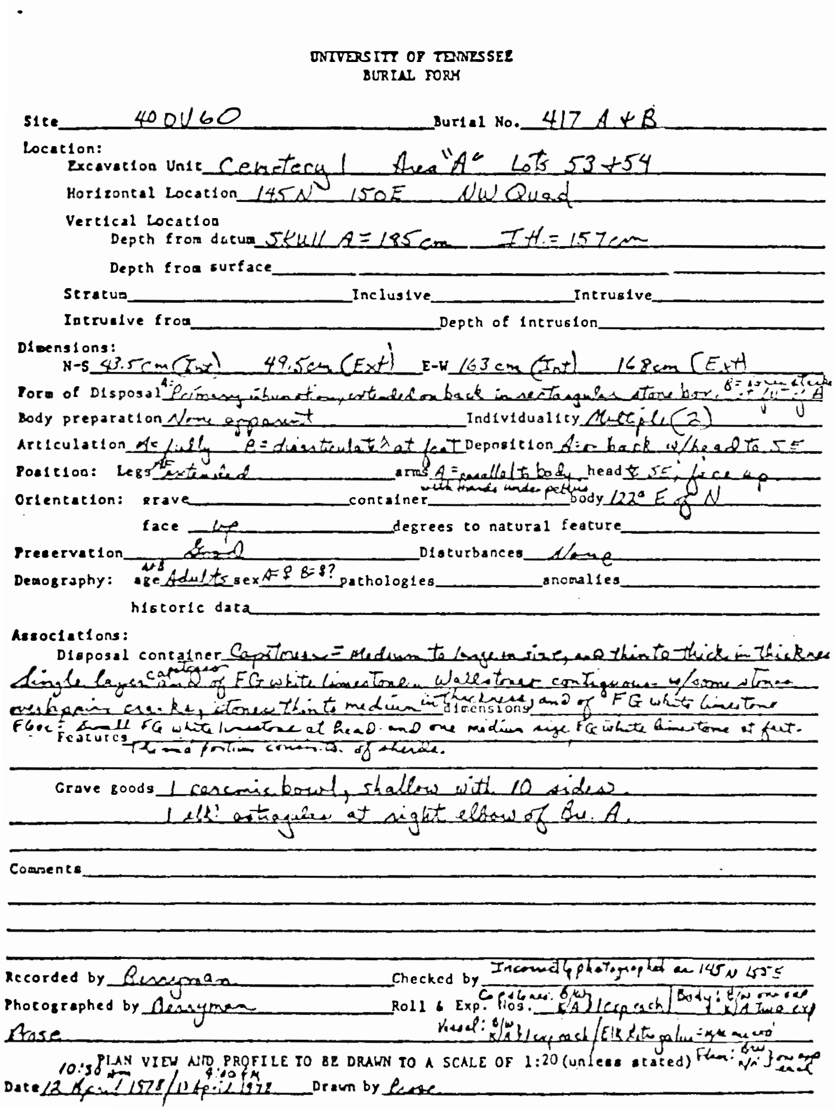
## II. ARCHAEOLOGY OF THE SITE

The vast majority of burials at Averbuch were confined to three separate and distinct cemeteries with a smaller number accompanying structures. Cemeteries 1 and 2 were situated approximately 30 to 35 meters from each other in the western half of the site and both were within the portion of the site enclosed by the palisade. Cemetery 3 was located in the northeastern section of the site and outside the palisade wall. A portion of the palisade superimposes graves in the southwest corner of Cemetery 3 suggesting that Cemetery 3 predates Cemeteries 1 and 2. It is hoped that a microseriation study of the artifacts may better substantiate the temporal positioning of the three cemeteries.

Demographically, both sexes and all age groups were found in these three cemeteries; however, the younger age ranges were notably deficient. Perinatal dead were commonly found in well made graves beneath the floors of the structures. Cemetery 1 was unique in that the graves, especially those in the outer part of the cemetery, were generally oriented in such a manner to form an overall circular pattern. A similar pattern could not be discerned in either Cemetery 2 or Cemetery 3.

During the Averbuch excavation, each burial was photographed (color slides and black and white prints) as well as drawn and an extensive effort was made to collect information pertinent to mortuary variability (Figure 3). Variation in stone box construction in the Southeast and Midwest is considerable as is evident by the stone box varieties established by Ferguson (1972:15,20) and the many descriptions of stone box manufacture (Bushnell 1920:45; Dowd 1972: 2-5; Ferguson 1972:20; Jones 1869:66; Troost 1845:358). Stone box construction varies considerably at Averbuch in the type of materials used, time expended and care devoted to manufacture. Dowd (1972:3-6) presents a rasonable description of the steps involved in box construction:

> After the grave was roughed out, a digging stick was used to cut a small trench around the outside of the box. This trench was five to eight inches lower than the grave floor and two or three inches wide. Thin stones were then selected and placed upright in the prepared trench, with about a third of the upright side and end stones below the level of the grave floor, anchoring the box firmly in the ground. . . .


UNIVERSITY OF TENNESSEE
BURIAL FORM

Site 40DV60 Burial No. 417 A + B

Location:
Excavation Unit Cemetery I Area "A" Lots 53 + 54
Horizontal Location 145N 150E NW Quad
Vertical Location
Depth from datum Skull A = 185 cm IH = 157 cm
Depth from surface
Stratum Inclusive Intrusive
Intrusive from Depth of intrusion

Dimensions:
N-S 43.5 cm (Int) 49.5 cm (Ext) E-W 163 cm (Int) 168 cm (Ext)
Form of Disposal A: Primary inhumation, extended on back in rectangular stone box. B: ...
Body preparation None apparent Individuality Multiple (2)
Articulation A: fully B: disarticulated at feet Deposition A: on back w/head to SE
Position: Legs A: extended arms A = parallel to body with hands under pelvis head to SE, face up
Orientation: grave container body 122° E of N
face up degrees to natural feature
Preservation Good Disturbances None
Demography: age A+B Adults sex A: ♀ B: ♀? pathologies anomalies
historic data

Associations:
Disposal container Capstones = Medium to large in size, and thin to thick in thickness, single layer and of FG white limestone. Wallstones contiguous w/some stones overlapping cracks, stones thin to medium in thickness and of FG white limestone. Floor: Small FG white limestone at head and one medium size FG white limestone at feet. The rest portion consists of sherds.
dimensions
Features

Grave goods 1 ceramic bowl, shallow with 10 sides.
1 elk astragulus at right elbow of Bu. A.

Comments

Recorded by Berryman Checked by Incorrectly photographed as 145N 155E
Photographed by Berryman Roll & Exp. Nos. Capstones: B/W K/A 1 exp each | Body: B/W one exp K/A two exp
Rose Vessel: B/W K/A 1 exp each | Elk astragalus: ...
PLAN VIEW AND PROFILE TO BE DRAWN TO A SCALE OF 1:20 (unless stated)
Date 12 April 1978 / 13 April 1978 (10:30 am / 4:00 PM) Drawn by Rose

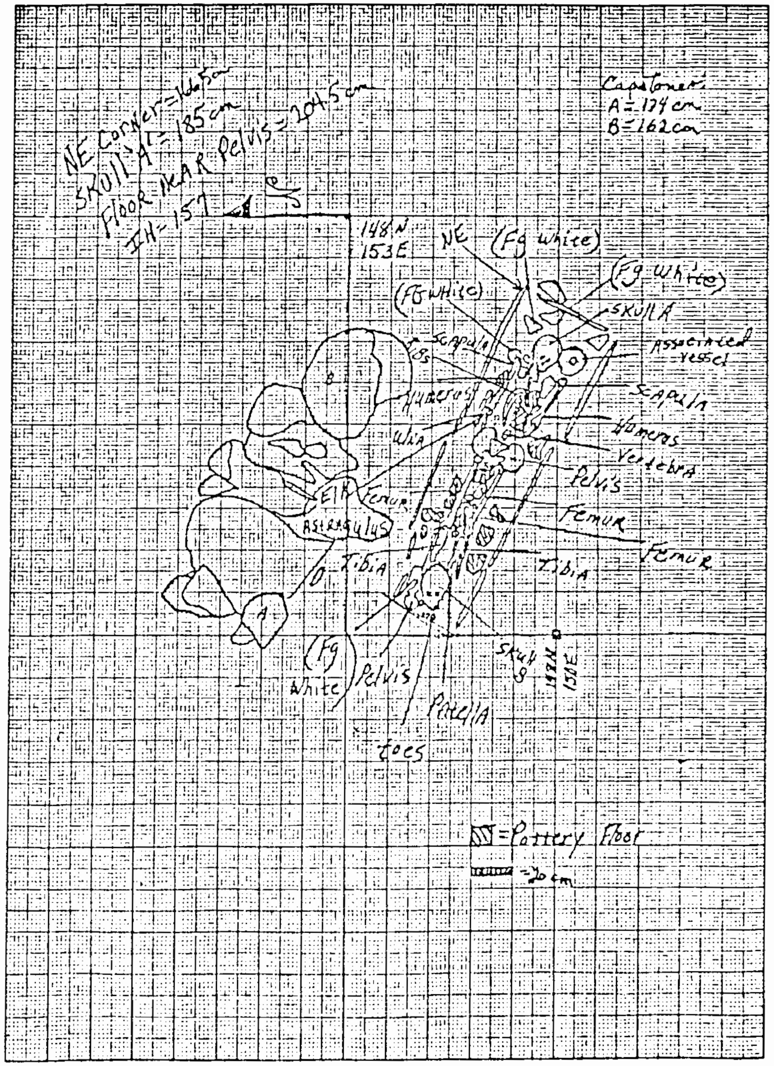



Figure 3. Example of an Averbuch burial form.

> Usually two or more stones were used to make the side of a box and they were sometimes overlapping to assure a tighter fit. A somewhat thicker stone was used for the ends, and if a suitable one could not be found, two thin stones were doubled . . . . After the side and end stones were positioned, they would be broken off across the top as evenly as possible. This would make the top of the side and end stones level, thereby allowing the topstones to lay flat on the box. . . . Large sherds of pottery were occasionally placed over the outer seams, especially at the corners, to seal the box. . . .
>
> The most common type of floor was constructed with thin pieces of limestone. Floors were also made of pottery sherds, and if there was a nearby supply, mussel shells were sometimes used. . . .
>
> After the body was put in the box, the topstones (capstones) were set in place. The topstones were usually laced on by each one overlapping the edges of the other. Sometimes there are many layers of topstones but often there are just enough to afford protection for the corpse.

Variation may be demonstrated at Averbuch in the depth of the interments which range from shallow to fairly deep. Many of the shallow burials—those covered by only a few centimeters of earth—were often plow disturbed. Burial 455, with a floor approximately 80 centimeters below the surface, was one of the deeper graves encountered at the site. Grave construction at Averbuch varied from the absence of a prepared stone coffin, though uncommon, to well made boxes with lined floors and one to several layers of capstones. The presence of lined floors and capstones seem to have been optional; however, plow disturbance may account for the absence of some capstones while the use of perishable materials such as wood, bark or skins may represent additional factors. The wall stones used in grave construction varied from overlapping to contiguous. Coffins were rectangular in shape to accompany the extended corpse and the size of the box varied proportionally to

the size of the individual. The most common material used in box construction was limestone (white, red and fossiliferous) which occurs in a readily available, laminated form in the Nashville Basin. Shale, sandstone, mudstone and ceramic sherds (often salt pan) were also utilized in varying degrees for box construction.

The burials at Averbuch were almost exclusively interred on their back in an extended position. Rarely, exceptions do exist and usually result from individuals being placed in too small a box, necessitating a slight flexing of the legs. The arms of most of the burials were extended behind the back with the hands beneath the pelvic girdle. Variation was also noted in multiple burials in which individuals were oriented with their heads to the same or opposite ends of the grave. Also, the body preparation of one individual was unique; the corpse had been placed on a floor of limestone, partially cremated, and buried in situ.

A fairly common phenomenon at Averbuch, as well as other Middle Cumberland sites, is the reuse of graves. It is evident that many of the graves were reopened and reused after the initial burial had been made. Upon such occasion, the primary burial was disarticulated and moved to the foot of the grave, placed along one of the walls, or discarded. It is uncertain whether the basis of grave reuse is conjugal affinity, consanguinity or simply for the sake of convenience. Conjugal pairing is suggested by cases in which adult males and females were buried side by side in similarly constructed boxes or in the same box. Simultaneous multiple interments were also prevalent with two,

three and sometimes more individuals placed in a single grave. Consanguinity is suggested by the burial of children inside or beside boxes containing adult females. Burial 517B, a primary inhumation of an adult female, and 517A, a child who was entered at a later date than B, may provide an example of this. To make room for the child the pelvic girdle and legs of the female were moved toward the head of the box. It is evident that the female's body had not thoroughly decomposed since several of the bones remained articulated throughout their move.

O'Brien (1977:346) comments that closely associated burials at the Mound Bottom site

> . . . could occur when a woman dies during, or soon after, childbirth and her child dies soon after that. . . . Another possibility is that the child was killed upon the death of its mother due to [sic] the lack or desire of anyone to care for it.

Grave reuse suggests that the location and perhaps the identity of each grave was marked. Such activity was observed in the mortuary practice of the Delaware who after filling the grave with earth

> . . . set up a long pole at each end of the grave, they paint the one at the head, if the deceased has been a warrior with certain hieroglyphics—denoting how often he had gone to war—how many he had killed—if he had been a _Moy-a-ooh'whese_, or foreman, how many men he had lost, and how often he had been wounded. (M'Cullough in London 1971, I:297)

Many Averbuch graves were intruded into or cut through by later burials, suggesting that sufficient time had passed to allow the placement of earlier graves to be forgotten.

When Averbuch is compared with other large Late Mississippian sites (e.g., Moundville, Etowah, etc.), there is a notable absence

of the quantity of the more elaborate artifacts and exotic materials. However, an absence of artifacts has long been a characteristic of Middle Cumberland graves. This is reflected in Moore's (1916:485) statement:

> As to the discovery of artifacts, as is usually the case with stone graves, we had our labor for our pains as the saying goes.

The majority of the adult burials at Averbuch possessed no artifact associations. Adult associations, when present, were usually utilitarian (e.g., awls, potter's anvils, blades, celts, etc.) or ornamental (e.g., ear plugs, hair pins, etc.). Ceramic vessels were occasionally found with adults. Copper was also included in some adult graves, though extremely rare. Approximately one half of the subadult burials were accompanied by grave goods. The most elaborate ceramics at the site were normally found with the children; these include both human and animal effigy vessels, human effigy ceramic figurines, shell spoons, and ornaments (e.g., beads, ear plugs, shell gorgets). Such a practice severely limits the use of burial associations in defining social status. However, variation in the materials used and the care and time involved in stone box construction may prove valuable. Dowd (1972:2,5) notes that ". . . the finest made boxes generally also contained the nicest artifacts."

The information potential offered by mortuary remains is often reduced by post burial forces that alter the character of the grave or its contents. The following is a review of the forces at Averbuch that hindered burial recovery or altered the accuracy of the data collected:

1. Aboriginal disturbance through both grave reuse and the intrusion of stone coffins into preexisting graves was a factor in all three cemeteries.

2. The stone boxes made excellent shelter for rodents such as groundhogs and mice. The complete skeletons of mice were often found in the graves and on one occasion a family of live mice was discovered in a stone box grave. Brehm and Evans (1977:23) note that "There appears to be considerable movement of small items from rodent activity inside the box." Also, bony ridges and tubercles of some of the bones often exhibit gnaw marks.

3. Curiosity seekers and vandals were also a problem. Little evidence of "pot hunting" activity was found; however, the children of an earlier owner of the property were reported to have dug in the graves. During the second field season vandals damaged materials from several graves that were left open in Cemetery 2 throughout the night.

4. Water and root activity can also damage and move objects within a stone coffin. Soil type, drainage and other factors may influence seepage. Ceramic vessels and even crania will occasionally float to different areas of the box as it fills with water. Boxes with lined floors tend to hold water for longer periods of time promoting bone destruction. Roots also penetrate the boxes and damage bones.

5. Cultivation was responsible for the damage and destruction of many of the very shallow burials, and the removal of the capstones from deeper graves. This was especially a problem in Cemetery 2 in

which many of the boxes were disturbed and occasionally fragments of limestone and bone were found suggesting the complete destruction of some boxes.

6. Landscaping and construction from the expansion of the Royal Hills Subdivision was responsible for damage to some of the burials in Cemetery 1 and the heavy machinery used in construction of Putnam Circle badly crushed many of the burials in Cemetery 3.

7. Differential preservation was further affected by a combination of soil acidity and material used in box construction. Limestone boxes acted to neutralize the acid soil and better preserved the bones. Boxes constructed of shale offered little or no protection for the bones and in many instances only the teeth and a few fragments of bone were preserved.

## CHAPTER III

## THE DEMOGRAPHIC APPROACH TO SKELETAL STUDIES

### I. INTRODUCTION TO THE DEMOGRAPHIC APPROACH

A thorough study of a prehistoric skeletal series demands the full cooperation of both the archaeologist and the biological anthropologist. It must include a concerted effort by the biological anthropologist to explore both the cultural and biological data through all pertinent methodological avenues. Within the past decade and a half, demography has become a relatively common term in the realm of anthropology, and it is only within this time frame that its utility and potential in prehistoric skeletal analysis has been demonstrated (Acsâdi and Nemeskéri 1970; Buikstra 1972; Vallois 1960; Weiss 1973).

Demography has its origin in sociology and geography; sociologists and geographers were among the first to apply demographic theory to the study of existent populations. Its utility in the study of prehistoric populations was soon recognized and its methodology was embraced by the anthropologist. The implementation of demographic principles in the study of extinct human populations has been termed paleodemography by Angel (1969a) and Acsâdi and Nemeskéri (1970). Howells (1960) and Cook (1972) refer to it as prehistoric demography, and Weiss (1975) calls it skeletal demography. Information available through demographic study—age and sex composition, age specific

mortality, adult longevity for each sex, fertility, and population size—reflects the adaptive efficiency of a group to its environment. Such information can contribute greatly to our knowledge of the demise, growth, and migration of a population or even the origin of certain cultural or social practices.

This is further reflected in a statement by Wobst (1973:vii) concerning the demographic structuring of archaeological data:

> Thus, the age and sex structure of a population will be reflected, if only indirectly, in the number of points, the volume of pots or the size of houses encountered by archaeologists. More complex archaeological parameters are more intricately structured demographically. For example, the mean length of occupation of residential structures not only derives from the mating pattern, the postmarital residence rules and various other social and economic factors, but also from mortality (household abandonment) and fertility (rate of household formation).

There are several archaeological approaches to the estimation of demographic parameters, particularly population size. Population size and dynamics are estimated from house and mound frequency (Ascher 1959; Haviland 1965, 1966, 1970), settlement pattern (Bullard 1960; Dumond 1972; Willey et al. 1965), surface ceramic collection (Schwartz 1956), and ecological resource potential of an area (Cowgill 1962; Thompson 1966). However, the use of skeletal data in population estimates may well represent the most accurate approach of all. Howells (1960:160) notes that

> It is evident that the more use is made of factors having a biological component, the closer one comes to the reality of population, a biological phenomenon. Finally, we come to skeletal material, the most important evidence of all, since it is completely biological, and one individual however many rooms he may occupy or however many clams he may eat or pots he may make, produces one skeleton and one only.

The major problem that the American physical anthropologist must face is the lack of adequate skeletal populations. This largely limits the utility of the demographic approach in the New World to that of the theoretical realm (Weiss 1973). Physical anthropologists must also face the possibility of an incomplete sample. Factors which contribute to this are poor preservation, death and burial away from the village, and differential treatment according to status. Many other, yet unknown, social and cultural practices may alter the completeness of a prehistoric cemetery sample. Regardless of these factors a number of anthropologists have attempted demographic studies of New World skeletal series.

## II. DEMOGRAPHIC RECONSTRUCTIONS FROM NEW WORLD SKELETAL SERIES

New World demographic research began with Hooton's (1920) analysis of a prehistoric cemetery near Madisonville, Ohio. Hooton's goal was the determination of the mean death rate and estimation of population size. The age distribution at death of the Madisonville population was compared to that of a number of European countries and found to be most similar to Switzerland. The crude death rate of Switzerland was assumed by Hooton to approximate the Madisonville crude death rate. He then used the crude death rate, the total number of graves at the site and the number of years the site was occupied to compute the village population size. Hooton (1930) later attempted a demographic analysis of the Pecos Pueblo skeletal material.

Approximately 1,800 burials were recovered from the excavation of an estimated 15 to 20 percent of the site. He assumed that the portion of the site excavated was representative of the demographic distribution of the remainder of the cemetery. Hooton used ethnohistoric sources to establish an estimate of 1,000 years as the length of occupation. The emphasis of this report was the reconstruction of population dynamics throughout this 1,000 year period. Howells (1960) estimated the Pecos Pueblo population size using the number of skeletons, newly published archaeological data and an assumed death rate of 30 per thousand per year. Howells' estimates are probably more accurate than those of Hooton; however, the reliability of the death rate and the number of years of occupation must remain uncertain.

Snow (1948) examined the mortality curve of the Archaic skeletons from Indian Knoll, Kentucky. The mortality curve was ascertained by aging and sexing the skeletons and plotting the ages. Unfortunately, Snow determined adult age by cranial suture closure—an unreliable technique. In an attempt to rectify this problem, Johnston and Snow (1961) used a variety of aging criteria to reassess Indian Knoll. Stewart (1962) questioned the accuracy of many of these aging techniques.

Bass et al. (1971) examined the mortality and population size of the Leavenworth site cemetery, a historic Arikara Indian site from South Dakota. Age distributions of deaths were presented; however, it was determined that a large number of skeletons was not recovered thus limiting the demographic utility of this sample.

Churcher and Kenyon (1960) were among the first to attempt to use a demographic approach in the study of ossuary deposits (i.e., two Iroquois ossuaries). The major aging technique employed was cranial suture closure. Mortality and the sex ratio were examined, but pot hunting and heavy equipment contributed to the incompleteness of the series and limited its value. A more thorough demographic approach to the study of ossuary remains is that of Ubelaker (1974). He examined two Late Woodland ossuaries from the Juhle site in Maryland. Both the pubic symphysis and osteon count were used to determine age. Ubelaker was among the first to apply life tables in the demographic investigation of New World skeletal series. The life table approach permits data to be obtained concerning longevity, mortality and age-specific probabilities of death and life expectancy. The life table also permits the calculation of population size from the crude mortality rate, total number of burials and the number of years the ossuaries were used. Owsley (1975) also employed a life table approach to a skeletal series derived in part from "ossuary-like" circumstances (commingling). The study produced the vital statistics and population size of the Larson site, South Dakota.

The emphasis of the present study is closely related to the demographic approach of Blakely (1971, 1977), Goldstein (1953), and Owsley et al. (1977). Goldstein (1953) examined the relationship between mortality and subsistence pattern through demographic statistics. The study was thorough and includes sex and age specific mortality in a comparison of agricultural and hunting/gathering

societies. The report represents one of the first problem oriented studies employing demography. In a similar fashion, Blakely (1971) compared the mortality profiles of an Archaic, Middle Woodland, and Middle Mississippian skeletal series. He offered a discussion of the disease and cultural considerations influencing the mortality profiles of these groups. Blakely (1977) also utilized demographic techniques in conjunction with multivariate discriminant analysis to examine sociocultural phenomena at Etowah, Georgia. Owsley et al. (1977) use demographic and osteological data to demonstrate the presence of intertribal warfare at the Larson site, South Dakota.

## III. PREREQUISITES TO THE DEMOGRAPHIC ANALYSIS OF A SKELETAL SERIES WITH REFERENCE TO THE AVERBUCH SITE

The previously discussed articles demonstrate the potential of the demographic approach to the study of aboriginal populations. However, the literature is relatively deficient in such studies. This deficiency is due to the prerequisites demography places on skeletal data. Ubelaker (1974:5) outlines these demands as follows:

(1) a knowledge of the completeness of the sample;
(2) information about the archaeological associations of the skeletons;
(3) a determination of the length of time the sample represents;
(4) an adequate assessment of sex and age at death, and
(5) a proper selection of demographic methodology.

Each of these demands will be discussed in reference to the Averbuch skeletal series.

The Completeness of the Sample

As previously mentioned, total burial recovery was the aim of The University of Tennessee excavations. Unfortunately, many burials could not be recovered due to destruction by cultivation and construction, or a lack of time to complete the excavation. It is fortunate that mortuary patterning at Averbuch facilitates the estimation of the number of burials missing.

Cemetery 1. All of the graves discovered were excavated; however, several graves were destroyed along the west side of the cemetery by the construction of Putnam Drive. Cemetery 1 was somewhat circular in shape which allows an approximation of the number of graves missing. Each five meter unit within the cemetery contained an average of fifteen graves with approximately 1.3 individuals per grave. From these figures an estimated 32 individuals were claimed by the construction of Putnam Drive.

Cemetery 2. Every grave that was uncovered was excavated. These graves were not as deep as those in either Cemetery 1 or Cemetery 3. Many graves were plow disturbed and some were completely destroyed. It is estimated from the scattered remnants of boxes that the remains of as few as seven or eight (7.5) individuals were destroyed in this manner.

Cemetery 3. Time allowed all but four graves—located on the west side of Putnam Circle—to be removed from Cemetery 3. In

addition, that portion of the cemetery beneath Putnam Circle could not be excavated. The street covered approximately eight, five meter units. Thus, at approximately eight to eight and one half individuals per five meter unit, 66.5 individuals remain beneath the street. This number, plus the five individuals not recovered due to a lack of time, results in a final estimate of 71.5 individuals.

Structures. Approximately 80 structure loci were discovered. Of this number 12 structure loci were randomly selected and excavated producing 2.92 individuals each. Approximately 30 percent of the site had been destroyed by construction. If it can be assumed that the structures were randomly distributed throughout the missing portion of the site, then approximately 34 structure loci could not be recovered. A total of 102 structure loci can be assumed to have been present at Averbuch in addition to the 12 which were excavated. At 2.92 individuals per structure locus an estimated 297.84 individuals were missed. The majority of the structure burials contained fetal and infant remains.

The three cemeteries and the twelve structures yield a total of 887 individuals (Table 1). The above estimates indicate that an additional 409 individuals were not recovered. Therefore, the Averbuch site contained an estimated total skeletal series of 1,296 individuals (Table 2). The fractional individuals displayed in Table 1 result from the proportioning of individuals who could not be accurately aged or sexed into defined age and sex categories. The fractional individuals in Table 2 result from the proportioning of

TABLE 1

AGE AND SEX DISTRIBUTION OF SKELETONS RECOVERED FROM THE AVERBUCH SITE
(EXCLUDING ESTIMATES OF MISSING INDIVIDUALS)

| Age | Cemetery 1 | | | Cemetery 2 | | | Cemetery 3 | | | Structures | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Interval | Male | Female | Unsexed | Male | Female | Unsexed | Male | Female | Unsexed | Male | Female | Unsexed | Number |
| 0 - 1.5 | --- | --- | 40.33 | --- | --- | 8.69 | --- | --- | 11.28 | --- | --- | 21.00 | 81.30 |
| 1.5- 5.5 | --- | --- | 118.70 | --- | --- | 16.30 | --- | --- | 36.11 | --- | --- | 5.00 | 176.11 |
| 5.5-10.5 | --- | --- | 34.62 | --- | --- | 5.00 | --- | --- | 13.44 | --- | --- | 1.00 | 54.06 |
| 10.5-15.5 | --- | --- | 18.32 | --- | --- | 2.00 | --- | --- | 5.10 | --- | --- | --- | 25.42 |
| 15.5-20 | 23.72 | 36.94 | --- | 2.10 | 4.21 | --- | 6.40 | 5.49 | --- | --- | --- | --- | 78.86 |
| 20 -25 | 56.36 | 35.94 | --- | 13.87 | 8.10 | --- | 13.33 | 23.12 | --- | --- | --- | 1.00 | 151.72 |
| 25 -30 | 34.56 | 26.73 | --- | 4.40 | 2.21 | --- | 9.63 | 14.99 | --- | --- | --- | --- | 92.52 |
| 30 -35 | 18.24 | 18.35 | --- | 8.81 | 1.10 | --- | 9.63 | 8.17 | --- | --- | --- | --- | 64.30 |
| 35 -40 | 15.63 | 17.04 | --- | 5.51 | 2.21 | --- | 5.51 | 2.73 | --- | --- | --- | --- | 48.63 |
| 40 -45 | 10.64 | 9.74 | --- | 0.65 | 2.50 | --- | 5.45 | 1.08 | --- | --- | --- | --- | 30.06 |
| 45 -50 | 10.64 | 9.74 | --- | 0.65 | 2.50 | --- | 5.45 | 1.08 | --- | --- | --- | --- | 30.06 |
| 50 -55 | 6.65 | 6.74 | --- | 1.95 | 0.63 | --- | 3.70 | 1.30 | --- | --- | --- | --- | 20.97 |
| 55 -60 | 6.65 | 6.74 | --- | 1.95 | 0.63 | --- | 3.70 | 1.30 | --- | --- | --- | --- | 20.97 |
| Adult | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1.00 | 1.00 |
| Subtotal | 183.09 | 167.96 | 211.97 | 39.89 | 24.09 | 31.99 | 62.80 | 59.26 | 65.93 | --- | --- | 29.00 | 875.98 |
| Fetal | --- | --- | 1.00 | --- | --- | 2.00 | --- | --- | 2.00 | --- | --- | 6.00 | 11.00 |
| Total | 183.09 | 167.96 | 212.97 | 39.89 | 24.09 | 33.99 | 62.80 | 59.26 | 67.93 | --- | --- | 35.00 | 886.98 |

TABLE 2

AGE AND SEX DISTRIBUTION OF SKELETONS RECOVERED FROM THE AVERBUCH SITE
(INCLUDING ESTIMATES OF MISSING INDIVIDUALS)

| | Cemetery 1 | | | Cemetery 2 | | | Cemetery 3 | | | Structures | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Interval | Male | Female | Unsexed | Male | Female | Unsexed | Male | Female | Unsexed | Male | Female | Unsexed | Number |
| 0 - 1.5 | --- | --- | 42.62 | --- | --- | 9.36 | --- | --- | 15.54 | --- | --- | 208.70 | 276.22 |
| 1.5- 5.5 | --- | --- | 125.44 | --- | --- | 17.56 | --- | --- | 49.72 | --- | --- | 45.79 | 238.51 |
| 5.5-10.5 | --- | --- | 36.58 | --- | --- | 5.40 | --- | --- | 18.48 | --- | --- | .84 | 61.30 |
| 10.5-15.5 | --- | --- | 19.38 | --- | --- | 2.16 | --- | --- | 7.00 | --- | --- | .39 | 28.93 |
| 15.5-20 | 25.07 | 39.04 | --- | 2.26 | 4.54 | --- | 8.80 | 7.54 | --- | --- | --- | 2.67 | 89.92 |
| 20 -25 | 59.56 | 37.98 | --- | 14.93 | 8.72 | --- | 18.35 | 31.82 | --- | --- | --- | 5.39 | 176.75 |
| 25 -30 | 36.52 | 28.25 | --- | 4.74 | 2.38 | --- | 13.25 | 20.63 | --- | --- | --- | 3.33 | 109.10 |
| 30 -35 | 19.27 | 19.39 | --- | 9.48 | 1.18 | --- | 13.25 | 11.25 | --- | --- | --- | 2.32 | 76.14 |
| 35 -40 | 16.52 | 18.01 | --- | 5.93 | 2.38 | --- | 7.59 | 3.76 | --- | --- | --- | 1.71 | 55.90 |
| 40 -45 | 11.24 | 10.30 | --- | 0.70 | 2.70 | --- | 7.51 | 1.50 | --- | --- | --- | 1.06 | 35.01 |
| 45 -50 | 11.24 | 10.30 | --- | 0.70 | 2.70 | --- | 7.51 | 1.50 | --- | --- | --- | 1.06 | 35.01 |
| 50 -55 | 7.03 | 7.12 | --- | 2.11 | 0.68 | --- | 5.02 | 1.79 | --- | --- | --- | .72 | 24.47 |
| 55 -60 | 7.03 | 7.12 | --- | 2.11 | 0.68 | --- | 5.02 | 1.79 | --- | --- | --- | .72 | 24.47 |
| Subtotal | 193.48 | 177.51 | 224.02 | 42.96 | 25.96 | 34.48 | 86.30 | 81.58 | 90.74 | --- | --- | 274.70 | 1231.73 |
| Fetal | --- | --- | 1.06 | --- | --- | 2.15 | --- | --- | 2.75 | --- | --- | 57.96 | 63.92 |
| Total | 193.48 | 177.51 | 225.08 | 42.96 | 25.96 | 36.63 | 86.30 | 81.58 | 93.49 | --- | --- | 332.66 | 1295.65 |

the estimated 409 individuals that could not be recovered. The manner in which these individuals are distributed into the various categories is discussed in detail later in this chapter.

The factors thus far discussed as responsible for the exclusion of certain burials from recovery are largely those which occurred after the site was abandoned. A burial series may also be incomplete due to the exclusion of certain individuals for social or cultural reasons. This is best exemplified at Averbuch by the noted absence of newborns and infants in the cemeteries. Evidently society dictated an age prerequisite for cemetery burial which relegated this age group to burial in or around the structures. As discussed above, the number of cemetery exclusions (i.e., those burials associated with the structures) can be estimated, however, if others were excluded due to status differences or deaths away from the village the demography may be altered. Although this may have occurred to some degree, it is assumed that the Averbuch series accurately reflects the demographic structure of the village.

Archaeological Associations of the Skeletons

Much effort was made during site excavation to insure both vertical and horizontal control of all archaeological remains. The integrity of each skeleton was maintained in the field and sorted and rechecked in the lab. Occasionally, enough extra skeletal components were separated in the lab to determine the existence of an additional individual not noted in the field. For a detailed discussion of Averbuch archaeology,

please refer to the previous chapter. It is felt that the archaeology at the Averbuch site is adequate for a demographic approach and is comparable with or surpasses the archaeology of other sites to which demography has been applied.

Length of Occupation

Even though the Averbuch site is Mississippian and was probably continuously occupied, the length of this occupation is not easily ascertained. There are several indicators that suggest the occupation was not of extreme duration. For example, the single palisade that encompasses most of the site shows no evidence of rebuilding, and the midden deposit throughout the site is thin and incomplete in its distribution. However, some of the structures demonstrate a second period of rebuilding. Since most woods in this area will survive only eight to ten years in the ground, the rebuilt structures may suggest 16 to 20 years of occupation. Also, Cemetery 1, and 3 to a lesser extent, posses several graves that are cut through by later burials. This suggests that sufficient time had transpired between the earlier and the later burials to permit later inhabitants to forget the exact location of earlier graves. Although it is impossible to determine the absolute number of years the site was occupied, the above indicators suggest that 15 to 25 years might be a reasonable estimate.

Age Determination

Subadults are classified in a birth to six month interval and in one year intervals thereafter up to and including the age of 19.5. Two techniques are utilized to achieve this: (1) dental calcification and eruption, and (2) long bone growth and maturation.

Dental estimates of chronological age are accomplished with the Moorrees et al. (1963a, 1963b) method. This method provides separate standards according to sex for the formation and resorption of three deciduous teeth and the formation of 10 permanent teeth. It is necessary to pool the male and female standards since subadult sex at Averbuch is uncertain. The degree of sex specific dental development diverges with age, increasing to a maximum of only 5 percent, with females slightly ahead of males in time of dental maturity (Garn et al., 1958). Thus the pooling of the Moorrees et al. sex standards may introduce some bias, however, it is believed to be small. This method requires periapical x-rays for all subadults whose teeth cannot be readily removed from their sockets for inspection.

Several researchers provide growth standards which may be consulted for comparison: Johnston (1962) for the Indian Knoll series; Merchant (1973) and Merchant and Ubelaker (1977) for an Arikara series from the Mobridge site, South Dakota; Stewart (1968) for Eskimo femora; Sundick (1972) for Indian Knoll; Walker (1969) for a Late Woodland series from Illinois; Y'Edynak (1976) for a Western Eskimo series. Both the Johnson (1962) and Merchant and Ubelaker (1977) standards were utilized for comparison as the need arose. These standards also provide

a cut off point important in distinguishing fetal from postnatal burials. Dental eruption (Schour and Massler 1941, 1944) standards are applied as a general check of other estimators of age and to age cases on which the Moorrees et al. method is judged impractical. Epiphyseal closure (Krogman 1962; McKern and Stewart 1957) is likewise employed and is of additional use in aging adolescent skeletons.

It is commonly recognized that tooth formation and eruption more highly correlates with the chronological age of an individual than osseous maturation. Although the variability of both tooth formation and longitudinal bone growth increases with age, the magnitude of dental variability is far less prominent (Garn, Lewis and Polacheck 1959; Lauterstein 1961; Lewis and Garn 1960). Garn, Lewis, and Blizzard (1965) and Niswander and Sujaku (1965) note that endocrine imbalance, disease and major physical defects have less effect on the alteration of dental development than on bone growth and maturation. Also, the majority of the variation in dental maturation is genetic with nutrition accounting for approximately 10 percent (Garn, Lewis and Kerewsky 1965).

Considering these factors, more emphasis is placed on the use of dental calcification and eruption in aging the Averbuch subadults. In most cases, longitudinal bone growth and maturation are utilized as secondary or backup sources of aging.

Individuals between 19.5 and 39 years of age are placed in five year intervals as suggested by Swedlund and Wade (1972). Present aging techniques do not permit reliable classification into categories

smaller than this. Unfortunately, osteon counting (Ahlquist and Damsten 1969; Kerley 1965, 1970)—one of the more accurate of available techniques—is not feasible due to the excessive expense and time required to age a skeletal series of this magnitude. Instead, morphological changes in the surface of the pubic symphsis and dental attrition are considered more practical in aging adults.

Adult males 17 to 40 years of age with intact pubic bones are aged with the McKern and Stewart (1957) system. With this system, three aspects of the pubic symphsis are examined and scored as one of five developmental stages. However, the system is limited to a maximum age assessment of 36 plus years. To rectify this, males aged at 36 plus with the McKern and Stewart method are subjected to a method derived by Todd (1920-21). Todd follows nine characteristics of the pubic symphysis through 10 developmental phases from 18 to 50 plus years. Even though Todd's method tends to over age (Brooks 1955), it is felt that the error of misclassification can be minimized by classifying individuals 40 years of age and older into 10 year age intervals (e.g., 40-49, 50-59).

Factors related to childbirth produce different stresses and morphological changes on the female symphyseal surface. Females, when aged with male standards, may appear older by as much as 10 years. The Gilbert and McKern (1973) method for aging from the female pubic bone is employed and is comparable to the McKern and Stewart (1957) system. Individuals 17 to 55 years old may be aged with this method, however, the upper ages cannot be confined to five year

intervals. For this reason females older than 39 are aged in 10 year intervals as are the males.

