UNIVERSITY OF ALBERTA

BIOLOGICAL VARIATION AND POPULATION AFFINITY IN THE ANCIENT NILE VALLEY: AN ANALYSIS OF DENTAL MORPHOLOGICAL TRAITS

BY

ANDREW LAUREN JOHNSON ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of MASTER OF ARTS.

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The other was a softer voice,
As soft as honeydew:
Quoth he, "The man hath penance done,
And penance more will do."

~ From *The Rime of the Ancient Mariner*
by; Samuel Taylor Coleridge

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled BIOLOGICAL VARIATION AND POPULATION AFFINITY IN THE ANCIENT NILE VALLEY: AN ANALYSIS OF DENTAL MORPHOLOGICAL TRAITS submitted by ANDREW LAUREN JOHNSON in partial fulfillment of the requirements for the degree of MASTER OF ARTS.

Nancy C Lovell

Owen B Beattie

Sharon M Compton

For my sons, Joseph and Thomas...

Abstract

This thesis presents the results of an analysis of dental morphological traits of several samples from the ancient Nile Valley. The purpose of this analysis was to discern the degree of biological variation among these samples using the Mean Measure of Divergence (MMD) statistic. After determining, through simulations, that the MMD statistic can successfully be applied to small samples, an analysis was undertaken of three cemeteries from the site of Naqada. It was found that the sample from one of the Cemeteries (Cemetery T) which had been suggested as being an elite cemetery was distinguishable from the other cemeteries on the basis of dental morphological traits, in support of a hypothesis that this cemetery represented a ruling or elite class. An analysis of all nine of the samples from ancient Egypt and Nubia showed a considerable degree of biological differentiation. However, the samples representing the Nubian A- and C-Groups were similar, suggesting biological continuity, and were also similar to some Predynastic Upper Egyptian samples, leading to the conclusion that these Nubian populations may have been derived from Predynastic Upper Egyptian populations. Further, it was found that three samples associated with royal or elite burials were not significantly different from each other. This may be seen as supporting the hypothesis that an immigrant population gave rise to the Dynastic period, or alternatively, that a ruling or elite class developed *in situ* out of the Predynastic population at Naqada and, through preferential within class marriage rules and genetic drift, over time became biologically distinct from the general population. The similarity between the Naqada Cemetery T sample and the two later samples associated with royal burials from Abydos and Giza may then reflect a biological continuity of this ruling class. However, such hypotheses cannot be fully tested at the present time.

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Chapter One

Dental Morphology of Ancient Egyptians: Introduction and Background

Introduction

This thesis is a contribution to the investigation of the biological affinities of several Predynastic and Dynastic period skeletal samples from Egypt and Nubia based upon dental morphological traits. A total of ten samples were used in this investigation spanning a time frame of some 3000 years from the early Predynastic (ca. 4500 B.C.) to the end of the 2nd Intermediate period (ca. 1500 B.C.), and a geographical range along the Nile Valley from Giza in Lower Egypt to the second cataract just south of Wadi Halfa in Lower Nubia. As such, these samples can allow an investigation into the degree of biological continuity in ancient Egypt during the critical period in which occurred the rise of the Dynastic phase marked by the political unification of Egypt (ca. 3050 B.C.).

Wenke (1991) characterizes the period from 4000 to 2000 B.C. in Egypt as a single transformational epoch— in terms of environmental, agricultural, and demographic variables— which culminated in the mature Old Kingdom state just prior to 2000 B.C. A great deal of research has been done regarding the processes and mechanisms by which this transformation took place, and much of this has focussed on to what degree the rise of Dynastic Egypt could be due to contacts with, or invasions from, other geographical regions such as western Asia, Sub-Saharan Africa, and the circum-Mediterranean area (for reviews see: Adams 1968; Arkell and Ucko 1965; Blanc 1978; Hassan 1988; Hoffman 1979; Kemp 1983; Trigger 1983; Tutund Zic 1989; Vercouter 1978; Wenke 1989, 1991). With the wealth of skeletal remains recovered in the late 19th and early 20th century many scholars immediately sought to sort out the issue of who the ancient Egyptians were through comparisons of measurements of their skeletal elements—primarily crania—with skeletal series from other, already quantified, "racial types" to construct a "racial history" of Egypt (for example: Angel 1972; Batrawi 1945, 1946; Fawcet and Lee 1902; Morant 1925, 1935; see also: Brace *et al.* 1993; Keita 1992).

While so-called "biological affinity" or "biological distance" studies of skeletal material originated with comparisons of metrical data of the crania, more recently, other types of data have been successfully applied to questions of biological affinities among human skeletal samples—notably, non-metric characteristics (also referred to as epigenetic variants) of the cranium (Berry, Berry and Ucko 1967; Berry and Berry 1967, 1972; Saunders 1989), and, more importantly for this study, morphological variations of the human dentition (for review see Scott and Turner 1988). While dental morphological studies have been highly successful in characterizing populations and population movements in many parts of the world, there has been very little such research done on skeletal samples from the Nile Valley and what has been done has focussed primarily on samples from Lower Nubia (Greene 1966, 1972; Irish and Turner 1990; Turner and Markokwitz 1990).

The research objectives of this thesis were threefold: 1) to assess the usefulness of the multivariate Mean Measure of Divergence (MMD) statistical technique for measuring biological affinity using discrete characters under conditions of small and variable sample sizes, 2) to assess the degree of biological differentiation among three Predynastic cemeteries at the site of Naqada, one of which has been suggested as representing an 'elite' burial cemetery, using dental morphological traits—the focus of this analysis was to determine whether there was any biological differentiation associated with the presumed social differentiation of the elite cemetery, and 3) to assess the degree of biological differentiation or continuity during the 3000 year phase spanning the early Predynastic to the Middle Kingdom period in ancient Egypt and Nubia. The following three chapters will address, independently, each of the research objectives mentioned above and will contain their own materials and methods sections and their own bibliographies.

Subsequent sections of this chapter will provide: background information on the chronology of ancient Egypt; previous investigations regarding biological affinities of the ancient Egyptians; a discussion of the samples used in the present study; and information on the use of dental morphological traits in studies of biological affinity.

Brief Chronology of Ancient Egypt

After the late Paleolithic the chronology of Egypt is divided into two distinct periods, the Predynastic and the Dynastic, each of which are further sub-divided on the basis of either archaeologically defined cultural groups or political events. The chronological boundary between these two broad divisions is marked by the political unification of Egypt (ca.3050 B.C.)—an event that defined the transformation of social structure along the Nile from one characterized by many settlements or communities of at least somewhat independent local rule to one in which the whole of Egypt was unified under a single political system of divine kingship (Trigger *et al*. 1983).

Though there are several roughly equivalent systems of dividing the Predynastic into chronological periods, the simplest of these uses only three periods, the early, middle, and late Predynastic periods which correspond to the Badarian, Amratian and Gerzean cultural phases respectively. The final 250 years of the late Predynastic period is often referred to as the Protodynastic, or equivalently the Naqada III period. The dates for these periods (see Table 1.1) are by no means fully agreed upon by scholars, though discrepancies between various authors are usually not too great (Hassan 1988; Hoffman 1988; Trigger 1983).

The Badarian phase, from roughly 4400-3800 B.C. (Hassan 1988), developed in central Egypt and is reflective of a simple semi-sedentary way of life with a mixed subsistence pattern of hunting, fishing and some degree of agriculture (Arkell and Ucko 1965; Hoffman 1988). Burials in the Badarian period were usually simple pits, either oval or rectilinear, containing one or more bodies in a loosely contracted position on their left sides with their heads to the south, and often covered with a matted roof (Trigger 1983). Grave goods were often included in burials and although Trigger (1983) argues that there are no obvious distinctions in wealth among the graves, Hoffman (1988) states that the clear differences in the quality and number of goods in some graves is suggestive of a society already stratified by wealth and status differentiation.

The Amratian phase, ca 3800-3500 B.C., appears to have developed directly from the Badarian as suggested by numerous similarities in material goods such as pottery, slate palettes and ivory combs, and by stratigraphic continuity at the sites of Hemamieh and Hierakonpolis (Arkell and Ucko 1965; Hoffman 1988). The subsistence of the Amratian appears little different from the Badarian (Trigger 1983), but with perhaps a more developed agricultural component and less concentration on hunting (Hassan 1988). Graves are generally larger and more richly furnished and reflect wealth and status differences even more clearly than in the Badarian (Hoffman 1988; but see Trigger 1983 for contrasting view).

The Gerzean phase (3500-3050 B.C.) has been generally thought to reflect an invasion of peoples from southwest Asia or from the northern delta region of Lower Egypt into Upper Egypt (Arkell and Ucko 1965; Grimal 1992; Trigger 1983). However, Arkell and Ucko (1965) and Hoffman (1988) see no reason not to believe that the Gerzean actually developed in Upper Egypt and then spread to the south and north. Most evidence of this period comes from Petrie's excavations of the cemeteries at the Naqada site. These cemeteries continue the trend of increasingly rich grave good inclusions and the richest tombs are located in a separate cemetery suggesting that wealth and status differentiation had become a dominant theme by this time period (Hoffman 1988).

With the political unification of Egypt begins the historic or Dynastic phase of Egypt. The general chronology of the Dynastic period comes from the Egyptian historian Manetho who probably lived in the late fourth and early third century B.C., and wrote a history of Egypt (Hoffman 1979). Manetho's chronicle grouped the kings into thirty dynasties, thought to represent ruling families. These have since been assembled, by Egyptologists and archaeologists, into the larger categories of the: Archaic period, the Old Kingdom, the Middle Kingdom, the New Kingdom, and the Late period, with the three Intermediate periods immediately following each of the Kingdoms (Hoffman 1988). These groupings generally reflect political events such as the shifting of the capital center of rule or the partial collapse of the polity in the Intermediate periods.

The Archaic period, which covers the first two dynasties, runs from 3050-2700 B.C. and represents the time of consolidation under pharaonic rule (Hoffman 1988). The city of Nekhen, or Hierakonpolis, has been suggested as the seat of power during the Archaic period, but it is the city of Abydos where the royal tombs were located during this period.

The Old Kingdom begins with the Third Dynasty (2700 B.C.) and continues until the end of the Sixth Dynasty (2230 B.C.) and is marked by a relocation of the central government to the northern delta city of Memphis. This period is also referred to as the "Age of the Pyramids" during which the step pyramid at Saqqara was built for king Djoser in the Third Dynasty followed by the so-called Great Pyramids of the Fourth Dynasty which were built for Khufu (Cheops) and his successors Chephren and Menkaure (Grimal 1992; Willoughby and Terry 1988). The First Intermediate period (2230-2050 B.C.: Dynasties VII to X) represents a time of political and religious upheaval in which no one ruler was able exert control over all of Egypt, and may have been partially caused by a serious decline in rainfall which would have necessarily affected resources (Wenke 1990; Willoughby and Terry 1988).

In the Middle Kingdom (Dynasties XI to XII; 2050-1750 B.C.) Egypt was once again united under one ruler, Mentuhotep II and his successors, and a great deal of expansion in trade was undertaken as well as a recommencement of monumental architecture (Wenke 1990). This stability and expansion were to be rather short lived, however, as foreign invaders (the Hyksos) gradually took over Egypt in what is referred to as the Second Intermediate period which lasted from about 1750-1552 B.C.(Hoffman 1988; Wenke 1990). This period was followed by the New Kingdom (1552-1080 B.C.) which is a period not considered in this study but is well known for the monuments of Ramesses II and, of course, the boy king Tutankhamun (Willoughby and Terry 1988).

Lower Nubia lies at the southern end of Egypt, and the Nubian cultural periods of interest in this study are referred to as the A-Group and C-Group periods. The Nubian A-Group is thought to begin just prior to the Dynastic period of Egypt and ends at the end of the First Dynasty probably due to the military incursions of Egypt into the Lower Nubian region (Adams 1977; Trigger 1983). Although the A-Group peoples are thought to have been somewhat egalitarian, some of the evidence from apparently wealthy graves may indicate some level of stratification (Geus 1991) or even Kingdoms (Haynes 1988). Material goods suggest that the A-group peoples traded extensively with Egyptians and perhaps with western Asians as well (Adams 1977; Trigger 1983).

Although a B-Group was originally proposed to follow the A-Group, this has not been shown to be a viable archaeologically defined group and is rather thought to be an impoverished form of the A-Group during a time of rather sparse occupation (Adams 1977). The C-Group period is generally thought to begin during the First Intermediate period, perhaps due to a lack of political influence from Egypt at the time, and lasts through the Middle Kingdom and the Second Intermediate period after which Lower Nubia was again invaded and annexed by Egypt (Adams 1977; Adams 1968). The C-Group peoples practiced farming and had a highly developed cattle complex (Adams 1968; Haynes 1988).

