MARRIAGE PATTERNS IN AN ARCHAIC POPULATION
A STUDY OF SKELETAL REMAINS FROM
PORT AU CHOIX, NEWFOUNDLAND

BRENDA VALERIE ELKINS KENNEDY

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us a poor photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de mauvaise qualité.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS REÇUE

MARRIAGE PATTERNS IN AN ARCHAIC POPULATION

A Study of Skeletal Remains from Port au Choix, Newfoundland

by

©Brenda Valerie Elkins Kennedy B.A.

A Thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts

Department of Anthropology
Memorial University of Newfoundland
March 1980

St. John's Newfoundland

ABSTRACT

In recent years there have been a variety of attempts to reconstruct prehistoric patterns of endogamy, exogamy, and post-nuptial residence using data collected from archaeological sites. This thesis is concerned with the use of data collected from skeletal remains in studies of this nature. More specifically, it is concerned with the use of osteological data in reconstructing the marriage patterns of a group of Archaic Indians buried at Port au Choix, Newfoundland.

This study is based on the premise that marriage patterns determine the composition of the adult segment of hunter-gatherer groups, and that the composition of the adult segment is reflected in the expression of osteological traits within and between the sexes. A model is proposed which links the various combinations of endogamy and exogamy (three forms) and the three principle types of residence units with specific patterns of within- and between-sex variability of trait expression.

A group of eighteen adult females and twenty-two adult males from Locus II of the Port au Choix-3 site is used as the sample for this study. A series of metric and non-metric traits describing the cranial and infracranial skeleton, and a number of univariate and multivariate statistical techniques are employed in the analysis. The results of the analysis seem to indicate the practice of

exogamy coupled with a virilocal post-nuptial residence pattern.

The use of osteological data in reconstructions of prehistoric marriage patterns would seem to be a valid endeavor if a well-defined sample is available, and if careful consideration is given to the selection of traits and statistical techniques employed in the analysis.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank the many people who have assisted me in various ways throughout this study. In particular, I would like to thank my thesis advisor, Dr. Sonja Jerkic, who introduced me to the field of physical anthropology, and who has been a valued source of advice and encouragement throughout my university career, Dr. James Tuck who suggested a study of the marriage patterns of the Archaic Indians of Port au Choix, and made available all the necessary material and information, and Dr. Bock Kim who provided invaluable help with the statistical analysis. My thanks are also extended to Mr. Robert McNeil of Parks Canada (Historic Parks and Sites, Newfoundland and Labrador), who made arrangements for me to examine skeletal material housed in the Interpretation Center of the Port au Choix National Historic Site, to Dr. El Molto of Lakehead University who designed and supplied a copy of the computer program used in the non-metric trait analysis, and to Mrs. Ruth Cornish of the Statistical Consulting Unit, Memorial University, and members of the staff of Computing Services who provided help with various aspects of the computer programming. A very special thank-you goes to my husband, Denis, for his never-ending patience and encouragement, his unceasing efforts in typing the various drafts of this thesis, and his help in preparing the maps and illustrations. Special thanks also go to my wonderful son, Aaron, who so generously gave me time

that should have been his.

This investigation was supported by financial aid from several sources: an A. G. Hatcher Memorial Scholarship from Memorial University, a Newfoundland and Labrador Provincial Government Fellowship, a Memorial University Bursary, and a research assistantship in the Department of Anthropology, Memorial University. The Department of Anthropology also supplied the necessary computer time.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 The problem

The second half of the twentieth century has witnessed a shift in the general concerns of archaeological research. The previous emphasis on descriptions of material culture and problems of chronology has been replaced by a concern with reconstructions of whole cultural systems, incorporating information on the natural environment, and the social and cultural contexts (Willey 1968). This change of emphasis has been accompanied by a growing sophistication in methods of gathering and describing data, and the construction of new theoretical methods for interpreting these data (Freeman 1968).

One concern of this so-called 'new archaeology' has been the reconstruction of prehistoric patterns of endogamy, exogamy, and post-nuptial residence. Attempts at such reconstructions have been limited in number, but have employed a variety of sources of data, including artifact assemblages, settlement patterns, linguistic records, and skeletal remains. This thesis is concerned with the application of data from the last of these sources, skeletal remains, to studies of this nature. More specifically, it is concerned with the use of osteological data in reconstructing the marriage patterns of a group of Archaic Indians buried at Port au Choix, Newfoundland.

The basic premise underlying this study is that marriage patterns determine the composition of the adult segment of hunter-gatherer groups, and hence, have biological reference. It is suggested, therefore, that a study of the biological composition of an adult sample from any hunter-gatherer group may provide a basis from which to infer the marriage patterns of the group.

The specific and general aims of this analysis of Archaic Indian remains from Port au Choix may be summarized as follows:

1. To assess the degree of biological homogeneity or heterogeneity evidenced by the Port au Choix sample through a study of within- and between-sex variability of osteological trait expression
2. To consider how the pattern of sexual variation may relate to the nature of group composition, and to patterns of endogamy, exogamy, and post-nuptial residence
3. To consider the results of this study in relation to previous models of hunter-gatherer marriage patterns
4. To assess the validity of using osteological data to reconstruct the marriage patterns of prehistoric groups

1.2 Previous studies

Ethnographic studies

The history of ethnographic research records a variety of attempts to discern both general and specific patterns of marriage for hunter-gatherer groups. Interest in this particular area of research may be seen as beginning with Radcliffe-Brown (1931) and his description of the 'patrilineal, patrilocal, territorial, exogamous horde' as the basic unit of social organization among hunter-gatherers of Australia. This theoretical base was expanded by Julian Steward (1955) who described two polar types of group structure among hunter-gatherer groups - the 'patrilineal band', an exogamous virilocal group, and the 'composite band', a group lacking exogamic rules and explicit marital residence customs. According to Steward (1955), the patrilineal band provided certain advantages by allowing males to remain after marriage within the hunting territory familiar to them. The larger composite bands occurred only when an abundance of food from large migratory herds permitted groups to grow beyond the point where exogamous marriage was necessary.

An alternative explanation for the existence of these two types of band organization was offered by Elman Service (1971, 1979). Service suggested that the 'patrilocal band', as he called it, fostered male cooperation in hunting and defense. He viewed the patrilocal band as the aboriginal form of all hunter-gatherer groups, and suggested the composite band was the product of European contact influences on this aboriginal form.

More recent ethnographic work has suggested that groups of hunter-gatherers tend to be flexible in their patterns of social organization in order to adapt to changing circumstances (Lee and DeVore 1968; Woodburn 1968; Damas 1969; Leacock 1969). According to this model, groups may display tendencies toward endogamy, exogamy, virilocality or uxorilocality, as circumstances require, but flexibility remains the underlying principle (Spence 1974). It has been argued, however, that the hunter-gatherer groups investigated by ethnographers all show some 'scars of contact', and that this flexibility of social organization may be a post-contact phenomenon (Service 1971). Lee and DeVore (1968) have pointed out that

> Although fluid social organization makes ecological sense for many hunters, and could be shown to be more adaptive than patrilocal organization, in itself this is not evidence for aboriginal conditions...... (Lee and DeVore 1968:8).

Since there is at present no proof that any of the ethnographic models derived from studies of recent hunter-gatherer groups are applicable to aboriginal groups, archaeologists must be very cautious in using these models to reconstruct the way of life of prehistoric populations. Instead, archaeologists must strive to find methods of extracting such information directly from the sites they examine.

Archaeological studies

A Soviet archaeologist, Tretyakov, seems to have been the first to suggest that archaeological remains might produce information on marriage practices (Binford 1968). Tretyakov (1934) suggested a simple argument based on the form of ceramic designs

> [This] argument was fairly straight forward: the form of fingerprints on the inside of vessels indicated that it was females who manufactured pottery. In societies where matrilocal residence was the rule, there would be less formal variability expected in the execution of ceramic designs within any single community than under conditions where patrilocality was the rule, since patrilocality brings about a mixed population of female potters (Binford 1968:269-270).

In other words, ceramic homogeneity is associated with exogamous marriage and an uxorilocal post-nuptial residence pattern, and ceramic heterogeneity with exogamous marriage and a virilocal post-nuptial residence pattern.

MacPherron (1967) used this sort of model to explain ceramic changes at the Juntunen site in Michigan. MacPherron suggests that ceramic heterogeneity in the earlier occupation of the Juntunen site (AD 800-1000) may reflect the absorption of women from a variety of sources, as would be expected in a situation of band exogamy and virilocality, while ceramic homogeneity in the later occupation (AD 1200-1400) of the site may reflect the development of uxorilocal preferences, perhaps coinciding with closer contact with agriculturalists from Ontario. A variety of other workers have used similar models to account for variability in pottery samples and to infer patterns of endogamy, exogamy and post-nuptial residence. These workers include Longacre (1964), Deetz (1965), Wright (1965, 1966, 1968), and Hill (1966).

Lewis and Sally Binford (1966) have suggested that stone tools may provide an alternate source of information on marriage practices, assuming that a particular class of tools is made by members of one sex only, and that this sex is known. By adapting Tretyakov's (1934) model for use with such data, it may be suggested that exogamous virilocal groups will display less variability in tools manufactured by men than would uxorilocal groups, since uxorilocality brings about a mixed population of males. Likewise, it may be proposed that exogamous uxorilocal groups will display less variability in the tools manufactured by women than virilocal groups, since virilocality brings about a mixed population of females.

Deetz (1968) used this approach in his study of the Chumash, a hunting-gathering group in southern California. He found historic period Chumash sites characterized by a site-to-site diversity of artifacts produced by males (projectile points), and by a widespread uniformity of artifacts produced by females (baskets and milling equipment). This situation led Deetz to suggest that Chumash women moved widely in their society, while the men remained relatively localized. In other words, the data suggest the practice of exogamy coupled with virilocal post-nuptial residence, a pattern which is known to have existed for the historic period Chumash.

Ember (1973) has proposed a correlation between house size and residence patterns. He suggests that societies with uxorilocal residence will have dwellings with larger floor areas than those with virilocal residence, since women do not move after marriage in uxorilocal societies, and since sisters married to different men would find it easier to live under one roof after marriage than would unrelated women married to different men. Ember (1973) supports this hypothesis with evidence from two separate random samples drawn from the Human Relations Area File (HRAF).

Of primary interest in this study, however, is the correlation which has been proposed between the biological variability evidenced by skeletal samples and marriage patterns. Hulse (1941) made such a connection in his study of skeletal remains from the Irene site in Chatham County, Georgia. Hulse found greater variability of metric trait expression within the male sample from this site, suggesting that biological ties within the male group were not as strong as those within the female group. Based on this information, he proposed that the people of Irene were exogamous and practiced uxorilocal post-nuptial residence. Madelaine Kneberg Lewis (Lewis and Lewis 1961) found females from one component of the Eva site in the Tennessee Valley displayed greater metric trait variability than did the males, and using the same logic as Hulse (1941), suggested that the Eva people were exogamous and virilocal. Similarly, in a study of Eskimo crania from Cape Kialegak on St. Lawrence Island in the Bering Sea, Spence (1974) found greater metric trait variability within the female sample, and used this information as a basis from which to infer the practice of exogamy coupled with a virilocal post-nuptial residence pattern. This inference is supported by evidence from historical accounts.

In a study of skeletons from a large residential structure in Teotihuacán, Mexico, Spence (1971) used a battery of non-metric traits to infer marriage patterns. His analysis indicated greater variability of trait expression within the female sample, once again suggesting the practice of exogamy and virilocality. In a similar manner, Lane and Sublett (1972) used non-metric traits to study a group of skeletons from several historic period Seneca cemeteries in New York State. They found differences in trait expression from one cemetery to another to be greater for males than for females, suggesting that the males remained relatively localized while the females circulated more widely in the society. This information is consistent with the practice of group exogamy and virilocal post-nuptial residence.

This study of Archaic Indian remains from Port au Choix, Newfoundland, incorporates both metric and non-metric traits. As in the studies outlined above, the pattern of within- and between-sex variability of trait expression is used as a basis from which to infer the marriage patterns of the group.

CHAPTER 2

THE MATERIAL

2.1 Archaic burials from Port au Choix

Port au Choix is a small fishing community located on Newfoundland's Great Northern Peninsula (Figure 1). Over the past forty years this town has been the site of a series of periodic discoveries of Archaic Indian burials. More than sixty such burials have been found, containing the remains of over one hundred individuals, and dating from sometime late in the third millenium B.C., down to the end of the second millenium B.C. (Tuck 1976).

All the Archaic Indian burials found at Port au Choix come from an ancient beach lying about 6 meters (20 feet) above the present sea level (Figure 2). This beach runs throughout the town on a course parallel to that of the 'Back Arm', a small sheltered harbor which forms the northern limit for most of the town. The sand which comprises this beach has a high shell content which makes it very alkaline. The pH values average close to 8.0 (Tuck 1976). This alkalinity has permitted remarkable preservation of the skeletal material buried at Port au Choix.

The earliest recorded discoveries of Archaic Indian burials in this community have been described by Harp (1951,

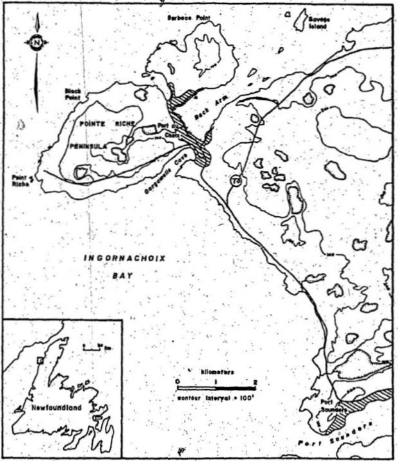


FIGURE 1 · LOCATION OF PORT AU CHOIX

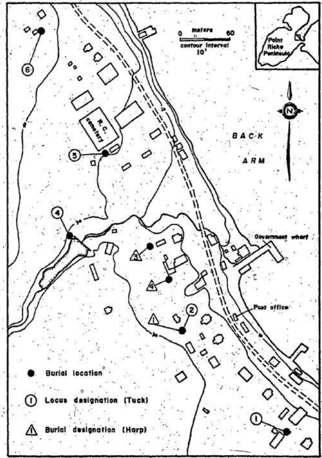


FIGURE 2 LOCATION OF ARCHAIC INDIAN BURIALS

1963), and Harp and Hughes (1968). The first such discovery dates from around 1939, and is referred to as Burial 1 of the Port au Choix village remains (Harp and Hughes 1968). This burial was uncovered ten years before Harp's archaeological expedition to Newfoundland in 1949, and when he arrived the evidence which remained was fragmentary. However, Harp was able to determine that the grave had contained the remains of at least five individuals in association with grave goods identical to those from Archaic Indian burials later found in Port au Choix (Harp and Hughes 1968).

A second burial was found in 1959 during the course of excavation for a semi-subterranean ice-house (Harp and Hughes 1968). This burial, designated Burial 3 of the Port au Choix village remains, was situated about 100 meters (328 feet) north-northeast of the first burial, and contained the skeleton of a single adult male accompanied by artifacts relating to the Archaic Indian tradition.

A third Archaic Indian burial was found in the summer of 1960 lying approximately midway between the two burials described above (Harp and Hughes 1968). The remains were those of a single adult male accompanied by grave goods. This burial was designated Burial 4 of the Port au Choix village remains.

A number of more recent discoveries of Archaic Indian skeletal remains in Port au Choix have been described in a series of articles by James Tuck (1970, 1971, 1976). The first of these discoveries was made in the fall of 1967 when a group of eight skeletons was exposed during excavations for a theater basement. An archaeological field crew under the direction of Dr. Tuck investigated this find. Unfortunately, when the field crew arrived in Port au Choix they discovered that most of the skeletal material and the accompanying artifacts had been removed by the builders and other observers. However, this material was subsequently returned to the site, and the crew was able to locate one additional burial containing the remains of two adult females. A carbon-14 date of 3410 ± 100 BP (I-3788) was obtained on a fragment of human bone from this area, which was designated Locus I of the Port au Choix-3 site (Tuck 1976).

In the summer of 1968 an archaeological field crew from Memorial University, once again under the direction of Dr. Tuck, returned to Port au Choix. The crew located a group of fifty-three generally undisturbed burials, containing the remains of eighty-nine individuals with accompanying grave goods (Tuck 1976). This group of burials, designated Locus II of the Port au Choix-3 site, represents the largest single concentration of burials from the site. Harp's Burial 1 comes from the perimeter of this locus (J. Tuck, personal communication).

Five carbon-14 dates were obtained for Locus II. A sample of wood charcoal from Burial 22 was divided into three pieces which yielded the following dates: 4290 ± 110 BP (I-3788), 3690 ± 90 BP (I-4682), and 3770 ± 80 BP (Y-2608). A piece of wood preserved inside a nodule of bog iron found in

Burial 42 yielded a date of 5120 ± 120 BP (Y-2609), and a piece of human bone from Burial 50 yielded a date of 3930 ± 130 BP (I-4678). Tuck (1976) has suggested that the oldest date for Locus II (5120 ± 120 BP) may be unreliable, since the bog iron nodule from which the wood sample was taken may have formed around the dead wood core many years before it was collected by the Indians. He has also noted that the variance evidenced by the three wood charcoal dates makes these subject to suspicion. Therefore, the most reliable date for Locus II may be the human bone date of 3930 ± 130 BP.

The history of discoveries of Archaic Indian burials in Port au Choix does not end here. In 1969, excavations to bury the town water line revealed the remains of two infants near a small stream about 175 meters (575 feet) northwest of Locus II. These burials were designated Locus IV of the Port au Choix-3 site, since a Dorset Eskimo settlement discovered in 1968 had already been designated Locus III (Tuck 1976). A carbon-14 date of 3230 ± 220 BP (I-4380) was obtained on a fragment of human bone from this locus, suggesting that the Locus IV burials post-date those from Locus II. The artifacts associated with the burials from these two loci support this sequence (Tuck 1976).

In 1971, excavations for a house being built next to the southern corner of the Roman Catholic cemetery of Port au Choix revealed another Archaic Indian burial. This burial contained the remains of two adult individuals with accompanying grave goods. In 1978, excavations for a house being built on an adjacent lot produced the remains of six other individuals. The area where these two discoveries were made has been designated Locus V of the Port au Choix-3 site. The grave goods associated with these burials suggest that they date from approximately the same time period as those from Locus I (J. Tuck, personal communication).

Finally, it may be noted that excavations for the town water line in 1976 also revealed Archaic Indian remains, when a single burial containing the remains of one adult male was found about 160 meters (525 feet) northwest of Locus V (J. Tuck, personal communication). This area has been designated Locus VI of the Port au Choix-3 site.

The preceding history, summarized in Table 1, makes it clear that the Port au Choix-3 site was a preferred Archaic Indian burial ground for a period of seven hundred years or more. The nature of the site and the remarkable preservation of material excavated there has made the site a unique and very valuable find. In view of this fact, the Port au Choix-3 site was declared a Provincial Historic site by the Government of Newfoundland and Labrador in 1967, and in 1975 it was declared a National Historic site by the Government of Canada. A small museum built by the Provincial government in 1969, and later expanded by the Federal government, displays several skeletons excavated since 1967 and an assortment of grave goods with accompanying pictures and texts. The remainder of the skeletal material excavated since 1967 is on loan to Memorial University's Archaeology Unit. The material found before 1967

TABLE 1

ARCHAIC INDIAN BURIALS FROM PORT AU CHOIX

Date of discovery	Designation	Number of individuals	C-14 date
c. 1939	Port au Choix village remains - Burial 1 (Harp and Hughes 1968)	5	n.d.
1959	Port au Choix village remains - Burial 3 (Harp and Hughes 1968)	1	n.d.
1960	Port au Choix village remains - Burial 4 (Harp and Hughes 1968)	1	n.d.
1967	Locus I (Tuck 1976)	10	3410±100 BP
1968	Locus II (Tuck 1976)	89	3930±130 BP
1969	Locus IV (Tuck 1976)	2	3230±220 BP
1971	Locus V (Tuck pers. comm.)	2	n.d.
1976	Locus VI (Tuck pers. comm.)	1	n.d.
1978	Locus V (Tuck pers. comm.)	6	n.d.

is housed at Dartmouth College, New Hampshire.

A description of the skeletal remains from Burials 1, 3, and 4 of the Port au Choix village remains has been prepared by David Hughes (Harp and Hughes 1968). The remains from Loci I, II, and IV have been described by James Anderson (1976). The remains from Loci V and VI are being studied by Sonja Jerkic of Memorial University and the author.

2.2 The sample

The validity of any statistical study depends, at least in part, on the choice of a good sample. This may prove to be a difficult task when dealing with archaeological remains, given the existence of such problems as differential or select preservation, or a lack of information on chronology.

The Archaic Indian burials from Port au Choix span a period of approximately seven hundred years or more (Tuck 1976). A study of the nature and distribution of these remains indicates the presence of one large burial site known as Locus II, and a series of smaller sites separated from Locus II and from one another. The true meaning of this distribution may never be completely understood. However, the limited information on chronology seems to suggest that the sites reflect a number of different burial episodes by members of one or more bands.

The lack of precise information on the nature of these burial sites made it unacceptable to include skeletal material from all these areas in the sample for this study. Instead, the decision was made to limit the sample to skeletal material from Locus II. This burial site could be more clearly defined, and provided a sample of sufficient size to permit valid statistical manipulation of the data collected.

The fifty-three burials from Locus II are distributed in three relatively distinct clusters (Figure 3).

> The northernmost includes Burial 1-4, 6-14, and 21 (14 burials and 18 individuals); the central group includes Burial 5, 15-31, and 33 (19 burials and 29 individuals); and the southerly group includes Burials 32 and 34-53 (22 burials and 42 individuals) (Tuck 1976:10).

Tuck (1976) and D'Entremont (1978) suggest that these clusters may represent three 'family plots'. Alternatively, Tuck says, they may represent three slightly different periods during which the burials were made, though he suggests that the time difference involved may not be large enough to be detected by the carbon-14 method. He points out that

> (1) the overall arrangement of the graves, the compactness of the cemetery, and the clustering of the burials indicate an intensively utilized burial area, and (2) that the relative homogeneity of the artifacts [from Locus II] indicates that this intensive use took place over a short period of time (Tuck 1976:12).

The evidence suggests that the Locus II cemetery represents all the individuals that died during the period of time that this cemetery was in use. Both primary and secondary interments were found. Tuck (1970) points out that

> Skeletons were found reflecting all stages of decomposition, which suggests that people who died in the winter were not buried until the ground thawed in spring or early summer (Tuck 1970:5).

Thus the individuals from Locus II do not seem to represent a

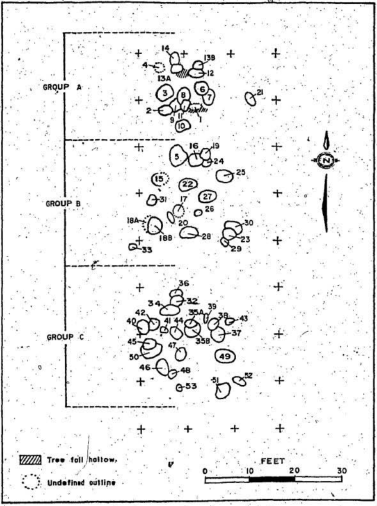


FIGURE 3 · LOCUS II - LOCATION OF BURIALS (modified after Tuck 1976) select sample of individuals dying at a particular place or at a particular time of the year. Of course, there still exists the possibility that the individuals buried at Locus II represent members of more than one band. However, the uniformity of artifacts and burial style, and the intensive use of the cemetery suggest that this is unlikely. This possibility will be reconsidered when the results of this study are evaluated.

CHAPTER 3

THEORY AND METHOD

3.1 Introduction

The band level of social organization

Ethnographic research has described the basic unit of social organization for most hunter-gatherer groups as the 'band'. However, the term 'band' has yet to be defined in a manner acceptable to the majority of workers (Lee and DeVore 1968; Damas 1969). In this study, the term will be used to refer to a group of individuals who live together and take part in common economic, social and ceremonial activities. It is accepted that this form of social organization does not include

> specialization of labour beyond that based on sex; nor include class divisions, a formal priesthood, or hierarchical political organization. In addition, basic sources of livelihood are not privately owned (Leacock 1969:3).

It is of note that within the band level of social organization, a distinction is sometimes made between what are referred to as 'microbands' and 'macrobands'. The term 'microband' is used to refer to the minimum viable unit of band social organization, while the term 'macroband' is used to refer to an aggregation of several microbands for the purpose of communal activities. This study is concerned only with the microband level of social organization, and use of the term 'band' in this study refers to this kind of unit.

Marriage patterns

In any given society there are rules, sometimes general and sometimes specific, governing 'marriage patterns', that is, the choice of a spouse and the form of post-nuptial residence. These rules define ideal behavior patterns which may not be reflected in the actual behavior of a group. A study such as this one can be used to reveal actual patterns of choosing a spouse and determining post-nuptial residence, but cannot be assumed to reveal ideal patterns.

Anthropologists distinguish two sets of possible marriage partners - those within the group to which a particular individual belongs, and those outside the group. If an individual marries someone from within the group to which he belongs, the union is termed 'endogamous'. If an individual marries someone from outside the group to which he belongs, the union is termed 'exogamous'. All societies have rules of exogamy in that, under normal circumstances, an individual cannot marry into the family to which he belongs. However, this thesis is not concerned with this 'family level' of exogamy, but with the practice of endogamy or exogamy, as the case may be, at the 'band level'.

