
TIES THAT BIND

Investigating Hyksos provenance and migration using dental morphology



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Abstract

The term Hyksos commonly refers to the foreign dynasty that inhabited and held power in Egypt during the Second Intermediate Period, circa 1640–1530 BCE. Recent research has integrated archaeological, artistic and textual evidence, revealing the Hyksos origin and presence in Egypt to be more complex than previously envisioned. Answers to questions regarding the Hyksos origin (and reasons for migration), ethnic and biological homogeneity, nature of rule and impact on the Egyptian worldview have been sought by the 'Hyksos Enigma Project'. The aim of this study was to produce new information on Hyksos provenance and migration pathways, as well as understand its place in the landscape of the Middle Bronze Age Near East.

Mobility studies have experienced a new awakening in archaeology, caused by recent theoretical and methodological developments in both non-destructive and biochemical techniques. Biological distance, or biodistance, measures the similarity and dissimilarity of individuals and groups from skeletal remains using multivariate statistical analysis. Distance measures can be based on allele frequencies or haplotypes (measuring genotypic expression), or on phenetics, grouping organisms together according to their morphological similarity. Phenotypic analysis rests on the assumption that phenotypic expression is informative of underlying genetic heritability.

Due to the state of preservation, biodistance was explored using dental nonmetric traits and the Arizona State University Dental Anthropology System (ASUDAS). The traits have been selected due to their repeatability, resistance to attrition, lack of sexual dimorphism and an underlying genetic component. The method was complimented with an application of 2D geometric morphometrics, comparing shapes in multidimensional space.

Dental data was recorded on all available individuals from Tell el-Dab'a (n=96) for an intra-site and inter-site (total number of individuals n= 1095) analysis. C.A.B Smith's mean measure of divergence (MMD) and Gower distance analysis were utilised due to their ability to accommodate missing values. Geometric morphometrics were explored digitising standardised photographs of lower first permanent molars and converted into shape data using the R package geomorph.

Due to missing data, MMD was the most appropriate method for analysing the material, followed by Gower distance analysis and 2D geometric morphometrics. The results create a pattern of movement, visible in both biological data and the archaeological record. Tell el-Dab'a shared a biological closeness with sites along the Levantine coast (such as Ugarit and Sidon), but the only site to indicate significant similarity was the Southern Levantine site of Pella on the Jordan River. No other comparative site from the Southern Levant exhibited similar closeness, pointing to a specific trade route connecting Pella and Egypt, possibly via Tell el-'Ajjul. However, the samples from Tell el-Dab'a did not cover the earliest occupation phases or represent each cemetery of the site, potentially masking other previous or coinciding affiliations.

Together with other affiliations (Ugarit-Sidon and Ugarit-Pella), Tell el-Dab'a generates a pattern of movement, visible also in the reconstructed trade networks. Material and biological evidence from Tell el-Dab'a, ancient Avaris, exhibits the interconnectedness of the Middle Bronze Age Eastern Mediterranean, moving both commodities and people. Climate and political turmoil may have been compounding factors in initiating migration to Egypt, but once started, the movement may have been maintained by economic interests and kinship networks. The results not only offer new insight of the Tell el-Dab'a population but provide further information of the Middle Bronze Age world of the Near East.

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1. Introduction

Pharaonic Egypt spans from circa 3100 to 332 BCE, maintaining a continuity of customs and traditions we recognise as ancient Egyptian culture. Through the millennia, the ancient Egyptian culture saw the rise and fall of three major Pharaonic Kingdoms, separated by intermediate periods where power was shared between smaller regional centres (Egyptian and Near Eastern chronologies provided in figure 9 and appendix A1). The Second Intermediate Period (SIP) saw the rise of the 15th dynasty, ruled from the ancient town of Avaris by the Hyksos kings of foreign origin. They stand as a strong contrast in the middle of Pharaonic history, with archaeological evidence exhibiting a mixture of both Egyptian and foreign customs and material culture. According to the Turin Canon, a hieratic king-list compiled during the reign of Ramses II, the Hyksos rule lasted circa 1650-1540 BCE (Bietak 1996, p. 7). The presence of the Hyksos not only had political implications, but it also affected the ideological foundation of the following New Kingdom period.

Who were the Hyksos and how did they assume power? According to Manetho, as recounted by later historians, they were a group of foreign invaders who were able to overthrow the Egyptian rule (Manetho's *Aegyptiaca*, Frg. 42: 1.75-76, translated by Waddell 1940, pp. 78-9). Current research suggests the shift in power was much less dramatic, with the weakening of central government enabling regional entities to increase their influence already visible in the archaeological record of the 13th dynasty (Bader et al. 2008). According to Bourriau (2010), the dispersal of the Middle Kingdom caused the formation of regional centres across the land, including the Eastern Delta, Memphis/Fayum, Middle Egypt, Upper Egypt (Thebes) and Elephantine, not to mention the Nubian forts and Western oases. No indications of Hyksos occupation have been found from Memphis (Bader et al. 2008).

Where did the Hyksos come from? Lack of contemporary texts, particularly ones produced by the Hyksos, has led to a vast variety of suggestions that have even been described at times as “sketchy and colourful” (Redford 1970). Excavations at Avaris, the modern Tell el-Dab’a,

have revealed a fluent mixture of both Egyptian and Levantine cultural elements, putting to rest much of the early speculation of the Hyksos provenance (e.g. Beckerath 1964, Engberg 1939, Helck 1979, Ward 1961). However, no consensus has been reached on the exact whereabouts of the 'Hyksos homebase', and compelling arguments have been made promoting both Northern and Southern Levantine origin (e.g. Ben-Tor 2007, 2010, Bietak 2010, Kopetzky 2012). The diversity of material culture also questions the assumption of a simple migration event, consisting of people from a single place of origin.

Where did they go? The siege and dispersal of the Hyksos kingdom by the rivalling Theban rulers led to the establishment of the New Kingdom, unifying the land under an Egyptian sovereign once more. The fate of the people inhabiting Avaris at the time has remained unclear, as the archaeological evidence only points to abandonment of the site. Contemporary sources are limited, describing the siege of Avaris only briefly, and the events are often linked to the military campaign launched against Sharuhēn briefly after. The town has been interpreted as the last stronghold of the Hyksos, but the site's modern location has only been speculated.

1.2 Aims and objectives

For the past decades, the Hyksos record has grown from containing mostly textual sources and artistic and iconographic representation to vast quantities of primary archaeological source material from original contexts, enabling more elaborate interpretations of the influence and nature of the Hyksos presence in Egypt. Excavations at Tell el-Dab'a (ancient Avaris) and other associated sites, such as Tell el-Retaba and Tell el-Maskhuta, have improved our understanding of the structure of the Hyksos urban settlement patterns, burial customs and ritual activity (Holladay 1982, Bietak 1996, Redmount 2000, Rzepka et al. 2009, Forstner-Müller 2010, Forstner-Müller et al. 2015).

Aside from few singular cases (mainly that by Mourad 2014) no large, exhaustive studies have been conducted on the currently available material. To create a holistic interpretation of the Hyksos, the Austrian Academy of Sciences together with Bournemouth University hosted the first Egyptological

ERC-funded project 'The Hyksos Enigma', investigating eight interrelating research tracks (figure 1). **The project has six main objectives** that were investigated by synergising results from the research tracks: (1) origins – ethnicity, (2) causes and ways of immigration, (3) defining the MB-culture in the Delta, (4) how did the Hyksos rise and rule, (5) why did the Hyksos fail and (6) Hyksos impact on Egypt

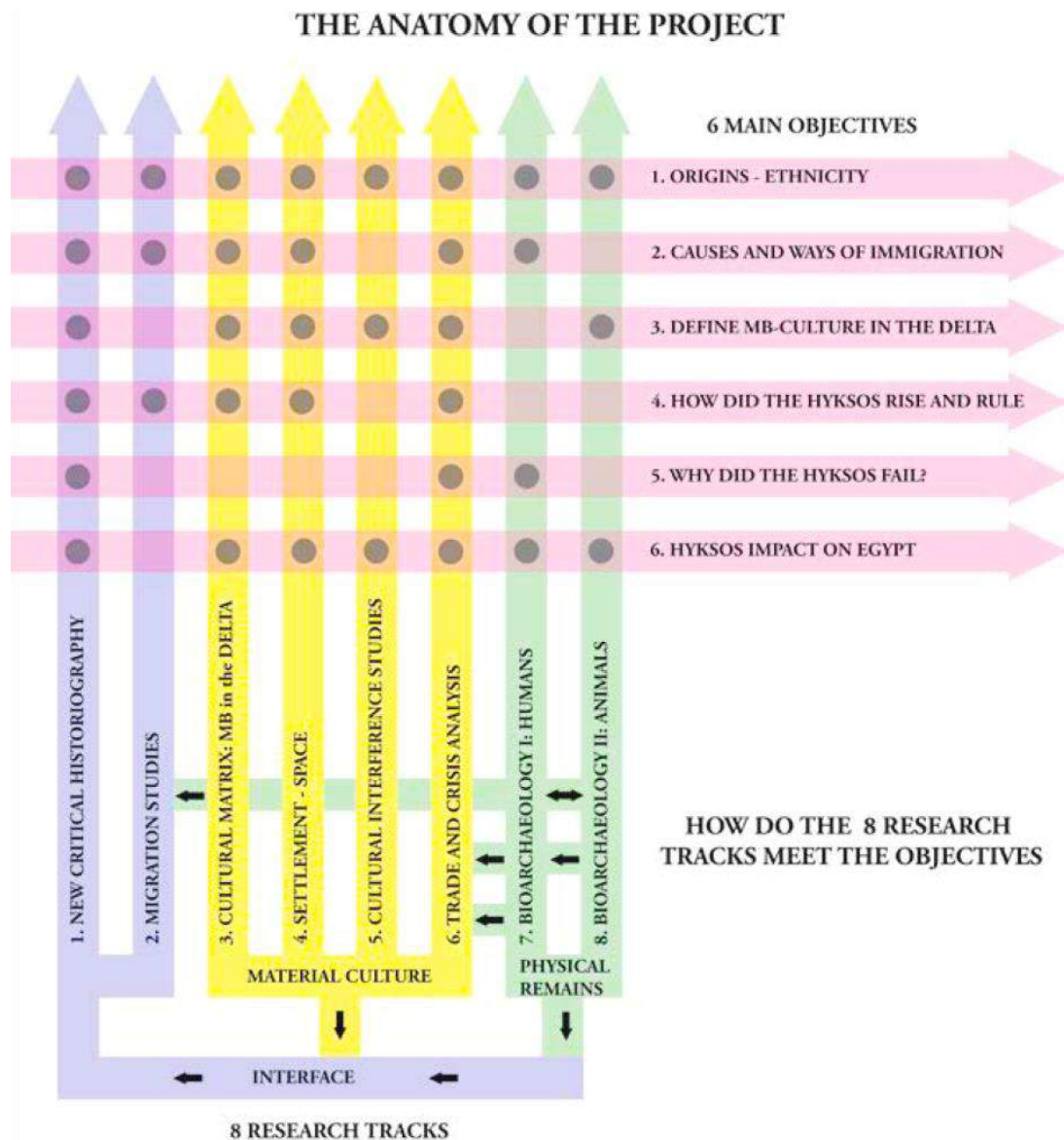


Figure 1. Eight research track of the Hyksos Enigma project (Hyksos Enigma 2020).