Physical Anthropology

During the late nineteenth and early twentieth centuries, migration was the dominant form of anthropological explanation for cultural change. Indeed, at one time or another, each of the Predynastic cultural groups outlined in the previous section, as well as the two Nubian groups, have been explained as the result of a migration or invasion of new peoples into the area (see for example: Adams 1968; Arkell and Ucko 1965; Hassan 1988; Hoffman 1979; Petrie and Quibell 1896; Trigger 1983). More recently, *in situ* evolution and continuity have become more favored themes of anthropological thought.

The tools and techniques of physical anthropology have long been applied in attempts to answer questions regarding migrations, admixture and *in situ* evolution by attempting to discern the 'racial' types present in ancient Egypt. Race is a biological term referring to a taxonomic category below the species level and is an essential concept in evolution (Chopra 1992). Though most of modern evolutionary biology prefers the term subspecies, the term 'race' is still often used when referring to modern human groups and their relatively recent (post-Paleolithic) ancestors. Essentially, a race or subspecies is a group of organisms which are more or less reproductively isolated from other such groups and in which selection and drift processes may be operating to produce genetic differences which may eventually lead to speciation (Mayr 1988; Sober 1984). That the so-called major human races around the world have been shown to contain more variation within them than between them, and that when finer grain analyses are done the variation between geographical areas often shows a clinal distribution, is suggestive that the assessment of 'race' for any particular human group will be problematic (Brace *et al*. 1993; Keita 1992; Wiercinski 1978). Nevertheless, the history of physical anthropology in general, and the physical anthropology of ancient Egypt in particular, has been dominated by a typological approach to the classification of ancient peoples into racial groupings.

The basic racial types of concern to most studies of ancient Egypt and Nubia are those referred to as Negroid, Caucasoid, and a Mediterranean type, all of which are problematic categories (Keita 1992). The general hypothesis suggests that there was a hiatus in the occupation of the Nile Valley prior to the Badarian phase, and that the subsequent Egyptians were not indigenous to the area but that instead the Nile Valley served as a corridor and melting pot for various incursions of Negroid, Caucasoid and Mediterranean peoples (Adams 1968; Brace *et al*. 1993; Carlson and Van Gerven 1979; Keita 1992; Vercouter 1978). The majority of the investigations have been based upon metric characteristics of the crania (Batrawi 1945, 1946; Billy 1977; Brace *et al*. 1993; Crichton 1966; Derry 1956; Keita 1992; Morant 1925,1935; Stoessiger 1927) though more recently non-metric traits of the crania have been investigated (Berry, Berry and Ucko 1967; Berry and Berry 1967, 1972; Wiercinski 1969) and some recent and Paleolithic Nubian populations have been compared on the basis of dental morphological traits (Greene 1966, 1972; Irish and Turner 1990; Turner and Markokwitz 1990).

The results of all of these studies have not been altogether in agreement with each other, though the notion that the ancient Egyptians did not form an insular and homogeneous population throughout the Predynastic and Dynastic periods is a recurrent theme. The studies of Morant (1925, 1935), Stoessiger (1927) and Batrawi (1945, 1946) suggest that there were two distinct 'racial' types in ancient Egypt—an Upper Egyptian and a Lower Egyptian type. These authors concluded that the Upper Egyptian type gradually gave way to the Lower Egyptian type due to admixture. Derry (1956) also noted a Northern and Southern race in Egypt, though he saw the Northern race as having come from Western Asia and eventually being responsible for the rise of the Dynastic phase—this was Derry's "Dynastic Race". Petrie (Petrie and Quibell 1896) had also postulated a "New Race" as responsible for Dynastic origins, though the existence of this "New Race" was based on differences in grave goods in the Naqada cemeteries, which turned out to be from the Predynastic period.

More recently, Keita (1992) has re-analyzed crania from Abydos and other sites using metric data and found some evidence of heterogeneity and admixture, though he does not suggest that the Egyptians of the First Dynasty were of an external origin. Brace *et al*. (1993) have also re-investigated ancient Egyptian crania with metric techniques and found that the Egyptians had definite biological ties to the North and the South, as well as being intermediate between West and Eastern populations, but that the Egyptians themselves have remained relatively uninfluenced—biologically— from Neolithic to recent historic times.

Studies using non-metric traits of the human cranium (Berry, Berry and Ucko 1967; Berry and Berry 1967, 1972) applied to several ancient Egyptian populations suggest a great deal of continuity from the Predynastic through the Dynastic periods. However, these studies did find some difference between the Badari sample and the later Predynastic and Dynastic series studied.

Greene (1966, 1972) has examined the dental morphology of three historical Nubian samples (Meroitic, X-Group, and Christian—ca. 500 B.C.-1350 A.D.) and found strong evidence for continuity among these samples. He also (1972) suggests, through a comparison of his data with other literature regarding Predynastic Egyptian dental morphology, that there is a good deal of similarity between Predynastic Upper Egyptians and the more recent Nubian samples. Turner and Markowitz (1990) and Irish and Turner

(1990) have also applied dental morphological studies to these same three Nubian populations and found strong support for continuity from the Meroitic to the Christian period. However, these same studies also included a Late Paleolithic Nubian sample and the large differences found between this sample and the later samples leads these authors to conclude that a Holocene population replacement had definitely occurred within this region.

Sources of the Samples

The samples which form the basis of this study come from the following sites: Badari, Naqada, Naga ed Der, Qena (Keneh), Abydos, Giza and the two Nubian sites designated SJE277 and SJE179. The locations of these sites along the Nile River are shown on the map in Figure 1.1.

Badari was excavated by Guy Brunton in the early 1920's and published shortly thereafter (Brunton 1927, 1928, 1930; Brunton and Caton-Thompson 1928). The site is located in Middle Egypt and is the type site for the Badarian culture. There are no absolute dates for this site thus it can only be assigned to the general Badarian or Early Predynastic phase ca. 4400-3800 B.C. The sample used in this study consists of 69 individuals and is part of the Duckworth Collection housed at Cambridge University.

The site of Naqada is located not far from modern Luxor in Upper Egypt and is perhaps the most famous Predynastic Egyptian site. Flinders Petrie excavated three cemeteries at Naqada (Cemetery B, T and the Great Cemetery) in the mid-1890's, though only a small portion of the burials was actually published in his report of the site (Petrie and Quibell 1896; Hoffman 1979). The Great Cemetery was the largest and contained 1,953 burials while Cemetery B and T contained 133 and 57 burials respectively. These cemeteries were in use during both the Amratian and Gerzean periods, though Cemetery T may have only been in use in the latter part of the Gerzean (Hoffman 1979). Cemetery T, as mentioned above, has been postulated as the burial ground for an elite or special status group on the basis of the larger and more richly furnished tombs contained there (Arkell and Ucko 1965; Davis 1983; Hoffman 1979; Petrie and Quibell 1896). The actual Naqada material used in this study consists of 131 individuals: 67 from the Great Cemetery, 38 from Cemetery B and 26 from Cemetery T. This material is also housed at Cambridge University as part of the Duckworth Collection.

The site of Naga ed Der is located in Upper Egypt and was excavated by George Reisner in the early 1900's (Hoffman 1979). The material used in this study comes from the

Predynastic cemetery N 7000 and covers a time span of some 600 years from 3900-3300 B.C. (Podzorski 1990). Only 20 individuals were well enough preserved to collect dental data from, and these are currently housed at the Hearst Museum at the University of California, Berkeley.

The site of Qena is located just a little north of the site of Naqada on the East bank of the Nile. Excavated by Reisner, the site has never been published, though his field notes reveal that this site also fits chronologically into the Late Predynastic period (Lovell; pers. comm.). The human remains used in the present study (n=50 individuals) are currently housed at the Peabody Museum of Harvard University.

While the site of Abydos was occupied in the Predynastic period, it is the royal tombs of the first two Dynasties, discovered by Petrie in the late nineteenth century, for which the site is best known (Trigger 1983). A nearby cemetery was excavated later by Peet (1913, 1914), and subsequently identified as the "Tombs of the Courtiers" for the First Dynasty rulers (Petrie 1925). It is the human remains from these tombs (n=50 individuals) that form the Abydos sample used in this study, and these are part of the Duckworth Collection at Cambridge University.

The site of Giza, in northern Egypt, is perhaps the most famous ancient Egyptian location, known for the Great Pyramids of the Old Kingdom. Forty-six individuals from Giza were examined for the present study. These were excavated by Reisner in the early twentieth century and belong to the mastaba tombs of the royal attendants, adjacent to the Great Pyramid, dating to the Fourth and Fifth Dynasties and are currently housed at the Hearst Museum at the University of California at Berkeley.

The two Nubian sites used in the present study are located near Wadi Halfa and were excavated by the Scandinavian Joint Expedition, as part of the UNESCO archaeological salvage project brought about by the construction of the Aswan Dam. The A-Group site, SJE277, is located just south of Wadi Halfa and dates to the latest Predynastic and earliest Dynastic period of Upper Egypt (Nordström 1972). The C-Group site is located just north of Wadi Halfa and is coeval with the First Intermediate period and the early Middle Kingdom (Vagn Neilson 1970). The material used here, 34 individuals from the A-Group site and 38 individuals from the C-Group site, is now housed at the Laboratory of Biological Anthropology at the University of Copenhagen.

Dental Morphology and Population Affinity

Because they are durable, evolutionarily conservative and contain a wealth of morphological and genetic information, teeth and dentitions have been of great value in paleontological and evolutionary anthropological research for over a century (Keene 1991). Since the early part of the twentieth century, tooth morphology has been used to study recent human population relationships and discriminate among the various 'races' of the world (Dahlberg 1945,1951; Hellman 1928; Hrdlicka 1920,1921; Scott 1980; Turner and Scott 1977). The majority of more recent work has focussed upon much finer scales of microdifferentiation among local groups (Greene 1966, 1972; Haeussler *et al*. 1989;; Hemphill *et al*. 1991; Irish and Turner 1990; Scott *et al*. 1983; Sofaer *et al*. 1986; Turner and Markowitz 1990; Turner 1987).

Following Dahlberg's (1951, 1963) classic work on American Indian dental morphology, Christy Turner II has gone on to reconstruct population histories of American Indians and several West Asian and Pacific populations using dental morphological traits (Turner 1971, 1976, 1983a, 1983b, 1987; Turner and Hanihara 1977). Turner's research on the peopling of the Americas concords well with archaeological and linguistic evidence for three separate migrations into the New World, though he is probably best known for his delineation of two dental morphological patterns among West Asian and Pacific populations— Sinadonty and Sundadonty— and his discussions of the evolution of these patterns and their significance in the origins and dispersal of modern humans (Turner and Scott 1988; Turner 1983b, 1987, 1992).

Turner (1986) has also formulated a technique for estimating times of divergence between populations based on dental morphological distances calculated with the MMD statistic. This technique, "dentochronology", is still quite experimental though many of its estimates concur with other independent lines of evidence (Scott and Turner 1988).

One problem with dental morphological studies in the past has been a lack of standardization in scoring procedures leading to difficulties in comparing the results among various researchers (Mayhall 1992). Early on, A.A. Dahlberg developed a set of plaques to standardize the scoring of variants of several dental traits, and these have been widely used in studies of dental morphology (Mayhall 1992). Christy Turner II has since developed a set of plaques for a larger number of traits and has provided a published description of the scoring criteria for each trait (Turner *et al*. 1991). Turner's plaques are available from the

Department of Anthropology, Arizona State University, and were used in the present study.

A problem related to the standardization of scoring criteria is that there is more than one method of calculating the frequencies of traits, and this is due to the fact that dental traits are bilateral and often demonstrate fluctuating asymmetry. There are three basic methods for calculating frequencies of bilateral dental morphological traits: the total tooth count method, the unilateral count method, and the individual count method (Scott 1980). The individual count method is recommended by Scott (1980) and Turner and Scott (1977) because it maximizes sample size relative to the number of individuals who possess only a single antimere, and provides the best overall estimate of total trait and individual grade frequencies. In the individual count method, all traits are scored on both antimeres (if present), but only the antimere exhibiting the highest grade of trait expression is used in the calculation of trait frequencies. This method assumes that when asymmetry is present, the antimere which demonstrates the higher grade of expression for a trait is more reflective of the underlying genotype (Scott 1980).