The term 'band endogamy' will be used in this study to refer to a situation in which individuals from a given band marry other individuals from the same band; for example, Band A males marry females who are also from Band A. The term 'band exogamy' will be used to refer to a situation in which individuals from a given band marry individuals from bands other than their own; for example, Band A males marry females from Bands B, C, and D.

In order to more clearly define marriage patterns, a distinction will be made between three possible forms of exogamy, each of which has a different effect on the way individuals are channelled between bands. These three forms of exogamy, referred to here as 'non-specific', 'prescribed', and 'reciprocal exogamy', are defined as follows:

Non-specific exogamy - a form of exogamy in which the only specification is that individuals take marriage partners from bands other than their own: for example, Band A males marry females from Bands B, C, and D

Prescribed exogamy - a form of exogamy in which a specific set of marriage partners is relied upon: for example, Band A males marry Band B females

Reciprocal exogamy - a particular form of prescribed exogamy in which marriage partners are exchanged between groups: for example, Band A males marry Band B females, and Band B males marry Band A females

Anthropologists use a variety of terms to describe patterns of post-nuptial residence. The terms employed in this study are as follows:

Virilocal post-nuptial residence - a form of residence in which a couple resides with or near the husband's male kinsmen

Uxorilocal post-nuptial residence - a form of residence in which a couple resides with or near the wife's female kinsmen

Avunculocal post-nuptial residence - a form of residence in which a couple resides with or near the husband's mother's brother

Bilocal post-nuptial residence - a form of residence in which a couple has the option of residing with or near either the husband's or wife's group

Neolocal post-nuptial residence - a form of residence in which a couple resides independently, with no reference to either partner's kingroup

3.2 The model

Theory

The use of osteological data in reconstructing any feature of social organization depends on the existence of some agreement between the social ties and the biological relationships uniting individuals (Spence 1971, 1974; Lane and Sublett 1972). Lane and Sublett have suggested that such reconstructions are possible

> to the degree that any social organizational feature corresponds to the biological referents of the kinship system (Lane and Sublett 1972:187).

For several reasons, the marriage patterns of hunter-gatherer groups seem ideally suited to osteological analysis and reconstruction. Firstly, marriage patterns in hunter-gatherer societies are intimately tied to kinship systems, and hence, fulfill the requirement set by Lane and Sublett (1972). Secondly, marriage patterns determine the composition of the adult segment of hunter-gatherer societies, and hence, determine the biological makeup of such segments.

The basic principle employed in this analysis of the marriage patterns of the Archaic Indians of Port au Choix is that the composition of the adult segment of hunter-gatherer societies may be determined through a study of the expression of biological traits within and between the sexes, and that this information may be used to infer marriage patterns. It is assumed that the homogeneity of trait expression within and between the sexes will vary directly with the homogeneity of group composition (Edmonson 1965).

A model is proposed for use in this study which describes the various combinations of endogamy, exogamy (three forms), and post-nuptial residence, and links them to specific patterns of within- and between-sex variability of trait expression. Since some of the residence patterns are based on similar social ties (that is, virilocality and avunculocality are both based on male-male social ties, and bilocality and neolocality are both based on flexible social ties), the residence patterns are defined in terms of male-male ties, female-female ties, and flexible ties, rather than by the terms defined earlier. The model is as follows:

I. In situations of band endogamy:

A. If the residence units of a band are based on male-male ties (virilocality and avunculocality), then
1. males and females will display little within-sex variability of trait expression, since they all belong

to one band, say, Band A, and

2. there will be no significant differences in trait expression between the sexes, for the same reason.

B. If the residence units of a band are based on female-female ties (uxorilocality), then

1. males and females will display little within-sex variability of trait expression, for the same reason as A, and

2. there will be no significant differences in trait expression between the sexes, for the same reason.

C. If the residence units of a band are not strictly based on either of the above types of ties (bilocality and neolocality), then

1. males and females will display little within-sex variability of trait expression, for the same reason as A and B, and

2. there will be no significant differences in trait expression between the sexes, for the same reason.

It is of note that the practice of endogamy prohibits the introduction of new members, and hence new genes, into a population. Thus, the biological composition of the group always remains the same. It follows that, while it may be possible to detect the practice of endogamy in a given group from the homogeneity of the total sample, it is impossible to discern patterns of post-nuptial residence, at least in as far as biological data are concerned. It is only when exogamous marriages take place that new genetic material is introduced into the gene pool, making it possible to detect specific patterns of within- and between-sex variability of trait expression which may be used to infer residence.

It is also of note that, while this model predicts that in situations of band endogamy males and females should display little within-sex variability of trait expression, the general human tendency for males to express slightly greater variability than females (Goldstein 1936; Tanner 1964) will likely be evident.

II. In situations of non-specific band exogamy:

A. If the residence units of a band are based on male-male ties, then
1. males will display less variability in trait expression than females, since the males share a common ancestry, while the females come from a variety of bands, and
2. there will be significant differences in trait expression between the sexes, for the same reason.

B. If the residence units of a band are based on female-female ties, then
1. males will display greater variability of trait expression than females, since the males come from a variety of bands, while the females share a common ancestry, and
2. there will be significant differences in the expression of biological traits between the sexes, for the same reason.

C. If the residence units of a band are not strictly based on either of the above types of relationships, then
1. males and females will display a notable degree of within-sex variability of trait expression, since the male group includes those who belong to say, Band A, and those from a variety of other bands who have married females who belong to Band A, and the female group includes those who belong to say, Band A, and

those from a variety of other bands who have married males who belong to Band A, and

2. there will be significant differences in trait expression between the sexes, since both groups come from a variety of sources.

It should be noted that the practice of non-specific band exogamy presented the most problems in creating a model for this study. Consider, for example, the case in which a group practices non-specific band exogamy in conjunction with, say, a virilocal post-nuptial residence pattern. In such a situation, one can readily assume that females will form a relatively heterogeneous group, since they come from a variety of biological sources. However, the discussion becomes more complex when the male group is considered. It may be assumed that the hypothetical 'first group of men to engage in these marriage practices' formed a relatively homogeneous group, since up to this point no exogamic unions had occurred. However, what of the biological makeup of the second, third, and fourth generations of males taking part in these customs? Given the input into the male gene pool of the genes of their mothers who have come from a variety of sources, do the males remain a relatively homogeneous group?

Present-day genetic research has isolated several 'sex-linked' genetic traits. However, it has yet to explain the more complex ways in which inheritance may relate to the sex of the individual. Thus, it cannot be said that males may express more characteristics similar to their fathers, owing to their common maleness. It is known, however, that genetic systems strive toward a reduction in variability. Thus the offspring of mixed unions will tend to exhibit less variability than the parent generation.

Given the fact that in exogamous virilocal groups the male offspring of mixed unions remain in the band, while new females from varying sources are continually added to it, it would seem permissable to suggest that these males will display relatively less variability than the females.

III. In situations of prescribed band exogamy:

A. If the residence units of a band are based on male-male ties, then
1. males and females will display little within-sex variability of trait expression, since the males are all products of prescribed matings of, say, Band A males with Band B females, and the females are all from one band, say, Band B, and
2. there will be significant differences in trait expression between the sexes, since the males are products of say, A-B unions, but the females are not.

B. If the residence units of a band are based on female-female ties, then
1. males and females will display little within-sex variability of trait expression, since all the males come from one band, say, Band B, and the females are all products of the mating of, say, Band A females with Band B males, and
2. there will be significant differences in trait expression between the sexes, since the females are products of, say, A-B matings, but the males are not.

C. If the residence units of a band are not strictly based on either of the above types of ties, and

a) if the prescribed marriage pattern is that, say, Band A males marry Band B females, and Band C males marry Band A females, then

1. males and females will display a notable degree of within-sex variability of trait expression, since the male group may include males from Band A who have married females from Band B (and chosen to reside near the husband's kin), and males from Band C who have married females from Band A (and chosen to reside near the wife's kin). Similarly, the female group may include females from Band B who have married males from Band A, and females from Band A who have married males from Band C, and

2. there will be significant differences in trait expression between the sexes, since the male group includes individuals from Bands A and C, while the female group contains individuals from Bands A and B.

b) If the prescribed marriage pattern is that, say, Band A females marry Band B males, and Band C females marry Band A males, then

1. males and females will display a notable degree of within-sex variability of trait expression, since the male group may include males from Band B who have married females from Band A (and chosen to reside near the wife's kin), and males from Band A who have married females from Band C (and chosen to reside near the husband's kin). Similarly, the female group may include females from Band A who have married males from Band B, and females from Band C who have married males from Band A, and

2. there will be significant differences in trait expression between the sexes, since the male group includes individuals from Bands A and B, while the female group includes individuals from Bands A and C.

IV. In situations of reciprocal band exogamy:

A. If the residence units of a band are based on male-male ties, then
1. males and females will display little within-sex variability of trait expression, since all individuals are products of, say, Band A and Band B unions (in effect, the males and females of Bands A and B tend to become members of one large gene pool, since there is continuous mating between the two bands), and
2. there will be no significant differences in trait expression between the sexes, for the same reason.

B. If the residence units of a band are based on female-female ties, then
1. males and females will display little within-sex variability of trait expression, for the same reason as A, and
2. there will be no significant differences in trait expression between the sexes, for the same reason.

C. If the residence units of a band are not strictly based on either of the above types of social ties, then
1. males and females will display little within-sex variability of trait expression, for the same reason as A and B, and
2. there will be no significant differences in trait expression between the sexes, for the same reason.

It is of note that in situations of reciprocal band exogamy, the two bands involved become part of one large gene pool. Since no new genetic material is added to this gene pool, the net effect is the same as that in a situation of band endogamy: it is impossible to discern residence patterns. It is also suggested that while theoretically, males and females should display little within-sex variability of trait expression, in actuality, the general human tendency toward slightly greater male variability of trait expression may be evident.

It is apparent that, within the model outlined above, each marriage pattern is not uniquely associated with a specific pattern of within- and between-sex variability of trait expression. The pattern of variation predicted for non-specific exogamy coupled with flexible residence units is the same as that predicted for prescribed exogamy and flexible residence units. The pattern predicted for prescribed exogamy coupled with male-male residence units is the same as that predicted for prescribed exogamy and female-female residence units. The pattern predicted for endogamy coupled with any type of residence unit is the same as that predicted for reciprocal exogamy coupled with any type of residence unit.

However, the model does allow an investigator to be a little more specific about marriage and residence customs than would be possible through pure speculation. It permits identification of the combination of non-specific exogamy and male-male residence units or female-female residence units, the combination of prescribed exogamy and male-male or female-female residence units, the combination of either non-specific or prescribed exogamy with a flexible residence pattern, and the practice of either reciprocal exogamy or endogamy.

Application to archaeological samples

The sample used in this study comes from an Archaic Indian cemetery which may have been in use for a period of several hundred years or more, and thus may include individuals who were never simultaneously alive. In studies of archaeological samples of this nature, it is necessary to consider that the total amount of variability present may reflect not only the biological composition of the sample, but also the effects of microevolution. However, given the fact that the model proposed for this study is concerned with the relative amount of variability displayed within and between the sexes, rather than the absolute amount of variability present, the presence of microevolutionary changes is not judged to be of serious consequence.

It is hypothesized that the microevolutionary process should affect males and females in a similar manner. Thus, in an endogamous group, males and females should express the same degree of within-sex variability of trait expression in samples taken from a single generation as those taken from a number of generations, despite the fact that the actual amount of variability present in a sample from a single generation will be less than that in a sample taken from a number of generations. Furthermore, there should be no significant differences in trait expression between the sexes in either sample. In an exogamous group, the presence of individuals from a variety of different sources should continue to be evident in the display of greater variability of trait expression within this group, and significant differences in trait expression between the sexes.

3.3 Age determination

In order for a study of endogamy, exogamy, and post-nuptial residence patterns to have validity, the sample must be limited to those individuals affected by these customs, namely, married individuals. Since the marital status of an individual is not generally reflected in skeletal evidence (unless some biological deformation is performed upon marriage), an alternate means of obtaining this information is required. Spence (1971) deals with this problem by selecting an 'age of marriage', such than any individual of at least this age has a high probability of being married. Spence notes that such an age cannot be too high, lest the sample size be reduced to an unnecessarily low number, nor can it be too low, lest unmarried adults be included in the sample. After some deliberation, Spence chooses an arbitrary age of twenty-one years for use in his study of marriage patterns. The same 'age of marriage' is used in this study.

The main criterion used to evaluate whether an individual met the age requirement for inclusion in the sample used in this study was closure of the spheno-occipital synchondrosis. The timing of complete closure of this joint is subject to some debate, with eighteen to twenty years being the age commonly designated as the time at which it begins to fuse and twenty to twenty-five years designated as the time of complete closure (McKern and Stewart 1957). However, it seems reasonable to assume that closure is complete or nearing completion by the age of twenty-one years.

When the spheno-occipital synchondrosis could not be examined, or when further information was required, the following factors were taken into consideration: the presence of the third molars, the degree of dental attrition, the state of epiphyseal union and suture obliteration, the morphology of the pubic symphysis, and the presence of degenerative joint changes.

The aging procedure yielded a total of forty-three adults (Table 2), one less than that given by Anderson (1976). This discrepancy reflects the fact that the remains of individual 18D could not be located for examination. It may be noted that the catalogue card for this individual in the Archaeology laboratory at Memorial University indicates that the remains were very fragmentary, and would have been unsuitable for inclusion in the sample used in this study.

3.4 Sex determination

This thesis is concerned with measuring the relative variability evidenced by male and female skeletal remains. In order for such a study to have validity, it is of utmost importance that adult individuals be correctly sexed. However, this may prove to be a difficult task, since the process of

TABLE 2

ADULT INDIVIDUALS FROM LOCUS II

1A	18B	37A
1B	19	37B
4	21	37C
5	22D	40A
6	23	44A
7	25	44B
8A	27A	46A
9	28A	47A
10	28B	47B
12	29	49A
14A	30C	50A
15	31	50B
16A	32	51
18A	34	52
	35A	

Total = 43

sexing skeletal material is generally based on subjective estimations. The amount of overlap in the characteristics of the two sexes complicates the task. Hrdlička (1972) has noted that

> If a large number of individuals of each sex were arranged on the basis of their bodies and parts, it would be found that the whole bodies as well as many of the parts would range in the males from the hypo- to the hyper-masculine, in the females from the hypo- to the hyper-feminine, and that the hypo- of the two groups so overlapped that a distinction between them was difficult or even impossible (Hrdlička 1972:111-112).

Estimates of the reliability of sexing skeletal material by visual methods range upward from approximately 70%, depending on the criteria used. Krogman (1962) has suggested that an experienced observer may sex a skull with 82-87% accuracy, a pelvis with 85-90% accuracy, and long bones with 70-75% accuracy. He has also suggested that sexing based on the characteristics of the skull and pelvis has an accuracy of 88-93%, that sexing based on characteristics of the pelvis and long bones has an accuracy of 80-85%, and that sexing based on characteristics of the whole skeleton (that is, skull, pelvis and long bones) has an accuracy of 90-95%.

T. D. Stewart's (1948) estimates are in close agreement with these outlined by Krogman (1962). He has suggested that an experienced observer may sex a skull with 80% accuracy, and a pelvis or entire skeleton with 90-95% accuracy. Focusing on features of the pelvis, Washburn (1948, 1949) has suggested that the ischium-pubis index may be used to sex individuals with over 90% accuracy, the sciatic notch with around 75% accuracy, and the notch and index together with around 98% accuracy. Phenice (1969) has suggested that the ventral arc, subpubic concavity, and medial aspect of the ischio-pubic ramus may be used with 96% accuracy.

In general, the process of sex determination involves a consideration of a variety of elements relating to both size and shape. Sublett (1966) has provided a particularly clear and concise summary of the characters generally relied upon in her study of Seneca remains from New York State. Her summary was supplemented with information from several other sources (Keen 1950; Krogman 1962; Phenice 1969; Bass 1971; Ubelaker 1978) to produce a list of criteria to be used in sexing the individuals from Port au Choix. These criteria are listed in Table 3, while a detailed explanation of them is provided in Appendix A. It may be noted that while these criteria have been derived from modern White and Negro dissecting room specimens, Sublett's (1966) work with Seneca skeletal remains suggests that these standards are applicable to Indian populations.

The sexing of the Port au Choix remains produced a total of eighteen females and twenty-two males (Table 4). The remains of three individuals were so fragmentary that no sex could be assigned with an acceptable degree of certainty. These results were compared to those listed by Anderson (1976) in his description of the Port au Choix remains, and to those listed on catalogue cards for these individuals in the

TABLE 3

CRITERIA FOR SEXING

SKULL
Overall size and robustness
Size of the supraorbital ridges
Configuration of the supraorbital margins
Degree of parietal and frontal bossing
Muscle markings
Size of the mastoid process
Development of the posterior root of the zygomatic process
Width of the zygomatic arches
Breadth of the palate
Size of the mandible
Chin form
PELVIS
Muscle markings
Sub-pubic angle
Presence of the ventral arc
Medial aspect of the ischio-pubic ramus
Presence of a sub-pubic concavity
Angle of the sciatic notch
Presence of a preauricular sulcus
Ischium-pubis index
Size of the obturator foramen
Size of the acetabulum
Lateral view of the sacrum
Size of the first sacral body
Size of the articular surface of the sacrum
LONG BONES
Overall size
Muscle markings
Size of the articular surfaces

TABLE 4

SEXING OF LOCUS II INDIVIDUALS

Individual	Sex	Individual	Sex
1A	female ?	28B	?
1B	female ?	29	male
4	female ?	30C	male
5	male	31	male
6	female	32	male
7	female ?	34	male
8A	male	35A	male
9	female ?	37A	male
10	female	37B	female
12	male	37C	female ?
14A	male	40A	male
15	male	44A	female
16A	female	44B	male
18A	male	46A	male ?
18B	female	47A	male
19	male	47B	male
21	female	49A	female
22D	male	50A	female
23	?	50B	male
25	female ?	51	?
27A	male	52	female
28A	female		

Total number of individuals = 43

Number of females	= 11	Number of males	= 21
Number of females ?	= 7	Number of males ?	= 1
Total females	= 18	Total males	= 22

Number of individuals for whom no sex could be assigned = 3

Archaeology laboratory at Memorial University. When a discrepancy was found to exist, the remains were re-examined and re-evaluated. In all but one case, the assignments agreed. The exception was individual 1A, whom Anderson describes as probably male (male?), but whom the author and catalogue card describe as probably female (female?). Following re-evaluation, the latter designation was used.

It should be noted that the cases of 'probably male' and 'probably female' were included in the sample used in this study, since, in general, the sexing of these individuals carried only a limited amount of doubt. The 'probably' designation was used because the remains were fragmentary. Given the limited amount of material available for study, and the limited amount of doubt associated with the sexing of these individuals, the inclusion of these cases seemed to be justified.

3.5 The genetic basis of osteological traits

Introduction

It is obvious that the validity of any study of biological relationships depends on the use of data which reflect genetic information. Traditional methods of osteological analysis have relied on the use of metric data for such comparisons. However, in recent years, such methods have fallen into disfavor, owing to a growing controversy regarding the influence of environmental factors on metric trait expression. This controversy has led to an investigation of the use of non-metric traits in osteological analyses, and to a proliferation of studies using non-metric data. The influence of environmental factors on non-metric trait expression, however, has also become a subject of debate (Corruccini 1975; Trinkauss 1978).

As the situation now stands, both methods of analysis have their proponents. A number of workers defend the use of metric data suggesting that studies based on metric traits produce results comparable with linguistic, geographic, and historical evidence (Jantz 1970; Howells 1970, 1972; Rightmire 1972; Carpenter 1976). Other workers defend the use of non-metric data, pointing out that studies using non-metric traits have also produced results which are comparable with known or suspected relationships between the populations involved (Laughlin and Jorgensen 1956; Brothwell 1959, 1965; Sublett 1966; Berry and Berry 1967; A. C. Berry et al 1967; Anderson 1968; DeVilliers 1968; Lane 1969; Ossenberg 1969, 1970; Kellock and Parsons 1970a, 1970b; Knip 1970a, 1970b, 1971a, 1971b; Buikstra 1972; Finnegan 1972; Rightmire 1972; Birkby 1973; Pfeiffer 1977).

In order to determine which, if either, of these sources of data might provide more reliable results in this study, the available evidence on the genetic basis of metric and non-metric traits was investigated. The author's findings are summarized in the following sections.

Metric traits

Metric traits may be described as "continuous morphological variables dealing with the size and dimensions [of the skeleton]" (El-Najjar and McWilliams 1978: 112). The genetic basis of these traits is not completely understood, although it is accepted that the inheritance of metric traits is based on the combined influence of many genes (DeVilliers 1968).

The two principle sources of information on the heritability of metric traits in humans are studies of twins and studies of the descendents of immigrants (Wilkinson 1971). However, the results of these studies are not in agreement. Estimates of metric trait heritability based on studies of twins suggest a low environmental influence on metric trait expression (Vandenberg 1962; Nakata et al 1972) while estimates of metric trait heritability based on studies of the descendents of immigrants suggest a high environmental influence on metric trait expression (Lasker 1946; Kaplan 1954).

In any case, the existence of environmental influences on metric trait expression may not be of serious consequence in a study such as this one. It is proposed that a group of genetically related individuals living together in a common situation would be subject to a common set of general environmental influences, such as climate and nutrition, and would constitute a relatively homogeneous sample. Exceptions to this rule might accompany the existence of status or class distinctions within the group if such distinctions manifested themselves in ways which affect osteological trait expression, for example, differential access to food or differential application of such practices as cranial deformation. Band level societies, however, are not generally characterized by the presence of class distinctions. D'Entremont's (1977) work on the existence of status differences among the Archaic Indians of Port au Choix supports the idea that their society was an egalitarian one. He points out that the grave goods associated with each individual do not indicate the presence of any social distinctions beyond those which may be ascribed to family affiliation. The present author found no evidence of cranial deformation or any other practice which might have affected osteological trait expression within the Port au Choix sample. Thus, it is proposed that, within this sample, individuals coming from the same band would indeed form a relatively homogeneous group, while individuals coming from different bands would form a relatively heterogeneous group - part of this heterogeneity stemming from differences in their genetic makeup, and part from differences in the environmental influences to which they were subjected.

Non-metric traits

Non-metric traits may be described as minor morphological variants of the skeleton or other body structures. For most non-metric traits, variation seems to result from normal developmental processes, and thus, such variants are not usually described as 'normal' or 'abnormal' features. These variants may display a continuous or discrete distribution. Those with a continuous distribution show varying 'degrees of expression' and are referred to as 'continuous traits', while those with a discrete distribution may be described as either present or absent, and are referred to as 'discrete traits'. The use of non-metric traits allows data to be collected from cranial and infracranial remains which are fragmentary or incomplete. In addition, it has been suggested that non-metric traits may be easier to score than metric traits (Knip 1971a, 1971b), although this point has been debated (Carpenter 1976).

The existence of non-metric variation has been recognized for a number of years. Chambellan (1883), in his study of sutural bones, seems to have been the first to suggest using non-metric traits as anthropological characters. Twenty years later, Le Double (1903, 1906, 1912) collected non-metric data from numerous sources, and demonstrated the range of variation present in large samples, as well as the existence of racial and regional differences in variant incidences. A variety of other writers also contributed to the early literature on non-metric variation, including Dorsey (1897), Russell (1900), Sullivan (1925), Collins (1926), and Wood-Jones (1931a, 1931b, 1931c, 1933).

In the last 20 years, an increasing amount of time and energy has been devoted to the study of non-metric traits. Anderson (1968) reports finding more than 1500 references in which such variants are discussed. Finnegan and Faust (1974) list 1556 references in their more recent bibliography on non-metric variation, and Finnegan (1979) lists over 300 more references in his supplement to this bibliography.

Most of the existing information on the genetic basis of non-metric traits comes from studies of animals, particularly rodents (Gruneberg 1950, 1952, 1955, 1961; Weber 1950; Searle 1954a, 1954b, 1960; Deol and Truslove 1957; Deol 1958; Harland 1958; Truslove 1961; Grewal 1962; Berry and Searle 1963; R. J. Berry 1963, 1964, 1969a, 1969b; Howe and Parsons 1967; Parsons and Howe 1967; Berry and Jakobson 1975). This work suggests that non-metric traits are at least partially genetically determined, although not in simple Mendelian fashion. Rather, most non-metric traits seem to be determined as continuous variables controlled by the complex interaction of a number of gene loci. A. C. Berry (1972) has suggested that such traits may illustrate the remote effects of genes whose main activity lies elsewhere. Whatever the case, for each trait there appears to be a genetically determined point which acts as the threshold between phenotypic presence and absence of the trait (Gruneberg 1952). It was this genetic model which led Gruneberg (1952) to propose the term 'quasi-continuous traits' to describe non-metric variants.

It has been suggested that the 'polygenic' nature of non-metric traits may add to their value in studies of population affinities, since polygenic traits are relatively less sensitive to the action of selection, mutation and drift than monogenic traits, and hence, much more likely to remain stable through time (Oschinsky 1959; Bielicki 1962; Hanna 1962; DeVilliers 1968). DeVilliers (1968) suggests that, in view of this evidence, polygenic characters may "offer the best basis for determining the effects of population mixture and hybridization (on characteristics of a population)" (DeVilliers 1968:2).