In research track seven, hosted by Bournemouth University, human remains were approached from a multidisciplinary perspective, combining information gained from biochemical (aDNA and isotope) and non-invasive analyses. In this PhD, the **aim was to assess Hyksos provenance and potential migration pathways using dental morphology** by asking the following **research questions**:

1. **Who were the Hyksos?** What was the population structure of Tell el-Dab'a? Was there morphological continuity? Were there differences according to sex, time period or contextual information?
2. **Where did they come from?** Did the Tell el-Dab'a population come from a single origin, or were they a mixed population with multiple origins? Were there differences between sex, time period or contextual information?
3. **Where did they go?** Did the Tell el-Dab'a population exhibit any close biological affiliation to the Late Bronze Age material in the sample?

These questions were approached using a number of non-invasive techniques with the following **objectives**:

1. **Establishing comparative sites.** Comparative sites from the Eastern Mediterranean were established according to previous research regarding material culture and textual evidence.
2. **Examining human remains from Tell el-Dab'a.** A selection of skeletal remains from area A/II and F/I from Tell el-Dab'a were available for osteological analysis, hosted by several institutes in Vienna. Though prior analyses has been conducted on the remains (Jungwirth 1968, 1969, 1970, Winkler and Wilfing 1991), the emergence of novel techniques, especially in the field of biodistance studies (used to investigate provenance), required further examination.
3. **Recording and analysing biological distance.** The biological closeness of Tell el-Dab'a and Eastern Mediterranean populations was assessed using dental nonmetric traits (crown and root variation described by ASUDAS) and patterning in first lower molar shape (2D landmark coordinate

information used in geometric morphometrics). A plethora of statistical tools were utilized in the analysis.

4. **Pooling and synergizing results.** During the course of the investigation, data began trickling down from fellow researchers, such as the work by Dr Silvia Prell (RT3) and Dr Anna-Latifa Mourad (RT5). Their work on mortuary data and cultural interference has shaped some of the interpretations of this study already, and forms only the beginning of the dynamic process of formulating interpretations across all research tracks.

1.2 Defining the Hyksos

The term Hyksos (Ἰκσῶς) is attested to the Greco-Egyptian historian Manetho (Engberg 1939, p. 4), though his work is only known from passages quoted by later historians, such as Josephus, Africanus and Eusebius (Waddell 1940). In his work *Contra Apionem* (1.73-105), the Roman-Jewish historian Flavius Josephus (first century AD) translated Manetho's Hyksos as "Shepherd Kings", however the term is believed to derive from the Egyptian term *Hq3-ḥ3swt* (HKA-XAswt)¹, 'rulers of foreign lands' (Griffith 1897, p. 297). The term was a common designator for non-Egyptian rulers, used from as early as the Old Kingdom through to the Ptolemaic period (Gunn and Gardiner 1917), but never quite as extensively as during the Second Intermediate Period (Candelora 2017). It is believed that at least three of the Hyksos kings adopted the term HKA-XAswt as part of their royal title, possibly to better assimilate their foreign identity to local population using familiar rhetoric (Candelora 2017, Mourad 2017). In its narrowest definition, the term Hyksos would only cover the kings of the 15th dynasty and some contemporary smaller dynasties (Bietak 2001, p. 136, 2010, p. 139), but in the context of the current research question it is extended to the people residing in Tell el-Dab'a at the time, performing the same material culture, and were possibly the founders of the Hyksos dynasty.

Another term commonly used by Egyptian to describe the residents of Tell el-Dab'a was Aamu (aAmw), Asiatics (Bietak 2007, pp. 124-2). The term refers to people originating from the Western Asia but no exact location is known (and the term may have been general and fluctuated depending on the people the Egyptians were in contact with). Another term occurring slightly less frequently is Retjenu (RTnw), referring to a location in the Southern Levant and often combined with official titles (Bietak 1996, p 19). Another few terms (even more infrequent) are known, which will be discussed further in chapter 2 with the more common denominators. The intermittent use of different denominators is further justification to include the whole Tell el-Dab'a population in the analysis.

¹ Transliteration guide provided in appendix A2.

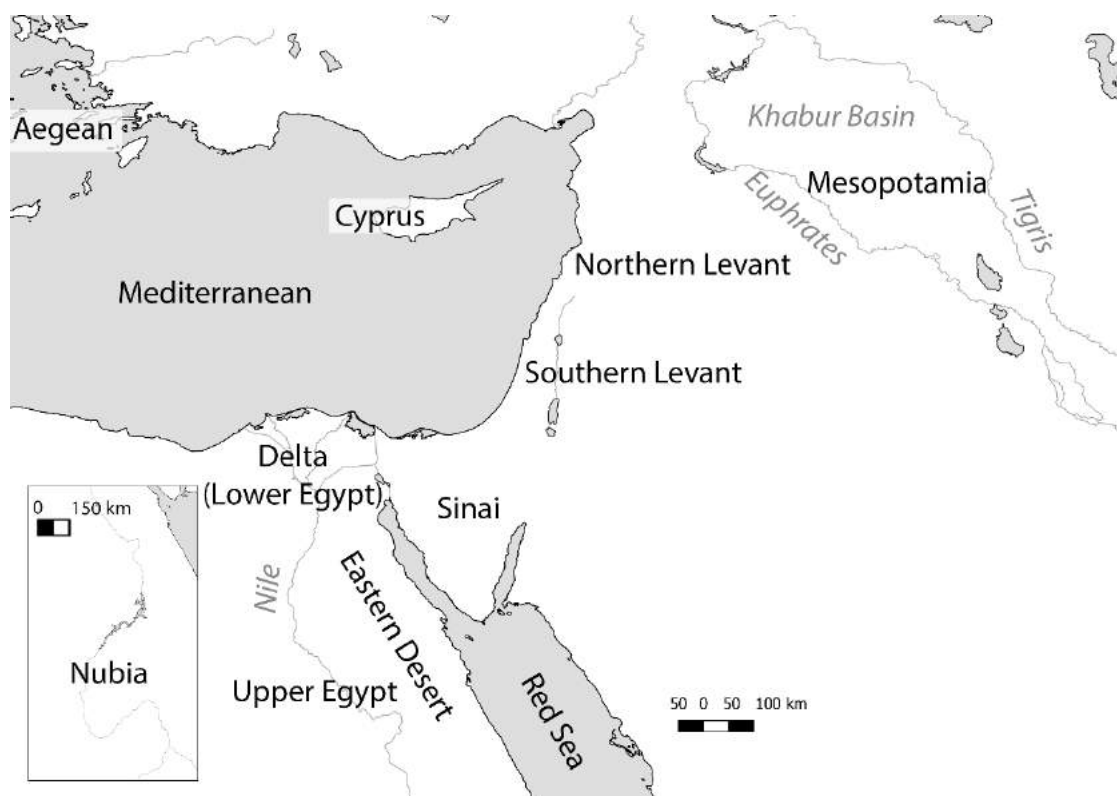


Figure 2. Map of the Eastern Mediterranean.

1.3 Research outline

Chapter two gives a brief outline of the previous research conducted on the Hyksos, before and after the discovery of the site. The former sources are engaged only minimally due to the drastic shift in understanding that has taken place since the discovery of site. Consequently, the latter research, in combination with contemporary sources, is used to build a narrative of the Hyksos and their predecessors. An account of the presence of Asiatics in Egypt is included to understand the ease in which this synergic Eastern Delta culture was born and to question the Manethonian idea of a sudden invasion. The individual Hyksos rulers and speculated rulers are not focused on as they are ambiguous in archaeological evidence (table 1 and table A3 in appendices) and non-existent in the osteological evidence, offering no real insight to the current study.

Chapter three presents the theoretical framework of migration studies and its connection points to bioanthropology. Migration, biodistance and archaeology have been intertwined since the beginning, making it only natural to explore how they have shaped one another over the years. The chapter also outlines

the biodistance methods used in this study and how they are connected to the modern concepts of migration theory. One of the topics raised by researchers is the theoretical disconnection of the archaeological and modern migration research despite shared interests. The connection points between the two have been explored only relatively recently, providing an interesting field for further research. The main ideas of this chapter are also available in two forthcoming papers (Maaranen et al. 2019ab).

Table 1. Examples of Hyksos dynasties according to different sources (Allen 2010, Lang 2015, Ryholt 1997).

Dynasty	Manetho by Africanus	Manetho by Eusebius	The Turin king-list
14	76 kings from Xoïs (184 years)	76 kings from Xoïs (184, 284, or 484 years)	lines 8.28-10.21: 51 kings
15	six Shepherd kings (284 years)	Diopolitan kings (250 years)	lines 10.22-10.29: six rulers of foreign lands (100+ years)
16	32 Shepherd kings (518 years)	five Theban kings (190 years)	15 kings (lines 10.30-11.15)
17	43 Shepherd kings and 43 Theban kings (151 years)	foreign kings, listing four names (103 years)	line 11.16-: 16th Dynasty rulers

Chapter four presents material evidence in two main sections. The first section discusses the elements that connect Tell el-Dab'a to the Eastern Mediterranean material cultural network (e.g. Forstner-Müller 2010, Maguire 2009, Philip 2006, Prell, in press). The material record not only connects the sites to one another but creates a timeline of events, exhibiting a fluctuation of patterns in trade and influence, as envisaged through the typology of pottery and metal objects (weapons, in essence). The second section offers brief site descriptions for collected material. Despite decades of research, Tell el-Dab'a is still an ongoing excavation project, though currently non-operational. As a consequence, the publication work is also in embargo, meaning not all information is yet available. The osteological material available for this study was focused on area A/II, the most published area of the site, allowing for the utilisation of contextual information. Only few individuals were available from area F/I, which has not been published completely and only dating was available for these individuals. Due to the scarcity of information and available osteological material from other Eastern Delta sites exhibiting Near Eastern

material culture (such as Tell el-Retaba and Tell el-Maskhuta), the focus of the discussion rests on Tell el-Dab'a.

Chapter five presents the methods and protocols used to collect, treat and analyse the data. Chapter six presents the results, moving from Tell el-Dab'a intra-site to inter-site analysis. The former focuses on understanding the internal structure and kinship networks at the main site, while the latter explores the Hyksos biological dental affinities in relation to other sites in Egypt as well as the wider Eastern Mediterranean. The results are conceptualized in chapter seven, offering interpretations of Hyksos provenance, internal organization of Tell el-Dab'a and the fate of the 'exiled' people. The limitations of the research are discussed and future avenues are presented.

1.4 Summary

This research project pursues to understand the Hyksos through the Tell el-Dab'a population by investigating biodistance using dental morphology. The investigation utilises previous analyses on the archaeological record, using them as clues to not only in seeking comparable material but understanding pathways of migration and the possible reasons to migrate. The results will not stand alone but will become a part of a larger interpretation of the provenance, identity, migration pathways, cultural matrix, social organization and impact. The project is an example of the potentials of research when provided with enough resources. For this, credit must be bestowed upon the Austrian Academy of Sciences for its long interest in excavation and research of Tell el-Dab'a, and the European Research Council for enabling a synergizing project.

2. The Hyksos

“...unexpectedly, from the regions of the East, invaders of obscure race marched in confidence of victory against our land. By main force they easily seized it, without striking a blow; and having overpowered the rulers of the land, they then burned our cities ruthlessly, razed to the ground the temples of the gods, and treated all the natives with a cruel hostility, massacring some and leading into slavery the wives and children of others.”