Another possible difficulty with using dental morphological traits to discern population relationships is that these are phenetic traits and as such can only be useful in studies of population relationships if the variation in such traits has a strong genetic component (Saunders 1989; Turner and Scott 1988). The genetics and inheritance of dental morphological traits are not fully understood at the present time (Dahlberg 1965; Keene 1991; Mayhall 1992), and this has led some (e.g., Berry 1976) to question their utility in studies of biological distances. However, many studies have shown a strong congruence between distances calculated from dental morphological data and others based on genetic and linguistic data (Scott and Dahlberg 1982; Scott *et al.* 1983; Scott *et al.* 1988: Sofaer *et al.* 1986).

Recent studies of dental genetics have shown that morphological traits show a polygenetic inheritance pattern, though some major gene action has also been detected (Dahlberg 1971; Goose and Lee 1971; Nichol 1989; Scott and Turner 1988; Sharma 1992). The specific mechanisms underlying the differentiation of the dentition into morphological types, and the morphological variation within tooth types is poorly understood at the present time (Dahlberg 1965; Keene 1991). The two dominant models in the past have been Butler's Field Model (Butler 1939) and Osborne's Clone Model (Osborne 1973, 1978). Keene (1991) summarizes these two models as follows: Essentially, the Field Model of dental morphogenesis suggests that aspects of morphology and size are determined by the position or type and the strength of the morphogenetic field into which ectomesenchymal (tooth forming) cells migrate; while the Clone Model, on the other hand, suggests that morphogenetic properties are already possessed by the ectomesenchymal cells prior to migration and that clones of these cells migrate into the tooth bearing portions of the developing jaw.

Heterchrony, or differences in timing of various developmental parameters, probably accounts for some of the variation in size, cusp number and morphology of the human dentition. The parameters of importance are the timing of the onset of proliferation of inner enamel epithelium cells and the onset of differentiation within the inner enamel epithelium, and these parameters are thought to be largely under genetic control (see review by Keene 1991). Thus, variation in dental morphology is likely due to a multifactorial process involving the direct genetic specification of certain aspects of tooth form (perhaps cusp generating mechanisms), and the influence of genetically controlled developmental parameters.

The evolutionary perspective regarding dental morphological traits is that most such traits are selectively neutral and their relative frequencies are primarily effected by genetic drift, founder effects and gene flow (Scott and Turner 1988). It has been postulated, however, that crown simplification may be passively related to the general Holocene reduction in tooth size among most human populations, or actively selected for because simplified crowns may be less susceptible to dental caries (Greene 1972; Scott and Turner 1988). It is, however, likely that such selection pressure would be minimal over such a short period of time as considered in the present study.

While much of the earlier work in the field of population studies based upon dental morphology has used simple frequency comparisons and univariate statistics, more recently the multivariate MMD statistic has been applied as it provides an average distance statistic which is useful in comparing populations. The MMD statistic was developed by C.A.B. Smith and was first used in measuring genetical change in mice (Grewal 1962). This statistic has since become common in population comparisons based upon non-metric cranial traits and dental morphological traits (Berry *et al.* 1967; Berry and Berry 1967, 1972; Hemphill *et al.* 1991; Irish and Turner 1990; Lukacs and Hemphill 1991; Sofaer *et al.* 1986; Turner and Markowitz 1990).

The primary assumption in using the MMD statistic is that the traits under consideration are independent of each other (Sjøvold 1973). Recent studies have shown that many dental morphological traits have low intertrait correlations (Sofaer *et al*. 1986; Turner and Markowitz 1990), though Sjøvold (1977) suggests that this is likely due to the small samples used in many comparisons. However, Sjøvold (1977) also contends that because the sample sizes in most anthropological studies are relatively low, intertrait correlations should not affect distance studies any more than the random fluctuations of independent variables.

The MMD statistic is related to the Chi-squared statistic with an expectation of zero and thus, with sufficiently large samples it approximates a normal distribution. Hence, if an MMD value exceeds twice its standard deviation it is significant at the .05 level (Sjøvold 1973, 1977). The MMD statistic is often referred to as a 'distance' statistic, however this is somewhat misleading and has perhaps led to certain misuses of the technique. The statistic itself is non-euclidean which means, among other things, that it may not satisfy the "triangle inequality" and that negative values may be obtained (Sjøvold 1973, 1977). Sjøvold (1973) states that a negative value is interpretable as analogous to a Chi-square value not exceeding its expectation, and is to be expected if there is little difference between the two populations being compared. In fact, if two populations are identical in all trait frequencies, they will obtain a negative MMD value whose magnitude is inversely proportional to the size of the samples used in the calculation. Thus, while the MMD statistic is appropriate when assessing whether or not two populations differ significantly in their trait frequencies, it is clearly inappropriate to use a matrix of MMD values as input for a procedure (such as multidimensional scaling) designed to reduce the dimensionality (and thereby enhance visualization) of euclidean distances.

Because the permanent teeth do not continue to develop once they are fully formed, the age of individuals is only a problem in terms of carious lesions, tooth loss, and tooth wear all of which can render particular teeth or traits unobservable. However, some studies have found differences between the sexes for a few traits, though this dimorphism is population specific and usually slight (Mayhall 1992). Chi-squared statistics are used to assess sex differences on a trait by trait basis within each population, and, in order to increase sample sizes by pooling of the sexes, any traits found to be significantly different between the sexes in the populations being compared are generally dropped from the analysis of population affinity.

Summary

The origins of ancient Egyptian civilization has long been a concern of anthropologists and Egyptologists, and much debate has surrounded the question of whether this civilization was the result of a slow, continuous, *in situ* development, or the result of outside influences and migrations of peoples from elsewhere. Physical anthropological studies have often been applied to skeletal series from ancient Egypt and Nubia in an attempt to answer these questions by reconstructing a racial history of Egypt through a determination of the biological relationships among the various Predynastic and Dynastic populations using various skeletal and dental characteristics. Many of the earlier studies emphasized differences and, following the dominant mode of explanation of culture change at the time, supported postulations of various migrations to account for the changes seen both in the Predynastic and the Dynastic periods. The demise of typological approaches and the concept of true "races", and a greater sensitivity to variation and to finer scales of analysis have led to recent revisions which emphasize continuity, *in situ* evolution and clinal patterns as evidence of gene flow among local populations.

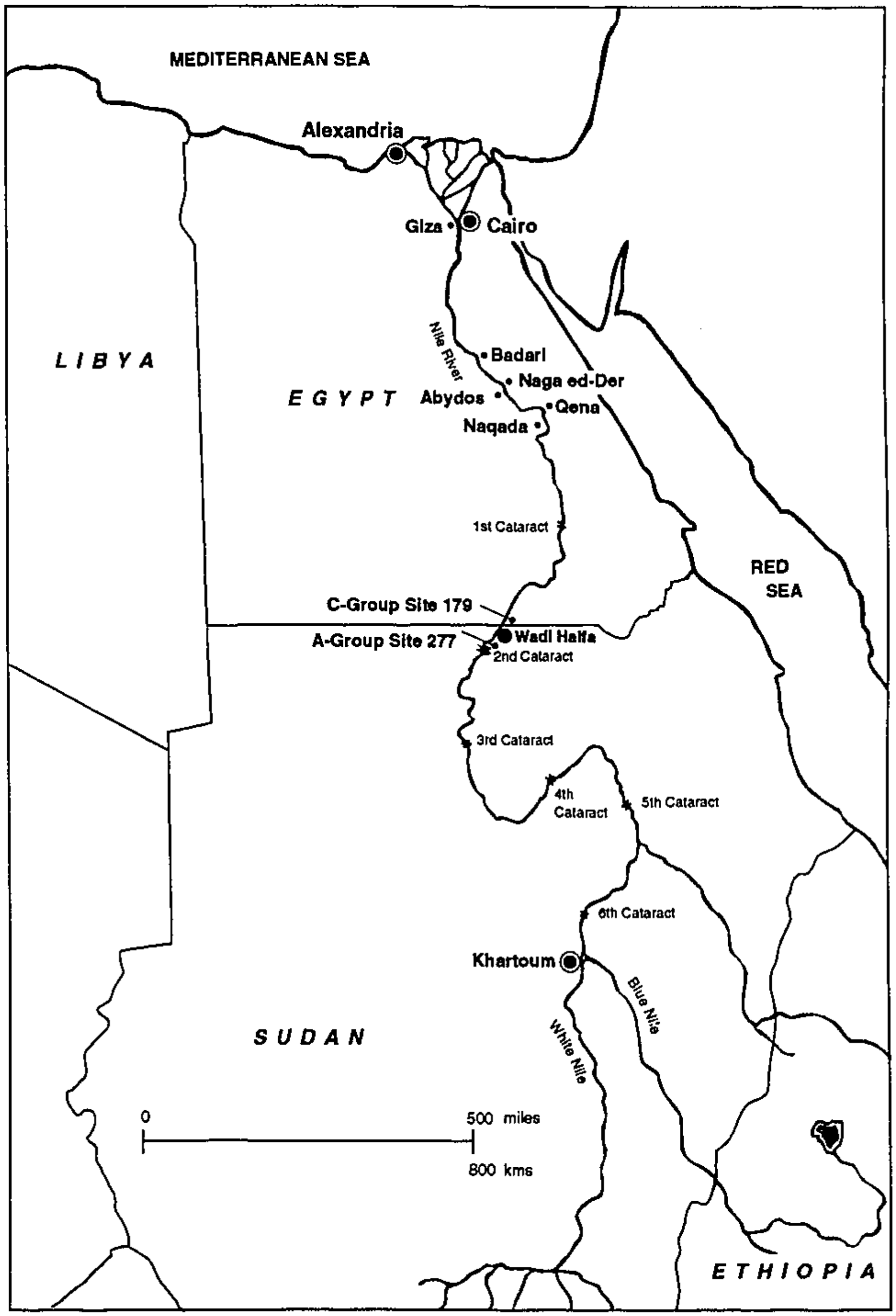
Dental morphological studies have shown a great deal of success in assessing the relationships among populations, but the application of these techniques to skeletal populations of ancient Egypt and Nubia has been minimal. Such traits show a strong genetic component and the analysis of these traits can be used in studies of microdifferentiation among local groups. This thesis will apply modern statistical methods in an analysis of dental morphological traits to a series of skeletal populations in an attempt to assess the degree of biological continuity from the Early Predynastic through to the Middle Kingdom period of ancient Egypt and Nubia.

Table 1.1 Cultural Chronology for ancient Egypt and Nubia

	Egypt	Lower Nubia
4400 B.C.	Badarian	Neolithic
3800 B.C.	Amratian	
3500 B.C.	Gerzean	
3000 B.C.	Archaic	A-Group
2700 B.C.	Old Kingdom	
2200 B.C.	1st Intermediate Period	
2000 B.C.	Middle Kingdom	C-Group
1700 B.C.	2nd Intermediate Period	
1500 B.C.		

[the dashed lines between the A- and C-Groups in Nubia refers to fact that the region was very sparsely occupied during this time with no clearly defined archaeological complexes]

Figure 1.1 Map of Egypt and Lower Nubia showing locations of all of the sites used in the analysis



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Chapter Two

Small Sample Sizes and the MMD Statistic: a Monte Carlo Simulation

Introduction

A brief review of some recent studies which have used the Mean Measure of Divergence (MMD) statistic (Hemphill et al., 1991; Irish & Turner, 1990; Lukacs & Hemphill, 1991; Sofaer et al., 1986; Turner & Markowitz, 1990) suggests that many anthropological investigations involve sample sizes which fail to measure up to what might be considered a reasonable interpretation of "moderate" or "large" sample sizes. With regard to significance testing, the distributional properties of the MMD statistic, as developed by Sjøvold (1973), are approximate for "moderate" sample sizes, and exact for "sufficiently large" sample sizes. In particular, Sjøvold (1973) suggested that when an MMD statistic exceeds twice its standard deviation, it is significant with α=.05, and Green and Suchey (1976) suggested that when an MMD statistic exceeds twice its standard deviation it is significant with α=.03. While work has been done in regards to the various forms of angular transformations for trait frequencies (Green and Suchey, 1976), little has been done to assess how well these distributional properties apply to small sample sizes.

The number of individuals used in a particular study may seem to be reasonably large, but it is the number of individuals observable for particular traits that is the real criterion. In this regard, the proportion of actual observable individuals ranges from 15% to 100% (i.e., up to 85% missing data) of the number of individuals in the studies cited above, and in many cases the number of observable individuals for a particular trait falls below ten. This paper presents the results of Monte Carlo simulations to assess the robustness of the MMD statistic, in terms of type I errors, under a broad array of sample sizes, including situations in which the number of observations within trait categories fluctuates widely.

