To the Graduate Council:

I am submitting herewith a thesis written by Anne Hawkins Prisock entitled "The a-b Dermatoglyphic Ridge Breadth: An Indication of Developmental Significance." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Richard L. Jantz
Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

THE a-b DERMATOGLYPHIC RIDGE BREADTH: AN INDICATION OF DEVELOPMENTAL SIGNIFICANCE

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Anne Hawkins Prisock

June 1981

ACKNOWLEDGMENTS

This research endeavor would not have been possible without the total support of the Anthropology Department at The University of Tennessee, Knoxville. All data used in the study was taken from the Dermatoglyphic Laboratory at The University of Tennessee, Knoxville. Dr. Richard L. Jantz has collected the necessary finger print data for a number of years. It was through his active participation in dermatoglyphic research, both locally and internationally, that the data was made available to me. Dr. Jantz made available his data on the Cashinahua, the Rajput and Tharus groups (collected by Dr. Chopra of Hamburg University), the Yoruba collections (collected and analyzed by Jantz, Mr. H. Brehme, and Mr. K. Parham), and The University of Tennessee, Knoxville, samples. Additionally, special gratitude is extended to Dr. William M. Bass whose continued support inspired the completion of this study. Dr. Jantz, Dr. Bass, and Dr. Fred Smith, the members of my thesis committee, each provided the necessary patience, guidance, and knowledge to direct the culmination of this study.

My gratitude is further extended to my fellow graduate students. Mr. Terry Zobeck provided me with assistance in data analysis as well as allowing me to use his research of the Cashinahua, Tharus, and Rajputs. Mr. Gary Scott and Mr. Kenneth Parham also allowed me access to their analyses.

Finally, none of this research would have been possible without the continued support, understanding, and encouragement of my husband, David.

ABSTRACT

The purpose of this study was threefold: to present a-b ridge breadth data on various populations; to synthesize factors influencing the a-b ridge breadth; and to suggest areas of developmental significance which are important in the a-b ridge breadth determination. The a-b ridge breadths of ten sample groups representing Whites, Blacks, Amerindians, and Indians were collected and determined.

The mean a-b ridge breadths were determined for each of the ten sample populations. These a-b ridge breadths were compared with previously published a-b ridge breadth data. The primary procedure used in data analysis was analysis of variance (ANOVA). The groups were further divided to determine differences between sexes. An F ratio was calculated for both the males and the females to determine if there were significant differences in a-b ridge breadths.

The major findings of the research were that the differences in the mean a-b ridge breadths of the ten populations were significant. These results agreed with other studies of the a-b ridge breadths. It appears that there are differences between sexes when the a-b ridge breadths are compared. Ridge breadth was found to indicate significant group differences. Additionally, there was noted a geographic patterning of ridge counts and ridge

distances. The a-b ridge count was found to be the one factor that varied between groups with consistency.

The developmental significance of the a-b ridge breadth was further highlighted by this study. It was previously known that the ridges of the palms are a record of the developing fetus. However, the exact nature of the record which is marked on the palms is unclear. It was perceived through this research endeavor that the actual width of the dermatoglyphic ridges in the a-b palmar area was the aspect of the a-b ridge breadth which illustrates developmental significance.

Systematic population comparisons were proposed in this study to help illustrate the aspects of palmar dermatoglyphics which are affected during development. More diverse sample populations need to be included in future studies. With more populations being examined for differences in palmar dermatoglyphics, the developmental significance of the a-b ridge breadth will be better understood.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Dermatoglyphics, the study of ridged skin, has throughout history been used as a means of individual identification. An examination of early studies dealing with dermatoglyphics illustrates the significance of dermal ridges. Cummins and Midlo (1961) reviewed records of some of the earliest palmar and digital prints. The following illustration was taken from Mallery (Picture-Writing of the American Indians, Tenth Annual Report, Bureau of Ethnology, 1893):

> The frequency with which partial representations of the eye are met with appeared to me so striking that I requested Mr. Jacobsen to ask the Bella Coola Indians whether they had any special idea in employing the eye so frequently. To my great surprise the person addressed pointed to the palmar surface of his finger tips and to the fine lineaments which the skin there presents; in his opinion a rounded or longitudinal field, such as appears between the converging or parallel lines, also means an eye, and the reason of this is that originally each part of the body terminated in an organ of sense, particularly an eye, and was only afterward made to retrovert into such rudimentary conditions.

The Chinese in approximately the Third Century B.C. used finger prints as a seal which served to validate a document. (Laufer, 1912). Later Purkinje (1823) first classified the varieties of patterns of the fingers. Purkinje defined and illustrated nine types of patterns.

The science of dermatoglyphics evolved from all of the different manners in which each investigator viewed the unique qualities of ridged skin, palmar patterns, and flexion creases. As a discipline, dermatoglyphics has evolved into a useful tool of identification. Dermatoglyphics are used by law enforcement personnel to identify criminals. Dermatoglyphics are used by geneticists to classify patients with birth defects. Dermatoglyphics are used for identification in checks in the banking world. Dermatoglyphics are presently being investigated to demonstrate not only unique individual differences, but also to give insight into group differences. Therefore, it seems that dermatoglyphics are a part of the picture that can bring some understanding to how persons are developmentally different. It is with this basic conviction that the present study was begun.

CHAPTER I

STATEMENT OF THE PROBLEM

Evidence suggesting that certain features of dermal ridges are genetically determined has been compiled during the last century. Sir Francis Galton (1892) in a preliminary study of finger print patterns provided the first evidence favorably implying that pattern types have a hereditary basis. Galton compared the frequencies with which similar patterns occurred on digits of pairs of sibs compared with corresponding digits of randomly paired unrelated persons. The frequencies of similarities among sibs was much greater than expected by chance. Wilder (1902, 1904) compiled information from his research and isolated studies of finger and palm print patterns which supported the belief that heredity played an important part in ridge determination. During the 1920's dermal prints from family groups were assembled and analyzed to determine genetic implications. Studies were instituted on twin dermatoglyphics, and have since been studied in more detail. Finger and palm prints have been used in genetic research. Additionally, dermatoglyphic data from families have been qualitatively analyzed for pattern type, pattern form, and pattern direction—all with the hope of determining the mode of inheritance. Most studies agreed that dermatoglyphics have a genetic basis.

The genetic mechanisms which act to determine pattern type and pattern form have been investigated. Bonnevie (1924) proposed that the eliptical form was dominant. It is not generally agreed that pattern direction (ulnar and radial) is inherited (Holt, 1968). Genetic research on palmar patterns has also been inconclusive. Wilder (1902) suggested a dominant inheritance of the thenar/first interdigital patterns. Holt (1968:36) stated that the capacity to form patterns in a definite area is inherited.

The failure of qualitative methods to produce insight into the genetics of epidermal ridge characteristics has necessitated a new approach. Instead of using qualitative classification with finger print patterns, quantitative measures of some pattern features are used. Two such methods have been used on finger print patterns: first, measuring the epidermal pattern height and breadth; and second, counting the number of ridges occurring between two fixed points on the pattern. Similar methods can be used on the toes. Palmar patterns are more difficult to quantify. Instead of examining patterns, features are examined in the palmar areas. Measurements that have been used are: first, counting the number of ridges between pairs of triradii; second, measuring the distance between pairs of triradii; and third, angular measurements.

The differential development of epidermal ridges makes them an excellent source of study. The finger ridges have received much attention in dermatoglyphic studies. Newman (1960) stated that dermatoglyphic traits are polygenically controlled, putatively nonadaptive, and undergo no postnatal modifications. They have distinct methodological advantages over anthropometry or serology in clarifying the older and more basic relationships between human populations. The advantages for studying the second interdigital area (a-b) of the palm include: one, the ridges are well defined; two, the boundary points or triradii a and b are nearly always present; and three, the straight line joining them is crossed by the ridges approximately at right angles.