Suchey (1977) criticizes the Gilbert and McKern method on two points: (1) the sample upon which the study is based is quite small and (2) interobserver error is fairly significant. Even so, it is felt that the method offers a practical and acceptable approach to aging Averbuch females. However, a conscious effort is made to consult other aging techniques to insure a higher degree of accuracy.

Since most of the Averbuch pubic bones are missing or poorly preserved, it became necessary to employ an alternate technique. An accurate yet inexpensive and expedient method was needed. Previously developed dental attrition techniques (Brothwell 1963; Hrdlička 1952) are both expedient and inexpensive to apply. Unfortunately, they were developed on populations culturally distinct from Averbuch, and, if employed, would bias the aging. Thus, a method of aging based on site specific dental attrition was developed.

The method was developed using Averbuch mandibular molars and was patterned after Miles (1963). The reliability and validity of the Miles approach has been demonstrated by Nowell (1978) and is applied here with some modification. The posterior teeth are used since they more clearly reflect age related attrition than do the anterior teeth. Anterior teeth are subject to cultural related attrition (e.g., the use of teeth as tools) while the posterior teeth function almost exclusively in the context of mastication (Molnar 1972).

The first step in developing this technique is to determine as accurately as possible the ages at which the first, second and third molars in the Averbuch series began to experience attrition. The dentitions of subadults and young adults were examined and individuals possessing molars that express initial evidence of wear were aged with the Moorrees et al. (1963b) method. The average Averbuch molar may have erupted slightly earlier than in modern populations. The wear appearing on the first, second and third molars at five, ten and seventeen years of age, respectively (see Figure 4), may occur prior to their reaching the occlusal plane. These ages form the base-line from which the rate of wear for each of the molars is determined.

Before the rate of wear can be determined, the degree of wear must be recorded. The most objective manner of accomplishing this is by dividing the occlusal surface area of each molar into quadrants and assigning a wear score from 0 through 10 to each. The definitions of these scores are presented in Table 3 and are derived from Scott (1979:214, Table 1).

The molars of individuals aged at less than 20 years are scored. The third molars are genetically unstable and their eruption time is often variable. For this reason, the attrition rate developed for Averbuch is based largely on first and second molar wear rates.
As can be seen by the scores in Figure 4, the first and second molars wear at approximately the same rate during the first 20 years of life. This fact is important in the construction of Figure 4.

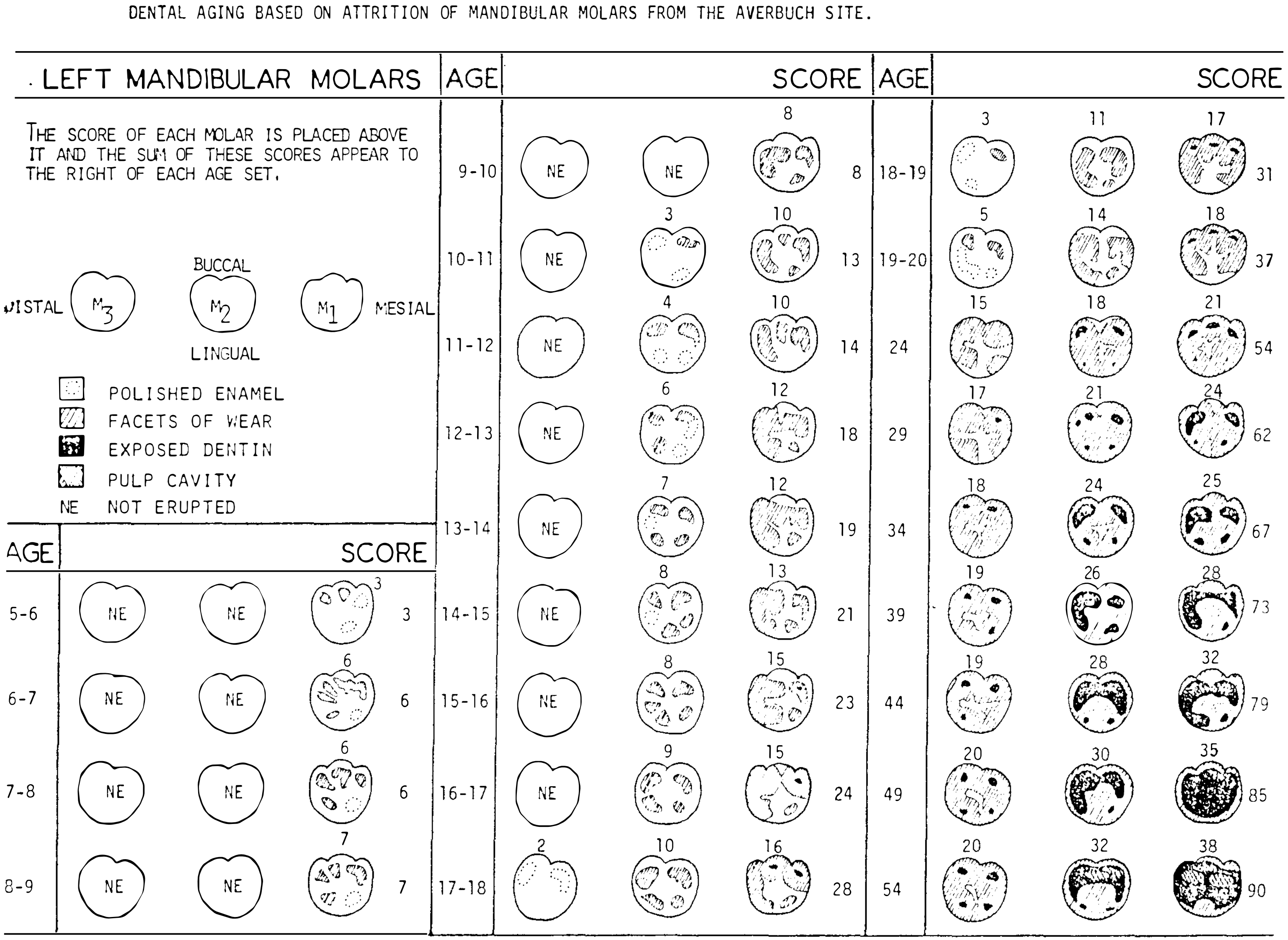



Figure 4. Dental aging based on attrition of mandibular molars from the Averbuch site.

TABLE 3

DENTAL ATTRITION SCORES

| Score | | Description |
|---|---|---|
| 0 | | No information available (tooth not occluding, unerupted, antemorten or postmortem loss, etc.) |
| 1 | | Wear facets invisible or very small |
| 2 | | Wear facets large, but large cusps still present and surface features (crenulations, noncarious pits) very evident. It is possible to have pinprick size dentine exposures or "dots" which should be ignored. This is a quadrant with much enamel. |
| 3 | | Any cusp in the quadrant area is rounded rather than being clearly defined as in 2. The cusp is becoming obligerated but is not yet worn flat. |
| 4 | | Quadrant area is worn flat (horizontal) but there is no dentine exposure other than a possible pinprick sized "dot." |
| 5 |  | Quadrant is flat, with dentine exposure one-fourth of quadrant or less. (Be careful not to confuse noncarious pits with dentine exposure.) |
| 6 |  | Dentine exposure greater: more than one-fourth of quadrant area is involved, but there is still much enamel present. If the quadrant is visualized as having three "sides" (as in the diagram) the dentine patch is still surrounded on all three "sides" by a ring of enamel. |
| 7 |  | Enamel is found on only two "sides" of the quadrant. |
| 8 |  | Enamel on only one "side" (usually outer rim) but the enamel is thick to medium on this edge. |
| 9 |  | Enamel on only one "side" as in 8, but the enamel is very thin—just a strip. Part of the "edge" may be worn through at one or more places. |
| 10 |  | No enamel on any part of quadrant—dentine exposure complete. Wear is extended below the cervicoenamel junction into the root. |

(From Scott 1979:214, Table 1.)

For individuals less than 20 years of age, the scores are recorded directly from the molars. However, the scores for individuals 20 to 34 years of age are estimated by extending the wear rate developed on the younger individuals and utilizing samples of molars from older individuals. For example, at age 19 the first molar has experienced 15 years of attrition and is assigned a score of 18 (Figure 4). At age 24 the second molar will also have experienced 15 years of wear and is assigned a score of 18. To determine the amount of attrition undergone by the first and third molar at this age, a sample of 120 previously scored Averbuch dentitions were utilized. A subsample including each dentition with a second molar score of 18 was isolated and the mean attrition scores for their first and third molars were used to define first and third molar attrition scores at age 24. This procedure was followed to establish wear for ages 24, 29 and 34.

Due to decreased subsample size with increased age, it became necessary to modify this procedure. Of the 120 individuals scored, those with the greatest degree of attrition were assumed to represent the older individuals (i.e., 50-60 years) from the series. This was further borne out by one individual in the series who expressed the most extreme attrition. This individual possessed a full complement of teeth and well preserved pubic bones. The pubic symphysis was aged at 55.71 years which corresponds to the age suggested by the degree of dental attrition. Thus, the attrition score for this, as well as the other dentitions with extreme wear, is assumed to typify that of individuals 54 (50-60) years of age.

The rate of wear for each of the three teeth is considered to be continuous from age 34 to age 54. Thus the attrition scores for the three molars for the ages 39, 44 and 49 are derived through interpolation.

To age an individual with this technique it is first necessary to score the attrition for each of the three left (or right) mandibular molars and sum their scores. This score is then matched with the scores presented in Figure 4. For example, a score of 65 would characterize the wear of an individual 30 to 34 years of age.

Care must be taken to assure that all twelve molars are present in the dentition that is to be aged. The loss of one or more molars decreases the surface area available for grinding and thus increases the rate of attrition for the remaining molars. Individuals with antemorten tooth loss may be overaged with Figure 4. The presence of dental pathologies (i.e., caries, abcesses, etc.) must also be considered. In a healthy dentition wear may be evenly distributed while unilaterial wear may result from shifting chewing in a pathological condition. Also, with age, wear may tend to concentrate disproportionately on one of the three teeth. Occasionally the second molar may demonstrate a greater attrition than the first, but, even in these cases, the scores of the three teeth combined should mask this variation. The majority of error with this technique is in the upper age categories. For this reason, individuals above 40 years of age are placed in 40-49 and 50+ age categories as the degree of attrition dictates.

Other aging techniques, of varying degrees of reliability, are employed in the absence of the more accurate techniques. Standards developed by McKern (1970) and McKern and Stewart (1957) for the degrees of epiphyseal union of the long bones, iliac crest, ischium, medial clavicle, and vertebral bodies are used to estimate young adult age. Endocranial and ectocranial suture closure (Krogman 1962; McKern and Stewart 1957; Todd and Lyon 1924), though too variable to be very accurate (Singer 1953), is used to ascertain general age. However, closure of the basilar suture is considered reliable in aging young adults between 18 and 21 years. The degree of osteophytic lipping of the vertebral bodies (Stewart 1958) and ossification of costrochondral cartilages (Kerley 1970) are also used as general age indicators.

Dental attrition and pubic symphysis morphology are the main approaches used in aging Averbuch adults. More general techniques are consulted as a means of corroborating the ages derived from these two methods. In addition, these general techniques are used to smooth the dental attrition and, more specifically, the pubic symphsis ages. For example, the use of the mean ages of the McKern and Stewart (1957) system does not age individuals in the 30 to 34 range. Thus individuals aged at 29 years who possess other age indicators suggestive of an older individual are assigned to the 30 to 34 category as are individuals aged at 35 who had age indicators suggestive of a younger individual.

Sex Determination

Accurate sex classification of the Averbuch skeletons is required for all aspects of biological research. Even though an extensive variety of sexing techniques is available, inherent problems make some degree of misclassification inevitable. Weiss (1972, 1973) notes that a review of the published literature indicates a male sexing bias of approximately 12 percent. Weiss ascribes this (1) to the basic tendency of sexing unknown individuals as male and (2) the possibility of differential cultural practices in respect to the burial of males and females. At Averbuch this problem is further complicated by many incomplete and poorly preserved burials. To insure against bias, the sex assignments were cross checked with those of other researchers who had access to the skeletal series and borderline cases were reexamined.

Both nonmetric and certain metric techniques were employed in sexing the Averbuch adults. Stewart (1954) suggests that it may be a waste of effort to apply metric sexing techniques to skeletons that can be readily sexed visually. Visual techniques, due to their expedient nature, are favored in every case where skeletal completeness and preservation allow their use. However, metric techniques are favored in those cases which are borderline by visual sexing or those which are poorly preserved but not to an extent that would prevent measurement. In all cases, the best technique or combination of techniques is used to achieve the most accurate sexual classification possible.

The innominate is generally recognized as the most accurate means of visual sexing. Bass (1971), Brothwell (1965), and Krogman (1962) suggest that pubic length, subpubic angle, sciatic notch, and sacroiliac articulation are important in differentiating sex. However, Phenice (1969) presents three characteristics of the pubic bone (i.e., ventral arc, subpubic concavity, and the medial aspect of the ischiopubic ramus) which correctly sex in excess of 95 percent of the cases. Kelly (1978), in a recent critique, concludes that the Phenice method provides a reliable approach to sex determination. Also, each Averbuch pelvis is examined for alterations from partrition (i.e., partritional pits) in the sacroiliac and pubic areas (Angle 1969a, 1969b; Putschar 1931; Stewart 1957, 1970; Suchey et al. 1979; Ullrich 1975).

The sacrum is also used in sexing. It is usually more curved in males and flatter in females (Bass 1971). Anderson (1962) also notes that in females the first sacral body is equal in width to each ala, while the width of the first sacral body in males exceeds that of each ala.

Bass (1971) defines the major points of sexual dimorphism in craniofacial dimensions. Of these indicators, the bluntness of the upper edge of the eye orbits, shape of the chin, and size of the supraorbital ridges, palate, occipital muscle markings, supramastoid ridge and mastoid process are examined in the Averbuch series. Also, maximum diameters of the humeral (Dwight 1905) and femoral (Pearson 1919) heads are utilized due to their simplicity and accuracy.

Sexual dimorphism, though not greatly pronounced, is shown by several studies to be present in fetal and immature skeletons. Hrdlička (1942) notes minor size and shape differences in fetal scapulae but they are too small to be reliable indicators of sex. However, Reynolds (1945) finds that measurements from pelvic girdle roentgenograms taken during the first postnatal year reflect significant sex differences. Boucher (1955, 1957) examines fetal pelves and observes significant sex difference in the subpubic angle, and the width and depth of the sciatic notch.

Hunt and Gleiser (1955) devise a method for the determination of subadult sex based on the fact that hand bone maturation is more sex dependent than dental maturation. It was proposed that dental age and skeletal age derived by male standards are less divergent if the individual is male and are more divergent if female standards are applied to a male skeleton. Opposite results are obtained when applied to a female skeleton. A test of the method, using radiographs on living children, indicates that correct sex classification is achieved for 73 percent of the two year olds, 76 percent of the five year olds, and 81 percent of those at age eight (Hunt and Gleiser 1955:486).

Other subadult sexing methods demonstrate less success. Bailit and Hunt (1964) devise two sexing methods based on the variable rates of development of mandibular teeth. Unfortunately, only 58 to 70 percent of the children are correctly sexed. Choi and Trotter (1970) subject fetal bones to a multivariate approach. Seventy-two percent accuracy is achieved with a discriminant analysis of bone weight and length.

Weaver (1980) evaluates 153 fetal and infant iliae of known sex using three indices and one nonmetric character. The three indices show no significant sex differences; however, the nonmetric observation proves accurate for 91 percent of the males.

Studies such as these serve to indicate that sex determination of subadult skeletons is possible. Unfortunately, the nature of these techniques is such that they are not easily adapted to an archaeological series. It is for this reason that no attempt is made by the author to sex Averbuch subadults.

In summary, a conscious effort is made to apply the best nonmetric and, to a lesser extent, metric techniques to the problem of adult sex determination. In view of the accuracy of Krogman, Stewart, and Hrdlička (Krogman 1962:112-113), the major weight in deciding sex is based on the (1) pelvis, (2) skull, and (3) long bones in a descending order of importance. Although subadult sexing may be possible, it is neither practical nor reliable for an archaeological series.

## Demographic Methodologies

Three techniques have been employed in the demographic study of skeletal populations: the United Nations Model Life Table approach, the Angel approach, and the Life Table approach. For this study, the Life Table approach is deemed the most appropriate and it is the purpose of this section to discuss the rationale behind its choice.

Bennett (1973a) employs model life tables—devised for determinng the demographic parameters of underdeveloped countries

to a study of the demography of the Point of Pines skeletal series from Arizona. Two assumptions are necessary:

1. The Point of Pines population was stable (i.e., the mortality rate and fertility rate were constant, but Bennett permits the possibility of natural increase).

2. The demographic parameters of the Point of Pines population were similar to those of one of a variety of model UN stable populations.

Bennett (1973a) notes that the major problem with this approach is that the intrinsic rate of increase (r) must be known or accurately approximated. Carrier (1958) recognizes this as a possible source of error and also critizes the comparison of models based on post-1920 populations, that had access to modern health care, to prehistoric populations. It is these two problems that prevent the use of the Model UN Life Table approach in the study of Averbuch demography.

Angel (1947, 1955, 1958, 1968, 1969a, 1969b, 1971) uses age distribution of deaths and the number of offspring produced by each woman (i.e., realized fecundity) to determine birth rate, both female and family fertility, adult longevity and population growth rate. Realized fecundity is estimated by an examination of parturitional pits on the dorsal side of the os pubis. The problems of determining parity from parturitional pits have been presented by Gilbert (1973) and Stewart (1970). Suchey et al. (1979) observe a statistical relationship between the extent of pitting and the number of full term pregnancies. However, they conclude that ". . . number of full term

pregnancies cannot be predicted from the morphology of the dorsal aspect of the os pubis" (Suchey et al. 1979:522). Thus, the problems of determining exact parity from parturitional pits are considered severe enough to prohibit the use of Angel's approach with the Averbuch series.

As previously stated, the life table approach is the most appropriate for this study. Although the Averbuch cemeteries may represent several generations, the series is considered as a single generation or cohort. This can be done only by assuming that the Averbuch skeletal series represents a stationary population model (i.e., equal birth and death rates, growth rate of zero and fixed age-specific mortality rates). It must also be assumed that Averbuch experienced no in or out migration (Acsádi and Nemeskéri 1970:61) since either would influence the values of life expectancy as calculated from the life table.

The life table method is criticized by Angel (1969a:428) on the assumptions:

> . . . that the cemetery represents a single generation cohort, that death rates are even at all ages after infancy and hence directly reflected in cemetery age frequencies, and that the population is virtually stable biologically and socially over the period of cemetery use.

The consideration of a skeletal series as a single cohort is basic to all three demographic approaches. Fortunately, Averbuch seems to have been continuously occupied for a short period of time and probably consists of only a few generations. Concerning Angel's second criticism Mobley (1980:521) notes that it is ". . . difficult to

evaluate. There is no empirical basis for considering variability in death rates after infancy, and uniformity in death rates must be assumed to proceed with the analysis." It can be argued that although an "ideal" stationary population may not have existed at Averbuch, the results obtained from this assumption will not be totally inaccurate (Weiss 1973:10). Weiss (1975), in an examination of the effects of various demographic events on populations examined with an abridged life table, notes that

> . . . given the uncertainties in sampling, aging and sexing of skeletons, demographic reconstruction from burial series is not vitiated by the occurrence of sporadic demographic events or stochastic fluctuations. A large cemetery can indeed be used with some confidence that the general death rates derived from it will represent the prevailing demography of the time of deposit. (Weiss 1975:55)

Acsádi and Nemeskéri (1970:45) note that the importance of stationary population theory in skeletal demographic research

> . . . lies in the fact that, with the exception of certain periods and areas, the rate of growth of human population was very slow even between 1 A.D. and the middle of the 17th century. According to estimates, the number of world population grew during these sixteen centuries from about 210-250 millions to nearly 550 millions, so the annual rate of natural growth may have been only 0.05-0.1 per thousand. Assuming that the first man using implements had appeared about half a million years ago, the size of the primordial population must have changed very little and its rate of growth must have been extremely low. It is obvious that in such circumstances—for lack of other data—the stationary model population is a hypothesis that approximates the one-time historical reality fairly well.

# IV. CONSTRUCTION OF THE LIFE TABLES FOR THE AVERBUCH SERIES

The construction of the life table necessary for this study follows the guidelines set forth by Ascâdi and Nemeskéri (1970) and demonstrated by Owsley (1975). A life table functions to ". . . transform age-at-death data for skeletal samples into such statistics as mortality and life expectancy" (Mobley 1980:520). Eight columns are contained within a life table which provide the basic data and the statistics calculated from this data. These eight columns will now be discussed in reference to the Averbuch series.

1. The age categories (x) are in intervals of five years duration each with the exception of the first two and the fifth. The first age interval is from birth to 1.5 years (1.5 year interval) and the second is from 1.5 years to 5.5 years (4 year interval). The half year age intervals result from the aging technique used for subadults. The fifth age category is from 15.5 years to 20 years (4.5 year interval) and reflects a transition from subadult to adult aging techniques. The last four age categories (i.e., 40-45, 45-50, 50-55, 55-60) are derived from individuals aged broadly into two age groups (i.e., 40-50 and 50-60).
2. The second column (Dx) represents the actual number of individuals dying at each age interval. Sixty-four individuals (actual plus estimated) are excluded from the study due to their fetal age. The estimated number of missing individuals,

those individuals who, due to poor preservation, cannot be accurately sexed, and those individuals who could only be aged in broad categories are proportioned into sex groups and age intervals for each of the three cemeteries. The number placed into the sex and age groups is based on the pattern (percentages) produced by individuals of known age and sex (see Tables 1 and 2, pages 27 and 28). In distributing the "unknown individuals," those which cannot be sexed are distributed first; the adult sex ratio is maintained for unsexed adults (greater than 15.5 years) and subadults (less than 15.5 years) are distributed as 50 percent male and 50 percent female. Those individuals aged in very broad categories (i.e., adult and subadult) are then partitioned into the "knowns" followed by individuals aged in more narrowly defined categories (e.g., newborn to 5.5 years, or 20 to 30 years). Those estimated as missing are the last to be partitioned into the categories. Such partitioning explains the appearance of fractions in the Dx column. Aging techniques necessitate the assigning of individuals over 40 years of age into 10 year intervals (i.e., 40-50 and 50-60). The number of individuals assigned to the last four age intervals in the life table is ascertained by halfing the number aged as 40 to 50 and 50 to 60. This method of proportioning individuals of unknown sex and age in the Dx column is used at the cemetery level as well as the total site level.

3. The dx column represents the percentage of deaths at each age category and is calculated as follows:

$$dx = \frac{\frac{Dx}{w}}{\sum\limits_{x=0-1.5} Dx}$$

w = maximum age attainable (i.e., 55-60)
x = the initial age category (i.e., 0-1.5)

The dx value expresses the mortality curve of the series.

4. The survivorship (lx) of the group is expressed in the fourth column and represents the percentage of individuals surviving to enter the designated age category. For example, 100 percent is assigned as the first lx value and the remaining lx values are calculated by subtracting the dx value from the lx value:

$$l_{(1.5-5.5)} = l_{(0-1.5)} - d_{(0-1.5)}$$

5. The probability of death (qx) at each age category is essential in the examination of age-specific mortality. The qx value reflects the probability of an individual in one age category dying before reaching the next, and is calculated as follows:

$$qx = \frac{dx}{lx} \quad \text{e.g., } q_{0-1.5} = \frac{d_{0-1.5}}{l_{0-1.5}}$$

6. The number of years lived in each age category (Lx) is presented in column six. The majority of Lx values for the study of the total site, and each cemetery, independently, is calculated as follows:

$$Lx = \frac{5(lx+lx+5)}{2}$$

$$\text{e.g., } Lx_{5.5-10.5} = \frac{5(l_{5.5-10.5} + l_{10.5-15.5})}{2}$$

$$\text{e.g., } Lx_{55-60} = \frac{5(l_{55-60})}{2}$$

In these calculations it is assumed that the deaths are distributed evenly throughout each five year age category; however, it is known that deaths are more frequency during the first few months of life. Acsádi and Nemeskéri (1970:54) control for this increased frequency and the uneven time distributions as follows:

$$L_{0-1} = 0.2\ l_{0-1} + 0.8\ l_{1-4}$$

$$L_{1-4} = 0.34\ l_{0-1} + 1.184\ l_{1-4} + 2.782\ l_{5-9}$$

Although these intervals are for 0 to 1 years and 1 to 4 years which are shorter than the Averbuch intervals (0 to 1.5 years and 1.5 to 5.5 years, respectively), the formulas are used in the study of the <u>total site</u> (cemeteries and structure dead). The use of these formulae should not greatly alter the results. In the examination of intra cemetery demographies, the individuals buried in structures are excluded. This results in an underenumeration of individuals mainly in the 0 to 1.5 year age interval. The Lx value for this interval is calculated as follows:

$$L_{0-1.5} = \frac{1.5(l_{0-1.5} + l_{1.5-5.5})}{2}$$

Similarly, the Lx value for the 15.5 to 20 age interval for each cemetery and the total site is calculated as follows:

$$L_{15.5-20} = \frac{4.5(l_{15.5-20} + l_{20-25})}{2}$$

The Lx value for the 55 to 60 age interval is calculated as follows:

$$L_{55-60} = \frac{5(l_{55-60})}{2}$$

7. The total number of years lived by survivors at each age interval (Tx) is determined by summing all Lx values:

$$T_{0-1.5} = \sum^{w}_{x = 0-1.5} Lx$$

The remaining age intervals are calculated by subtracting Lx from Tx as in the following examples:

$$T_{1.5-5.5} = T_{0-1.5} - L_{0-1.5}$$

$$T_{5.5-10.5} = T_{1.5-5.5} - L_{1.5-5.5}$$

$$T_{55-60} = L_{55-60}$$

8. The eighth and final column is life expectancy ($e°x$) and represents the average number of years remaining to be lived by individuals in any given age category. Life expectance

is necessary in the estimation of population size and is calculated as follows:

$$e^{\circ}x = \frac{Tx}{lx}$$

# CHAPTER IV

## THE AVERBUCH DEMOGRAPHIC ANALYSIS

### I. OBJECTIVES AND ASSUMPTIONS OF THE AVERBUCH DEMOGRAPHIC STUDY

The demographic analysis of the Averbuch series serves two purposes. First, this study reconstructs the vital statistics for the total Averbuch series, including those estimated as missing (see Chapter III, Section III, subsection 1, page 25). All individuals, with the exception of fetal skeletons, are included; skeletons from the three cemeteries and the structures are combined and treated as a single cohort. The results will be compared to that of other skeletal series, and Averbuch population size will be calculated.

For this study it must be assumed that the site was continuously occupied for a relatively brief period by a single homogeneous group. Multivariate statistical analyses of Averbuch craniometric variables, completed by the author for a later publication, attests to the homogeneity of the cemeteries. Archaeologically, a thin midden, no evidence of palisade wall rebuilding and superposition of structures provide evidence of the longevity of the village. For a more detailed discussion of the length of time the site was occupied consult Chapter III, Section III, subsection 3, page 30).

Second, this study reconstructs the male and female vital statistics of each of the three cemeteries separately. The differences between the sexes for each cemetery are examined, and the intercemetery

relationship of each sex is explored. Since Cemetery 3 is thought to predate Cemetery 1, such an approach may reveal a great deal about the nature of stress at Averbuch. It is recognized that, due to the relatively short occupation of the site, any significant changes in the demography between the cemeteries would certainly suggest sociocultural or environmental changes of great magnitude.

In order for the demographies of the cemeteries to be comparable, it must first be assumed that the three cemeteries do not represent distinct social units (e.g., clans). Archaeologically, there is no cultural evidence that markedly differentiates the three cemeteries as to their functions. Secondly, it must be assumed that the cemeteries represent distinct, or relatively distinct, temporal units. Theoretically, it is assumed that Cemetery 1, 2, and 3 do not overlap in time. Realistically, Cemetery 3 and 1 may have coexisted for a time, hopefully brief, during the transition from 3 to 1. The temporal situation of Cemetery 2, though it is thought to have coexisted with Cemetery 1, is more ambiguous. For a more detailed discussion of the archaeological relationship of these cemeteries, refer to Chapter III, Section III, subsection 2, page 29. Third, the cultural practice of burying infants in house floors results in a deficiency of this age group in the cemeteries. However, some social or cultural circumstances permitted the burial of certain infants in the cemetery. For the cemeteries to be comparable, it must be assumed that the frequency of infants who had access to each cemetery remained constant through time. For the cemetery comparisons, only those burials within the confines of each

of the three cemeteries are used; those burials associated with structures are excluded.

## II. THE VITAL STATISTICS OF THE AVERBUCH SITE

The purpose of this section is to reconstruct the vital statistics of the total Averbuch skeletal population. The only burials excluded from this study are the fetal remains. Life tables are constructed and presented in Tables 4, 5 and 6. Averbuch total vital statistics and the vital statistics of males and females will now be viewed in reference to mortality, survivorship, probabilities of death and life expectancy. In addition, the life expectancy at birth and the crude mortality rate are examined and compared to that of other sites. The population size is also estimated.

Mortality curves (dx) for the Averbuch population are presented in Figure 5. The combined male and female curve reveals an elevated frequency of deaths for the first age interval (total $dx_{0-1.5}$ = 22.43 percent) which decreases throughout subadult life. The most healthy period of Averbuch life is in the 10.5 to 15.5 age interval; at this age combined sex mortality is 2.35 percent. Mortality increases for both sexes during young adult life. Combined sex mortality for age 15.5 to 20 is 7.30 percent. Mortality continues to increase until the 20 to 25 age interval at which point maximum adult mortality is reached (total $dx_{20-25}$ = 14.35 percent). Mortality declines throughout the remaining age intervals.

Adult female mortality ($dx_{15.5-20}$ = 8.84 percent) is higher than male mortality ($dx_{15.5-20}$ = 5.86 percent) during the 15.5 to 20 age

TABLE 4

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF ALL INDIVIDUALS FROM AVERBUCH

| x | Dx | dx | lx | qx | Lx | Tx | $e^{o}x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 276.22 | 22.43 | 100.00 | .224 | 82.06 | 1661.22 | 16.61 |
| 1.5- 5.5 | 238.51 | 19.36 | 77.57 | .250 | 287.78 | 1579.16 | 20.36 |
| 5.5-10.5 | 61.30 | 4.98 | 58.21 | .086 | 278.60 | 1291.38 | 22.18 |
| 10.5-15.5 | 28.93 | 2.35 | 53.23 | .044 | 260.28 | 1012.78 | 19.03 |
| 15.5-20 | 89.92 | 7.30 | 50.88 | .143 | 212.54 | 752.50 | 14.79 |
| 20 -25 | 176.75 | 14.35 | 43.58 | .329 | 182.03 | 539.96 | 12.39 |
| 25 -30 | 109.10 | 8.86 | 29.23 | .303 | 124.00 | 357.93 | 12.25 |
| 30 -35 | 76.14 | 6.18 | 20.37 | .303 | 86.40 | 233.93 | 11.48 |
| 35 -40 | 55.90 | 4.54 | 14.19 | .320 | 59.60 | 147.53 | 10.40 |
| 40 -45 | 35.01 | 2.84 | 9.65 | .294 | 41.15 | 87.93 | 9.11 |
| 45 -50 | 35.01 | 2.84 | 6.81 | .417 | 26.95 | 46.78 | 6.87 |
| 50 -55 | 24.47 | 1.99 | 3.97 | .501 | 14.88 | 19.83 | 4.99 |
| 55 -60 | 24.47 | 1.99 | 1.98 | 1.005 | 4.95 | 4.95 | 2.50 |

TABLE 5

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH MALES

| x | Dx | dx | lx | qx | Lx | Tx | $e^ox$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 138.11 | 21.74 | 100.00 | .217 | 82.61 | 1743.73 | 17.44 |
| 1.5- 5.5 | 119.25 | 18.77 | 78.26 | .240 | 292.16 | 1661.12 | 21.23 |
| 5.5-10.5 | 30.65 | 4.82 | 59.49 | .081 | 285.40 | 1368.96 | 23.01 |
| 10.5-15.5 | 14.47 | 2.28 | 54.67 | .042 | 267.65 | 1083.56 | 19.82 |
| 15.5-20 | 37.23 | 5.86 | 52.39 | .112 | 222.57 | 815.91 | 15.57 |
| 20 -25 | 95.76 | 15.07 | 46.53 | .324 | 194.98 | 593.34 | 12.75 |
| 25 -30 | 56.23 | 8.85 | 31.46 | .281 | 135.18 | 398.36 | 12.66 |
| 30 -35 | 43.32 | 6.82 | 22.61 | .302 | 96.00 | 263.18 | 11.64 |
| 35 -40 | 30.99 | 4.88 | 15.79 | .309 | 66.75 | 167.18 | 10.59 |
| 40 -45 | 20.07 | 3.16 | 10.91 | .290 | 46.65 | 100.43 | 9.21 |
| 45 -50 | 20.07 | 3.16 | 7.75 | .408 | 30.85 | 53.78 | 6.94 |
| 50 -55 | 14.59 | 2.30 | 4.59 | .501 | 17.20 | 22.93 | 5.00 |
| 55 -60 | 14.59 | 2.30 | 2.29 | 1.004 | 5.73 | 5.73 | 2.50 |

TABLE 6

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH FEMALES

| x | Dx | dx | lx | qx | Lx | Tx | $e^{o}x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 138.11 | 23.16 | 100.00 | .232 | 81.47 | 1462.98 | 14.63 |
| 1.5- 5.5 | 119.25 | 19.99 | 76.84 | .260 | 283.14 | 1381.51 | 17.98 |
| 5.5-10.5 | 30.65 | 5.14 | 56.85 | .090 | 271.40 | 1098.37 | 19.32 |
| 10.5-15.5 | 14.47 | 2.43 | 51.71 | .047 | 252.48 | 826.97 | 15.99 |
| 15.5-20 | 52.70 | 8.84 | 49.28 | .179 | 90.99 | 574.49 | 11.66 |
| 20 -25 | 80.99 | 13.58 | 40.44 | .336 | 168.25 | 483.50 | 11.96 |
| 25 -30 | 52.87 | 8.86 | 26.86 | .330 | 112.15 | 315.25 | 11.74 |
| 30 -35 | 32.82 | 5.50 | 18.00 | .306 | 76.25 | 203.10 | 11.28 |
| 35 -40 | 24.91 | 4.18 | 12.50 | .334 | 52.05 | 126.85 | 10.15 |
| 40 -45 | 14.94 | 2.50 | 8.32 | .300 | 35.35 | 74.80 | 8.99 |
| 45 -50 | 14.94 | 2.50 | 5.82 | .430 | 22.85 | 39.45 | 6.78 |
| 50 -55 | 9.88 | 1.66 | 3.32 | .500 | 12.45 | 16.60 | 5.00 |
| 55 -60 | 9.88 | 1.66 | 1.66 | 1.000 | 4.15 | 4.15 | 2.50 |

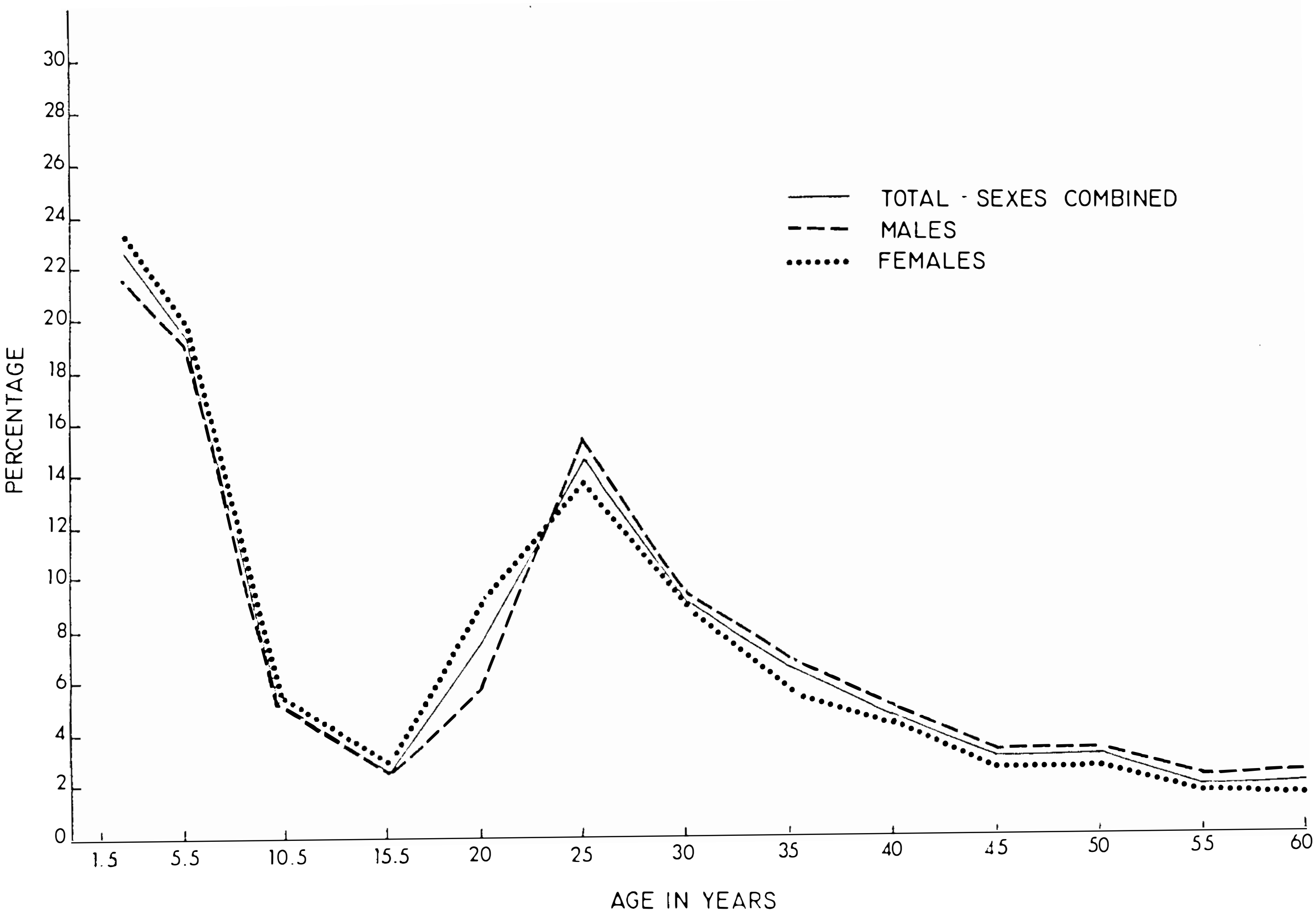



Figure 5. Age distribution of male and female mortality in the Averbuch population.

interval; but, though both increase, the male mortality ($dx_{20-25}$ = 15.07 percent) exceeds that of the female ($dx_{20-25}$ = 13.58 percent) by 20 to 25 years of age. After this age the mortality of both sexes decreases; however, male dx values basically are higher than those of the female for the remainder of adult life. The age distributions for Averbuch males and females do not differ statistically.