Manetho, *Aegyptiaca*, Frg. 42, 1.75-76 (Waddell 1940, pp. 78-9)

The second intermediate period has been the focus of extensive scholarly interest for over a century but, before the discovery of Tell el-Dab'a, sources were scarce. The most referred source was Manetho, a priest and a historian during the Ptolemaic period (323-30 BCE). Though several literary works have been attributed to him, *Aegyptiaca* is the most interesting for Egyptologists due to its referral to the regnal years of pharaohs (Waddell 1940). His use of dynasties was focussed on identifying ruling groups that occurred between discontinuities that were caused by either geographic or genealogic changes (Waddell 1940, p. xxv). However, nothing of the original work of Manetho has survived, and the earliest known reference comes from the work *Contra Apionem* by the historian Josephus, 37- circa 100 CE (Redford 1970). The other early mentions are even later in date, such as Sextus Julius Africanus, 3rd century CE, and Eusebius, 4th century CE (Ilin-Tomich 2016).

As quoted by Josephus, the invaders from the East assumed power by force, levying the local ruler from his throne in Memphis and building the fortified city of Avaris (Manetho 42, 1.76-79 after *Contra Apionem* I.14.78-79 after Waddell 1940: 79-83). Manetho's account of the Hyksos has been questioned by numerous researchers (beginning with Tomkins 1890, Maspero 1901). Redford (1970) lays out specific counter arguments against Manetho's account and points out that “generations of scholars have, both consciously and unconsciously, allowed themselves to be influenced by [the story of an armed invasion]” (Redford 1970, p. 3). This is understandable as Manetho's

account on the establishment of the Hyksos kingdom is the only one of its kind.

Josephus, Africanus and Eusebius attempted to identify the Hyksos with a certain population, the former with the Israelites, the latter two with Phoenicians. Neither of these suggestions really took a stand on who the Hyksos were but rather who they became. Tomkins (1890) suggested a connection between the Hyksos and the Levant, while Maspero (1901 vol 1 p. 161) simply referred to the Hyksos as strangers from Asia. Labib (1936) was the first to compile all the contemporary sources, but it was Engberg (1939, p. 42) who focused on the material similarities between the Hyksos and the Levantine area and argued a Hurrian or Indo-Aryan origin. Though the Hurrian theory was supported by several later scholars (e.g. Ward 1961, von Beckerath 1964, Helck 1971), not all agreed. Instead, Alt (1954) preferred the Phoenician-Palestinian origin. Van Seters (1966, pp. 1-4) criticised Engberg's work for referring to Levantine material culture as Hyksos, causing confusion in later analyses (a similar conduct was practised by other researchers as well, such as Schaeffer 1949), but still saw the evidence sufficient enough to identify the Hyksos as Asiatics (aAmw).

The chapter focuses on the evidence of Asiatics in Egypt, beginning from the Old Kingdom, in order to emphasise the continuity of the phenomenon that culminated in the foundation of Tell el-Dab'a and the Hyksos kingdom. The chapter also gives an overview of the history of Tell el-Dab'a from its emergence at the end of the Middle Kingdom to its abandonment in the beginning of the New Kingdom. To maintain cohesion, the presence of other foreigners (such as the Nubians) is only mentioned when they intersect with the main narrative.

2.1 Asiatics in Egypt

Egypt's interests in trade are evident from the very beginning of the Pharanonic period. Evidence from the Old Kingdom refers to trade connections with the Levantine coast (figure 3), particularly with Byblos. Royal gifts were sent as offerings to the town's goddess (Dunand 1937, p. 26-7), and the local princes took Egyptian epithets (Bietak 2010, p. 159). Inscriptions from the fifth dynasty reveal the presence of Byblites in Egypt, from which some even adopted Egyptian names (Fischer 1991 p.63, Schneider 1996, pp. 13-27). Trade was done particularly in pitch, bitumen, copper, olive oil and most notably cedar wood, found growing even in modern Lebanon. This wood was used for prestigious buildings, tombs and both sacred boats and seafaring ships. (Bietak 2010, p. 142)

It has been assumed that the connection also brought over not only merchants but sailors and other skilled workers. At the time, seagoing ships were generally called Keбенet (kbnt), translating to Byblos ships (Säve-Söderbergh 1946, pp. 48-9), suggesting the employment of Levantine ship builders (Bietak 2010). The pyramid temple of Sahura (5th dynasty) depicts the arrival of large ships with non-local travellers (Bietak 2010, pp. 142). A century later a similar scene was depicted in the causeway of Unas with ships manned by Asiatics sailors and Egyptian superiors (Bietak 2007, pp. 418-9). Foreign soldiers in the Egyptian army are believed to have been abundant. In the inscription of troop leader Weni the classifier used for the soldiers under him was marked by a bearded man wearing a headband, believed to have been reserved to depict Asiatics (Shalomi-Hen 2003). The term aamu (aAmw) is already known from the 6th dynasty biography of Pepynakht Heqaib which tells his story of having to collect the body of an officer, killed in an attack by aamu and sand-dwellers (Hryw-S) (Strudwick 2005 p. 335).

Bietak (2003) has suggested that some of the Asiatic people employed in the various professions may have settled in Tell Ibrahim Awad, less than 10 kilometres from Tell el-Dab'a. The most notable (though still indirect) evidence of non-Egyptian presence in the site is the temple which was first built as a

broad-room temple² and later transformed into a bent-axis temple³. Neither temple type is typical for Egypt but well-attested in the Near East.

During the first Intermediate Period (circa 2181-2055 BCE) Egypt had divided into two major regional centres, the Lower Egyptian Heracleopolis and the Upper Egyptian Thebes. The period came to an end during the reign of the 11th dynasty Theban king Nebhepetra Mentuhotep (circa 2043-1992 BCE) whose successful campaign to the north led to the unification of Egypt under one ruler. Bietak (2010, p. 145) believes the regional powers utilised Asiatic and Nubian mercenaries, the former employed by the Lower Egyptian armies and the latter by the Upper Egyptian. Mentuhotep's mortuary temple in Deir el-Bahri and the tomb painting of general Intef in Asasif depicted Asiatics in warfare with Egyptians and Nubians (Jaroš-Deckert 1984, pp. 37-44, Smith 1965, pp. 18-9). Furthermore, the employment of Asiatic soldiers in the Middle Kingdom army from the very beginning of the 12th dynasty, suggests they had already been established in the country (Bietak 2010, p. 145). The teachings of Merikara and the Admonitions of Ipuwer suggest an influx of Asiatics in the country, but these two works are considered literary (and as such useful in general terms and in their sociocultural context) and the latter may date as early as the 18th dynasty (Van Seters 1964, 1966, pp. 103-20).

The Middle Kingdom shows more extensive evidence of the Asiatics in Egypt. The famous Tale of Sinuhe, best known from papyri Berlin 3022 and 10499 (circa 1900-1700 BCE), allude to Egypt's knowledge of the Asiatics from the Southern Levant (Cohen 2002, p. 39). The later Annals of Amenemhat II (circa 1911-1876 BCE) from Memphis (modern Mit Rahina) describe of military campaigns directed to the Levant (to places such as Xnty-S, sTt, iwa and iAy), and among the spoils over 1500 Asiatic prisoners are

² A popular temple type in the Canaan during Chalcolithic and EBA. The platform for the deity was usually placed next to the back wall in line with the main (central) entrance, allowing a direct view of the deity. Typical Chalcolithic broad-room temples are known from 'ein-Gedi, Teleilat el-Ghasul; EB temples from Megiddo, Jericho, Tel Yarmut, Bab edh-Dra; and MB temples from Nahariya, Hazor, Tell el-Hayyat. Some cases are known from later periods (LB 'Ain Dara', IA Arad and Hellenistic Lachish). (Herzog 1997, pp. 358-61)

³ Popular in Mesopotamia. The deity statue was placed in the central hall, but the statue could only be approached from a ninety-degree angle. One of the most well-known examples is the White Temple in Uruk (circa 3200-3000 BCE), dedicated to the skygod Anu. The temple was placed on top of a ziggurat, a platform resembling a cut-off pyramid, surrounded by stairs that spiralled (in angle) into the temple where the main room was narrow hall with smaller chambers. There few examples of the temple type used in EB Jericho and Ai, contemporary to the bent-axis temple in Tell Ibrahim Awad in the Egyptian Delta area. (Bietak 2003)

mentioned (Marcus 2007). The toponyms' current locations are ambiguous but the goods (timber, oil, resin) are suggestive of Northern Levantine provenance (Marcus 2007). Periods of settlement destruction have been identified from MBIIA and MBIIIC-LBIA Levant (Burke 2008, p. 98). Some of these events have been tentatively connected to the military expeditions ordered by Senusret III, mentioned in the Khu-Sebek stela (Pritchard 1969, p. 230):

"His majesty proceeded northward to overthrow the Asiatics. His majesty reached a foreign country of which the name was Skmm [Shechem?]. His majesty took the right direction in proceeding to the Residence of life, prosperity, and health. Then Skmm fell, together with the wretched Retjenu."

Burke (2008, p. 100) has suggested Skmm refers to a small local kingdom in the Southern Levant against which the Pharaoh's attack caused abandonment. These sources show Egypt's involvement with the Levantine area by sea and by land had both mercantile and raid aspects. The Old Kingdom trading partner Byblos retained its importance during the Middle Kingdom, visible in the wealth of Egyptian or Egyptianised luxury items in the Byblite Royal Tombs (Kopetzky 2012).

The Beni Hassan tomb of Khnumhotep II, believed to have been in charge of prospecting and mining activities in the Eastern Desert, shows a procession of Asiatic mercenaries and families (Kamrin 2009, 2013, Newberry 1893, pls. 16, 31, 47, Posener 1971, p. 541). The text refers to the travellers as the Aamu of Shu, believed to be somewhere between the Southern Levant and the Eastern Desert along the Sinai trade route. Inscriptions found near mines at Serabit el-Khadim in Sinai tell of the employment of Retjenu Asiatics in mining expeditions especially during the reign of Amenemhat III (during the 12th dynasty, circa 1844-1797 BCE (Bietak 1996, p. 19). During the Middle Kingdom, Retjenu referred to a large area in the Southern Levant and the Levantine coast (Gardiner 1947, p. 142-9, Posener 1949). Stela 112 from Serabit el-Khadim depicts the dignitary Khebeded, "the brother of the ruler of Retjenu", riding on a donkey and adorning an axe with a curved handle (possibly a scimitar) and a duckbill axe (seen also in the depictions at Beni Hassan), linking the individual with the Middle Bronze Age "warrior" culture prominent all over the ancient Near East at the time (Goldwasser 2012). The

petroglyphs found along the Sinai route suggest expeditions were a combination of land and sea operations (Bietak 1996, p. 27). In addition to aAmw (Asiatic) and rTnw (Retjenu), Western Asiatic people were called St-tyw (dwellers in the East?) in the Tale of Sinuhe (Mourad 2014, p. 219).