Recent research conducted in dermatoglyphics (Jantz and Parham, 1978; Scott, 1978; Penrose and Loesch, 1967) has elucidated the significance of the a-b dermal ridge breadth. In spite of the number of studies of the a-b ridge breadth, there have been few attempts to synthesize the genetic implications of the a-b ridge breadth. An evaluation of sex and race differences in the a-b ridge breadth in different populations would make more lucid the principal forces contributing to the developmental significance of the a-b ridge breadth.

The purpose of this research endeavor is to first, present a-b ridge breadth data on various populations to be used in future studies; second, synthesize factors influencing the a-b ridge breadth; and third, suggest areas of developmental significance which are important in the a-b ridge breadth determination.

CHAPTER II

LITERATURE REVIEW

Development of Epidermal Ridges

The palms of the hands and the soles of the feet exhibit ridged skin in all primates. Ridged skin is also found on the distal portions of the tail in some New World monkeys. The distribution and configurations vary considerably in primates. The function of this ridged skin is most likely associated with the prehensile use of the hands, feet, and tails (Holt, 1968 and Galton, 1892).

The development of dermatoglyphic patterns has been of tremendous interest to biologists for the past century. Purkinje (1823) proposed that epidermal ridge patterns and directional hair patterning in the body resulted from similar developmental processes. These developmental processes are unclear in his report. Galton (1892) illustrated the permanence of ridge patterns throughout life. The first quantitative measurement of ridge growth was performed by Hale (1949, 1952). Hale further established that ridge development was completed at the seventeenth week in utero. Cummins and Midlo (1961) stated that the critical stages of differentiation occurred in the third and fourth fetal months. The epidermal ridges in the fetus begin as thin layers, then gradually thicken. The process of the development of the epidermal ridges is seen first in the fingers and last in the soles of the feet. Mulvihill and Smith (1969) presented the following hypothesis concerning the genesis of dermatoglyphics:

> The dermal ridge configurations are a direct consequence of the surface topography of the fetal hand during the period of dermal ridge development —between the thirteenth and nineteenth weeks of prenatal life—during which time the ridges form transversely to the lines of growth stress. (Mulvihill and Smith, 1969:579)

Mulvihill and Smith (1969) further defined three stages of morphogenesis of dermal ridges. These three stages can be summarized as follows:

I Stage One. The fetal pads are formed at the sixth to seventh week in utero just after the hands have lost their webbed shape. These pads are elevations of the mesenchymal tissues in the regions of the fingertips, the distal palms between each finger, and in the hypothenar area of the palms.

II State Two. During the twelfth to thirteenth week the pads regress in relative size. There is a dermal-epidermal junction at this time, and the surface is smooth.

III Stage Three. At the twentieth week the underlying patterns are reflected by identical configurations on the skin surface. Thus, the final dermatoglyphic patterns are set by the nineteenth week of gestation (Mulvihill and Smith, 1969:579-589).

More recently Penrose and O'Hara (1973) used an electron microscope to investigate epidermal ridge development. Miller (1973) and Okijima (1975) proposed methods of examining the development of dermal patterns. Babler (1978) further expanded upon the topic of epidermal ridge development. In his investigation of aborted fetuses he found epidermal ridges as initially being seen in the form of localized cell proliferations in the basal layer of the epidermis at approximately the tenth to eleventh week in utero. The cell proliferations form epidermal ridges that project into the dermis (Babler, 1978:21). There is an increase in the number of primary ridges which accompanies the increase in the size of the digit. At the seventeenth week in utero the ridges are distinguished as fingerprints on the volar surface. According to Babler (1978) ridge patterns become more elaborate and the number of ridges comprising the pattern is increased. At the time of ridge formation, the fetus is susceptible to developmental disturbances from the environment as well as from genetic controls.

Factors Which Affect the Development of Ridges

Babler (1978) established that there were both internal and external factors which might affect ridge formation. Cell differentiation and control of growth rates are two genetic components which Babler felt might affect ridge development. Earlier studies (Cummins and Midlo, 1961) have stated that developmental disturbances which are in existence might produce ridge imperfections. When the factors producing imperfections are in operation, only those areas not yet active in ridge formation are susceptible. Bonnevie (1924) correlated ridge variations in the form of the finger pads and the presumed pattern formation. This correlation indicated the influence of generalized growth processes with the pattern. Cummins and Midlo (1961) emphasized the role of growth stresses in the developing skin. Dermatoglyphics, formed before the nineteenth week in utero, might be a record of conditions existing several months prior to birth. According to Cummins and Midlo (1961:185) the distinctions in adult dermatoglyphics—among races, between sexes, between right and left hands, or in any other comparison—reflect the existence of differences dating from the fetal period.

Dermatoglyphic Terminology

The recording of epidermal ridges for study can be performed with relative ease. One makes a print of the palms, soles, and digits usually with printer's ink. The ridges show up as dark lines. The printed palm and sole can be categorized and analyzed via rules now established in dermatoglyphic study. The most widely accepted method of dermatoglyphic analysis is best explained in Holt (1968). As the present study involved the palmar area, only palmar areas and methods of analysis will be discussed in detail.

There are five dermatoglyphic areas of the palm (Figure 1). Each area of the palm exhibits characteristic patterns. When viewing a palmar print the radial area (thumb side) is referred to as the thenar area. The ulnar area, near the small finger, is referred to as the hypothenar area. Patterns in these areas may be longitudinal, oblique, or transverse. The intersection of three ridge systems is referred to as a triradius. Normally a triradius occurs at the base of each digit except the thumb. These digital triradii are assigned the nomenclature a, b, c, and d. The axial triradius, t, is normally located between the thenar and hypothenar areas. The location of the palmar triradii is illustrated in Figure 1.

Penrose (1954) defined a triradius as the junction of three regions each containing systems of ridges which are approximately parallel in small fields of these regions. In theory the three angles between the radiants should measure 120°. This is not always so. Penrose established the criterion that the smallest angle must be at least 90°. These triradii are associated with patterns in the palmar areas. In analysis, counts are taken and measured from triradius to triradius. The following illustrations (Figure 2) are examples of triradii.