The percentage of the Averbuch population surviving to reach each age interval (lx) is plotted in Figure 6. The slope of the curve descends abruptly from birth to 10.5. By the 10.5 to 15.5 year category, only 53.23 percent of the original cohort has survived. At age 20 to 25, 43.58 percent of all individuals born to the Averbuch population survive; 9.65 percent remain alive at age 40 and 1.98 percent survive to age 55.

The male survivorship curve exceeds that of the female at all age intervals from birth to 60 years of age. For example, at age 20 to 25, 46.53 percent of the males have survived and only 40.44 percent of the females are alive. At age 35 to 40, 15.79 percent of the males and 12.50 percent of the females remain. Slightly more males ($lx_{55-60}$ = 2.29 percent) survive to the last age interval than females ($lx_{55-60}$ = 1.66 percent).

Figure 7 plots the probabilities of death (qx) for the Averbuch series. The probability of dying is high from birth to 5.5 years of age and at the terminal end of the age spectrum. Since perinatal life is normally more highly stressed than that of any other subadult age category, the fact that the birth to 1.5 qx values are lower than

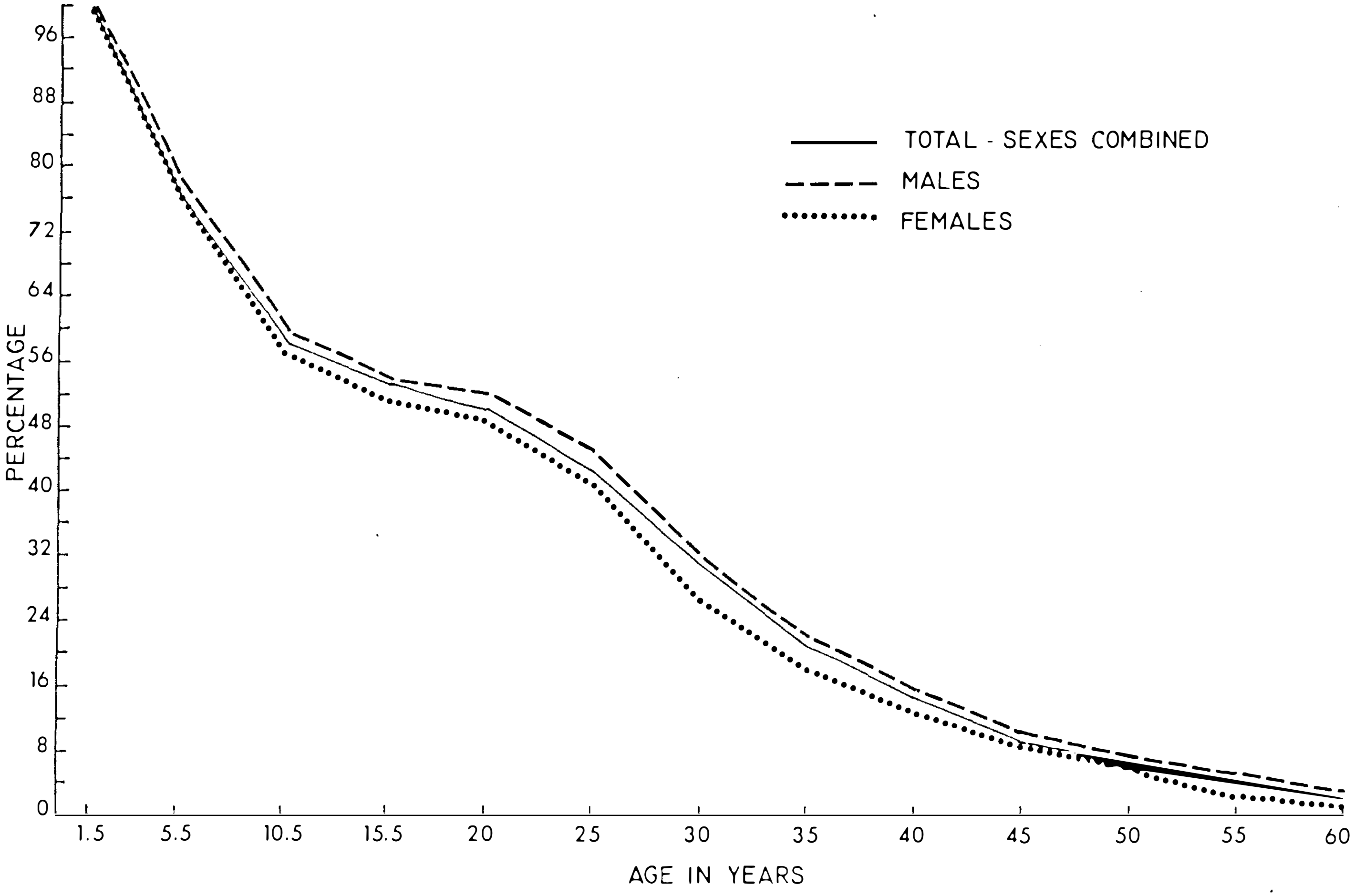



Figure 6. Survivorship of the Averbuch population.

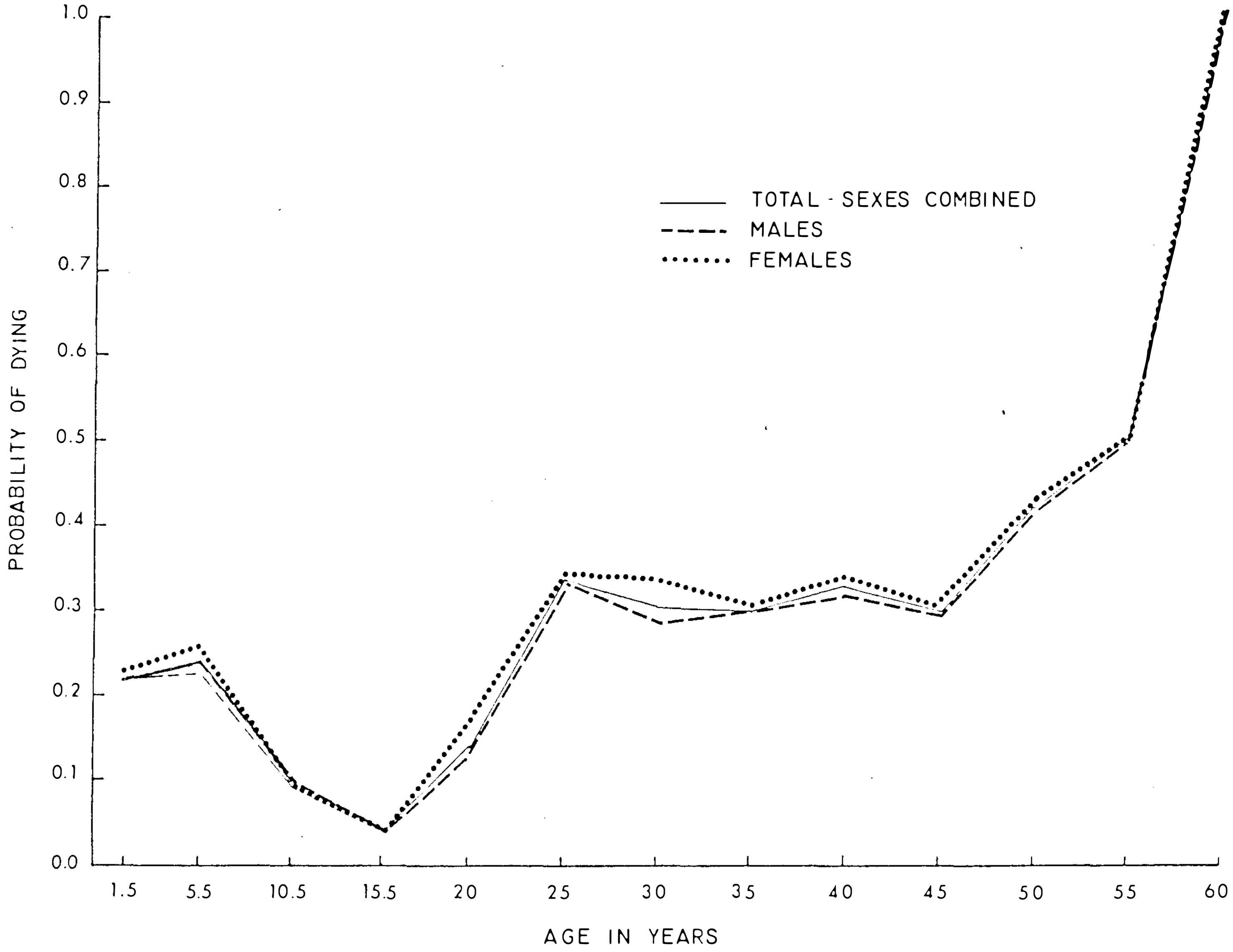



Figure 7. Probabilities of death in the Averbuch population.

that of the 1.5 to 5.5 age category is highly suspect. The lowest probability of death and thus healthiest segment of the population was in the 10.5 to 15.5 age interval (total $qx_{10.5-15.5} = .044$). After this age the probability of death increases until age 20 to 25 and remains relatively constant until age 40 to 45. The qx values increase after this age interval.

The probability of dying is greater for females than for males for all age intervals from birth to 50 years of age. After age 50, male qx values are slightly greater than those of the female. The greatest sex differences in qx values occur at the 15.5 to 20 age interval (male $qx_{15.5-20.0} = .112$; female $qx_{15.5-20} = .179$), the 25 to 30 age interval (male $qx_{25-30} = .281$; female $qx_{25-30} = .330$), and the 35 to 40 age interval (male $qx_{35-40} = .309$; female $qx_{35-40} = .334$).

Life expectancy curves ($e^o$) are shown in Figure 8. At birth, male life expectancy (male $e^o_{0-1.5} = 17.44$) is 2.81 years higher than female life expectancy (female $e^o_{0-1.5} = 14.63$). Life expectancy increases considerable for those surviving the early highly stressed years of life. At age 5.5 to 10.5, the male $e^o$ value is 23.01 years and female is 19.32 years. Male life expectancy exceeds that of the female by a minimum of 3 years at every age interval between birth and 15.5 to 20 years of age. After this the male/female differences are minimal throughout all remaining age intervals.

In general, the results of the life table approach suggests a number of key points concerning stress at the Averbuch site. Although infant mortality is high and represents one of the more stressed

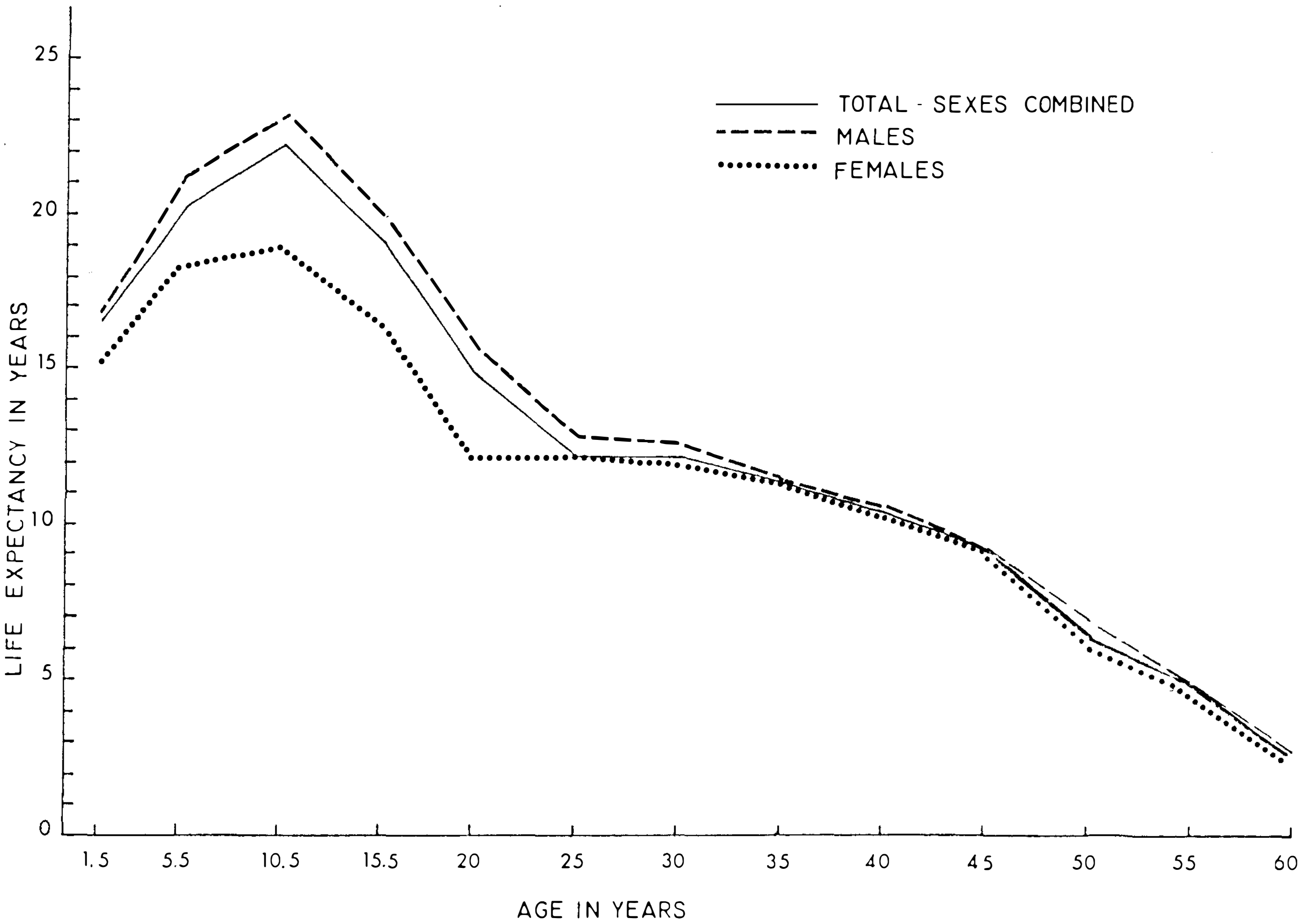



Figure 8. Life expectancy of the Averbuch population.

periods, the relationship of the qx values for the first and second age intervals are problematical. The qx value represents the chance of individuals in one age category dying before reaching the next age interval. The qx value for the birth to 1.5 age interval is less than that of the 1.5 to 5.5 interval. This may represent reality. If so, Averbuch individuals are more highly stressed during the second interval than the first. It more likely indicates an under enumeration of infant burials. An under enumeration could most likely have occurred in two ways:

1. The geographic size of the village (i.e., the number of structures) could have been underestimated.
2. The assumption that all of the infants not interred in one of the cemeteries were interred in the structures may not be entirely valid. Some infant dead may have been placed outside the village area or in areas of the site missed during testing.

The second of these is more probable. Mortality is high throughout childhood; however, the adolescent period (10.5 to 15.5 years) represents the least stressed of all age categories. During the young adult years (15.5 to 20 years), mortality increases for both sexes but is more extreme for the females. During the 20 to 25 year interval the males are more stressed than the females. These periods of stress suggest problems experienced in childbearing for the females and subsistence and/or warfare activity for the males. Overall, male mortality during the latter years is higher than female mortality. However, more males

survive to reach adult life than do females. The probability of dying is higher for females from birth to 50 years of age than for males. Life expectancy at each age interval from birth to the 45 to 50 year interval is higher for males. Of the total 1,232 individuals, only 4.59 percent of the males (15 individuals) and 3.32 percent of the females (10 individuals) reached the 50 to 55 year interval.

## Life Expectancy at Birth

Population longevity and health status as expressed by life expectancy at birth provides a basis for comparing the stress at Averbuch with that of other sites. Table 7 is modified from Owsley (1975). The sites recorded in this table are listed according to increasing life expectancy at birth. As can be seen from Table 7, the Averbuch site, with the exception of the Larson site, has the lowest life expectancy at birth of all groups illustrated. Life expectancy is lower for Averbuch, which is relatively late temporally, than for many of the earlier sites. It is known that the Larson site was exposed to stress not only through European introduced disease but also through intense warfare. As noted earlier, the Averbuch series seems to be deficient in the the number of infant dead. Thus, Averbuch life expectancy at birth represents a maximum expectancy. If the number of infant dead is increased, the Averbuch life expectancy at birth will probably be as low or lower than that of the Larson site. It may be concluded that the Averbuch site was exposed to much stress, as much as or more than any of the other sites illustrated.

TABLE 7

LIFE EXPECTANCY AT BIRTH IN SEVERAL WORLD POPULATIONS

| Populations | Dates | Life Expectancy (Years) |
|---|---|---|
| Larson, South Dakota | A.D. 1750-1781 | 13.7 |
| Averbuch (females), Tennessee | A.D. 1400 | 14.6 |
| Averbuch (males), Tennessee | A.D. 1400 | 17.4 |
| Indian Knoll, Kentucky | 3000 B.C. | 18.6 |
| Nubia, Egypt | A.D. 1050-1600 | 19.2 |
| Nanjemoy, Ossuary I | A.D. 1500-1600 | 20.9 |
| Nanjemoy, Ossuary II | A.D. 1500-1600 | 22.9 |
| Ancient Greeks | 670 B.C.-A.D. 600 | 23.0 |
| Texas Indians | A.D. 850-1700 | 30.5 |
| European Ruling Families | A.D. 1480-1579 | 33.7 |
| U.S. Caucasian | A.D. 1800 | 30.0-35.0 |
| U.S. Negro | A.D. 1900 | 33.8 |
| English | A.D. 1000-1100 | 35.3 |
| India (females) | A.D. 1951-1960 | 40.6 |
| India (males) | A.D. 1951-1960 | 41.9 |
| Pecos Peublo | A.D. 800-1700 | 42.9 |
| England and Wales (males) | A.D. 1965-1967 | 68.7 |
| England and Wales (females) | A.D. 1965-1967 | 74.9 |

Modified from Owsley (1975:84)

<u>Crude Mortality Rate</u>

The total number of individuals dying per 1000 per year is expressed as the crude mortality rate (m) and is calculated by Acsádi and Nemeskéri (1970:44, 67) as follows:

$$m = \frac{1}{e^{o}_{0-1.5}}$$

As can be seen, the crude mortality rate of a stationary population can be calculated from the life table. According to Ubelaker (1974:65) the crude mortality rate

> . . . is a direct reflection of overall life expectancy and can present evidence for population decline, equilibrium, or expansion when considered in relation to the birth rate.

The Averbuch crude mortality rate is 60.2 and, when compared to that of other skeletal series (Table 8), is quite high. However, this figure is considered to represent a minimum crude mortality rate. An increase in the number of infant deaths would decrease the life expectancy at birth and thus increase the crude mortality rate. The actual Averbuch rate is probably higher than that presented in Table 8.

The crude birth rate is the number born per 1000 total population per year. De Jong (1972) notes that many contemporary nonwesternized groups throughout the world possess a crude birth rate of 40 to 50 per 1000.

The rate of natural growth for the Averbuch population may be calculated from the interrelationship between the birth and death rates. According to Acsádi and Nemeskéri (1970:68), the rate of natural growth may be calculated as follows:

TABLE 8

CRUDE MORTALITY RATES FROM NORTH AMERICAN
SKELETAL SERIES

| Site | Location | Mortality Rate |
|---|---|---|
| Nanjemoy, Ossuary II | Maryland | 44 |
| Nanjemoy, Ossuary I | Maryland | 48 |
| Sully | South Dakota | 54 |
| Indian Knoll | Kentucky | 59 |
| Averbuch | Tennessee | 60 |
| Leavenworth | South Dakota | 63 |
| Larson | South Dakota | 73 |

$$e = n - m$$

e = the rate of growth per 1000 per annum

n = crude birth rate

m = crude mortality rate

The crude mortality rate for Averbuch may be calculated directly from the life table as previously described. However, the crude birth rate is assumed to approximate the 40 to 50 per 1000 range delimited by De Jong (1972) and is used to calculate the minimum rate of natural growth for the Averbuch site (Table 9).

TABLE 9

AVERBUCH RATE OF NATURAL GROWTH

| Crude Birth Rate Range per 1000 (n) | Averbuch Crude Mortality Rate (m) | Growth Rate (e) |
|---|---|---|
| 40 | 60 | -20 |
| 50 | 60 | -10 |

The minimum Averbuch rate of natural growth ranges from -10 to -20 per 1000. At Averbuch, mortality exceeded fertility and the population size decreased at a rate of 1 to 2 percent per annum. Once again, if the original number of dead from Averbuch suffered a deficiency in the recovery of infants, then these figures must be viewed as a minimum.

Averbuch Population Size

As demonstrated above, the Averbuch population suffered a decrease during the estimated 15 to 25 years of its existence. Although the

population size was not constant, it is the purpose of this section to estimate an average population size for the time the site existed.

Three variables are necessary to calculate population size from skeletal data: crude mortality rate, total number of individuals buried at the site, and number of years the site was occupied. Ubelaker (1974:66) provides the following formula for its calculation:

$$P = \frac{1000\ N}{m\ T}$$

P = population size

N = total number of burials

T = time interval represented by the skeletal series

m = crude death rate

The total number of individuals actually retrieved from the Averbuch site is 887; however, that portion of the cemetery and village dead that could not be obtained is estimated to number 409 individuals. Refer to Chapter III, Section III, page 24, for a thorough discussion of how the number of missing individuals is estimated. The total or corrected number of 1,296 is obtained, of which 64 are considered to be fetal. The fetal dead are excluded from both the life table construction and the calculation of population size to produce a total of 1,232 individuals.

The length of time the Averbuch site was occupied is estimated to be 15 to 25 years. For a discussion of how this length of time was estimated, refer to Chapter III, Section III, page 24. The length of time attributed to the Averbuch occupation represents a reasonable estimate and nothing more.

The crude mortality rate for the Averbuch series is determined directly from the life table and is used to calculate the results presented in Table 10.

TABLE 10

CALCULATION OF AVERBUCH POPULATION SIZE USING TWO ESTIMATES FOR LENGTH OF OCCUPATION

| Total Number of Dead | Crude Mortality Rate | Years of Occupation | Population Size |
|---|---|---|---|
| 1,232 | 60 | 15 | 1,369 |
| 1,232 | 60 | 25 | 821 |

The Averbuch population size ranged from 821 to 1,369 individuals. An increase in the number of infants would increase the crude mortality rate as well as the population size. For example, if the total number of dead are increased to 1,500 and the crude mortality rate to 65, the population size would range from 923 (25 years) to 1,538 (15 years) individuals.

## Summary and Conclusions

The Averbuch site represents a 15th century Mississippian Period village located on the outer portion of the Nashville Basin. The site was occupied for a relatively brief time, probably not exceeding 25 years in duration. The population size was probably between 800 and 1,400 individuals. A great deal of stress was experienced throughout the site's existence. Mortality at Averbuch exceeded fertility and the population suffered a decrease of 1 to 2 percent per annum. Due to this population decline, both the upper and lower estimates of population size may have actually been observed through time.

The Averbuch crude mortality rate of 60 was among the more severe when compared to that published from other skeletal series. A life expectancy at birth of 14.6 years for females and 17.4 years for males is among the lowest of any site examined. Overall, the females at Averbuch appear to have been more severely stressed than the males. Stress was greatest during the very early years of life with the adolescent years representing the least stressed period. Adult stress for both sexes was most intense during the early part of adult life (i.e., from 15.5 to 30 years of age). Female mortality exceeds male mortality during the 15.5 to 20 year interval while male mortality is greater than female for the 20 to 25 year interval. Increased mortality during this time period coincides with the childbearing period for the females and the period of peak subsistence and warfare activities for the males. Male and female chi-square values for age distributions show no statistically significant difference.

## III. THE VITAL STATISTICS FOR EACH AVERBUCH CEMETERY

The males and females from each of the three Averbuch cemeteries are now examined via the life table approach. Each of the three cemeteries will be described on the basis of mortality, survivorship, probabilities of death and life expectancy.

Cemetery 1 (Tables 11 and 12)

The mortality curve (dx) for both males and females from Cemetery 1 is presented in Figure 9. The curve begins very low with only 6.98

TABLE 11

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH MALES FROM CEMETERY 1

| x | Dx | dx | lx | qx | Lx | Tx | e°x |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 21.31 | 6.98 | 100.00 | .070 | 144.00 | 1904.65 | 19.05 |
| 1.5- 5.5 | 62.72 | 20.53 | 93.02 | .221 | 165.51 | 1760.65 | 18.93 |
| 5.5-10.5 | 18.29 | 5.99 | 72.49 | .083 | 347.48 | 1595.14 | 22.00 |
| 10.5-15.5 | 9.69 | 3.17 | 66.50 | .048 | 324.58 | 1247.66 | 18.76 |
| 15.5-20 | 25.07 | 8.21 | 63.33 | .130 | 266.51 | 923.08 | 14.58 |
| 20 -25 | 59.56 | 19.50 | 55.12 | .354 | 226.85 | 656.57 | 11.91 |
| 25 -30 | 36.52 | 11.95 | 35.62 | .335 | 148.23 | 429.72 | 12.06 |
| 30 -35 | 19.27 | 6.31 | 23.67 | .267 | 102.58 | 281.49 | 11.89 |
| 35 -40 | 16.52 | 5.41 | 17.36 | .312 | 73.28 | 178.91 | 10.31 |
| 40 -45 | 11.24 | 3.68 | 11.95 | .308 | 50.55 | 105.63 | 8.84 |
| 45 -50 | 11.24 | 3.68 | 8.27 | .445 | 32.15 | 55.08 | 6.66 |
| 50 -55 | 7.03 | 2.30 | 4.59 | .501 | 17.20 | 22.93 | 5.00 |
| 55 -60 | 7.03 | 2.30 | 2.29 | 1.004 | 5.73 | 5.73 | 2.50 |

TABLE 12

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH FEMALES FROM CEMETERY 1

| x | Dx | dx | lx | qx | Lx | Tx | $e^o x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 21.31 | 7.36 | 100.00 | .074 | 144.48 | 2019.75 | 20.20 |
| 1.5- 5.5 | 62.72 | 21.66 | 92.64 | .234 | 327.24 | 1875.27 | 20.24 |
| 5.5-10.5 | 18.29 | 6.32 | 70.98 | .089 | 339.10 | 1548.03 | 21.81 |
| 10.5-15.5 | 9.69 | 3.35 | 64.66 | .052 | 314.93 | 1208.93 | 18.70 |
| 15.5-20 | 39.04 | 13.48 | 61.31 | .220 | 245.57 | 894.00 | 14.58 |
| 20 -25 | 37.98 | 13.12 | 47.83 | .274 | 206.35 | 648.43 | 13.56 |
| 25 -30 | 28.25 | 9.76 | 34.71 | .281 | 149.15 | 442.08 | 12.74 |
| 30 -35 | 19.39 | 6.70 | 24.95 | .269 | 108.00 | 292.93 | 11.74 |
| 35 -40 | 18.01 | 6.22 | 18.25 | .341 | 75.70 | 184.93 | 10.13 |
| 40 -45 | 10.30 | 3.56 | 12.03 | .296 | 51.25 | 109.23 | 9.08 |
| 45 -50 | 10.30 | 3.56 | 8.47 | .420 | 33.45 | 57.98 | 6.85 |
| 50 -55 | 7.12 | 2.46 | 4.91 | .501 | 18.40 | 24.53 | 5.00 |
| 55 -60 | 7.12 | 2.46 | 2.45 | 1.004 | 6.13 | 6.13 | 2.50 |

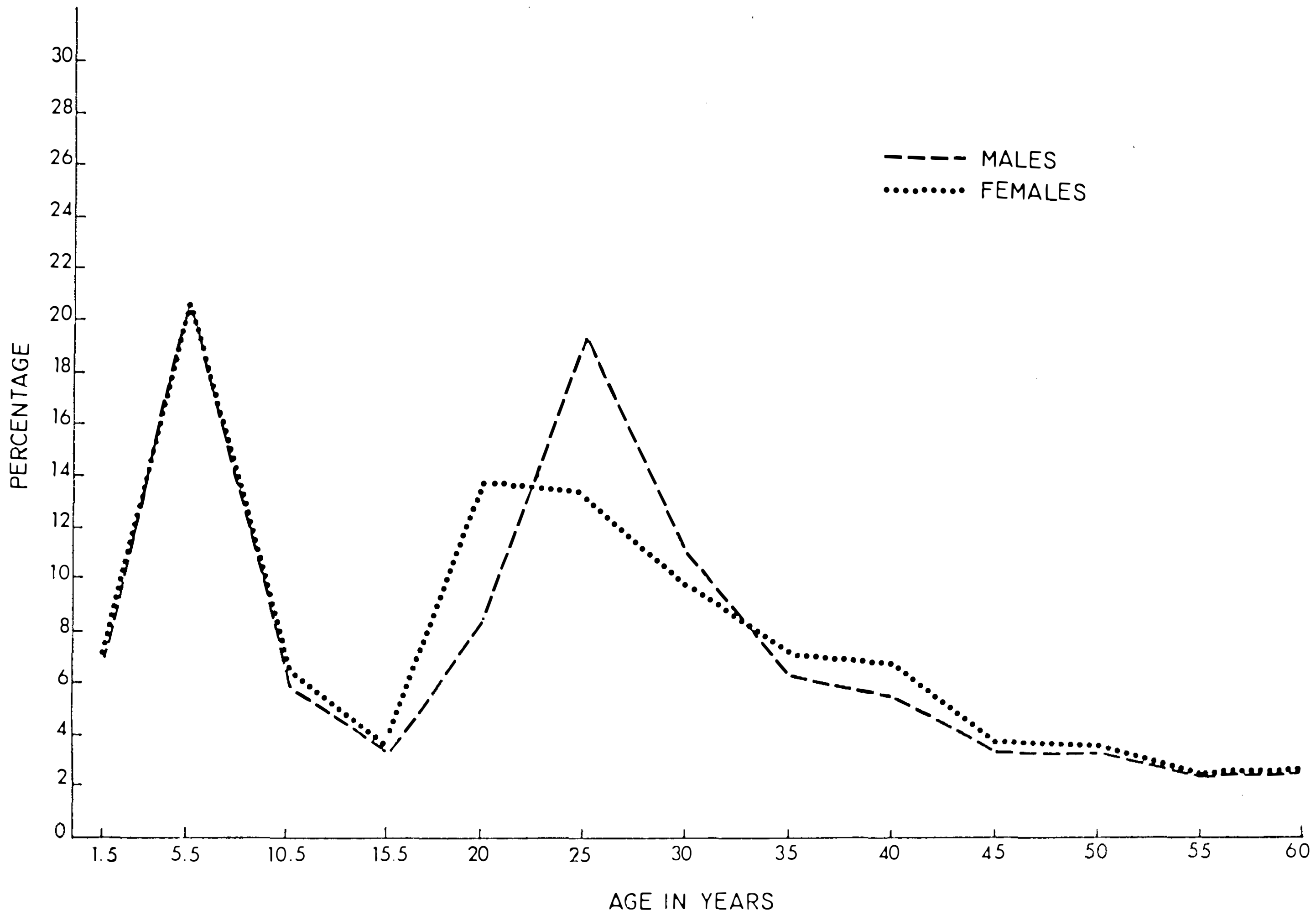



Figure 9. Age distribution of male and female mortality in Cemetery 1 at Averbuch.

percent of the males and 7.36 percent of the females dying by age 1.5 and clearly reflects the cultural practice of the burial of infants and newborns (usually individuals less than 3.5 years of age) outside the cemetery area. The majority of subadult deaths occur at 1.5 to 5.5 years of age (male $dx_{1.5-5.5}$ = 20.53 percent; female $dx_{1.5-5.5}$ = 21.66 percent). The curve decreases sharply with the most healthy period being between the ages of 10.5 and 15.5 years with only 3.17 percent of the males and 3.35 percent of the females assigned to this age category. Of the young adults, the female curve increases until it peaks at age 20 (female $dx_{15.5-20}$ = 13.48 percent) and drops slightly by age 25 (female $dx_{20-25}$ = 13.12 percent). The male mortality curve is less abrupt in its increase. However, a far greater number of males die during the early part of their adult life than do the females. The male curve is very high with 19.50 percent dying at age 20 to 25. After age 35 male and female mortality reflects little difference. The mortality curve gradually slopes downward in later adult years with only 16.76 percent of adult deaths occurring after age 45. The age distributions for Cemetery 1 males and females do not differ statistically.

The survivorship curve (i.e., the percentage surviving to each age interval or lx) is plotted in Figure 10. Male and female curves differ little throughout, with a slightly greater number of young adult males surviving to reach each age category than females. By age 20 to 25, 55.12 percent of the males have survived and 47.83 percent of the females. After age 30 to 35 this trend reverses but only slightly. At age 40 to 45, 11.95 percent of the males and 12.03 percent of the females from

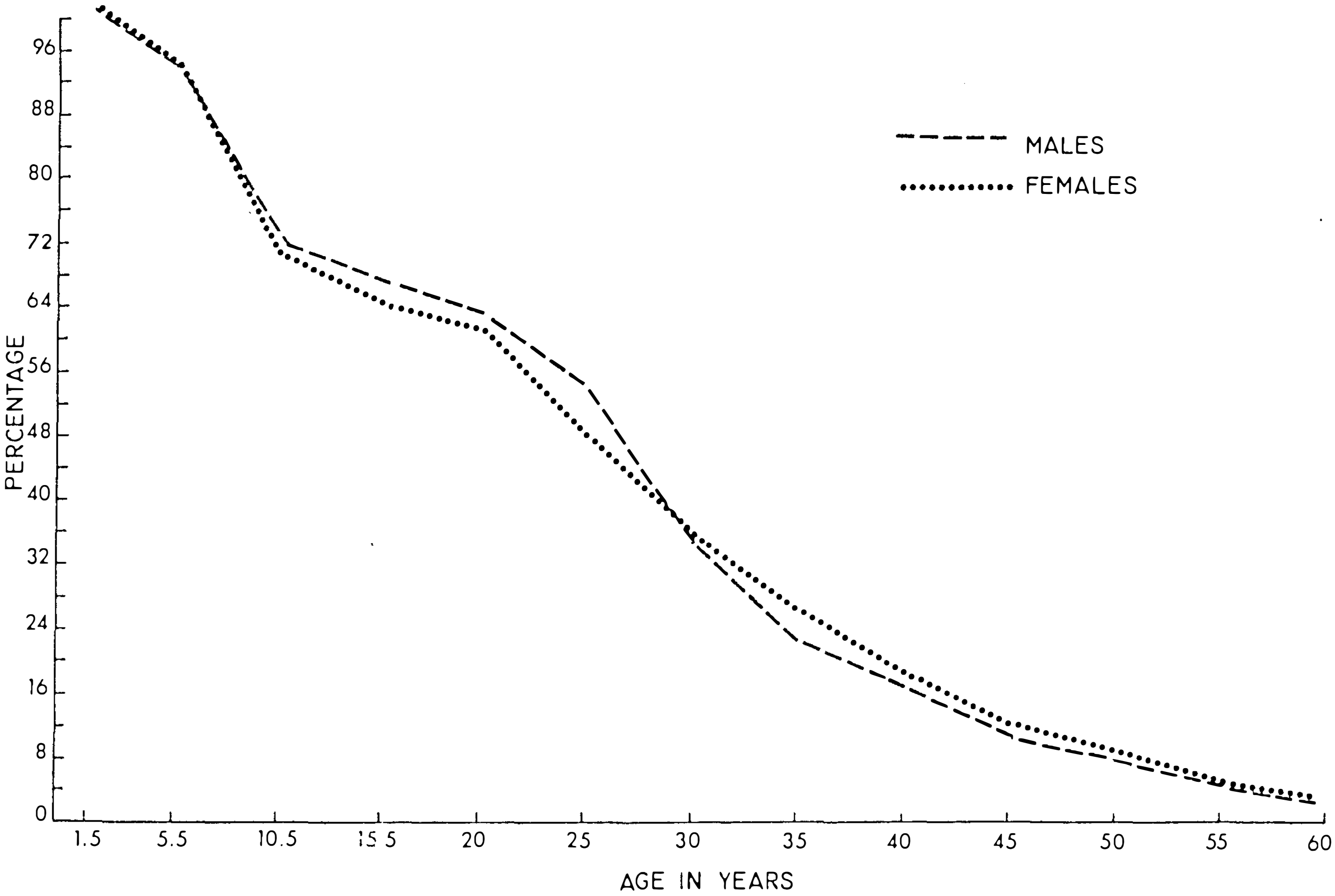



Figure 10. Survivorship of the Cemetery 1 population at Averbuch.

the original cohort remain. The age of 50 to 55 is reached by 4.59 percent of the males and 4.91 percent of the females.

Figure 11 provides a visual illustration of the probabilities of death (qx). Once again, the cultural or social exclusion of infants from burial in the cemetery is reflected in this curve. The probability of death would, under normal conditions, decrease from birth to 5.5 years of age instead of increasing as seen here. From age 15.5 to the early 20's the probability of death for females is higher than males, but just prior to age 20 to 25 this trend reverses and the males experience a higher probability of death which continues until age 30 to 35 (male $qx_{30-35}$ = .267; female $qx_{30-35}$ = .269). The qx values of both males and females decrease by age 40-45 but continually increase after that age. The male and female differences that exist after age 35 are relatively small. The greatest sex difference in the probability of death is at age 15.5 to 20 (male $qx_{15.5-20}$ = .130; female $qx_{15.5-20}$ = .220).

The life expectancy ($e^o$) for Cemetery 1 males and females is plotted in Figure 12. Male life expectancy at birth ($e^o_{0-1.5}$) is 19.05 years and female life expectancy is 20.20 years. Life expectancy peaks for both sexes at 5.5 to 10.5 years (male $e^o_{5.5-10.5}$ = 22.00; female $e^o_{5.5-10.5}$ = 21.81). Both male and female slopes are basically the same with the greatest adult sex differences appearing at age 20 to 25 (male $e^o_{20-25}$ = 11.91; female $e^o_{20-25}$ = 13.56) and at age 45 to 50 (male $e^o_{45-50}$ = 6.66; female $e^o_{45-50}$ = 6.85). Adult female life expectancy is slightly higher than male life expectancy for the majority of age categories.