In the beginning of the 12th dynasty, the kingdom capital was moved from Thebes to Itj-tawy, somewhere close to modern el-Lisht. The cemetery at el-Lahun was created for the ruler Senusret II, the royal family and officials and the nearby settlement Kahun consistent of workers of both Egyptian and Asiatic origin (Griffith 1898 pp. 35-6, Petrie et al. 1890). Though it is uncertain where these people came from, considering the numerous mercantile and military campaigns to the Levant, there may have been several pathways. Onomastic evidence points to Asiatics working in low-ranking professions such as servants, singers, doorkeepers and messengers (Bietak 2007, p. 421, Posener 1957, p. 152, Luft 1993, Schneider 2003, pp. 335-6). According to Bietak (2007, p. 421), some were given Egyptian names and they were assimilated to the majority culture. Sections of the Illahun papyrus refer to four female Asiatic slaves that Gardiner (1898, p. 36) believes were acquired from a recent raid (see Illahun papyrus pl. XII l.10, pl. XIII l.15, Griffith 1989, pp. 34-6). The Brooklyn papyrus 35.1446 from the 13th dynasty Thebes describes the purchase of 45 Asiatic slaves (translation by Hayes 1955). Though the presence of Asiatics, particularly in Kahun, has been attested from contemporary official documents, the archaeological record does not exhibit non-local influences. This has been explained by the relatively small number of Asiatics, as well as their subordinate position in relation to the main population, resulting in assimilation (Bader 2012).

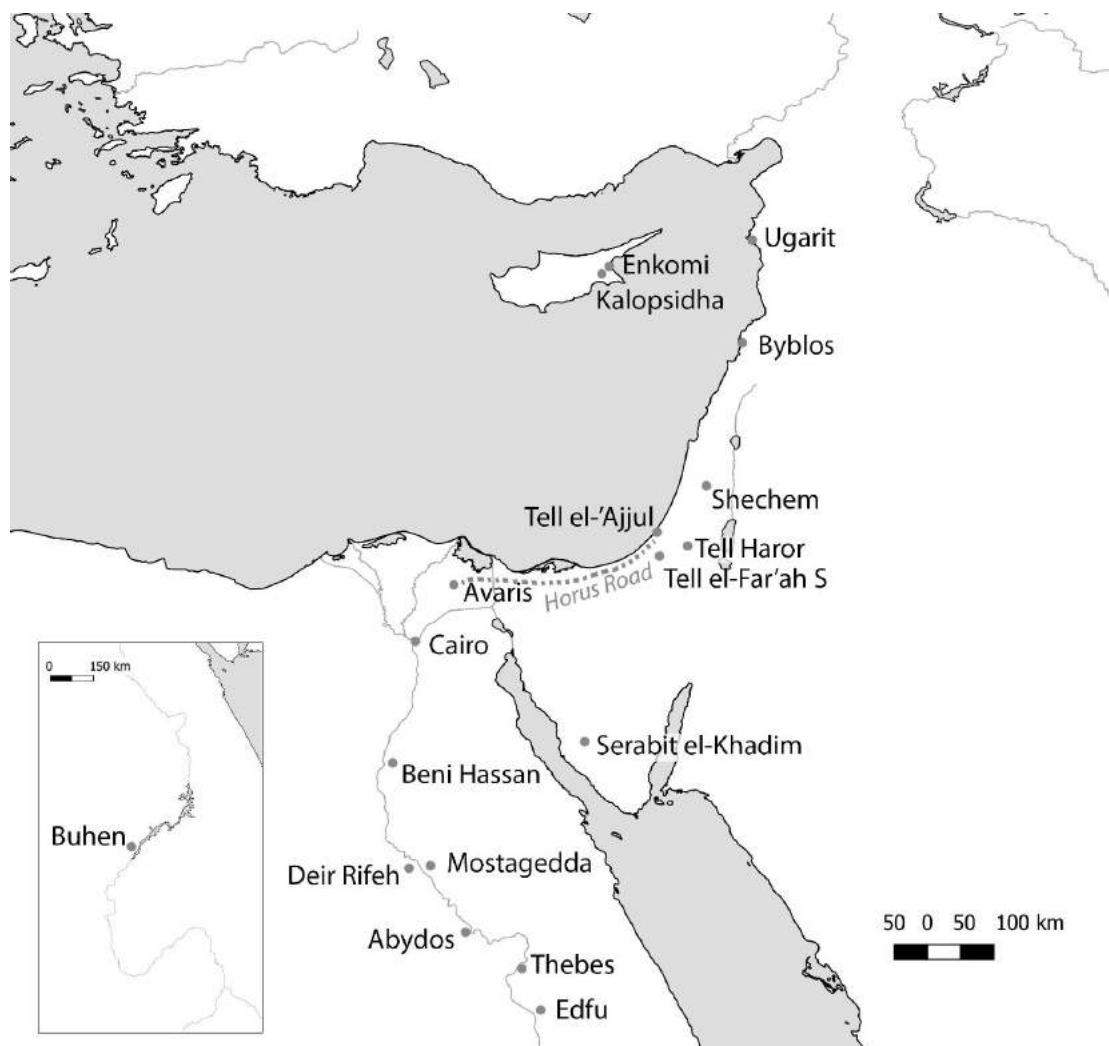


Figure 3. Map of sites mentioned.

2.2 The rise of Tell el-Dab'a

The oldest toponym (Hwt-wart) of Tell el-Dab'a (Arabic for "mound of the Hyena") has been dated to the 12th dynasty, from a sealing near 'Ezbet Rushdi (Czerny 2001), the area with the earliest settlement structures. Blocks found from the 18th dynasty building in 'Ezbet Helmi, are assumed to come from 'Ezbet Rushdi, area R/I (Bietak 1996, p. 64). Here, Senusret III erected "a doorway which belongs to the Djadjawy-of-the-palace-of-Amenemhat [I] [DADAwy-aH-aimn-m-xAt]." (Szafranski 1998, 105). The portal consisted of two jambs and a lintel, circa 4 metres tall and 1.3 metres wide (Janosi 1994, pp. 22-7, figs. 5-6, pl. 1). Though the exact purpose of the DADAw is debated, the building would have been of official (military, administrative or palatial) capacity (Bietak 1996, p. 64, Junker 1957, Kees 1962, Janosi 1994, Uphill 1984, p. 154).

The location along the Pelusiac branch of the river Nile gave it access to both the Mediterranean Sea as well as to the Sinai trade routes (via the ancient Horus Road) (Bietak 1996, p. 3). The 12th dynasty can be described as a period of rising prosperity, accumulating wealth for the people managing trade (Mourad 2018). A seal has been found from the site, dating to the end of the 12th dynasty, and mentions the “[ruler of R]tjenu” (Martin 1998). Bietak (2010, p. 147) has offered two possible options; either a ruler from Retjenu inhabited in Tell el-Dab’a at the time, or the title was appointed by the Egyptian crown to the person in charge of trading with Retjenu. The title may be connected to the scriptures along the Sinai route that refer to a campaign leader ‘the brother of the prince of Retjenu’ (Bietak 1996, p. 19).

In the beginning, material culture and settlement structure were mostly consistent with Egyptian material culture with few Aegean and Levantine imports (Bietak 2010, p. 150). By the end of 12th dynasty, however, the archaeological record becomes a combination of Egyptian and Near Eastern Middle Bronze Age (Bader 2012, Eigner 1985, pp. 19-25, Forstner-Müller 2002, Bietak 1991, p. 32, 2010, p. 139). Near Eastern temple types (such as the broad-room and bent-axis temples, with parallels particularly in northern Syria and Mesopotamia) were used in sacred spheres whereas the mortuary chapels were mostly Egyptian with often Near Eastern installations (Bomann 1991, pp. 85-86, Bietak 2007, p. 428, Bietak 2010, p. 153).

Burial customs, such as intramural burials and jar burials were distinctly Asiatic (Bietak 1996, pp. 36-41, Forstner-Müller 2002, 2010, Schiestl 2008, 2009). The placement of burial grounds within the settlement was a Near Eastern region-wide custom which is also believed to have spread into the Aegean during the Bronze Age (McGeorge 2013). The most striking divergence from Egyptian burial customs are the so-called warrior burials, characterised by the inclusion of Near Eastern weapon types (seen also in the depictions in Beni Hassan and Serabit el-Khadim) and associated equid burials (Bietak 1996, Goldwasser 2012). The presence of Nubian and Cypriot people currently rests on the evidence of locally made pottery types, and no agreement exists at least on the former (Bietak 2018, Matic 2014). Nevertheless, despite the increase of Middle Bronze Age material finds (mainly pottery), tomb superstructures and the majority of associated pottery

in the settlement and burials alike remained Egyptian in style (Aston 2002, p. 44, Schiestl 2009, p. 337).

The mixing of cultural elements is also apparent in the religious sphere, not only in the shared cultic space but the emergence of a hybrid deity Seth/Ba'al-Zephon (Mourad 2017). Seth was an ancient Egyptian god, present in the pantheon from the very beginning of Pharaonic Egypt. Associations with Seth fluctuated through time, but his association with storms during the Middle Kingdom may have provided the connection to the Northwest Semitic storm god Ba'al (translating to "Lord"). The earliest mentions of Ba'al or Ba'al-Zephon come from the 12th dynasty Illahun papyri, and iconographic sealings discovered from Tell el-Dab'a confirm the god's continued presence. Seth's epithet, "lord of Avaris", is known from numerous textual sources. (Mourad 2017)

The end of the Middle Kingdom was marked by a rapid succession of kings, alluding to a lack of stability. Currently there is no evidence to suggest outside interference in Memphis, el-Lisht or Dahshur at the time (Bourriau 1997, p. 164-6). In contrast, destruction and administrative abandonment took place in Tell Basta (Mourad 2017). The weakening of the central government is visible in the archaeological record (and particularly in the ceramic corpus) of the whole kingdom. During the Middle Kingdom, "residence style" pottery was developed under the reign of Senusret I in the royal residence Itj-tawy (in modern el-Lisht) and circulated across Egypt. In the 13th dynasty, new regional shapes emerged alongside the residence style not only in Tell el-Dab'a (Bader 2009, p. 705, Kopetzky 2010, pp. 270-1) but in Thebes as well (Bourriau 2010, Seiler 2010). Changes also took place in the religious sphere as the king lost his place as the mediator between the people and the divine, and Egyptian tomb biographies from the 13th to the 17th dynasties emphasise individuality (Kubisch 2010, Seiler 2010).

2.2.1 The Hyksos govern and network

Though the exact sequence has remained unclear, the 14th dynasty emerging in Tell el-Dab'a is believed to have been contemporaneous to the Middle Kingdom 13th dynasty (Ryholt 2010). Despite a disruption taking place at the

administrative district and a possible crisis (possibly an epidemic) resulting in the production of shallow pit graves, the site continued to grow steadily. By the time the 15th dynasty Hyksos kingdom was established, the site had reached circa 250 hectares in size (Bietak 1991, p. 29). Other sites in the Delta, both new and pre-existing (figure 4), represented similar cultural elements, indicating the formation of a local network (Mourad 2014, 2018).