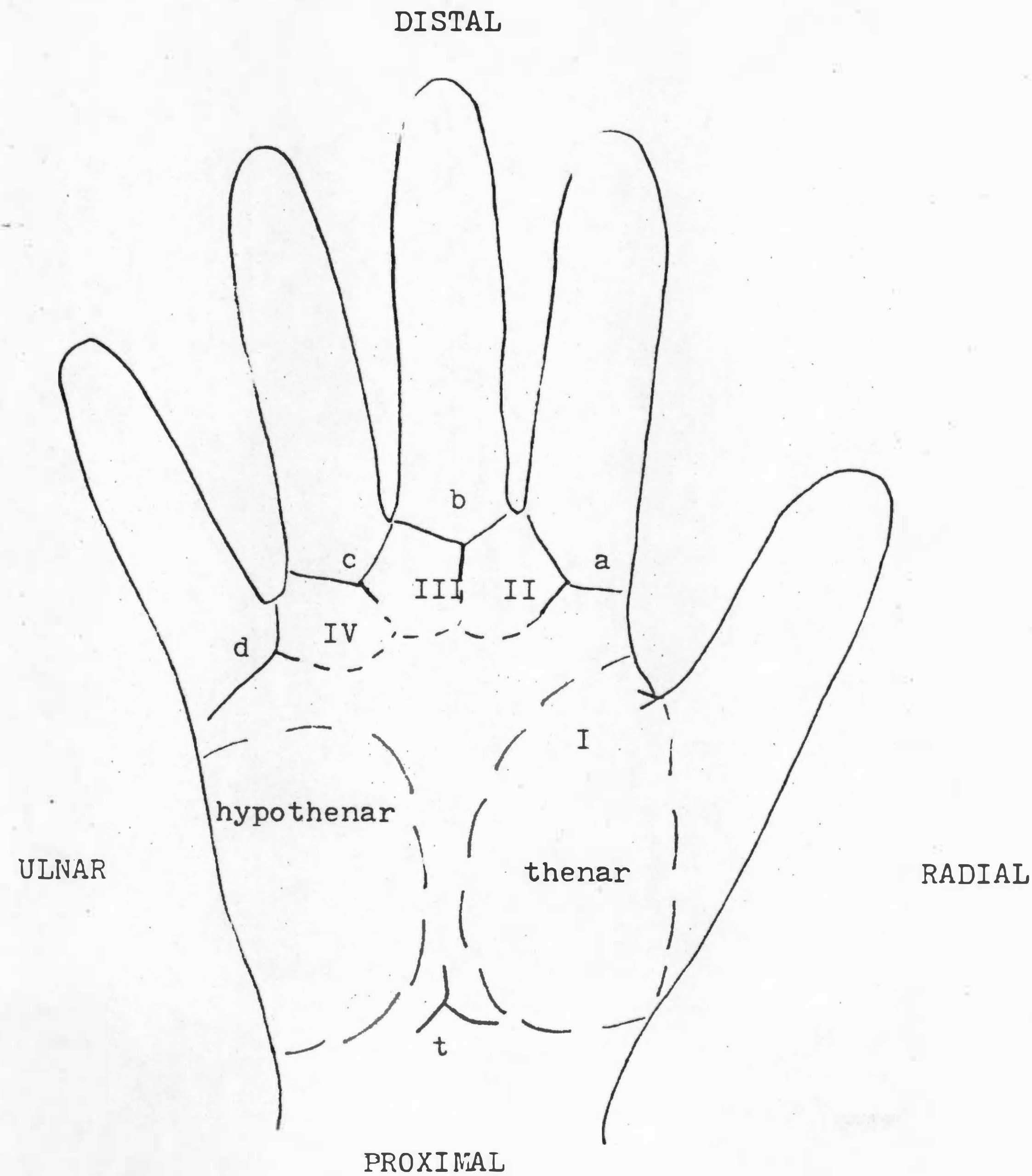

Figure 1. The principal palmar triradii and the five dermatoglyphic areas of the palm (Holt, 1968: 13).

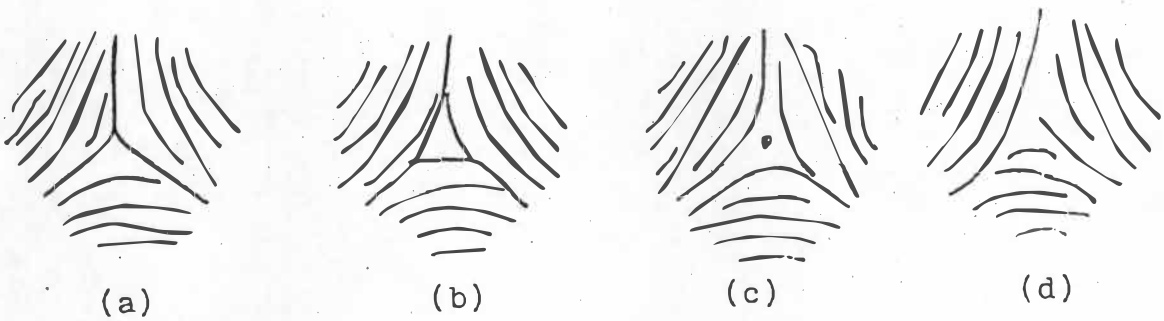

Figure 2. Examples of triradii (Holt, 1968:14).

Triradii vary a great deal. Therefore, the systematic analysis of one (or two) triradii requires that certain rules be followed. In counting and measuring, the center or core of the triradius is not taken. All ridges between the triradii are, however, included.

a-b Ridge Counts

The a-b ridge count is the number of ridges counted between the digital triradii a and b in the second interdigital area. All ridges which intersect or touch a straight line from a to b are included. Triradius a is sometimes duplicated. If triradius a is duplicated, the triradius nearest the radial border of the palm is used. Patterns in the interdigital III area and patterns in the interdigital IV area are commonly present. The occurrence of these patterns makes ridge counting in the b-c and c-d areas difficult. The a-b ridge count yields a measure of distance between the two triradii that is age independent. Holt (1968:89) states that the direct measure of the distance from a to b and the a-b count are highly correlated. The correlation coefficient in adults of both sexes is approximately 0.8.

There is no significant correlation between the summed a-b ridge count and the total finger ridge count (TRC), but there is a positive correlation between the a-b count and the maximum atd angle (Holt, 1968:90). Bimanual differences in a-b counts are apparent. Fang (1950) found the mean ridge count on the left hand to be significantly higher than on the right hand in both males and females. Pons (1964) found sex differences in the a-b ridge count to be small and not significant. Holt (1968), in her analysis of familial correlations of ridge counts, felt that her studies indicated that environmental factors exerted a greater effect on the a-b ridge count in early prenatal life than they did on finger ridge count. Flores (1975) found that among his Sardinian populations, males have a greater number of ridges than females and a greater a-b ridge count. Fang (1951) felt that the genetic factors which determined variation in the a-b count consisted of a main gene whose expression was affected by multiple modifying factors. In his study of the a-b count of Ontario British, European Jews, and Ontario-Indians, he proposed that the allele which determined a high count (79 ridges or more) was dominant over its corresponding allele determining a low count.

Dermatoglyphic Variability

Developmental Interpretations

Numerous techniques and studies have been undertaken to discern the developmental meaning of dermatoglyphic variability. Finger ridge counts, particularly total finger ridge counts, are becoming more important in human population studies due to evidence of high heritability (Holt, 1968; Loesch, 1971). Large numbers of studies exist which compare different population samples either by individual digits or by TRC. These studies demonstrate a considerable range among human populations. Jantz (1974) investigated interfinger variability ($S/\sqrt{10}$) and finger ridge counts in samples of Blacks and Whites. Jantz (1974) found that Whites, in general, have higher ridge counts than Blacks. He found that $S/\sqrt{10}$ is more efficient than TRC in distinguishing racial differences. Jantz (1975) found population variations with respect to finger ridge count asymmetry and diversity from finger to finger. He (Jantz, 1975) states that patterning along population lines suggested genetic rather than environmental bases for such variation. Holt (1958) studied the relationship between diversity from finger to finger and TRC by using a measure of diversity, S^2. Holt (1960) examined familial correlations of diversity from finger to finger using the quantity $S/\sqrt{10}$. $S/\sqrt{10}$ is an index of diversity measuring the standard deviation of the ten fingers. $S/\sqrt{10}$ has a high heritibility (Holt, 1960). Holt's family studies suggest that the diversity of finger to finger counts may, like ridge-counts, show meaningful population variation (Jantz, 1974).

Jantz and Owsley (1977) subjected finger ridge counts of an American White, American Black, and African Black sample to factor analysis. They used twenty counts, a radial and ulnar count from each digit. They found that radial and ulnar sides of the digits are apparently responding to different developmental instructions. Most of the intersample variation found by Jantz and Owsley was limited to shifts in emphasis among adjacent digits within a factor. They felt that this suggested similar developmental programs in different populations. Jantz and Hawkinson (1980) in a principal components analysis used to evaluate finger ridge count found that large amounts of ridge count variation are not genetically meaningful.

Racial and Sexual Interpretations

Jantz (1974, 1975) found that Blacks have a more homogenous distribution of counts. He found this to be the case when comparing Whites and Blacks with respect to the level of intraindividual variation among finger ridge counts. Jantz (1976) used finger ridge count correlations as indicators of sex and race differences. He hypothesized that differences between Blacks and Whites in TRC may be due to differences in finger ridge breadth rather than in the size of the pattern. Steinberg, Cereghino, and Plato (1975) examined the dermatoglyphics of 184 males and 224 females of normal American Negroes. They found that their sample of American Negroes' palmar pattern frequencies agreed with other samples of Negro populations. In a similar analysis of Caucasian populations, Steinberg, Cereghino, and Plato (1975) discussed differences of pattern frequencies among racial groups. Juberg, Morgan, and Faust (1980) searched for single gene effects in determining digital patterns. They concluded that the Louisiana population that they studied showed evidence for a single gene effects similar to an Israeli population.