Several workers have used both monogenic and polygenic traits in studies of group affinities and found a correspondence in the results (Sanghvi 1953; Laughlin and Jorgensen 1956; Pollitzer 1958). Other workers have had different results (Oschinsky 1959).

> Examples are known in which blood group isogenes fail to reveal any affinity between populations, whereas a comparison based upon genetically-complex traits gives conclusive evidence of relationship - in full accordance with historical, archaeological, or geographic data (Bielicki 1962:4).

There have been a limited number of studies on the genetic basis of non-metric traits in human groups. There are two main reason for this. Firstly, such studies require a sample which is well documented in terms of the relationships between individuals - an easy task if one is dealing with laboratory animals, but one which becomes almost impossible when dealing with human skeletal samples. Secondly, if one chooses to work with living individuals, relationships are easier to determine, but the number of traits available for study is reduced to those which may be palpated or observed on X-ray. Despite these problems, some studies are available, including those by Montagu (1937), Hess (1945), Torgersen

(1952), Selby, Garn, and Kanareff (1955), Grahnén (1956), Suzuki and Sakai (1960), Johnson, Gorlin and Anderson (1965), El-Najjar and Dawson (1977), and Saunders and Popovitch (1978). These studies seem to favour a degree of genetic control over non-metric trait expression.

Several workers have noted that the expression of non-metric traits may also be affected by the influence of non-genetic factors relating to the developmental environment (Searle 1954a, 1954b; Deol and Truslove 1957). These factors, determined from studies of rodents, include maternal physiology, parity, and diet, and seem to achieve their affects by influencing the size of structures or their primordia (Ossenberg 1970). However, Ossenberg (1970) has suggested that the differences in non-metric trait expression produced by these developmental factors is at a much lower level than those produced by genetic factors. It may be noted that the influence of non-genetic factors on the underlying genetic continuum is reflected in the term 'epigenetic polymorphism', proposed by Berry and Searle (1963).

As was the case with metric traits, the influence of environment on non-metric trait expression does not seem to pose a serious threat in this analysis. It is assumed that for any given group the influx of new individuals from other bands would continue to be measureable in terms of greater relative variability of trait expression than would be found among individuals from the same band.

Discussion

Existing information indicates that neither metric nor non-metric data are of superior value in studies of biological relationships. Both types of data have produced results comparable with known or suspected relationships between the populations being studied. Both metric and non-metric traits have been shown to be genetically determined, though the expression of both may be influenced to varying degrees by environmental factors, such as climate, nutrition, maternal physiology, or biomechanical stress. It has been suggested, however, that the presence of such influences may not be of serious consequence in this study, since it is assumed that individuals who come from the same band would share a similar genetic background and be subject to a common set of general environmental influences, and hence, should display relatively less variability than individuals coming from a variety of bands.

Thus the worker has a choice. He may use the type of data which appeals to him most, or he may use both types of data. The latter approach has been advocated by a number of workers who suggest that these two types of data produce complementary results (Sanghvi 1953; Laughlin and Jorgensen 1956; Pollitzer 1958; Brothwell 1959; DeVilliers 1968; Howells 1970, 1972; Jantz 1970; Knip 1970a, 1970b, 1971a, 1971b; Rightmire 1972; Corruccini 1974; Carpenter 1976; Trinkauss 1978). This is also the approach used in this study.

3.6 Metric trait selection

Previous work

The literature on metric trait analysis contains a limited amount of information on the reliability of specific measurements in describing and comparing populations (Howells 1957; Landauer 1962). There are some writers who have made a general distinction between the usefulness of size and shape measurements in osteological studies, advocating the use of 'shape-oriented measurements' for population comparisons and the use of 'size-oriented measurements' for sexing purposes (Zegura 1971). Other workers have been more specific. For example, Zegura (1971) and Crichton (1966) have suggested that measurements of the face may be more valuable than those of the vault for population comparisons. Howells (1969) has suggested that measurements of the breadth of the cranial base, the protrusion of the subnasal region, and the relative prominence of the orbital rim may be more important.

The use of factor analysis in future studies of biological relationships will no doubt contribute useful information on the reliability of using specific traits in such analyses. However, for the present, most authors seem to base their choice of measurements on precedent, rather than on the value any particular measurement may have in terms of the specific information it conveys.

This study

To a limited extent it was precedent which governed the choice of traits to be used in this study. However, given the small size of the Port au Choix sample, consideration was also given to choosing a battery of traits which would be applicable to the maximum number of individuals. The desired goal was to obtain a set of measurements which would give an overall picture of each individual (in so far as this was considered possible), but at the same time ensure inclusion of the maximum number of cases.

Giles and Bleibtreu (1961) have suggested that when the morphological differences being sought or studied are of a small order, use of a number of measurements may provide more useful information. Thus, despite the fact that most workers have tended to rely on cranial traits for the purpose of population comparisons, both cranial and infracranial traits were used in the analysis of the Port au Choix material. The sets of cranial and infracranial traits were chosen independently, and the subsequent statistical analyses performed separately, thus providing an opportunity to compare the results provided by these two types of data.

Two practical considerations were involved in the process of metric trait selection. The first of these was the availability of equipment, while the second was the amount of damage evidenced by the sample. A pilot study of the Port au Choix material was carried out using the University of Toronto data codification sheets. This pilot study was designed to identify those measurements which could not be taken due to a lack of equipment or frequent damage to the sample. Traits which could not be recorded for a large number of individuals were eliminated from the analysis, since their inclusion would require the use of a large number of estimations when multivariate statistics were used. Such estimations may bias the sample toward an artificial estimate of homogeneity, and are considered unacceptable.

The process of trait elimination resulted in exclusion of measurements of the palate, mandible, clavicle, scapula, innominate, sacrum, calcaneus, and patella. Many long bone measurements were also excluded due to frequent damage to shafts and epiphyses. The measurement of auricular height was eliminated due to lack of proper measuring equipment, that is, a craniostat. Measurements of the mandible were eliminated from the study for two reasons: 1) it was evident that areas of the mandible such as the mandibular condyles and ascending ramus were often damaged, thus limiting the number of measurements which could be taken, and 2) the use of only those skulls with preserved mandibles significantly reduced the sample size.

The selection of measurements partly on the basis of their preservation has certain implications. It may be argued that such selection precludes the selection of measurements on other bases, such as their usefulness in population comparisons. However, the traits which were chosen for use in this study do not seem to be significantly biased by this criterion. Indeed, the choice of cranial traits would probably have been exactly the same if the preservation criterion had not been used. In terms of infracranial remains more measurements would have been desirable. However, it may be noted that the available measurements do give some idea of the size and shape of the preserved infracranial remains, and should be of some value in this study.

The end product of the process of metric trait selection was a set of fourteen cranial measurements and thirteen infracranial measurements. The cranial traits pertained to the vault of the skull, face, base of the skull, orbits, nose, and upper alveolar process. The traits were as follows:

a) the vault: cranial length, cranial breadth, basion-bregma height, and minimum frontal breadth
b) the face: upper facial height, bizygomatic breadth
c) the base: basion-nasion length, and basion-prosthion length
d) the orbits: orbital breadth, and orbital height
e) the nose: nasal breadth, and nasal height
f) the upper alveolar process: maxillo-alveolar breadth and maxillo-alveolar length

These measurements are illustrated in Figures 4, 5, and 6. Definitions are given in Appendix B.

The infracranial traits used in this study pertain to the humerus, radius, femur, tibia, and talus. The traits are as follows:

a) humerus: maximum length, maximum shaft diameter, minimum shaft diameter, and maximum diameter of the head

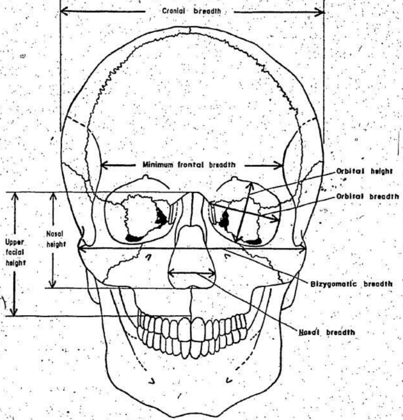


FIGURE 4 · CRANIAL MEASUREMENTS (norma frontalis)

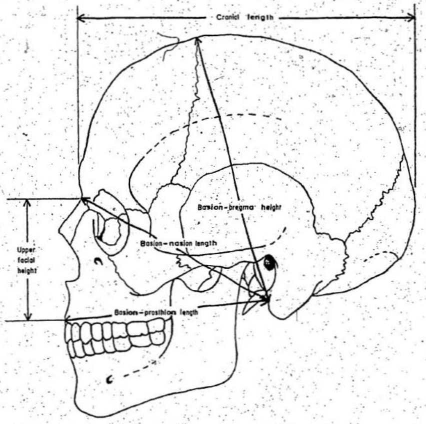


FIGURE 5 : CRANIAL MEASUREMENTS (norma lateralis)

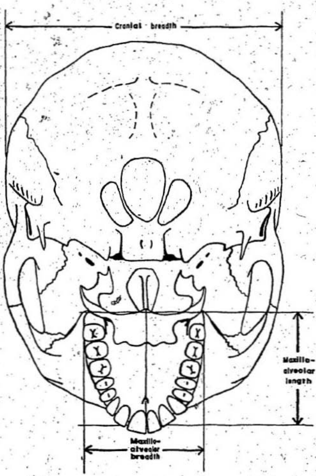


FIGURE 6 · CRANIAL MEASUREMENTS (norma basalis)

b) radius: maximum length

c) femur: subtrochanteric transverse shaft diameter, subtrochanteric anteroposterior shaft diameter, and maximum diameter of the head

d) tibia: anteroposterior nutrient foramen (or cnemic) diameter, and transverse nutrient foramen (or cnemic) diameter

e) talus: maximum length, maximum breadth, and height

These measurements are illustrated in Figures 7 and 8, and defined in Appendix B. All infracranial measurements were made on bones from the left side of the skeleton, following the convention adopted for bilateral skull measurements (cf. Knip 1970, 1971). This convention provides a means of dealing with the fact that bones from the right side are frequently larger than those from the left. This situation may reflect the slight retardation of ossification on the right side, and a resulting longer period of growth (Ossenberg 1970).

Procedure for recording metric data

While most of the skeletal remains from Port au Choix are remarkably well preserved, the remains of a number of individuals are fragmentary, making it impossible to record values for all the measurements outlined above. Since the use of estimations is not considered acceptable in multivariate studies, individuals whose remains were fragmentary, and thus did not provide a complete set of measurements, were eliminated from the sample used in the multivariate analysis of metric trait variability. The estimation of one measurement per

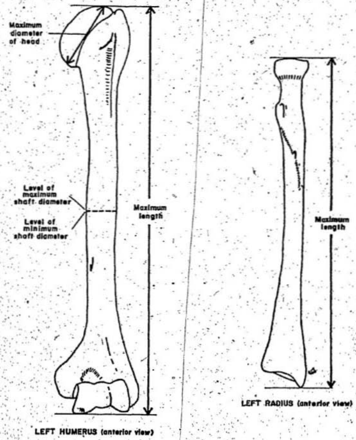


FIGURE 7 · UPPER LIMB MEASUREMENTS

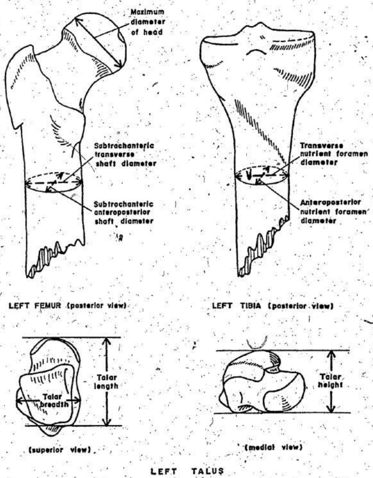


FIGURE 8 · LOWER LIMB MEASUREMENTS

individual was permitted.

The elimination of individuals who did not qualify for inclusion in this study made serious limitations on the sample size. In terms of cranial traits, the sample was reduced to nine males and eleven females, and in terms of infracranial traits, the sample was reduced to five males and seven females. These individuals are listed in Appendix B.

Since the author was interested in comparing the results of the univariate and multivariate analyses, it was decided that precisely the same individuals and measurements would be used in both analyses. With no differences in the traits or individuals utilized, it would seem that differences in the results of these analyses could be attributed to differences in the techniques used.

The metric data gathered from the Port au Choix sample were recorded in the appropriate spaces of the University of Toronto IBM codification sheets. In order to minimize error, all measurements were taken twice. When a bilateral measurement could not be taken on the left side, it was replaced with the measurement from the right side of the individual. This practice was used when there was no consistent difference between the measurements of bones from the right and left sides. This was the case with all traits except maximum length of the humerus, and maximum length of the radius. In these instances, and in cases when the measurement was unavailable from the right side, the blank was filled with the mean trait value for males or females as required. The latter procedure was also used for missing values of unilateral measurements. It is recognized that estimation from other available measurements through the use of regression equations would provide more precise results. However, in view of the limited number of estimations involved here, such a procedure was not considered necessary. When the recording procedures were complete, the data were transferred from the IBM sheets to computer cards, and checked for accuracy.

Indices

It has been suggested that the use of data from raw measurements in studies of biological relationships may produce results which reflect differences in size, rather than shape (Wilkinson 1971). In an effort to overcome this problem, and in an effort to make maximum use of the data at hand, a number of indices were added to the list of traits used in the analysis of the Port au Choix material. The use of these indices is considered one means of expressing shape relationships (cf. Wilkinson 1971). The indices used in this analysis are as follows:

Cranial Indices

$$\text{Cranial index} = \frac{(\text{cranial breadth})\ 100}{\text{cranial length}}$$

$$\text{Length-height index} = \frac{(\text{basion-bregma height})\ 100}{\text{cranial length}}$$

$$\text{Breadth-height index} = \frac{(\text{basion-bregma height})\ 100}{\text{cranial breadth}}$$

$$\text{Mean height index} = \frac{(\text{basion-bregma height})\ 100}{(\text{cranial length} + \text{cranial breadth})/2}$$

$$\text{Frontoparietal index} = \frac{(\text{minimum frontal breadth})\ 100}{\text{cranial breadth}}$$

$$\text{Upper facial index} = \frac{(\text{upper facial height})\ 100}{\text{bizygomatic breadth}}$$

$$\text{Cranio-facial index} = \frac{(\text{bizygomatic breadth})\ 100}{\text{cranial breadth}}$$

$$\text{Frontozygomatic index} = \frac{(\text{minimum frontal breadth})\ 100}{\text{bizygomatic breadth}}$$

$$\text{Gnathic index} = \frac{(\text{basion-prosthion length})\ 100}{\text{basion-nasion length}}$$

$$\text{Orbital index} = \frac{(\text{orbital height})\ 100}{\text{orbital breadth}}$$

$$\text{Nasal index} = \frac{(\text{nasal breadth})\ 100}{\text{nasal height}}$$

$$\text{Maxillo-alveolar index} = \frac{(\text{maxillo-alveolar breadth})\ 100}{\text{maxillo-alveolar length}}$$

Infracranial Indices

$$\text{Radio-humeral (or brachial) index} = \frac{(\text{maximum length of radius})\ 100}{\text{maximum length of humerus}}$$

$$\text{Mid-shaft (or diaphyseal) index of humerus} = \frac{(\text{minimum diameter of shaft})\ 100}{\text{maximum diameter of shaft}}$$

$$\text{Platymeric index of femur} = \frac{(\text{subtrochanteric anteroposterior diameter})\ 100}{\text{subtrochanteric transverse diameter}}$$

$$\text{Platycnemic index of tibia} = \frac{(\text{transverse nutrient foramen diameter})\ 100}{\text{anteroposterior nutrient foramen diameter}}$$

$$\text{Index of talar breadth} = \frac{(\text{talar breadth})\ 100}{\text{talar length}}$$

$$\text{Index of talar height} = \frac{(\text{talar height})\ 100}{\text{talar length}}$$

These indices were calculated for all individuals and the results recorded in appropriate spaces on the IBM codification sheets.

3.7 Non-metric trait selection

Previous work

As was the case with metric traits, the literature on non-metric trait analysis contains a limited amount of information on the reliability of specific traits in describing and comparing populations. Thus, once again the researcher is left to rely to a large degree on precedents set by other workers (which, in many cases, have never been questioned), or on personal preferences. There are, however, several additional factors which the researcher must take into consideration in choosing non-metric traits. These factors include the presence of sex and age correlations in non-metric trait expression, and will be discussed in the following sections.

Sex bias

The use of biological traits in group comparisons is based on the assumption that groups belonging to the same population will exhibit no significant differences in trait expression. Thus, any comparisons which make use of traits with a known bias toward members of a particular group or category must be considered invalid (Spence 1971).

It is an obvious fact that there is a sex bias in the expression of metric traits, in that males tend to be larger and more muscular than females. In the metric analysis of the Port au Choix material these differences are dealt with by structuring the analysis to measure the relative amount of variation present, not to detect differences in trait means.

Many studies using non-metric traits have assumed that there are no comparable sex differences in non-metric trait expression (Sjøvold 1973). Most of these studies cite the pioneering work of Berry and Berry (1967) as proof of this assumption. Berry and Berry did indeed test the differences in trait expression between the two sexes with non-significant results. However, they used a sample drawn from a number of different populations, and have been critized for lumping together individuals from different populations into "grand male and female samples" (Corruccini 1974:428). By so doing, the Berrys failed to consider the possibility that population differences might cancel any existing sex differences.

Other studies have produced results contrary to those of Berry and Berry. Deol's (1955) work with reciprocal crosses of mice showed one character to be 'matroclinous' and another 'patroclinous'. A. C. Berry's (1975) work with human skeletal material from London, Burma, Mexico and the Northwest Coast revealed a number of significant differences in trait expression between the sexes, as well as a number of non-significant trends. Berry and Jakobson's (1975) work on wild living house mice also demonstrated a sex bias for several variants. Nancy Ossenberg (1970) has described sex as an intrinsic factor in the expression of 'hypostotic' and 'hyper-ostotic' traits. She points out that women generally retain more infantile characters, and hence, exhibit a higher frequency of hypostotic traits, whereas men exhibit a higher frequency of hyperostotic traits, such as heavier brow ridges, large mastoid processes, and greater rugosity of muscle markings.

Gruneberg (1963) has suggested that the influence of sex may relate to differences in size.

> Whatever influences size will indirectly tend to affect the incidence of some of the minor variants. If at a critical time for the development of a variant, there is a sex difference in size, the variant will manifest itself more often in one sex than in the other (Gruneberg 1963:267).

Howe and Parsons (1967), Corruccini (1975), and Cheverud, Buikstra and Twichell (1979) have also suggested that the distribution of non-metric traits may be an expression of general and/or local size variations in the skeleton. Other workers have suggested specific relationships between certain metric and non-metric variants (Bolk 1917; Montagu 1937; Woo 1949a, 1949b, 1950; Bennett 1965; Carpenter 1976). However, these studies are not conclusive. As Corruccini (1975) has pointed out

> Either variable may be the impetus for variation in the other, or they may be functionally independent but both dependent on another, unrecorded stimulus (Corruccini 1975:291).

In an effort to determine which specific non-metric traits display a sex bias in their expression, the literature on non-metric variation was reviewed for information on the differential expression of traits between the sexes. A limited amount of information was available on this subject, since most researchers have tended to pool the sexes in group comparisons, and few have focused on the problem of sex bias in non-metric trait expression. However, a body of pertinent data was assembled, and is summarized in Appendices D and E.

In analyzing the information presented in these appendices, some method of assigning bias had to be established. It was decided that if the expression of a trait seemed to be correlated with one particular sex in over half the studies reviewed, the trait would be considered sex-biased. However, at least two indications of bias were required; a single study indicating bias was ignored, since it might represent peculiarities of the sample.

It becomes very obvious when one examines the data given in these appendices that the patterns of sexual variation in non-metric trait expression are characterized by a general lack of consistency. A. C. Berry (1975) encountered a similar situation in her study of sexual differences in trait expression, and suggested that it might reflect the influence of environmental factors.

> [Non-metric traits] are the outward manifestation of the activity of genetic, epigenetic, and even overtly environmental forces, and are a long way from the primary site of gene action (Berry 1975:529).

However, the information presented does indicate a male bias for expression of the following traits: presence of parietal foramina, accessory lessor palatine foramen, lambdic bone, suprameatal pit, lambdoidal wormians, pterygoid plate spurs and bridges, mandibular torus, paramastoid process, supramastoid crest, auditory exostoses, posterior atlas bridge, and sacralization. It indicates a female bias for absence of the mastoid foramen, presence of the infraorbital suture, metopism, frontal grooves, open foramen spinosum, tympanic dehiscence, palatine torus, precondylar tubercle, pharyngeal fossa, septal aperture and third trochanter. The available information also suggests a probable sex bias for presence of double atlas facet, lateral atlas bridge, suprascapular foramen, medial tibial squatting facet, trochanteric osteophytes, and vastus notch. However, the direction of this bias is not established.

There are three methods of dealing with the problem of sex bias in non-metric trait expression. These are: 1) to eliminate those traits which display a bias, 2) to use statistical procedures which account for any existing bias, or 3) to structure the analysis so as to avoid the affects of any bias. The first option was chosen for use in this study, and all traits which demonstrated a sex bias in their expression were eliminated from the non-metric analysis.

Age bias

The next criterion considered in the choice of non-metric traits was the existence of an age dependency among the variants, such that a trait might be expressed with different frequencies at different ages. However, once again the work which has been done in this area of research is limited. Ossenberg (1970) has noted a slight tendency for hyperostotic traits to be age progressive, whereas hypostotic traits seem to be slightly age regressive, although she has also suggested that such a small dependency may be ignored, since it would not greatly alter the significance of group comparisons. Korey (1970) has demonstrated age correlations for several non-metric traits when prepubertal material is used, and has suggested that such dependencies will affect studies of biological relationships if the age profiles of the groups compared are not similar. Buikstra (1972) has supported this idea, and suggested that age correlations disappear if individuals under twelve years are excluded as well as young material showing partial trait expression or older material showing the complete trait. Corruccini (1974) has reported significant differences in trait expression between samples of 'young' and 'old' adult Whites and Negros from the Terry skeletal collection. However, he has noted that there is little consistency in patterns of age dependence for different samples.

Most researchers seem to be in agreement that age correlations in non-metric trait expression are not significant or consistent if one is dealing with strictly adult samples. In view of this fact, and assuming that any correlations of trait expression with different stages of adulthood would apply to both sexes, the existence of age correlations was ignored in this study.

Other factors

The remaining procedures involved in choosing the non-metric traits to be used in this analysis parallel those used in the choice of metric traits. Once again, both cranial and infracranial traits were considered for inclusion in the analysis, despite the fact that most workers have tended to rely on only cranial traits. As with metric traits it is suggested that infracranial remains may provide an important source of information for population studies (Spence 1971; Wilkinson 1971; Finnegan and Faust 1974; Gaherty 1974; Finnegan 1978). Indeed, Finnegan (1978) has suggested that infracranial traits may be more aptly suited to non-metric analysis than cranial traits given 1) the possibility of bilateral expression for most infracranial traits, 2) the preservation rates of infracranial material, and 3) the number of available studies on sex and side dimorphism of infracranial trait expression.

Following the procedure used in the selection of metric traits, an assessment was made of those non-metric traits most frequently lost due to damage, or to poor preservation of particular areas of the skeleton. Once again, a pilot study of the material using the University of Toronto IBM codification sheets was employed for this purpose. Any traits which could not be recorded for the majority of individuals were omitted from the analysis, since the frequency of these traits could not be considered a valid reflection of the sample frequency. Thus the following traits were omitted: position of the anterior ethmoid foramen, absence of the posterior ethmoid foramen, all traits of the nasal region, presence of a sternal foramen, accessory sacral body, and Poirier's facet (femur).

There were also other reasons why particular traits were excluded from this study. Some traits had not been studied or used to an extent which established their usefulness in population comparisons. These traits included the form of the transverse palatine suture, the size of the jugular foramen, and the presence of multiple mental foramen. Other traits were excluded on the basis of subjectivity or difficulty of scoring. Such traits included the presence of an ossified apical ligament, peroneal tubercle, frontal foramen, vastus fossa, pharyngeal fossa, parietal notch, hypertrochanteric fossa, highest nuchal line, marginal foramen of the tympanic plate, and multiple mandibular foramen, as well as mastoid foramen position, sagittal sulcus direction, and traits of the clinoid region. Still other traits were excluded on the basis of questionable genetic origin. These traits included the presence of gonial eversion, the so-called squatting facets of the tibia and talus (Olivier 1969), and the accessory facets of the sacrum and the innominate (Trotter 1964). Any traits which related to size, rugosity, or excess ossification, such as marginal, malar and zygomaxillary tubercles, and presence of a subclavian or humeral facet, glenoid fossa extension (scapula), spurring of the tibia, patella, calcaneus, fibula, and iliac crest, were excluded in accordance with Ossenberg's (1970) suggestion that hyperostotic traits may be male-biased in their expression. Absence of the anterior facet of the calcaneus was excluded on the grounds that this feature is not independent of the presence of a double anterior facet. Vertebral traits, such as open foramen transversarium and divided foramen transversarium, were not recorded for all vertebrae due to statistical considerations to be discussed in the next chapter. The presence of spina bifida was not recorded, since this trait may be pathological, and hence, may be an abnormal variant. Only those traits which could be considered the result of normal developmental processes were included in this study. Spondylolysis was not included, since it may be a developmental anomaly related to stress fractures (Epstein 1968).