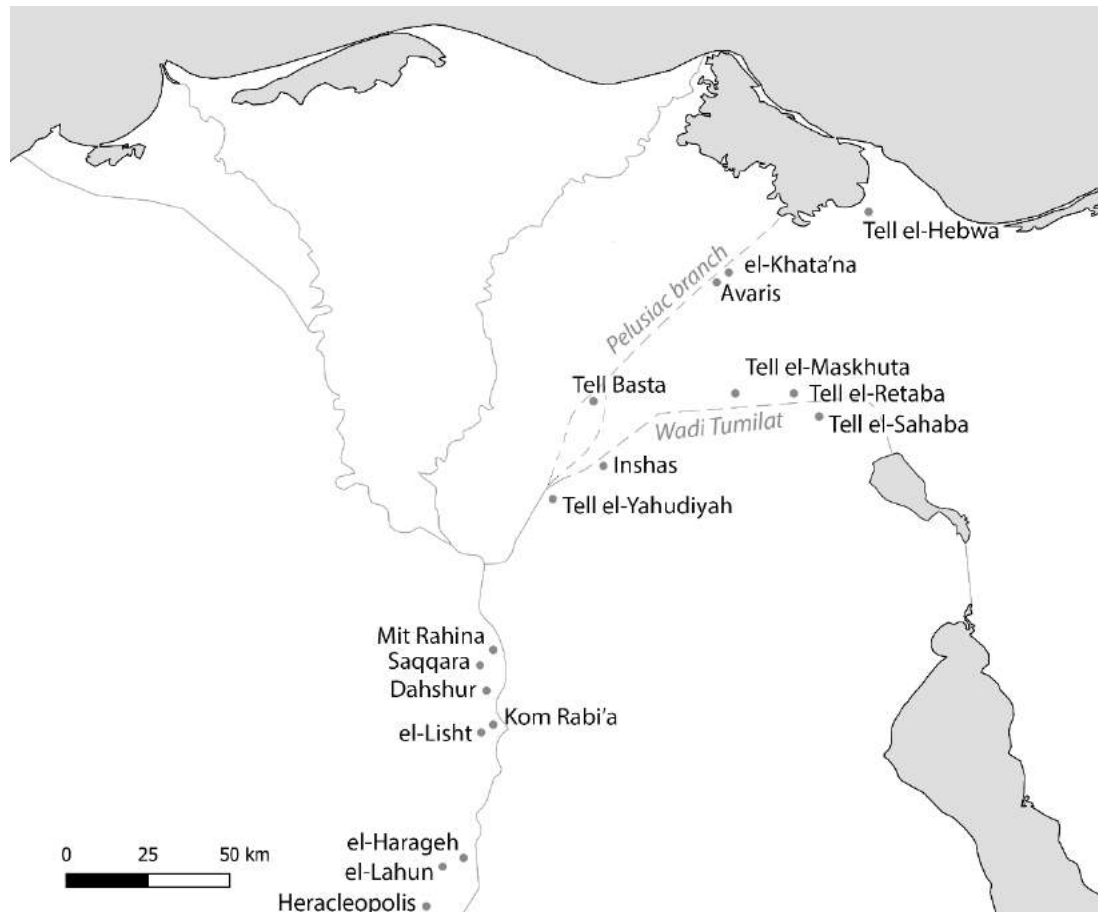


Figure 4. Map of the Nile Delta.

There are two easy inland routes between Egypt and the Levant. The northern route, called Horus Road or Ways of Horus, arrived at the Delta and Tell el-Dab'a via coastline (Hoffmeier and Moshier 2013, p. 488). The southern route, on the other hand, originated from south and north Arabia, Jordan and southern Sinai, and arrived at the heart of the Delta through Wadi Tumilat (Oren 1979). Several sites were formed along the Wadi Tumilat, important because of its topography, location and available resources. Results of the 1977 survey sites in the Wadi Tumilat produced evidence of

Middle Kingdom activity for Tell el-Retaba and Tell el-Maskhuta, and potentially earlier for the former (Oren 1979).

According to excavations by Hudec et al. (2015, p. 276), earliest occupation at Tell el-Retaba dates to the Middle Kingdom, possibly the reign of Senusret III, but more intense activity does not begin until early in the 15th Dynasty. The site may have been briefly abandoned at the end of the Hyksos period and then utilised as a military and administrative centre during the New Kingdom (Górka and Rzepka 2011, p. 99, Oren 1979, Rzepka et al. 2014). Though new investigations are currently still underway, the reports suggest the site shared material culture and burial practices with the Tell el-Dab'a Near Eastern corpus (Rzepka et al. 2011, 2014, Wodzińska 2018).

Tell el-Maskhuta was likely occupied during MBII, the published ceramic corpus correlated with Tell el-Dab'a strata E/I-D/3 (Holladay 1996, Redmount 1995). It may have acted as a supply point for caravans during the winter months it was occupied, explaining the "eclectic combination of Northern and Southern Levantine features" (Mourad 2014, p. 91). According to Holladay (1997a, pp. 432-4), products travelling northwest included incense, ivory, gold, gemstones and animal pelts, while items travelling southeast included copper, tin, silver, linen, alabaster and medicinal drugs. Settlement finds indicate local industry at the site, including weaving, spinning, pottery-making and even metallurgy (Holladay 1997b, pp. 195-6). The settlement architecture and activities as well as the burial practices and material culture resemble customs observed from Tell el-Dab'a (Holladay 1997b, p. 183). The site exhibits several interesting features which must (for the moment) wait for a more extensive publication. One of these interesting mentions are infant cist burials which have been found only from the earliest periods of Area F/I in Tell el-Dab'a (Holladay 1997a, pp. 432-3, Schiestl 2008, p. 245).

Tell el-Yahudiayh resided between Memphis and Wadi Tumilat. Though not readily agreed upon by its different excavators, occupation appears to have taken place from the late 13th to the 15th Dynasty (Ashmawy Ali 2016, Petrie 1906). Finds such as equid burials, MBA burial architecture, assemblages and pottery, all point to Levantines or Levantine-influenced

people at the site (Ashmawy Ali 2016). The transition from the pre-Hyksos to the Hyksos period resembles that of Tell el-Dab'a (Mourad 2014, p. 99-100).

Tell el-Hebwa, ancient Tjaru, was founded at the entrance of the northern Sinai during the Middle Kingdom and utilised as a stronghold during the New Kingdom (Abd el-Maksoud 1998). One of the most interesting finds from the site was a door jamb which followed a Middle Kingdom formula for titles but also mentioned the storm god Ba'al (Mourad 2014, pp. 77, 81). The find could allude to early knowledge of the god at the site, along with other material evidence signifying the increase of particularly Southern Levantine influences throughout Second Intermediate Period and the New Kingdom (Mourad 2014, pp. 77, 81).

Circa 70 so-called Hyksos burials have been discovered from Inshas, accompanied by equid burials, Tell el-Yahudiyah juglets and Hyksos scarabs but the finds have not been published (Mourad 2014, p. 81). El-Khata'na and Tell el-Sahaba have also not been published, but the few distinctions and mentions in secondary sources point to a 15th Dynasty material assemblage (Brink 1982, p. 56, Naville and Griffith 1890, pp. 56-7).

Though the extent of the Hyksos "vassal" rule is unclear, their influence may have reached as far south as Deir Rifeh and Mostagedda, with the former falling under Hyksos rule and the latter under the Thebans (Collin et al. 2000, Collin 2005, Bourriau 2010, p. 23, Flammini 2015). The (scarce) textual evidence suggests that borders fluctuated according to the local authorities. Egyptians were aligning not only with Thebans but sometimes the Hyksos or the rulers of Kush. The first stela of Kamose mentions a local dignitary who turned the town Neferusi into "a nest of Asiatics" (Smith and Smith 1976, p. 60), while some of the biographies from Buhen show Egyptians swearing allegiance to the ruler of Kush. (Kubisch 2010, p. 323) Relationships between the Hyksos rulers and local chiefs were maintained by a circuit of personal messages and gifts, meant to inspire mutual loyalty (Arnold 2010, p. 213, Flammini 2015, p. 242).

The Hyksos kings are mainly known from scarabs, but the identification of circa 500 seals with royal names has been deemed problematic (Ryholt 1997, pp. 40-52). Both the Turin king-list and Manetho's *Aegyptiaca* record

one dynasty of six rulers (Ryholt 2010). Much work has been done to organise these rulers between the 14th and 15th dynasties with no true consensus (Ben-Tor 1994, 1999, Krauss 1998, Ward 1984, Ryholt 1997, 2010). The only ruler on whose sequence there is an agreement is Apophis ('Awsr-ra-ipp) whose reign was mentioned in the Rhind Mathematical Papyrus (Ryholt 2010, p. 124). He is also referred to in the first and second stela of Kamose as the "chief in Avaris" (wr m Hwt-wart), "chief of Retjenu" (wr n rTnw) and the "ruler of Avaris" (HKA n Hwt-wart) (Flammini 2015, p. 241). Though most abundant during the Second Intermediate Period, not all Hyksos rulers assumed the title HKAw-HAswt (Candelora 2017, Ryholt 2010).

The numerous rulers indicated by scarabs that remain outside the king-lists, is suggested to indicate subordinate positions (Quirke 2007, p. 133, Redford 1970). Van Seters (1966, pp. 162-3) connected the Hyksos political tradition to the Old Babylonian world, based on a vassal system which divided rulers into "brothers" (indicating equal standing) or "fathers" and "sons" (indicating either dominance or seniority). However, a vassal system indicating socio-political subordination may not be fully descriptive of the Hyksos system (Flammini 2015). Nearly 200 names with the title "royal sealer" are known from the Second Intermediate Period, contrasting to the handful of people appointed to the task during the Middle Kingdom (Grajetzki 2010). Quirke (2007, p. 133) has wondered whether titles indicating kinship were used "to cover areas of authority, notably military control". Furthermore, Redford (1970) suspects the emergence of new epithets in the New Kingdom, such as 'king of kings' (nsw nsyw) and 'lord of lords' (HKA n HKAw) were inspired by the Hyksos vernacular.

Due to the lack of textual sources, the social organisation of Tell el-Dab'a has remained ambiguous. The most apparent evidence is the continued use of both Egyptian and Near Eastern material culture and the Seth/Ba'al cult (Bietak 1996, Forstner-Müller 2010, Mourad 2017). The generation and maintenance of the Seth/Ba'al cult may have carried multiple benefits to the ruling class of Tell el-Dab'a. In the case of a diverse population from multiple ethnic backgrounds, the generation of a hybrid deity provided everyone a familiar focal point. During the 15th dynasty Hyksos kingdom proper, the Ugaritic Baal cycle, recognising kingship gained through victory

instead of inheritance, may have provided further justification to the non-royal sovereigns of the Second Intermediate Period (Mourad 2018).

Tell el-Dab'a's active foreign relations are evident from its estimated two million imported amphorae (Bietak 1996, p. 20). Since the 12th-13th dynasty, trade was particularly active with Northern Levant and Cyprus (Aston and Bietak 2004, Cohen-Weinberger and Goren 2004, Maguire 2009, p. 21). Trade with Cyprus was at its largest during the peak of the Hyksos period, contemporary to the Late Palestinian style which also increased its presence at the site (Cohen-Weinberger and Goren 2004, p. 80-5, McGovern 2000). At its largest, the Hyksos trade network spanned from Babylonia to Kush (e.g. Ben-Tor 2007, 2010, 2011, Bietak 1989b, 1996, 2007, 2010, Bourke et al. 2006, Collin 2005, Collin et al. 2000, Forstner-Müller 2002, 2010, Koppen and Lehmann 2012, Maguire 2009, Philip 1995a, 2006, Schaeffer 1938, Schiestl 2009, Stewart 1974). The second stela of Kamose speaks of the ruler of Avaris having 300 ships made of ash and wood, filled with all the fine products of Retjenu (translated by Habachi 1972). Detailed in the first and second Kamose stela, the Hyksos were recorded importing commodities such as livestock, timber, precious metals and stones, oils, incense, fat and, honey (Bard 2008, p. 195, Bourriau 2003, p. 195). Little is known of the Hyksos exports, but it is possible the town's intermediary role, for which it was originally founded on, played a part in sustaining it during the Hyksos reign as well.