Females have a higher correlation for various dimensions and developmental events than males. This includes postnatal ossification timing of hand-wrist centers (Garn et al., 1967), crown dimensions of permanent teeth (Garn et al., 1965), and prenatal hand and dental development (Burdi et al., 1974). Jantz (1977) felt that since this was apparently a general developmental phenomenon it could be investigated. Jantz (1977) proposed an investigation via intercorrelations among finger ridge counts. In this investigation of 11 samples representing Negroes and Caucasians, he found that the pattern of sex and race differences suggested that the sex chromosomes, particularly the Y chromosome, played a role in dermal ridge development. Sex chromosome aneuploidy studies have established that both X and Y chromosomes have a predictable effect upon ridge count. Barlow (1973) showed a regular regression of TRC on the number of X and Y chromosomes. Penrose and Loesch (1967) demonstrated that supernumerary X and Y chromosomes increase ridge breadth.

Sex differences in TRC are due to differences in ridge breadth rather than pattern size. Jantz (1977) suggested that differences between Blacks and Whites in TRC may also be due in part to differences in ridge breadth rather than pattern size. This is perhaps an explanation of the lower sexual dimorphism in Blacks as compared to Whites in ridge counts.

a-b Ridge Breadth

There have been many diverse applications of ridge breadth. Hecht (1907) reported a very loose and indirect correlation between dermal ridge breadth and sitting height. Cummins, Waits, and McQuitty (1941) studied variation among individuals by using dermal ridge breadth. They determined that ridge breadth varies directly, but in a very loose correlation with body weight, stature, hand length, hand breadth, and digital breadth. Similarly, Ohler and Cummins (1942) showed sex differences via ridge breadth analysis. Penrose and Loesch (1967) studied ridge breadth of the second interdigital palmar area to examine aneuploid states of sex chromosomes. Katznelson and Ashbel (1973) included ridge breadths in their analysis of the dermatoglyphics of a group of Ashkenazi Jews. Racial differences in dermal ridge breadths were first discussed by Jantz and Parham (1977). Previous studies of the a-b palmar area were generally confined to the utilization of ridge counts, the number of ridges between two specific points. Ridge counts are measurements that provide useful information. They are especially important in that they are a constant measurement that does not change with age. Ridge breadths, however, vary with reference to age, sex, hand size, and body size (Cummins, Waits, and McQuitty, 1941).

Penrose and Loesch (1967) showed a relationship between ridge breadths and various sex chromosome aneupoidies. Penrose and Loesch found that males have wider ridges than females, and that generally there is a tendency for ridge breadth to increase with the addition of extra X and Y chromosomes. Jantz (1977) suggested that developmental differences between Blacks and Whites are reflected in finger ridge count correlations. Jantz and Parham (1978) suggested that finger ridge count differences between groups might be due to differences in pattern size or frequency, or to differences in ridge breadths. They found that the lower a-b ridge counts in Blacks were primarily due to wider ridges. Jantz and Parham (1978:38) speculated that the wider ridges in Blacks result from a slightly slower rate of intrauterine development on the basis of the suspected effects of sex chromosomes on intrauterine development. As an illustration of possible support of this interpretation, Jantz and Parham (1978) quote the findings of Roberts (1969) on birth weight that Black babies have a lower birth weight when compared to Whites.

CHAPTER III

METHODS AND PROCEDURES

Ridge Breadth Determination

Ridge breadth is defined as the distance from the center of one ridge furrow to the center of the next furrow along a line at right angles to the ridges (Penrose, 1968). There is no absolute way to measure ridge breadth from palmar prints, however, present methods have proven to be useful and consistent. Penrose and Loesch (1967) described a method for determination of ridge breadth in the second interdigital area. There are two quantities utilized, the a-b ridge count (the number of ridges between the a triradius and the b triradius), and the distance in millimeters between the a triradius and the b triradius. Ridge breadth is obtained by calculating:

$$D_L + D_R / (C_L + C_R + 2) \quad ,$$

where D is the distance in millimeters and C is the ridge count. The two added to the ridge count is to compensate for the omission of triradii in the counting process. Ridge breadth may be expressed in micrometers (μm) to eliminate decimals. The distance D varies with the age of the subject. Comparisons between groups must be carried out on subjects of comparable age. The count, C, is determined in utero; therefore, it is independent of age.

The palmar ridges in the present study were often thin and difficult to distinguish. A compound microscope was used to enlarge the a-b area. Upon enlargement (10X) the ridges are counted between triradius a and triradius b. A Dial Helios Caliper was used to measure the distance a-b in the same location as was used in the count a-b. Both right and left hands were used. All questionable prints were discarded.

Samples

Data collected by various persons for several projects affiliated with the Department of Anthropology at The University of Tennessee, Knoxville were used in the present study. Groups representing Black populations were the Yoruba of Nigeria and Black students from The University of Tennessee, Knoxville. A sample of White Students from The University of Tennessee, Knoxville represents a Caucasian stock. The Cashinahua Indians of South America represented an Amerindian stock for comparative purposes. Finally, two groups of Indian castes, the Tharus and the Rajput, an admixture of Asian and Indian origins, provided a comparison of eastern peoples. All groups are expected to provide a comparative background. Problems do exist in all samples.

The major discrepancies in the data exist in the size or differential methods of collections. A detailed discussion of the sample groups follows.

African Blacks

The Yoruba of Nigeria inhabit the southwestern portion of Nigeria from the coast to the river Niger north of its junction with the Benue. Linguistic evidence suggests a western origin for their language rather than an eastern origin (Bascom, 1969). Finger and palm prints were collected by Mrs. A. Kalmus in 1974. The sample consists of 126 males and 55 females. All were students at the University of Ife, Nigeria. Most students were 18 years or older, and all were at least 16 years of age. Previous investigations of dermatoglyphic data of this Yoruba sample include Jantz, 1977; Jantz and Owsley, 1977; Jantz and Parham, 1978; Jantz and Hawkinson, 1979 and 1980.

Ridge breadth calculations for the a-b palmar area were conducted by Jantz and Parham (1978). The sample size consisted of 119 males and 52 females. The procedure of analyzing this sample was consistent with the methods of a-b ridge breadth determination as described previously by Penrose and Loesch (1967).

American Indians

The Peruvian Cashinahua are a small isolate of American Indians living in the rain forest near the head waters of the

Jurua-Purus river systems in the state of Acre, western Brazil, and in the province of Coronel Portillo in south-eastern Peru (Jantz et al., 1970). Dermatoglyphic data were collected by Jantz, Johnston, Kensinger, and Walker in 1966. The Cashinahua have encountered no significant gene flow from non-Indian sources, and represent an isolated population of South American Indians. Palm prints collected by Jantz et al. (1970) included 81 males and 85 females, or 81% of the total population.

The a-b ridge breadths were determined by the investigator on those individuals 18 years and older. Previous investigations of the a-b ridge breadth of the Cashinahua include Zobeck (1978). The sample size of a-b ridge breadths in the present study consisted of 20 males and 36 females. Procedures for the determination of a-b ridge breadth were consistent with Penrose and Loesch (1967).

Indian Groups

The Tharus are a tribal people of the Himalayan Region with Mongolian affiliations. They live in Uttar Pradesh in an area called Tarai, between the Himalayan foothills and the northern Indian plains (Srivastara, 1965). Of the prints collected, 50 were analyzed by the investigator to determine a-b ridge breadth. Previous investigations of the a-b ridge breadth of the Tharus include Zobeck (1978). All subjects analyzed were male and at least 18 years of age. Procedures for a-b ridge breadth determination were consistent with Penrose and Loesch (1967).

The Rajput are an endogamous subcaste of Bengal. They belong to the subcaste Rarhi Brahmin. Of the prints collected, 50 were analyzed by the investigator to determine a-b ridge breadth. Previous investigations of the a-b ridge breadth of the Rajput include Zobeck (1978). All subjects analyzed were male and at least 18 years of age. Procedures for a-b ridge breadth determination were consistent with Penrose and Loesch (1967).

The University of Tennessee, Knoxville Students

An ongoing systematic study has been used by the Department of Anthropology via human variation questionnaires issued to anthropology students on the undergraduate level. Students participate on a voluntary basis. Detailed information is asked of the student (see Figure 3). Dermatoglyphic prints are recorded by graduate assistants in the Anthropology Department. The students represent a diverse sample of individuals from the United States as well as international students.