An additional consideration in the process of trait selection was the ability of a trait to be easily defined and standardized. Wood-Jones (1930a) has pointed to the difficulty of accurately scoring traits as "large or small, present or absent, according to [their] degree of development or prominence", especially when several populations are being compared (Wood-Jones 1930a:179). Moreover, the appearance of some traits may vary to some degree. For example, there may be one or several accessory palatine foramen, or one or more coronal wormian bones. This latter problem is considered by Sjøvold (1973), who comments:

> the essential question is whether the variant is present, not how it is present (Sjøvold 1973:205).

In order to limit subjectivity and inconsistencies in scoring, Sjøvold's philosophy was adopted for use in this study. Sjøvold has also noted that there are sometimes problems as to whether presence or absence of a certain feature, or which form of a feature, should be regarded as the variant. These decisions seem to rest on the researcher's personal preferences.

The end product of the process of non-metric trait selection for this study of the Port au Choix skeletal material was a set of eighteen cranial and fifteen infracranial traits. The cranial non-metric traits are as follows:

a) <u>foramina</u>: supraorbital foramen complete, multiple infraorbital foramen, zygomatico-facial foramen present, open foramen ovale, postcondylar canal absent, vesalian foramen present, multiple mental foramen

b) <u>wormians</u>: coronal wormians, sagittal wormians, bregmatic bone, os Inca, asterionic bone, parietal notch bone

c) <u>other</u>: fronto-temporal articulation, os japonicum, maxillary torus, condylar facet double, mylohyoid bridge

These traits are illustrated in Figures 9 to 12, and are described in Appendix F.

The infracranial non-metric traits chosen for use in this study pertain to the atlas and axis vertebrae, the scapula, humerus, ulna, innominate, femur, patella, talus, and calcaneus. They are as follows:

a) <u>vertebrae</u>: open foramen transversarium (atlas), divided foramen transversarium (atlas), posterior arch foramen (atlas), open foramen transversarium (axis), divided foramen transversarium (axis)

b) <u>scapula</u>: unfused acromion process

c) <u>humerus</u>: supracondylar process

d) <u>ulna</u>: trochlear notch form

e) <u>innominate</u>: acetabulum notch, acetabulum crease

f) <u>femur</u>: fossa of Allen

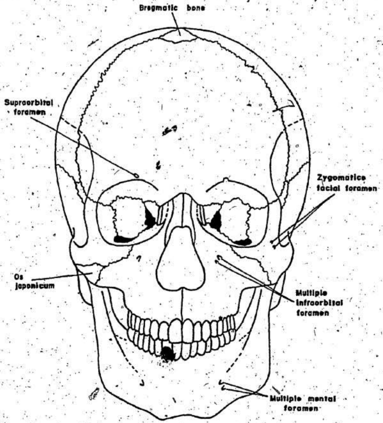


FIGURE 9 CRANIAL NON-METRIC TRAITS (norma frontalis)

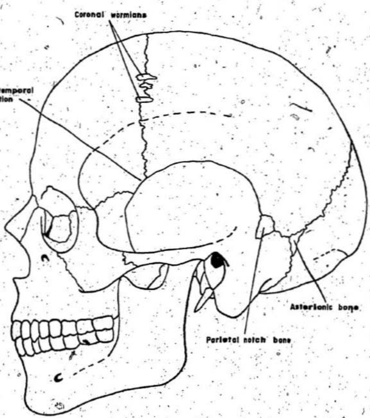


FIGURE 10 CRANIAL NON-METRIC TRAITS (norma lateralis)

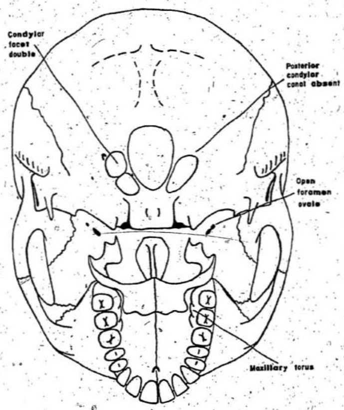


FIGURE 11 · CRANIAL NON-METRIC TRAITS (norma basalis)

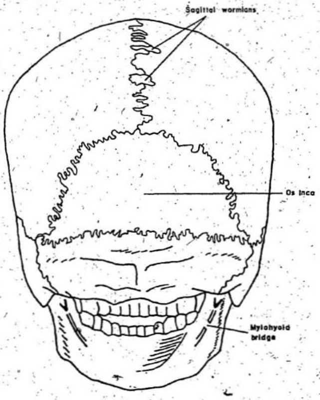


FIGURE 12 · CRANIAL NON-METRIC TRAITS (norma occipitalis)

g) patella: emarginate patella

h) talus: os trigonum, anterior facet double

i) calcaneus: anterior facet double

These traits are illustrated in Figures 13 and 14, and described in Appendix F.

Procedure for recording non-metric data

The presence or absence of metric traits was recorded using the University of Toronto IBM codification sheets. When a variant could not be observed due to damage to the region, no recording was made. In order to minimize error and reduce the subjectivity involved in scoring certain variants, the observations were rechecked. Once the data on the IBM sheets had been confirmed, they were transferred to computer cards.

Correlations between traits

The statistics used to analyze metric traits take into account the existence of inter-trait correlations. However, some of the statistics used to analyze non-metric trait variation do not take these factors into account and depend on the assumption that none of the traits utilized are statistically associated or correlated.

Many authors have assumed that associations between non-metric traits are virtually non-existant (Berry and Berry 1967; Benfer 1970; Spence 1971; A. C. Berry 1972; Lane and Sublett 1972). These authors have based their decision on evidence from studies of mice (Truslove 1961), and of men

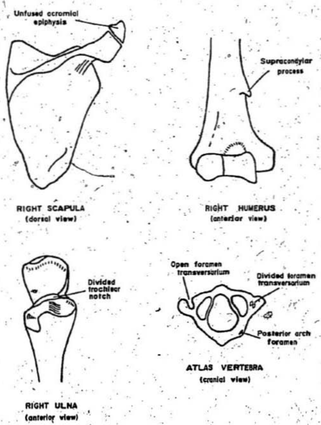


FIGURE 13 INFRACRANIAL NON-METRIC TRAITS
(scapula, humerus, ulna, and atlas vertebra)

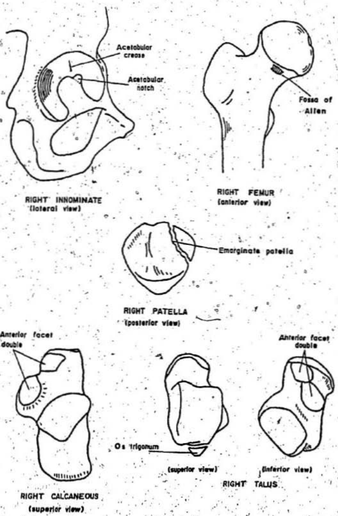


FIGURE 14 INFRACRANIAL NON-METRIC TRAITS (Innominate, femur, patella, calcaneus, and talus)

(Berry and Berry 1967; Kellock and Parsons 1970a; Corruccini 1974). Other workers have suggested that inter-trait correlations do exist. Hrdlička (1940), Woo (1950) and DeVilliers (1968) have suggested a correlation between the maxillary, palatine, and perhaps the mandibular tori. Similarly, Suzukai and Sakai (1960) have suggested a correlation between the latter two tori. DeVilliers (1968) has postulated a correlation between multiple infraorbital, mental, ethmoid and parietal foramina. Hertzog (1968) has suggested a 'neighbourhood pattern of association' for seven cranial traits of the parietal region (cf. Benfer 1970; Lane and Sublett 1972).

In general, however, studies of non-metric trait correlations have been inconclusive in their results, and as Corruccini (1974) has noted, the nature of such correlations often differs from group to group. In view of this fact, and in view of the limited amount of work which has been done in this area of research, the existence of correlations between the traits chosen for use in this study was disregarded.

Asymmetrical variation

The use of non-metric traits in the analysis of the Port au Choix sample also involved a consideration of the asymmetrical distribution sometimes evidenced by bilateral non-metric traits.

Several workers have sought to explain the existence of asymmetrical variation. Gruneberg (1963) has suggested that size may be a critical factor in determining the distribution of non-metric traits. He notes that

> If one side of the body is ahead of the other in development, asymmetrical manifestations may be the result (Gruneberg 1963:267).

Ossenberg (1970) offers the following comment:

> Probably the factor most consistently influencing side difference in the incidence of discrete traits is the slight retardation of ossification on the right side owing to richer innervation on that side, associated with cerebral hemisphere dominance and mediated, at least in part, by the blood supply (Ossenberg 1970:358).

Other workers have suggested that this asymmetry in body development may relate to environmental influences on trait expression, and indeed, it has been suggested that asymmetry in non-metric traits is proof of such environmental influences (Trinkauss 1978). R. J. Berry (1968) has suggested that the unilateral or bilateral expression of a trait is controlled by different genetic 'threshold levels'.

There are four possible ways of dealing with bilateral non-metric traits and the existence of asymmetrical distribution. The worker may choose: 1) to pool the sides, 2) to consider each side separately, 3) to use data from only one side, or 4) to consider a trait present if it is found on at least one side. Use of the second option is questionable, since there is the possibility that presence or absence of a trait on one side of the body may be highly correlated with its manifestation on the other, and most of the multivariate statistics utilized in studies of non-metric traits do not account for such correlations. Use of the third option is also questionable, since it would be very difficult to decide which side would present the most reliable data for biological comparisons. Method (4) is unacceptable, since it is conceivable (although unlikely) that if one had two samples of fifty individuals, one group could express a trait bilaterally in all instances, and the other unilaterally in all instances, and yet use of this method would show no difference in trait expression between the two groups. There remains one possibility - to use method (1), and to pool sides. Most workers using non-metric traits have tended to use this approach (Berry and Berry 1967; Ossenberg 1969, 1970; Knip 1970a, 1970b, 1971a, 1971b). Since it appears to be the least objectionable, it is also the approach utilized in this study. Thus, for bilateral traits, the expression of a trait on each side of the body was recorded and the total number of observations used as the sample size.

In view of the fact that pooling sides accords larger samples to bilateral traits than to unilateral traits, Lane and Sublett (1972) have suggested that the statistical analysis of bilateral traits should be performed separately from the analysis of unilateral traits. This seems to be a practical suggestion, since the difference in sample sizes may bias the results of the statistical analysis. However, as will be explained in the chapter on statistics, all the traits chosen for use in the multivariate analysis of non-metric trait expression are bilateral, and hence, no such separation was required in this study.

CHAPTER 4

STATISTICS

4.1 Introduction

The model designed for use in this study requires statistical techniques which assess the relative degree of biological variability expressed within and between the sexes. The choice of these techniques rests on their applicability to the samples and data at hand. In the following chapter, the specific tests used in this analysis are described, and the information they provide is presented.

4.2 Metric analysis

Univariate statistics

Measurements: The first step in analyzing the metric data collected from measurements of the Port au Choix sample was the construction of a set of descriptive statistics which might provide a measure of central tendency and dispersion for each trait within each of the sexes. Means ($\overline{x}$) and standard deviations (s) for each measurement were calculated using the Statistical Package for the Social Sciences (SPSS) program 'Condescriptive'. The results of this work are given in Tables 5 and 6.

The information on cranial and infracranial measurements presented in these tables indicates that, with one

TABLE 5

DESCRIPTIVE STATISTICS FOR CRANIAL MEASUREMENTS

Trait	Male (n=9)		Female (n=11)	
	$\bar{x}$ (mm)	s	$\bar{x}$ (mm)	s
Cranial length	187.0	5.3	178.1	4.2
Cranial breadth	142.1	5.6	139.1	3.4
Basion-bregma height	133.1	2.7	127.6	3.2
Minimum frontal breadth	95.4	4.1	91.5	4.4
Upper facial height	65.6	3.4	62.5	1.6
Bizygomatic breadth	142.9	4.5	132.5	5.2
Basion-nasion length	104.0	4.3	100.0	4.2
Basion-prosthion length	100.7	4.8	96.5	5.4
Orbital breadth	40.4	2.4	40.3	1.7
Orbital height	34.3	1.6	35.2	1.7
Nasal breadth	25.7	1.3	25.1	2.0
Nasal height	54.2	3.6	51.0	1.8
Maxillo-alveolar breadth	67.9	2.0	64.1	3.4
Maxillo-alveolar length	54.0	2.2	52.4	2.6

TABLE 6

DESCRIPTIVE STATISTICS FOR INFRACRANIAL MEASUREMENTS

Trait	Male (n=5)		Female (n=7)	
	$\bar{x}$ (mm)	s	$\bar{x}$ (mm)	s
Maximum length (humerus)	312.2	15.4	291.6	21.5
Maximum shaft diameter (humerus)	22.8	1.9	19.6	2.3
Minimum shaft diameter (humerus)	17.4	2.1	14.7	1.7
Maximum diameter of head (humerus)	44.8	1.3	39.4	2.1
Maximum length (radius)	242.8	12.4	220.1	16.0
Subtrochanteric transverse shaft diameter (femur)	32.0	4.5	29.7	3.6
Subtrochanteric anteroposterior shaft diameter (femur)	27.8	2.2	24.1	2.4
Maximum diameter of head (femur)	46.6	2.7	41.4	1.4
Anteroposterior nutrient foramen diameter (tibia)	23.4	1.9	20.4	1.7
Transverse nutrient foramen diameter (tibia)	35.0	1.4	29.4	2.3
Maximum length (talus)	51.4	1.9	47.6	3.4
Maximum breadth (talus)	43.6	1.3	39.1	1.9
Maximum height (talus)	32.4	1.1	28.9	1.3

exception, trait means for the male sample are higher than those for the female sample. The one exception is the measurement of orbital height, in which case the mean value for females is slightly higher than that for males. This information is consistent with the existence of an established sexual dimorphism within the human species, such that males tend to be larger and more muscular than females.

The existence of differences in mean values for the two sexes has implications for the study of relative variability within and between these groups for it has been suggested that variation may sometimes be a 'function of the mean'. In other words, traits with larger mean values may display larger standard deviations than traits with smaller mean values. Thus, in assessing the variability of trait expression within two or more groups which display differences in their means, it is wise to consider the size of the standard deviation relative to that of the mean, and not the absolute size of the standard deviation.

One statistic used to measure 'relative variability' is the coefficient of variation (Pearson and Davin 1924). The coefficient of variation (V) for a trait A is defined as

$$V_A = \frac{s_A}{\overline{x}_A} \times 100$$

where s_A is the standard deviation of trait A, and $\overline{x}_A$ is the mean of trait A. This statistic permits the comparison of trait variability by eliminating differences which exist in linear means (Blalock 1972). The validity of using this statistic with metric trait data has been confirmed by Pearson and Davin (1924), but its applicability to data from indices has yet to be proven (DeVilliers 1968). For this reason, the standard deviation must be retained as a measure of relative variability for cranial and infracranial indices.

Coefficients of variation were calculated for each of the measurements used in the analysis of the Port au Choix material. The results are presented in Tables 7 and 8. This information indicates that the coefficients of variation for cranial traits show higher values for males in five out of fourteen (35.7%) cases: cranial length, cranial breadth, upper facial height, orbital breadth, and nasal height. The coefficients of variation are higher for females in the remaining nine out of fourteen (64.3%) cases. These are: basion-bregma height, minimum frontal breadth, bizygomatic breadth, basion-nasion length, basion-prosthion length, orbital height, nasal breadth, alveolar breadth, and alveolar length. It should be noted that four of the five traits for which males show greater variability display coefficients of variation at least one unit higher than those for females. Only two of the nine traits for which females show greater variability display a difference of at least one unit.

The coefficients of variation for infracranial measurements are higher for males in three out of thirteen (23.1%) cases: minimum shaft diameter (humerus), subtrochanteric transverse shaft diameter (femur), and maximum diameter

TABLE 7

COEFFICIENTS OF VARIATION FOR CRANIAL MEASUREMENTS

Trait	Male (n=9)	Female (n=11)
Cranial length	2.8	2.4
Cranial breadth	3.9	2.4
Basion-bregma height	2.0	2.5
Minimum frontal breadth	4.3	4.8
Upper facial height	5.2	2.6
Bizygomatic breadth	3.1	3.9
Basion-nasion length	4.1	4.2
Basion-prosthion length	4.8	5.6
Orbital breadth	5.9	4.2
Orbital height	4,7	4.8
Nasal breadth	5.1	8.0
Nasal height	6.6	3.5
Maxillo-alveolar breadth	2.9	5.3
Maxillo-alveolar length	4.1	5.0

TABLE 8

COEFFICIENTS OF VARIATION FOR INFRACRANIAL MEASUREMENTS

Trait	Male (n=5)	Female (n=7)
Maximum length (humerus)	4.9	7.4
Maximum shaft diameter (humerus)	8.3	11.7
Minimum shaft diameter (humerus)	12.1	11.6
Maximum diameter of head (humerus)	2.9	5.3
Maximum length (radius)	5.1	7.3
Subtrochanteric transverse shaft diameter (femur)	14.1	12.1
Subtrochanteric anteroposterior shaft diameter (femur)	7.9	10.0
Maximum diameter of head (femur)	5.8	3.4
Anteroposterior nutrient foramen diameter (tibia)	8.1	8.3
Transverse nutrient foramen diameter (tibia)	4.0	7.8
Maximum length (talus)	3.7	7.1
Maximum breadth (talus)	3.0	4.9
Maximum height	3.4	4.5

of the femoral head. In two of these cases, the difference is greater than unity. Females display higher coefficients of variation for the remaining ten out of thirteen (76.9%) cases. These are: maximum length (humerus), maximum shaft diameter (humerus), maximum diameter of humeral head, maximum length (radius), subtrochanteric anteroposterior diameter (femur), anteroposterior nutrient foramen diameter (tibia), transverse nutrient foramen diameter (tibia), maximum length (talus), maximum breadth (talus), and height (talus). In nine of these cases, the difference is greater than unity.

In summary, females display higher coefficients of variation for nine out of fourteen (64.3%) cranial measurements and ten out of thirteen (76.9%) infracranial measurements - a total of nineteen out of twenty-seven (70.4%) measurements. Of these nineteen traits, eleven show a female difference greater than unity, while the remaining eight show a difference less than unity. This information suggests that the female sample is more variable than the male sample.

This situation is in contrast to what appears to be a general human tendency toward greater male variability (DeVilliers 1968; Wilkinson 1971; Spence 1974). Wilkinson (1971) has noted that the underlying cause of this difference has not been determined, although "a relationship to sex-linkage is a possibility" (Wilkinson 1971:32). He goes on to suggest that

> The slightly lower variability in females as compared to males might be due to the observed differences in the time and intensity of the adolescent growth spurt. Females begin their adolescent spurt earlier than in

> males, and it is less intense (Tanner, 1964:322). If we equate higher variability with a more intense growth spurt, as seems to be the case with most.... variables...., then the male-female differences in this growth spurt might account for the differences in variability (Wilkinson 1971:33).

If males do display a general tendency toward greater biological variability, then the display of even slightly greater female variability within the Port au Choix sample may be considered significant.

The differences in male and female coefficients of variation for metric traits are graphically illustrated in Figures 15 and 16, following the model used by Wilkinson (1971). The graph based on cranial metrics indicates a slight increase in variability as one moves from measurements of the skull vault to those of the face. This corresponds with findings by DeVilliers (1968) and Wilkinson (1971). Wilkinson suggests that this increase in variability "parallels the intensity of the adolescent growth spurt in these same regions" (Wilkinson 1971:32). He cites Tanner (1964) who has suggested that the strength of the adolescent growth spurt of the facial region lies midway between that of the cranial vault (where variability is low) and that of the infracranial skeleton (where variability is high). Goldstein (1936) notes a similar pattern.

Alternate explanations have also been offered. Pearson and Davin (1924) have suggested that coefficients of variation "will be lower among variables which encompass more than one anatomical unit — such as cranial length — than among single unit variables" (Wilkinson 1971:31). Hiernaux (1968) has suggested that coefficients of variation will be higher among

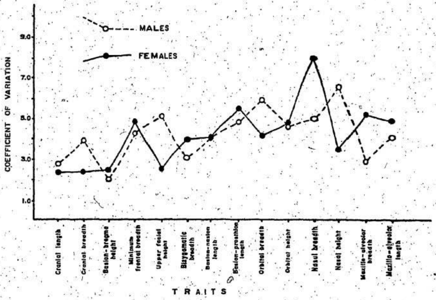


FIGURE 15 · COEFFICIENTS OF VARIATION – CRANIAL METRICS

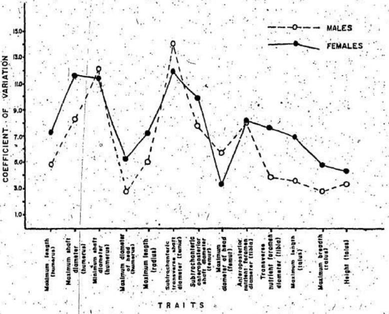


FIGURE 16 · COEFFICIENTS OF VARIATION – INFRACRANIAL METRICS variables which are more influenced by environmental factors. None of these other explanations, however, seems to fit the available information as well as the adolescent growth spurt explanation.

The graph based on coefficients of variation for cranial traits shows divergent courses for the male and female samples. This is in contrast to the graph based on cranial traits offered by Wilkinson (1971) which shows parallel courses for males and females. The Port au Choix samples diverge at the following points: cranial breadth, basion-nasion length, orbital height, nasal breadth, nasal height, and maxillo-alveolar breadth. These graphic divergences tend to support the idea that the males and females do not form a homogeneous group.

The graph based on infracranial metrics shows a parallel course for males and females, peaking with measurements of the diameters of the shaft of the humerus, femur and tibia. It is of note that the coefficients of variation for infracranial measurements are generally of a higher order than those for cranial measurements, as suggested by Goldstein (1936) and Tanner (1962, 1969).

Pearson and Davin (1924) have classified the size of the coefficient of variation into a series of grades. They have proposed that a value greater than 6.0 indicates high variability, a value of 4.5 to 6.0 indicates moderate variability, a value of 3.5 to 4.5 indicates moderately low variability, and a value less than 3.5 indicates low variability (cf. Simpson, Roe and Lewontin 1960; DeVilliers 1968). Within the male sample from Port au Choix only one cranial trait shows high variability (that is, has a coefficient of variation greater than 6.0) - nasal height. Similarly, only one cranial trait shows high variability within the female sample - nasal breadth. There are, however, five infracranial traits which show high variability within the male sample - maximum shaft diameter (humerus), minimum shaft diameter (humerus), subtrochanteric transverse shaft diameter (femur), subtrochanteric anteroposterior shaft diameter (femur), and anteroposterior nutrient foramen diameter (tibia) - and there are nine infracranial traits which show high variability within the female sample - maximum length (humerus), maximum shaft diameter (humerus), minimum shaft diameter (humerus), maximum length (radius), subtrochanteric transverse shaft diameter (femur), subtrochanteric anteroposterior shaft diameter (femur), anteroposterior nutrient foramen diameter (tibia), transverse nutrient foramen diameter (tibia), and maximum length (talus).

Certain workers have calculated a mean coefficient of variation for male and female samples based on the coefficients of variation for each trait used in the analysis (DeVilliers 1968; Spence 1974). The aim of such a calculation seems to be to find some measure of overall variability within each sample, so that a general comparison can be made on the basis of a number of traits. However, the statistical validity of averaging coefficients of variation from a series of often diverse and uncorrelated measurements must be questioned. For this reason, no such averaging procedure was applied to the Port au Choix data. Multivariate techniques are employed later in the analysis to assess overall group variability in terms of the battery of traits used above.

Indices: The first step in analyzing the data from indices calculated for the Port au Choix male and female samples was again the construction of a set of descriptive statistics. Means and standard deviations were calculated using the SPSS program 'Condescriptive'. The results are summarized in Tables 9 and 10.

The information given in these tables indicates a number of between-sex differences in the mean values of cranial and infracranial indices. However, these differences do not display the consistency which was characteristic of the measurement means discussed earlier.

The standard deviation is employed as a measure of relative variability in the analysis of indices, since it has been pointed out that calculation of the coefficient of variation has not been proven applicable to this type of data. Within the Port au Choix sample, males display higher standard deviations for seven out of twelve (58.3%) cranial indices. These are: cranial index, length-height index, breadth-height index, mean height index, frontoparietal index, upper facial index, and orbital index. Female values are higher for the remaining five out of twelve (41.7%) cases: cranio-facial index, frontozygomatic index, gnathic index,

TABLE 9

DESCRIPTIVE STATISTICS FOR CRANIAL INDICES

Index	Male (n=9)		Female (n=11)	
	$\bar{x}$ (mm)	s	$\bar{x}$ (mm)	s
Cranial index	76.0	3.3	78.1	2.4
Length-height index	71.2	2.7	71.7	2.0
Breadth-height index	93.8	3.8	91.8	3.4
Mean height index	51.6	1.7	51.6	1.4
Frontoparietal index	67.3	4.0	65.8	2.7
Upper facial index	45.9	2.2	47.3	2.1
Cranio-facial index	100.6	3.5	95.3	4.2
Frontozygomatic index	66.8	3.5	69.1	4.1
Gnathic index	96.8	2.7	96.5	3.2
Orbital index	85.1	5.4	87.5	5.0
Nasal index	47.5	3.1	49.2	3.7
Maxillo-alveolar index	125.8	4.3	122.6	7.1

TABLE 10

DESCRIPTIVE STATISTICS FOR INFRACRANIAL INDICES

Index	Male (n=5)		Female (n=7)	
	$\bar{x}$ (mm)	s	$\bar{x}$ (mm)	s
Radio-humeral index	77.8	1.2	75.5	1.9
Mid-shaft index (humerus)	76.3	6.0	75.5	6.2
Platymeric index (femur)	88.7	17.3	83.2	19.3
Platycnemic index (tibia)	66.9	5.9	69.7	6.6
Index of talar breadth	84.9	2.8	82.5	5.2
Index of talar height	63.0	0.9	60.8	2.1

nasal index, and maxillo-alveolar index.