2.2.2 The siege and exile

"I should like to know what serves this strength of mine, when a chieftain in Avaris, and another in Kush, and I sit united an Asiatic and a Nubian, each in possession of his slice of Egypt [...] I will grapple with him and open his belly. My desire is to deliver Egypt and to smite the Asiatics."

Carnarvon tablet (translation by Gardiner 1961, p. 166)

The Second Intermediate Period came to an end at the siege of Avaris by the Theban ruler Ahmose, founder of the 18th dynasty and the New Kingdom

(Bourriau 2000). Aside from the evidence available in the archaeological record of Tell el-Dab'a, the events must be constructed from contemporary and later Egyptian sources.

The first engagement is believed to have taken place in the reign of Seqenenra Taa, a 17th dynasty Theban ruler, whose tale is described in the literary work Quarrel of Apophis and Seqenenra (papyrus Sallier I, EA 10185) (Redford 1970). Written under the reign of Merenptah (19th dynasty), the tale glorifies the beginning of the rebellion and plays on collective memory. By referring to the Theban ruler as chief (wr) and Apophis as king (nsw) and paralleling the two rulers with Ra and Seth (respectively), the New Kingdom audience was galvanised into nationalism (Spalinger 2010, pp. 130-1). Seqenenra Taa's mummy, identified from the Deir el-Bahri cache in 1881, exhibits five severe head wounds (two perforating impression fractures, a case of blunt force trauma and two cases of sharp force trauma) (Berge and Goot 2002). Though the exact moment of these injuries has remained uncertain, they are generally accepted as the cause of death. No other signs of trauma were present in the post-cranial body (Berge and Goot 2002).

Seqenenra Taa was succeeded by Kamose, possibly his son, launching several military campaigns against the rivalling kingdoms. In addition to the accounts by Kamose, private inscriptions from Buhen and Edfu describe the king's re-conquest of Lower Nubia (Kubisch 2010, p. 325). After beginning the re-integration of Nubia into Egypt, Kamose turned his attention to the Hyksos kingdom and its allies. The Carnarvon tablet of Kamose shows no mercy for Egyptians who had aligned themselves with the Hyksos (Gardiner 1916, p. 108):

"I overthrew him, I destroyed his wall, I slew his folk, I caused his wife to go down to the river-bank. My soldiers were like lions with their prey, carrying off slaves, cattle, fat and honey, and dividing up their possessions, their rejoicing. The region of Nef[rusi] came down."

The stela of Kamose (Kamose II), discovered from Karnak, describes a similar assault to Avaris, but there is no archaeological evidence to suggest any destruction (Habachi 1972, Forstner-Müller 2010). Though suddenly dying around his third regnal year, his funerary cult survived till the Ramesside

period. The Hyksos ruler Apophis has been suspected to have died around the same time, causing a temporary stand-still in military actions (Bourriau 2003, p. 199-200). The Hyksos and Theban rulers were succeeded by Khamudi and Ahmose I, respectively. The Rhind Mathematical Papyrus has a brief diary entry describing how the peace was broken (Redford 1992, p. 71):

“Regnal year 11, second month of shomu, Heliopolis was entered. First month of akhet, day 23, this southern prince broke into Tjaru.”

Tjaru (modern Tell el-Hebwa) was located at the entrance of north Sinai and it was the first leg along the Road of Horus. Excavations at the site have uncovered skeletonised human remains dating to the end of the Second Intermediate Period or early New Kingdom, bearing signs of interpersonal violence.⁴ By taking Tjaru, Ahmose I was able to cut off traffic between the Levant and Avaris, thwarting hopes of supplies, help or retreat.

The siege of Avaris is best known from the tomb biography of Ahmose, son of Ibana (Bourriau 2003). The text focuses on Ahmose’s engagements with the Hyksos soldiers, and only mentions the eventual siege of Avaris in passing (Breasted 1906, p. 7):

“One captured Avaris; I took captive there one man and three women, total four heads, his majesty gave them to me for slaves.”

The next sentence describes the six-year-long campaign to the Southern Levantine town of Sharuhén, believed to have been the last stronghold of the Hyksos (Bourriau 2003, p. 197). Several modern locations have been suggested for Sharuhén, most often Tell el-’Ajjul, Tell el-Far’ah South and Tell Abu Hureirah/Tell Haror, however no consensus has been reached (Bietak 2010 p. 153, Bourke and Eriksson 2006, Kempinski 1974, Hoffmeier 1991, p. 117-120, Shea 1979, Weinstein 1991, p. 106).

Neither the account of Ahmose nor Manetho (after Josephus, Waddell 1940, p. 89) mentions the destruction of the city, which is supported by the archaeological evidence from Tell el-Dab’a. Instead, the city was mostly abandoned and nearly all tombs from the final occupation period were looted

⁴ News article from Saturday 16 March 2013:
english.ahram.org.eg/NewsContent/9/40/66979/Heritage/Ancient-Egypt/Hyksos-buildings-are-the-latest-ancient-discovery-.aspx. Accessed 13.06.2019.

(Bietak 1996, p. 67). A military camp was established, and the temple of Seth in area A/II continued in use for centuries, apart from a short disruption during the Amarna period (Bietak 2011, p. 22). The remnants of a Minoan wall painting have been found from a building in the area 'Ezbet Helmi, built during the Tuthmosid period, providing evidence together with onomastic and material finds of yet another wave of foreign influence at the site (Bietak 1996, pp. 63-83).

The abandonment of Tell el-Dab'a did not collapse the trade network, merely changed it. The abandonment of Tell el-Dab'a halted local pottery production for trade purposes, leaving Cyprus to assume a near complete monopoly of small trade containers (Maguire 2009, pp. 62, 66). The beginning of Late Bronze Age in Cyprus was a period of dramatic changes in settlement structures and material culture. Enkomi increased prominence over Kalopsidha and foreign material becomes more frequent in the archaeological record. Socketed axes and belts, Tell el-Yahudiyah ware and its imitations and Red Burnished Ware have been found from burials (Maguire 2009, p. 66). Cypriot copper production continues to grow, reaching its peak in the Late Bronze Age (Kassianidou 2014, p. 262). The Hyksos period built the foundations for several later trade networks, even facilitating Egypt's contact with Crete and the Aegean through Cyprus (Betancourt 1997, p. 431).

During the Ramesside period, the new capital Pi-Ramesses rose only two kilometres from Avaris, adding to the number of towns utilising the trade and military potential of the Eastern Nile Delta (Bietak 1996, p. 67). Seth/Ba'al-Zephon enters the state religion as one of the major deities during the Ramesside period (Bietak 2010, p. 157) The 'four hundred year' stela from Tanis with Ramses II and vizier Seti offering to Seth and his 'father and progenitor' (it itw=f), ancestral father, Seti I, emphasising Ramses' family's patronage of the Seth cult in the north-eastern Delta (Redford 1970). Since the 19th dynasty, Ba'al and Seth were synonymous, especially in texts showcasing the Egyptian god's prowess in the battlefield, overpowering disease and overseeing diplomatic relations (Mourad 2018). The decision to maintain the Seth/Ba'al cult may have been similar to the reasoning in establishing the hybrid deity as a stately god of Avaris. By retaining the god and its cultic temple, the new dynasty was able to ease its legitimisation of

power in the previous Hyksos kingdom area and maintain diplomatic relations with the Eastern Mediterranean (Mourad 2018).

According to Redford (1970), the New Kingdom rhetoric shifted from “vile Asiatics” to “vile Hyksos”, though a certain demotion may have been possible as the word *aamu* became associated with slave (Hannig 2006, p. 487, Schneider 2003, p. 289). At the temple of Mut in Karnak, a cemetery dating to the Second Intermediate Period and New Kingdom, was found. In this cemetery, under a pillar, an individual was found lying on his side with a rope binding his wrists to his ankles and around his neck (Bryan 2012). The way the body was bound resembles the ancient Egyptian classifiers for captives and to punish/execute. The Hyksos became a powerful tool to reenact the overcoming of enemies, grounded in historical facts but imbued with further ritualistic and symbolic meanings. These elements are present in the retelling of the Hyksos defeat in the Quarrel of Apophis and Seqenenra, the inscriptions in Speos Artemidos and Karnak, and the social memory that lived on till the time of Manetho (Redford 1970).

2.3 Summary: the Hyksos Enigma

The historical and contemporary sources that affected much of the early research, may be misleading for a variety of reasons. According to Bourriau (2000, p. 173), the challenges arising from the contemporary textual sources are not related to their scarcity but to the way they connect (or do not connect) with the archaeological evidence. Contemporary Egyptian texts, mainly from the end of the Second Intermediate Period and the New Kingdom, speak of “vile Asiatics” who oppressed the people and destroyed the land. The topoi maintained by Egyptian state may have carried over in social memory for millenia, administering the ‘historical’ accounts with a dose of ‘broken telephone effect’, until written down by Manetho. Before the discovery of Tell el-Dab’a, these written sources formed the main body of available information. The increasing evidence from archaeological investigations has shifted the role of textual sources, where the two sources together form a dynamic interpretation not only the physical past but the sociocultural sphere.

A brief account of the main textual and archaeological sources demonstrates the presence of Asiatics in Egypt since the beginning of the Old Kingdom. When set against all these accounts, the foundation of a site such as Tell el-Dab'a does not seem bizarre or sudden. Though very little of the evidence is from archaeological sources, mainly the sacred buildings in Tell Ibrahim Awad, there is no reason to question the onomastic evidence provided in administrative documents. Establishing foreigners as part of the Egyptian social structure prior to the Second Intermediate Period helps to explain the ease at which the mixture of Egyptian and Near Eastern cultural elements were amalgamated in Tell el-Dab'a. At least a portion of the population has always been assumed to be generated by Egyptianised migrants, leaving the question of the 15th dynasty rulers open.

The poor preservation of organic material in Tell el-Dab'a and the subsequent lack of textual sources, has kept several questions open despite the accumulation of information from material culture. Some interpretations have been made of the way the Hyksos structured their governance. Though the kingdom must have had a military force, the evidence presented by Flammini (2015) suggests connections were maintained through beneficiary agreements that were based on mutual (mercantile) interests and maintained by gift-giving. This mirrors the mode of operation that has been identified for the wider Hyksos trade network across the Eastern Mediterranean. Philip (1995, 2006) believes Tell el-Dab'a was only one port in a network of trade centres that acted under the same symbolic system. In this network, exchange took place for luxury items and people alike (both via marriage and "internships").

The discussion of Hyksos cultural and biological identity has often been muddled by simultaneously comparing the Tell el-Dab'a population to ethnic groups that existed before, during and after the 15th Dynasty. A clearer distinction has been established more recently (e.g. see Bietak 2010, p. 150). The archaeological evidence does not point to a single origin, which has led some researchers to criticise the use of denominator like the Hyksos in the first place as

"the propagation of such monocultural assumptions, combined with the simplistic conceptions of ethnicity that have typified much research on the

ancient Near East, have resulted in the framing of inappropriate research questions, in particular those which have sought to use archaeology to identify the 'homeland' of the Hyksos" (Philip 2006, p. 236).