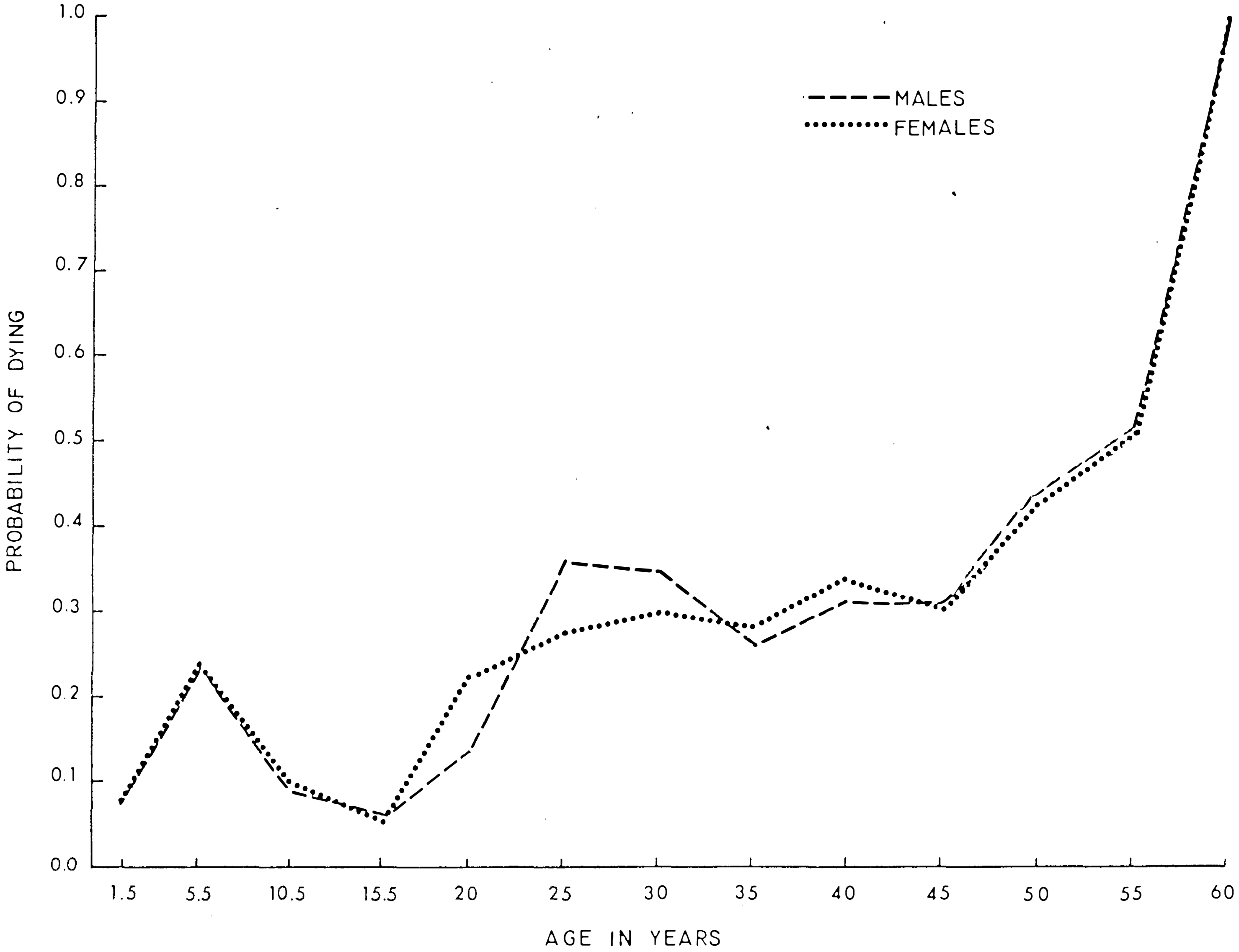



Figure 11. Probabilities of death in Cemetery 1 at Averbuch.

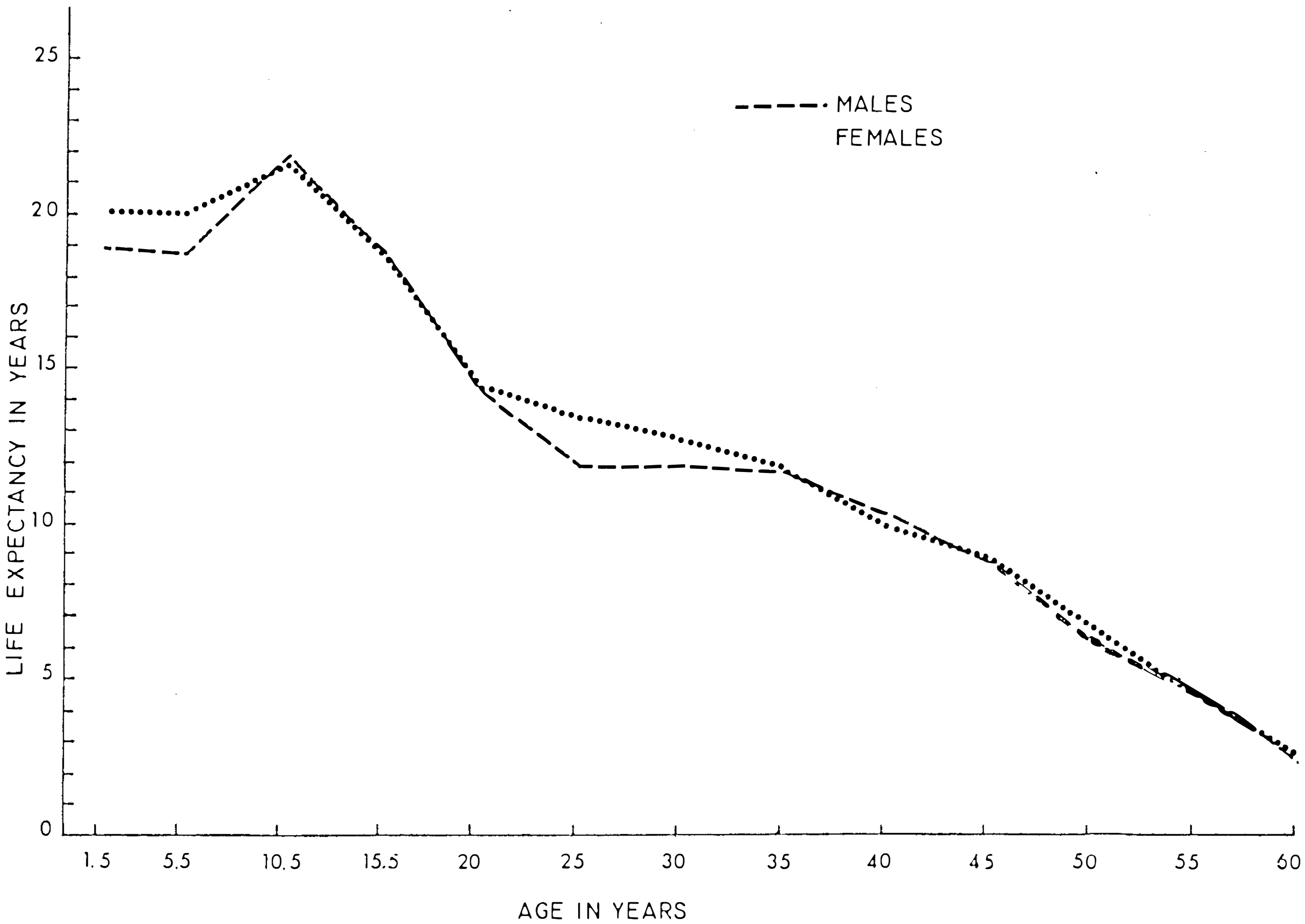



Figure 12. Life expectancy of the Cemetery 1 population at Averbuch.

Summary of Cemetery 1 Demography

Neonatal mortality in Cemetery 1 appears to be very low. However, these results do not represent a valid indication of the response of newborns to their environment. Rather, the vital statistics surrounding birth reflect the cultural practice of burying infants in or near the village structures. Since the majority of individuals buried in structures are 3.5 years of age or less, the remainder of the age intervals more closely reflect the true character of Cemetery 1 demography. For example, the most healthy group from Cemetery 1 is that containing adolescents 10.5 to 15.5 years of age. Adult males and females demonstrate slightly different demographic experiences. Females are severely stressed as young adults, primarily from 15.5 to 25 years of age. These deaths coincide with stress related to childbearing. Male mortality is greatest in the early to middle twenties and perhaps represents stress resulting from warfare and/or subsistence activities. Life expectancy for females is slightly higher than males at birth but those females and males surviving to reach the 25 to 30 year age interval experience approximately equivalent $e^o$ values for the remaining intervals. The age distributions of males and females do not differ statistically.

Cemetery 2 (Tables 13 and 14)

The male and female mortality curves (dx) for Cemetery 2 are presented in Figure 13. As with Cemetery 1, deficiencies due to infant exclusion from cemetery burial is clearly reflected in the low percentage of dead in the first age category. The subadult pattern of death is very similar to that of Cemetery 1. The greatest percentage of subadult

TABLE 13

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH MALES FROM CEMETERY 2

| x | Dx | dx | lx | qx | Lx | Tx | $e^{o}x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 4.68 | 7.77 | 100.00 | .078 | 144.17 | 2329.46 | 23.29 |
| 1.5- 5.5 | 8.78 | 14.58 | 92.23 | .158 | 339.76 | 2185.29 | 23.69 |
| 5.5-10.5 | 2.70 | 4.49 | 77.65 | .058 | 377.03 | 1845.53 | 23.77 |
| 10.5-15.5 | 1.08 | 1.79 | 73.16 | .024 | 361.35 | 1468.50 | 20.07 |
| 15.5-20 | 2.26 | 3.75 | 71.37 | .053 | 312.73 | 1107.15 | 15.51 |
| 20 -25 | 14.93 | 24.80 | 67.62 | .367 | 276.10 | 794.42 | 11.75 |
| 25 -30 | 4.74 | 7.87 | 42.82 | .184 | 194.43 | 518.32 | 12.10 |
| 30 -35 | 9.48 | 15.75 | 34.95 | .451 | 135.38 | 323.89 | 9.27 |
| 35 -40 | 5.93 | 9.85 | 19.20 | .513 | 71.38 | 188.51 | 9.82 |
| 40 -45 | 0.70 | 1.16 | 9.35 | .124 | 43.85 | 117.13 | 12.53 |
| 45 -50 | 0.70 | 1.16 | 8.19 | .142 | 38.05 | 73.28 | 8.95 |
| 50 -55 | 2.11 | 3.50 | 7.03 | .498 | 26.40 | 35.23 | 5.01 |
| 55 -60 | 2.11 | 3.50 | 3.53 | .992 | 8.83 | 8.83 | 2.50 |

TABLE 14

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH FEMALES FROM CEMETERY 2

| x | Dx | dx | lx | qx | Lx | Tx | $e^0x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 4.68 | 10.83 | 100.00 | .108 | 141.88 | 1985.26 | 19.85 |
| 1.5- 5.5 | 8.78 | 20.32 | 89.17 | .228 | 316.04 | 1843.38 | 20.67 |
| 5.5-10.5 | 2.70 | 6.25 | 68.85 | .091 | 328.63 | 1527.34 | 22.18 |
| 10.5-15.5 | 1.08 | 2.50 | 62.60 | .040 | 306.75 | 1198.71 | 19.15 |
| 15.5-20 | 4.54 | 10.51 | 60.10 | .175 | 246.80 | 891.96 | 14.84 |
| 20 -25 | 8.72 | 20.19 | 49.59 | .407 | 197.48 | 645.16 | 13.01 |
| 25 -30 | 2.38 | 5.51 | 29.40 | .187 | 133.23 | 447.68 | 15.23 |
| 30 -35 | 1.18 | 2.73 | 23.89 | .114 | 112.63 | 314.45 | 13.16 |
| 35 -40 | 2.38 | 5.51 | 21.16 | .260 | 92.03 | 201.82 | 9.54 |
| 40 -45 | 2.70 | 6.25 | 15.65 | .399 | 62.63 | 109.79 | 7.02 |
| 45 -50 | 2.70 | 6.25 | 9.40 | .665 | 31.38 | 47.16 | 5.02 |
| 50 -55 | 0.68 | 1.57 | 3.15 | .498 | 11.83 | 15.78 | 5.01 |
| 55 -60 | 0.68 | 1.57 | 1.58 | .994 | 3.95 | 3.95 | 2.50 |

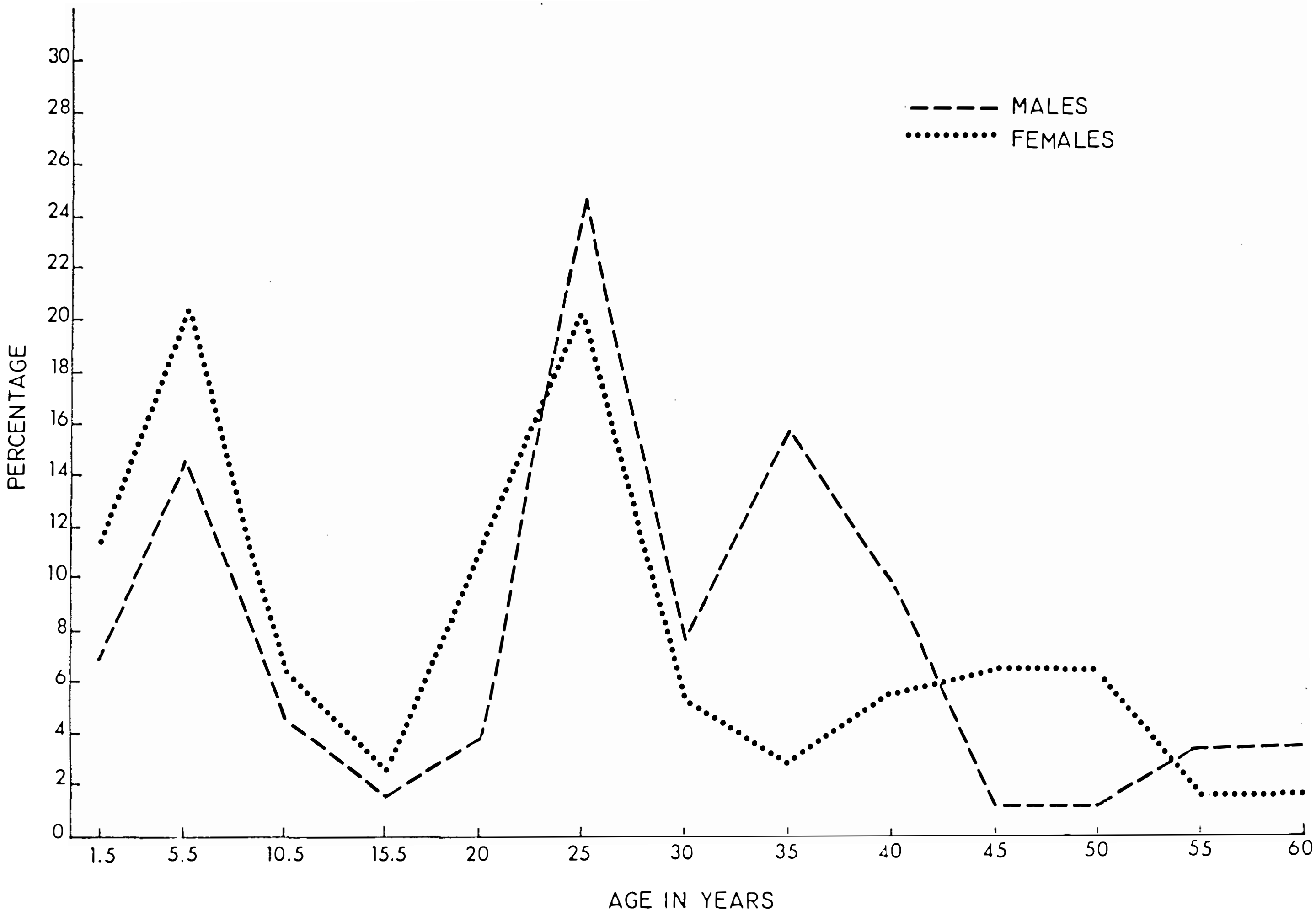



Figure 13. Age distribution of the male and female mortality in Cemetery 2 at Averbuch.

deaths (male $dx_{1.5-5.5}$ = 14.58 percent; female $dx_{1.5-5.5}$ = 20.32 percent) occur in the 1.5 to 5.5 age category and the healthiest period (male $dx_{10.5-15.5}$ = 1.79 percent; female $dx_{10.5-15.5}$ = 2.50 percent) is the 10.5 to 15.5 age category. After age 15.5 both male and female deaths increase greatly with the female deaths (10.51 percent) exceeding male deaths (3.75 percent) in the 15.5 to 20 age category. However, the frequencies increase in the next age category and male deaths ($dx_{20-25}$ = 24.80 percent) exceed female ($dx_{20-25}$ = 20.19 percent). After age 20 to 25 both male and female frequencies decline abruptly. At age 30 to 35 the male mortality (male $dx_{30-35}$ = 15.75 percent) increases and the female (female $dx_{30-35}$ = 2.73 percent) continues to decrease. After age 30 to 35 the female mortality gradually increases until age 40 to 45 (female $dx_{40-45}$ = 6.25 percent) and the male mortality decreases (male $dx_{40-45}$ = 1.16 percent). Both male and female frequencies remain constant during the 40 to 45 and 45 to 50 age categories. After age 45 to 50, the male curve increases and the female decreases. Of the male deaths, 9.32 percent occur after 40 years of age while 15.64 percent of the female deaths occur after this age. No statistically significant difference exists in the male/female age distributions.

The survivorship curves (lx) for both males and females are plotted in Figure 14. Male and female slopes differ very little in shape prior to age 35 to 40; however, a greater number of males survive to reach each age category than females. From age 40 to 50 this reverses with a slightly greater number of females than males surviving to reach each age category. By age 50 to 55 the trend once again reverses. The

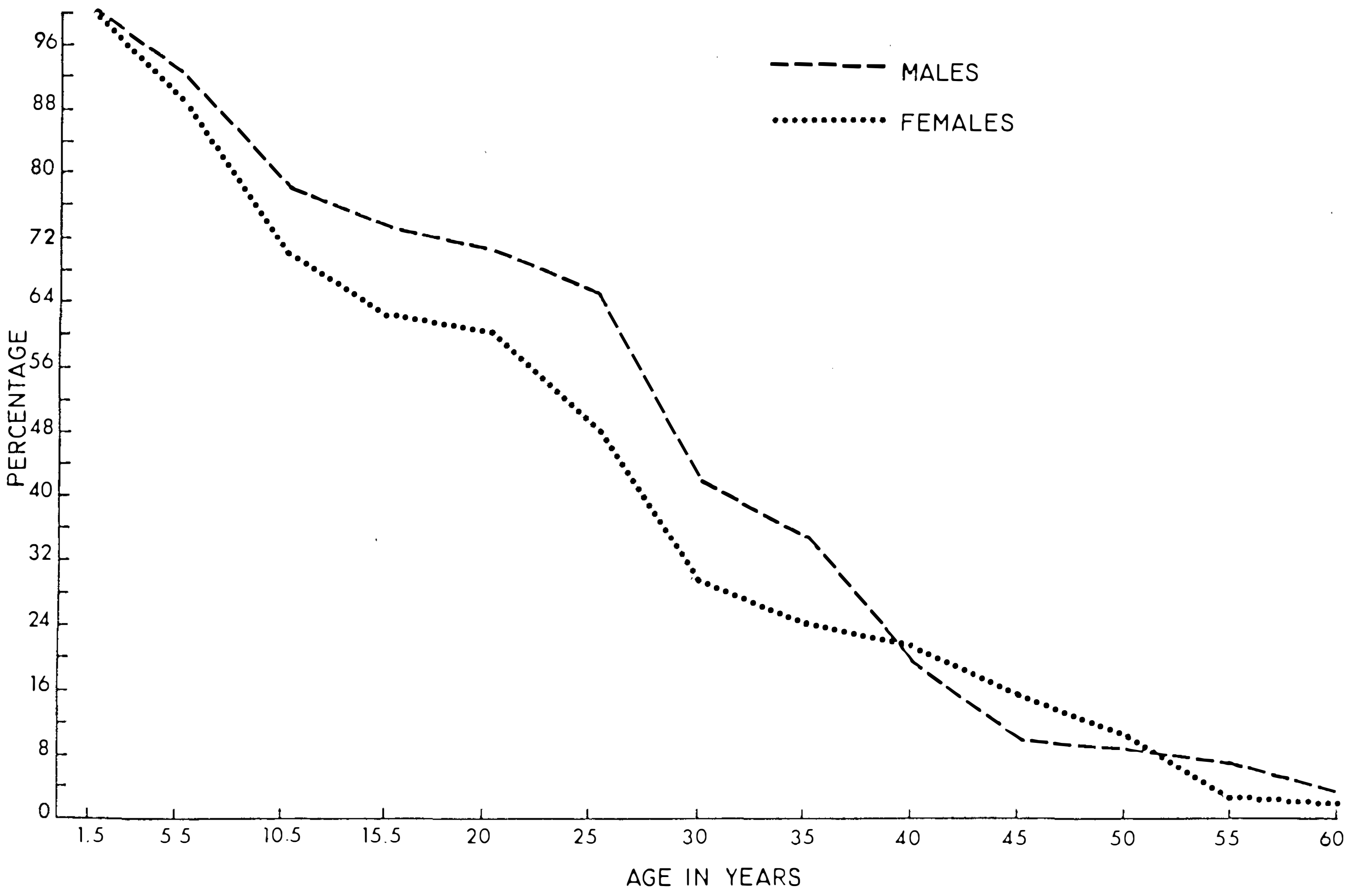



Figure 14. Survivorship of the Cemetery 2 population at Averbuch.

greatest diversity in survivorship between the sexes prior to 40 years of age occurs in the age interval 20 to 25 (male $lx_{20-25}$ = 67.62 percent; female $lx_{20-25}$ = 49.59 percent) and after age 40 it occurs in age interval 40 to 45 (male $lx_{40-45}$ = 9.35 percent; female $lx_{40-45}$ = 15.65 percent). The age of 50 to 55 is reached by 7.03 percent of the males and 3.15 percent of the females.

The probability of death (qx) for each sex in Cemetery 2 is represented in Figure 15. As with Cemetery 1, the subadult curves reflect a pattern which attests to the practice of infant burial outside of the cemetery. The qx values are higher for males at the age intervals of 30 to 35 and 35 to 40. The highest probability of death for males less than 35 years of age is in the 30 to 35 year age interval (male $qx_{30-35}$ = .451) and for females it is in the 20 to 25 year age interval (female $qx_{20-25}$ = .407). Between the ages of 35 and 50 years, the females experience their highest probability of dying in the 45 to 50 year age interval (female $qx_{45-50}$ = .665) while males are highest in the 35 to 40 year interval (males $qx_{35-40}$ = .513).

Life expectancy ($e^o$) for both sexes of Cemetery 2 is illustrated in Figure 16. Male life expectancy at birth ($e^o_{0-1.5}$) is 23.29 years and female life expectancy is 19.85 years. Male and female life expectancy peaks in the age category of 5.5 and 10.5 (male $e^o_{5.5-10.5}$ = 23.77; female $e^o_{5.5-10.5}$ = 22.18). Female life expectancy exceeds that of the males for the age intervals 20 to 25, 25 to 30, and 30 to 35. However, the male life expectancy is greater for the remainder of the age intervals with the exception of the last two which are equal.

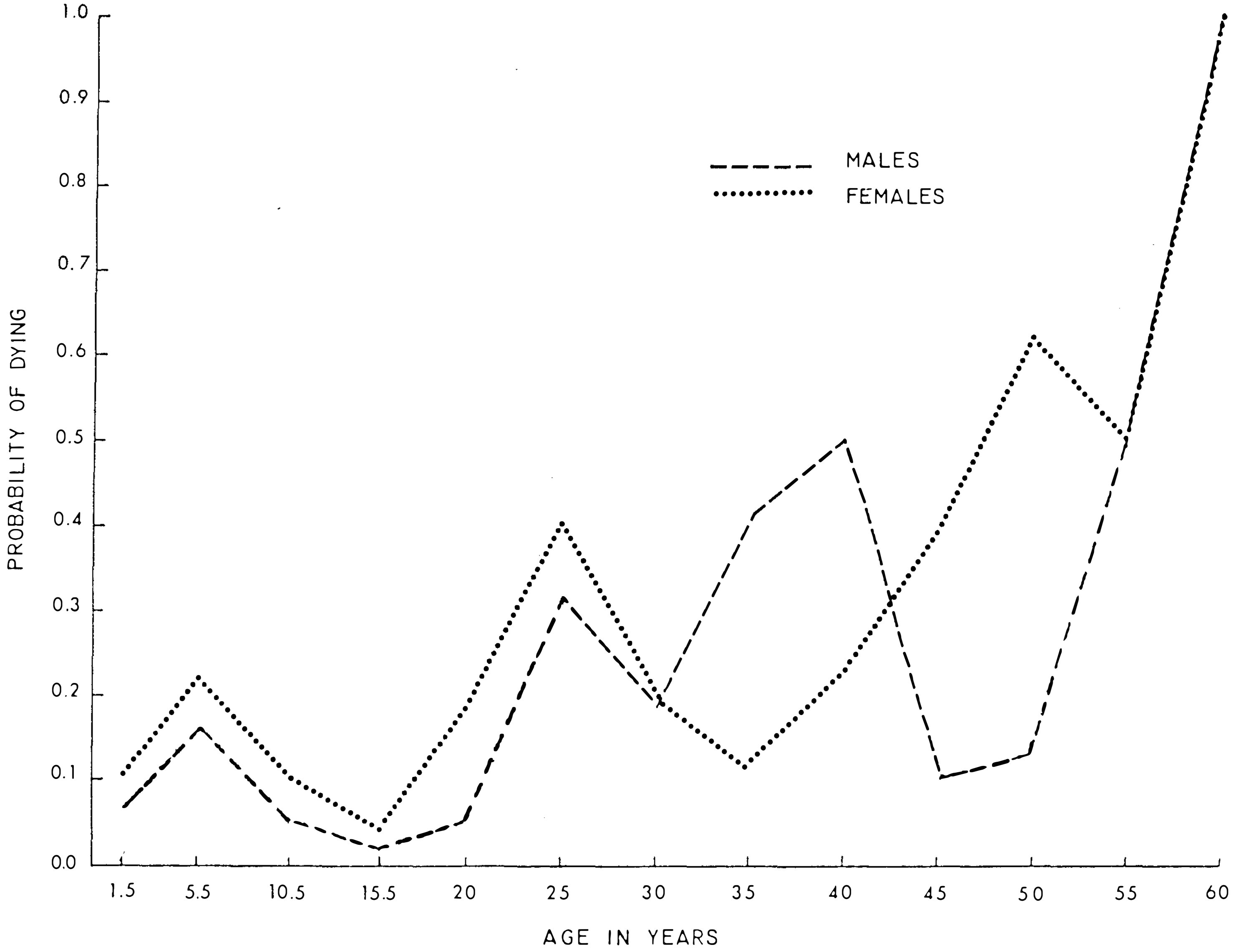



Figure 15. Probabilities of death in Cemetery 2 at Averbuch.

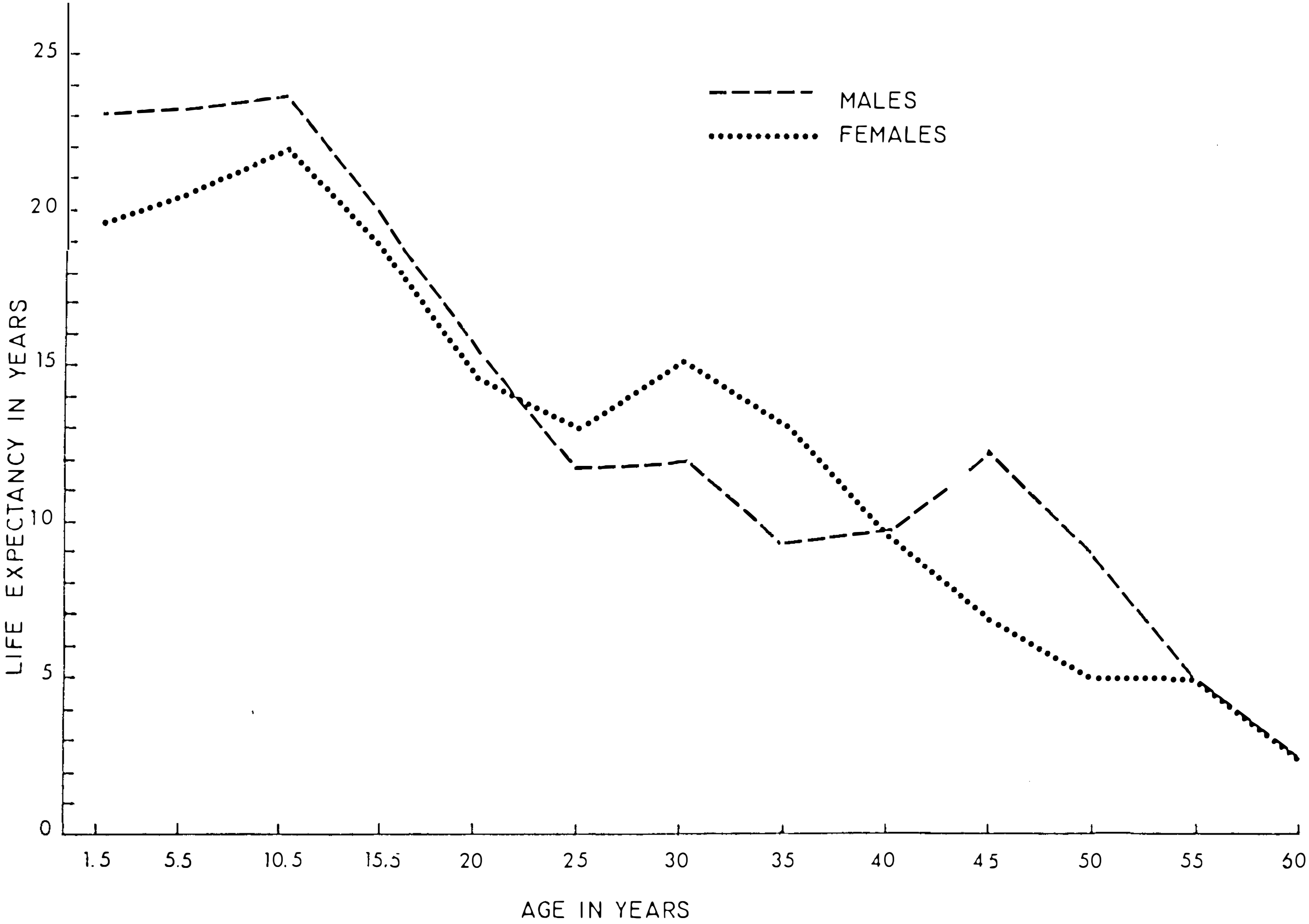



Figure 16. Life expectancy of the Cemetery 2 population at Averbuch.

Summary of Cemetery 2 Demography

The pattern of the vital statistics as expressed in Figures 13, 14, 15, and 16 is more erratic than that of Cemetery 1. This may be a product of the relatively small number buried in Cemetery 2 (i.e., 103.40 individuals). As with Cemetery 1, there is a deficiency in the number of infant dead and the most healthy age interval for both sexes is 10.5 to 15.5 years. Young adult females (15.5 to 25.5) are markedly stressed as are males. Both sexes experience their peak mortality during the 20 to 25 year age interval. However, the males are more severely stressed at this age than the females. As with Cemetery 1, childbearing may be used to explain the increase in female deaths, while increased activity related to subsistence and warfare best explain male deaths. Female mortality decreases after 20 to 25 years of age but the Cemetery 2 males experience a decrease followed by a second period of stress at 30 to 35 years of age. This pattern is difficult to interpret but it may be a product of a small sample size, inaccurate sex assignment (only 9.48 males are present at this age), or social or cultural influences of a yet undetermined nature. Male life expectancy is higher than female life expectancy at birth and remains so until 20 to 25 years of age. From age 20 to 35, female life expectancy is higher than that of the males. It once again reverses from 40 to 50 years of age with the $e^o$ values of the males exceeding those of the females (male $e^o_{40-45}$ = 12.53 years; female $e^o_{40-45}$ = 7.02). A chi-square test of the age distributions of male and female deaths produces no significant differences.

Cemetery 3 (Tables 15 and 16)

The mortality curve (dx) for each sex is presented in Figure 17. As with the previous two cemeteries, the deficiency of dead in the first category is expressed in the low percentage of deaths at this age (male $dx_{0-1.5}$ = 5.90 percent; female $dx_{0-1.5}$ = 6.12 percent.) Also, the subadult mortality curves are very similar to those of the two previous cemeteries; the highest mortality is in the 1.5-5.5 category (male $dx_{1.5-5.5}$ = 18.88 percent; female $dx_{1.5-5.5}$ = 19.58 percent) and the lowest mortality is in the 10.5 to 15.5 category (male $dx_{10.5-15.5}$ = 2.66 percent; female $dx_{10.5-15.5}$ = 2.76 percent). The 15.5 to 20 age category demonstrates an increase in the dx values with the male deaths ($dx_{15.5-20}$ = 6.68 percent) slightly exceeding those of the female ($dx_{15.5-20}$ = 5.94 percent). However, by age 20 to 25 the female dx values ($dx_{20-25}$ = 25.06 percent) are almost twice as high as the male values ($dx_{20-25}$ = 13.94 percent). The female values remain higher than the male for the following category (male $dx_{25-30}$ = 10.06 percent; female $dx_{25-30}$ = 16.25 percent). By age 30 to 35 the female mortality curve drops below the male curve and continues to decrease until age 40 to 45 where it levels off and remains relatively constant over the remaining age categories. The male curve remains constant from age 25 to 35 and then drops from age 35 to 40, remains constant from 40 to 50 and again drops after age 50. After age 30 to 35 the female dx curve is consistently lower than that of the male throughout the other age categories. A chi-square value ($\chi^2$ = 22.300, df = 6) for the male and female age distributions differ at the .005 level.

TABLE 15

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH MALES FROM CEMETERY 3

| x | Dx | dx | lx | qx | Lx | Tx | $e^{o}x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 7.77 | 5.90 | 100.00 | .059 | 145.58 | 2347.33 | 23.47 |
| 1.5- 5.5 | 24.86 | 18.88 | 94.10 | .201 | 338.64 | 2201.75 | 23.40 |
| 5.5-10.5 | 9.24 | 7.02 | 75.22 | .093 | 358.55 | 1863.11 | 24.77 |
| 10.5-15.5 | 3.50 | 2.66 | 68.20 | .039 | 334.35 | 1504.56 | 22.06 |
| 15.5-20 | 8.80 | 6.68 | 65.54 | .102 | 279.90 | 1170.21 | 17.85 |
| 20 -25 | 18.35 | 13.94 | 58.86 | .237 | 259.45 | 890.31 | 15.13 |
| 25 -30 | 13.25 | 10.06 | 44.92 | .224 | 199.45 | 630.86 | 14.04 |
| 30 -35 | 13.25 | 10.06 | 34.86 | .289 | 149.15 | 431.41 | 12.38 |
| 35 -40 | 7.59 | 5.76 | 24.80 | .232 | 109.60 | 282.26 | 11.38 |
| 40 -45 | 7.51 | 5.70 | 19.04 | .299 | 81.45 | 172.66 | 9.08 |
| 45 -50 | 7.51 | 5.70 | 13.54 | .421 | 52.95 | 91.21 | 6.74 |
| 50 -55 | 5.02 | 3.81 | 7.67 | .499 | 28.68 | 38.26 | 5.01 |
| 55 -60 | 5.02 | 3.81 | 3.83 | .995 | 9.58 | 9.58 | 2.50 |

TABLE 16

ABRIDGED LIFE TABLE CALCULATED USING THE AGE DISTRIBUTION OF AVERBUCH FEMALES FROM CEMETERY 3

| x | Dx | dx | lx | qx | Lx | Tx | $e^o x$ |
|---|---|---|---|---|---|---|---|
| 0 - 1.5 | 7.77 | 6.12 | 100.00 | .061 | 145.41 | 1944.24 | 19.44 |
| 1.5- 5.5 | 24.86 | 19.58 | 93.88 | .209 | 336.36 | 1798.83 | 19.16 |
| 5.5-10.5 | 9.24 | 7.28 | 74.30 | .098 | 353.30 | 1462.47 | 19.68 |
| 10.5-15.5 | 3.50 | 2.76 | 67.02 | .041 | 328.20 | 1109.17 | 16.55 |
| 15.5-20 | 7.54 | 5.94 | 64.26 | .092 | 275.81 | 780.97 | 12.15 |
| 20 -25 | 31.82 | 25.06 | 58.32 | .430 | 228.95 | 505.16 | 8.66 |
| 25 -30 | 20.63 | 16.25 | 33.26 | .489 | 125.68 | 276.21 | 8.30 |
| 30 -35 | 11.25 | 8.86 | 17.01 | .521 | 62.90 | 150.53 | 8.85 |
| 35 -40 | 3.76 | 2.96 | 8.15 | .363 | 33.35 | 87.63 | 10.75 |
| 40 -45 | 1.50 | 1.18 | 5.19 | .227 | 23.00 | 54.28 | 10.45 |
| 45 -50 | 1.50 | 1.18 | 4.01 | .294 | 17.10 | 31.28 | 7.80 |
| 50 -55 | 1.79 | 1.41 | 2.83 | .403 | 10.63 | 14.18 | 5.01 |
| 55 -60 | 1.79 | 1.41 | 1.42 | .993 | 3.55 | 3.55 | 2.50 |

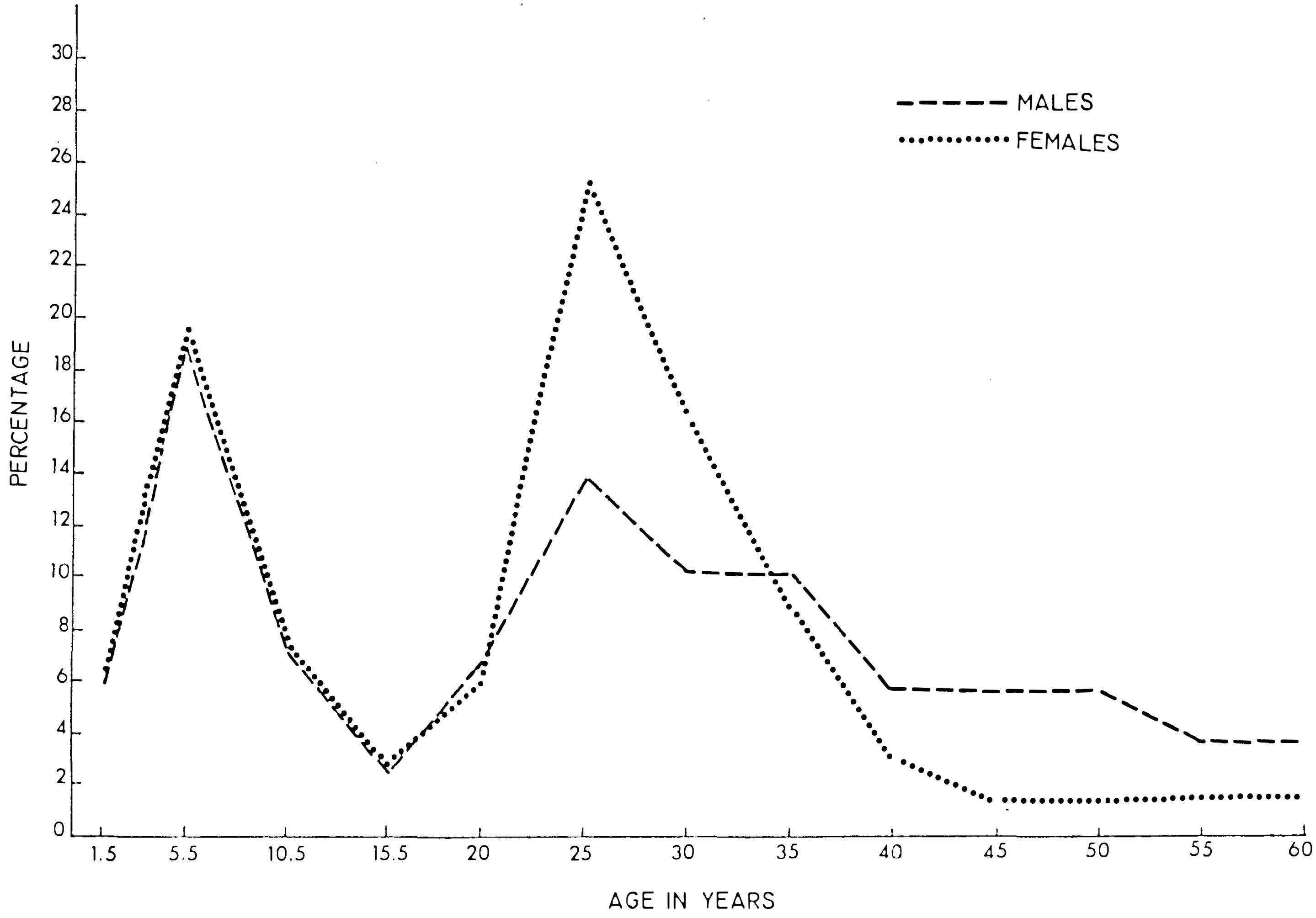



Figure 17. Age distribution of male and female mortality in Cemetery 3 at Averbuch.