The standard deviations for infracranial indices are higher for females in all six (100%) cases: radio-humeral index, mid-shaft index (humerus), platymeric index (femur), platycnemic index (tibia), index of talar breadth, and index of talar height.

To summarize, males show greater variability for seven out of eighteen (38.9%) indices. In only one of these cases does the difference between the male and female standard deviations exceed unity (frontoparietal index). Females show greater variability for the remaining eleven out of eighteen (61.1%) indices. In four of these cases the difference between the male and female standard deviations exceeds unity (maxillo-alveolar index, platymeric index, index of talar breadth, and index of talar height).

It is interesting to note that while the results of the analysis of infracranial indices are the same as those based on infracranial measurements, the results of the analysis of cranial indices are not the same as those based on cranial measurements. This may reflect the fact that all of the cranial indices for which males show greater variability incorporate four dimensions of the cranial vault for which male variability is greater than female variability. Thus, the greater variability evidenced by males for seven out of twelve cranial indices may reflect the fact that the same traits are used in a number of indices. It is notable, for example, that two of the measurements of the vault for which males show a higher coefficient of variation, namely, cranial length and breadth, are incorporated in five different indices, all of which show greater variability for males. Of the eleven out of eighteen indices for which females show greater variability there are only two examples of the same trait being used in more than one index. All seven other indices incorporate different traits. However, all of the indices for which females show greater values incorporate traits for which females show greater variability. In other words, index variation seems to reflect the variation present in the measurements on which the indices are based, as suggested by DeVilliers (1968).

The distribution of cranial and infracranial indices is graphically illustrated in Figures 17 and 18. The patterns of the male and female curves parallel each other in both cases. The graph of cranial indices more clearly illustrates the fact that male variation is greater for indices of the cranial vault, whereas female variation is greater for indices of the face, with the upper facial index acting as a kind of turning point. The gradual increase in variation as one proceeds from indices of the vault to those of the face is also evident. The graph of infracranial indices makes it very clear that female variation is consistently greater than male variation. It also illustrates the higher variability associated with indices based on long bone shaft metrics. The peak shown by the platymeric index denotes great variation at this locus.

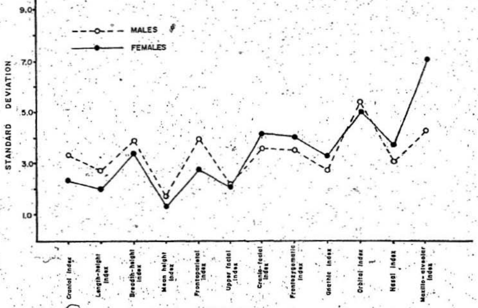


FIGURE 17 · STANDARD DEVIATIONS – CRANIAL INDICES

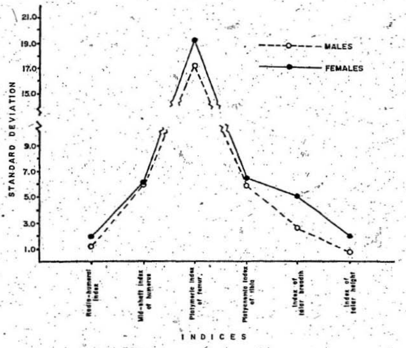


FIGURE 18 · STANDARD DEVIATIONS — INFRACRANIAL INDICES

To summarize, the results of the univariate analysis of cranial and infracranial measurements and infracranial indices suggest the presence of slightly greater variability of trait expression within the female sample, while the results of the analysis of cranial indices suggest the presence of slightly greater variability of trait expression within the male sample. The results of the latter analysis, however, must be viewed with some caution, since this analysis may have been biased by the use of a number of indices based on the same series of measurements.

Multivariate statistics

Measurements: The second part of the analysis of the Port au Choix metric data involved a multivariate approach to the assessment of group variability. A discriminant analysis was performed using the Biomedical Data Processing (BMDP) program entitled BMDP7M. This program is designed to detect outliers in a given population.

Use of this program depends on the assumption that the data possess a multivariate normal distribution. However, Cooley and Lohnes (1971) point out that they do not know of any test for multivariate normality.

> [Cooley and Lohnes] rely on the multivariate Central Limit Theorem which insures that a linear component of a vector variable will have an enhanced approximation to normality over that of the variable vector itself. Thus the degree to which the Central Limit Theorem holds determines how well the basic assumption is fulfilled (Zegura 1971:50).

For the purpose of this study, multivariate normality is assumed (Cooley and Lohnes 1971; Zegura 1971).

The BMDP7M program computes linear classification functions based on the variables used in the analysis. The discriminant function is designed to classify each case according to these classification functions. At each step the variable that adds most to the separation of the two groups is added to the discriminant function, all linear correlations being removed from the analysis. Each case is classified into a group and the percentage of 'correct classifications' is printed. The program examines each individual case in terms of its group mean using the Mahalanobis D^2 statistic, and prints the posterior probability of the individual belonging to that group. This posterior probability is defined as "the ratio of $\exp(D^2)$ for the group over the sum of $\exp(D^2)$ for all groups" (Jenrich and Sampson 1977:718). Outliers may be identified as cases with large D^2 from their group mean (or with a low posterior probability of belonging to their group). The presence of outliers in a given group may be seen as a measure of the relative variability of group composition.

A graphic representation of the results is produced as part of the program output.

> Group means and all cases are printed in a scatter diagram. The axes are the first two "canonical variables". The first canonical variable is the linear combination of variables entered that best discriminates among the groups..., the second canonical variable is the next best linear combination orthogonal to the first one, etc. (Jenrich and Sampson 1977:718).

If there is only one canonical variable a histogram is plotted. Wilkinson (1971) notes that the canonical vectors reduce an N-dimensional space (where N = number of variables) to a 2-dimensional space, and thus such graphs may not be totally accurate. However, they do offer a good approximation.

These graphs may be used to identify outliers, and to assess the relative variability of the sexes. One method of identifying these outliers is to define a 95% confidence interval around the mean for each sex. This may be done by constructing a circle of radius 1.96 (on the scale of the BMDP7M scattergram) around the respective means (this radius corresponds to almost two standard deviations). Once the given interval is plotted on the scatter diagram, the number of outliers may be counted.

It is also possible to assess the dispersion of individuals within the 95% confidence interval. A circle may be drawn with a radius corresponding to one standard deviation (64% confidence interval), that is, 1.0 units, and the number of individuals falling within the circle may be counted and compared to the number of individuals falling within the larger circle of radius 1.96. The distribution of individuals from the two groups may be compared and the group showing a greater precentage of individuals in the 1.0 unit circle may be considered more homogeneous in group composition.

Data from cranial and infracranial measurements were input (separately) into the BMDP7M program. The results are most clearly illustrated by the scatter diagrams produced.

These diagrams are displayed in Figures 19 and 20 with the circles describing one and approximately two standard deviations added.

The diagram based on the input of cranial metric traits (Figure 19) illustrates the presence of only one canonical variable. This variable is based on three traits: basion-bregma height, bizygomatic breadth and orbital height. All individuals are included within the circle describing a 95% confidence interval around each group mean. Thus there are no male or female outliers present. This suggests that the degree of group variability is not exceptionally great. The dispersion of individual cases around the respective group means indicates slightly greater male variability in cranial metric trait expression. There are five out of nine (55.6%) males within the circle describing one standard deviation, while there are eight out of eleven (72.7%) females within such a circle. These results are in contrast to those produced using univariate statistical methods, which showed slightly greater female variability of cranial trait expression. The difference in the results of these two levels of analysis may reflect the fact that the univariate results recognize all cases in which females show greater variability, no matter how slight this difference may be. In the discussion of the coefficients of variation for cranial traits, it was noted that in only two of the nine cases for which females showed greater variability was the difference greater than unity, while in four out of five cases, for which males showed

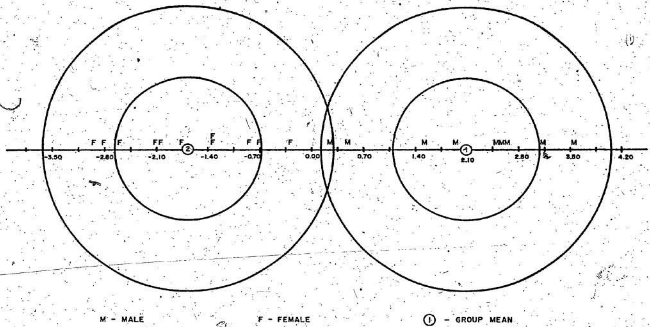
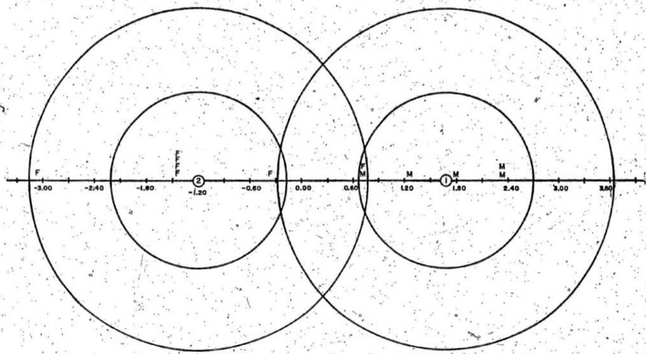


FIGURE 19: SCATTER DIAGRAM — CRANIAL METRIC TRAITS



M - MALE F - FEMALE (1) - GROUP MEAN

FIGURE 20 · SCATTER DIAGRAM - INFRACRANIAL METRIC TRAITS greater variability, the difference was greater than unity. It would seem that the BMDP7M reflects only the more marked differences in variability, and thus its results are not the same as those produced by the univariate technique.

The diagram illustrating the results of the multivariate analysis of infracranial metric traits produces results more in accord with those produced by the univariate analysis. The diagram is based on one canonical variable which, in turn, is based on one trait: maximum diameter of the humeral head. All males and females fall within a 95% confidence interval around their group means. Thus, there are no outliers present. However, the dispersion of individual cases around their respective group means indicates greater variability of trait expression among females. All five (100%) males fall within one standard deviation of the mean, while five out of seven (71.4%) females fall within this interval. The similarity between these results and those of the univariate analysis may be attributed to the fact that the univariate analysis of infracranial metrics indicated a more significant amount of female variability. In nine of the ten cases in which female coefficients of variation were greater than those of the males, the difference was greater than unity. The BMDP7M program seems to reflect the higher order of these differences as compared to those exhibited by cranial traits.

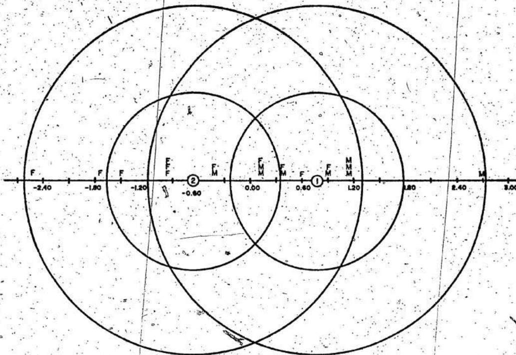
The fact that all cases included in the cranial and infracranial analyses lie within a 95% confidence interval and that, with one exception, the number of individuals found within one standard deviation of their means is greater than 68%, indicates that there is no marked variability present in the sample.

Indices: The usefulness of inputting data from indices into this sort of discriminant analysis program has been questioned by Wilkinson (1971). He suggests that

> The use of indices as estimates of shape distance is not warranted with this technique since the correlation and ratios between varaibles are considered by the computer program, and the variables themselves are not treated independently (Wilkinson 1971:26).

This author would argue, however, that while it is true that the program does consider the general subject of correlations and relationships, this is a different matter than inputting information on specific relationships and asking how these specific relationships differ between group. In analyzing this data the computer will consider, as it were, the existence of correlations between relationships. In view of this difference, this author felt it would be useful to input data from cranial and infracranial indices into the discriminant analysis program. Figures 21 and 22 display the results of these tests on scatter diagrams.

The scatter diagram of the analysis of cranial indices (Figure 21) is based on one canonical variable using one trait: the cranio-facial index. It does not indicate the presence of any male or female outliers. The dispersion of individual cases around the group means indicates slightly greater female variability of trait expression. There are



M - MALE F - FEMALE (1) - GROUP MEAN

FIGURE 21 · SCATTER DIAGRAM - CRANIAL INDICES

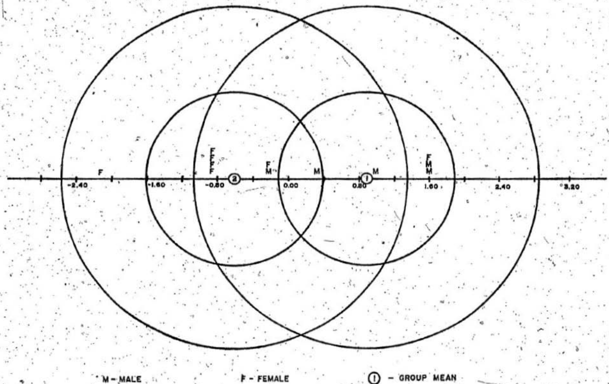


FIGURE 22 · SCATTER DIAGRAM - INFRACRANIAL INDICES seven out of nine (77.8%) males within one standard deviation of the male mean, and six out of eleven (54.5%) females within one standard deviation of the female mean. These results are in contrast with those produced by univariate methods, which suggested slightly greater male variability. This difference may, once again, reflect the magnitude of the differences in variation shown by individual traits, or it may reflect another factor which was discussed in the section on univariate statistics, namely, that a number of the indices used in this study are based on the same traits, and hence, are correlated. As noted earlier, the BMDP7M eliminates such correlations from the analysis and produces a pattern of results, free from any such bias.

The scatter diagram based on infracranial indices (Figure 22) indicates the presence of a single female outlier, suggesting a higher degree of variability than was evident in any previous BMDP7M analysis of the Port au Choix material. The outlier is identified as individual 49A. There is again only one canonical variable which is based on one trait: the radio-humeral index. The dispersion of individuals around their respective group means supports the idea of greater variability within the female sample. There are four out of five (80%) males within one standard deviation of the group mean, as compared to five out of seven (71.4%) females within one standard deviation of their group mean. The results of this multivariate analysis of data from infracranial indices correspond with those of the univariate analysis of this data.

To summarize, the results of the multivariate analyses of infracranial measurements and cranial and infracranial indices support the notion of slightly greater variability of trait expression within the female sample. However, the results do not indicate a marked degree of variability within the female sample, since only one outlier was detected. This is not surprising given that the differences between the male and female samples would not likely be of great magnitude even in situations of band exogamy. The small size of the Port au Choix samples would doubtless make the detection of outliers an even more difficult task.

4.3 Non-metric analysis

Univariate statistics

The non-metric traits used in this study vary in their expression only in so far as being present or absent for any given individual. The statistical procedures chosen for use in the analysis of these data are geared to the comparison of trait incidences within the sexes, and to testing whether or not significant differences exist between these groups. In summary, the techniques used are designed to provide some measure of between-group, rather than within-group, variability of trait expression.

The first step in the analysis of the non-metric data collected from the Port au Choix sample was the construction of a set of statistics which would describe the expression of non-metric traits within the sexes. The incidence of each trait was recorded and converted to a percentage in order to facilitate comparisons. This information is present in Tables 11 and 12.

An examination of the data presented in these tables indicates that four out of eighteen traits are expressed more frequently in the male sample. These traits are as follows: multiple infraorbital foramen present, vasalian foramen present, asterionic bone present, and post-condylar canal absent. Six out of eighteen traits are expressed more frequently in the female sample. These are: supraorbital foramen present, zygomatico-facial foramen present, Os Inca present, and parietal notch bone present. The remaining eight (44.4%) cranial traits are not present in either group. These are: open foramen ovale, coronal wormians present, sagittal wormians present, bregmatic bone present, fronto-temporal articulation, os japonicum present, maxillary torus present, and condylar facet double.

In terms of infracranial traits, males exhibit higher frequencies for two out of fifteen (13.3%) traits: acetabular notch present and fossa of Allen present. Females exhibit higher frequencies in ten out of fifteen (66.7%) cases: unfused acromial epiphysis, trochlear notch form, acetabular crease present, os trigonum present, bipartite anterior facet (talus), bipartite anterior facet (calcaneus), emarginate patella, open foramen transversarium (atlas), divided foramen transversarium (atlas), and open foramen transversarium (axis). The presence

TABLE 11

DESCRIPTIVE STATISTICS FOR CRANIAL NON-METRIC TRAITS

TRAIT	MALE Number	MALE Percentage incidence	FEMALE Number	FEMALE Percentage incidence
Supraorbital foramen complete	4/25	16.0	15/27	55.6
Multiple infraorbital foramen	2/24	8.3	1/23	4.3
Zygomatico-facial foramen	17/26	65.4	20/26	76.9
Open foramen ovale	0/18	0.0	0/19	0.0
Post-condylar canal absent	1/21	4.8	1/24	4.2
Vesalian foramen	10/15	66.7	10/20	50.0
Multiple mental foramen	2/34	5.9	3/28	10.7
Coronal wormians	0/6	0.0	0/12	0.0
Sagittal wormians	0/8	0.0	0/11	0.0
Bregmatic bone	0/8	0.0	0/13	0.0
Os Inca	0/13	0.0	1/15	6.7
Asterionic bone	2/19	10.5	1/26	3.8
Parietal notch bone	1/22	4.5	2/27	7.4
Fronto-temporal articulation	0/16	0.0	0/16	0.0
Os japonicum	0/25	0.0	0/26	0.0
Maxillary torus	0/30	0.0	0/27	0.0
Condylar facet double	0/28	0.0	0/25	0.0
Mylohyoid bridge	4/29	13.8	9/30	30.0

TABLE 12

DESCRIPTIVE STATISTICS FOR INFRACRANIAL NON-METRIC TRAITS

TRAIT	MALE Number	MALE Percentage incidence	FEMALE Number	FEMALE Percentage incidence
Unfused acromial epiphysis	2/18	11.1	3/23	13.0
Supracondylar process	0/24	0.0	0/27	0.0
Trochlear notch form	6/28	21.4	10/25	40.0
Acetabular notch	17/22	77.3	13/19	68.4
Acetabular crease	1/23	4.3	3/18	16.7
Os trigonum	6/30	20.0	6/21	28.6
Bipartite anterior facet (talus)	4/30	13.3	8/22	36.4
Bipartite anterior facet (calcaneus)	5/30	16.7	10/24	41.7
Emarginate patella	1/28	3.6	1/22	4.5
Fossa of Allen	13/18	72.2	2/15	13.3
Open foramen transversarium (atlas)	0/22	0.0	1/23	4.3
Divided foramen transversarium (atlas)	0/24	0.0	1/24	4.2
Posterior arch foramen (atlas)	0/25	0.0	0/26	0.0
Open foramen transversarium (axis)	3/26	11.5	5/22	22.7
Divided foramen transversarium (axis)	0/27	0.0	0/24	0.0

of three (20%) traits - supracondylar process present, posterior arch foramen present (atlas) and divided foramen transversarium (axis) - is not recorded for either sex.

This analysis is designed to test the homogeneity of trait expression between the two sexes. The main question is whether there are significant differences between the groups which would suggest that they do not belong to the same population. The most common method of testing the significance of differences in trait expression when dealing with 'nominal data' is to use the chi-square (X^2) test of homogeneity, an extension of the chi-square test of independence. However, whereas the chi-square test of independence is used to test whether the expression of a particular <u>trait</u> is independent of the expression of another trait within a single population, the test of homogeneity is concerned with whether one <u>sample</u> is significantly different from another independent sample with regards to the expression of a particular trait (Chou 1969). The chi-square test compares observed and expected frequencies using the following formula:

$$X^2 = \sum_{i=1}^{k} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})}{E_{ij}}$$

where O_{ij} = the observed frequency of the trait in the ij^{th} cell

E_{ij} = the expected frequency of the trait in the ij^{th} cell

k = the number of cells

The criteria for use of the chi-square statistic are related to the expected frequencies in each cell. These criteria are as follows: 1) no expected frequency may be less than 1, and 2) expected frequencies in each cell should be greater than or equal to 5, since the results of chi-square tests are inaccurate when cell frequencies are less than 5. However, there are methods of improving the accuracy of the chi-square test in the latter case. If the sample size is greater than or equal to 20, a Yates continuity correction may be incorporated into the calculations; if the sample size is less than 20, a Fisher's Exact test may be used. These corrections were applied whenever necessary in the analysis of the Port au Choix data.

The results of the chi-square analysis of the Port au Choix data are given in Tables 13 and 14, accompanied by the results of another test of independence which will be discussed later. The results show only one significant difference in cranial trait expression at the 5% level - presence of a supraorbital foramen. There are two significant differences in infracranial trait expression at the 5% level - presence of a bipartite medial facet (calcaneus) and presence of a fossa of Allen.

Souza and Houghton (1977) have proposed another method of testing the significance of differences in trait expression. They suggest a test, referred to here as Souza and Houghton's measure of divergence (md), which makes use of the following formula:

$$md = \frac{(\theta_{1i} - \theta_{2i})^2}{V_i}$$

where θ_{1i} = the incidence of trait i in population 1,

TABLE 13

TESTS OF INDEPENDENCE FOR CRANIAL NON-METRIC TRAITS

Trait	X^2	md
Supraorbital foramen complete	8.6*	8.754*
Multiple infraorbital foramen	0.0	-
Zygomatico-facial foramen	0.8	0.778
Open foramen ovale	-	-
Post-condylar canal absent	-	-
Vesalian foramen	0.9	0.869
Multiple mental foramen	0.1	0.441
Coronal wormians	-	-
Sagittal wormians	-	-
Bregmatic bone	-	-
Os Inca	-	-
Asterionic bone	0.1	-
Parietal notch bone	0.0	-
Fronto-temporal articulation	-	-
Os japonicum	-	-
Maxillary torus	-	-
Condylar facet double	-	-
Mylohyoid bridge	2.3	2.112

* Significant at 5% level

TABLE 14

TESTS OF INDEPENCENCE FOR INFRACRANIAL NON-METRIC TRAITS

Trait	X^2	md
Unfused acromial epiphysis	0.1	0.018
Supracondylar process	-	-
Trochlear notch form	2.2	2.022
Acetabular notch	0.4	0.197
Acetabular crease	0.6	-
Os trigonum	0.5	0.485
Bipartite anterior facet (talus)	3.7	3.51
Bipartite anterior facet (calcaneus)	4.1*	3.91*
Emarginate patella	-	-
Fossa of Allen	11.4*	11.723*
Open foramen transversarium (atlas)	-	-
Divided foramen transversarium (atlas)	-	-
Posterior arch foramen (atlas)	-	-
Open foramen transversarium (axis)	0.4	0.976
Divided foramen transversarium (axis)	-	-

* Significant at 5% level

θ_{2i} = the incidence of trait i in population 2

V_i = the variance of trait i ($V_i = 1/n_{1i} - 1/n_{2i}$, where n_{1i} and n_{2i} are the sizes of the samples)

This statistic is distributed as X^2 when there is no real difference in the incidence of trait i within the groups being compared. It is significant at the 0.05 level if it exceeds 3.8, or if the measure of divergence calculated on trait i is greater than $2.8(V_i)$. This statistic provides an interesting option to using the chi-square statistic and was calculated for the Port au Choix data so that a comparison of the results of the two procedures might be made. The results of this analysis are given in Tables 13 and 14. They indicate the presence of one significant difference in cranial trait expression at the 5% level (presence of a supraorbital foramen), and of two significant differences in infracranial trait expression at the 5% level (presence of a bipartite anterior facet of the calcaneus and presence of a fossa of Allen). These are precisely the same differences detected in the chi-square analysis.

In summary, the results of the univariate analysis of the Port au Choix non-metric data indicate one significant difference in cranial trait expression and two significant differences in infracranial trait expression at the 5% level. However, the overall significance of these differences is unknown, for while univariate statistics may indicate whether two samples are significantly different in terms of the expression of a single non-metric trait, they cannot indicate whether two samples are significantly different in terms of a battery of traits. In such instances, multivariate techniques must be employed.

Multivariate statistics

A number of different multivariate tests have been utilized in population comparisons based on non-metric trait expression (Weiner and Huizinga 1972). Finnegan and Cooprider (1978) have studied the results of research using different multivariate tests, in an attempt to determine the relative usefulness of the various techniques. They conclude that there is a high degree of similarity in the results produced by the various tests, and suggest that any equation may be used if one has large samples to work with.

This requirement is often difficult to meet if one is dealing with archaeological remains. It is extremely rare to find a single prehistoric site (with some control over time and other variables) which would provide a large sample of adult male and female remains in a relatively good state of preservation. This would be virtually impossible if the group being studied lived in relatively small bands. The Port au Choix sample includes only twenty-two males and eighteen females, and thus, is not considered adequate for use with many multivariate tests. It is possible, however, to modify one such statistic, Smith's Mean Measure of Divergence (MMD), for use with small samples (Souza and Houghton 1977).