Methods

A primary assumption in the use of the MMD statistic is that all of the traits are independent of each other (Sjøvold, 1973). This lends itself well to the use of simulations, in that a parent population can be programmed with trait frequencies defined by simple probability functions. For all simulations in this study, a parent population was defined with known trait frequencies and pairs of samples were randomly drawn from the parent populations. Samples were drawn with replacement from a parent population of size n=100. Observed trait frequencies of the sample were arcsine transformed using the Freeman- Tukey angular transformation suggested by Green and Suchey (1976) for small sample sizes. These transformed frequencies were used to calculate MMD distances between the sample pairs using the formula provided by Sjøvold (1973) and modified for the use of the Freeman-Tukey transformation (Green and Suchey, 1976). The MMD distances were then standardized using the standard deviation formula devised by Sjøvold (1973), with the recommended modifications of Green and Suchey (1976). For each simulation, this procedure was repeated 500 times and summary statistics were calculated on the distribution of the MMD statistic.

Two sets of simulations were run for any given sampling condition. In the first, samples were drawn from a parent population consisting of twenty traits with the following trait frequencies: $\{p_1=.05, p_2=.10, p_3=.15, ..., p_{19}=.95$, and $p_{20}=.05\}$. In the second set, samples were drawn from a parent population using only the first ten traits of the parent population just described. These trait frequencies were held constant in all trials in order to permit comparisons of the MMD statistic with only sample size and missing data effects.

The first simulations were run with the intention of providing a baseline for what could be considered "moderate" sample sizes (n_1=50, n_2=50) with no fluctuation of the numbers of individuals observable for any given traits. These simulations were then repeated with sample pairs of size: (n_1=30, n_2=30), (n_1=15, n_2=15), and, (n_1=30, n_2=15), for both the twenty and the ten trait cases. As mentioned previously, the number of individuals often fluctuates across traits within a single sample, ranging from approximately 15% to 100% of the actual sample size. To approximate this missing data another set of simulations was run; sample pairs of size: (n_1=15, n_2=30), (n_1=15, n_2=50) and (n_1=30, n_2=50) were specified. However, for a given trait, the sample size was reduced randomly by up to 85%. Only this number of individuals was used to calculate the sampled trait frequencies for a given trait in a given trial.

Results and Discussion

Summary statistics were calculated on each of the simulations; the means and the α=.05 and the α=.03 cutoff points are given in Table 2.1. In looking at the simulations in which sample sizes and the numbers of observations were held constant for all traits, it can be seen that the α=.03 cutoff point is nearly always greater than two. Thus, if one is making tests for differences between samples, one should assume a significance level of $\alpha \leq .05$ for a standardized MMD statistic of two or greater to reflect more accurately the probability of type I errors. The reason for the test becoming more conservative with smaller sample sizes is that while the Freeman-Tukey transformation recommended by Green and Suchey (1976) provides the best variance stabilization for small sample sizes, its direction of error is often in the direction of overestimating the actual variance. Thus, as sample size decreases the subtracted variance term in the calculations appears to increase more rapidly than the sampling error.

The simulations in which the number of observations is set to fluctuate randomly show the same expected pattern of the test becoming increasingly conservative with smaller sample sizes, except for the anomalous result in the 10 trait simulation with n_1=30 and n_2=50. Given the pattern of the cutoff points for the other simulations, one would expect an α=.05 cutoff point of approximately 1.9 to 1.95 and the anomalous result is likely the result of sampling error in the running of the simulation itself, the direction of which is on the conservative side.

Conclusion

The MMD statistic, when used with trait frequencies transformed by the Freeman-Tukey method recommended by Green and Suchey (1976) remains conservative under small sample sizes. This is also true when the number of observations fluctuates widely among traits and between samples. Although the true distribution has not been determined for small and fluctuating sample sizes (Sjøvold, 1973), it can be assumed that any two samples are different at the $\alpha \leq .05$ probability level when a standardized MMD value of 2.0 or greater is obtained. For a particular investigation, one can obtain an idea of how conservative such a test might be by pooling the trait frequencies of any two samples to be tested and running simulations using these frequencies for the parent population and the numbers of observations actually found in the samples. If a large number of trials is run and the test found to be overly conservative, it is suggested that the experimentally obtained α=.05 cutoff point be used so as to reduce the possibility of type II errors in the analysis.

Table 2.1. Means and cutoff points for the Standardized MMD statistic under various sampling conditions

Constant # of		20 Traits			10 Traits	
Observations	mean	a=.05	a=.03	mean	a=.05	a=.03
$n_1=n_2=50$	.016	1.95	2.28	.043	1.98	2.30
$n_1=n_2=30$	.024	1.86	2.15	-.003	1.89	2.13
$n_1=n_2=15$	-.156	1.59	1.91	-.104	1.70	2.38
$n_1=15$, $n_2=30$	-.026	1.80	2.00	-.032	1.99	2.39

Fluctuating # of		20 Traits			10 Traits	
Observations	mean	a=.05	a=.03	mean	a=.05	a=.03
$n_1=15$, $n_2=30$	-.225	1.49	1.78	-.025	1.88	2.21
$n_1=15$, $n_2=50$	-.173	1.64	1.95	-.053	1.90	2.26
$n_1=30$, $n_2=50$	-.096	1.70	1.99	-.038	1.61	1.83

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Chapter Three

Biological Differentiation at Predynastic Naqada, Egypt: An Analysis of Dental Morphological Traits[1]

Introduction

Ancient Egyptian civilization is well known for its striking remains, such as the pyramids, the burial riches of King Tutankhamun, and the hieroglyphic writing system. Some of the fundamental questions in the study of this civilization, however, concern aspects of its formation, such as its environmental, political and ideological associations and antecedents (Bard 1992; Hassan 1988; Wenke 1989, 1991), and the timing and nature of social inequality (Anderson 1992; Bard 1988, 1989; Griswold 1992). Social inequality is clearly evident in the pyramids of Giza, near Cairo, which are monumental tombs for pharaohs of the Old Kingdom (Dynasties III-VI), and in the grave goods found with the mummy of King Tutankhamun, who was buried in a rock cut tomb in the "Valley of the Kings" in southern Egypt. The origins of the inequality that manifested itself in monumental architecture and opulence in life and death for those of high status are not well established, however.

Several investigations into the origins of social inequality in ancient Egypt have focussed on the Upper Egyptian Predynastic site of Naqada (Figure 3.1), excavated by Petrie in 1894-1895. The Predynastic era falls before the period characterized by the royal dynasties and is generally agreed to cover the time frame from about 5500 - 3050 B.C. Petrie

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[1] A version of this chapter has been published previously: Johnson and Lovell 1994. American Journal of Physical Anthropology 93:427-433

mistakenly identified the site as belonging to the Dynastic period, and, observing the lack of material goods typical of that period, interpreted the site as representing the immigration of a "New Race" into Upper Egypt (Petrie and Quibell 1896). This was quickly discounted when the Predynastic nature of Naqada was demonstrated (De Morgan 1896-97). The site has remained significant, however, because, along with nearby Ballas, it served as the basis for Petrie's pottery Sequence Dating system (Petrie 1901), becoming the standard typological reference for the Egyptian Predynastic period. The site includes three main cemeteries, commonly designated "Cemetery B" (after a nearby mound called Kom Belal), "Cemetery T" (located near two tumuli), and the "Great Cemetery" (the largest of the cemeteries). Cemetery T often has been considered an elite cemetery because it was small in size and produced the largest and richest graves. Petrie (Petrie and Quibell 1896) attributed the burials to the wealthy citizens of Naqada, while other scholars have interpreted the burials as representing a special status group (Davis 1983), or as royal in nature, perhaps foreshadowing the royal tombs of the early Dynastic period (Arkell and Ucko 1965; Bard 1992; Case and Payne 1962; Hoffman 1979; Kemp 1973, 1991).

That Cemetery T may be an elite cemetery raises the possibility that the individuals buried there may be biologically distinct from the general population, since a ruling elite may consist of a family lineage or may have come from outside the local population. Naqada's contribution to studies of population affinity has been restricted so far to data obtained from bones. The Naqada skeletal material was originally sent to Karl Pearson at University College, London, for use by Pearson's biometric school, which quickly produced a correlation of skull length and breadth (Pearson 1895) followed by measurements of the major bones of the skeleton (Warren 1897). One of the research objectives of the biometric school was the metric definition of different human 'races', and the Naqada crania were examined in order to determine whether or not the ancient Egyptians resembled the Negro in cranial characteristics (Fawcett and Lee 1902; Morant 1925). Early in its development, cranial non-metric trait analysis also was applied to the Naqada series and to the question of racial admixture in Egyptian history (Berry and Berry 1972; Berry *et al.* 1967). Now part of the Duckworth Collection at Cambridge University, the material continues to be the subject of craniometric investigation into the biological affinities of the ancient Egyptians (Crichton 1966; Keita 1990, 1992).

Biological affinity studies also can be based profitably on dental morphological traits, which are well suited to biological distance analyses because: 1) many traits are independent of each other as well as independent of age and sex; 2) there is a high genetic component in occurrence and expression ; and 3) the amount of intergroup variation in trait frequencies is high (Irish and Turner 1990). Teeth also are often better preserved than are bones and are rarely altered significantly by postmortem diagenesis, so data can be obtained from fragmentary remains that are unsuitable for cranial metric and non-metric study. Non-metric traits of the dentition in skeletal samples from ancient Nubia have been examined in several studies of population affinity (Greene 1967, 1972, 1982; Irish and Turner 1990; Turner and Markowitz 1990). The purpose of this study was to examine non-metric morphological traits of the dentition to address the question of whether any degree of biological differentiation can be detected among the skeletal samples obtained from Cemeteries B, T, and the Great Cemetery at Naqada.

Materials and Methods

Skeletal samples were examined at the Department of Biological Anthropology at Cambridge University: 38 skulls from Cemetery B, 26 skulls from Cemetery T, and 67 skulls from the Great Cemetery. Sex of the individuals was determined at the time of excavation by Warren (1897) and later reassessed when the specimens were accessioned by the Duckworth laboratory. The sex of each specimen was confirmed at the time of this study following contemporary osteological procedures (Bass 1987; Ubelaker 1989; White 1991). Fifty females, 72 males, and 9 individuals of indeterminate sex comprise the total sample; the sex distribution is similar in all three cemetery subsamples.

Forty-three morphological traits of the permanent dentition were scored by Dr. Nancy Lovell in accordance with the criteria and scoring plaques established by Turner *et al.* (1991). Nearly all of the teeth scored were *in situ* in the mandible or maxilla and agenesis was assessed with the use of a portable x-ray machine. Intraobserver variation was assessed by repeated scoring of a random sample of individuals and was found to be well within the limits recommended by Nichol and Turner (1986). All available teeth were scored individually, but only the antimere showing the highest degree of trait expression was used in the analysis, according to the individual count method (Turner and Scott 1977; Scott 1980). Unfortunately, the scores for many of the traits could not be included in subsequent statistical analysis due to small samples of observable teeth within the cranial samples of each cemetery; premortem and postmortem tooth loss, severe wear, and breakage were the causes of the small samples of teeth. Although some workers include a trait in an intersample comparison if it is observable in only one of the samples, this procedure can magnify the influence of chance occurrences of rare traits in small samples such as those available in the present study. Therefore, only traits that were observed in at least two of the three samples were included in the analysis. Any tooth trait combination that was wholly unobservable in any of the samples was necessarily ignored. Accordingly, the final data set was reduced to 11 morphological traits, scored as 24 tooth trait combinations. Since anterior teeth (incisors and canines) are most easily lost or broken in the burial environment, it is not surprising that these traits are all found on the premolars and molars. To avoid eliminating traits which have constant frequencies (i.e., are expressed to some degree) in all groups being compared, those traits were dichotomized by scoring only full expressions of the trait as present. Thus, any expression of a trait was scored as present except for the following (scores refer to the definitions set out by Turner *et al.* 1991): Cusp no. (all) presence = a score of 5 or greater; Root no. (UPM1) presence = a score of 2 or greater; Root no. (UM3) presence = a score of 3 or greater; Hypocone (UM2 and UM3) presence = a score of 3 or greater; Hypocone (UM1) presence = a score of 5; Metacone (all) presence = a score of 5. Table 3.1 lists the traits, their sample frequencies for each cemetery, and the total sample frequencies.