By combining bioanthropological and statistical tools, it is possible to explore these phenomena in a manner that does not assume that either (single versus diverse, sudden versus continuous) mode is correct.

A dynamic trade relationship seems to have existed between Cyprus, the Levant (and later particularly Southern Levant) and Tell el-Dab'a, evident in the forms of pottery distributed particularly between these regions (Maguire 2009, pp. 86-7). The Tell el-Dab'a trade network contains evidence of trade with the Memphis/Fayum area, Nubia, Cyprus, and the Levantine region. However, changes in trade networks take place during the 15th Dynasty. It is possible that Kamose's successful campaign to Kush and the interception of the plea for help by Apophis to the Kushite king (Kubisch 2010) disconnected the Hyksos from important commodities and disrupted the whole trade system. Tell el-Dab'a may have also suffered from epidemics, alluded to by the London Medical Papyrus and the Papyrus Hearst from the 18th dynasty which refer to the bubonic plague as 'the Asiatic disease' (Goedicke 1986).

Regardless of the reason, Avaris was conquered, but not destroyed (Bietak 1996). The establishment of a military camp at the site may have been practical at the time due to the ongoing campaigns directed north of the border, but the potential of the site and its location was clearly not lost, evident in the continued use of the local temple, the small-scale production of MBII pottery and the later establishment of the Ramesside capital and the evidence of new mercantile connections with Minoans in the Tuthmosid period (Bietak 1996, pp. 81-3). The area remained important for Eastern Mediterranean networking till the disappearance of the Pelusiac branch (Tronchère et al. 2012).

Whether the Hyksos exodus, described by Josephus, is factual, remains uncertain. It seems unlikely that all the occupants, from which a majority are believed to have been Egyptianised Asiatics and their descendants, would have left. Furthermore, Ahmose's biography describes the receiving of slaves. Hoch's (1994) analysis has discovered over 500

Semitic words appearing in the Egyptian texts of New Kingdom and Third Intermediate Period, emerging in Egyptian language at all levels and “in virtually every genre of Egyptian writing” (Hoch 1994, p. 475). In most cases, the words cannot be specified further than West Semitic, but some cases are identified with Akkadian, the *lingua franca* of Amarna letters.

The retention of the hybrid god Seth/Ba'al seems indicative of previous worshippers remaining in Egypt, continuing to influence the semantic sphere the god Seth had become associated with (Allon 2007). Mourad (2018) has pointed out that there is no mention of Ba'al in Thebes prior to the onset of the 18th dynasty as the god would not have been transferrable for Upper Egyptians. The transformation of the semantic sphere which Seth was associated with, suggest the transference was not merely superficial but conceptual, requiring a much deeper cultural interference. In short, the same way the people forming the Tell el-Dab'a population may have come from several locations, they were equally likely to disperse to several locations. This includes staying in Egypt, either voluntarily or involuntarily.

3. Migration and biodistance analysis

Migration has been called “a key constituent element of human life in virtually all periods” (Greenblatt 2010, i). There are several definitions, here it is defined as “the movement of people across significant sociocultural, political, or environmental boundaries that involves uprooting and long-term relocation” (Tsuda et al. 2015, p. 19). It has socioeconomic implications on both the migrating population and the receiving community (Bader 2012, Kelly 1992, O’Rourke 2012).

Mobility and migration studies in archaeology have been criticised for lacking dimensionality and theoretical vigour, presenting migration as merely an explanation for change, not as an object of research of itself. Early migration theories in Egypt were formulated by hyperdiffusionists who placed little stock on human ingenuity, believing inventions were rarely made more than once and merely transferred along to other cultures. Egyptocentric Diffusionism, formulated particularly by Grafton Elliot Smith and William James Perry, proposed Egypt as the origin of most technological advancements, such as the production of copper (Priglinger 2018, p. 28). It was also linked to concepts of eugenics, discussed further in section 3.1.

The processualist criticism of the culture-historical view ultimately led to the temporary abandonment of migration studies, focusing on explaining culture as an adaptation mechanism (Adams 1968, Adams et al. 1978, Burmeister 2000, Myhre and Myhre 1972). Though valid as one mode of change, the replacement of migration solely with adaptation has been described as “throwing the baby out with the bathwater” (Anthony 1990). Currently, the two approaches form aspects of the same process in ever-evolving theoretical and methodological framework. The shift coincided with the emergence of bioarchaeology, a bioanthropological framework that considers the dynamic relationship of human culture and the surrounding social, political, economic and ecological environment (Buikstra 1977, Clark 1972, Larsen 1987, 1997, Levins and Lewontin 1985, Stinson et al. 2012, Zuckerman et al. 2011). Within this framework, biological distance analyses offer new insights into migration studies.

3.1 Biodistance analysis in bioarchaeology

Biological distance, or biodistance, measures the similarity and dissimilarity of individuals and groups from skeletal remains using multivariate statistical analysis. Distance measures can be based on allele frequencies or haplotypes (measuring genotypic expression), or based on phenetics, grouping organisms together according to their morphological similarity. Phenotypic analysis rests on the assumption that phenotypic expression is informative of underlying genetic heritability and can be used to study the effect of gene flow (or migration) and genetic drift (Hefner et al. 2016, p. 3, Stojanowski and Schillaci 2006). More specifically, the assumption is that genetic drift and gene flow within and between geographically close populations affect allele frequencies, that allele frequencies cause measurable changes in skeletal appearance, the inheritance of phenotypic expressions is additive (more prevalent among closely related individuals), the environmental effects to phenotypic expression are minimal and random and the samples represent the populations (Stojanowski and Schillaci 2006).

Biodistance analyses can use both metric and nonmetric characteristics as proxies for genotypes. Though any element can theoretically be used for analysis, some are more reliable and/or commonly used than others. Most phenotypic studies consider craniometrics, cranial nonmetrics and dental morphology (Berry and Berry 1967, Hauser and DeStefano 1989, Konigsberg and Ousley 1995, Scott and Turner 1997, Sjøvold 1984, Sparks and Jantz 2002). The relationship between genotypic and phenotypic expression has been measured with narrow-sense heritability measurement h^2 (variation of additive effects divided by population variation), which clusters around 0.55 (55%) for skeletal and dental morphology (Stojanowski and Schillaci 2006), a common heritability measure for phenotypic expressions. Post-cranial traits and measurements are less common in biodistance analyses as the changes in shape and expression are also affected by function (Moore 2013, p. 397).

Biodistance methods are commonly used to assess intra- or inter-site variation or regional continuity, but, with enough samples in size and number, analysis can be extended to continental and even global variation (figure 5).

Inter-regional analyses have remained popular as they consider a broader spectrum of human evolution, but they have theoretical challenges due to the extended temporal contexts. Consequently, regional and intra-cemetery analyses with more restricted time frames have a better theoretical foundation, and can offer insight into kinship, cemetery structure analysis, post-marital residence analysis, phenotypic variation and temporal microchronology (Stojanowski and Schillaci 2006). However, the theoretical and methodological development of intra-site analyses is varied, strongest for post-marital and temporal microchronology studies but still developing for studies regarding phenotypic variation (Stojanowski and Schillaci 2006).

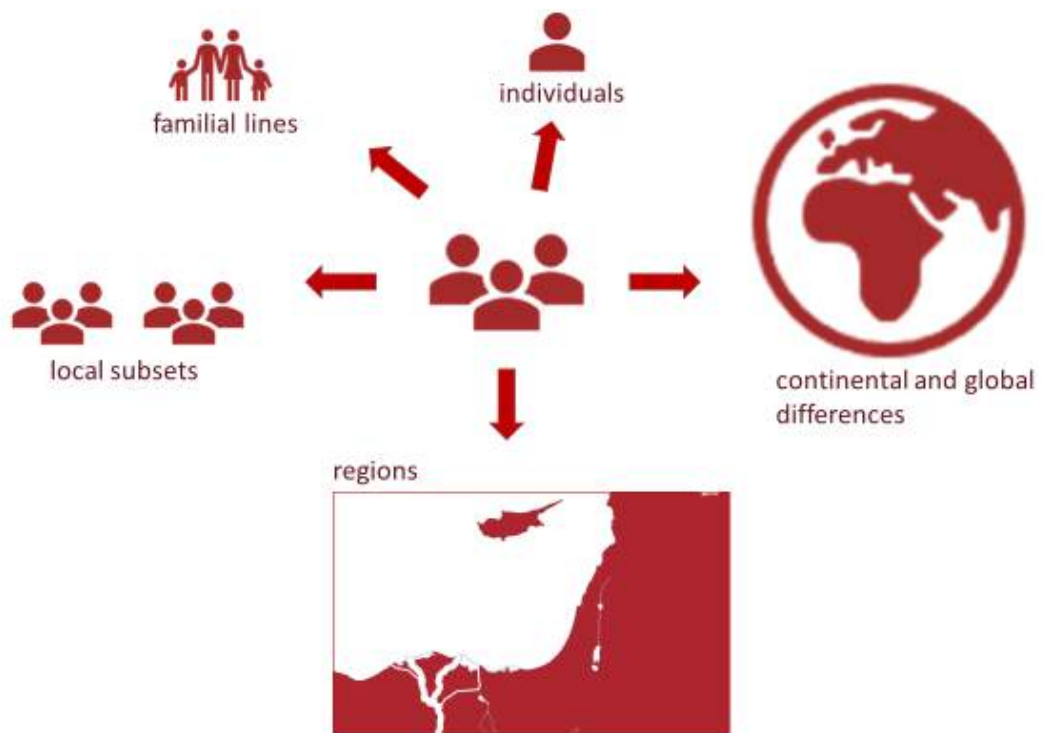


Figure 5. Different levels of biodistance analysis.

The interest in identifying groupings has a long history. The taxonomy system first introduced by Linnaeus (1735, 1758) was also extended to humans, dividing the species into subclasses which formed the basis of “races”. The initial sub-classification followed geographic regions, but later the inclusion of behavioral traits took the groupings even further from a morphological basis (Marks 1995). Though the Linnaean approach was not the only one (e.g. Ray 1682, de Tournefort 1700), it became the consensus.

The interest in human origin was heavily infused with the desire to rank the Linneaeian human varieties (Blumenbach 1775, Morton 1844). Blumenbach (1775, 1781, 1795) was particularly interested in human variation, developing his descriptions of human varieties from geographical areas to more generic labels. Even when Darwinian theory was introduced, the prior perception drove the analysis to regard phylogenies though ranking with little attention to biological functionality and significance (Armelagos et al. 1982). It particularly spurred the popularity of eugenics, a term coined by the naturalist (and Darwin's half-cousin) Sir Francis Galton in 1883. Starting from the United Kingdom and spreading to the rest of Europe and North America, it inspired research into the metric analyses of contemporary and past humans to determine racial classifications to identify "the best stock" for breeding purposes (Sheppard 2010). Flinders Petrie, the father of Egyptian archaeology, was a supporter of eugenics and worked with Galton and the mathematician Karl Pearson who later became the director of the eugenics laboratory in London.