The Black student sample was composed of 49 females and 21 males. The investigator determined a-b ridge breadths on these individuals consistent with those methods

ANTHROPOLOGY HUMAN VARIATION QUESTIONNAIRE

You are requested to give as much of the information listed below as possible. It is to be used in obtaining human genetic information, and the larger the number of people in the sample, the more representative it will be of the population as a whole. In the interests of being as frank as possible, do not put your name on the questionnaire sheet. We are not interested in tracing any one piece of information to any one individual.

Circle the correct answer to each question.

1. Your sex:
   a. Male
   b. Female

2. Your racial background:
   a. Afro-American
   b. Euro-American
   c. American Indian
   d. Other (specify)

3. Your twin status:
   a. not a twin
   b. I have a twin of the same sex
   c. I have a twin of the opposite sex
   d. my twin is in this class
   e. I am a member of a set of triplets, or a group based on a higher order of multiple births (describe)

4. Your height:
   a. less than 4'11" (specify)
   b. 5'0"
   c. 5'1"
   d. 5'2"
   e. 5'3"
   f. 5'4"
   g. 5'5"
   h. 5'6"
   i. 5'7"
   j. 5'8"
   k. 5'9"
   l. 5'10"
   m. 5'11"
   n. 6'0"
   o. 6'1"
   p. 6'2"
   q. 6'3"
   r. 6'4"
   s. 6'5"
   t. 6'6"
   u. greater than 6'6" (specify)

5. Your weight:
   a. less than 76 lbs.
   b. 76-85
   c. 86-95
   d. 96-105
   e. 106-115
   f. 116-125
   g. 126-135
   h. 136-145
   i. 146-155
   j. 156-165
   k. 166-175
   l. 176-185
   m. 186-195
   n. 196-205
   o. 206-215
   p. 216-225
   q. 226-235
   r. 236-245
   s. 246-255
   t. more than 255 lbs.

Figure 3. Anthropology human variation questionnaire.

described by Penrose and Loesch (1967). All subjects used were 18 years of age or older.

The White student sample was composed of 132 females and 88 males. All subjects used were 18 years of age or older. Mr. Gary Scott, Master's degree candidate at The University of Tennessee, Knoxville, determined a-b ridge breadths on these individuals consistent with those methods described by Penrose and Loesch (1967).

CHAPTER IV

RESULTS

The means and standard deviations of the a-b ridge counts, a-b distances, and a-b ridge breadths were calculated for all ten sample populations and are presented in Table 1. A cursory examination of Table 1 shows that the a-b ridge counts, $C_L + C_R$, range from 75.07 mm, the Yoruba male count, to 82.45 mm, The University of Tennessee, Knoxville, White female count. The a-b ridge counts of the Cashinahua males and females, The University of Tennessee, Knoxville, White males and females, and The University of Tennessee, Knoxville, Black males and females are very similar. The a-b ridge counts of the Yoruba males and females, the Rajputs, and the Tharus are nearly alike. The summed a-b distances, $D_L + D_R$, are also similar among all groups except the Cashinahua females. The Cashinahua females exhibit the smallest a-b distance of 38 mm. The Rajput males exhibit the largest a-b distance of 48 mm. The a-b ridge breadths, $D_L + D_R$ / $C_L + C_R + 2$, range from the smallest of 470 μm, the Cashinahua females, to the largest of 605 μm, the Yoruba males.

Various techniques were used in order to discern differences among the ten populations. Z and t tests are two techniques used for testing statistically significant

TABLE 1

Means and Standard Deviations of a-b Ridge Counts, a-b Distances, and Ridge Breadths of Ten Populations

Sample Populations	N	$C_L + C_R$ $\bar{X}$	S	$D_L + D_R$ X	S	Ridge Breadth* X	S
Yoruba Males	119	75.07	11.32	46.36	6.06	605	55
Yoruba Females	52	77.25	10.79	43.85	4.96	556	41
Cashinahua Males	20	82.0	7.39	41.0	4.05	480	43
Cashinahua Females	36	80.0	9.53	38.0	4.31	470	37
Tharus Males	50	77.0	8.95	46.0	4.88	580	68
Rajput Males	50	76.0	10.98	48.0	5.90	600	43
UTK White Females	132	82.45	10.87	41.0	6.66	521	44
UTK White Males	88	81.84	11.17	45.77	6.09	584	46
UTK Black Females	49	79.0	13.33	43.0	9.64	531	64
UTK Black Males	21	78.0	11.08	47.0	5.38	590	42

*Ridge breadth = $D_L + D_R / C_L + C_R + 2 \times 1000$.

differences between two groups. Samples involving more than two groups can be tested for differences by taking the means in pairs and then testing the various combinations of pairs to see if they differ significantly. However, by taking two groups at a time, $N(N - 1)/2$ number of different tests would be necessary. An additional complication to this process is that when data are analyzed in this way, the fact that these samples exist in a subset is ignored. The elements of sets are known to interact. Analysis of variance does not ignore interaction.

Statisticians have designed analysis of variance (sometimes called ANOVA) techniques in which all of the data are treated at once and a general null hypothesis of no difference among the means of the various groups is tested. It stands to reason that if subjects are exposed to the same conditions as others in their own group, but to conditions that differ from those to which subjects in other groups are exposed, and those conditions make a difference, then subjects within groups will be more alike than subjects between groups. Two forms of variation are examined in analysis of variance; the variation of group means from the total means of groups, the "between groups" variance, and the average variability of the scores within each group, the "within groups" variance. Inherent in the analysis of variance is the following: if the groups are random samples from the same population, the two variances, within and between, are unbiased estimates of the same population variance. The test for the significance of the difference of the two types of variance is the F test. When the analysis of variance technique is used, the following assumptions should be met:

1. Individuals in the subgroups should be selected on the basis of random sampling from normally distributed populations;
2. The variance of the subgroups should be homogeneous. This assumption of homogeneity of subgroup variance should be tested by determining Chi-Square (χ^2) for independence when analysis of variance is to be used; and
3. The samples comprising the subgroups should be independent.

Assumptions one and three depend upon the adequacy of the sample design. Assumption two is very important and should be tested. The computational method for performing χ^2 yields a Chi-Square value. If the χ^2 is significant with number of groups, n, minus one degree of freedom, then the second assumption has not been met (Loether and McTavish, 1976).

It is assumed that all ten populations represented in the present study were selected on the basis of random sampling from normally distributed populations. Although the Yoruba, Rajput, Tharus, and The University of Tennessee, Knoxville, samples were drawn from university students, there was no intended bias to any category of individual. The Cashinahua represent a population isolate; therefore, the only sampling bias is that of the gene pool. The χ^2 value was determined to be 1.503 which is not significant at the .05 level with n minus one or nine degrees of freedom. Therefore the variance of the subgroups are assumed to be homogeneous. All groups are independent of each other. The samples represent wide spans of population variation both geographically and genetically. No one individual was felt by the investigator to be a member of two groups at the same time.