Chi-squared statistics were calculated to evaluate sex differences in trait frequencies, and since none of the traits were found to have any significant degree of heterogeneity, the sexes were pooled for further analysis. Since the expressions of traits are believed to be correlated among teeth in a given tooth class, the distance calculations were performed on a subset of nine traits which are thought to be genetically independent of each other: Protostylid LM2, Cusp 5 UM2, Carabelli UM2, Absence UM3, Root no. UPM1, Cusp no. LM1and LM2, Hypocone UM2, and Y-Groove LM2. For traits whose presence is thought to be correlated across the three molars, the second molar was chosen as the defining tooth since this resulted in the largest sample sizes. Excessive wear was the primary cause of reduced sample sizes for traits scored on first molars.

Traits were arcsine transformed using the Freeman and Tukey transformation recommended by Greene and Suchey (1976) for small sample sizes:

$$\theta = \tfrac{1}{2}\sin^{-1}\left(1 - 2\frac{k}{n+1}\right) + \tfrac{1}{2}\sin^{-1}\left(1 - 2\left[\frac{k+1}{n+1}\right]\right)$$

Where, k= the observed frequency of the trait, and n= the number of individuals observable for the trait. Comparisons were made between the three samples using the multivariant Mean Measure of Divergence (MMD) statistic (Berry & Berry 1967, Sjøvold

1973, Greene & Suchey 1976), and the variance and standard deviations were calculated according to the mathematical method of Sjøvold (1973):

$$\mathrm{MMD} = \frac{\sum_{i=1}^{r}\left(\left[\theta_{1i}-\theta_{2i}\right]^{2}-\left[\frac{1}{n_{1i}+\frac{1}{2}}+\frac{1}{n_{2i}+\frac{1}{2}}\right]\right)}{r}$$

$$\mathrm{Var}_{\mathbf{MMD}} = \frac{2}{r^{2}}\sum_{i=1}^{r}\left(\frac{1}{n_{1i}+\frac{1}{2}}+\frac{1}{n_{2i}+\frac{1}{2}}\right)^{2}$$

$$\mathrm{SD}_{\mathbf{MMD}} = \sqrt{\mathrm{Var}_{\mathbf{MMD}}}$$

Where; θ=the angular transformation of the sample for the i^{th} trait; n_{1i}, n_{2i}= the number of individuals observed for the i^{th} trait for sample 1 and 2 respectively; and r= the number of traits.

Standardized distances were then calculated by dividing the raw MMD score by its standard deviation, as these are the appropriate distances to use when evaluating and comparing samples of different sizes (Sofaer *et al.* 1986). Sjøvold (1973) suggested that a standardized MMD greater than 2.0 denotes a significant difference at the alpha=.05 level. However, simulation experiments (see chapter two) have shown that this is a conservative estimate, thus, approximate significance levels were obtained by simulation. The simulations used the sampling conditions reflected in the present study under the null hypothesis that each cemetery represents a random sample from a single parent population which is best estimated from the pooled trait frequencies.

Results

Table 3.2 gives the raw distances, their standard deviations, the standardized distances, and the approximated p-value for each pairwise comparison using the subset of nine independent traits. Table 3.3 presents similar information for comparisons in which each of the smaller two cemeteries were compared to a pooled sample of the remaining cemeteries.

The results presented in Table 3.2 indicate that the Great Cemetery and Cemetery B are not statistically distinguishable from each other. The two isolated cemeteries are quite distinct ($p=0.026$) and Cemetery T and the Great Cemetery are very nearly significant in their differentiation ($p=0.068$). The comparisons of each of the isolated cemeteries to a pooled sample of the other two (Table 3.3) are very much in line with the pairwise comparisons and suggest that Cemetery T represents a significant departure from the other two cemeteries. These results favor rejecting the null hypothesis that all three samples represent random samples from a single general population, and further, indicate that the rejection of the null hypothesis is due to the differentiation of Cemetery T from the other two cemeteries.

Discussion and Conclusions

This analysis indicates that the sample of individuals interred at Cemetery T can be differentiated from those interred in Cemetery B and the Great Cemetery on the basis of dental morphology. Therefore, the suggestion that Cemetery T represented an elite or even royal burial ground is supported over the argument that it merely represented a special status group of some kind. Cemetery B, on the other hand, is much closer in affinity to the Great Cemetery than it is to Cemetery T. Thus, Cemetery B may still represent, as Davis (1983) suggested, a status differentiated group which is not biologically distinct from the population using the Great Cemetery.

One possible explanation of the biological distinction among the cemeteries is that it represents temporal variation. Hoffman (1979) suggested that Cemetery T was constructed and used only in the Late Gerzean period (ca. 3200-3050 B.C.) while Davis (1983) concluded from an examination of Petrie's sequence system that Cemetery T was used contemporaneously with the Great Cemetery throughout the entire Gerzean period. The possibility exists, therefore, that the distinctions found among the three cemeteries are the result of micro-evolutionary changes over time, rather than a contemporaneous distinction of an elite group from the general population. The magnitudes of the raw MMD distances, however, appear incompatible with this interpretation given the time period in question. According to Turner's (1986) proposed rate of dental micoevolution, these distances would represent up to 13,000 years of temporal differentiation, if indeed the occupants of Cemetery T were a temporally distinct population from the population represented by the other two cemeteries.

Alternatively, Cemetery T may represent a different (immigrant) population, although this would have taken place several generations earlier in order for the cultural assimilation to be completed — the grave goods are unquestionably similar in style, if not richness, among the three cemeteries. Although population movements undoubtedly occurred along the Nile Valley, these were more likely family or small group phenomena rather than the transplantation of large groups. Given the archaeological and biological evidence, it is suggested that the most parsimonious explanation for the distinctions between Cemetery T and the other cemeteries is that of inbreeding within a segment of a population. Ruling or elite classes often have preferential, within group, marriage rules. Thus, genetic drift and founder effect could account for the greater than expected differences between this group and the general population. Although the data are supportive of a conclusion that Cemetery T represented a ruling or elite segment of the local population at Naqada, small sample sizes temper the reliability of this interpretation and, thus, necessitates caution until further evidence can be brought to bear on this question.

Figure 3.1 Map of Egypt and Lower Nubia showing location of the site of Naqada

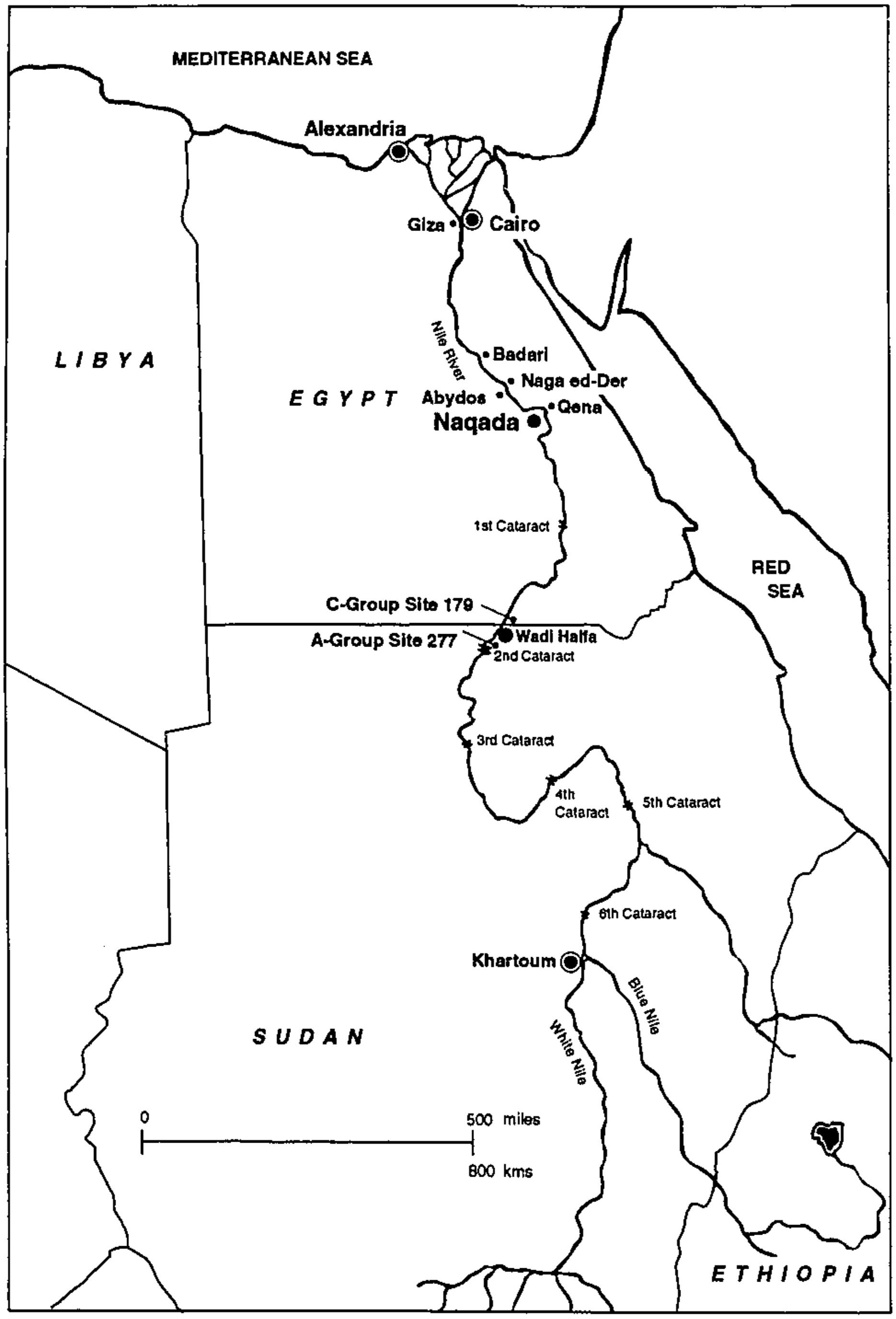

Table 3.1 Frequencies[1] of non-metric dental traits for the Naqada cemeteries.

Traits	Cemetery B	Great Cemetery	Cemetery T	Pooled
Protostylid LM3	2/7	10/28	0/3	12/38
Protostylid LM2	6/16	17/32	4/7	27/55
Protostylid LM1	3/12	11/24	1/4	15/40
Cusp 5 UM3	3/9	21/35	1/7	25/51
Cusp 5 UM2	4/18	6/38	5/14	15/70
Cusp 5 UM1	1/13	8/33	1/9	10/55
Carabelli UM3	1/10	7/31	1/5	9/46
Carabelli UM2	3/16	10/36	1/11	14/63
Carabelli UM1	2/11	6/29	3/10	11/50
Absence UM3	0/22	2/49	3/17	5/88
Absence LM3	2/20	4/46	2/13	8/89
Root# UPM1	9/14	24/29	8/15	41/58
Cusp# LM3	1/6	14/26	2/3	17/35
Cusp# LM2	0/15	4/31	2/7	6/53
Cusp# LM1	6/9	17/25	4/5	27/39
Root# UM3	8/10	6/18	2/8	16/36
Access Cusp UPM2	1/8	6/16	0/5	7/29
Access. Cusp UPM1	1/7	2/13	0/3	3/23
Hypocone UM3	5/6	23/32	4/4	32/42
Hypocone UM2	15/15	32/37	10/14	57/66
Hypocone UM1	3/14	4/37	0/11	7/62
YGroove LM2	6/14	9/26	0/7	15/47
Metacone UM1	7/16	25/37	3/11	35/64
Metacone UM2	16/19	33/44	11/14	60/77

[1]Frequencies are given as the number of expressions of the trait over the number of observable teeth.
[see appendix for trait descriptions, and Turner *et al.* (1991) for full description of traits]

Table 3.2 Between cemetery distances using nine independent traits.

	Cemeteries		
	B-Great	T-Great	B-T
MMD	0.0101	0.1065	0.2415
SD	0.0464	0.0665	0.0836
Standardized MMD	0.2186	1.6006	2.8890
Approx. p-values	0.3350	0.068	0.0206

MMD=mean measure of divergence; SD=standard deviation

Table 3.3 Cemetery to pooled cemetery distances using nine independent traits.

	Cemeteries	
	B-(Great and T)	T-(Great and B)
MMD	0.0370	0.1388
SD	0.0431	0.0621
Standardized MMD	0.8584	2.2350
Approx. p-values	0.1780	0.0375

MMD=mean measure of divergence; SD=standard deviation

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Chapter Four

Biological Variation in Ancient Egypt: an Analysis of Dental Morphological traits.