The necessary modification to the MMD, as suggested by

Green and Suchey (1976), is the use of the Freeman-Tukey (1950) inverse sine transformation. Souza and Houghton (1977) have pointed out that use of the Grewal-Smith angular transformation (Grewal 1962) is valid only if one is dealing with a sample of at least 100 individuals, and the probability (p) of a trait occurring lies between 0.05 and 0.95, or if one has a sample of at least 40 individuals and the probability of a trait occurring is between 0.25 and 0.75. With samples less than 40, the approximations are not good. The Freeman-Tukey transformation, however, is valid for sample sizes even as small as 10, when p is in the range [0.05, 0.95] for all traits.

In order to meet the requirements of the Freeman-Tukey transformation, the Port au Choix data was scrutinized and traits with sample sizes of less than 10, or frequencies less than or equal to 5% or greater than or equal to 95% were omitted from the analysis. For these reasons, the following cranial traits were excluded: multiple infraorbital foramen present, open foramen ovale, posterior condylar canal present, coronal wormians present, sagittal wormians present, bregmatic bone present, Os Inca present, asterionic bone present, parietal notch bone present, frontotemporal articulation, os japonicum present, maxillary torus present, and double condylar facet. The following infracranial traits were also excluded from the multivariate analysis: supracondylar process present, acetabular crease present, emarginate patella, open foramen transversarium (atlas), divided foramen transversarium (atlas), posterior arch foramen present (atlas), and divided foramen transversarium (axis). Five cranial traits and eight infracranial traits remained for use in the analysis. These are listed in Table 15.

The formula for the Mean Measure of Divergence is as follows (Molto n.d.):

$$MMD = \sum_{i=1}^{N} \frac{(O_1^i - O_2^i)^2 - (1/(n_1^i + .05) + 1/(n_2^i + .05))}{N}$$

where $O = \frac{1}{2}\sin^{-1}(1 - (2k/n-1)) + \frac{1}{2}\sin^{-1}(1 - (2(k+1)/n+1))$
(the Freeman-Tukey inverse sine transformation)

k/n = the observed incidence of the trait

O_1^i = transformed incidence of the i^{th} trait in the first group

O_2^i = transformed incidence of the i^{th} trait in the second group

n_1^i = number of observations in the first group examined for trait i

n_2^i = number of observations in the second group examined for trait i

N = number of traits

Sjøvold (1973) has proposed a formula for calculating the variance (s^2) of the MMD with .05 inserted for use with the Freeman-Tukey transformation. This formula is as follows:

$$s^2 = \frac{2}{N^2} \sum_{i=1}^{N} (1/(n_1^i + .05) + 1/(n_2^i + .05))^2$$

The MMD can vary from 0.00, indicating no difference between the samples, to 3.14^2 (that is, 9.86), indicating the maximum possible difference. Sjøvold (1973) has suggested that if the

TABLE 15

NON-METRIC TRAITS USED IN ANALYSIS OF MEAN MEASURE OF DIVERGENCE

CRANIAL
Supraorbital foramen complete
Zygomatico-facial foramen
Vesalian foramen
Multiple mental foramen
Mylohyoid bridge
INFRACRANIAL
Unfused acromion process
Trochlear notch form
Acetabular notch
Os trigonum
Bipartite anterior facet (talus)
Bipartite anterior facet (calcaneus)
Fossa of Allen
Open foramen transversarium (axis)

MMD is equal to or greater than twice the standard deviation of the MMD, it is significant at the 5% level.

MMD's for the Port au Choix samples were calculated using a program prepared by Dr. El Molto of Lakehead University, Thunder Bay, Ontario. This program makes use of the Freeman-Tukey transformation and Sjøvold's .05 correction. The program prints the theta scores, or individual measure of divergence, calculated for the various traits, the value for the MMD, the standard deviation of the MMD, and the chi-square probability of getting such a value. The output also includes a table of the percentage contribution of each trait to the MMD.

Three separate tests of the Port au Choix data were made, the first using the battery of cranial traits, the second using the battery of infracranial traits, and the third using both cranial and infracranial traits. The results of these analyses, as given in Table 16, are as follows: test 1 (cranial traits) produced an MMD of 0.1225, test 2 (infracranial traits) produced an MMD of 0.2022, and test 3 (all traits) produced an MMD of 0.1716. All three of these MMD's are significant at the .05 level, indicating that in all three cases the sexes display significant differences in the expression of non-metric traits.

The information on the percentage contribution of each trait to the MMD shows that it is the presence of a supraorbital foramen which makes the greatest contribution (63.8%) to the MMD calculated for cranial traits, the presence of a fossa of Allen which makes the greatest contribution

TABLE 16

RESULTS OF ANALYSIS OF MEAN MEASURE OF DIVERGENCE

Trait	Percentage contribution to MMD
CRANIAL TRAIT ANALYSIS: MMD = 0.1225	
Supraorbital foramen complete	63.8
Zygomatico-facial foramen	7.3
Vesalian foramen	7.6
Multiple mental foramen	5.5
Mylohyoid bridge	15.8
	100.0
INFRACRANIAL TRAIT ANALYSIS: MMD = 0.2022	
Unfused acromion process	0.0
Trochlear notch form	7.3
Acetabular notch	1.5
Os trigonum	2.3
Bipartite anterior facet (talus)	12.4
Bipartite anterior facet (calcaneus)	13.2
Fossa of Allen	59.3
Open foramen transversarium (axis)	4.0
	100.0
JOINT CRANIAL AND INFRACRANIAL TRAIT ANALYSIS: MMD = 0.1716	
Supraorbital foramen complete	20.0
Zygomatico-facial foramen	2.3
Vesalian foramen	2.4
Multiple mental foramen	1.7
Mylohyoid bridge	5.0
Unfused acromion process	0.0
Trochlear notch form	5.0
Acetabular notch	1.0
Os trigonum	1.6
Bipartite anterior facet (talus)	8.5
Bipartite anterior facet (calcaneus)	9.1
Fossa of Allen	40.7
Open foramen transversarium (axis)	2.7
	100.0

(59.3%) to the MMD calculated for infracranial traits, and the presence of a fossa of Allen followed by the presence of a supraorbital foramen which make the greatest contribution (40.7% and 20%, respectively) to the MMD calculated for all traits. These results parallel the significant differences which were evident in calculations of the chi-square and measure of divergence statistics.

4.4 Summary of statistical results

The results of the analysis of the metric and non-metric data collected from the male and female samples provide the following information on within- and between-sex variation of the Port au Choix sample.

Metric trait analysis

Univariate statistics: The coefficient of variation was used to assess the variability of metric trait expression within the male and female samples. The results suggested slightly greater female variability, with females displaying higher coefficients of variation for 19 out of 27, or 70.4% of the measurements used in this analysis. This situation is in contrast to the general human tendency toward greater male variability, a tendency which has been linked to difference in the time and intensity of the adolescent growth spurt in the two sexes (Goldstein 1936; Tanner 1964; DeVilliers 1968; Wilkinson 1971). The graphs of the coefficients of variation indicated a general increase in variability as one moves from traits of the skull vault to those of the face and then to those of the infracranial skeleton. This increase in variability may be linked to regional differences in the timing and strength of the adolescent growth spurt (Tanner 1964).

The analysis of variability of trait expression of cranial and infracranial indices relied on the standard deviation, since use of the coefficient of variation with data from indices has not been proven a valid procedure. Males showed higher standard deviations for indices based on measurements of the cranial vault, while females showed higher standard deviations for indices based on measurements of the face and infracranial skeleton. The graphs of the standard deviations demonstrated a similar pattern of variation for males and females. These graphs illustrated an increase in variability as one proceeds from indices of the vault to those of the face, and then to those of the infracranial skeleton. The graphs also indicated the presence of higher male variation for indices of the vault and higher female variation for indices of the face and infracranial skeleton.

In summary, the results of the univariate analyses of measurements and indices seem to suggest slightly greater within-sex variation for the female sample. It is interesting to note that this higher female variability seems to be associated with areas in which variation is normally greater.

This would suggest that these areas may be important sources of information in comparisons of closely related groups. This idea takes on added significance if one considers that the infracranial skeleton is the area of greatest variability and the area of the skeleton most often ignored as a source of data for such studies.

Multivariate statistics: The multivariate analysis of the Port au Choix data relied on the BMDP7M discriminant analysis program. Scatter diagrams produced by this program were used to assess the variability of the male and female samples. Circles of radius 1.0 unit (corresponding to one standard deviation each side of the mean) and of 1.96 units (corresponding to almost two standard deviations - a 95% confidence interval) were superimposed on these diagrams in order to assess the homogeneity of trait expression. The number of individuals falling within the limits of these circles was counted, and the number of outliers noted.

The analysis of cranial measurements did not detect the presence of any outliers, but indicated slightly greater male variability of trait expression. These results are in contrast to those produced by the univariate analysis of cranial measurements, which indicated greater female variability of trait expression. However, the results of the univariate tests incorporate very slight differences in male and female coefficients of variation, while these differences do not seem to be considered significant in the multivariate analysis. The analysis of infracranial measurements did not indicate the presence of any outliers, but reflected slightly greater female variability. These results were in agreement with those of the univariate analysis.

The analysis of cranial indices indicated no outliers, but suggested greater female variability of trait expression. These results were in contrast to those of the univariate anlaysis, probably reflecting the fact that the BMDP7M program eliminates correlations from the analysis, and hence removes the bias which exists when a number of indices are based on the same series of traits. The analysis of infracranial indices detected one female outlier and greater female variability of trait expression. These results were in agreement with those of the univariate analysis of infracranial indices.

In general, the results of the univariate and multivariate analyses of the Port au Choix metric data seem to be in agreement; both indicated slightly greater female variability of trait expression. Moreover, the two levels of analysis provided complementary information. The univariate statistics were able to detect slight differences in male and female variability, an important consideration when the differences between sampels are not likely to be great. The univariate statistics also illustrated the specific areas of difference between the two sexes and the areas of the skeleton where variability was most marked. The multivariate statistics, on the other hand, allowed comparisons to be made on the basis of a battery of traits, and incorporated a means of removing the effects of correlations from the analysis.

Non-metric trait analysis

Univariate statistics: The chi-square and measure of divergence statistics were used to assess between-group differences in non-metric trait expression. Both statistics indicated one significant difference in cranial trait expression at the 5% level, and two significant differences in infracranial trait expression at the 5% level.

Multivariate statistics: The multivariate analysis relied on use of Smith's Mean Measure of Divergence statistic adapted for use with small samples by using the Freeman-Tukey inverse sine transformation. Three separate tests were made, the first based on cranial data, the second based on infracranial data, and the third based on both cranial and infracranial data. The analysis of cranial traits yielded a Mean Measure of Divergence of 0.1225, which is significant at the 5% level. The analysis of infracranial traits yielded a Mean Measure of Divergence of 0.2022, also significant at the 5% level. The analysis of both cranial and infracranial data gave a Mean Measure of Divergence equal to 0.1716, again significant at the 5% level. The percentage contribution of individual traits to the Mean Measure of Divergence was highest for those traits which had shown significant differences in the univariate analysis.

To summarize, the results of the univariate and multivariate analyses of the non-metric data collected from the Port au Choix material indicate significant differences between the male and female samples. Assuming that none of the traits used in this analysis display a 'normal' bias for one particular sex, these differences can be explained only by suggesting that the two groups do not belong to the same population.

Conclusions

The analysis of metric data collected from the Port au Choix skeletal material indicates a greater variability of trait expression within the female sample. The analysis of non-metric data indicates a significant difference in trait expression between the male and female samples. This pattern of within- and between-sex variation corresponds with the proposed model for the practice of non-specific exogamy coupled with male-male residence units. The small size of the sample on which the statistical analyses are based must render these results subject to some suspicion. However, since the statistical techniques used in this study were applicable to small samples, the results may be considered valid.

CHAPTER 5

DISCUSSION

This study has been concerned with the use of osteological data in reconstructing the marriage patterns of a group of Archaic Indians buried at Port au Choix, Newfoundland. Based on the premise that marriage patterns determine the adult composition of hunter-gatherer groups, it has been suggested that a study of differences in the expression of biological traits within and between the sexes may provide some idea of the homogeneity of group composition and form a basis from which to infer marriage patterns. To facilitate interpretation of the results of such studies, a model has been suggested which links the various combinations of endogamy or exogamy (three forms) and the three principle types of residence units with different patterns of within- and between-sex variability of trait expression.

A group of eighteen adult females and twenty-two adult males from Locus II of the Port au Choix-3 site was used as the sample for this study. A series of forty-five metric traits (twenty-seven measurements and eighteen indices) and thirty-three non-metric traits describing the cranial and infracranial skeleton were employed in the analysis. A series of univariate and multivariate statistical techniques were used to assess the variability of osteological trait expression. By nature, the metric data were better suited to the analysis of within-sex variability, while the non-metric data were better suited to the analysis of between-sex variability.

The results of the statistical analyses indicated a slightly greater variability of trait expression within the female sample, and significant difference in trait expression between the sexes. When compared to the proposed model, these results suggested the practice of non-specific exogamy coupled with male-male residence units.

The practice of non-specific exogamy indicates a form of exogamy in which individuals take marriage partners from bands other than their own, with no one set or sets of marriage partners being relied upon. The existence of male-male residence units indicates the practice of virilocal or avunculocal post-nuptial residence. It may be noted, however, that in a sample of more than eight hundred societies taken from Murdock's (1967) Ethnographic Atlas, avunculocal residence is found in less than five percent of the cases (Ember 1973). Thus it seems reasonable to suggest that the presence of male-male residence units in the Port au Choix sample more likely reflects the practice of virilocal post-nuptial residence.

In general, the marriage pattern proposed for the Archaic Indians of Port au Choix corresponds to that described by Radcliffe-Brown (1931), Steward (1955), and Service (1971, 1979) as 'patrilineal' and/or 'patrilocal'. It has been suggested that this pattern may provide certain advantages to the groups involved. It is generally accepted that the practice of exogamy serves as a means of establishing alliances and maintaining peaceful relations between groups, and it has been suggested that such contact may be of added importance in areas of low population density (Owen 1965; Service 1971, 1979). Steward (1955) has pointed out that virilocal residence permits men to remain in the hunting territory familiar to them, and Service (1971, 1979) has suggested that this type of residence fosters male cooperation in hunting and defense. Given the importance of hunting in the Archaic Indian lifestyle in Newfoundland and Labrador, either of these suggestions may be used to explain the practice of virilocal residence by the Indians of Port au Choix.

Previous archaeological research has suggested that the Archaic Indians of Newfoundland and Labrador engaged in a trade of 'luxury items'

> Native copper...may have been passed from band to band along the coast of Newfoundland or southward from Harp Lake, Labrador, and the distinctive Ramah chalcedony from northern Labrador has also been found in Maritime Archaic contexts far to the south (Tuck 1976:83).

Assuming that such channels of exchange existed between various groups, it is not difficult to imagine that women may also have passed from one group to another along these routes, the exchange of personnel strengthening existing relationships. It is possible that such exchanges took place at all times of the year, or they may have been limited to a specific period of time when contact between groups was increased, for example, at a gathering of various bands for communal religious or economic activities.

Given the existence of a marriage pattern based on non-specific exogamy and virilocal residence (or at least, male-male residence units) it is of interest to consider why the variability of metric trait expression evidence by the female sample from Port au Choix is not of a higher order. There are several possible explanations for this:

1. The morphological differences between the bands of Archaic Indians living in that area of Newfoundland and Labrador which surrounds Port au Choix may not have been pronounced, and therefore, a sample of females taken from a number of different bands would display only slightly greater variability of trait expression than a sample of females from any one band
2. The female sample from Port au Choix may have been comprised of individuals who came from a variety of bands, all of which were linked by exogamous unions, and hence, shared a degree of genetic homogeneity
3. The contribution of female genes to the male gene pool may have acted to diminish the differences in variability evidenced by the sexes
4. The Port au Choix band may have permitted some flexibility in marriage patterns, such that a limited number of exogamous uxorilocal unions occurred bringing new males into the group, and diminishing the differences in variability evidenced by the sexes

Any or all of these suggestions may explain why the female sample from Port au Choix does not display a higher order of variability.

It is of note that the pattern and degree of within- and between-sex variation found in the Port au Choix sample indirectly confirms the hypothesis that all the individuals buried in the Locus II cemetery belonged to a single band. It may be assumed that if a number of bands were burying their dead in this cemetery, the amount of variability present in the male and female samples would have been of a higher order, and that, with the effects of marriage patterns cancelled by the use of a communal burial ground, the normal pattern of slightly greater male variability of trait expression would have been evidenced.

The use of osteological data in reconstructing marriage patterns is dependent on several factors relating to the nature of the remains studied and the nature of the data utilized. Firstly, the sample must be well-defined as to its origin and chronological placement, and of sufficient size to permit valid statistical manipulation. Secondly, the traits used in the analysis must have an established genetic basis and be free of any sex bias in their expression. Thirdly, the statistical techniques employed in the analysis must be applicable to the sample and data at hand. If careful consideration is given to each of these factors, such studies may be considered valid.

It is hoped that this analysis of the marriage patterns of the Archaic Indians of Port au Choix, Newfoundland, will become part of a growing body of data on the social organization of prehistoric groups. Information accumulated in such a body of data may be of used in solving some of the conflicts in present-day social theory.

REFERENCES

Akabori, E.

1934 "The Non-metric Variations in the Japanese Skull", Japanese Journal of Medical Science 1, Anatomy 4:61-318.

Anderson, James E.

1962 The Human Skeleton, A Manual for Archaeologists, National Museums of Man, Ottawa.

1968 "Skeletal Anomalies as Genetic Indicators" in The Skeletal Biology of Earlier Human Populations, D. R. Brothwell, ed., Pergamon Press, Oxford.

1976 "The Human Skeletons" in Ancient People of Port au Choix by James A. Tuck, Newfoundland Social and Economic Studies No. 17, Institute of Social and Economic Research, Memorial University.

1978 Grant's Atlas of Anatomy, seventh edition, William's and Wilkins Co., Baltimore.

Bass, W. M.

1964 "The Variation in Physical Types of the Prehistoric Plains Indians", Plains Anthropologist 9: 65-145.

1971 Human Osteology, Missouri Archaeological Society, Columbia.

Benfer, Robert A.

1970 "Associations among Cranial Traits", American Journal of Physical Anthropology 32:463-464.

Benington, R.

1912 "A Study of the Negro Skull with Special Reference to the Congo and Gaboon Crania", Biometrika 8: 292-340.

Bennett, K. A.

1965 "The Etiology and Genetics of Wormians Bones", American Journal of Physical Anthropology 23: 255-260.

Berry, A. C.

1972 The Use of Minor Skeletal Variants in Human Population Studies, unpublished Ph.D. dissertation, University of London.

1975 "Factors Affecting the Incidence of Non-metrical Skeletal Variants", Journal of Anatomy 120:519-535.

Berry, A. C. and R. J. Berry

1967 "Epigenetic Variation in the Human Cranium", Journal of Anatomy 101:361-379.

Berry, A. C., R. J. Berry, and Peter J. Ucko

1967 "Genetical Change in Ancient Egypt", Man 2:551-568.

Berry, R. J.

1963 "Epigenetic Polymorphism in Wild Populations of Mus musculus", Genetical Research 4:193-220.

1964 "The Evolution of an Island Population of the House Mouse", Evolution 18:468-483.

1968 "The Biology of Non-metrical Variation in Mice and Men" in The Skeletal Biology of Earlier Human Populations, D. R. Brothwell, ed., Pergamon Press, Oxford.

1969a "History in the Evolution of Apodemus Sylvaticus (Mammalia) at One Edge of its Range", Journal of Zoology 159:311-328.

1969b "Non-metrical Skull Variation in Two Scottish Colonies of the Grey Seal", Journal of Zoology 157;11-18.

Berry, R. J. and M. E. Jakobson

1975 "Ecological Genetics of an Island Population of the House Mouse", Journal of Zoology 175:523-540.

Berry, R. J. and A. G. Searle

1963 "Epigenetic Polymorphism of the Rodent Skeleton", Proceedings of the Zoological Society of London 140:577-615.

Bielicki, T.

1962 "Some Possibilities for Estimating Interpopulation Relationships on the Basis of Continuous Traits", Current Anthropology 3:3-38.

Binford, Lewis R.

1968 "Methodological Considerations of the Archaeological Use of Ethnographic Data" in Man the Hunter, R. B. Lee and I. DeVore, eds., Aldine, Chicago.

Binford, Lewis R. and Sally R. Binford

1966 "A Preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies" in Recent Studies in Paleoanthropology, J. D. Clarke and F. C. Howell, eds., American Anthropologist 68, part 2.

Birkby, W. H.

1973 Discontinuous Morphological Traits of the Skull as Population Markers in the Preshistoric Southwest, unpublished Ph.D. dissertation, University of Arizona.

Blalock, H. M.

1972 Social Statistics, Second Edition, McGraw-Hill, New York.

Bolk, L.

1917 "On Metopism", American Journal of Anatomy 22: 27-47.

Boyd, G. I.

1931 "The Emissary Foramina in Man and the Anthropoids", Journal of Anatomy 65:108-121.

Brothwell, D. R.

1959 "The Use of Non-metrical Characters of the Skull in Differentiating Populations", Deutsch Gesellshaft Anthropologie Bericht Uber Tagung 6:103-109.

1965 "Of Mice and Men: Epigenetic Polymorphism in the Skeleton" in Homenaje a Juan Comas en Sue 65 Anniversario, Vol. II, Editorial Libros de Mexico, Mexico.

Buikstra, Jane

1972 Hopewell in the Lower Illinois River Valley: A Regional Approach to the Study of Biological Variability and Mortuary Activity, unpublished Ph.D. thesis, University of Chicago.

Carpenter, James C.

1976 "A Comparative Study of Metric and Non-metric Traits in a Series of Modern Crania", American Journal of Physical Anthropology 45:337-343.

Chambellan, M.

1883 Etude Anatomique et Anthropologique sur les Os Wormiens, Thesis, Paris. Cited in Dorsey, 1897.

Cheverud, J. M., J. E. Buikstra, and E. Twichell

1979 "Relationships between Non-metric Skeletal Traits and Cranial Size and Shape", American Journal of Physical Anthropology 50:191-198.

Chouké, K. S.

1945 "On the Incidence of Foramen Civinni and Porus Crotaphitico-buccinatorius in American Whites and Negroes. II. Observations on 2,745 additional skulls", American Journal of Physical Anthropology 5:87-94.

Collins, H. M.

1926 "The Temporo-frontal Articulation in Man", American Journal of Physical Anthropology 9:343-348.

1930 "Notes on the Pterion", American Journal of Physical Anthropology 14:41-44.

Cooley, W. W. and P. R. Lohnes

1971 Multivariate Data Analysis, Wiley, New York.

Corruccini, R. S.

1974 "An Examination of the Meaning of Cranial Discrete Traits for Human Skeletal Biological Studies", American Journal of Physical Anthropology 40: 425-446.

Corruccini, R. S.

1975 "The Interaction between Non-metric and Metric Cranial Variation", American Journal of Physical Anthropology 44:285-294.

Crichton, J. M.

1966 "A Multiple Discriminant Analysis of Egyptian and African Negro Crania", Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, No. 57:47-67.

Damas, David

1969 Contributions to Anthropology: Band Societies, National Museums of Canada, Bulletin No. 228.

Deetz, James J. F.

1965 The Dynamics of Stylistic Change in Arikara Ceramics, Illinois Studies in Anthropology, No. 4, University of Illinois Press, Urbana.

1968 "The Inference of Residence and Descent Rules from Archaeological Data" in New Perspectives in Archaeology, Sally R. Binford and Lewis R. Binford, eds., Aldine, Chicago.

D'Entremont, Stanley A.

1978 The Determination of Status at Port au Choix, unpublished M.A. thesis, Memorial University of Newfoundland.

Deol, M.S.

1955 "Genetical Studies on the Skeleton of the Mouse XIV. Minor Variations in the Skull", Journal of Genetics 53:498-514.

1958 "Genetical Studies on the Skeleton of the Mouse XXIV. Further Data on Skeletal Variations in Wild Populations", Journal of Embryology and Experimental Morphology 6:569-574.

Deol, M. S. and G. M. Truslove

1957 "Genetical Studies on the Skeleton of the Mouse XX. Maternal Physiology and Variation in the Skeleton of C57BL Mice", Journal of Genetics 55: 288-312.

DeVilliers, H.

1968 The Skull of the South African Negro, Witwatersrand University Press, Johannesburg.

Dixon, A. F.

1900 "On Certain Markings on the Frontal Part of the Human Cranium and their Significance", Journal of the Royal Anthropological Institute 30:96-97.

1904 "On Certain Markings due to Nerves and Blood Vessels upon the Cranial Vault. Their Significance, and Relative Frequency of their Occurrence in the Different Races of Mankind", Journal of Anatomy 38:377-398.

Dorsey, G. A.

1897 "Wormian Bones in Artificially Deformed Kwakiutl Crania", American Anthropologist 10:169-173.

Edmonson, Munro S.

1965 "A Measurement of Relative Racial Difference", Current Anthropology 6:167-192.

El-Najjar, Mahmoud and George L. Dawson

1977 "The Effect of Artificial Cranial Deformation on the Incidence of Wormian Bones in the Lambdoidal Suture", American Journal of Physical Anthropology 46:155-160.