Cemetery 3 survivorship (lx) is presented for both sexes in Figure 18. A smooth and continuously decreasing slope may be seen for both sexes from birth to age 25. Very little difference is exhibited between the sexes prior to 25 years of age. By 25 to 30 the percentage of survivors declines abruptly. The downward slope continues throughout the remaining age intervals with a greater percentage of males surviving at each age interval than females. The percentage of Cemetery 3 males surviving to the age of 50 to 55 exceeds the percentage of females (male $lx_{50-55}$ = 7.67 percent; female $lx_{50-55}$ = 2.83).

Figure 19 contains the probability of death (qx) for both males and females from Cemetery 3. The infant deficiency is once again reflected in the qx curve. At age 15.5 to 20, the probability of dying is basically the same for males ($qx_{15.5-20}$ = .102) and females ($qx_{15.5-20}$ = .092). After age 20 the female probability of death increases sharply to age 20 to 25 and continues to increase, but to a lesser extent, until age 35. From age 35 to 45 the probability of female deaths decline but increase after this age. The male probability of death also increases, but less sharply relative to the female, after age 20. The highest probability of death for both males and females between 20 and 40 years of age occurs in the 30 to 35 age category (males $qx_{30-35}$ = .289; female $qx_{30-35}$ = .521). After age 40 the male qx values exceed those of the female.

Male and female life expectancy ($e^o$) for Cemetery 3 is illustrated in Figure 20. At birth the male life expectancy ($e^o_{0-1.5}$ = 23.47) is greater than that of the female ($e^o_{0-1.5}$ = 19.44). Peak life expectancy

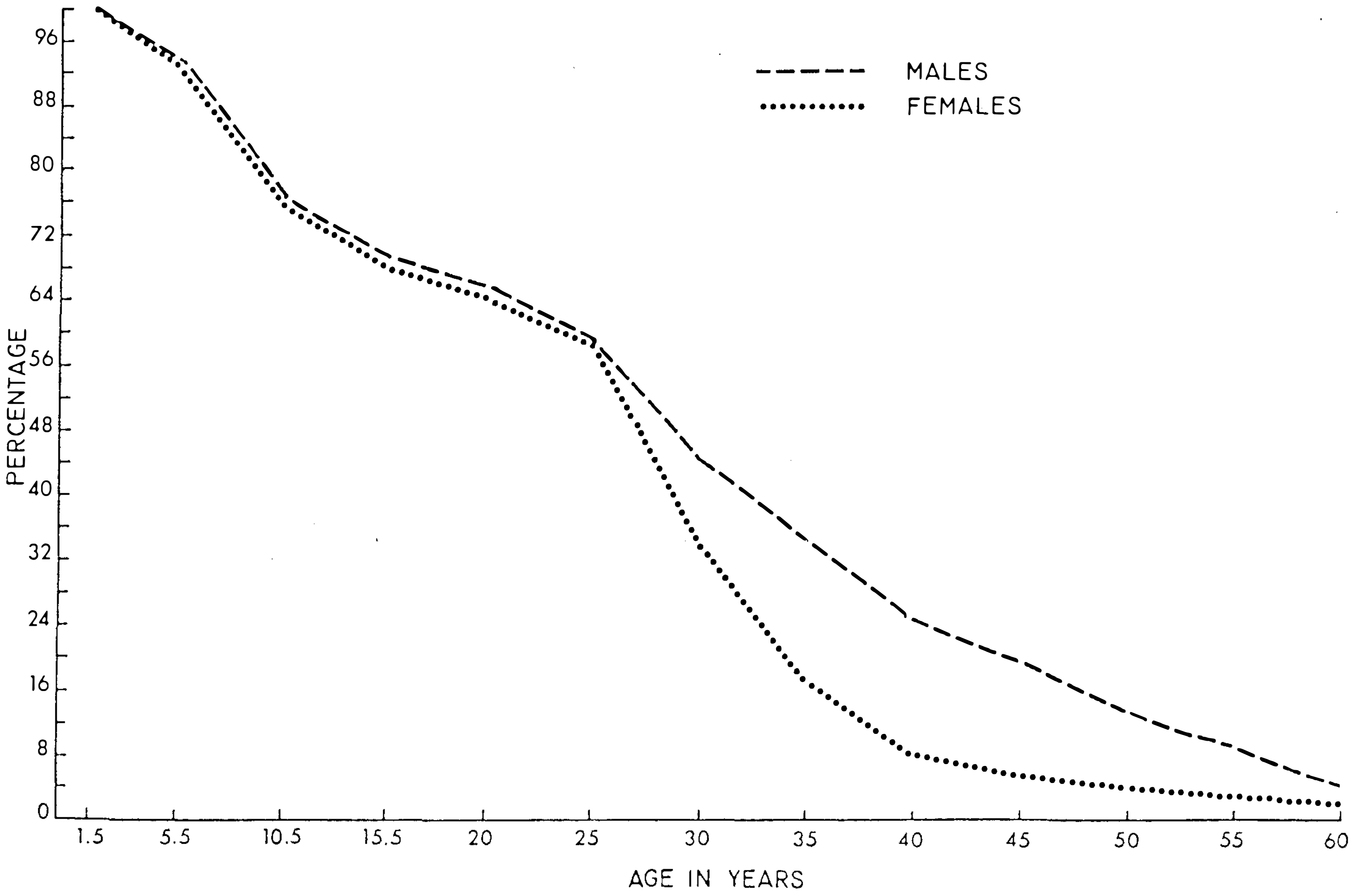



Figure 18. Survivorship of the Cemetery 3 population at Averbuch.

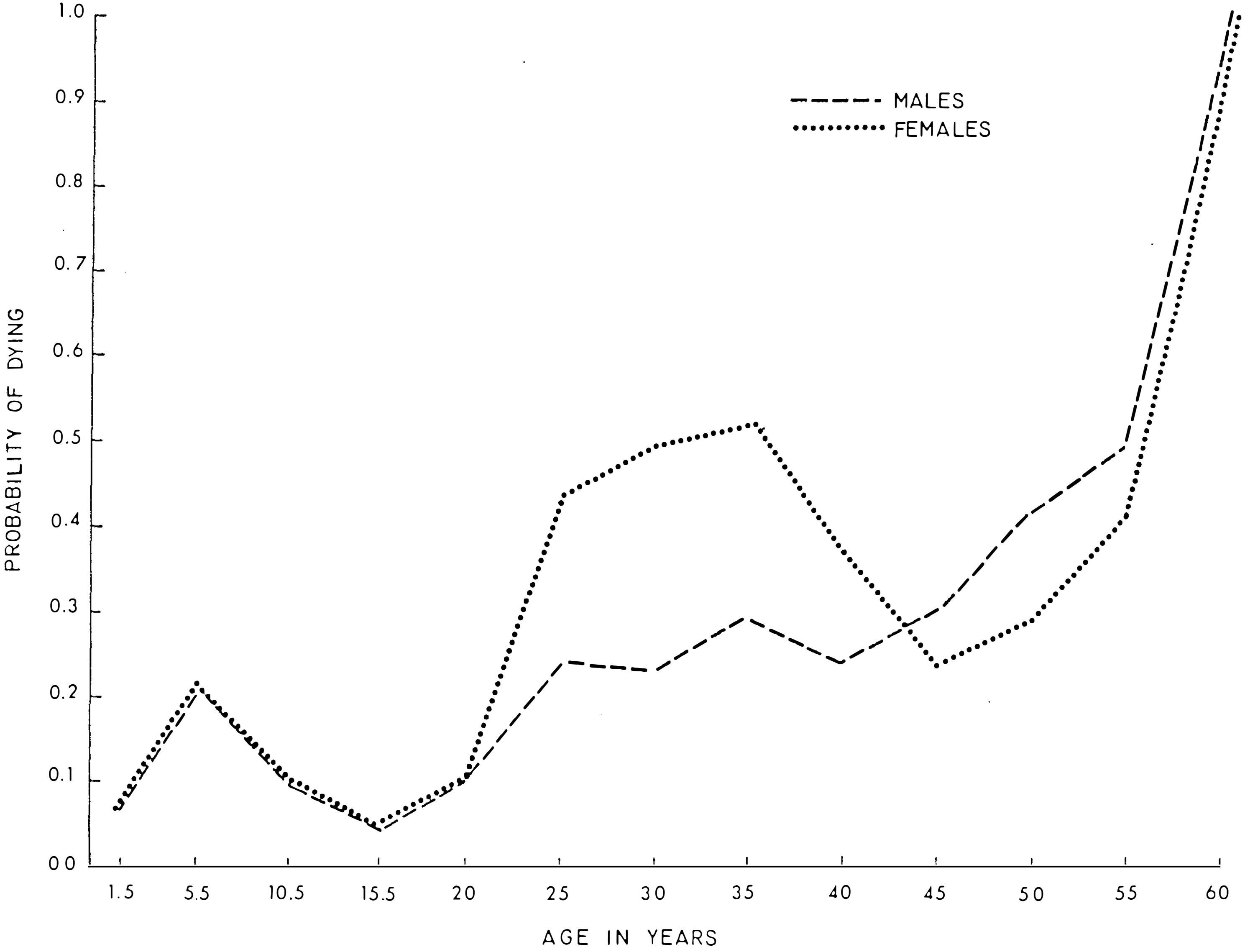



Figure 19. Probabilities of death in Cemetery 3 at Averbuch.

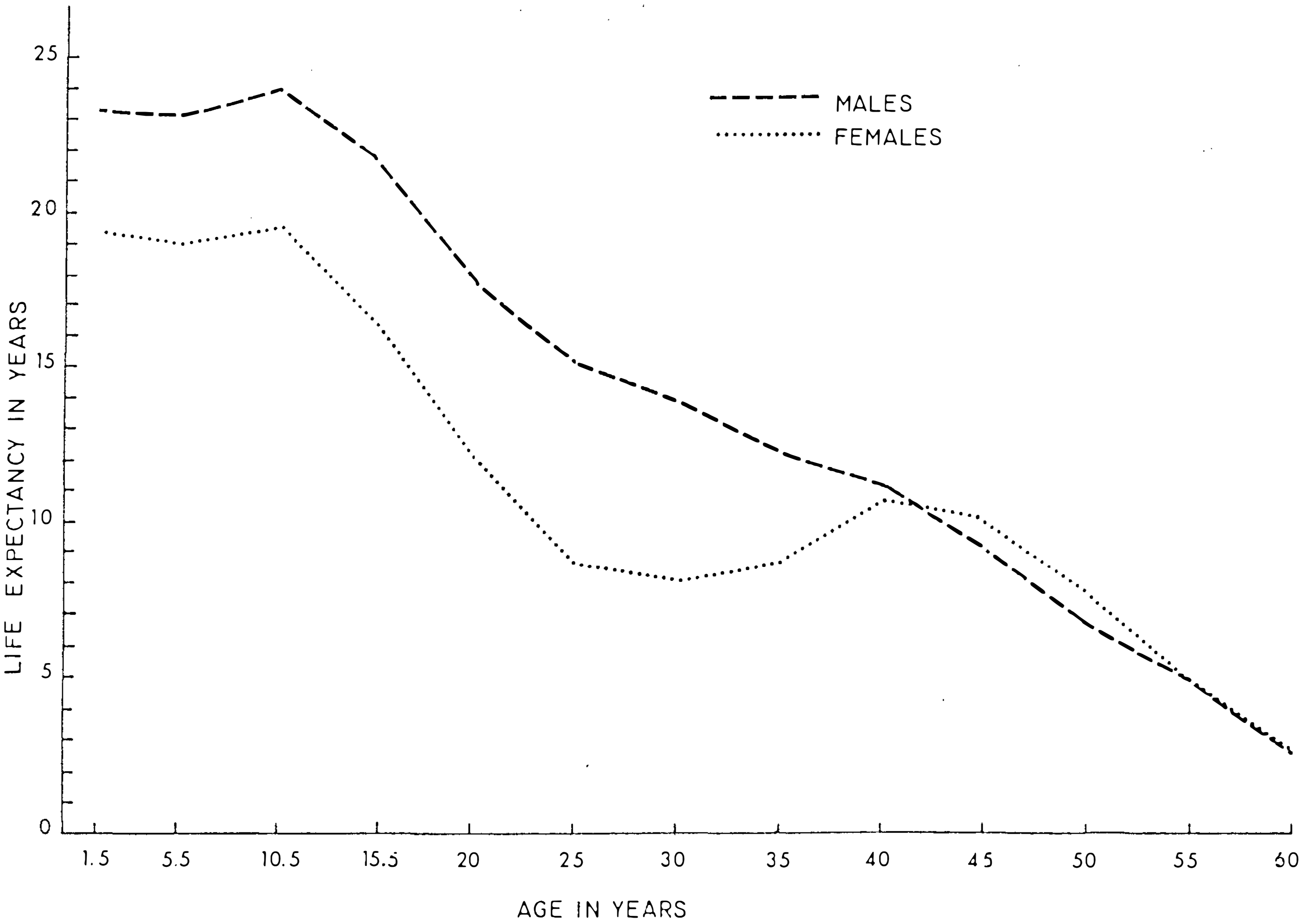



Figure 20. Life expectancy of the Cemetery 3 population at Averbuch.

for both sexes is during the 5.5 to 10.5 interval (male $e^o_{5.5-10.5}$ = 24.77; female $e^o_{5.5-10.5}$ = 19.68). Male values exceed female values at all age intervals from birth to age 40. The female values are higher than male values for the age intervals 40 to 45 and 45 to 50. Life expectancy for the sexes are the same for the age intervals 50 to 55 and 55 to 60.

Summary of Cemetery 3 Demography

The usual absence of infants so typical of Cemeteries 1 and 2 is observed for Cemetery 3 and, as with the two previous cemeteries, is attributed to the practice of infant burial in the village area. The overall male to female age distributions differ statistically at the .005 level. Neither male nor female mortality differs greatly from birth to 20 years of age. Both male and female deaths reach their peak in the 20 to 25 year age interval with female mortality greatly increasing over that of the males. It is this diversity in the percentage of male and female deaths that is mainly responsible for the statistical difference. The interpretation for the increased female mortality will be discussed in detail in the concluding section of this chapter.

Survivorship, though almost identical for the sexes prior to age 25, differs markedly in favor of the males after that age. This results largely from the extremely high female mortality during the early adult years and is further expressed in the male mortality curve after 35 years of age. Male mortality in the older age categories is higher than corresponding female mortality mainly because fewer females than males survived to reach late adult life. It is in this respect that male life expectancy exceeds that of the female from birth to 40 years of age

while female life expectancy slightly surpasses that of the male from 40 to 50 years of age.

## IV. INTERCEMETERY COMPARISON OF AVERBUCH VITAL STATISTICS ACCORDING TO SEX

The previous section describes the vital statistics of each of the three cemeteries, independently. The purpose of this section is to compare the vital statistics of the three Averbuch cemeteries according to sex. Table 11, page 75, Table 12, page 76, Table 13, page 84, Table 14, page 85, Table 15, page 94, and Table 16, page 95, are used to construct the illustrations necessary for these comparisons.

### Male Demography

The male mortality curves (dx) from the three cemeteries are compared in Figure 21. Subadult mortality for the 1.5 to 5.5 age interval is highest for the Cemetery 1 males ($dx_{1.5-5.5}$ = 20.53 percent) with Cemetery 3 males ($dx_{1.5-5.5}$ = 18.88 percent) less stressed and Cemetery 2 males ($dx_{1.5-5.5}$ = 14.58 percent) the least. The most healthy period of subadult life (10.5 to 15.5 years) reflects a similar relationship; Cemeteries 1, 3, and 2 represent the greatest to least stressed groups, respectively. All three curves are elevated in the 20 to 25 year interval. During this age interval Cemetery 3 males ($dx_{20-25}$ = 13.94 percent) demonstrate the lowest mortality, with Cemetery 1 males ($dx_{20-25}$ = 19.50 percent) showing a greater percentage of deaths. The highest percentage of male deaths, not only for the 20 to 25 year interval but for all other intervals, is exhibited by

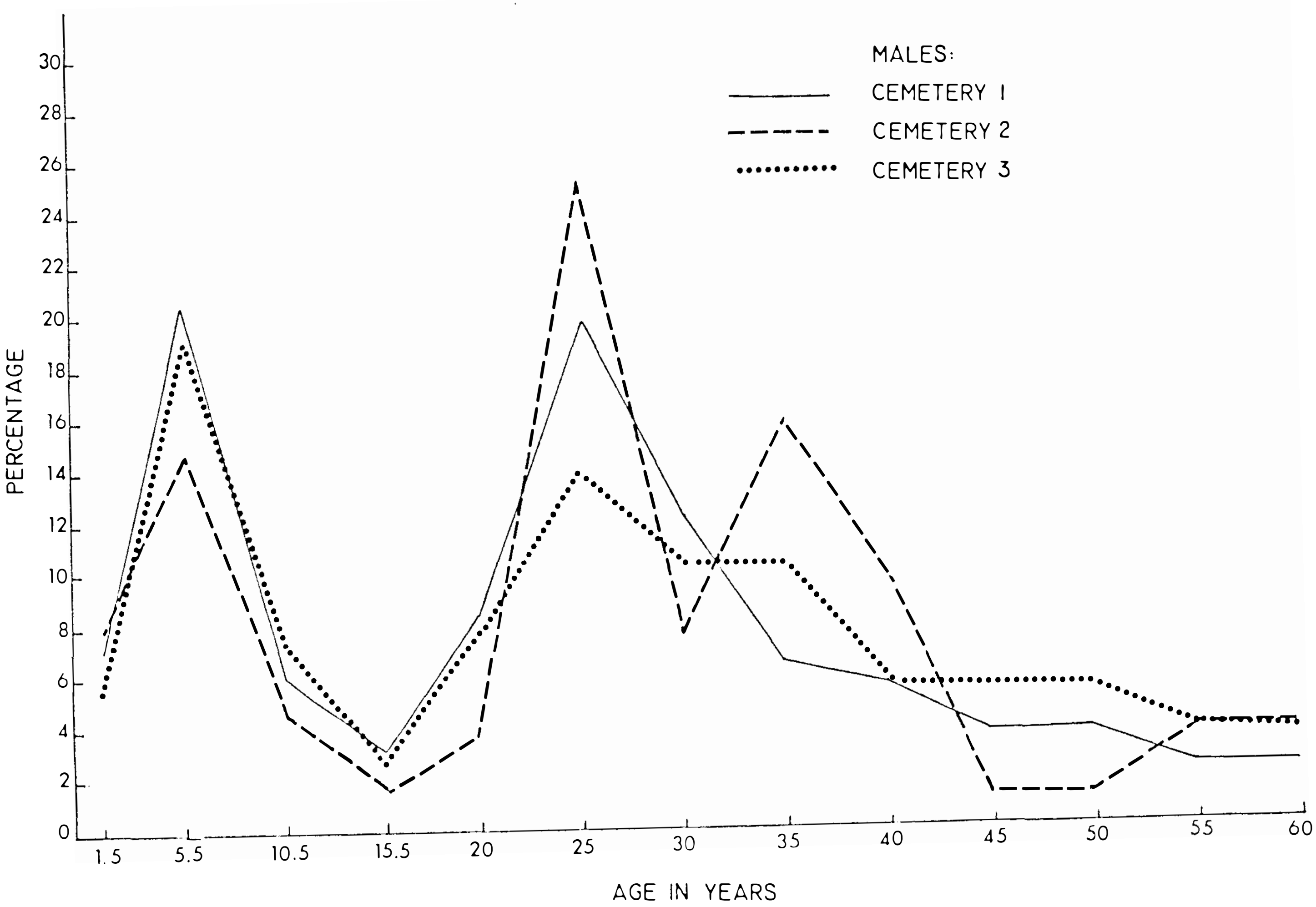



Figure 21. Age distribution of male mortality from Cemeteries 1, 2 and 3.

Cemetery 2 ($dx_{20-25}$ = 24.80 percent). Following this age interval there is a decline in mortality for Cemeteries 1 and 3 with Cemetery 3 mortality exceeding that of Cemetery 1 for all remaining age intervals. Cemetery 2 mortality, unlike that of Cemeteries 1 and 3, increases in the 30 to 35 year age interval to a point higher than the other two groups at this interval. The age distribution for the males from the three cemeteries do not differ significantly when tested with chi-square.

Survivorship (lx) curves comparing the males from each of the three cemeteries are presented in Figure 22. After 5.5 years of age, the survivorship for Cemetery 3 males is higher for each age interval than Cemetery 1 males. Little difference exists between these two groups from birth to 25 years of age. The Cemetery 2 male survivorship curve is higher than the other two through most of the subadult and young adult years but falls between the Cemetery 1 and 3 curves for the majority of the remaining intervals. At age 20 to 25, 67.62 percent of the Cemetery 2 males remain; whereas, only 58.86 percent of the Cemetery 3 males and 55.12 percent of the Cemetery 1 males survive to reach this age. By age 40 to 45, 9.35 percent of the Cemetery 2 males survive. At age 55 to 60, 2.29 percent of the Cemetery 1 males, 3.53 percent of the Cemetery 2 males, and 3.83 percent of the Cemetery 3 males survive.

The probability of dying (qx) for the males from the three Averbuch cemeteries is shown in Figure 23. The probability of death for the children 1.5 to 5.5 years of age increases from Cemetery 2 ($qx_{1.5-5.5}$ = .158) to Cemetery 3 ($qx_{1.5-5.5}$ = .201) to Cemetery 1 ($qx_{1.5-5.5}$ = .221).

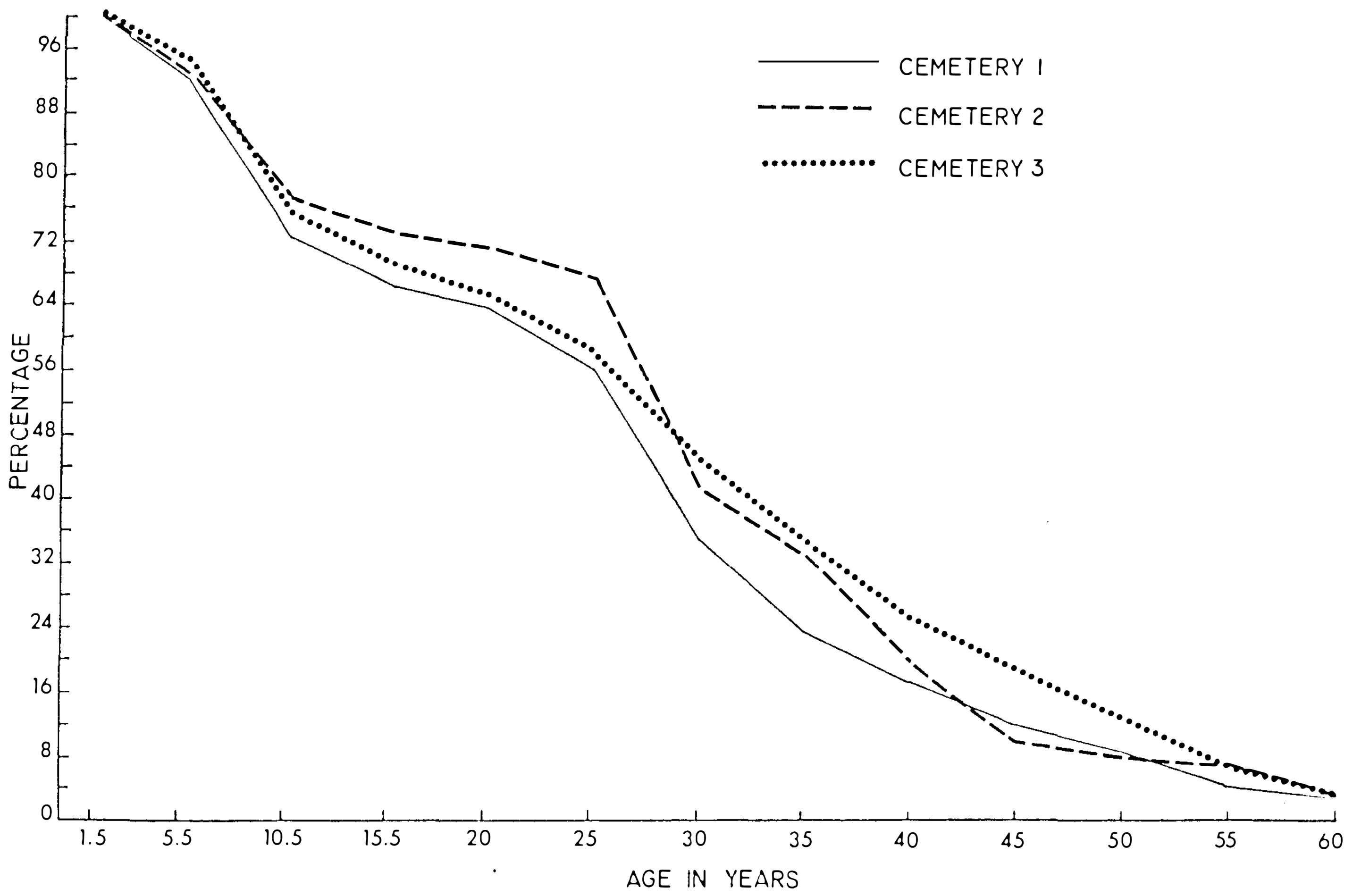



Figure 22. Survivorship of the males from Cemeteries 1, 2 and 3.

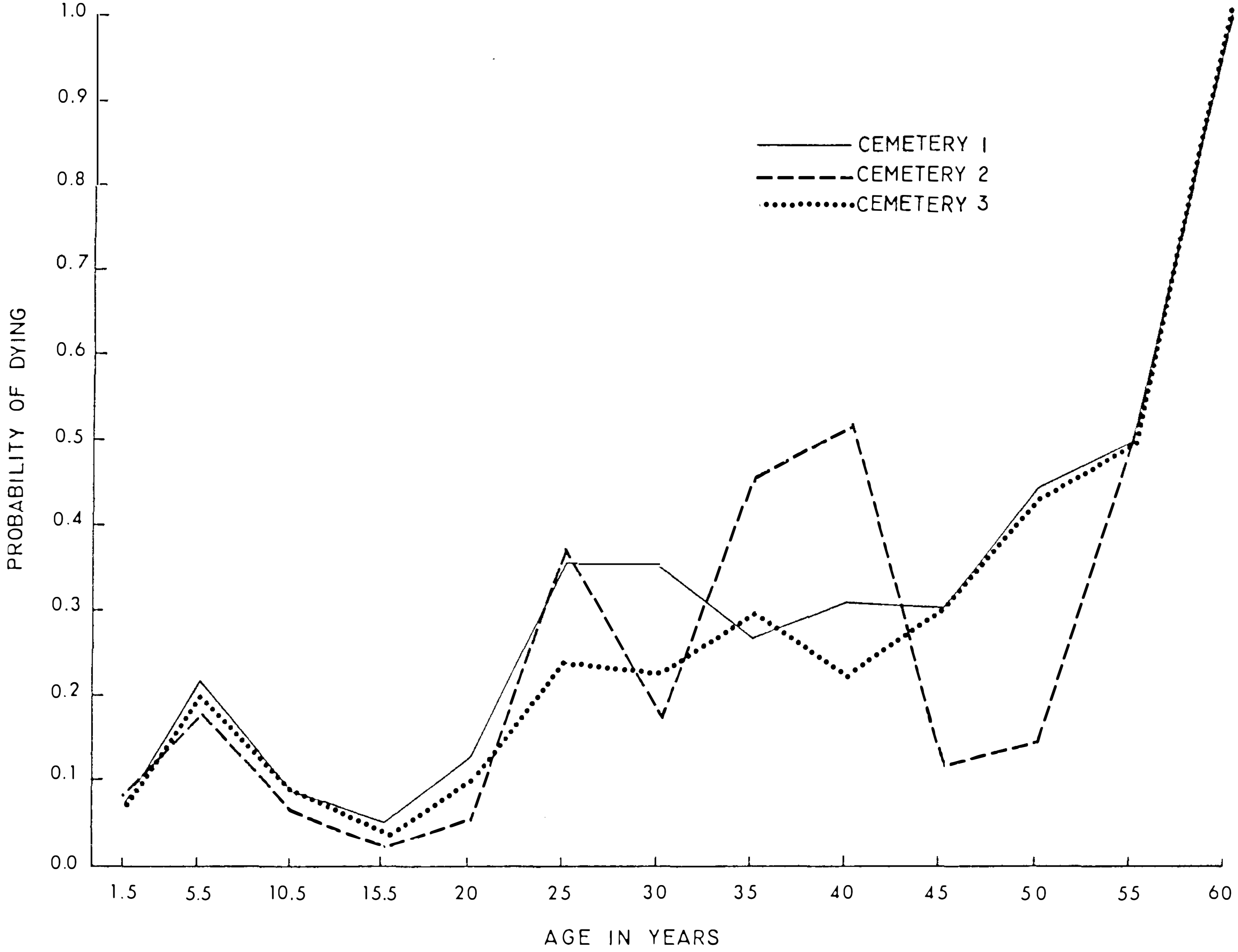



Figure 23. Probabilities of death for the males from Cemeteries 1, 2 and 3.

The relationship remains relatively the same during the least stressed subadult period (10.5 to 15.5 years of age). In the 20 to 25 year interval, Cemetery 1 and 2 probabilities are roughly the same and much higher than that of Cemetery 3. In the 25 to 30 year interval, Cemetery 1 qx values remain high while the qx values for Cemetery 2 drop below that of Cemetery 3. Cemetery 2 males than experience a great increase over the other two cemeteries in the probability of dying from age 30 to 40. Cemetery 2 qx values then drop dramatically from 40 to 50 years of age before increasing. The qx patterns of Cemeteries 1 and 2 correspond very closely with each other, with the probability of dying being higher for Cemetery 1 males than Cemetery 3 males for the majority of the age intervals. The comparatively more erratic pattern of the Cemetery 2 qx values may be, to some degree, a function of small sample size.

Life expectancy ($e^o$) curves for males from the three cemeteries may be seen in Figure 24. Basically, Cemetery 1 male life expectancy is lower than that of Cemetery 3 males for all but the oldest age interval. Cemetery 2 male life expectancy remains between that of Cemeteries 1 and 3 from 5.5 to 20 years of age. It is roughly the same as Cemetery 1 values during the 20 to 30 age intervals. Cemetery 2 male life expectancy is much lower than that of the other two cemeteries for the 30 to 35 year interval but becomes much higher than the others for the 40 to 45 year interval.

## Female Demography

Figure 25 illustrates the relationship of female mortality (dx) from the three cemeteries. Subadult stress at the 1.5 to 5.5 year

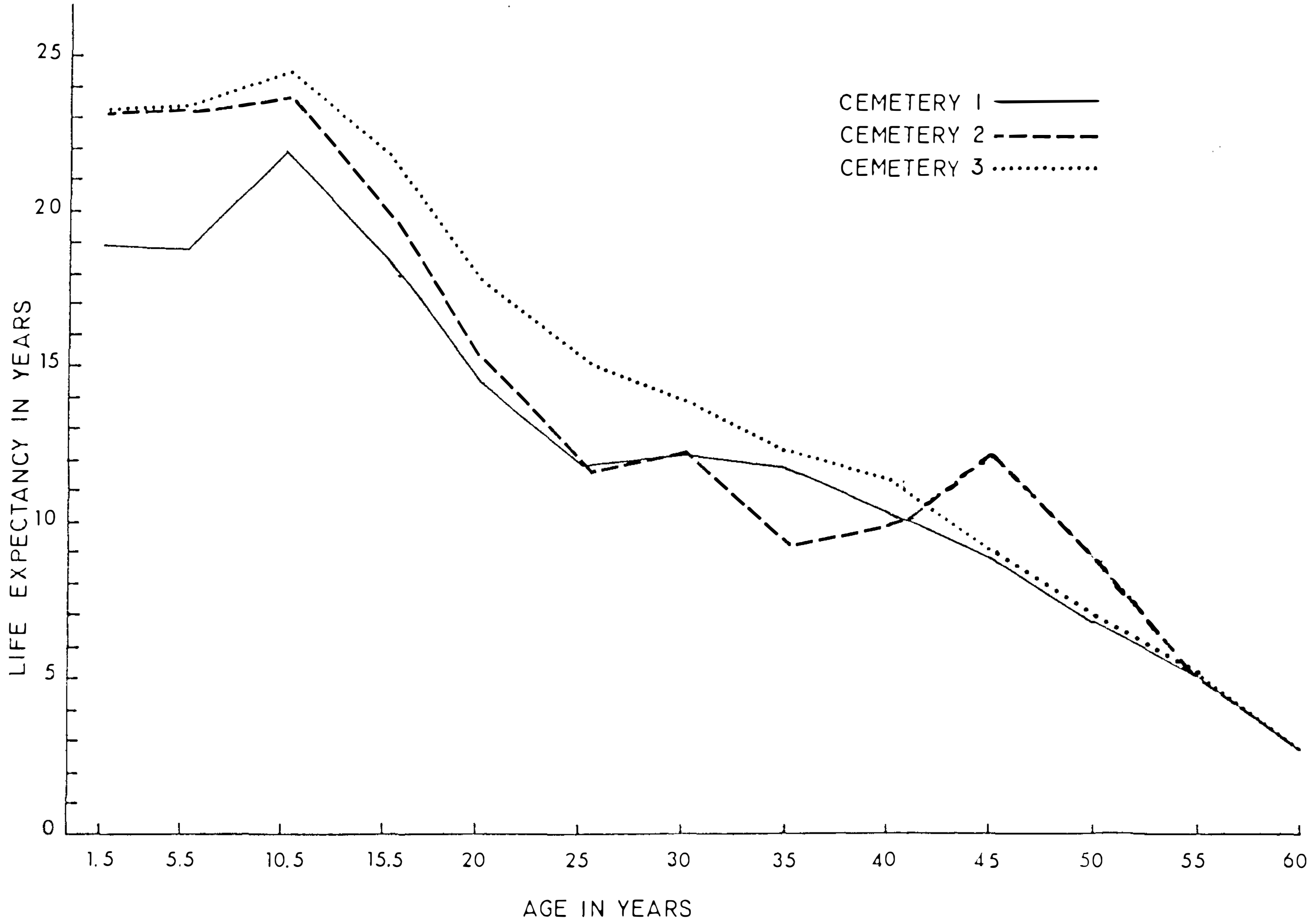



Figure 24. Life expectancy for the males from Cemeteries 1, 2 and 3.