Introduction

This paper presents the results of an investigation into the degree of dental morphological variation among several ancient Egyptian populations. Ancient Egyptian civilization is well known for its rich material goods, hieroglyphic writing system, and the monumental architecture of many pharaohs. However, the origins of ancient Egyptian civilization have long been debated among anthropologists and Egyptologists, and, in particular, this debate has involved the question of whether this civilization arose as a result of outside influences and the immigration of peoples from elsewhere, or instead was the result of a continuous *in situ* development.

During the late nineteenth and early twentieth centuries, typological thinking dominated much of the literature in anthropology as in other fields such as the biological sciences. Thus, changes in the archaeological record were seen as discontinuities requiring some causal explanation. The simplest, and most common, explanation for detectable changes in the archaeological record, such as in material goods or subsistence patterns, was that such changes were the result of a migration or invasion of new peoples into the area, complete with their distinctive material culture and or lifeways. Indeed, differences in material culture between geographically and temporally close archaeological sites often served as an implicit indicator of the biological distinctiveness of those responsible for such traces when other lines of evidence, such as skeletal remains, were lacking. Even when skeletal remains were present, differences were likely to be emphasized over similarities. More recently, however, a greater understanding of evolution and population variation, along with an increased data base of archaeological sequences, has led to a shift in view in which similarities as well as differences are taken into account, and in which continuity and evolution are, if not the prime candidates, at least as likely candidates for explanations of change as are migrations and population replacements.

Such a change in thought is clearly evident in the literature regarding Predynastic and early Dynastic Egypt. In the early twentieth century, all three of the primary archaeologically defined cultures of the Egyptian Predynastic (Badarian, Amratian, and Gerzean: see Table 4.1) were, based on differences in material culture, thought to represent different peoples, as were the Nubian A- and C-Groups (Arkell and Ucko 1965; Berry, Berry and Ucko 1967; Hassan 1988; Hoffman 1979; Trigger 1983). The Amratian is now seen as more likely developing directly from the Badarian (Arkell and Ucko 1965; Hoffman 1979), and the Gerzean, originally thought to reflect an invasion of Upper Egypt from the northern delta region or from southwest Asia (Arkell and Ucko 1965; Grimal 1992; Trigger 1983), is also seen by some as possibly developing in Upper Egypt and then spreading outwards from there (Arkell and Ucko 1965; Hoffman 1988). Petrie (Petrie and Quibell 1896) also attributed the rise of the Dynastic phase to an invasion of a "New Race", and, although this postulation was based upon the mistaken identification of the Naqada cemeteries as being early Dynastic in origin rather than reflecting a then unknown Predynastic period, it does indicate the degree to which differences in material culture were assumed to reflect distinct biological populations.

Physical anthropological investigations into the origins of the ancient Egyptian populations and their 'racial' affinities began almost immediately after the initial recovery of human remains from the area by Petrie in the late nineteenth century. A great many crania from the Naqada cemeteries were sent by Petrie to Karl Pearson in London for use by Pearson's biometric school. Many more skeletal populations were eventually recovered and a great deal of biometrical investigation has since focussed upon the 'racial' history of ancient Egypt (e.g., Batrawi 1945, 1946; Billy 1977; Brace *et al.* 1993; Crichton 1966; Derry 1956; Keita 1992; Morant 1925, 1935; Stoessiger 1927). Ancient Egyptians have been seen variously as having been derived from one or some combination of at least 11 different peoples ranging from Libyans, Arabs, and Negroes to Australian Aboriginals (Batrawi 1946), although the most parsimonious explanations have recognized but two races in ancient Egypt: a northern (Lower Egypt) and a southern (Upper Egypt) type (Morant 1925; Batrawi 1946; Stoessiger 1927).

Keita (1992) has recently analyzed crania from early Dynastic Abydos and several other sites using craniometric data and found evidence of heterogeneity and admixture among the

Abydos sample with affinities to both Upper and Lower Egyptian samples, though no evidence of any external populations to account for the rise of Dynastic period. Similarly, Brace *et al.* (1993) has investigated ancient Egyptian crania using metrical data, and suggests that while the Egyptians had definite biological ties to the north and south (as well as the eastern and western populations) they have, as a whole, remained relatively uninfluenced, in biological terms, from the Neolithic to recent historical times.

Investigations using non-metric variants of the human skull have also been applied to several ancient Egyptian populations (Berry *et al.* 1967; Berry and Berry 1967, 1972). These authors have concluded that although there are differences among some of the Predynastic populations, there is a great deal of continuity from the Predynastic through the Dynastic periods. However, they did find that the early Predynastic Badarian sample and a late Predynastic Naqada sample differed significantly from most of the other samples considered as well as from each other. Additionally, dental morphological traits were used by Greene (1966, 1972) to investigate three Nubian samples from historical times (Meriotic, X-Group, and Christian—ca.500 B.C. to 1350 A.D.) and a great deal of similarity was found. Greene (1972) also suggests, by comparison of his data with some published descriptions of dental morphology of Predynastic Egyptians, that this similarity extends back to the Predynastic of Upper Egypt. This is merely a suggestion, however, and not based upon a systematic analysis and comparison of these samples with Predynastic Upper Egyptian samples. In a similar vein, Turner and Markowitz (1990) and Irish and Turner (1990) have applied dental morphological studies to the same Nubian populations and found strong support for continuity among these groups, though a comparison of these with a Late Paleolithic Nubian sample showed such a large difference that these authors concluded that a Holocene population replacement had occured within this region.

The present study provides an analysis and comparison of dental morphological traits of nine Predynastic and early Dynastic Egyptian samples (six of which are Upper Egyptian) along with two Nubian samples (A-Group and C-Group). The purpose of this study is to examine to what degree biological continuity or differentiation exists between the Predynastic and the early Dynastic samples considered. No samples from outside of Egypt and Nubia are considered here, though this study will provide the first systematic assessment of dental morphological variation among ancient Egyptians populations which will form the basis of future planned comparisons with other populations which may have had biological ties with the ancient Egyptians.

Materials and Methods

The skeletal samples used in the present study come from the following sites: Badari, Naqada, Naga ed Der, Qena, Abydos, Giza, Nubia SJE277, and Nubia SJE179 (see map Figure 4.1 and Table 4.2). An earlier analysis (Johnson and Lovell 1994) of biological differentiation among the Naqada cemeteries, based on dental morphology, found no significant difference between the Great cemetery and cemetery B and hence these two cemeteries have been pooled and are referred to as the general Naqada sample for the present study. The sex distribution varied among the samples but in general showed a bias towards males with 54%, while females accounted for 35% of the total sample, and 11% of the individuals were of indeterminate sex.

The skeletal samples were examined and scored for forty-three morphological traits of the permanent dentition using the dental plaques and published scoring criteria of Turner *et al.* (1991). All of the samples except for those of Giza and Naga ed Der were scored by Dr. N. Lovell during the summers of 1991 and 1992. The author was trained by Dr. Lovell and subsequently scored the samples of Giza and Naga ed Der in the summer of 1993. Dr. Lovell's presence during the 1993 data collection allowed continual rechecking and callibration to maintain a minimum of interobserver error. Intraobserver error was assessed by each worker by means of repeated scoring and found to be within the limits recommended by Nichol and Turner (1986). While all teeth were scored individually, only the antimere showing the highest degree of trait expression was used in the calculation of trait frequencies according to the individual count method recommended by Turner and Scott (1977) and Scott (1980).

Due to causes such as severe tooth wear, breakage, carious lesions and premortem and postmortem tooth loss, many of the morphological traits were simply not observable in some of the samples and thus could not be used in the analysis. While some workers have included traits which are present in only a single sample, this can magnify the effects of rare traits when dealing with small sample sizes. Therefore, only traits which were present in at least six (two thirds) of the nine samples were included in the analysis. Sjøvold (1973) states that traits which do not vary in frequency among samples being compared (so called 'dummy' variables) should not be used in the calculation of Mean Measure of Divergence (MMD) values. For this reason, traits which were expressed to some degree in all samples were dichotomized by choosing a grade of expression which best revealed variation among the samples. Thus, any expression of a trait was scored as presence of the trait except for the following (scores refer to the criteria set out by Turner *et al.* 1991): Cusp no. (all) presence = a score of 5 or greater; Hypocone (UM1) presence = a score of 5 (full expression); Hypocone (UM2, UM3) presence = a score of 4 or greater; Metacone (all) presence = a score of 5 (full expression). There were a total of nine traits, scored as 23 tooth trait combinations, available for use in the present analysis. Table 4.3 lists the traits and their frequencies for each sample.

Sex differences were evaluated using Chi-squared statistics. Only two traits showed any significant degree of heterogeneity between the sexes, each in a single, but different, sample. Since this is far less than would be expected by chance, the sexes were pooled for further analysis. In light of the results of the Chi-square test, the bias towards more males in the overall sample, and the differences in sex distributions among the samples, does not pose a problem in the present study. Because traits which are scored on multiple teeth within a given tooth class are likely to be correlated with each other, a subset of nine traits thought to be genetically independent of each other was selected for the actual analysis. The nine traits used in the final analysis are as follows: Protostylid LM2, Cusp 5 UM2, Cusp no. LM2, Y-Groove LM2, Carabelli UM2, Hypocone UM2, Metacone UM2, Absence UM3, and Accessory Cusp UPM1. Where possible among the molar tooth class (i.e., except for Absence UM3), the second molar was used as the defining tooth since this generally resulted in the largest sample sizes.

Traits were arcsine transformed using the Freeman and Tukey transformation recommended by Greene and Suchey (1976) for small sample sizes:

$$\theta = \tfrac{1}{2}\sin^{-1}\left(1 - 2\frac{k}{n+1}\right) + \tfrac{1}{2}\sin^{-1}\left(1 - 2\left[\frac{k+1}{n+1}\right]\right)$$

Where, k= the observed frequency of the trait, and n= the number of individuals observable for the trait. Comparisons were made between the three samples using the multivariant Mean Measure of Divergence (MMD) statistic (Berry & Berry 1967; Greene & Suchey 1976; Sjøvold 1973), and the variance and standard deviations were calculated according to the mathematical method of Sjøvold (1973):

$$\mathrm{MMD} = \frac{\sum_{i=1}^{r}\left(\left[\theta_{1i} - \theta_{2i}\right]^2 - \left[\frac{1}{n_{1i} + \frac{1}{2}} + \frac{1}{n_{2i} + \frac{1}{2}}\right]\right)}{r}$$

$$\mathrm{Var}_{\mathbf{MMD}} = \frac{2}{r^2}\sum_{i=1}^{r}\left(\frac{1}{n_{1i}+\frac{1}{2}}+\frac{1}{n_{2i}+\frac{1}{2}}\right)^2$$

$$\mathrm{SD}_{\mathbf{MMD}} = \sqrt{\mathrm{Var}_{\mathbf{MMD}}}$$

Where; θ=the angular transformation of the sample for the i^{th} trait; n_{1i}, n_{2i}= the number of individuals observed for the i^{th} trait for sample 1 and 2 respectively; and r= the number of traits.

Standardized distances were then calculated by dividing the raw MMD score by its standard deviation, as these are the appropriate distances to use when evaluating and comparing relative distances among samples of different sizes (Sofaer *et al.* 1986). Sjøvold (1973) has suggested that a standardized MMD greater than 2.0 is significant at the .05 level. However, simulation studies by the author (see Chapter Two) have shown that under small sample sizes, this value can greatly underestimate significance levels. Therefore, approximate cutoff points have been calculated based on simulations for each pairwise sample comparison. For these simulations, trait frequencies for a parent population were obtained for any pairwise comparison by pooling the two sample frequencies under consideration. A pair of samples was then drawn from this population, with sample sizes equal to those of the two samples being compared. Standardized MMD distances were then calculated between the two simulated samples and this process was repeated 500 times to estimate the distribution of standard MMD values produced under the specified sampling conditions. Cutoff points for the .05 and .01 level were estimated from the resulting distribution.

In addition to the MMD calculations, a cluster analysis using Ward's minimum variance method was also performed on the arcsine transformed traits for each analysis. The dendograms produced by this method can allow patterns to be detected in the data which are harder to discern when only presented with a matrix of MMD distances.