El-Najjar, M. Y. and K. R. McWilliams

1978 Forensic Anthropology, Charles C. Thomas, Springfield, Illinois.

Ember, M.

1973 "An Archaeological Indicator of Matrilocal Versus Patrilocal Residence", American Antiquity 38:177-182.

Epstein, B. S.

1968 The Spine, Radiological Text and Atlas, Lea and Febiger, Philadelphia.

Fenner, F. J.

1939 "The Australian Aboriginal Skull. Its Non-metrical Morphological Characters", Transactions of the Royal Society of South Australia 63:248-306.

Finnegan, M. J.

1972 Population Definition on the Northwest Coast by Analysis of Discrete Character Variation, unpublished Ph.D. dissertation, University of Colorado, Boulder, Colorado.

1978 "Non-metric Variation of the Infra-cranial Skeleton", Journal of Anatomy 125:23-37.

1979 "Supplement to the Bibliography of Human and Nonhuman Non-metric Variation", The Connective Tissue 6(1).

Finnegan, M. and Kevin Cooprider

1978 "Empirical Comparison of Distance Equations Using Discrete Traits", American Journal of Physical Anthropology 49:39-46.

Finnegan, M. and M. A. Faust

1974 Bibliography of Human and Nonhuman Non-metric Variation, Research Reports No. 14, Dept. of Anthropology, University of Massachusetts, Amherst.

Freeman, L. G.

1968 "A Theoretical Framework fo Interpreting Archaeological Materials" in Man the Hunter, R. B. Lee and I. DeVore, eds., Aldine, Chicago.

Freeman, M. F. and J. W. Tukey

1950 "Transformations Related to the Angular Square root", Annals of Mathematical Statistics 21: 607-611.

Gaherty, G.

1974 "Infracranial Discrete Traits in Seven African Populations", American Journal of Physical Anthropology 41:480-481.

Giles, E. and H. K. Bleibtreu

1961 "Cranial Evidence in Archaeological Reconstruction: a Trial of Multivariate Techniques for the Southwest", American Anthropologist 63:48-61.

Girdany, B. R. and E. Blank

1965 "Anterior Fontanelle Bones", American Journal of Roentgenology, Radiological Therapy, and Nuclear Medicine 95:148-153.

Glanville, E. V.

1967 "Perforation of the Coronoid-olecranon Septum", American Journal of Physical Anthropology 26:85-92.

Goldstein, M. S.

1936 "Changes in Dimensions and Forms of the Face and Head with Age", American Journal of Physical Anthropology 22:37-89.

Grahnen, H.

1956 "Hypondentia in the Permanent Dentition. A Clinical and Genetical Investigation", Odont. Revy. 7, Supplement 3.

Green, Richard F. and Judy Myers Suchey

1976 "The Use of Inverse Sine Transformations in the Analysis of Non-metric Cranial Data", American Journal of Physical Anthropology 45:61-68.

Grewal, Manjit Singh

1962 "The Rate of Genetic Divergence of Sublines in the C57BL Strain of Mice", Genetics Research 3:226-237.

Gruneberg, H.

1950 "Genetical Studies on the Skeleton of the Mouse I. Minor Variations of the Vertebral Column", Journal of Genetics 50:112-173.

1952 "Genetical Studies on the Skeleton of the Mouse IV. Quasi-continuous Variations", Journal of Genetics 51:95-114.

1955 "Genetical Studies on the Skeleton of the Mouse XV. Relations Between Major and Minor Variants", Journal of Genetics 53:515-535.

1961 "Evidence for Genetic Drift in Indian Rats, Rattus rattus", Evolution 15:259-262.

1963 The Pathology of Development: A Study of Inherited Skeletal Disorders in Animals, Wiley, New York.

Hanna, B. L.

1962 "The Biological Relationships Amoung Indian Groups of the Southwest", American Journal of Physical Anthropology 20:499-508.

Harland, P. S. E. G.

1958 "Skeletal Variation in Wild House Mice from Peru", The Annals and Magazine of Natural History 1:193-196.

Harp, Elmer Jr.

1951 "An Archaeological Reconnaissance in the Strait of Belle Isle Area", American Antiquity 16(3): 203-220.

1963 Evidence of Boreal Archaic Culture in Southern Labrador and Newfoundland, National Museum of Canada, Bulletin No. 193, Ottawa.

1968 "Five Prehistoric Burials from Port au Choix, Newfoundland", Polar Notes, No. VIII, Hanover, New Hampshire.

Hess, L.

1945 "The Metopic Syndrome", Human Biology 17:107-136.

Hiernaux, Jean

1963 "Heredity and Environment: Their Influence on Human Morphology. A Comparison of Two Independent Lines of Study", American Journal of Physical Anthropology 21:575-590.

1968 La Diversite Humaine en Afrique Subsaharainne, Editions de L'Institut de Sociologie, Universite Libre de Brunelles.

Hill, James N.

1966 "A Prehistoric Community in Eastern Arizona", Southwestern Journal of Anthropology 22:9-30.

Hockett, C. F.

1964 "The Proto Central Algonquin Kinship System" in Explorations in Cultural Anthropology: Essays in Honour of George Peter Murdock, W. H. Goodenough, ed., McGraw-Hill, London.

Hooten, E.

1930 Indians of Pecos, Yale University Press, New Haven.

Howe, W. L. and P. A. Parsons

1967 "Genotype and Environment in the Determination of Minor Skeletal Variants and Body Weight in Mice", Journal of Embryology and Experimental Morphology 17:283-292.

Howells, W. W.

1957 "The Cranial Vault: Factors in Size and Shape", American Journal of Physical Anthropology 15: 19-48.

1969 "The Use of Multivariate Techniques in the Study of Skeletal Populations", American Journal of Physical Anthropology 31:311-314.

1970 "Theory and Methodology in Multivariate Analysis of Human Crania", Proceedings of the VIII International Congress of Anthropological and Ethnographical Science 1:1.3.

1972 "Analysis of Patterns of Variation in Crania of Recent Man", in The Functional and Evolutionary Biology of Primates, R. Tuttle, ed., Aldine-Atherton, Chicago.

Hrdlička, A.

1916 "Physical Anthropology of the Lenape or Delawares and of the Eastern Indians in General", Bureau of American Ethnology Bulletin LXII.

1935 Ear Exostoses, Smithsonian Miscellaneous Collection No. 93.

1937 "The Gluteal Ridge and Gluteal Tuberosities", American Journal of Physical Anthropology 23: 127-198.

1940 "Mandibular and Maxillary Hyperostoses", American Journal of Physical Anthropology 27:1-68.

1972 Practical Anthropometry, First AMS Edition, the Wistar Institute of Anatomy and Biology, Philadelphia.

Hulse, F. S.

1941 "The People who Lived at Irene", in Irene Mound Site, Chatham County, Georgia, J. Caldwell and C. McCann, eds., University of Georgia Press, Athens.

Jantz, R. L.

1970 Change and Variation in Skeletal Populations of Arikara Indians, unpublished Ph.D. thesis, University of Kansas at Lawrence, Lawrence, Kansas.

Jenrich, R. and P. Sampson

1977 "P7M: Stepwise Discriminant Analysis", in BMDP-77 (P-series), W. J. Dixon, ed., (M. B. Brown, ed., 1977 edition), University of California Press, Berkeley.

Johnson, C. C., R. J. Gorlin and V. E. Anderson

1965 "Torus Mandibularis: A Genetic Study", American Journal of Human Genetics 17:433-442.

Kaplan, B. A.

1954 "Environment and Human Plasticity", American Anthropologist 56:780-800.

Kitson, E.

1931 "A Study of the Negro Skull with Special Reference to the Crania from Kenya Colony", Biometrika 32:271-315.

Keen, J. A.

1950 "A Study of the Differences Between Male and Female Skulls", American Journal of Physical Anthropology 8:65-79.

Kellock, W. L. and P. A. Parsons

1970a "Variation of Minor Non-metrical Cranial Variants in Australian Aborigines", American Journal of Physical Anthropology 32:409-422.

1970b "A Comparison of the Incidence of Minor Non-metrical Cranial Variants in Australian Aborigines with those of Melanesia and Polynesia", American Journal of Physical Anthropology 33:235-239.

Knip, Agatha S.

1970a "Metrical and Non-metrical Measurements on the Skeletal Remains of Christian Populations from two Sites in Sudanese Nubia I, Proceedings of Nederlandse Akademie van Wetenschappern, Amsterdam, Series C, 78:433-450.

1970b "Metrical and Non-metrical Measurements on the Skeletal Remains of Christian Populations from two Sites in Sudanese Nubia II, Proceedings of Nederlandse Akademie van Wetenschappern, Amsterdam, Series C, 78:451-468.

1971a "The Frequencies of Non-metrical Variants in Tellem and Nakara Skulls from the Mali Republic I, Proceedings of Nederlandse Akademie van Wetenschappen, Amsterdam, Series C, 74:422-430.

1971b "The Frequencies of Non-metrical Variants in Tellam and Nokara Skulls from the Mali Republic II, Proceedings of Nederlandse Akademie van Wetenschappen, Amsterdam, Series C, 74:431-443.

Korey, Kenneth

1970 Characteristics of the Distribution of Non-metric Variants, unpublished M.A. thesis, University of Chicago.

Krogman, W. M.

1962 The Human Skeleton in Forensic Medicine, Charles C. Thomas, Springfield, Illinois.

Landauer, C. H.

1962 "A Factor Analysis of the Facial Skeleton", Human Biology 34:239-254.

Lane, R. A.

1969 Population Perspective in Osteology: A Case Study, unpublished M.A. thesis, Dept. of Anthropology, Florida Atlantic University, Florida.

Lane, R. A. and A. Sublett

1972 "Osteology of Social Organization: Residence Pattern", American Antiquity 37:186-201.

Lasker, G. L.

1946 "Migration and Physical Differentiation", American Journal of Physical Anthropology 4:273-300.

1947 "Penetrance Estimated by Frequency of Unilateral Occurrence and by Discordance in Monozygotic Turns", Human Biology 19:217-230.

Laughlin, W. S. and J. B. Jorgensen

1956 "Isolate Variation in Greenlandic Eskimo Crania", Acta Genetica et Statistica Medica 6:3-12.

Leacock, Eleanor

1969 "The Montagnais-Naskapi Band" in Contributions to Anthropology: Band Societies, D. Damas, ed., National Museums of Canada, Bulletin No. 228.

Le Double, A. F.

1903 Traite des Variations des Os du Crane de l'Homme et de leur Signification au Point de Vue de l'Anthropologie Zoologique, Vigot, Paris.

1906 Traite des Variations des Os de la Face de l'Homme et de leur Signification au Point de Vue de l'Anthropologie Zoologique, Vigot, Paris.

1912 Traite des Variations de la Colonne Vertebrale de l'Homme et de leur Signification au Point de Vue de l'Anthropologie Zoologique, Vigot, Paris.

Lee, R. and I. DeVore

1968 "Problems in the Study of Hunters and Gatherers" in Man the Hunter, R. B. Lee and I. DeVore, eds., Aldine, Chicago.

Limson, M.

1924 "Metopism as Found in Filipino Skulls", American Journal of Physical Anthropology 7:317-324.

Longacre, W. A.

1964a "Archaeology as Anthropology: A Case Study", Science 144:1454-1455.

Lewis, T. and M. K. Lewis

1961 Eva, an Archaic Site, University of Tennessee Press, Knoxville.

MacDonnell, W. R.

1904 "A Study of the Variation and Correlation of the Human Skull, with Special Reference to English Crania", Biometrika 3:191-244.

MacPherron, A.

1967 "On the Sociology of Ceramics: Pottery Style Clustering, Marital Residence, and Cultural Adaptations of an Algonkian-Iroquoian Border" in Iroquois Culture, History and Prehistory, E. Tooker, ed., University of the State of New York, Albany.

McKern, Thomas W. and T. Dale Stewart

1957 Skeletal Age Changes in Young American Males, Quartermaster Research and Development Center, Technical Report EP-45, Natick, Massachusetts.

Miller, S. C. and H. Roth

1940 "Torus Palatinus, a Statistical Study", Journal of the American Dental Association 27:1950-1957.

Molto, J. E.

n.d. "Saugeen Osteology: The Evidence of the Second Cemetery at the Donaldson Site", unpublished manuscript.

Montagu, M. F. A.

1937 "The Medio-frontal Suture and the Problem of Metopism in the Primates", Journal of the Royal Anthropological Institute 67:157-201.

1954 "The Direction and Position of the Mental Foramen in the Great Apes and Man", American Journal of Physical Anthropology 12:503-518.

Moorrees, C. F. A.

1957 The Aleut Dentition, Harvard University Press, Cambridge.

Moorrees, C. F. A., R. H. Osborne, and E. Wilde

1952 "Torus Mandibularis: Its Occurrence in Aleut Children and its Genetic Determinants", American Journal of Physical Anthropology 10:319-329.

Murdock, George P.

1967 "Ethnographic Atlas: A Summary", Ethnology 6: 109-236.

Nakata, M., P. L. Yu, B. Davis and W. Nance

1972 "An Analysis of Cranio-facial Structure in Human Twins and their Parents", Abstract, American Journal of Physical Anthropology 37:446.

Oetteking, B.

1930 "Craniology of the North Pacific Coast", Memoirs of the American Museum of Natural History, Jesup North Pacific Expedition 11:1-391.

Olivier, Georges

1969 Practical Anthropology, Charles C. Thomas, Springfield, Illinois.

Oschinsky, L.

1959 "A Reappraisal of Recent Serological, Genetical and Morphological Research on the Taxonomy of Races of Africa and Asia", Anthropologica 1:2-25.

Ossenberg, Nancy S.

1969 Discontinuous Morphological Variation in the Human Cranium, unpublished Ph.D. dissertation in Anatomy, University of Toronto.

1970 "The Influence of Artificial Cranial Deformation on Discontinuous Morphological Traits", American Journal of Physical Anthropology 33:357-371.

Owen, Roger C.

1965 "The Patrilocal Band: A Linguistically and Culturally Hybrid Social Unit", American Anthropologist 67:675-690.

Parsons, P. A. and W. L. Howe

1967 "Morphogenetic Homeostasis in Mice", Australian Journal of Biological Science 20:777-784.

Pearson, K. and A. Davin

1924 "On the Biometric Constants of the Human Skull", Biometrika 16:328-368.

Pfeiffer, Susan

1977 The Skeletal Biology of Archaic Populations of the Great Lakes Region, National Museum of Man, Mercury Series, No. 64.

Phenice, T. W.

1969 "A Newly Developed Visual Method of Sexing the Os Pubis", American Journal of Physical Anthropology 30:297-302.

Pollitzer, W. S.

1958 "The Negros of Charleston (S.C.); A Study of Haemoglobin Types, Serology, and Morphology", American Journal of Physical Anthropology 16: 241-263.

Radcliffe-Brown, A. R.

1931 Social Organization of Australian Tribes, Oceania Monographs, 1.

Rightmire, G. P.

1972 "Cranial Measurements and Discrete Traits Compared in Distance Studies of African Negro Skulls", Human Biology 44:263-276.

Russell, Frank

1900 "Studies in Cranial Variation", The American Naturalist 34:737-745.

Sanghvi, L. D.

1953 "Comparison of Genetical and Morphological Methods for Study of Biological Differences", American Journal of Physical Anthropology 11:385-404.

Saunders, Shelly R. and Frank Popovitch

1978 "A Family Study of Two Skeletal Variants: Atlas Bridging and Clinoid Bridging", American Journal of Physical Anthropology 49:193.

Schultz, A. H.

1923 "Bregmatic Fontanelle in Mammals", Journal of Mammalogy 4:65-77.

Schultz, A. H.

1929 "The Metopic Fontanelle, Fissure, and Suture", American Journal of Anatomy 44:475-499.

Searle, A. G.

1954a "Genetic Studies on the Skeleton of the Mouse IX. Causes of Skeletal Variation Within Pure Lines", Journal of Genetics 52:68-102.

1954b "Genetic Studies on the Skeleton of the Mouse XI. The Influence of Diet on Variation Within Pure Lines", Journal of Genetics 52:413-424.

1960 "The Genetics and Evolution of Threshold Characters", Proc. Cent. Bicent. Congr., Singapore: 220-224.

Selby, S., S. M. Garn and V. Kanareff

1955 "The Incidence and Familial Nature of a Bony Bridge on the First Cervical Vertebra", American Journal of Physical Anthropology 13:129-141.

Service, Elman R.

1971 Primitive Social Organization: An Evolutionary Perspective, second edition, Random House, New York.

1979 The Hunters, second edition, Prentice-Hall, Englewood Cliffs, New Jersey.

Simpson, G. G., A. Roe and R. C. Lewontin

1960 Quantitative Zoology, Harcourt, Brace and Co., New York.

Sjøvold, Torstein

1973 "The Occurrence of Minor Non-metrical Variants in the Skeleton and their Quantitative Treatment for Population Comparisons", Homo 24:204-233.

Souza, Peter and Philip Houghton

1977 "The Mean Measure of Divergence and the Use of Non-metric data in the Estimation of Biological Distances", Journal of Archaeological Science 4:163-169.

Spence, M. W.

1971 Skeletal Morphology and Social Organization in Teotihuacán, Mexico, unpublished Ph.D. dissertation, Southern Illinois University.

1974 "The Study of Residential Practices Among Prehistoric Hunters and Gatherers", World Archaeology 5:346-357.

Steward, Julian H.

1955 Theory of Culture Change: The Methodology of Multilinear Evolution, University of Illinois Press, Urbana.

Stewart, T. D.

1948 "Medico-legal Aspects of the Skeleton I. Age, Sex, Race and Stature", American Journal of Physical Anthropology 6:315-321.

1954 "Sex Determination of the Skeleton by Guess and Measurement", American Journal of Physical Anthropology 12:385-392.

Sublett, A. J.

1966 Seneca Physical Type and Changes Through Time, unpublished Ph.D. dissertation, State University of New York at Buffalo.

Sullivan, L. R.

1925 "The Frequency and Distribution of Some Anatomical Variations in American Crania", Anthropological Papers of the American Museum of Natural History 23:207-257.

Suzuki, Makoto and Takuro Sakai

1960 "A Familial Study of Torus Palatinus and Torus Mandibularis", American Journal of Physical Anthropology 18:263-272.

Tanner, J. M.

1962 Growth at Adolescence, Blackwell Scientific Publications, Oxford.

Tanner, J. M.

1964 "Human Growth and Constitution" in Human Biology: An Introduction to Human Evolution, Variation and Growth, G. A. Harrison, J. S. Weiner, J. M. Tanner and N. A. Barnicot, eds., Oxford University Press, New York.

Torgensen, J.

1952 "Genetic Dynamics of Human Evolution", Actes du IV congres International des Sciences Anthropologiques et Ethnologiques, Vienna 1, Tome I: 98-102.

Tretyakov, P. N.

1934 "K Istorii doklassovogo obsh' chestva verkhnego Povolzhya (On the History of Pre-class Society in the Area of the Upper Volga)", Iz Istorii Rodovogo Obsh' chestva na Territorii SSSR, Gosudarstavannaia Akademiia Istorii Material'noi Kul'tury (Moscow) 106:97-180.

Trinkaus, Erik

1978 "Bilateral Asymmetry of Human Skeletal Non-metric Traits", American Journal of Physical Anthropology 49:315-318.

Trotter, M.

1934 "Septal Apertures in the Humerus of American Whites and Negroes", American Journal of Physical Anthropology 19:213-227.

1964 "Accessory Sacroilias Articulation in East African Skeletons", American Journal of Physical Anthropology 22:137-141.

Truslove, G. M.

1961 "Genetic Studies on the Skeleton of the Mouse XXX. A Search for Correlations Between Some Minor Variants", Genetical Research 2:431-438.

Tuck, James A.

1970 "An Archaic Indian Cemetery in Newfoundland", Scientific American 222:112-121.

Tuck, James A.

1971 "An Archaic Cemetery at Port au Choix, Newfoundland", American Antiquity 36(3):343-358.

1976 Ancient People of Port au Choix, Newfoundland Social and Economic Studies No. 17, Institute of Social and Economic Research, Memorial University.

Turner, C. G. II

1969 "Microevolutionary Interpretation from the Dentition", American Journal of Physical Anthropology 30:421-426.

Turner, C. G. II and N. S. Laughlin

1963 "Postnatal Development of the Sadlermiut Eskimo Temporal Bone", American Journal of Physical Anthropology 21:406.

Ubelaker, Douglas H.

1978 Human Skeletal Remains, Aldine, Chicago.

Vandenberg, S. G.

1962 "How 'Stable' are Hereditary Estimates? A Comparison of Heritability Estimates from Sex Anthropometric Studies", American Journal of Physical Anthropology 20:331-338.

Washburn, S. L.

1947 "The Relation of the Temporal Muscle to the Form of the Skull", The Anatomical Record 99:239-248.

1948 "Sex Differences in the Pubic Bone", American Journal of Physical Anthropology 6:199-207.

1949 "Sex Differences in the Pubic Bone of Bantu and Bushmen", American Journal of Physical Anthropology 7:425-432.

Weber, W.

1950 "Genetical Studies on the Skeleton of the Mouse III. Skeletal Variation in Wild Populations", Journal of Genetics 50:174-178.

Weiner, J. S. and J. Huizinga

1972 The Assessment of Population Affinities in Man, Clarendon Press, Oxford.

Wilkinson, R. G.

1971 Preshistoric Biological Relationships in the Great Lakes Region, Anthropological Paper 43, University of Michigan Museum of Anthropology.

Willey, Gordon R.

1968 "One Hundred Years of American Archaeology" in One Hundred Years of Anthropology, J. O. Brew, ed., Harvard University Press, Cambridge.

Woo, J. K.

1949a "Direction and Type of the Transverse Palatine Suture and its Relation to the Form of the Hard Palate", American Journal of Physical Anthropology 7:385-400.

1949b "Racial and Sexual Differences in the Frontal Curvature and its Relation to Metopism", American Journal of Physical Anthropology 7:215-225.

1950 "Torus Palatinus", American Journal of Physical Anthropology 8:81-112.

Woodburn, J.

1968 "Stability and Flexibility in Hadza Residential Groupings", in Man the Hunter, R. B. Lee and I. DeVore, eds., Aldine, Chicago.

Wood-Jones, F.

1930a "The Non-metrical Morphological Characters of the Skull as Criteria for Racial Diagnosis I", Journal of Anatomy 65:179-195.

1930b "The Non-metrical Morphological Characters of the Skull as Criteria for Racial Diagnosis II, Journal of Anatomy 65:368-378.

1930c "The Non-metrical Morphological Characters of the Skull as Criteria for Racial Diagnosis III, Journal of Anatomy 65:438-445.

1933 "The Non-metrical Morphological Characters of the Skull as Criteria for Racial Diagnosis IV, Journal of Anatomy 68:96-108.

Wright, J. V.

1965 "A Regional Examination of Ojibwa Culture History", Anthropologica 7:189-227.

1966 "The Pic River Site", National Museums of Canada Bulletin 206:54-99.

1968 "The Michipicoten Site, Ontario", National Museums of Canada Bulletin 224:1-85.

Zegura, S. L.

1971 A Multivariate Analysis of the Inter- and Intra-population Variation Exhibited by Eskimo Crania, unpublished Ph.D. dissertation, University of Wisconsin, Madison.

APPENDICES

APPENDIX A

CRITERIA FOR SEX DETERMINATION

SKULL

Overall size and robustness: Male crania are larger and heavier.

Size of the supraorbital ridges: Males usually have more prominent ridges due to greater development of the frontal sinuses. (This criterion was not particularly useful in terms of the Port au Choix material, since females share the characteristic of well-developed ridges).

Configuration of the supraorbital margins: Males generally have rounded or blurred supraorbital margins, while females tend to display sharp, defined margins.

Degree of parietal and frontal bossing: Females tend to retain the childhood characteristics of frontal and parietal bossing into adulthood.

Muscle markings: Male crania have more prominent markings along the temporal line and in the nuchal region of the occiput.

Size of the mastoid process: Male processes are larger.

Development of the posterior root of the zygomatic process: In males, the posterior root of the zygomatic process extends as a well-marked ridge some distance past the external auditory meatus. It is absent or poorly developed in females.

Width of the zygomatic arches: Male arches are significantly wider.

Breadth of the palate: Male palates are larger.

Size of the mandible: The male mandible is larger, heavier, higher and more robust. The ascending ramus is broader with a well developed coronoid process, and the gonial regions are well developed.

Chin form: The chin tends to be square in males (bilateral chin form), but more rounded with a point in the midline in females (median chin form).

APPENDIX A - Continued

PELVIS

Muscle markings: The male pelvis has more pronounced muscle markings.

Sub-pubic angle: The sub-pubic angle is more acute in males.

Presence of the ventral arc: This ridge is typically present in females and absent in males, though a line may occasionally be seen in males at the site of the ventral arc.

Medial aspect of the ischio-pubic ramus: This area is usually flat in males, while a ridge occurs at this site in females.

Presence of a sub-pubic concavity: This concavity is large and obvious in females, but usually absent or very slight in males.

Angle of the sciatic notch: The angle of the sciatic notch is narrower and more acute in males. The angle is typically about 60° or more in females, while in males it is less.

Presence of a preauricular sulcus: A sulcus is infrequent in males, but more common and better developed in females.

Ischium-pubis index: The ratio of acetabulum-pubis length to acetabulum-ischium length is significantly higher in females.