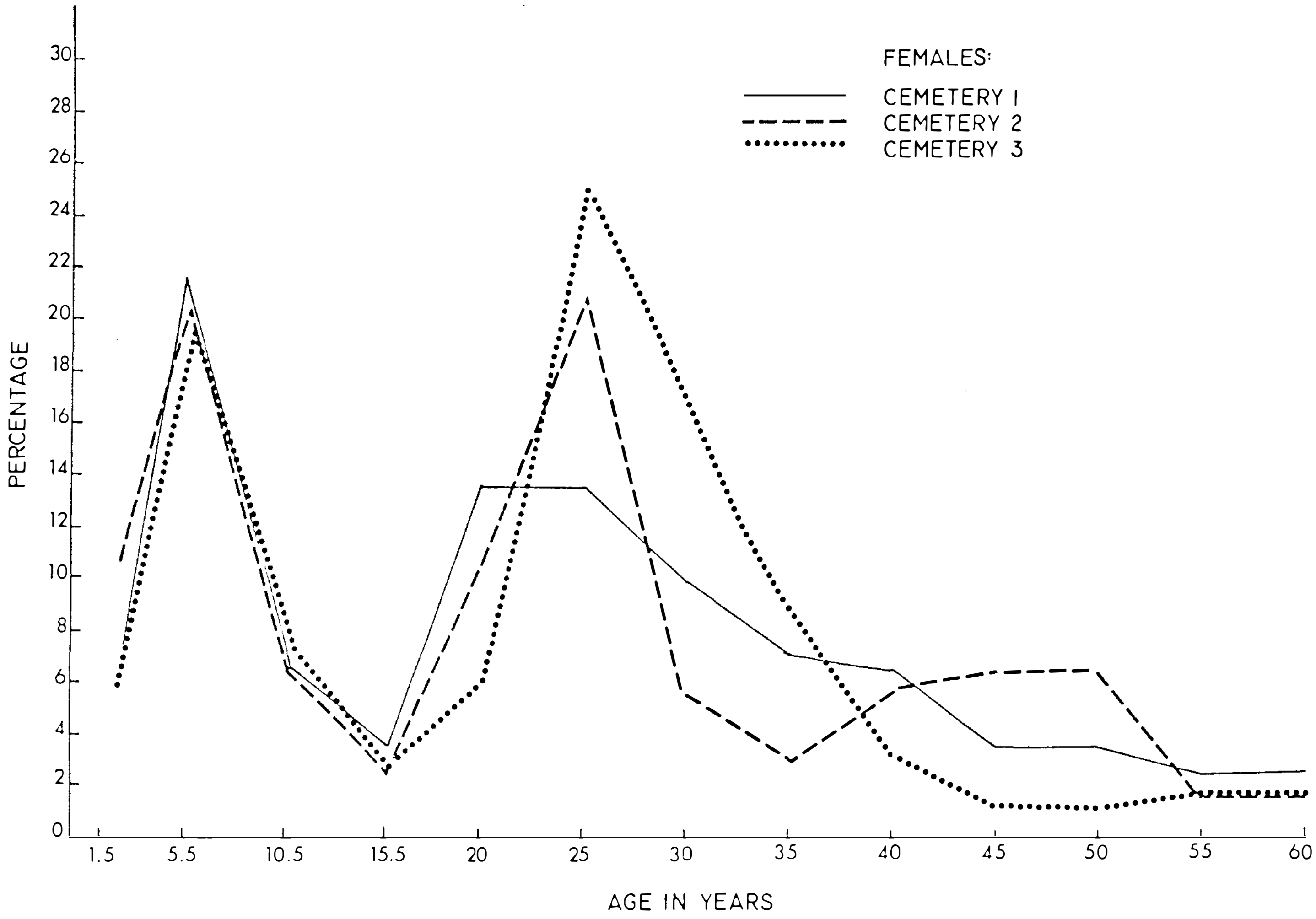



Figure 25. Age distribution of female mortality from Cemeteries 1, 2 and 3.

interval is least intense in Cemetery 3 ($dx_{1.5-5.5}$ = 19.58 percent), increases in Cemetery 2 ($dx_{1.5-5.5}$ = 20.32 percent), and is most intense in Cemetery 1 ($dx_{1.5-5.5}$ = 21.66 percent). Subadult mortality curves (10.5 to 15.5 year interval) are very similar to each other and increase from Cemetery 2, to 3 to 1. Young adult females experience high mortality in the 20 to 25 year interval. The most severely stressed group at this interval is Cemetery 3 ($dx_{20-25}$ = 25.06 percent), Cemetery 2 ($dx_{20-25}$ = 20.19 percent) is next and Cemetery 1 females ($dx_{20-25}$ = 13.12 percent) possess the lowest dx values. Female mortalities for all three cemeteries decrease after this interval and, with the exception of Cemetery 2, continue a basically downward trend for the remaining ages. Cemetery 2 females experience an increase between 40 and 50 years of age before decreasing sharply for a final time. The female age distributions for the three cemeteries are compared and Cemetery 1 and 3 are found to differ at the .005 level ($\chi^2$ = 19.787, df = 6).

Survivorship (lx) for Cemetery 3 females (Figure 26) is higher than that of the other two cemeteries at each age interval from birth to 30 years of age. After this age it becomes lower than the other two cemeteries until 50 to 55 years of age. The lx values of Cemetery 1 are intermediate to the other two cemeteries from birth to 20 years of age. Cemetery 2 females demonstrate the lowest survivorship between birth and the 15.5 to 20 year interval but become intermediate to the other two cemeteries from 20 to 25 years of age. From 25 to 35 years of age, Cemetery 2 lx values decrease below that of Cemetery 1. However, from 35 to 50 these values exceed those of both Cemeteries 1 and 3. At

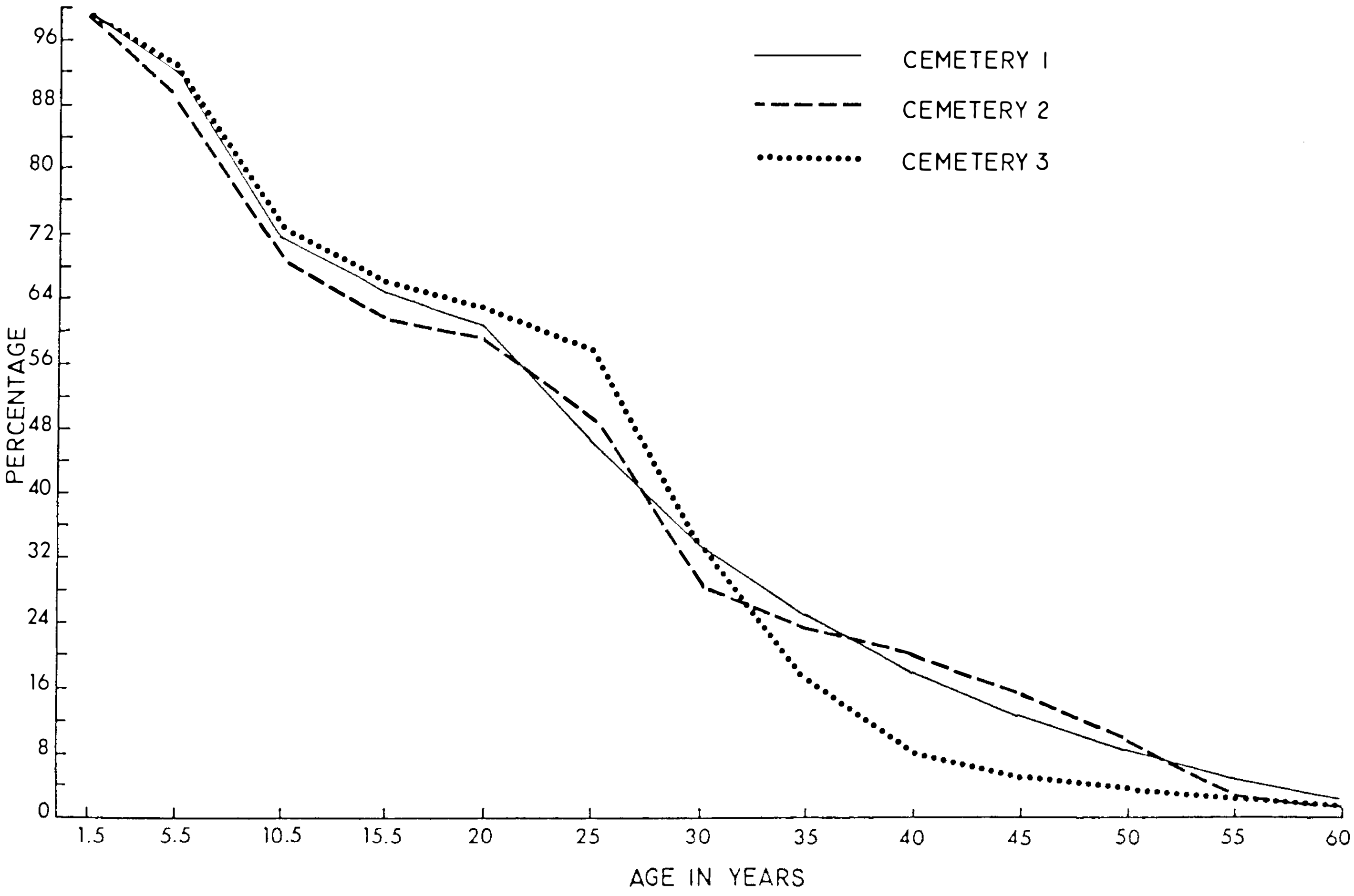



Figure 26. Survivorship of the females from Cemeteries 1, 2 and 3.

age 20 to 25, 58.32 percent of Cemetery 3 females survive; however, only 49.59 percent of the Cemetery 2 females and 47.83 percent of the Cemetery 1 females survive. At age 40 to 45, the greatest percentage of survivors is found among the Cemetery 2 females ($1x_{40-45}$ = 15.65 percent) while Cemetery 1 females ($1x_{40-45}$ = 12.03 percent) are second and Cemetery 3 females ($1x_{40-45}$ = 5.19 percent) possess the lowest 1x values. At age 55 to 60, 1.42 percent of Cemetery 3 females, 1.58 percent of Cemetery 2 females, and 2.45 percent of Cemetery 1 females remain.

The female probabilities of death (qx) for each of the cemeteries may be examined in Figure 27. The probabilities of death for the three cemeteries are very similar to each other at the 1.5 to 5.5 age category, with Cemeteries 3, 2 and 1 arranged in increasing order. This relationship is the same for the 10.5 to 15.5 age interval which represents the most healthy period of female life. The probability of death increases in the 15.5 to 20 age interval with Cemetery 3 females ($qx_{15.5-20}$ = .092) representing the least increase. Cemetery 2 females ($qx_{15.5-20}$ = .175) demonstrate moderate increase and Cemetery 1 females ($qx_{15.5-20}$ = .220) show the highest probability of death. This relationship reverses in the next age interval. The qx values increase from Cemetery 1 females ($qx_{20-25}$ = .274) to Cemetery 2 females ($qx_{20-25}$ = .407) to Cemetery 3 females ($qx_{20-25}$ = .430). The greatest difference in qx values appears at the 30 to 35 year interval. At this interval Cemetery 3 females ($qx_{30-35}$ = .521) are elevated. This relationship reverses at 45 to 50 years of age to produce a second quite diverse set of curves. Above 25 years of age, the qx curves for Cemeteries 2 and 3 become much more

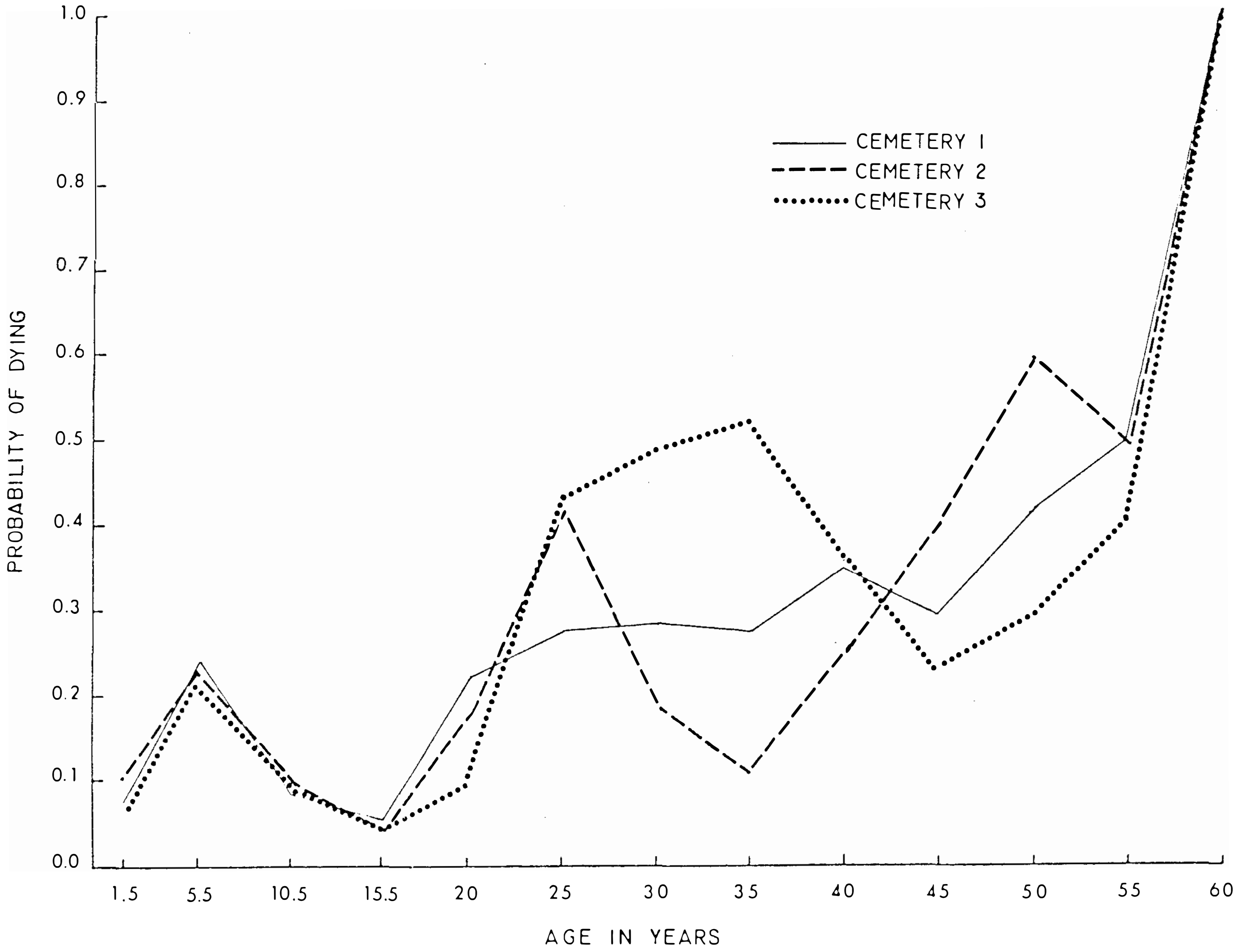



Figure 27. Probabilities of death for the females from Cemeteries 1, 2 and 3.

erratic than that of Cemetery 1. Small sample size may explain the erratic character of Cemetery 2's curve.

The life expectancy ($e^o$) curves for females is presented in Figure 28. From 5.5 to 20 years of age Cemeteries 3, 1 and 2 are ordered from the lowest to highest $e^o$ values. Cemetery 1 females surviving to the 20 to 25 year interval can expect to live an additional 13.56 years. Cemetery 2 and 3 females at this level can expect to live an additional 13.01 and 8.66 years, respectively. Female life expectancy is most diverse in the 25 to 30 age interval. Cemetery 2 females reaching this age can expect to live 15.23 years longer, Cemetery 1 females 12.74 years, and Cemetery 3 females 8.30 years. After this the $e^o$ curves of Cemeteries 2 and 3 reverse and reach their maximum difference at 40 to 45 years of age. Cemetery 3 females surviving to the 40 to 45 year age interval can expect to live 10.45 years longer, Cemetery 1 females 9.08 years and Cemetery 2 females 7.02 years.

## V. SUMMARY AND CONCLUSION OF AVERBUCH INTERCEMETERY DEMOGRAPHIC COMPARISONS

The crude mortality rate and life expectancy at birth for each cemetery are presented in Table 17, and provide a convenient summary and comparison of the overall cemetery-specific stress. Cemetery 1 males are the most stressed group of the three cemeteries with a crude mortality rate of 52.49. The males of Cemetery 3 possess a crude mortality rate of 42.61 and represent the least stressed. The females demonstrate the opposite relationship. Cemetery 3 female crude mortality rate (51.44) is higher than that of Cemetery 1 (49.50). The

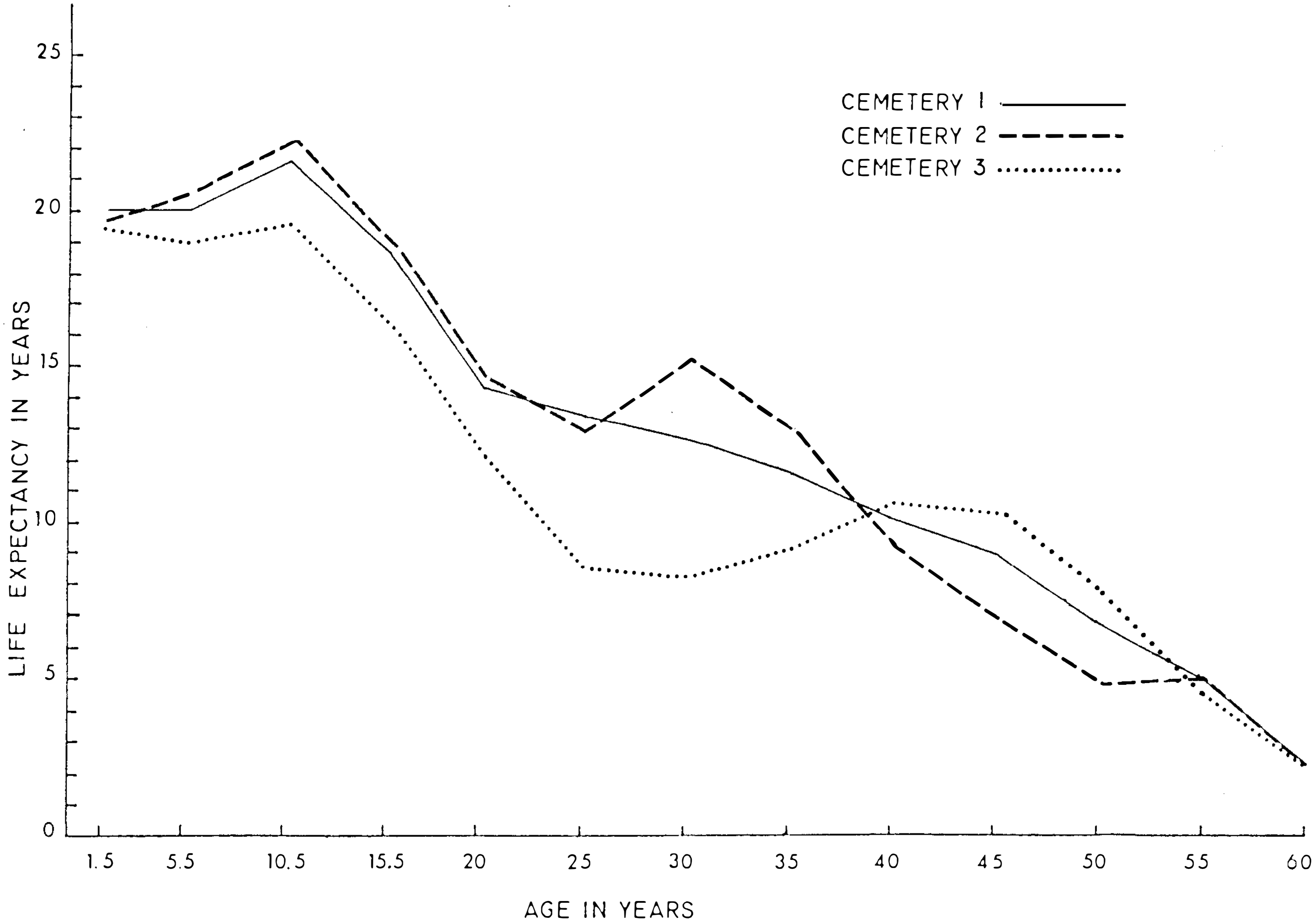



Figure 28. Life expectancy for the females from Cemeteries 1, 2 and 3.

TABLE 17

COMPARISON OF CEMETERY SPECIFIC LIFE EXPECTANCIES AND CRUDE MORTALITY RATES

| Males | | | Females | | |
|---|---|---|---|---|---|
| Cemetery | Life Expectancy at Birth | Crude Mortality Rate | Cemetery | Life Expectancy at Birth | Crude Mortality Rate |
| 1 | 19.05 | 52.49 | 3 | 19.44 | 51.44 |
| 2 | 23.29 | 42.94 | 2 | 19.85 | 50.38 |
| 3 | 23.47 | 42.61 | 1 | 20.20 | 49.50 |

life expectancies at birth reflect the same relationships. However, female life expectancies at birth as well as the crude mortality rates demonstrate much less difference than does that of the males (see Table 17). For example, the least stressed females from Cemetery 1 could expect to live only nine months longer than the most stressed females of Cemetery 3. In contrast, the least stressed males of Cemetery 3 could expect to live approximately four and one half years longer than the most stressed males of Cemetery 1. Cemetery 2 males exhibit values more closely aligned to those of Cemetery 3 than to those of Cemetery 1, but its questionable temporal placement and function renders it of little use.

The evidence presented thus far indicates that the Averbuch inhabitants, both male and female, experienced a great deal of stress throughout the occupation of the site. The intensity of the stress is seen to remain fairly constant for the females through time but to increase with the males. Although the Averbuch people probably experienced the same pressures which brought about a demise or disappearance of other late Mississippian groups from the Nashville Basin, the source of this pressure is as yet uncertain.

A temporal examination of the age and sex specific changes in mortality may provide some degree of insight into the nature of the stress experienced by the Averbuch people. The overall high degree of stress for both sexes is suggestive of diseases or nutritional problems that were constant through time. Epidemic or highly contagious disease may be ruled out, since the pattern of adolescent mortality for each

of the three cemeteries does not conform to that expected under such conditions. The increase in stress experienced by the males, as opposed to the females, must be more closely scrutinized for an adequate explanation.

Cemetery 1 and 3 male mortality curves demonstrate little diversity at most of the age intervals examined. Basically, the males of Cemetery 1 exhibit a higher mortality rate during the first half of life while Cemetery 3 male mortality is higher throughout the later half of life. The 20 to 25 year age interval shows a 5.5 percent increase in mortality from the earlier to later occupants of the site. An increase in deaths during this age interval is suggestive of an increase in social stress as expressed through warfare. However, a chi-square analysis of the male mortality profiles for the three cemeteries produces no significant differences.

Chi-square was also used to test the age distributions of the females from each of the cemeteries. The only significant difference noted was between Cemeteries 1 and 3 ($\chi^2 = 19.787$, $p > .005$). Cemetery 1 and 3 female mortality curves demonstrate little diversity prior to the 15.5 to 20 year age interval. Cemetery 3 mortality increases from 15.5 to 25 years of age. An increase in deaths for females at this age is not unusual and is attributed to the stress experienced during the child-bearing years. The significant difference between the cemeteries result both from the pronounced increase in Cemetery 3 mortality at 20 to 25 years of age and the truncation of Cemetery 1 female mortality during this age. The intense stress experienced by Cemetery 3 females can

only partially result from complications associated with childbirth and pregnancy. Temporally, Cemetery 3 predates Cemetery 1, and archaeologically it also predates the palisade wall. The females in the 20 to 25 year category were probably the most active participates in subsistence activities away from the village. Such activities plus the absence of a palisade wall may have rendered this group more vulnerable to social stress in the form of raids. This interpretation may also account for significant difference ($\chi^2 = 22.300$, $p > .005$) between the male and female age distribution of deaths at Cemetery 3. The decrease in female deaths in the 20 to 25 year category from Cemetery 1 may reflect the beneficial effects of the palisade wall. Perhaps the truncation in the female mortality curve at this age reflects a decrease in female deaths from childbearing and/or subsistence activity. Or, perhaps the young adult females from Cemetery 1 were subjected to social or cultural rules which resulted in their burial outside of Cemetery 1. The increase in Cemetery 2 female dead in the 20-25 year interval suggests that the "missing" Cemetery 1 females were buried in Cemetery 2.

According to Moore et al. (1975:69) the life table ". . . provides a framework, not for the testing of paleodemographic hypotheses, but for the generation of hypotheses." The interpretations presented above bear this out. The remainder of this study is dedicated to further investigation of these interpretations and the general nature of stress at Averbuch.

# CHAPTER V

## BIOLOGICAL INDICATORS OF STRESS AT THE AVERBUCH SITE

### I. INTRODUCTION TO THE STRESS INDICATORS EXAMINED AT AVERBUCH

Averbuch crude mortality rate is high, and although warfare may be responsible to some degree, the contribution of biological stress (i.e., malnutrition, disease, etc.) to the overall increase in deaths cannot be overlooked. The Averbuch skeletal series is examined for three biological indicators of stress: stature reduction, Harris lines and enamel hypoplasia. The interrelationship of these indicators is studied and the implications of their occurrence are examined for the site as a whole, as well as the three cemeteries separately. Of particular interest are the temporal dynamics of stress at the site as expressed by the comparison of Cemeteries 1 and 3. Guagliardo's (1980) examination of dental asymmetry at Averbuch reveals a temporal increase in stress when the cemeteries are compared. He concludes that "These differences may reflect gradually increasing population pressures in the Nashville Basin" (Guagliardo 1980:61). This chapter examines these three indicators to determine whether they complement Guagliardo's results.

Decreased stature, Harris lines and enamel hypoplasia represent the end product of environmental insults affecting growth and development. The etiology and method of collection will now be reviewed for each of these indicators.

Stature

Adult stature is the ultimate culmination of both genetic and environmental factors. Johnston et al. (1976) suggest that growth and development prior to adolescence is largely regulated by the environment. During adolescence, hereditary (ethnic) factors are the primary controllers of growth (Johnston et al., 1976). Maximum potential stature varies between ethnic groups and immigration of taller outsiders may produce stature increase (Buikstra 1976a:38). Also, Mange (1964) presents evidence that stature may decrease as a result of endogamy. Coon (1965:153-154) notes that the unusually short stature of certain populations living at Lake Atitlan, Guatemala ". . . can probably be explained by local inbreeding and by dietary deficiencies . . ." Fortunately, the Averbuch population represents a single ethnic group who occupied the site for a relatively brief period, where it can be assumed that significant differences in stature between the cemeteries reflect different degrees of disease and dietary stress experienced during growth.

The environment can prevent maximum stature attainment through dietary limitations or differential access to food sources (Acheson, 1966; Blanco et al., 1974; Buikstra, 1976a; Haviland, 1967; Johnston et al., 1976) even within the same ethnic group. Miller (1974:167) examines stature of ancient Hawaiians and notes:

> There seems, therefore, to be rather good evidence that the chiefly class was likely to be taller and better formed than most of the common people, because an assured food supply for the ali'i meant that probably they were never subjected to short or prolonged periods of hunger, as were the lower classes.

Chronic illness occurring during adolescent or preadolescent growth may also restrict adult stature (Roche, 1974; Wells, 1967).

Prader et al. (1963) in Blanco et al. (1974:45) suggest that

> . . . compensatory acceleration of growth and differences in genetic growth potential could readily eclipse, in some children, a temporary arrest of growth. . .

Although this will obscure the extent to which episodes of disease and malnutrition contribute to differential stature within a population, several studies have demonstrated a relationship between increased stature and high social status (Buikstra, 1976a; Hatch and Willey, 1974; Haviland, 1967).

Both age and sex are sources of differential stature. Males are normally taller than females from the same population (Krogman, 1962). The female body is more resistant to change than that of the male. Wolański and Kasprzak (1976:549) note that

> . . . both disadvantageous and advantageous stimuli induce change first in males; only a much stronger stimulus induces change in females.

Averbuch male and female stature is examined separately.

Averbuch femoral and tibial length are measured according to definitions provided by Bass (1971). All measurable femora and tibiae, both left and right, are used. Bones with antemortem fractures or postmortem damage are deleted.

## Harris Lines

Harris lines (transverse lines, bone scars, lines of arrested growth) appear radiographically as lines of dense cancellous bone which traverse the marrow cavity of long bones. They vary in thickness

from a millimeter to more than a centimeter and are generally expressed symmetrically throughout the bones of the body. The lines occur with greater frequency in the distal tibia and appear with decreasing frequency in the proximal tibia, distal femur, distal radius, and metacarpals but rarely occur in the pelvis and scapula (Garn et al., 1968), Harris lines form only during the growing years, primarily in the very young.

Environmental stress of adequate severity arrests bone growth by preventing enlargement of the cartilage cells in the growth plates. The osteoblasts, unable to invade the cartilage cells, form a thin stratum of bone (i.e., primary stratum beneath the growth plate). When the stress passes, the primary stratum is thickened due to the immediate recovery of osteoblastic activity relative to the delayed cartilage cell formation (Park, 1964; Park and Richter, 1953).

Radiographic longitudinal studies of living children and experimental research on laboratory animals furnish much information concerning the etiology of transverse line formation. Malnutrition (vitamin A deficiency and kwashiorkor), starvation, severe dehydration, emotional disturbance, mental illness and disease (measles, whooping cough, influenza, laryngitis, chicken pox, scarlet fever, congenital syphilis, diabetes and pneumonia) may produce transverse lines (Acheson, 1959; Garn et al., 1968; Gindhart, 1969; Harris, 1933; Jones and Dean, 1959; McCance et al., 1961; Park, 1964; Platt and Stewart, 1962; Sontag and Comstock, 1938; Sontag and Harris, 1938; Wolbach, 1947). The application of Harris line data to evaluate the health and nutritional status of skeletal

populations is demonstrated by Allison et al., (1974), Buikstra (1976b), McHenry (1968), and Wells (1961, 1963, 1964).

Since Garn et al. (1968) determined that Harris line frequency is higher in the distal and proximal tibia than any other bone, radiographs of Averbuch tibiae are taken for line count. Adults of both sexes are used but reconstructed or grossly pathological bones are excluded for fear that the lines were destroyed. Only lines which extend at least one third the transverse diameter of the tibia shaft are noted as present (Buikstra, 1976b) and oblique lines as described by McHenry (1968) for the femur are excluded. Both the proximal and distal aspects of the tibia are examined. The age at which the line formed is estimated in accord with Allison et al. (1974) with some alteration. To estimate the age at which the line formed, tibia length at birth (estimated at 70 mm) is subtracted from maximum diaphyseal length providing the amount the bone has grown since birth. Since tibia growth is disproportional, three-fifths of the growth is attributed to the proximal end and two-fifths to the distal end. Each end is then divided into a number of equal segments equivalent to the number of years of growth experienced by the individual (i.e., a maximum of sixteen years for females and eighteen years for males). These age intervals are marked on the radiographs and the maximum number of stress periods is estimated by recording the age at which each line (proximal and distal) formed. For example, if a tibia or pair of tibiae are examined and proximal and distal lines are found which occur close to the same year of age, it is considered to represent one period of stress. Thus, the total number

of stress periods experienced by an individual is important, not the total number of Harris lines occurring in the bone. The total number of Harris lines is also recorded for the left and right distal tibia when possible.

An x-ray machine manufactured by Litton Medical Systems (model: Jupiter 300, 150KV) is used. Adult bones are exposed to 50 MA and 70 KVP for .1 second while subadult bones require 50 MA and 58 KVP for .1 second. The majority of the radiographs are of excellent quality. However, some of the radiographs of tibiae from perinatal dead are radiotransparent and cannot be used.

## Enamel Hypoplasia

The teeth, the most durable structures of the body, are commonly recognized as valuable indicators of biological adaptation and stress (Perzigian, 1977). Ameloblastic cells are among the most sensitive in respect to metabolic functions and act to record periods of stress as a pathological condition termed enamel hypoplasia. Macroscopically, enamel hypoplasia appears as a defective formation of the organic enamel matrix. This pathology has been found not only in modern dentition dentitions but in the teeth of fossil humans as well (Brothwell, 1963; White, 1978). Two types of enamel hypoplasia are reported in the literature: hereditary and environmental. Shafer et al. (1974) discuss both types; however, only the environmentally induced form is of interest here.

Environmental enamel hypoplasia may involve either deciduous or permanent dentitions, with both enamel and dentin usually affected.

Sometimes only a single tooth may be altered (Shafer et al., 1974). Shafer et al. (1974:49-50) describe the range of expression:

> In mild environmental enamel hypoplasia, there may be only a few small grooves, pits or fissures on the enamel surface. . . . If the condition is more severe, the enamel may exhibit rows of deep pits arranged horizontally across the surface of the tooth. . . . There may be only a single row of such pits or several rows indicating a series of injuries. In the most severe cases, a considerable portion of enamel may be absent, suggesting a prolonged disturbance in the function of the ameloblasts.

The sources of enamel hypoplasia have been examined clinically and experimentally. Although it has no specific etiology, it is largely dependent on disease or nutritional conditions. Major systematic upsets responsible for enamel hypoplasia are starvation, nutritional deficiencies (e.g., vitamins A, C, and D, protein malnutrition), exanthematous diseases (e.g., measles, chicken pox, diphtheria, scarlet fever), failure of alimentary absorption due to intestinal irritation (e.g., chronic gastroenteritis), birth injury or prematurity, local infection or trauma, congenital syphilis, hypocalcemia, ingestion of certain chemicals (e.g., fluoride) and idiopathic causes (Cobly et al., 1971; Giro, 1947; Kraus et al., 1969; Molnar and Ward, 1975; Sciulli, 1977, 1978; Shafer et al., 1974; Spouge, 1973). The frequency of enamel hypoplasia is used to explore health conditions in skeletal as well as living populations (Cook and Buikstra, 1973; El-Najjar et al., 1978; McHenry and Schulz, 1976; Rose, 1977; Rose et al., 1978; Saul, 1972; Sciulli, 1977, 1978).

Only environmentally induced enamal hypoplasia is recorded for the Averbuch material. Hereditary enamel hypoplasia normally involves most

of the tooth's enamel. Those observations in which the distinction between environmental and hereditary enamel hypoplasia is uncertain are eliminated from the study. The major emphasis is the recording of the frequency of occurrence and its distribution according to age and sex. Averbuch mandibular canines, second and third molars, and maxillary central and lateral incisors, except those limited by attrition, are examined for this pathology. Only relatively complete dentitions are utilized. Crown development of these teeth covers an age range from the prenatal period to twelve and one half years. The general age at which the stress occurred is estimated for these teeth with the Moorrees et al. (1963a, 1963b) standards.

The range of severity, as modified from Shafer et al. (1974), is recorded as follows:

0 = Absence of enamel hypoplasia.

1 = Enamel hypoplasia is present in the form of a few small pits or a single groove.

2 = Enamel hypoplasia is present in the form of a row of deeper pits, a single more pronounced groove, or two or more slight grooves.

3 = Enamel hypoplasia is expressed in two or more deeply pitted rows or grooves or the absence of a considerable portion of the enamel.

4 = The condition is indeterminate due to damaged or missing teeth.

## II. RELATIONSHIP OF THE THREE STRESS INDICATORS

A prerequisite to this portion of the study is an examination of the interrelationship of the three stress indicators as expressed by the degree to which they correlate. Since stature increase has been associated with improved nutrition and health conditions, it seems reasonable that the taller individuals within a skeletal series consist of those less stressed during growth. Wells (1967) notes that it is reasonable to assume that a person who has experienced many episodes of arrested growth will have a reduced final stature; however, Gindhart (1969) observed little relationship between Harris line formation and significant growth retardation. An examination of the relationship between Averbuch stature and Harris line frequency may reveal much concerning this assumption. Also, since Harris lines and enamel hypoplasia have similar etiologies, a close relationship is expected. However, McHenry and Schulz (1976) found no significant association between the two.

An SPSS package program (SCATTERGRAM) is employed to examine the extent to which the three variables correlate and the subprogram for the Pearson product-moment correlation is used. The formula for Pearson product-moment correlation is calculated as follows:

$$r = \frac{\sum_{i=1}^{N} (X_i - \overline{X})(Y_i - \overline{Y})}{\left\{\left[\sum_{i=1}^{N} (X_i - \overline{X})^2\right]\left[\sum_{i=1}^{N} (Y_i - \overline{Y})^2\right]\right\}^{1/2}}$$

where $X_i$ = ith observation of variable X

$Y_i$ = ith observation of variable Y

N = number of observations

$\overline{X} = \sum_{i=1}^{N} X_i/N$ = mean of variable X

$\overline{Y} = \sum_{i=1}^{N} Y_i/N$ = mean of variable Y

Nie et al. (1975:280)

Table 18 provides a summary of the findings for both males and females. As illustrated, none of the correlation coefficients are significant at the .05 level.

Both maximum femur and tibia lengths are examined against the number of Harris lines occurring in the distal right tibia. Although Wells' (1967) proposal of decreased stature with increased episodes of arrested growth seems feasible, the present study is in complete agreement with Gindhart (1969) and can demonstrate no correlation between the two (see Table 18). The relationship of the maximum number of stressful episodes, as expressed by the age specific occurrence of Harris lines in the tibiae, are also tested against tibial length. No significant correlation can be demonstrated between these two for either sex. The remodeling and disappearance of these lines with increasing age, as described by Garn and Schwager (1967) could be responsible for a distortion of the results and thus a lack of correlation. However, an examination of the correlation coefficients of the number of lines found in the right distal tibia and increasing adult age (see Table 18) reveals an absence of any significant correlation at the .05 level. The best explanation for the lack of a significant correlation between

TABLE 18

CORRELATION COEFFICIENTS OF THE VARIOUS STRESS INDICATORS (PAIRED) FOR AVERBUCH MALES AND FEMALES

| Paired Variables* | Male N | Male r | Male Signif. | Female N | Female r | Female Signif. |
|---|---|---|---|---|---|---|
| FEMX with RDIST | 47 | -0.016 | 0.911 | 29 | -0.186 | 0.333 |
| TIBMX with RDIST | 49 | -0.036 | 0.801 | 28 | 0.048 | 0.805 |
| TIBMX with HRMAX | 62 | 0.190 | 0.137 | 43 | 0.222 | 0.151 |
| TIBMX with EHYPCSV | 50 | 0.110 | 0.444 | 47 | -0.200 | 0.175 |
| TIBMX with EHYNO | 37 | 0.162 | 0.335 | 32 | 0.044 | 0.810 |
| RDIST with EHYPCSV | 31 | 0.070 | 0.705 | 23 | 0.059 | 0.787 |
| HRMAX with EHYNO | 27 | 0.018 | 0.926 | 20 | -0.097 | 0.683 |
| AGE with RDIST | 51 | 0.087 | 0.541 | 31 | -0.030 | 0.868 |

*FEMX = Maximum femur length.

TIBMX = Maximum tibia length.

RDIST = The number of Harris lines in the right distal tibia.

HRMAX = The maximum number of stressful periods as expressed by Harris lines in the proximal and distal ends of left and/or right tibia.

EHYPCSV = Severity of enamel hypoplasia as expressed on paired adult mandibular canines.

EHYNO = The maximum number of stressful periods as expressed by enamel hypoplasia in the teeth outlined in the text.

AGE = Adults 15.5 years of age to 50+ by five year intervals.

Harris line number and stature is that offered by Prader et al. (1963). They point out that catch up growth during adolescence may compensate for any growth arrest which occurred earlier in life.

As previously stated, enamel hypoplasia and Harris lines are similar in their etiology and the mechanisms involved in their formation. One advantage an analysis of enamel hypoplasia offers over that of Harris lines is that Harris lines are suspect due to their possible resorption with age while enamel hypoplasia lines are permanent. Their presence is masked only by dental attrition. It is for this reason that dentitions with moderate to excessive wear are excluded.