Results and Discussion

Table 4.4 gives the raw MMD distances, the standard deviations, the standardized MMD distances and an indication of the significance level of the standardized MMD distances as calculated from the simulations. With 36 pairwise comparisons one would only expect to find about two comparisons to be significantly different at the 5% level. Using Sjøvold's

(1973) conservative estimation of significance (i.e., a standardized MMD exceeding 2.0 is significant at the 5% level) we can see that the minimum number of significant differences is 25 standardized MMD's exceeding a value of 2.0. When the significance levels derived from the simulations are used, the number of significant differences rises to 27. This indicates that there was a great deal of dental morphological variation among the ancient Egyptian populations. Given the great number of significant differences, it is perhaps easier to point out those samples which show the least differentiation.

Nubian Continuity

The two Nubian samples representing the A- and C-Groups show no significant differentiation from each other. This lack of differentiation is suggestive of biological continuity, hence, if Turner and Markowitz (1990) and Irish and Turner (1990) are correct in asserting a population replacement in Nubia between the Paleolithic and the more recent historical Meroitic, X-Group, and Christian populations, it must have occurred either prior to or after the A- and C-Group periods. It is also noteworthy that the two Nubian samples also show no significant differentiation from either the general Naqada or the Qena samples, both of which are from Predynastic Upper Egypt. However, the general Naqada and the Qena samples do differ significantly from each other, which seems somewhat inexplicable in light of their temporal and geographical proximity as well as their similarity to the Nubian samples. Two possible explanations are 1) that the result is due to chance, or 2) that both the Qena and the generalized Naqada populations were in fact different but contributed genetically to the Nubian A-group (one way gene flow?) from which the C-group was eventually derived.

The site of Qena has never been published, however, and its designation as Late Predynastic comes from the field notes of its principal excavator, G. Reisner (Lovell 1994; pers. comm.), thus, its differentiation from the general Naqada sample may be partially a result of an incorrect chronological assignment. The fact that Qena lies closest to the Badarian sample in the cluster analysis, though still significantly different according to the MMD analysis, may point to an earlier chronological assignment than has been assumed here.

Additionally, the site of Naga ed Der, also from Predynastic Upper Egypt, shows no differentiation from the Nubian A-Group sample, though it does differ from all of the other samples used in the analysis. Thus, returning to the notion of a Nubian Holocene population replacement, based on Greene's (1967, 1972) suggestion of similarities between the later Nubians and the Predynastic Egyptians, and the present findings of a similarity between some Predynastic Egyptians and the Nubian A- and C-Group samples, it seems most likley that if such a replacement did occur, it was prior to the A-group period. Indeed, it is tempting to speculate that such a replacement might even have been a result of invasions of Nubia from Predynastic Egyptian populations. However, testing this hypothesis would require a full comparison of the Paleolithic Nubian material and the later Nubian material with the present material, which is not possible at the present time.

A Royal Connection?

The other group of notable similarities involve the Abydos, Giza, and Naqada T samples, all of which are associated in some manner with royal or elite burials. The fact that all three of these samples are associated with elite or royal cemeteries suggests that the similarities among them, in terms of dental morphological variation, when compared to the amount of overall intersample heterogeneity, are not likely due to chance. Because the MMD itself represents a statistical test rather than a euclidean measure of distance, a euclidean cluster analysis was run on the nine independent arcsine transformed traits using Ward's minimum variance method (Systat 5.1), and the resulting dendogram is shown in Figure 4.2. This dendogram points out graphically the same basic patterns as the results of the MMD analysis. There are two overall clusters separating the samples associated with royal or elite burials from the rest of the samples.

This result could be seen as supporting the hypothesis of an immigrant population from outside of Egypt being responsible for the rise of the Dynastic period in Egypt as suggested by Derry (1956). Such a result could also been seen to favor equally either the hypothesis that a Lower (northern) population invaded Upper Egypt at some point during the Late Predynastic period and eventually brought about the unification of Egypt and the beginning of the Dynastic period (Grimal 1992; Trigger 1983), or, alternatively, the hypothesis that the Naqada T cemetery represents an *in situ* development of a Late Predynastic precursor to the Dynastic period, which eventually spread north after the unification (Arkell and Ucko 1965; Hoffman 1979). Under this hypothesis, cemetery T from Naqada is assumed to represent an elite segment or class which developed out of the general Naqada population and whose biological differention from that general population could be explained as a result of a combination of founder effect and genetic drift. Such an explanation assumes that such an elite class would likely have preferential, within class marriage rules, and that the initial derivation of this class constituted neither a large nor random sample from the general population. The great similarity of grave goods between the Naqada T and the other two Naqadan cemeteries would seem to support this hypothesis as opposed to that of an immigration of new peoples into the area. However, whether or not the similarities between the Naqada T sample and the later cemeteries associated with royal burials in the Dynastic period (Abydos and Giza) is due to a biological continuation of this elite class is still open for debate.

Referring back to the MMD analysis shown in Table 4.4, it can be seen the Badarian sample shows significant differences from all of the other samples considered. This is similar to to the findings of Berry *et al.* (1967) who found that the Badarian population appeared significantly different from other Predynastic and Dynastic samples based upon non-metric traits of the human cranium. It is quite impossible to decide at the moment whether this finding is a result of a population replacement in Upper Egypt subsequent to the Badarian period, or whether it is simply that populations of the Badarian period were relatively isolated and biologically distinct from each other and that the sample used here (from the site of Badari) may have contributed very little, if at all, to succeeding populations. This will only be possible to test when additional material from the Badarian period becomes available for analysis.

Conclusions

The results of an analysis of dental morphological variation among Predynastic and early Dynastic Egyptian and Nubian samples show that overall there is a great deal of intersample heterogeneity. The two Nubian samples , representing the A- and C-Groups, did not show a significant difference from each other, nor did they differ significantly from two Predynastic Egyptian samples from Upper Egypt (general Naqada and Qena). Thus, it seems likely that biological continuity exists from the A-group to the C-group in Nubia, and that the A-group may have been derived from some Predynastic Upper Egyptian populations.

While intersample variation was large, overall, two clusters are apparent in both the MMD analysis and the cluster analysis. The three samples associated with elite or royal burials (Abydos, Giza, and Naqada T) form a separate cluster from the rest of the samples considered. The fact that all three are associated with elite or royal burials suggests that this clustering is not merely due to chance. While this may seem to provide evidence for an immigration of a new ruling class accounting for the rise of the Dynastic period, there is an alternate explanation. It may be the case that continual social stratification during the Predynastic led to the eventual rise of an elite or ruling class represented by the Naqada T cemetery. That this class may have continued and developed further and played a part in the unification of Egypt and the rise of the Dynastic period is an equally plausible explanation based upon the present analysis. Further investigation, utilizing samples from several likely surrounding regions which may have served as a source for an immigrating population, is necessary before the balance can be weighed in favor of either of these two hypotheses.

Table 4.1 Cultural Chronology for ancient Egypt and Nubia

	Egypt	Lower Nubia
4400 B.C.	Badarian	Neolithic
3800 B.C.	Amratian	
3500 B.C.	Gerzean	
3000 B.C.	Archaic	A-Group
2700 B.C.	Old Kingdom	
2200 B.C.	1st Intermediate Period	
2000 B.C.	Middle Kingdom	C-Group
1700 B.C.	2nd Intermediate Period	
1500 B.C.		

[the dashed lines between the A- and C-Groups in Nubia refers to fact that the region was very sparsely occupied during this time with no clearly defined archaeological complexes]

Figure 4.1 Map of Egypt and Lower Nubia showing locations of all of the sites used in the analysis

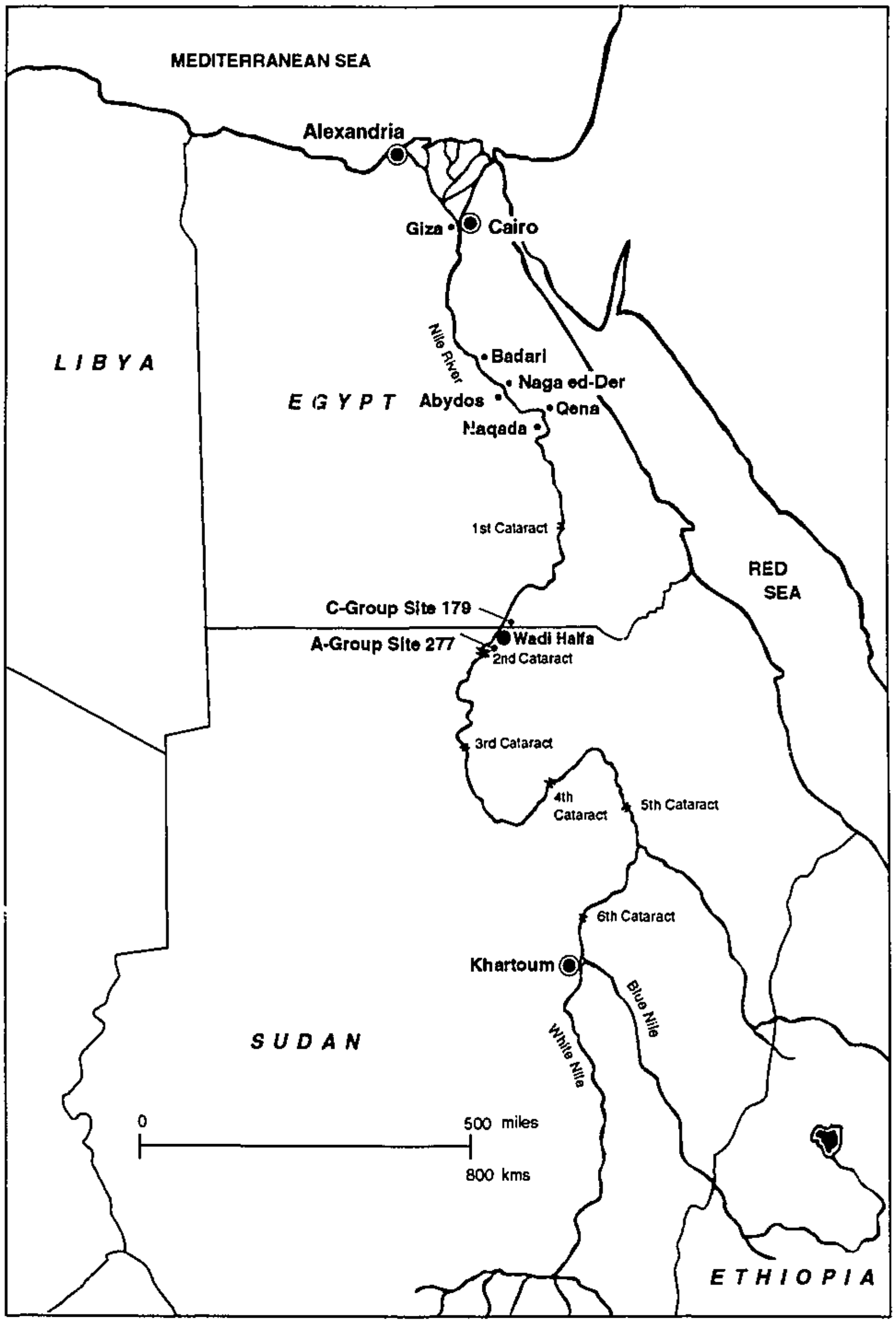

Table 4.2 Table of sample sizes, time periods and sex breakdown for all samples.

Samples	N	Period	% Male	% Female	% Unknown
Abydos	50	Archaic	74%	24%	2%
Badari	62	Badarian	61%	31%	8%
Giza	46	Old Kingdom	37%	33%	30%
Naga ed Der	20	Amratian/Gerzean	35%	65%	0%
Naqada G&B	105	Amratian/Gerzean	61%	30%	9%
Naqada T	26	Gerzean	63%	33%	4%
Qena	49	Gerzean	37%	47%	16%
SJE 277	34	Nubian A-Group	65%	26%	9%
SJE 179	38	Nubian C-Group	39%	47%	14%
Totals	430	n/a	54%	35%	11%

Table 4.3 Frequencies of non-metric dental morphological traits for all samples.