Table 2 summarizes the means, $\bar{x}$, sums of the observations, $\overset{n_i}{\Sigma} Y$, and sum of the squared observations, $\overset{n_i}{\Sigma} Y^2$, of the ten groups. Table 3 summarizes the between group variances and the within group variance of the male samples. Table 4 summarizes the between group variances and the within group variance of the female samples. If the null hypothesis that the two sample variances estimate a common population variance is true, then the ratio of the two sample variances has an F sampling disbribution. To test the null hypothesis, F is computed from the following formula:

$$\frac{\text{MS Between}}{\text{MS Within}} .$$

TABLE 2

Summarization of Means, Sums of Observations, Sum of Squared Observations of a-b Ridge Breadths in Ten Populations

Sample Population	$\overline{X}$	$\overset{n_i}{\Sigma Y}$	N	$\overset{n_i}{\Sigma Y^2}$
Yoruba Males	605	71995	119	43913925
Yoruba Females	556	28912	52	16160803
Cashinahua Males	480	9600	20	4643131
Cashinahua Females	470	16920	36	8000315
Tharus Males	580	29000	50	17046576
Rajput Males	600	30000	50	18090601
UTK White Females	521	68772	132	36083828
UTK White Males	584	51392	88	30197020
UTK Black Females	531	26019	49	14012697
UTK Black Males	590	12390	21	7345380

TABLE 3

Summary Table of Analysis of Variance (ANOVA) for a-b Ridge Breadth of Males

Source of Variation	df	SS	MS	F
Between groups	5	279471	55894.24	20.65
Within groups	342	925524	2706.22	
Total	347			

TABLE 4

Summary Table of Analysis of Variance (ANOVA) for a-b Ridge Breadth of Females

Source of Variation	df	SS	MS	F
Between groups	3	161359	53786.54	24.45
Within groups	265	583071	2200.27	
Total	268			

The F ratio compares the observed differences between the sample means of the groups being studied with an error term consisting of measures of variability of scores within the groups being studied. To find the F value for the samples using the 5% level of significance, the F table summarized in Loether and McTavish (1976:599) was consulted. For males the F value was determined to be 2.21, using 5 and 342 degrees of freedom. For females the F value was determined to be 2.60, using 3 and 265 degrees of freedom. As both calculated F values (20.65 for males and 24.45 for females) are larger than the values which bound the critical region, the null hypothesis is rejected. The rejection of the null hypothesis means that there are significant differences among the mean ridge breadths of the a-b ridge breadths of both the male and female groups tested.

CHAPTER V

DISCUSSION OF RESULTS

The suggestion of these data, that there exists significant differences among the means of the various a-b ridge breadths of the groups of males tested together and the females tested together, should be considered more thoroughly. The differences were considered separately for males and females to avoid confusing group variation with sex variation. The differences between the mean a-b ridge breadths both of males and of females are significant. This measured difference highlights the critical point of the analysis—what, exactly, does the a-b ridge breadth measure. The a-b ridge breadth measures the distance between two points as well as the number of ridges between these two points. Significant differences in a-b ridge breadths indicate that there are more or fewer ridges in an area that varies from individual to individual. Therefore, both aspects of a-b ridge breadth determination, the a-b count and the a-b distance, need to be considered.

The a-b ridge counts have been calculated for numerous populations having Black and White origins. Table 5 summarizes data on a-b ridge counts. Whites have a-b ridge counts of 80 mm to 85 mm and Blacks have ridge counts of 75 mm to 80 mm. The Cashinahua sample and The University of Tennessee, Knoxville, White sample agree with the

TABLE 5

Mean a-b Ridge Counts of Representative Samples of Blacks and Whites

	N	Male	N	Female	Source
Blacks					
Yoruba	119	75.1	52	77.3	Jantz and Parham, 1978
Hadza	110	75.1	51	79.8	Barnicot et al., 1972
Zulu	200	72.0	200	78.5	Grace and Ally, 1973
UTK Blacks	21	78.0	49	79.0	Present study
Whites					
Spanish	200	82.6	200	84.0	Pons, 1964
British	424	83.0	435	83.0	Fang, 1951
Sardinian	418	83.0	391	81.1	Floris, 1975
UTK Whites	88	81.8	132	82.4	Present study
Amerindians					
Cashinahua	20	82.0	36	80.0	Present study
Indians					
Tharus	50	77.0	---	----	Present study
Rajput	50	76.0	---	----	Present study

White data presented in Table 5. The Yoruba, the Indian groups, Tharus and Rajput, and The University of Tennessee, Knoxville, Black group also agree with the Black data presented in Table 5. At the risk of speculating beyond the evidence of the data, there appears to be a geographical distribution with regard to a-b ridge counts. Those groups originating in Africa and in the eastern Asian countries have fewer ridges than those whose origins are based in the American continent.

The a-b distances as measured exhibit fewer differences than the a-b ridge counts. As stated before the Cashinahua females have the smallest interdigital distance. The females of all groups exhibit smaller distances than the males. Other than sex differences, there are between-group difference in the ten populations. The Cashinhua exhibit the lowest measured a-b distance, while the Rajput exhibit the highest a-b distance. The Black, White, and Tharus samples vary between the highest and lowest distances. The White samples exhibit a-b distances similar to the Cashinahua samples. The Black samples and the Rajput sample exhibit a-b distances similar to the Tharus. This may be related to hand size or body size. Hrlička's (1928) data on hand measurements demonstrated that American Blacks have longer hands than Whites, but the breadth is not significantly different. There appears to be a geographical distribution with regard to a-b distance. Those groups whose origins are based in the American continent display a smaller a-b distance than those groups whose origins were founded in the Asian and African continents.

There are relatively few data on a-b ridge breadths. Table 6 presents a-b ridge breadth data on samples of males and females. Ridge breadths vary between sexes. Males have greater ridge breadth values than females. An examination of the males presented in Table 6 illustrates that the males vary from the lowest of 480 μm (Cashinahua) to the highest of 600 μm (Rajputs). Females vary from the lowest of 470 μm (Cashinahua) to the highest of 561 μm (Bogilazo). As stated previously, the a-b ridge breadth is an expression of the a-b ridge count and the a-b distance. The number of actual ridges in a count depends on two factors: the distance contained between the two reference points and the breadth of these ridges. Figure 4 presents a comparison of a-b ridge counts and a-b distance. The females of all groups cluster together in the upper left part of the graph. The upper left part of the graph is the area where high a-b ridge counts are matched with low a-b distances which combine to make narrow ridges. The males, with the exception of the Cashinahua males, are grouped in the lower right part of the graph. The lower right part of the graph is the area where low a-b ridge counts are matched with high a-b distances

TABLE 6

Mean a-b Ridge Breadths of Samples of Males and Females

Population	N	RB	S	Source
		Males		
Western Armenian	58	582	53	Hawkinson, 1981
Eastern Armenian	34	582	47	Hawkinson, 1981
English	259	541	48	David and Ajdukiewicz, 1978
Bwaka	85	579	46	Vrydagh-Laoureux, 1979
Ngombe	32	582	42	Vrydagh-Laoureux, 1979
Sango	34	596	48	Vrydagh-Laoureux, 1979
Mongwandi	28	570	43	Vrydagh-Laoureux, 1979
Yoruba	119	605	55	Jantz and Parham, 1978
Cashinahua	20	480	43	Present study
Tharus	50	580	68	Present study
Rajput	50	600	43	Present study
UTK Whites	88	584	46	Present study
UTK Blacks	21	590	42	Present study
		Females		
Western Armenian	46	538	43	Hawkinson, 1981
Eastern Armenian	32	542	60	Hawkinson, 1981
English	381	492	43	David and Ajdukiewicz, 1978
Bwaka Bogilazo	33	561	39	Vrydagh-Laoureux, 1979
Ngombe	22	545	42	Vrydagh-Laoureux, 1979
Sango	42	541	29	Vrydagh-Laoureux, 1979
Yoruba	52	556	41	Jantz and Parham, 1979
Cashinahua	36	470	37	Present study
UTK White	132	521	44	Present study
UTK Blacks	49	531	64	Present study