When the correlation coefficients of the severity of the enamel hypoplasia, as expressed on the permanent mandibular canines, and maximum tibial length are examined, no significant correlation is noted for males or females. The maximum number of stressful periods as expressed by a general examination of each dentition is paired with maximum tibial length and the resulting correlation coefficients for each sex are not significant. Stress, as expressed by the presence of enamel hypoplasia, is obvious among the Averbuch population. Stress intense enough to interfere with enamel formation would probably alter longbone growth. However, as with the interpretation of the Harris line/tibial length relationship, adolescent catch-up growth may mask any disruption of growth during childhood.

Since both Harris lines and enamel hypoplasia are produced by biological stress and form in much the same fashion, an examination of the degree to which they correlate is of interest. The number of Harris

lines in the right distal tibia is paired with the severity (slight, moderate, and extreme) of enamel hypoplasia occurring on the manidbular canines. Neither male nor female correlation coefficients are significant. Surprisingly, these results seem to suggest that Harris line number and enamel hypoplasia severity share no underlying commonalities.

It must be emphasized that Harris lines represent an enumeration of each stress period experienced from birth to sixteen or eighteen years of age. In addition, the severity of enamel hypoplasia reflects the number of lines as well as the extent to which the enamel is affected. These observations are made on mandibular canines, the crown of which forms between birth and 4.5 years of age. For example, the enamel hypoplasia "extreme stress" category contains individuals whose canines express extreme single or multiple responses to single or multiple episodes of stress occurring between birth and 4.5 years of age. Thus, the lack of a significant correlation between these two stress indicators may be expressed in a simple, more direct fashion. Those individuals who experienced repetitive or seasonal stress (as represented by Harris lines) did not necessarily express evidence of extreme stress (as represented by enamel hypoplasia) between birth and 4.5 years of age. Once viewed in this manner, it is not surprising to find a lack of correlation.

Of particular interest is the pairing of the maximum number of stress periods expressed by Harris lines with the maximum number expressed by enamel hypoplasia. If, as it is assumed, each of these two indicators represent two different ways of acquiring the same

information (i.e., the number of stress episodes experienced by an individual), then a high positive correlation would be expected between them. However, as can be seen in Table 18, page 130, no significant correlation can be found between these two for either sex. This is difficult to interpret since any number of factors may account for these results.

One of the first and most obvious factors involves the manner in which the data were collected. The maximum number of stressful periods, as determined from the Harris lines, is based on determining the age at which the line formed. This procedure is described earlier and mainly consists of dividing the bone, proximal and distal ends, into sixteen equal units for females and eighteen for males. Each of these "equal" units is assumed to roughly correspond to a year of growth. In reality the lengths of these units vary with the exception of the intervals from 5 to 12 years where growth is nearly linear. Although error may be introduced in this fashion, it is assumed that the maximum number of stress episodes obtained would reflect the general stress history of each individual.

A second factor that may contribute to this is that the dentition is more resistant to environmental influences than is bone. Episodes of stress that are severe enough to produce a Harris line in the bone may not upset enamel formation. It may also be conjectured that some individuals when stressed produce no Harris lines or lines of enamel hypoplasia, while others may react by producing a Harris line and yet some may produce only lines of enamel hypoplasia. Or perhaps bone and enamel may be susceptible to lines only during certain periods of their development and perhaps these susceptible periods do not conincide.

If this is the case, then there may actually be no correlation between Harris lines and enamel hypoplasia; however, they both provide general avenues for examining population stress and will be treated as such in this study.

## III. STATURE, HARRIS LINES AND ENAMEL HYPOPLASIA AT AVERBUCH

Stature, Harris lines and enamel hypoplasia are examined in an attempt to better understand the biological stress to which these fifteenth century Middle Tennessee inhabitants were subjected. Each of these three stress indicators is described for the Averbuch series as a whole and a cemetery specific examination is used to better understand the temporal dynamics of each.

The stress data from each of the three cemeteries are compared via an analysis of variance derived from a SAS package program (Helwig and Council, 1979). SAS provides two procedures for an analysis of variance: ANOVA and GLM. The ANOVA procedure requires less storage and is faster than GLM for balanced designs. However, if the design is unbalanced, the output may be invalid. The GLM procedure can handle both balanced and unbalanced designs and is preferred for this study. The program produces two types of sums of squares, Type I and Type IV. Type I represents the sequential sum of squares, while Type IV represents the effects of each treatment conditioned on the others. In balanced designs, the two do not differ but in unbalanced designs they may differ considerably. The Type IV sum of squares are considered more conservative in unbalanced design, so the F ratio associated with Type IV sum of

squares is used to test whether the treatments have any effect on the dependent variable.

Stature

Since stature calculated from long bone lengths provide, at best, a rough estimation of true stature, raw femur and tibia measurements are used in an analysis of variance to examine the relationship of stature between the cemeteries. The dependent variables are femur and tibia length and the independent variables are sex and cemetery (Table 19).

Tables 20 and 21 provide an examination of the analysis of variance for femur and tibia length from each of the three cemeteries and both sexes. Both the femur and the tibia measurements are significantly (0.0001) different. The source of this diversity is further clarified in these tables by a breakdown of the analysis of variance model into its various treatments. Neither the cemetery nor the cemetery by sex interaction are responsible for this, but sex has a significant effect at the 0.0001 level.

A Duncan's multiple range test is used to test the mean femur and tibia length for both sexes with the cemeteries pooled (Table 22) and for the three cemeteries with the sexes pooled (Table 23). The results exhibit a significant difference ($p \geq .05$) for the sexes while femur and tibia lengths between the cemeteries are indistinguishable.

Trotter and Gleser (in Huber, 1968:72) note that

> . . . the sum of the lengths of femur and tibia yield the most reliable estimation of stature, then the length of the femur alone, then that of the tibia . . .

TABLE 19

MAXIMUM FEMUR AND TIBIA MEAN LENGTHS AND STANDARD DEVIATIONS FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| | | Femur | | | Tibia | | |
|---|---|---|---|---|---|---|---|
| Cemetery | Sex | N | Mean | S.D. | N | Mean | S.D. |
| 1 | M | 56 | 451.02 | 18.6 | 55 | 373.11 | 16.7 |
| 1 | F | 55 | 420.49 | 16.9 | 38 | 342.89 | 14.6 |
| 2 | M | 16 | 443.94 | 18.0 | 10 | 367.80 | 22.0 |
| 2 | F | 7 | 424.71 | 25.7 | 5 | 344.20 | 8.6 |
| 3 | M | 15 | 447.93 | 17.6 | 9 | 370.67 | 13.5 |
| 3 | F | 10 | 428.70 | 11.0 | 9 | 345.44 | 11.6 |

TABLE 20

ANALYSIS OF VARIANCE FOR FEMUR LENGTHS FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Source | DF | Sum of Squares | Mean Square | F Value | P |
|---|---|---|---|---|---|
| Model | 5 | 30301.06 | 6060.21 | 19.03 | 0.0001 |
| Error | 153 | 48736.13 | 318.54 | | |
| Type I | | | | | |
| CEM | 2 | 280.86 | 140.43 | 0.44 | 0.6443 |
| SEX | 1 | 29023.25 | 29023.25 | 91.11 | 0.0001 |
| CEM*SEX | 2 | 996.95 | 498.48 | 1.56 | 0.2124 |
| Type IV | | | | | |
| CEM | 2 | 189.97 | 94.99 | 0.30 | 0.7426 |
| SEX | 1 | 11661.74 | 11661.74 | 36.61 | 0.0001 |
| CEM*SEX | 2 | 996.95 | 498.48 | 1.56 | 0.2124 |

n = 159 (all measurable adult femora are included).

TABLE 21

ANALYSIS OF VARIANCE FOR TIBIA LENGTHS FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Source | DF | Sum of Squares | Mean Square | F Value | P |
|---|---|---|---|---|---|
| Model | 5 | 25347.73 | 5069.55 | 20.18 | 0.0001 |
| Error | 120 | 30145.55 | 251.21 | | |
| Type I | | | | | |
| CEM | 2 | 117.11 | 58.56 | 0.23 | 0.7924 |
| SEX | 1 | 25038.02 | 25038.02 | 99.67 | 0.0001 |
| CEM*SEX | 2 | 192.60 | 96.30 | 0.38 | 0.6824 |
| Type IV | | | | | |
| CEM | 2 | 48.03 | 24.02 | 0.10 | 0.9089 |
| SEX | 1 | 11022.70 | 11022.70 | 43.88 | 0.0001 |
| CEM*SEX | 2 | 192.60 | 96.30 | 0.38 | 0.6824 |

n = 126 (all measurable adult tibiae are included).

TABLE 22

DUNCAN'S MULTIPLE RANGE TEST OF FEMUR AND TIBIA LENGTH BETWEEN AVERBUCH MALES AND FEMALES

| Bone | Sex | Mean | Number | Grouping[1] |
|---|---|---|---|---|
| Femur | Male | 449.18 | 87 | A |
| | Female | 422.04 | 72 | B |
| Tibia | Male | 372.09 | 74 | A |
| | Female | 343.46 | 52 | B |

[1]Means with the same letter are not significantly different at the .05 level.

TABLE 23

DUNCAN'S MULTIPLE RANGE TEST OF FEMUR AND TIBIA LENGTH BETWEEN THE THREE AVERBUCH CEMETERIES

| Bone | Cemetery | Mean | Number | Grouping[1] |
|---|---|---|---|---|
| Femur | 1 | 435.89 | 111 | A |
| | 2 | 438.09 | 23 | A |
| | 3 | 440.24 | 25 | A |
| Tibia | 1 | 390.76 | 93 | A |
| | 2 | 359.93 | 15 | A |
| | 3 | 358.05 | 18 | A |

[1]Means with the same letter are not significantly different at the .05 level.

Relatively few Averbuch skeletons possess both an intact femur and tibia. For this reason, estimates used in the descriptive summary of Averbuch stature and its comparison to other sites are calculated solely from femoral measurements. Both right and left femur means are examined for the three cemeteries and the site as a whole. Although the difference in left and right mean values is slight, the side with the greater value is used.

The Trotter and Gleser (1952) regression formulae for mongoloid males and, due to a lack of regression formulae for mongoloid females, white females are used to calculate Averbuch stature. The average Averbuch male was 168.87 cm tall (5'6") and the average female stood 158.33 cm (5'2"). Compared to other archaeological populations, the Averbuch people were on the upper end of the stature continuum (Table 24). This is also true of the other Middle Cumberland populations (i.e., Arnold and Ganier) from the Nashville Basin. The shortest Averbuch male obtained a stature of 158.14 cm (5'2") and the tallest measured 179.43 cm (5'10"). The shortest "normal" Averbuch female was 146.48 cm (4'9") and the tallest 173.15 cm (5'8"). Of particular interest is burial 256A from Cemetery 1—a female of abnormally short stature. Unlike the skeletons of the two achondroplastic dwarfs from Moundville (Snow, 1943), the skeleton of burial 256A is a midget. The female stood only 111.90 cm (3'8") high and possessed limbs and trunk of normal proportion.

In conclusion, there exists no significant stature (femur or tibia length) difference between the three cemeteries. Under the

TABLE 24

A COMPARISON OF STATURES AMONG VARIOUS ARCHAEOLOGICAL SKELETAL POPULATIONS

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Femur Mean | | Stature | | Femur Mean | | Stature | |
| Population | cm | No. | cm | in | cm | No. | cm | in |
| Arnold[1] | 42.80 | 14 | 164.59 | 64.19 | 42.90 | 2 | 160.06 | 62.42 |
| Arikara[2] | 44.68 | 164 | 168.63 | 65.77 | 41.50 | 159 | 156.61 | 61.08 |
| Averbuch | 44.92 | 87 | 168.87 | 65.86 | 42.20 | 72 | 158.33 | 61.75 |
| Dallas[3] | ----- | 117 | 168.38 | 65.67 | ----- | 94 | 157.89 | 61.58 |
| Ganier[1] | 44.06 | 6 | 167.30 | 65.25 | 41.80 | 4 | 157.35 | 61.37 |
| Indian Knoll[4] | 43.71 | 263 | 166.68 | 65.01 | 41.27 | 192 | 156.04 | 60.86 |
| Point of Pines[5] (Middle Pop.) | 42.65 | 37 | 164.27 | 64.07 | 39.88 | 37 | 152.60 | 59.51 |
| Point of Pines[5] (Late Pop.) | 43.77 | 31 | 166.68 | 65.01 | 40.38 | 40 | 153.84 | 60.00 |

[1]Ward (1972). [2]Bass et al. (1971). [3]Hatch and Willey (1974). [4]Snow (1948).
[5]Bennett (1973b).

assumption of this study there is a positive correlation between stature increase and improved health and nutrition. The Averbuch people obtained a stature which is among the tallest reported for an American Indian skeletal series. Above average stature is a characteristic of Averbuch during the earlier (Cemetery 3) and later (Cemetery 1) phases of its existence. Whatever the source of the biological stress at the site, its intensity, as expressed through stature, seems to have been constant with time. Averbuch demography is suggestive of intense stress of both a social and environmental nature. Thus, the demographic and stature results are somewhat inconsistent. Perhaps the genetic growth potential at Averbuch was much greater than that achieved by the inhabitants. It is more likely that arrested growth at Averbuch was temporary, and the adolescent acceleration in growth may have compensated for stature losses during childhood periods of disease or malnutrition. Catch-up growth during adolescence may have allowed individuals to approximate their genetically programed growth potential.

It must be concluded that adult stature is, at best, a questionable approach to the study of biological stress at the Averbuch site. A comparison of age specific preadolescent stature at the site is suggested as a more profitable approach for future studies of this nature.

## Harris Lines

As with stature, an analysis of variance is employed in determining the relationship of the three cemeteries based on the occurrence of lines. The dependent variables are the number of lines in the right

distal tibia and the number of stress episodes represented by the presence of these lines in the tibiae in general. The independent variables are sex and cemetery.

Table 25 presents an overall analysis of variance of the number of Harris lines recorded for the right distal tibia of both sexes and the three cemeteries. The F value of 0.63 is far from significant (p = 0.6814). This table also provides a breakdown of the model into its components but no significant difference is observed.

The overall analysis of variance for the number of stress episodes is presented in Table 26. The F value (1.30) is not significant nor are the three components of the conservative Type IV sum of squares.

The mean number of distal tibia lines and stress episodes, as expressed by a general examination of both left and right tibiae, is presented in Table 27 and 28, respectively. The Cemetery 1 males experience a slightly greater number of stress episodes (3.10) than do those of Cemetery 3 (2.67). The females from these two cemeteries demonstrate the opposite relationship. Cemetery 1 females experience fewer episodes of stress (2.27) than Cemetery 3 females (2.67).

The maximum number of Harris lines visible in the right distal tibiae may be suggestive of the character of the stress at the Averbuch site. For example, McHenry (1968:4) notes that the high frequency of lines occurring in the femora of California Indians is suggestive of ". . . acute starvation followed by a period of good nutrition." The frequency of Harris line occurrence is recorded for 86 Averbuch right distal tibiae (54 males and 32 females). Of this number, 76 individuals

TABLE 25

ANALYSIS OF VARIANCE FOR HARRIS LINE NUMBER OF THE RIGHT DISTAL TIBIA FOR BOTH SEXES AND THE AVERBUCH CEMETERIES

| Source | DF | Sum of Squares | Mean Square | F Value | P |
|---|---|---|---|---|---|
| Model | 5 | 5.80 | 1.16 | 0.63 | 0.68 |
| Error | 79 | 146.01 | 1.85 | | |
| Type I | | | | | |
| CEM | 2 | 0.80 | 0.40 | 0.22 | 0.81 |
| SEX | 1 | 3.40 | 3.40 | 1.84 | 0.18 |
| CEM*SEX | 2 | 1.60 | 0.80 | 0.43 | 0.65 |
| Type IV | | | | | |
| CEM | 2 | 1.34 | 0.67 | 0.36 | 0.70 |
| SEX | 1 | 1.48 | 1.48 | 0.80 | 0.37 |
| CEM*SEX | 2 | 1.60 | 0.80 | 0.43 | 0.65 |

TABLE 26

ANALYSIS OF VARIANCE FOR THE TOTAL NUMBER OF STRESS EPISODES EXPERIENCED, AS EXPRESSED BY HARRIS LINES IN THE TIBIA, IN BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Source | DF | Sum of Squares | Mean Square | F Value | P |
|---|---|---|---|---|---|
| Model | 5 | 20.30 | 4.06 | 1.30 | 0.27 |
| Error | 110 | 342.90 | 3.12 | | |
| Type I | | | | | |
| CEM | 2 | 4.24 | 2.12 | 0.68 | 0.51 |
| SEX | 1 | 13.09 | 13.09 | 4.20 | 0.04 |
| CEM*SEX | 2 | 2.97 | 1.49 | 0.48 | 0.62 |
| Type IV | | | | | |
| CEM | 2 | 4.40 | 2.20 | 0.71 | 0.50 |
| SEX | 1 | 5.25 | 5.25 | 1.68 | 0.20 |
| CEM*SEX | 2 | 2.97 | 1.49 | 0.48 | 0.62 |

TABLE 27

MEAN NUMBER OF STRESS EPISODES—BASED ON THE TIBIA—FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Cemetery | Sex | N | Mean |
|---|---|---|---|
| 1 | M | 49 | 3.10 |
| 1 | F | 33 | 2.27 |
| 2 | M | 8 | 2.50 |
| 2 | F | 5 | 1.60 |
| 3 | M | 12 | 2.67 |
| 3 | F | 9 | 2.67 |

TABLE 28

RIGHT DISTAL TIBIA HARRIS LINE MEAN FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Cemetery | Sex | N | Mean |
|---|---|---|---|
| 1 | M | 37 | 1.95 |
| 1 | F | 23 | 1.43 |
| 2 | M | 5 | 1.80 |
| 2 | F | 3 | 1.00 |
| 3 | M | 12 | 1.83 |
| 3 | F | 5 | 2.00 |

(88.37 percent) exhibit one or more lines. A larger portion of males (92.59 percent) exhibit Harris lines than females (81.25 percent). The average number of lines expressed for Averbuch males is 1.9 per distal tibia while females averaged 1.5. The maximum number of lines expressed by Averbuch males (7) and females (7) is far less than that observed by McHenry (1968) for the California series (20) and equal to that found by Allison et al. (1974) for a Peruvian series (7). The breakdown of the percentage of individuals according to the number of lines expressed is presented in Table 29. No statistically significant difference exists between the number of males and females who have no Harris lines and one Harris line. However, of those individuals who exhibit more than two Harris lines, the males (57.5 percent) significantly ($p \geq .005$) outnumber the females (37.5 percent).

The morbidity at each age, as reflected by the age at which the lines form for both males and females, is presented in Table 30 and illustrated in Figure 29. The age interval which possesses the greatest percentage of individuals with Harris lines (males = 41.18 percent and females = 35.42 percent) is from birth to 0.5 year. The lowest percentage of individuals possessing lines (males = 5.88 and females = 2.08) occurs in the 10.5 to 11.5 age interval.

In conclusion, few Averbuch inhabitants were free of Harris lines. The females at the site appear to respond differently to stress than do the males. The percentage of males (92.59 percent) with lines in the distal tibia exceeds that of females (81.25 percent). The males possess a slightly greater mean number of lines (1.9) in the distal tibia than

TABLE 29

PERCENTAGE OF AVERBUCH MALES AND FEMALES POSSESSING VARIOUS NUMBERS OF HARRIS LINES IN RIGHT DISTAL TIBIAE

| No. of Lines | Males (n = 54) | | Females (n = 32) | |
|---|---|---|---|---|
| | n | % | n | % |
| 0 | 4 | 7.4 | 6 | 18.8 |
| 1 | 19 | 35.2 | 14 | 43.8 |
| 2 | 18 | 33.3 | 8 | 25.0 |
| 3 | 8 | 14.8 | 2 | 6.3 |
| 4 | 3 | 5.6 | 1 | 3.1 |
| 5 | 1 | 1.9 | 0 | 0.0 |
| 6 | 0 | 0.0 | 0 | 0.0 |
| 7 | 1 | 1.9 | 1 | 3.1 |

TABLE 30

PERCENTAGE OF AVERBUCH MALES AND FEMALES POSSESSING HARRIS LINES FOR AGE INTERVALS BETWEEN BIRTH AND SEVENTEEN AND ONE HALF YEARS

| Age (Years) | Males (n = 68) n | % | Females (n = 48) n | % |
|---|---|---|---|---|
| NB - .5 | 28 | 41.18 | 17 | 35.42 |
| .5 - 1.5 | 11 | 16.18 | 7 | 14.58 |
| 1.5 - 2.5 | 12 | 17.65 | 7 | 14.58 |
| 2.5 - 3.5 | 9 | 13.24 | 9 | 18.75 |
| 3.5 - 4.5 | 10 | 14.71 | 8 | 16.67 |
| 4.5 - 5.5 | 13 | 19.21 | 11 | 22.92 |
| 5.5 - 6.5 | 11 | 16.18 | 10 | 20.83 |
| 6.5 - 7.5 | 13 | 19.21 | 2 | 4.67 |
| 7.5 - 8.5 | 7 | 10.29 | 3 | 6.25 |
| 8.5 - 9.5 | 6 | 8.82 | 7 | 14.58 |
| 9.5 - 10.5 | 6 | 8.82 | 2 | 4.17 |
| 10.5 - 11.5 | 4 | 5.88 | 1 | 2.08 |
| 11.5 - 12.5 | 9 | 13.24 | 5 | 10.42 |
| 12.5 - 13.5 | 5 | 7.35 | 4 | 8.33 |
| 13.5 - 14.5 | 7 | 10.29 | 8 | 16.67 |
| 14.5 - 15.5 | 9 | 13.24 | 6 | 12.50 |
| 15.5 - 16.5 | 6 | 8.82 | 1 | 2.08 |
| 16.5 - 17.5 | 9 | 13.24 | 0 | 0.00 |

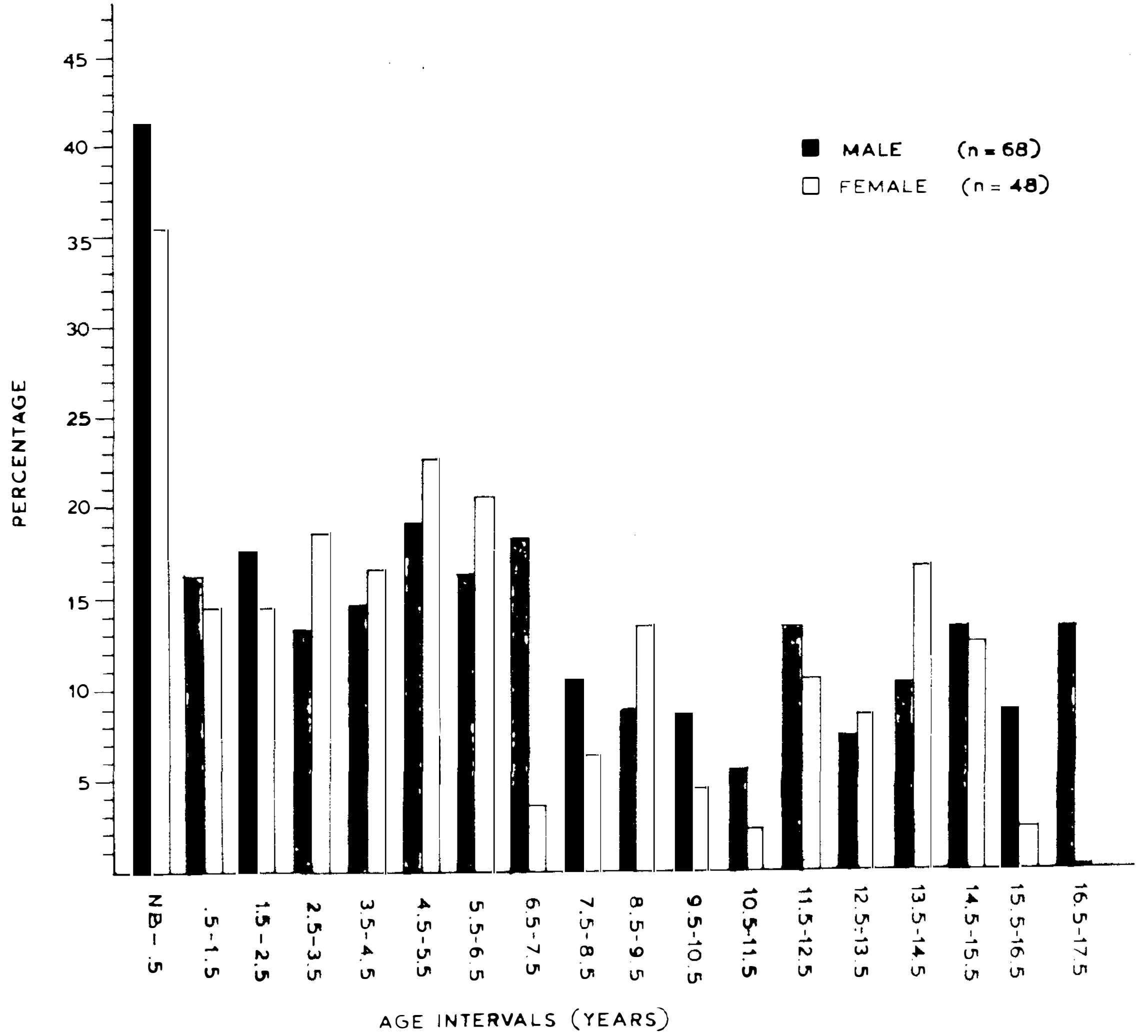



Figure 29. Percentage of Averbuch males and females possessing Harris lines for age intervals between birth and seventeen and one half years.

the females (1.5). Also, the mean number of syress episodes, as expressed by observations made of both left and right tibiae, is greater in males (2.96) than in females (2.27). Although the male values exceed those of the female, the diversity is not statistically significant when subjected to chi square and t-tests. The only significant difference ($p \geq .005$) is between the number of males (57.5 percent) and females (37.5 percent) who possess two or more Harris lines in their distal tibiae. These results indicate Averbuch males were more severely stressed than females. However, similar findings are suggested by Steinbock (1976:47) to

> . . . support the belief that boys are more vulnerable to environmental insults or may reflect the greater rate of subperiosteal apposition and linear growth of bone in boys. (Garn et al., 1968; Gindhart, 1969)

The age specific pattern of morbidity as expressed by the percentage of Harris lines present at each age interval (Figure 29) mimics to some extent the mortality profile of the subadults presented in the previous chapter. A larger percentage of individuals exhibit lines prior to 7.5 years of age than between 7.5 and 17.5 years. Also, the most stressed of the age intervals is from birth to six months and the least stressed interval is from 10.5 to 11.5 years.

Of major concern is the relationship of Harris lines between the three cemeteries as this may reflect the temporal behavior of stress at Averbuch. However, the analysis of variance tests indicate distal tibia lines and the number of stress episodes do not differ statistically between the three cemeteries. Thus, the Harris line data indicate

Averbuch inhabitants experienced considerable stress that remained constant throughout the longevity of the village.

Enamel Hypoplasia

As with the stature and Harris line data, an analysis of variance is utilized to determine the relationship of the three cemeteries on the basis of enamel hypoplasia. The dependent variables are the number of stress episodes represented by the presence of enamel hypoplasia in the dentition. The independent variables are sex and cemetery.

Table 31 presents an analysis of variance for the number of stress episodes. The F value of 2.32 is significant ($p = 0.0470$) and an inspection of the components suggest that neither sex nor cemetery alone are responsible for this difference. However, the interaction of sex and cemetery produce an F value of 3.39 which is significant at the 0.0368 level. Factors responsible for this significance are best interpreted by examining Table 32. The mean number of stress episodes is greater for Cemetery 1 females than males whereas this relationship is reversed for the males and females from Cemeteries 2 and 3. Such a reversal could produce the cemetery/sex difference.

A total of 57 relatively complete dentitions is examined and lines of enamel hypoplasia are found in 91.2 percent ($n = 52$) of the cases. Of those possessing this pathology, 92.6 percent are male and 90.0 percent are female. The occurrence of these lines in the adult mandibular canines is also examined and a larger number of males (92.79 percent) than females (88.29 percent) possess them. Table 33 provides the percentages of males and females possessing lines between birth and 12.5 years and Figure 30

TABLE 31

ANALYSIS OF VARIANCE FOR THE TOTAL NUMBER OF STRESS EPISODES EXPERIENCED, AS EXPRESSED BY ENAMEL HYPOPLASIA, IN BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Source | DF | Sum of Squares | Mean Square | F Value | P |
|---|---|---|---|---|---|
| Model | 5 | 17.69 | 3.54 | 2.32 | 0.05 |
| Error | 128 | 195.60 | 1.53 | | |
| Type I | | | | | |
| CEM | 2 | 5.08 | 2.54 | 1.66 | 0.19 |
| SEX | 1 | 2.26 | 2.26 | 1.48 | 0.23 |
| CEM*SEX | 2 | 10.36 | 5.18 | 3.39 | 0.04 |
| Type IV | | | | | |
| CEM | 2 | 4.64 | 2.32 | 1.52 | 0.22 |
| SEX | 1 | 0.47 | 0.47 | 0.31 | 0.58 |
| CEM*SEX | 2 | 10.36 | 5.18 | 3.39 | 0.04 |

TABLE 32

MEAN NUMBER OF STRESS EPISODES—BASED ON AN EXAMINATION OF ENAMEL HYPOPLASIA IN THE DENTITION AS A WHOLE—FOR BOTH SEXES AND THE THREE AVERBUCH CEMETERIES

| Cemetery | Sex | n | Mean |
|---|---|---|---|
| 1 | M | 48 | 1.38 |
| 1 | F | 42 | 1.98 |
| 2 | M | 9 | 2.33 |
| 2 | F | 9 | 1.33 |
| 3 | M | 11 | 2.18 |
| 3 | F | 15 | 2.13 |

TABLE 33

PERCENTAGE OF AVERBUCH MALES AND FEMALES POSSESSING LINES OF ENAMEL HYPOPLASIA FOR AGE INTERVALS BETWEEN BIRTH AND TWELVE AND ONE HALF YEARS

| Age (Years) | Males (n = 28) n | % | Females (n = 29) n | % |
|---|---|---|---|---|
| NB - .5 | 4 | 14.29 | 3 | 10.34 |
| .5 - 1.5 | 9 | 32.14 | 4 | 13.79 |
| 1.5 - 2.5 | 16 | 57.14 | 8 | 27.59 |
| 2.5 - 3.5 | 13 | 46.43 | 22 | 75.86 |
| 3.5 - 4.5 | 8 | 28.57 | 14 | 48.28 |
| 4.5 - 5.5 | 1 | 3.57 | 13 | 44.83 |
| 5.5 - 12.5 | 1 | 3.57 | 2 | 6.90 |

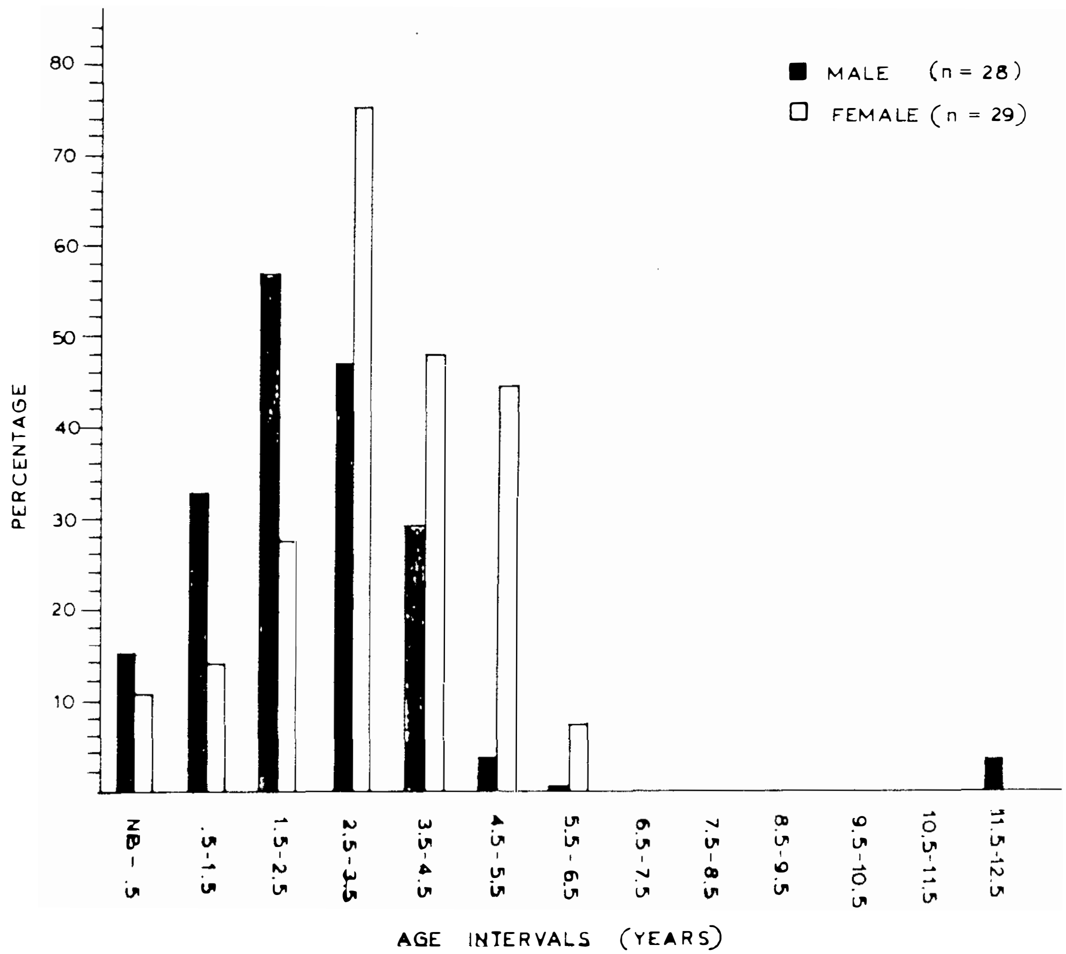



Figure 30. Percentage of Averbuch males and females possessing lines of enamel hypoplasia for age intervals between birth and twelve and one half years.

provides an illustration of this. Stress in the Averbuch series, as expressed by enamel hypoplasia, is most pronounced from birth to 5.5 years of age and almost nonexistent between 5.5 and 12.5 years of age. Only two of 29 females (6.90 percent) and one of 28 males (3.57 percent) possess lines of enamel hypoplasia that formed after 5.5 years of age. The line attributed to the one male formed at 11.5 to 12.5 years while both females possess lines that formed at 5.5 to 6.5 years. The 2.5 to 3.5 age interval exhibits the highest percentage of individuals with lines of enamel hypoplasia. Also, prior to 2.5 years of age, a greater percentage of males express this pathology than females. However, after 2.5 females demonstrate a higher frequence of lines than males. Only at 4.5 to 5.5 years of age does the frequency of males and females differ significantly ($p > .005$). At this age 3.57 percent of the males possess lines as compared to 44.83 percent of the females.

In conclusion, analysis of variance of the number of stress episodes represented by the presence of enamel hypoplasia in dentition is significant at the .05 level. A close examination indicates neither sex nor cemetery components produced this difference; rather, the interrelationship between these components is responsible. The difference is produced by a reversal in the number of sex specific stress episodes between the three cemeteries. Cemetery 1 females express a greater mean number of stress episodes than do the males; however, in Cemeteries 2 and 3 the opposite is found.

Enamel hypoplasia in adult mandibular canines (the crown of which forms between birth and 4.5 years of age) occurs in 93 percent of the

males and 88 percent of the females. This high occurrence reflects considerable stress experienced by Averbuch inhabitants during their first few years of life. The percentage of occurrence according to age indicates the 2.5 to 3.5 group experienced the greatest amount of stress. This may reflect the age at which children were weaned. At weaning, the child is stressed not only from malnutrition but also from an introduction of a new diet which may subject them to parasites and harmful microorganisms. In addition, with the exception of the birth to .5 age interval, the male and female relationship expressed in Figure 30, page 156, for each of the intervals from .5 to 6.5 correspond with those ascertained from Harris line data (see Figure 29, page 151). The percentage of males stressed exceeds the females for the age intervals of .5 to 1.5 and 1.5 to 2.5. However, more females are stressed than males between the ages of 2.5 and 6.5.

Although other explanations exist, two assumptions may be used to account for this:

1. male infants and children are more susceptible to stress than females.
2. male infants and children were more highly prized than females at the Averbuch site.

If these two assumptions are accepted, then it may follow that increased attention directed toward male children resulted in the males being less stressed than the females. The fact that more males between .5 and 2.5 years of age were stressed than females may reflect the ability of the females to withstand stress. The reversal in the male/female relationship

from 2.5 to 6.5 may correlate with the time when the child becomes more possessive and demanding. Perhaps, the increased demands for food and attention by the male child received increased adult indulgence at the expense of the female children.

## IV. SUMMARY AND CONCLUSION

Stature, Harris lines and enamel hypoplasia are utilized as indicators of biological stress at the Averbuch site. The first step in this analysis was to examine the interrelationship of these three indicators. An SPSS package program (SCATTERGRAM) with the subprogram for Pearson product-moment correlation is used for this purpose. The results of this examination indicate none of the correlation coefficients are significant at the .05 level for either sex. Thus each of the three indicators appear to behave independent of one another.

The lack of correlation between stature and the number of Harris lines, or the number of stress episodes as expressed by Harris lines, was first thought to be a product of Harris line resorption with age. However, an examination of the interrelationship of Harris line number and age reveals no significant correlation. The best explanation for there being no correlation between stature and Harris lines is that adolescent catch-up growth may compensate for growth arrest during childhood. This may also account for the lack of correlation between stature and severity of enamel hypoplasia as expressed by the permanent mandibular canines.

No significant correlation exists between Harris line number and enamel hypoplasia severity. Similarly, there is no correlation between

the number of stress episodes as expressed by Harris lines and the number represented by enamel hypoplasia. Although many explanations may be offered for this, it is conjectured that individuals may respond to stress differently. Some individuals may produce both Harris lines and enamel hypoplasia lines, while others may respond with only one of the two. A second possibility is that bone and enamel may be susceptible to such pathologies only during certain periods of their development. Thus a bone or tooth must be in a particular stage of development for Harris lines or lines of enamel hypoplasia to form. If stress is of short duration, perhaps these susceptible periods do not coincide. Even so, it is felt that both Harris lines and lines of enamel hypoplasia provide an adequate means for evaluating population stress and the nature of that stress.