Size of the obturator foramen: The obturator foramen is smaller and more triangular in females.

Size of the acetabulum: The male acetabulum is larger.

Lateral view of the sacrum: The male sacrum is uniformly curved with the deepest point at the third segment. In females, the upper portion is flatter and the lower portion sharply angulated with the deepest point of curvature at the fourth segment.

Size of the first sacral body: In males the first sacral body is relatively larger than its ala, while in females the body is equal in size to its ala.

Size of the articular surface of the sacrum: This surface is

APPENDIX A - Continued

limited to the first and second sacral vertebrae in females, while in males it often extends to the middle of the third vertebra.

LONG BONES

Overall size: Male long bones are longer and more robust.

Muscle markings: Male long bones have more pronounced muscle markings.

Size of the articular surfaces: Articular surfaces of long bones are larger in males.

APPENDIX B

SAMPLES USED IN METRIC ANALYSIS

Cranial Trait Analysis		Infracranial Trait Analysis	
Males	Females	Males	Females
12	1B	8A	9
22D	6	27A	10
27A	9	34	18B
29	10	47A	25
32	16A	50B	44A
34	18B		49A
35A	28A		52
44B	37B		
47A	44A		
	49A		
	52		

APPENDIX C

DEFINITIONS OF METRIC TRAITS

CRANIAL METRIC TRAITS

Vault

Cranial length: The distance from glabella to opisthocranion, the most posterior point on the skull in the mid-sagittal plane (spreading calipers).

Cranial breadth: The maximum transverse diameter of the skull taken above the supramastoid crests, perpendicular to the median sagittal plane (spreading calipers).

Basion-bregma height: The distance from basion to bregma (spreading calipers).

Minimum frontal breadth: The minimum breadth between the right and left temporal crests of the frontal bone (spreading calipers).

Face

Upper facial height: The distance from nasion to prosthion (sliding calipers).

Bizygomatic breadth: The distance between the most widely separated points on the external surface of the zygomatic arches, taken perpendicular to the median plane. If one arch is damaged the measurement may be approximated by doubling the distance from the midline to the intact side (sliding calipers).

Base

Basion-nasion length: The distance from basion to nasion (spreading calipers).

Basion-prosthion length: The distance from basion to prosthion (spreading calipers).

Orbits

Orbital breadth: The distance from dacryon to ectoconchion, the point on the lateral orbital border farthest from dacryon, taken on the left orbit parallel to the line bisecting the orbit into equal upper and lower portions. If the left orbit is missing or

APPENDIX C — Continued

damaged, measurement of the right orbit is substituted (sliding calipers).

Orbital height: The maximum distance between the upper and lower margins of the left orbital cavity, taken at right angles to the orbital breadth and bisecting it. If the left orbit is missing or damaged, measurement of the right orbit is substituted (sliding calipers).

Nose

Nasal breadth: The maximum horizontal distance between the anterior edges of the nasal aperture (sliding calipers).

Nasal height: The average distance from nasion to the lowest point on the border of the nasal aperture on either side (sliding calipers).

Upper Alveolar Process

Maxillo-alveolar breadth: The maximum breadth across the external alveolar borders, taken perpendicular to the median plane (sliding calipers).

Maxillo-alveolar length: The distance in the median plane from prosthion to a line joining the maxillary tuberosity (sliding calipers).

INFRACRANIAL METRIC TRAITS

Humerus

Maximum length: The distance between the most proximal and most distal points of the humerus (osteometric board).

Maximum shaft diameter: The maximum diameter of the shaft at the mid-point of maximum length (sliding calipers).

Minimum shaft diameter: The minimum diameter of the shaft at the mid-point of maximum length (sliding calipers).

Maximum diameter of the head: The maximum length on the transverse diameter of the humeral head (sliding calipers).

APPENDIX C - Continued

Radius

Maximum length: The distance between the most widely separated points on the two extremities of the bone, including the styloid process (osteometric board).

Femur

Subtrochanteric transverse shaft diameter: The transverse diameter taken at the level of the greatest subtrochanteric expansion, at a point usually about 2-5 cm below the lesser trochanter (sliding calipers).

Subtrochanteric anteroposterior shaft diameter: The sagittal diameter taken at the level of the preceding measurement and at right angles to it (sliding calipers).

Maximum diameter of the head: The maximum diameter of the head, avoiding any abnormal extensions of the articular surface onto the anterior surface of the neck (sliding calipers).

Tibia

Anteroposterior nutrient foramen (or cnemic) diameter: The sagittal diameter of the shaft at the level of the nutrient foramen (sliding calipers).

Transverse nutrient foramen (or cnemic) diameter: The transverse diameter of the shaft at the level of the nutrient foramen (sliding calipers).

Talus

Maximum length: The maximum distance between the head and the sulcus for the Flexor hallucis longus (sliding calipers).

Maximum breadth: The maximum transverse distance between the lateral tubercle and the medial side (sliding calipers).

APPENDIX D

SEX BIAS IN CRANIAL NON-METRIC TRAIT EXPRESSION

Trait	Reference	Bias
*Accessory lesser palatine foramen present	Berry and Berry 1967	Neither sex
	†A. C. Berry 1975	Males
		Males ?
		Males ?
		Females
Anterior ethmoid foramen exsutural	A. C. Berry 1975	Males
		Neither sex
		Males
		Neither sex
Asterionic bone present	Akabori 1934	Neither sex
	Sublett 1966	Females
	A. C. Berry 1975	Males
		Neither sex
		Males
		Neither sex
*Auditory exostoses present	Hrdlička 1935	Males
	A. C. Berry 1975	-
		-
		Males
		Neither sex
Bregmatic bone present	Schultz 1923	Males
	Girdany and Blank 1965	Yes (sex not specified)
	A. C. Berry 1975	Neither sex
		Neither sex
		Neither sex
		Neither sex
Condylar facet double	Berry and Berry 1967	Neither sex
	‡Corruccini 1974	-
		Neither sex
	A. C. Berry 1975	Neither sex
		Males
		Neither sex
		Neither sex

APPENDIX D - Continued

Trait	Reference	Bias
Coronal wormians present	Sublett 1966 A. C. Berry 1975	Males Neither sex Males Neither sex Neither sex
Divided hypoglossal canal	Oetteking 1930 Sublett 1966 Ossenberg 1969 A. C. Berry 1975	Males Males Neither sex Neither sex Males Females ? Neither sex
Epipteric bone present	Oetteking 1930 Sublett 1966 DeVilliers 1968 Ossenberg 1969 A. C. Berry 1975	Males Females Neither sex Females Females Males Neither sex Females
Frontal foramen present	A. C. Berry 1975	Males Neither sex Males Neither sex
*Frontal grooves present	Dixon 1900, 1904 Sublett 1966 Ossenberg 1969 Corruccini 1974	Females Females Females Yes (sex not specified)
Frontal-temporal articulation	Collins 1926, 1939 Murphy 1956 DeVilliers 1968 A. C. Berry 1975	Neither sex Neither sex Neither sex Neither sex Females Females Neither sex

APPENDIX D - Continued

Trait	Reference	Bias
Highest nuchal line present	A. C. Berry 1975	Males Males Females Females
Hourglass nasal bone shape	Sublett 1966	Males
*Infraorbital suture present	Oetteking 1930 Akabori 1934 Ossenberg 1969 Corruccini 1974 Carpenter 1976	Females Females Females Yes (sex not specified) Yes (sex not specified) Yes (sex not specified)
Jugular foramen size	Oetteking 1930 Akabori 1934	Neither sex Neither sex
*Lambdic bone present	Akabori 1934 Sublett 1966 Berry and Berry 1967 DeVilliers 1968 Ossenberg 1969 A. C. Berry 1975	Males Females Neither sex Males ? Males ? Neither sex Males Neither sex Males
*Lambdoid wormians present	Kitson 1931 Sublett 1966 Ossenberg 1969 A. C. Berry 1975	Females Males Males Males Males Neither sex Neither sex

APPENDIX D - Continued

Trait	Reference	Bias
*Mandibular torus present	Moorrees *et al* 1952	Males
	Moorrees 1957	Males
	Suzukai and Sakai 1960	Males
	Sublett 1966	Males
	DeVilliers 1968	Neither sex
*Mastoid foramen absent	Akabori 1934	Females
	Berry and Berry 1967	Neither sex
	Corruccini 1974	Females
		Females
	A. C. Berry 1975	Females
		Females
		Females
		Females
Mastoid foramen exsutural	A. C. Berry 1975	Neither sex
		Neither sex
		Neither sex
		Neither sex
Maxillary torus present	DeVilliers 1968	Neither sex
	A. C. Berry 1967	Females
		Neither sex
		Neither sex
		Neither sex
Mental alveolar foramen present	DeVilliers 1968	Neither sex
*Metopism present	Limson 1924	Males
	Schultz 1929	Yes (sex not specified)
	Akabori 1934	Females
	DeVilliers 1968	Neither sex
	Ossenberg 1969	Females
	A. C. Berry 1975	Females
		Neither sex
		Females
		Neither sex

APPENDIX D - Continued

Trait	Reference	Bias
Multiple infraorbital foramen present	Sublett 1966 DeVilliers 1968 Spence 1971 A. C. Berry 1975	Males Neither sex Neither sex Males Males Females Females
Multiple mandibular foramen present	Sublett 1966 Corruccini 1974	Neither sex Yes (sex not Specified)
Multiple mental foramen present	Montagu 1954 Sublett 1966 DeVilliers 1968 Ossenberg 1969	Females Neither sex Neither sex Neither sex
Multiple zygomatico-facial foramen present	Berry and Berry 1967 A. C. Berry 1975	Neither sex Neither sex Neither sex Neither sex Females
Mylohyoid bridge present	Sublett 1966 Ossenberg 1969	Males Neither sex
Nasal foramen absent	Akabori 1934	Males
Open foramen ovale	Wood-Jones 1930 Akabori 1934 A. C. Berry 1975	Neither sex Neither sex Neither sex Females Neither sex Females

APPENDIX D - Continued

Trait	Reference	Bias
*Open foramen spinosum	A. C. Berry 1975	Females
		Females
		Neither sex
		Females
Os Inca present	Hooten 1930	Neither sex
	A. C. Berry 1975	–
		–
		Neither sex
		–
Os japonicum present	Oetteking 1930	Females
	DeVilliers 1968	Neither sex
	Ossenberg 1969	Neither sex
	A. C. Berry 1975	–
		–
		Neither sex
		Neither sex
*Palatine torus present	Miller and Roth 1940	Females
	Lasker 1947	Females
	Woo 1950	Females
	Suzukai and Sakai 1960	Neither sex
	Sublett 1966	Females
	DeVilliers 1968	Females
	Corruccini 1974	Yes (sex not specified)
		–
	A. C. Berry 1975	Females
		Neither sex
		Females
		Males
*Paramastoid process present	De Villiers 1968	Neither sex
	A. C. Berry 1975	–
		–
		Males
		Males

APPENDIX D - Continued

Trait	Reference	Bias
*Parietal foramen present	Russell 1900	Males
	Le Double 1903	Males
	Hooten 1930	Males
	Oetteking 1930	Males
	Boyd 1931	Males
	Akabori 1934	Neither sex
	Fenner 1939	Males
	Bass 1964	Males
	Sublett	Males
	DeVilliers 1968	Neither sex
	Ossenberg 1969	Males
Parietal notch present	Sublett 1966	Neither sex
	Berry and Berry 1967	Neither sex
	A. C. Berry 1975	Neither sex
		Females
		Neither sex
		Females
*Pharyngeal fossa present	Collins 1926	Females
	Oetteking 1930	Neither sex
	Ossenberg 1969	Females
Postcondylar canal present	Sublett 1966	Neither sex
	Berry and Berry 1967	Neither sex
	Ossenberg 1969	Females
	A. C. Berry 1975	Females
		Males
		Neither sex
		Males
Posterior ethmoid foramen present	DeVilliers 1968	Neither sex
	A. C. Berry 1975	Neither sex
		Neither sex
		Females
		Males
*Precondylar tubercle present	A. C. Berry 1975	Females
		Females
		Females
		Males

APPENDIX D – Continued

Trait	Reference	Bias
*Pterygoid plate spurs and bridges present	Hooten 1930 Chouké 1946 Sublett 1966 DeVilliers 1968 Ossenberg 1969	Males Neither sex Males Neither sex Males
Sagittal sinus turns left	Le Double 1903 Sublett 1966	Neither sex Neither sex
Sagittal wormians present	MacDonnell 1904 Sublett 1966	Neither sex Males
*Supramastoid crest present	Hooten 1930 DeVilliers 1968	Males Males
*Suprameatal pit present	Akabori 1934 Turner and Laughlin 1963	Males Males
Supraorbital foramen complete	Oetteking 1930 Akabori 1934 Fenner 1939 Sublett 1966 Berry and Berry 1967 DeVilliers 1968 Ossenberg 1969 A. C. Berry 1975	Neither sex Neither sex Neither sex Neither sex Neither sex Neither sex Neither sex Neither sex Males Males Neither sex
Transverse palatine suture bulges anteriorly	Oetteking 1930 Akabori 1934 Woo 1949 Sublett 1966	Females Neither sex Males Females

APPENDIX D – Continued

Trait	Reference	Bias
*Tympanic dehiscence present	Hooten 1930	Males
	Laughlin and Jorgensen 1956	Females
	Anderson 1962	Females
	Sublett 1966	Females
	DeVilliers 1968	Neither sex
	Ossenberg 1969	Females
	Corruccini 1974	– Females
	A. C. Berry 1975	Neither sex Females Females Neither sex
Tympanic marginal foramen present	Ossenberg 1969	Females
Tympanic thickening present	Sublett 1966	Neither sex
	DeVilliers 1968	Males
Vesalian foramen present	Ossenberg 1969	Neither sex

* Trait shows a sex bias in its expression

† Results are given for each of the four samples studied by A. C. Berry (1975) in the following order: Londoners, Burmese, Northwest Coast Indians, and Mexicans

‡ Results are given for each of the two groups studied by Corruccini (1974) in the following order: Whites and Negroes

APPENDIX E

SEX BIAS IN INFRACRANIAL NON-METRIC TRAIT EXPRESSION

Trait	Reference	Bias
Accessory sacral facet present	†Finnegan 1978	Neither sex Neither sex
Acromial articular facet present	Finnegan 1978	Yes (sex not specified) Neither sex
Anterior calcaneal facet absent	Finnegan 1978	Neither sex Yes (sex not specified)
Anterior calcaneal facet double	Anderson 1968 Finnegan 1978	Neither sex Neither sex Neither sex
*Atlas facet double	Finnegan 1978	Yes (sex not specified) Yes (sex not specified)
Acetabular crease present	Finnegan 1978	Neither sex Yes (sex not specified)
Emarginate patella	Finnegan 1978	Neither sex Neither sex
Fossa of Allen present	Finnegan 1978	Neither sex Yes (sex not specified)
Hypotrochanteric fossa present	Finnegan 1978	Neither sex Yes (sex not specified)

APPENDIX E - Continued

Trait	Reference	Bias
*Lateral atlas bridge present	Finnegan 1978	Yes (sex not specified) Yes (sex not specified)
Lateral extension talus present	Spence 1971 Finnegan 1978	Males Neither sex Neither sex
Lateral tibial squatting facet present	Finnegan 1978	Neither sex Yes (sex not specified)
*Medial tibial squatting facet present	Finnegan 1978	Yes (sex not specified) Yes (sex not specified)
Os trigonum present	Finnegan 1978	Neither sex Neither sex
Peroneal tubercle present	Finnegan 1978	Neither sex Neither sex
Poirier's facet present	Finnegan 1978	Neither sex Neither sex
*Posterior atlas bridge present	Le Double 1912 Selby et al 1955 Finnegan 1978	Males Males Neither sex Yes (sex not specified)
	Saunders and Popovich 1978	Males
Posterior atlas foramen present	Spence 1971	Males

APPENDIX E - Continued

Trait	Reference	Bias
*Sacralization of 5th lumbar vertebra	Hooten 1930 Olivier 1969	Males Males
*Septal aperture present	Akabori 1934 Trotter 1934 Glanville 1967 Anderson 1968 Olivier 1969 Finnegan 1978	Females Females Females Females Females Yes (sex not specified) Yes (sex not specified)
*Suprascapular foramen present	Hrdlička 1916 Hooten 1930 Finnegan 1978	Males Males Yes (sex not specified) Yes (sex not specified)
*Third trochanter present	Hrdlička 1937 Olivier 1969 Anderson 1978 Finnegan 1978	Females Females Neither sex Yes (sex not specified) Neither sex
*Trochanteric osteophytes present	Finnegan 1978	Yes (sex not specified) Yes (sex not specified)
Vastus fossa present	Finnegan 1978	Neither sex Neither sex
*Vastus notch present	Anderson 1968 Finnegan 1978	Males Neither sex Yes (sex not specified)

APPENDIX E – Continued

* Trait shows a sex bias in its expression

† Results are given for each of the two groups studied by Finnegan (1978) in the following order: Whites and Negroes.

APPENDIX F

DEFINITIONS OF NON-METRIC TRAITS

CRANIAL TRAITS

Foramina

Supraorbital foramen complete: The medial one-third of the superior margin of the orbit is the site of a foramen or notch which permits passage of the supraorbital vessels and nerve. The passage usually takes the form of a notch, which may be either broad and shallow or narrow and deep, but it may also approach or reach the stage of a closed foramen. This foramen is formed by ossification of a supraorbital ligament which crosses the notch. Other variations in this area include the presence of a foramen plus a notch, multiple notches or foramina or multiple notches plus a foramen. In terms of this study, the trait was recorded as present, if a foramen occurred on its own or as part of the variations indicated above (Figure 9).

Multiple infraorbital foramen: This foramen allows passage of the infraorbital nerve and vessels. It is usually single, but may be divided by a bar of bone, or occur as two or more separate foramina (Figure 9).

Zygomatico-facial foramen present: This foramen, occurring on the external surface of the lateral portion of the malar bone, opposite the junction of the infraorbital and lateral margins of the orbit, transmits the zygomatico-facial branch of the zygomatic nerve and a small artery. The foramen may be absent, single, or multiple. It is, on occasion, difficult to separate multiple foramina from the normal porosity of the bone. However, one or more of these foramina are usually distinctly larger than pores, and can be detected as zygomatico-facial foramen. The trait was recorded as present if at least one zygomatico-facial foramen was found (Figure 9).

Open foramen ovale: This foramen allows passage for the mandibular division of the fifth cranial nerve and the accessory meningial artery. In some cases, the postero-lateral wall of ovale is incomplete, making it continuous with the foramen spinosum (Figure 11).

Postcondylar canal absent: This canal usually pierces the condylar fossa immediately posterior to the occipital

APPENDIX F-- Continued

condyle, transmitting an emissary vein from the sigmoid sinus to the vertebral plexus of the spine. The foramen is sometimes absent (Figure 11).

Vesalian foramen present: These foramina, also known as sphenoidal emissary foramina, are the least constant of the emissary foramina. The vesalian foramen occurs anteromedially to the foramen ovale. The foramen is usually found near the base of the lateral pterygoid plate, but may lie anywhere from 2 mm from ovale, to some distance forward in the fossa pterygoidea. The foramen may take the form of a single foramen which is more or less oval in outline, or may be present in the form of a slit-like orifice or a number of irregular orifices scattered between ovale and the pterygoid fossa (Wood-Jones 1930) (not illustrated).

Multiple mental foramen: The mental foramen permits passage of the mandibular branch of the trigeminal nerve and its accompanying vessels from the interior of the body of the mandible to the external surface where it serves the fascia of the lower lip. The mental foramen is usually single, but may be multiple. Two types of accessory foramina occur: a) an extra foramen on or just within the rim of the principal foramen and separated from the latter by only a small spicule of bone, or b) an extra discrete foramen slightly smaller than the principal foramen. An accessory foramen may occur in any direction from the mental foramen, but is usually posterior to the it.

Wormians

Coronal wormians: Ossicles may occur in the coronal suture. The trait is recorded as present if at least one ossicle is found (Figure 9).

Sagittal wormians: Ossicles in the sagittal suture are recorded as present.

Bregmatic bone: An ossicle may occur at the junction of the coronal and sagittal sutures (the position of the posterior fontanelle) (Figure 9).

Os Inca: Occasionally the inferior and superior squama of the occipital bone are separated by a suture which runs from asterion to asterion. The bone created by this suture is known as an Inca bone, or Os Inca.

APPENDIX F - Continued

Asterionic bone: An ossicle may occur at the junction of the temporoparietal suture and the lambdoid suture - the point called asterion. The bone may vary in size, but is normally triangular in shape (Figure 10).

Parietal notch bone: The temporal bone in the fetus is composed of two parts separated by the squamosal suture of the temporal bone: a petrous portion and a squamous portion. Before the union of these two parts of the temporal at approximately six months in utero, a notch may form at the point where the squamosal suture meets the temporosquamosal suture. This notch may be present or absent, or may form a separate bone. Due to difficulties in scoring the presence of a notch, it was decided that only the presence of a notch bone would be recorded (Figure 10).

Other

Fronto-temporal articulation: The area of junction between the greater wing of the sphenoid, the frontal, parietal and temporal bones is known as pterion. The configuration of this area is variable: the sphenoid and parietal may articulate, the frontal and temporal may articulate, or the four bones may meet at one point. This study is concerned with the second variant, the articulation of the frontal bone with the temporal (Figure 10).

Os japonicum: The malar bone is usually single. However, it may be divided into superior and inferior portions by a transversozygomatic suture resulting from incomplete fusion of the two primary growth centers. The inferior portion is termed an os japonicum. Occurrence of a complete os japonicum is rare, but the transversozygomatic suture may be partially or faintly present on the lateral surface of the zygoma (Figure 9).

Maxillary torus: A bony hyperostosis known as a torus may occur on the surface of the maxilla just lateral to the molars. The torus may vary in size, but is usually globular and irregular in shape (Figure 11).

Condylar facet double: In general the articular surface of the occipital condyles is single. However, it may vary from single to hourglass to double. The trait is recorded as present if two distinct facets are found (Figure 11).

APPENDIX F — Continued

Mylohyoid bridge: The mylohyoid groove found on the internal surface of the ascending ramus of the mandible, lodges the mylohyoid vessels and nerve. Sometimes a bridge of bone is formed over this groove. This bridge may be partial or complete. Only complete bridges were included in this study (Figure 12).

INFRACRANIAL NON-METRIC TRAITS

Open foramen transversarium (atlas): The transverse process of the atlas vertebra is perforated at its base by a canal for the vertebral artery. Sometimes the lateral wall of this foramen transversarium is incomplete, and the foramen is described as open (Figure 13).

Divided foramen transversarium (atlas): The foramen transversarium of the atlas vertebra may be divided by a bar of bone (Figure 13).

Posterior arch foramen (atlas): The posterior arch of the atlas vertebra may display a small foramen (Figure 13).

Open foramen transversarium (axis): Same as for atlas vertebra.

Divided foramen transversarium (axis): Same as for atlas vertebra.

Unfused acromion process (scapula): The acromial epiphysis usually starts to fuse with the scapula before the seventeenth year, and fusion is usually complete between the eighteenth and twentieth year (Anderson 1978). However, occasionally the acromion fails to fuse with the body of the scapula and persists into adult life as a separate center (Figure 13).

Supracondylar process (humerus): A small spine or process may extend from the medial side of the humerus 5-7 cm above the medial epicondyle. A fibrous band joins this process to the medial epicondyle, and the median nerve and brachial artery pass through the foramen so formed (Anderson 1978) (Figure 13).

Trochlear notch form (ulna): The trochlear notch of the ulna may appear as a single, constricted or divided articular surface (Figure 13).

APPENDIX F - Continued

Acetabulum notch (innominate): The innominate consists of three distinctive segments that unite about the twelfth year: the ilium, ischium and pubis. The meeting point of these three elements is often characterized by an irregularity in the bone, which may take the form of a notch (Figure 14).

Acetabulum crease (innominate): The articular surface of the acetabulum may exhibit a fold, pleat or crease in the area between the junctures of the ilium with the pubis and ischium. The defect is not a remnant of incomplete fusion of these junctures, but "may arise anywhere along a line from the acetabular fossa superiorly to the border of the articular surface" (Finnegan and Faust 1974:11) (Figure 14).

Fossa of Allen (femur): The anterior superior margin of the femoral neck may display a reaction in the area close to the border of the head. "This reaction can vary from a small depression to a large eroded area one centimeter square where the cortical bone has been removed exposing underlying trabecular. The border of this fossa may have a ridge or thickening around it reminiscent of an inflammatory response" (Finnegan and Faust 1974:7). The trait is scored as present if a clearly defined depression is evident or if the underlying trabecular can be seen (Figure 14).

Emarginate patella: Occasionally, the supero-lateral angle of the patella ossifies independently and remains discrete, leaving a notch in the supero-lateral border (Figure 14).

Os trigonum (talus): A separate center of ossification appears for the postero-lateral tubercle of the talus (Steida's process) between seven and thirteen years. Sometimes this center fails to fuse with the body of the talus, and is then known as an os trigonum (Figure 14).

Anterior facet double (talus): The anterior calcanear facet of the talus may exist at two levels as a kind of double facet (Figure 14).

Anterior facet double (calcaneus): The anterior-middle facets of the calcaneus lie on the sustentaculum tali. These facets may be continuous, constricted or discrete. The occurrence of two discrete facets is recorded (Figure 14).