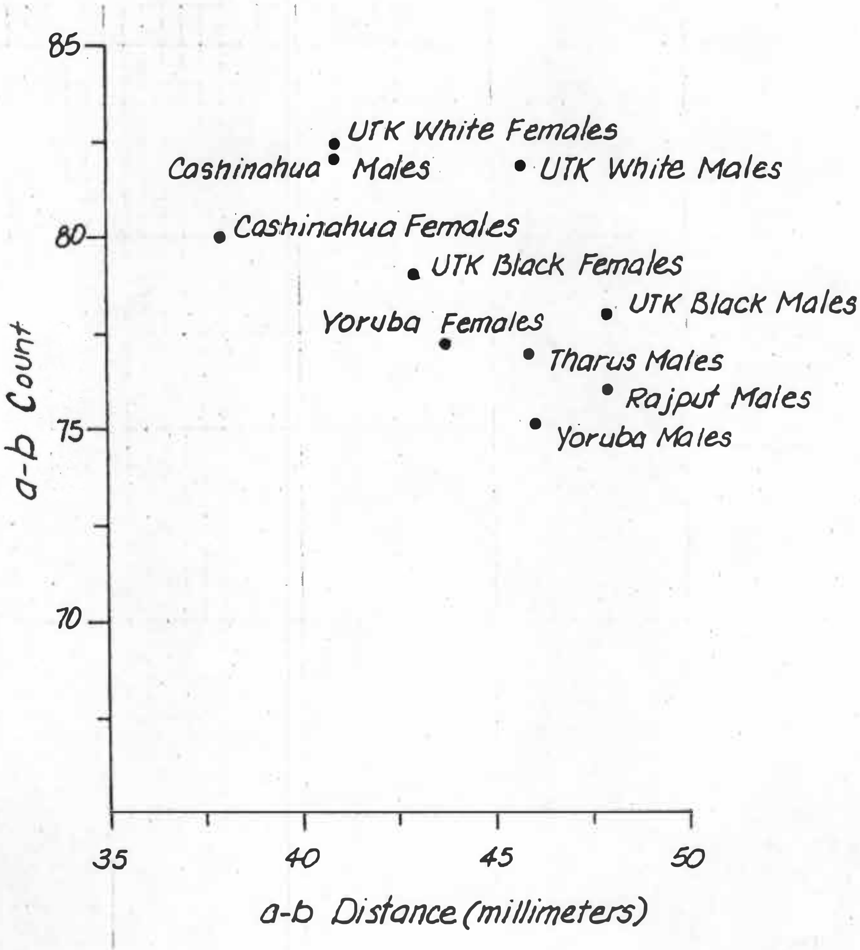

Figure 4. a-b Ridge counts contrasted with a-b distances for ten samples.

which combine to make wide ridges. The Yoruba fall below the general cluster of points, which means that for a given distance their counts are lower than the other populations. Similarly, the Tharus and Rajput groups fall below the general cluster of points, indicating that for a given distance their counts are lower than the other populations. The Cashinahua are grouped together in the upper left part of the graph, which means that for a given distance their counts are higher than the other populations. The University of Tennessee, Knoxville, samples have very similar counts, but distance varies a great deal. The difference in ridge breadths between The University of Tennessee, Knoxville, samples appears to be one of size. The University of Tennessee, Knoxville, White females have the lowest distance and the lowest ridge breadth. The University of Tennessee, Knoxville, Black males have the greatest distance and the greatest ridge breadth.

Variations in fetal development might influence dermatoglyphics. However, little is known about how this variation affects dermal ridges. Jantz and Parham (1978) suggested that the wider ridges in Blacks resulted from a slightly slower rate of intrauterine development. It appears that The University of Tennessee, Knoxville, Black samples and the Indian groups also exhibit similarities with the Blacks in Table 5. The Black samples and the Indian groups have wider ridges. Again, there is the geographical distribution of a-b ridge counts and a-b distances which must be considered. Ridge widths, though not quantified, appear to be the feature of dermatoglyphics which is affected the most by developmental processes. Babler (1978) supports this idea with his studies of pad formation and regression in fetuses.

More indepth studies of the a-b ridge breadth need to be conducted before its developmental significance is understood. The a-b ridge breadth probably is a reflection of various developmental processes. Whether these processes are controlled by one or more genes, a direct reflection of untrauterine growth, or some other process not yet discerned is still open to investigation. The results of this study have illuminated several areas of importance. First, the variation between the mean a-b ridge breadths of the ten sample populations is significant. Other important indications of this study are that the a-b ridge counts and a-b distances are an essential indication of population variation. Finally, more systematic research is needed in the area of a-b ridge breadth studies. When a palmar print is collected, information on the individual needs to be collected. This information needs to include data collected by studies such as the Human Variation Questionnaire (Figure 3, p. 27). Additionally, information needs to be collected on palmar height and breadth. Though inconclusive at the present time, there is evidence that the a-b ridge breadth provides some indication of developmental significance. With future studies it is hoped that this indication will be more interpretable.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

The a-b ridge breadths of ten sample populations were collected and analyzed. The ten sample populations were drawn from Black populations, White populations, an American Indian population, and Indian caste populations. Through the analysis of variance an F ratio was calculated for the ten populations. It was determined that the differences in the mean a-b ridge breadths of the ten populations were significant.

The ten populations represent a random sampling of individuals. The results of the present study agree with other studies of the a-b ridge breadths. It appears that there are differences between sexes when the a-b ridge breadths are compared. These sex differences represent differences in hand dimensions as well as differences between ridge widths. Ridge breadth was found to indicate significant group differences. The a-b ridge counts calculated in the present study and compared with other studies appear to indicate group differences. The developmental significance of the a-b ridge breadth is not fully understood. The ridges of the palms are a record of the developing fetus. It is felt that the data presented here support the idea proposed by Jantz and Parham (1978) that the wider ridges in Black populations are an indication of slower intrauterine development. It is also felt that the actual width of the dermatoglyphic ridges in a-b palmar area is the aspect of the a-b ridge breadth which illustrates developmental significance.

The data presented here should be expanded to include more diverse samples. Systematic population comparisons should help to illustrate the aspects of palmar dermatoglyphics which are affected during development. Already the evidence of dermatoglyphic studies has demonstrated that ridge widths are an indication of developmental timing. The present study suggests that there is perhaps a geographical distribution of populations as indicated by the a-b ridge counts. Future studies will perhaps define the developmental significance of the a-b ridge breadth.

BIBLIOGRAPHY

BIBLIOGRAPHY

Babler, W. J.
1978 Prenatal selection of dermatoglyphic patterns. American Journal of Physical Anthropology, 48: 21-28.

Barlow, P.
1973 The influence of inactive chromosomes on human development. Humangenetik, 17:105-136.

Barnicot, N. A., Mukherjie, D. P., Woodburn, J. C., and F. J. Bennett
1972 Dermatoglyphics of the Hadza of Tanzania. Human Biology, 44:261-628.

Bascom, W.
1969 The Yoruba of Southwestern Nigeria. Holt, Rinehart, and Winston, New York.

Bonnevie, K.
1924 Studies on papillary patterns of human fingers. Journal of Genetics, 15:1-14.

Burdi, A. R., Garn, S. M., and W. J. Babler
1974 Greater female communalities in prenatal hand and dental development. Archive of Oral Biology, 19:461-466.

Campbell, R. C.
1967 Statistics for Biologists. University Press, Cambridge.

Chattopadhyay, P. K. and P. D. Sharma
1969 Finger dermatoglyphics of the Rarhi Brahmins of Bengal. American Journal of Physical Anthropology, 30:397-401.

Cummins, H. and C. Midlo
1961 Finger Prints, Palms, and Soles. Dover Press, New York.

Cummins, H., Waits, W. J., and J. T. McQuitty
1941 The breadths of epidermal ridges of the finger tips and palms: a study of variation. American Journal of Anatomy, 68:127-151.

David, T. J., and A. B. Ajdukiewicz
1978 Palmar dermatoglyphics in Celiac Sprue. In: Dermatoglyphics: an International Perspective. Edited by J. Mavalwala. World Anthropology. The Hague: Mouton.

Fang, T. C.
1950 The inheritance of the a-b ridge count on the human palm. Journal of Mental Science, 95:945-949.

1951 Racial differences in palm-print ridge counts, the a-b ridge count in the Ontario-British, European Jew, and Ontario-Indians. Journal of Heridity, 42:261-263.

Floris, G.
1975 Sex and side differences and correlations between quantitative palmar characteristics in a sample Sardinian population. American Journal of Physical Anthropology, 42:277-280.

Galton, F.
1892 <u>Finger Prints.</u> Macmillan, London.

Garn, S. M., Lewis, A. B., Kerewsky, R. S., and K. Jaegart
1965 Sex differences in intraindividual tooth-size communalities. Journal of Dental Research, 44:476-479.

Garn, S. M., Rohman, C. G., Blumenthal, T., and F. N. Silverman
1967 Ossification communalities of the hand and other body parts: their implications to skeletal assessment. American Journal of Physical Anthropology, 27:75-82.