In general, enamel hypoplasia and Harris line data indicate that the Averbuch population experienced widespread environmental stress. Lines of enamel hypoplasia formed in 93 percent of the males and 88 percent of the females during the first 4.5 years of life. Distal tibiae exhibited Harris lines in 93 percent of the males and 81 percent of the females. The nature of stress does not appear to have been seasonal, rather it is a result of sporatic acute periods. Males averaged 1.9 Harris lines in the distal tibia and females 1.5 lines. The mean number of stress episodes as expressed by the Harris lines was 2.9 for males and 2.3 for females while the mean number expressed by enamel hypoplasia was 2.0 for males and 1.8 for females. Stature at Averbuch is among the highest reported for an American Indian skeletal series.

This is inconsistent with the Harris line and enamel hypoplasia data and may be due to adolescent catch-up growth masking growth arrest during infancy and childhood. These results suggest that stature is a questionable approach in the study of biological stress.

Temporal dynamics of stress at Averbuch was also examined. The occurrence of each of the three stress indicators—short stature, Harris lines and enamel hypoplasia—was tested with an analysis of variance and no significant difference could be demonstrated between the cemeteries. Since Cemetery 3 predates Cemetery 1, it may be concluded that stress neither increased nor decreased during the 15 to 25 years of occupation. Biological stress at Averbuch was experienced by the majority of inhabitants and remained high throughout the existence of the site. Both Harris line and enamel hypoplasia data suggest that males were more stressed than females. However, the analysis of variance tests failed to demonstrate a significant difference.

An examination of the age specific morbidity indicates a general correspondence between periods of stress, as determined by the Harris line and enamel hypoplasia data, and the subadult mortality curve presented in the previous chapter. In general, a larger percentage of individuals express lines prior to 7.5 years of age than those individuals between 7.5 and 17.5 years. Harris line data indicate the most stressed age interval was from birth to .5 years and the least stressed interval was from 10.5 to 11.5 years. Even in modern technologically advanced societies the first one half year of life represents one of the highest risk groups. Thus, it is not surprising that this

is reflected by the Harris line data, as well as the mortality curves of the Averbuch series. Enamel hypoplasia data indicate the most stressed age was 2.5 to 3.5 years. The 2.5 to 3.5 age interval may represent stress resulting from weaning, and the malnutrition and poor health which may accompany it.

Of those individuals who express Harris lines and/or enamel hypoplasia, the percentage of stressed males exceeds stressed females from .5 to 2.5 years of age. However, from 2.5 to 6.5 years the percentage of stressed females exceeds the males. This reversal in the male to female relationship at 2.5 years of age may correlate with a time when the children were weaned and were beginning to assert their independence. Perhaps male children were more highly prized at Averbuch than female children. If this were the case, possibly the demands of the male child for food and attention were met at the expense of the female's well-being.

# CHAPTER VI

# OSTEOLOGICAL EVIDENCE OF SCALPING AT THE AVERBUCH SITE (40DV60)

## I. INTRODUCTION

Scalping has long been associated with warfare and conflict among American Indians. Ethnographic references to scalping are not uncommon and much is written on its origin and distribution. Knowles (1940:155) states that: "Most of the material associated with the war complex was of a perishable nature, thus precluding the possibility of archaeological evidence." Although this is basically true, several studies provide osteological evidence of warfare and scalping (Neumann, 1940; Hoyme and Bass, 1962; Owsley and Berryman, 1975; Owsley et al., 1978; Snow, 1941, 1942; Willey and Bass, 1978). Archaeological excavation at the Averbuch site near Nashville, produced several skeletons that exhibit evidence of trauma induced by conflict. The osteological evidence and ethnographic record will be discussed in reference to these new finds.

## II. DESCRIPTION OF SKELETAL TRAUMA

Burial 277A:

Sex: Male

Age: 25-29

Cemetery: 1

Evidence of scalping appears as cut marks on the frontal, parietal and occipital bones (Figure 31). The frontal bone exhibits two areas of cutting on the right side near the coronal suture. The left parietal has a long, discontinuous cut that appears above the posterior aspect of the squamosal suture. Shorter, more delicate cuts are found superior to this one. A continuation of the cuts on the frontal bone is found on the right parietal near the coronal suture. Also, short, faint cuts appear in the posterior one-third of the right parietal near the lambdoidal and sagittal sutures. The occipital exhibits one indistinct cut at lambda and two short, deep cuts near the external occipital protuberance. The majority of the cuts over the cranial vault are short, and appear in groups of two or three parallel lines.

A portion of a projectile point is embedded in the sixth cervical vertebra (Figure 32). The projectile point entered the back of the individual's neck and shattered on impact, leaving the tip in the posterior aspect of the neural arch at the base and to the left of the spinous process. The tip of the projectile point does not penetrate the neural arch; however, striations extending from the point of impact to the superior margin of the arch indicate that fragments of the projectile may have entered the spinal cord. The shock of the impact alone would have probably rendered the individual unconscious and if the spinal cord had been severed it would have certainly paralyzed if not killed the individual.

Cut marks are also found on the posterior part of three ribs—two right and one left—from the midthoracic area (Figure 33). It is

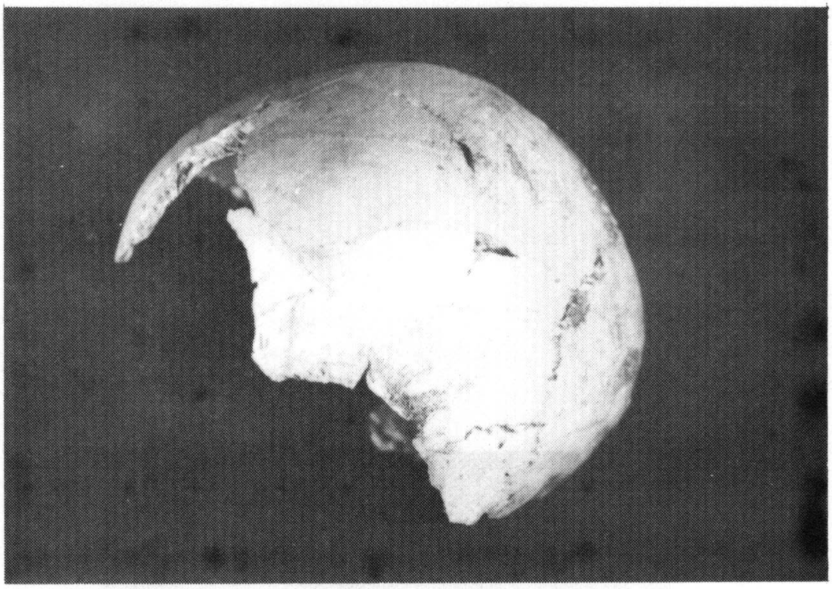


Figure 31. Cut marks on left parietal of skull of burial 277A.

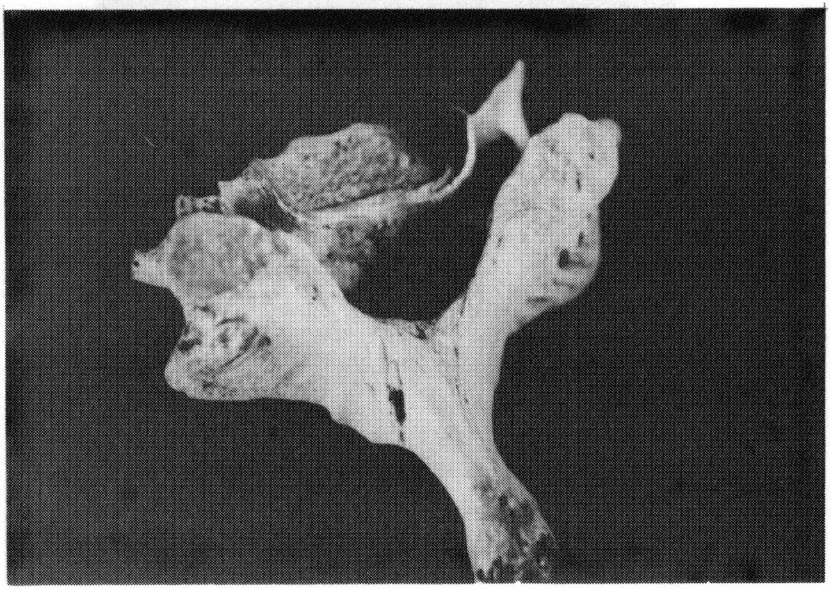


Figure 32. Projectile point tip embedded in the neural arch of the sixth cervical vertebra of burial 277A.

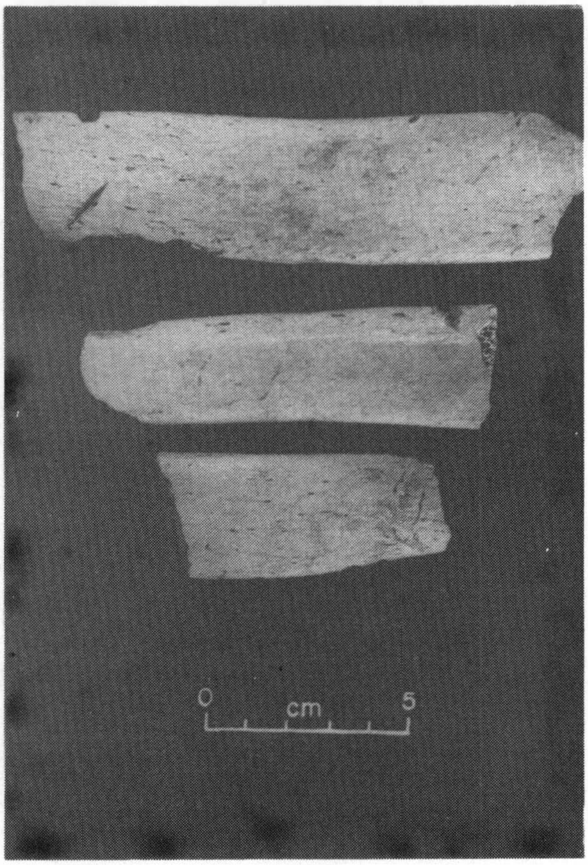



Figure 33. Cut marks on rib fragments from mid-thoracic area of burial 277A.

uncertain whether these represent wounds from projectile points or a knife. Penetration in this area would have punctured the lungs. No evidence of healing is associated with the trauma exhibited by this skeleton.

Of the artifacts associated with burial 277A, a projectile point recovered from beneath the skull deserves special note. The tip of the projectile is broken from impact. Since the material from which it is made differs from that embedded in the cervical vertebra, it may represent a second projectile point shot into the body of the victim.

Burial 270A:

Sex: Female

Age: 18.5-19.5

Cemetery: 1

The skull of burial 270A is fragmented and incomplete; however, two fragments of right parietal exhibit several deep cuts. These cuts appear as groups of parallel lines that bisect the temporal line. They are also present above the posterior half of the squamosal suture.

Burial 417A:

Sex: Female

Age: 30-34

Cemetery: 1

The frontal bone exhibits a single cut that bisects the left temporal line approximately 25 mm above the eye orbit (Figure 34). Two poorly defined cut marks are present on the left parietal near the

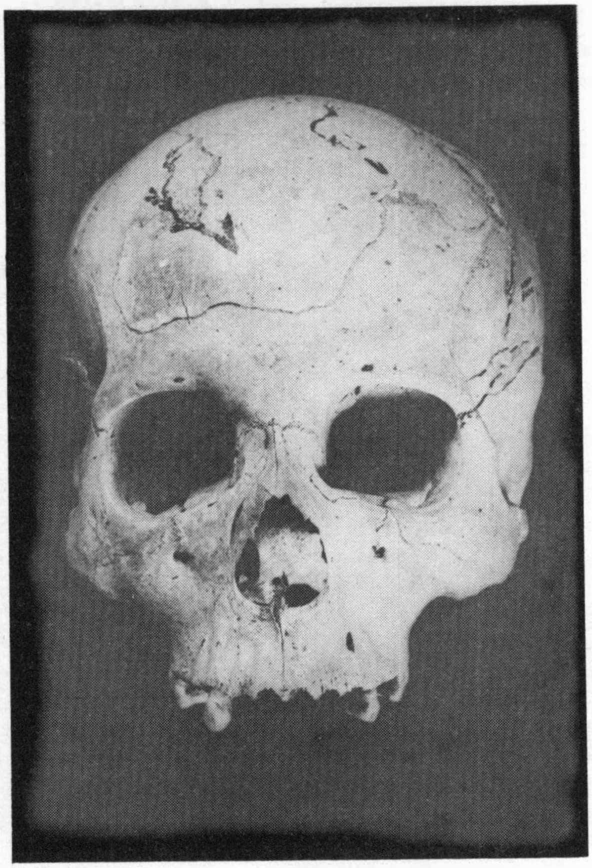


Figure 34. Groove produced by infection on the frontal bone of burial 417A.

lambdoidal suture, and several similar cuts appear along the lambdoidal suture of the right parietal. Both temporal bones have cuts superior to the mastoid processes, and several long cuts are found along the squamosal suture of the left temporal. Cuts on the occipital are limited to the left side of the bone, primarily the nuchal area.

The outer table exhibits evidence of infection that extends from the frontal bone to the parietals and the superior aspect of the occipital. The bony reaction appears as a narrow groove which transects the frontal bone above the brow ridges and widens into areas of pitting as it proceeds posteriorly. Moderate pitting appears primarily superior to the temporal lines, and affects less than half of the top of the skull.

A healed fracture of the right nasal bone and maxilla, near the nasomaxillary suture is also evident. The relationship of this pathology to the cut marks is uncertain; however, it likely represents a separate and earlier episode.

Burial 585:

Sex: Male

Age: 25-29

Cemetery: 3

A narrow groove produced by infection bisects the frontal bone approximately midway, and follows the superior margin of both left and right temporal lines (Figure 35). The groove is obliterated in the posterior aspect of the skull by weathering. The superior portion of the skull exhibits no indication of bony reaction.

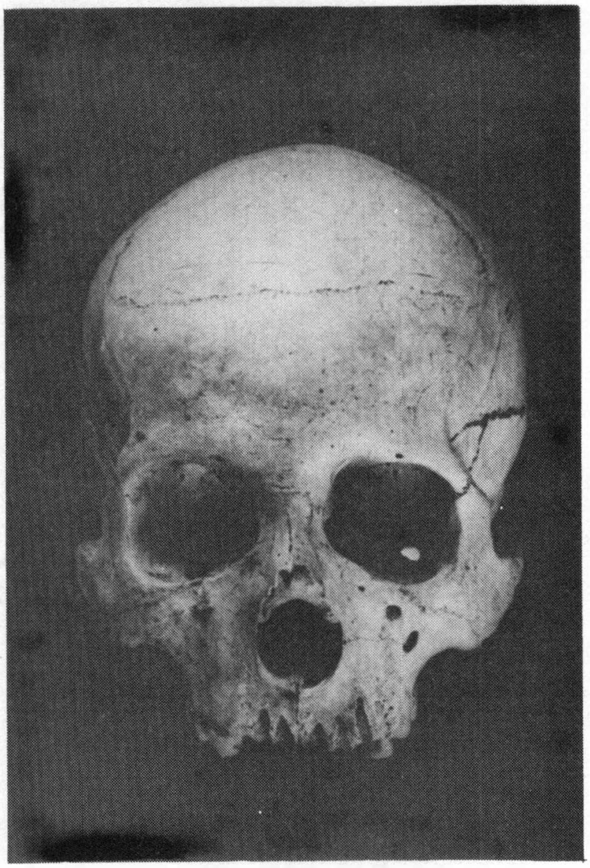


Figure 35. Groove produced by infection and associated cut marks which appear on the frontal bone of burial 585.

Two rows of cut marks appear superior and parallel to the groove on the frontal bone. Additional cuts are present on the posterior part of the right parietal above the temporal line.

<u>Burial 561B</u>:

Sex: Male

Age: 40-49

Cemetery: 3

The outer table of the skull exhibits irregular erosion and sclerosis that extends from the superior half of the frontal bone to lambda, and is limited laterally by the temporal lines (Figure 36). Small "pinhead size" pits or holes are distributed on the inner table in a pattern reflecting that of the outer table. A thorough examination of the cranium produces no evidence of cutting.

<u>Burial 679</u>:

Sex: Male

Age: 30-34

Cemetery: 3

Although the skull is fragmented, a groove of osteitis similar to that of the Moundville skull described by Snow (1941) is detectable (Figure 37). The groove traverses the right parietal, from the coronal to the lambdoidal suture, approximately 30 mm above the squamosal suture. It continues across the superior aspect of the occipital bone to the left parietal where it is obliterated by poor preservation. The groove morphology is identical to that depicted photographically by Snow (1941).

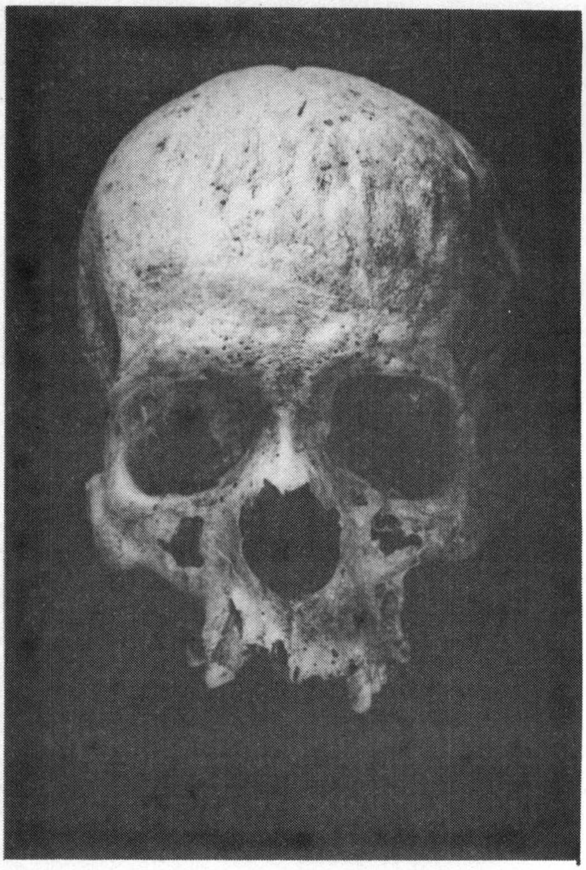


Figure 36. Irregular erosion of the outer table of the skull from burial 561B.

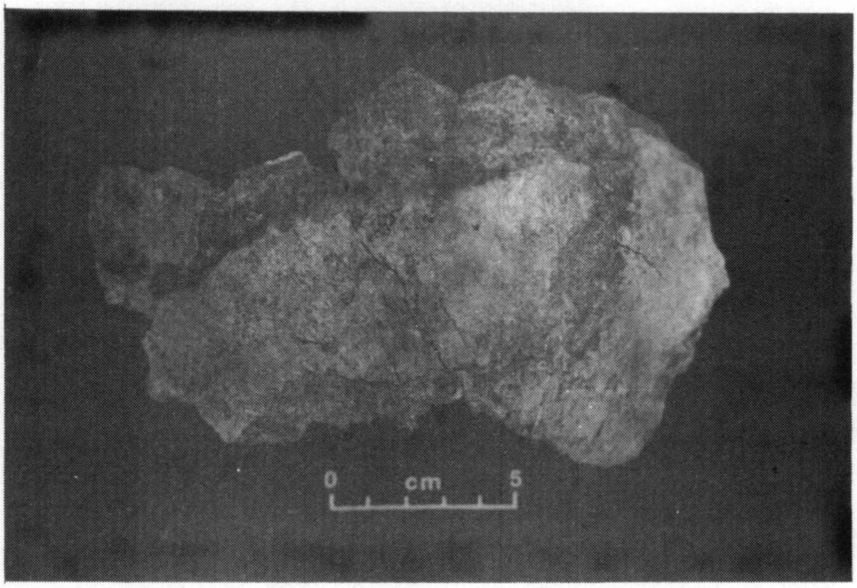



Figure 37. Groove of osteitis on the right parietal of burial 679.

The apex of the skull appears unaffected by infection; however, two small cut marks of uncertain origin appear on one of the parietal fragments. Since none of the other cranial fragments possess cuts, it is questionable whether these may be ascribed to scalping. Unfortunately, the fragmented condition of the skull limits further interpretation.

## III. DISCUSSION

Scalping consists of the removal of hair and underlying soft tissue from the top and back of the head. Adair (1775:387-388) describes this procedure:

> They seize the head of the disabled, or dead person, and placing one of their feet on the neck, they with one hand twisted in the hair, extend it as far as they can— with the other hand, the barabarous artists speedly draw their long sharp-pointed scalping knife out of a sheath from their breast, give a slash round the top of the skull and with a few dexterous scoops, soon strip it off. They are so expeditious as to take off a scalp in two minutes.

Osteological evidence has been presented (Neumann, 1940; Owsley and Berryman, 1975) which suggests that some victims were placed face down as Adair describes.

The cut pattern of burial 585 is also suggestive of this procedure; cuts are deeper and occur in greater frequency on the frontal bone, and possibly represent the point where the initial incision was made. The cuts are in pairs and continue back over the top of the skull indicating the direction the scalp was removed. The pattern of cutting appearing on the crania of burials 417A and 277A varies from that of burial 585 suggesting the initial cuts were made

above the ear as opposed to the forehead. Such findings also suggest that the victim was not always placed face down.

In all cases, the cuts appear more prevalent on one portion of the skull and decrease on the opposite side. This suggests that the scalp was initially cut free in one area of the skull and largely torn off in the opposite direction. Variation in cut pattern, location, and frequency may reflect the position of the victim as well as the skill of the scalper.

The Averbuch cuts also vary from a thin line to a bold "groove-like" mark. Such variation results not only from the amount of force applied by the assailant, but also the type of knife used. Materials used in knife manufacture, prior to European contact, included reeds (Smith, 1907:80; LeMoyne, 1875:7), shell (Smith, 1907:80) and flint (Neumann, 1940:287). The Averbuch cut marks differ from those observed by Owsley et al. (1977) in a South Dakota series which were attributed to a metal knife. Hamperl's (1967) research indicates that a sharp knife may leave no marks at all on a skull unless the blade has become dulled or notched. Averbuch cuts, characterized by relatively short, parallel lines, were likely produced by the "saw-like" action of a stone knife.

The low position of many of the cut marks on the Averbuch crania indicate the major objective was the removal of as much of the scalp as possible. Johnson (1973:259) notes that the Shawnee

> . . . perform the process of scalping without regard to the size of the portion of skin taken from the crown of the head. If, in their haste to cut it off, they take more than is sufficient for their purpose, they afterwards,

> when at leisure, pare it down in a round shape to the diameter of about two inches.

The Seminole have been observed to divide scalps among tribal members.

> The scalps of these victims to their revenge were cut into small pieces, to satisfy the craving appetites of all and to make known among their comrades their participation in an event. (Sprague, 1964:89)

Victims of scalping thus far observed at Averbuch consist of adults of both sexes. The scalping of females and children was not uncommon in historic times and was probably a prevalent practice in prehistoric times. In 1540, Spanish soldiers were informed of a Muskogean (possibly Apalachee) raid in which men, women and children were scalped (Irving, 1869: 214). According to Spence (1919:67) some tribes treated male and female scalps differently; eagle feathers were attached to male scalps while a comb or scissors was suspended from the frame of a female scalp.

Victims of scalping were not always killed prior to the event nor did death necessarily result from it. Robertson (1855:447-448) describes the plight of a man who, while traveling in the Nashville area in January 1780, was scalped.

> . . . David Hood, in passing from the lower to the upper fort was fired on by Indians in ambush at the sulfur spring, in the northern part of the city. He was pierced by three balls, and fell on his face, apparently dead. The Indians rushed on him and scalped him, and stamped him on the back of the neck to dislocate it, and left him, believing he was dead. He lay perfectly still for a long time, as it seemed to him, and, when he believed they had gone, he cautiously peeped about, and could not see them. He then got up, and slowly wended his way toward the upper fort. . .; but what must have been his horror when getting near the top of the bank, he saw the whole company on the hill but a few steps from him. . . . He turned and trotted

> back . . . , some four or five firing at him as he turned back, two balls wounding him slightly. They did not attempt to pursue him . . . , and he crept into the brushwood and lay there until men went out from the forts and found him, and conveyed him in . . . David did get well, and lived to a good old age.

Additional cases have been discussed by Bruesch (1974), Joutel (1906), Knowles (1940), and others.

Survivors of scalping were so common in East and Middle Tennessee during the eighteenth century that a surgical treatment was often employed to facilitate a cure. Robertson (1855:448) describes this procedure:

> This was to perforate the outer table of the skull with a shoemaker's awl over the whole naked surface, making these perforations pretty close together. Through these perforations, granulations sprang up, and gradually spreading, finally all united, and formed a covering of denuded skull, before it should die and exfoliate, and thus expose the brain. . . . This operation became, in time, so common, that there were persons in every fort who performed it.

Osteological evidence of individuals who possibly survived scalping is presented by Hamperl and Laughlin (1959), Morse (1973), Owsley and Berryman (1975), and Snow (1941; 1942). Hamperl (1967:631-632) describes the bone changes experienced in such a case:

> The bone, deprived of its periosteum, will gradually exsiccate in its superficial portions and become necrotic . . . , an inflammatory granulation tissue then separates it from deeper layers of living bone through demarcation . . . a new spongy bone tissue . . . is formed by the remaining inner bone layers, which is eventually covered by regenerating epidermis and the wound closes.

The cranium of burial 561B exhibits similar bone remodeling and probably represents an additional example of an individual who survived the trauma of scalping. In contrast, burial 277A, who obviously died

at the time he was scalped, shows no indication of healing. However, burials 417A and 585 have cut marks and slight signs of bone remodeling suggesting survival for a brief period following the ordeal. The pathology in both cases appears as a narrow groove which traverses the frontal bone and continues to the posterior aspect of the skull where it becomes less distinctive. Snow (1941) describes a condition—similar to that of burial 679—in which the skull is encircled by a groove of osteitis. According to Snow (1941:55)

> The position of this groove immediately suggested the possibility that the Indian had been scalped and that infection had subsequently set in at the line of the cutting.

Hamperl (1967) questions the interpretation of the Moundville find, and notes that if the scalp and periosteum had been removed, more of the cranial vault would have been subject to infection.

Burials 417A and 585 differ from Snow's Moundville skull and skull 679 in that the grooves are less pronounced and both skulls exhibit cuts indicative of scalping. The position of the groove on skulls 417A and 585 circumscribes an area identical in position to the remodeled area found on skull 561B. The bony reaction, in all three crania, involves the superior half of the frontal bone and the parietals above the origin of the temporalis muscles. Also, the cut marks on the frontal bone of skull 585 are parallel to and slightly above the groove. Perhaps burials 417A and 585 may best be interpreted as demonstrating the initial bony reaction experienced by the survivors of scalping. If either individual had survived for a longer period of

time their skull would have experienced the remodeling described by Hamperl (1967) and demonstrated by burial 561B.

## IV. CONCLUSION

The external social interaction experienced by the Averbuch people was often hostile. Examination of skulls at Averbuch indicate that adults of both sexes were being scalped, and there is evidence that the trauma was often survived for varying periods of time. Larson (1972) hypothesizes that warfare in the Southeast during Mississippian times resulted from competition for arable land. Conversely, Gibson (1974) states that warfare was usually for achieving or maintaining social status. Klippel (personal communication 1980) suggests that Averbuch may represent a splinter community forced on to less desirable land by population pressure. If so, friction between those who occupied the more productive bottom land and the people of the fringe area may account for the conflict demonstrated by the skeletal material. The reasons for the peripheral position of the Averbuch site are difficult to ascertain; however, palisade walls and warfare attest to the importance of defending its location.

# CHAPTER VII

## THE AVERBUCH SITE: SUMMARY AND CONCLUSION

The Nashville Basin was densely populated during the Mississippian Period as is evident from the many large Middle Cumberland Culture cemeteries excavated from this area in the past century. However, the first Europeans who came into the Nashville area during the 1770's record that it was uninhabited. During the relatively brief span of time separating the Mississippian Period from the Historic Period, the Middle Cumberland population disappeared. Among speculations offered for this disappearnace are European introduced epidemics and aboriginal warfare. Unfortunately, a scarcity of systematically excavated archaeological sites and the small skeletal series from this area restrict the type of research needed to examine these questions.

Recent excavation of the Averbuch site (40DV60), a late Mississippian village from the Nashville Basin, produced one of the largest systematically excavated skeletal series from Tennessee. The goal of the present study has been the investigation of Averbuch demography and the examination of evidence for both biological and social stress at the site. Skeletal remains of the 887 individuals from Averbuch, its fifteenth century date, and its location in the Nashville Basin present a unique opportunity to study conditions that may have resulted in population decline and ultimate disappearance in this area.

The Averbuch village was, for the most part, surrounded by a palisade wall. Three cemeteries were located at the site, Cemeteries 1 and 2 within the palisade and Cemetery 3 outside. Intrusion of the palisade through a section of Cemetery 3 suggests that it was the earliest of the three cemeteries. The temporal relationship of Cemeteries 1 and 2 could not be determined, and the small sample size from Cemetery 2 rendered it of little use in the statistical procedures used in this study. Temporal alighment of Cemetery 3 (the earlier cemetery) and Cemetery 1 (the late cemetery) provides the basis for examining the temporal dynamics of stress at the site.

Over 70 structure loci were discovered at the site, some of which demonstrate evidence of rebuilding (i.e., the superposition of a second structure). The major woods in this area which were available for construction can decay in as few as 8 to 10 years. This plus the relatively thin midden deposit suggests that 15 to 25 years would be a reasonable estimate for the duration of the village.

Not all Averbuch burials could be recovered; however, the archaeology at the site permitted the estimation of the number of dead that could not be recovered. This number, plus the number recovered, produced an estimated total of 1,232 dead. This permitted the construction of life tables for the total site with sexes combined, the total site with sexes separate, and for the males and females from each cemetery.

The overall life table indicates Averbuch people experienced considerable stress. Mortality at the site exceeds fertility which

produced a population decline of 1 to 2 percent per annum. Life expectancy at birth was 14.6 years for females and 17.4 years for males. These estimates were among the lowest of those published from other archaeological series. A chi-square test of the age distribution of male and female mortality produces no significant difference. An examination of the sex specific mortality curves indicate that the highest mortality for both sexes was in the very early years of life. The lowest mortality, and thus the most healthy period, was from 10.5 to 15.5 years of age. Adult mortality for both sexes was most pronounced in the early part of adult life (i.e., 15.5 to 30 years of age). Stress during these age intervals coincides with the childbearing period for the females, while the males at this age would be participating in subsistence procurement and perhaps warfare activities.

A crude mortality rate of 60 deaths per 1,000 per annum reflects the extreme stress experienced by this group. It was also used, along with the estimate of the length of the occupation (15 to 25 years) and the estimated total number of dead (1,232) to calculate the size of the Averbuch population. If the site had been occupied for 15 years, then 1,369 individuals would have inhabited the village at any one time. If the site had been occupied for 25 years, then the average village size would have been 821 individuals.

Male and female mortality is examined for each cemetery. With the exception of the males and females from Cemetery 3 who differ at the .005 level, the patterns of the curves are basically similar.

This difference is produced by an increase in female mortality, compared to male mortality, in the 20 to 25 year age interval.

Cemetery specific stress for the females, as represented by life expectancy and crude mortality rate, was relatively constant through time. The male crude mortality rate increased between Cemetery 3 (i.e., 43) and Cemetery 1 (i.e., 52), suggesting a temporal increase in stress for males at the site. However, a chi-square test of the age distributions of deaths between the cemeteries produced only one significant difference; the female mortality profile for Cemetery 3 differed with that of Cemetery 1 at the .005 level. The peak in Cemetery 3 female deaths at the 20 to 25 year interval—responsible for the male/female difference outlined above—and the relative decrease in Cemetery 1 deaths at this age produced the difference.

Increase in Cemetery 3 female deaths at the 20 to 25 year interval cannot be explained solely by the stress produced by childbearing. These individuals may have been prime targets during raids. The absence of a palisade during the early phases of the site plus the probability that these individuals were active participants in subsistence activities that involved their venturing into the countryside surrounding the village may have increased their vulnerability. Or, perhaps subsistence activities practiced by the early inhabitants of the site produced sufficient stress to account for this increase in deaths.

The relative decrease in deaths among Cemetery 1 females in the 20 to 25 year age interval may reflect the beneficial effects of the palisade wall. It could also be suggestive of a change to less stressful subsistence activities or a decrease in childbearing pressures. Or, perhaps social or cultural rules, for some unknown reason, forbade the burial of young adult females in Cemetery 1. The elevated number of Cemetery 2 females 20 to 25 years of age may have been produced by the burial of Cemetery 1 females here.

It may be concluded from the Averbuch demography that inhabitants were greatly stressed. The overall stress, as expressed by the crude mortality rates, appeared relatively constant for females but increased for males. The pattern of the mortality curve and the proportionately low number of deaths during the 10.5 to 15.5 age interval suggests that an epidemic was not a factor at Averbuch. The mortality curve is more suggestive of chronic diseases, or sporadic periods of acute stress. In order to better understand the nature of the forces that shaped the demography, both biological (i.e., short stature, Harris lines and enamel hypoplasia) and social (i.e., warfare) indicators of stress were examined.

A prerequisite to the use of decreased stature, Harris lines and enamel hypoplasia in the examination of biological stress at the site is the examination of the interrelationship of these three indicators. Correlation coefficients demonstrate no significant correlation between them; each of the indicators behave independently of one another. Thus, the study of each provides information that is unique.

Harris line and enamel hypoplasia data reflect the considerable stress evident in the demographic analysis. Ninety-three percent of the males and 83 percent of the females exhibit enamel hypoplasia in the mandibular canines. Also, Harris lines are found in the distal tibiae of 93 percent of the males and 81 percent of the females. The mean number of Harris lines in the distal tibia is 1.9 for males and 1.5 for females. The mean number of stress episodes expressed by the Harris lines is 2.9 for males and 2.3 for females, whereas, the number of episodes suggested by enamel hypoplasia was 2.0 for males and 1.8 for females. This suggests that the stress was chronic or sporadic acute periods and did not result from seasonal periods of stress (e.g., seasonal periods of starvation or malnutrition).

Age specific morbidity, as indicated by the age of occurrence of Harris lines and enamel hypoplasia, roughly corresponds to the subadult mortality profile. The high morbidity at 2.5 to 3.5 years of age is suggestive of stress resulting from weaning.

Temporal (i.e., intercemetery) dynamics of stress and the intersex relationship of stress was examined via an analysis of variance. No significant difference between the cemeteries could be demonstrated for any of the three proposed indicators of stress. Also, the only difference between the sexes was for femur and tibia length which was anticipated. Thus, biological stress at Averbuch affected almost every inhabitant and showed no significant difference between the sexes or the cemeteries. However, a significant chi-square, between the number of males and females who possessed two or more Harris lines,

suggests that the males were more severely stressed, or perhaps more vulnerable to environmental stress than the females. Or, they may have experienced greater subperiosteal apposition and growth than females (Steinbock 1976:47).

Evidence for social stress is present at Averbuch in the form of scalping. Skulls with cuts, as well as some that exhibit varying degrees of healing along with the cuts, were recovered from both Cemetery 1 and Cemetery 3. A variety of adult ages and both sexes are represented among the victims. Attempts to explain this hostility range from methods of achieving status to competition for arable land.

From this study of the Averbuch skeletal series, it may be concluded that the Averbuch people were severely stressed. There is no statistically significant evidence of an increase or decrease in stress throughout the occupation of the site. Biological stress at the site was reflected in the skeletal remains of almost every one of the inhabitants. The number of stress episodes experienced are suggestive of chronic or sporadic acute stress as opposed to a seasonal patterning of acute stresses. In addition, evidence of scalping is indicative of the extreme social stress present at the site. As previously stated, the Averbuch site, with its location away from the major rivers, is unique in a number of respects when compared to the more typical Middle Cumberland Culture villages. However, the type and nature of stress experienced by the Averbuch people may to some degree reflect conditions that contributed to the late prehistoric demise of the Middle Cumberland population.

The Mississippian Period, of which the Middle Cumberland Culture belonged, marked a time in prehistory when complex social, religious and cultural activities were commonplace. Subsistence based on agriculture permitted a more stable diet and thus more sedentary and larger population. In order to continue this way of life, a relatively large "worker" base of young and middle-aged adults of both sexes was necessary to procure food and provide protection for the "nonworkers" and/or "semiworkers." The "nonworker"/"semiworker" group would have included the very young, the very old, the sick, specialized craftsmen and high status individuals. The rich arable soils of the Cumberland River flood plain probably sparked a population explosion in the Nashville Basin during the early and middle Mississippian Period. Population pressure during the late Mississippian Period may have forced settlements along the Cumberland to splinter forming many smaller satellite villages that centered on less desirable lands. Perhaps such pressure was responsible for the hinterland location of the Averbuch village. Regardless, the soils of these more remote areas would have been depleted after a few years of repeated farming. This soil depletion would have three very detrimental effects that together may have resulted in the collapse of the Mississippian Culture in the basin:

1. A demand for more and better soils may have stimulated warfare activities that required increasing numbers from the "worker" group as warriors.

2. An increase in food shortages would have required that increasing numbers from the "worker" group be involved in food procurement activities.

3. The increase in warfare and the increase in malnutrition would, through increased mortality and morbidity, decrease the numbers in the "worker" group and increase the numbers in the "nonworker"/"semiworker" group. Overall, less manpower would have been available for the maintenance of the social, religious and cultural traditions so characteristic of the Mississippian period.

This hypothesis, based on the initial findings at the Averbuch site, should be further explored by investigating biological and social evidence of stress at sites located on more arable soils. In addition, future research on the Averbuch skeletal series should be directed toward the examination of the frequency, and age and sex distribution of specific pathological conditions. For example, a study of infections, porotic hyperostosis, fracture patterns, etc., may more clearly illuminate the nature of stress at this and other Middle Cumberland Culture sites.

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# VITA

Hugh E. Berryman was born May 20, 1949, in Paris, Tennessee. He graduated from Palmersville High School, Palmersville, Tennessee, in 1967 and completed two years of study at The University of Tennessee, Martin. After marriage in 1971 his study continued at The University of Tennessee, Knoxville, where he received the Bachelor of Science degree in 1973 with a major in Anthropology. The Master of Arts degree was awarded in August 1975, also from The University of Tennessee, Knoxville.

While working toward his doctorate, Hugh was a Graduate Teaching Assistant, a Field Supervisor and later a Graduate Research Assistant. In September 1980 he began work as an Instructor for the Department of Pathology and Director of Morgues with The University of Tennessee Center for Health Sciences in Memphis, Tennessee, where he is employed at the time of receiving his Doctor of Philosophy degree, June 1981.

Hugh is a member of Sigma Xi, Phi Kappa Phi, American Association of Physical Anthropology, Society for American Archaeology, American Anthropological Association and Tennessee Anthropological Association.

Hugh and his wife, Treva, have one child, Johnathan Fagan, born October 5, 1980.