Traits	Nubia C	Nubia A	Badari	Qena	Abydos	Giza	Naga ed Der	Naqada Cem B&G	Naqada Cem T
Absence LM3	4\31	3\31	2\50	5\30	7\42	0\42	0\4	6\66	2\13
Protostylid LM1	10\12	9\20	0\29	3\14	3\23	11\28	2\4	14\36	1\4
Protostylid LM2	8\18	6\27	0\43	3\19	11\37	16\37	3\4	23\48	4\7
Protostylid LM3	5\18	7\25	2\35	3\17	3\33	18\38	1\2	12\35	0\3
Cusp no. LM1	11\13	15\21	18\22	16\23	16\24	14\37	1\4	23\34	4\5
Cusp no. LM2	4\18	3\30	4\39	1\24	2\37	11\38	0\4	4\46	2\7
Cusp no. LM3	8\16	12\26	12\31	4\19	8\31	12\36	1\2	15\32	2\3
Y-groove LM2	7\18	13\23	7\37	6\20	9\36	8\35	3\4	15\40	0\7
Absence UM3	5\31	0\29	3\43	5\38	3\38	1\31	0\20	2\71	3\17
Carabelli UM1	5\9	5\22	4\21	5\10	2\15	6\19	2\13	8\40	1\11
Carabelli UM2	3\9	2\25	1\31	0\20	2\31	1\27	1\19	13\52	1\5
Carabelli UM3	5\12	5\22	1\31	2\15	10\29	4\23	2\16	8\41	1\9
Cusp 5 UM1	2\16	0\26	2\11	2\26	1\19	1\19	1\16	9\46	5\14
Cusp 5 UM2	4\15	3\26	2\22	6\29	5\28	4\24	2\18	10\56	1\7
Cusp 5 UM3	8\13	11\25	9\20	8\18	14\25	11\24	7\16	24\44	1\4
Hypocone UM1	0\16	1\26	0\30	1\28	2\35	6\27	9\16	7\51	0\11
Hypocone UM2	12\14	15\21	17\28	15\20	14\29	4\25	8\19	34\52	4\14
Hypocone UM3	6\12	6\22	5\21	2\16	1\20	4\24	1\16	7\38	2\4
Metacone UM1	16\16	27\27	32\34	28\29	34\35	27\28	16\16	52\53	11\11
Metacone UM2	16\16	27\28	29\38	32\32	23\37	16\28	19\19	58\63	12\14
Metacone UM3	11\13	17\26	13\27	17\21	4\30	3\26	12\16	38\46	3\7
Accessory Cusp UPM1	1\5	4\14	4\22	2\8	5\17	7\14	7\9	3\20	0\3
Accessory Cusp UPM2	1\6	5\15	3\18	0\10	2\22	6\13	1\3	7\24	0\5

[all frequencies given as number of present expressions over number of observable teeth. Teeth are abbreviated using the following: U=upper, L=lower, M=molar, PM=premolar, and the number indicates which tooth in the tooth class. See appendix for list of trait traits and see Turner *et al.* (1991) for full description of traits and scoring criteria.]

Table 4.4 Matrix of MMD distances for intersample comparisons

Sites	Badari	Giza	Naga ed De	Naqada G&E	Naqada T	Nubia A	Nubia C	Qena
Abydos	0.088 0.031 2.842*	0.059 0.034 1.712	0.279 0.078 3.575**	0.088 0.027 3.222**	0.108 0.078 1.386	0.109 0.036 3.030*	0.205 0.056 3.663**	0.127 0.042 3.027*
Badari		0.308 0.033 9.232**	0.623 0.077 8.073**	0.253 0.026 9.623**	0.312 0.077 4.074**	0.146 0.035 4.148**	0.329 0.055 5.995**	0.101 0.041 2.485*
Giza			0.277 0.079 3.489**	0.275 0.03 9.276**	0.127 0.08 1.582	0.299 0.038 7.774**	0.422 0.059 7.223**	0.384 0.044 8.677**
Naga ed Der				0.188 0.075 2.520*	0.055 0.122 4.490**	0.109 0.082 1.331	0.25 0.097 2.572*	0.26 0.087 2.980**
Naqada G&B					0.142 0.074 1.916*	0.025 0.032 0.783	-0.006 0.052 -0.11	0.11 0.038 2.910*
Naqada T						0.356 0.082 4.337**	0.181 0.102 1.775*	0.261 0.089 2.934**
Nubia A							0.06 0.06 1.006	0.017 0.046 0.373
Nubia C								0.082 0.067 1.233

[Entries give the raw MMD value, its standard deviation, and the standardized MMD v alue for each pairwise comparison. A single asterisk indicates significance at the .05 level, and a double asterisk indicates significance at the .01 level.]

Figure 4.2 — Dendogram for Cluster Analysis using Ward's Minimum Variance Method for 9 independent traits

```
Naga ed Der ----------------------------------------------------
                                                               +------
    Nubia C --------------------------                         |     |
                                     +----------------         |     |
 Naqada G&B --------------------     |               |         |     |
                               +------               |         |     |
    Nubia A --------------------                     |         |     |
                                                     +----------     |
       Qena -----------------------------            |               |
                                        +-------------               +-
     Badari -----------------------------                            |
                                                                     |
       Giza ------------------------                                 |
                                   +--------------                   |
     Abydos ------------------------             |                   |
                                                 +--------------------
   Naqada T --------------------------------------
```

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Chapter Five

Concluding Remarks

Discussion

An analysis of biological differentiation among several ancient Egyptian and Nubian samples based on dental morphological traits has been undertaken. The goals of this research were to 1) assess the robustness of the commonly used multivariate Mean Measure of Divergence (MMD) statistic under small sample conditions, 2) to assess the degree of biological differentiation among three cemeteries at the site of Naqada, one of which (Cemetery T) has been suggested as representing an 'elite' burial cemetery — in order to determine whether the presumed social differentiation had a biological correlate, and 3) to assess the degree of biological differentiation or continuity from the early Predynastic through the Middle Kingdom period in ancient Egypt and Nubia.

It was found (Chapter Two) that the MMD statistic, when used with trait frequencies transformed by the Freeman-Tukey method recommended by Green and Suchey (1976) remains conservative under conditions of small sample sizes. With moderate sample sizes, Sjøvold (1973) suggested that a standardized MMD value of 2.0 or greater was significant at the .05 level and this is born out by the results of the simulations. However, when sample sizes decrease, or when missing data decreases the number of observable teeth for particular traits, the simulations have shown that this estimate can become quite conservative and may lead to an increase in type II errors. Thus, it is suggested that under conditions of small samples and/or missing data, simulations which mimic the sampling conditions of the true data be performed and cutoff points of the desired significance level be calculated from the resulting distribution as a first approximation to the actual significance levels for the particular comparison in question.

Chapter Three presented the results of an analysis of biological differentiation among the three cemeteries at Predynastic Naqada, Egypt, based upon dental morphological traits. The results showed that the sample of those interred at Cemetery T, which has been postulated as the burial site for an elite or ruling class based upon the richness of the grave goods and its small size (Arkell and Ucko 1965; Bard 1992; Hoffman 1979), can be differentiated from the samples representing the other two cemeteries. This would lend support to the suggestion that Cemetery T represented a ruling or elite burial ground over the argument that it merely represented a special status group (Davis 1983). However, Cemetery B's lack of differentiation from the Great Cemetery may suggest that it did represent such a special status group. The biological and archaeological evidence appear to favor the interpretation that Cemetery T represented a ruling or elite class which developed *in situ* and whose biological differentiation from the rest of the population was the result of preferential, within group marriage rules, leading to differentiation through genetic drift. While this finding appears to concur most parsimoniously with the available data, it should be remembered that parsimony is not always reflected in the real world, and that the small sample sizes in the present study warrant caution in interpretation until other lines of evidence can be brought to bear on this problem.

Chapter Four considers the broader question of biological differentiation along the ancient Nile Valley. The origins and movements of peoples along the ancient Nile Valley has long been of interest to anthropologists and Egyptologists, and while earlier archaeological investigations tended to assume that differences in material culture at different sites and time periods pointed to biological discontinuity, more recently continuity has been looked for and found to some degree in the material cultures which define the primary Predynastic cultural periods (Arkell and Ucko 1965; Hoffman 1979). A great many studies have been conducted on the skeletal remains of ancient Egyptians and Nubians (largely crania) with a variety of results. Batrawi (1946) points out that as many as 11 different peoples ranging from Libyans to Australian Aboriginals have been postulated as possible sources for peoples occupying the ancient Nile Valley. This can be seen as an indication that there is at least some degree of heterogeneity among ancient Egyptian and Nubian populations. The most parsimonious explanations of this diversity favor the recognition of two distinct populations (a northern and a southern) in the ancient Nile Valley, and various degrees of admixture between them (Batrawi 1945, 1946; Brace *et al.* 1993; Keita 1992; Morant

1925; Stoessiger 1927). Berry *et al.* (1967) have suggested, on the basis of non-metric cranial traits, that there is heterogeneity among the ancient Egyptian populations, but that this is rather small when compared to outlying groups.

Additionally, the question of continuity or discontinuity in Lower Nubia has been addressed by some workers (Greene 1966, 1972; Irish and Turner 1990; Turner and Markowitz 1990). Turner's group found evidence for a Holocene population replacement in Lower Nubia, on the basis of dental morphological traits, at some point between the Late Paleolithic and the recent historical Meroitic, X-Group, and Christian populations. Greene's studies, also based on dental morphological traits, found evidence of continuity among the recent historical populations and suggested some continuity to Predynastic Egyptian populations.

The results of the analysis presented in Chapter Four suggest that there is a great deal of heterogeneity among the ancient Nile populations. However, there are some intriguing similarities among some of the samples considered. In the first place, the samples from Giza, Abydos, and the Naqada T cemetery, all of which are associated with royal or elite burials, show no significant degree of differentiation from each other while demonstrating definite differences from all of the other populations considered. While this could be seen as supporting an invasion or immigration of new peoples from elsewhere near the beginning of the Dynastic phase or admixture between some northern and southern populations around the time of the unification and the Dynastic phase, there is an alternate explanation. It may be the case that continual social stratification during the Predynastic led to the eventual rise of an elite or ruling class represented by the Naqada T cemetery. That this class may have continued and developed further and played a part in the unification of Egypt and the rise of the Dynastic period is an equally plausible explanation based upon the present analysis. Further investigation, utilizing more early samples from northern Egypt and other samples from surrounding regions which may have served as likely sources for an immigrating population, is necessary before the balance can be weighed in favor of any of these hypotheses.

With regard to a possible Lower Nubian Holocene population replacement, the lack of differentiation between the two Nubian samples considered, the similarities of these with some of the Predynastic Upper Egyptian samples, and Greene's (1967,1972) suggestion of similarities between Predynastic Egyptians and later, historical Nubian populations leads to the conclusion that if a population replacement did occur in this region (Irish and Turner 1990; Turner and Markowitz 1990), then it most likely would have occurred prior to the beginning of the Nubian A-Group period. Indeed, it might be speculated, on the evidence presented here, that such a population replacement may have the result of some Predynastic Upper Egyptian groups moving into Lower Nubia and giving rise to the Nubian A-Group. Testing this speculation, however, would require a single comparative analysis utilizing all of the Nubian material from the Paleolithic samples to the recent historical samples, and this is not possible at the present time.

Conclusion

Thus, considered as a single region, the populations of the ancient Nile Valley show a considerable degree of biological differentiation on the basis of dental morphological traits. Notwithstanding this differentiation, there is evidence of biological continuity from some of the somewhat disparate Predynastic Upper Egyptian populations and the Lower Nubian A- and C-Group populations. There is also evidence of biological continuity among all three of the samples associated with elite or royal burial. However, interpretation of the nature of this royal connection must await further data, particularly data from Predynastic Lower Egyptian populations, and from nearby areas such as the Near East, Northwest Africa, and Southern Africa which may have served as source areas for immigrant populations into ancient Egypt.

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Appendix Description of dental traits used in the analysis

PM accessory cusp: (upper premolars) accessory cusps are sometimes found at the distal and/or mesial ends of the sagittal grooves. (presence or absence)

Metacone: (upper molars) this is the distobuccal cusp (3). (graded 0-5)

Hypocone: (uper molars) this is the distolingual cusp (4). (graded 0-5)

Cusp 5: (upper molars) this is the metoconule found in the distal fovea between cusps 3 and 4. (graded 0-5)

Carabeli's Cusp: (upper molars) found on the lingual surface of the mesiolingual cusp (1). (graded 0-7)

PM root no.: (upper premolars) number of roots of the upper premolars. (graded 1-3)

Molar root no.: (upper molars) number of roots of the upper molars. (graded 1-4)

Absence: (upper and lower third molars) assessed in adult individuals only. X-ray equipment may be used. (presence or absence)

Cusp no.: (lower molars) number of cusps on lower molars. (graded 4-6)

Protostylid: (lower molars) found on the buccal surface of mesiobuccal cusp. (graded 0-7)

Cusp 5: (lower molars) the hypoconulid, found in the distal fovea of lower molars. (graded 0-7)

Y-Groove: (lower molars) refers to one of the three groove patterns (Y, +, X) found on the lower molars. (present or absent)

LM root no.: (lower molars) number of roots on lower molars. (graded 1-3)