Grace, H. J. and F. E. Ally
1973 Dermatoglyphics of the South African Negro. Human Heredity, 23:53-58.

Hale, A. R.
1949 Breadth of epidermal ridges in the human fetus and its relation to growth of the hand and foot. Anatomical Record, 105:763-776.

1952 Morphogenesis of volar skin in the human fetus. American Journal of Anatomy, 91:147-180.

Hawkinson, C. H.
1981 Dermatoglyphic Variability in Armenian Fingertips and Palms: A Directional Asymmetry Approach to Identify Developmental Stress. M. A. Thesis, The University of Tennessee, Knoxville.

Hecht, V.
1907 Die Daktyloskipie als klinische Untersuchungsmethode. Mitt. aus d. Grenzbegieten d. Med. u. Chir., 18:27-48. (see Cummins and Midlo, 1961)

Holt, S. B.
1958 Genetics of dermal ridges: the relation between total ridge-count and the variability of counts from finger to finger. Annals of Human Genetics, London, 22:323-341.

1960 Genetics of dermal ridges: familial correlations for $(S/\sqrt{10})$, a measurement of the diversity of ridge-counts from finger to finger. Annals of Human Genetics, London, 24:253-564.

1968 The Genetics of Dermal Ridges. Charles C. Thomas Publishers. Springfield, Illinois.

Hrdlička, A.
1928 The full-blood American Negro. American Journal of Physical Anthropology, 12:15-34.

Jantz, R. L.
1974 Finger ridge-counts and inter-finger variability in Negroes and Whites. Human Biology, 46:663-675.

1975 Population variation in asymmetry and diversity from finger to finger for digital ridge-counts. American Journal of Physical Anthropology, 42: 215-224.

1976 The relation between total ridge-count and variability of counts from finger to finger; genetic implications of racial variation. Annals of Human Genetics, London, 40:221-224.

1977 Sex and race differences in finger ridge-count correlations. American Journal of Physical Anthropology, 46:171-176.

Jantz, R. L. and H. Brehme
1978 Finger and palmar dermatoglyphics of a Yoruba (Nigeria) sample. Annals of Human Biology, 5: 539-546.

Jantz, R. L. and C. H. Hawkinson
1980 Components of racial variation in finger ridge-counts. American Journal of Physical Anthropology, 52:139-144.

1979 Finger ridge-count variability in Sub-Saharan Africa. Annals of Human Biology, 6:41-53.

Jantz, R. L., Johnston, F. E., Kensinger, K. M., and G. F. Walker
1970 Palmar dermatoglyphics of the Peruvian Cashinahua. Human Heredity, 20:642-649.

Jantz, R. L. and D. W. Owsley
1977 Factor analysis of finger ridge-counts in Blacks and Whites. Annals of Human Biology, 4:357-366.

Jantz, R. L. and K. Parham
1978 Racial differences in dermal ridge breadth. Human Biology, 50:33-40.

Juberg, R. C., Morgan, L. Y., and C. C. Faust
1980 The inheritance of digital dermatoglyphic patterns in 54 American Caucasian families. American Journal of Physical Anthropology, 52:7-12.

Katznelson, B. and S. Ashbel
1973 Dermatoglyphics of Jews: I. normal Ashkenazi population. Zeitshrift fur Morphologie und Anthropologie, 65:14-28.

Laufer, B.
1912 History of the Finger Print System. Annual Report, Smithsonian Institute. (See Cummins and Midlo, 1961)

Loesch, D.
1971 Genetics of dermatoglyphic patterns on palms. Annals of Human Genetics, London, 34:277-293.

Loether, H. J. and D. G. McTavish
1976 Descriptive and Inferential Statistics. Allyn and Bacon, Inc., Boston.

Mallery, T.
1893 Picture-Writing of the American Indians. Tenth Annual Report, Bureau of Ethnology. Smithsonian Institution. (See Cummins and Midlo, 1961)

Miller, J. R.
1973 Dermatoglyphics. Journal of Investigative Dermatoglyphics, 60:435-442.

Mueller, B.
1930 Untersuchungen über die Erblichkeit von Fingerbeerenmustern unter besonderer Berücksichtigung rechtlicher Fragestellungen. (See Cummins and Midlo, 1961)

Mulvihill, J. and D. Smith
1969 The genesis of dermatoglyphics. The Journal of Pediatrics, 74:579-589.

Newman, M. T.
1960 Populational analysis of finger and palm prints in highland and lowland Maya Indians. American Journal of Physical Anthropology, 18:45-48.

Ohler, E. A. and H. Cummins
1942 Sexual differences in breadths of epidermal ridges on finger tips and palms. American Journal of Physical Anthropology, 29:341-362.

Okijima, M.
1975 Development of dermal ridges in the fetus. Journal of Medical Genetics, 12:243-250.

Penrose, L. S.
1968 Memorandum on dermatoglyphic nomenclature. Birth Defects Original Article Series, 4.

1954 The distal triradius t on the hands of parents and sibs of mongol imbeciles. Annals of Human Genetics, London, 19:10-13.

Penrose, L. S. and D. Loesch
1967 A study of dermal ridge width in the second (palmar) interdigital area with special reference to aneuploid states. Journal of Mental Deficiency Research, 1:36-42.

Penrose, L. S. and P. T. O'Hara
1973 The development of epidermal ridges. Journal of Medical Genetics, 10:201-208.

Plato, C. C., Cereghino, J. J., and F. S. Steinberg
1975 The dermatoglyphics of American Caucasians. American Journal of Physical Anthropology, 42:183-194.

Pons, J.
1964 Genetics of the a-b ridge count on the human palm. Annals of Human Genetics, 27:273-277.

Purkinje, J. E.
1823 Commentatio de Examine Physiologico Organi Visus et Systematis Cutanie. Breslau. (Translated into English by Cummins, H. and R. W. Kennedy, American Journal of Criminal Law and Criminology, 31:343-356, 1940).

Roberts, D. F.
1969 Race, genetics, and growth. Journal of Biological Science, supplement, 1:43-67.

Scott, G. T.
1978 An investigation of environmental influences on fetal development as revealed by palmar ridges. Class paper on file at The University of Tennessee, Knoxville.

Sokal, R. R. and F. J. Rohlf
1973 Introduction to Biostatistics. W. H. Freeman, San Francisco.

Srivastara, R. P.
1965 A quantitative analysis of the finger prints of the Tharus of Uttar Pradesh. American Journal of Physical Anthropology, 23:99-106.

Steinberg, F. S., Cereghino, J. J., and C. C. Plato
1975 The dermatoglyphics of American Negroes. American Journal of Physical Anthropology, 42:183-194.

Vrydagh-Laoureux, S.
1979 Dermatoglyphes palmaries de Noirs de la région de Libenge (Zaire). Bull. Soc. roy. belge Anthrop. Préhist., 90:179-195.

Wilder, H. H.
1902 Scientific palmistry. Popular Science Monthly, 61:41-54.

1904 Racial differences in palm and sole configuration. American Anthropology, 6:244-292.

Zobeck, T. S.
1978 An analysis of ridge breadth on three populations. Class paper on file at The University of Tennessee, Knoxville.

VITA

Anne Hawkins Prisock was born in Cherry Point, North Carolina on January 1, 1956. She attended elementary school at Christ Episcopal Day School in Bay St. Louis, Mississippi and was graduated as valedictorian from Coast Episcopal High School in Pass Christian, Mississippi in June 1973. She attended the University of the South at Sewanee, Tennessee from September, 1973 to May, 1974. The following September she entered Mississippi State University, and in December 1976 she received a Bachelor of Arts degree in Anthropology. In the fall of 1977 she began study toward a Master's degree at The University of Tennessee, Knoxville, with an emphasis in physical anthropology. She received the Master of Arts degree with a major in Physical Anthropology in June 1981.

Ms. Prisock is a member of the American Association of Physical Anthropologists and the American Planning Association. She is currently employed as a Transportation Planner, and is completing graduate studies in Urban Planning.

She is married to David S. Prisock.