Eugenics began to decline at the end of WWII (Hakenbeck 2008, Sheppard 2010, Trigger 2006, pp. 241-50). The shift extended into archaeology as well, as the long-held idea of associating material assemblages with cultures (Childe 1925, 1950, 1958, inspired by Kossinna 1911), a view that developed alongside linguistic and racial typologies, was being questioned by new emerging methodological and theoretical approaches (Binford 1965, Willey and Phillips 1958). However, the five racial typologies, introduced by Blumenbach (1795) as human varieties, persist in every-day vernacular, despite his best efforts to demonstrate variation even among populations. The misunderstanding of Blumenbach and the misconception that race forms a meaningful biological classification has been called an 'original sin' of anthropology (Levi-Strauss 1952, pp. 1-3), which still haunts the terminology used by some researchers.

As a result, studies turned away from descriptions and race classifications, and towards functional morphology where physical changes formed a part of a dynamic process (Armelagos and van Gerven 2003). The turning point has been marked by Georg Neumann's (1952, 1954a, 1954b) work, the last pieces of old-time racial typology studies before the

development of modern bioarchaeology (Armélagos and Van Gerven 2003, Konigsberg 2006). The paradigm shift began with Washburn who, in the wave of “New Archaeology”, rejected the previous “religion of taxonomy” and demanded for hypothesis testing and a holistic consideration of human remains (Mikels-Carrasco 2012, Washburn 1951, 1953). Focus was directed towards understanding evolutionary pathways and formulating interpretations combining biological, sociocultural and environmental factors (Armélagos and van Gerven 2003, Johnson and Paul 2016).

The benefit of statistical tools was already realised in the 19th and early 20th centuries (e.g. Broca 1863, Campbell 1925, Hrdlička 1927, Krogman 1927, Morton 1844, Pearson 1926, Shaw 1931), and continued to develop, particularly at the onset of privately available computers. Increased computing power, technological development in biochemistry and the new theoretical framework inspired a whole host of studies in multivariate statistics and molecular and population genetic. Table 2 lists different statistical tools available for biodistance analyses, however even more are available (e.g. see Konigsberg 1988, 2006, Konigsberg and Buikstra 1995, Lande 1976, Schillaci et al. 2009, Turelli et al. 1988, see Stojanowski and Schillaci 2006 for more examples). Population genetic theory was first utilised in biodistance studies in the 1970s (e.g. Cadien et al. 1974, Lane 1977). Since then, the field has expanded to concern uxori-local and viri-local residence patterns (Corruccini 1972, p. 386, Lane and Sublett 1972, Kennedy 1981), microevolution and the diachronic nature of archaeological samples (Cadien et al. 1974), genetic kinship and morphological similarity (Lane 1977) and the related theory of model-free and model-bound trait analysis (Relethford and Lees 1982). The recent strides in DNA analysis and morphometrics have been substantial enough to initiate a new transformation of the field (Konigsberg 2006).

Table 2. Statistical tools used to assess biodistance.

Method	Reference	Description	Practical applications
Coefficient of racial likeness (CRL)	Pearson 1926	Combines measurements from two populations to estimate divergence, critiqued because it could not take into consideration the intercorrelation of measurements (Hubbard 2012, Seltzer 1937).	Pearson 1928
Gower similarity	Gower 1971, Kaufman and Rousseeuw 1990, Maehler et al. 2018	Can measure distance in a mixed dataset (of interval, ordinal and nominal values) and cope with missing data by computing distances between units and giving them values between 0 and 1.	Gamble et al. 2001, McClelland 2003, Paul et al. 2013
Modified Mahalanobis D²	Konigsberg 1990, 2006, Mahalanobis 1936, Bedrick et al. 2000	Calculates weighted average correlations for each sample, can adjust for small sample sizes and account for any residual inter-trait correlation but cannot cope with missing data (Irish 2010).	Irish 2006, Irish 2010, Schillaci et al. 2009
Modified MMD	Harris and Sjøvold 2004, Sjøvold 1973, Sjøvold 1977, Smith 1972	Uses summary data to estimate the measure of similarity, takes into account small sample sizes (less than 10) and frequencies that are close to 0 and 1. Cannot be used to estimate R-matrix directly and requires inter-trait correlation testing (Irish 2010).	Berry and Berry 1967, Irish 2005, 2006
Multiple-discriminant analysis	Cooley and Lohnes 1962, 1971	each individual's chi-square value is compared to a group centroid in a two-dimensional space, the individual is assigned to the group they fit best	Long 1966
R-matrix extension	Harpending and Jenkins 1973, Relethford and Blangero 1990, Relethford et al. 1997, Williams-Blangero and Blangero 1989, Workman et al. 1973	A square matrix compares populations to one another in rows and columns, first developed to estimate allele frequencies. An extension of the original R-matrix was developed to allow for biodistance analysis from quantitative traits.	Ishida et al 2009, Irish 2010, Nikita 2015
Size and shape statistic	Penrose 1952	Similar to CRL where size (square of the mean of the averages) is combined with shape (variance of mean differences between populations).	Brothwell 1960, Laughlin and Jørgensen 1956

3.1.1 Dental anthropology and morphology

Dental anthropology has been defined as a “branch of physical anthropology concerned with the origin, evolution, and development of dentition of primates, especially humans, and to the relationship between primates’ dentition and their physical and social relationships” (Medical Dictionary for the Dental Professions, retrieved from <http://medical-dictionary.thefreedictionary.com/nickel>, accessed September 8, 2019). The term was first coined by Georg Buschan in the beginning of the 20th century (Scott and Turner 1988), though interest in tooth characteristics had developed well before (see earliest sources in table 3).

Following the theoretical development of the field, dental anthropology has transformed from descriptive works to multifactorial studies assessing stress, adaptation, diet, migration, biological distance, evolution, social and cultural behaviour, health and identity in forensic cases (Haeussler and Turner 1992, Larsen 2016, p. xv, Sofaer et al. 1972). The assessments are possible using a combination of measurements, dental morphology, biochemical analyses and histology (Hillson 1996, 2014, Irish and Nelson 2008, Irish and Scott 2016, Scott and Irish 2017, Scott and Turner 1997).

Human teeth consist of three tissue types: enamel covering the crown of the tooth, cementum on root and the neck, and the primary underlying dentine (figure. 6). Unlike other vertebrates, mammals have only up to two tooth generations, which has been explained by the need for precise occlusion during mastication, the mammal jaw being unique with its ability to move both up and down as well as side to side (Ungar 2015, pp. 25-7). Human deciduous teeth begin forming in utero and begin erupting a few months after birth and become replaced by permanent teeth approximately between the ages of six to eighteen or later, depending on the eruption of the third molar (Hillson 1996, pp. 6-12). However, tooth eruption can vary within and between populations, and recent studies have shown that human polymorphism can cause vast differences in eruption and growth patterns (Ramirez Rozzi 2016).

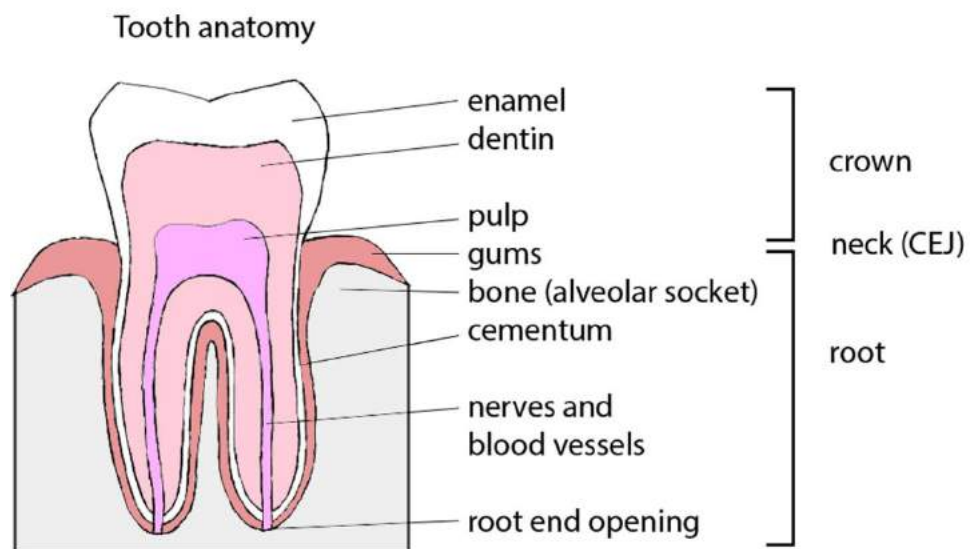
Due to their high mineral content (circa 95% for enamel, 45-50% for cementum and 70% for dentine), teeth endure taphonomic stressors well, making them ideal for archaeological studies. Dental morphological studies

rest on tooth ontogeny, governed by circa 300 genes in interaction with epigenetic and environmental factors (Ramirez Rozzi 2016, Thesleff 2006, Townsend et al. 2009, 2012). Tooth ontogenesis, or odontogenesis, (figure 6) has the following stages (Brook 2009, Hillson 1996, Scott et al. 2018, pp. 71-8):

1. Initiation (placode): on week 6 of development in utero, mesenchymal stem cells lay out epithelial tissue which forms the dental lamina, U-shaped thickened tissue loci that mark the subsequent development of dentition.
2. Bud: By week 10, groups of cells (with no clear organisation) are visible in the lamina for deciduous dentition and by week 16 for permanent dentition.
3. Cap: the beginning of cap stage is marked by the formation of an enamel knot, a molecular signalling centre which provides information on tooth position, morphogenesis and tooth cusps. The primary enamel knot forms at the tip of the bud and the bud itself begins to hollow out at the proliferation of cells.
4. Bell: The initiation of histodifferentiation of cells. The dental lamina, connecting the tooth to the oral cavity, disappears. The enamel knot undergoes apoptosis, though teeth with multiple cusps develop secondary enamel knots to direct the formation of cusps.
5. Advanced bell (maturation): The differentiated cells from previous stage are now forming enamel (amelogenesis by ameloblasts) and dentin (dentinogenesis by odontoblasts). Hard tissue formation is initiated by odontoblasts that create an organic matrix against the dentin which mineralises immediately and becomes the initial layer of enamel. In amelogenesis, mineralisation begins from the cusp tip. The formation of cementum (cementogenesis by cementoblasts) begins after most of the tooth formation is complete, creating a calcified substance around the root. The roots begin forming immediately after the crowns. Cementum, along with periodontal ligaments, gingiva and alveolar bone are the main components of the periodontium, the supporting structure of teeth.

The sequence of cusp calcification follows a predictable pattern. The mesiobuccal cusp is always the first to calcify, likely reflecting its long-term

evolutionary role, and proceeding to the mesial and eventually to the distal cusps (Turner et al. 2018, p. 78). Much like the growth process in general, the biomolecular process of odontogenesis has only begun to clarify in recent years. According to Thesleff (2014), four main families of signalling molecules (bone morphogenetic protein, FGF, Hedgehog and Wnt), along with mediators and transcription factors, initiate and direct various stages of odontogenesis. These processes have been considered substantially stable to perceive teeth as ideal structures for biodistance analyses. Biodistance studies can utilise tooth size and morphology both separately and together, using odontometrics, nonmetrics or geometric morphometrics. Odontometrics, though often used in biodistance analyses (e.g. Stojanowski 2001, 2005), was not possible in this study due to the state of preservation of the dental material. Instead, the following description focuses on dental nonmetrics and geometric morphometrics.



Odontogenesis

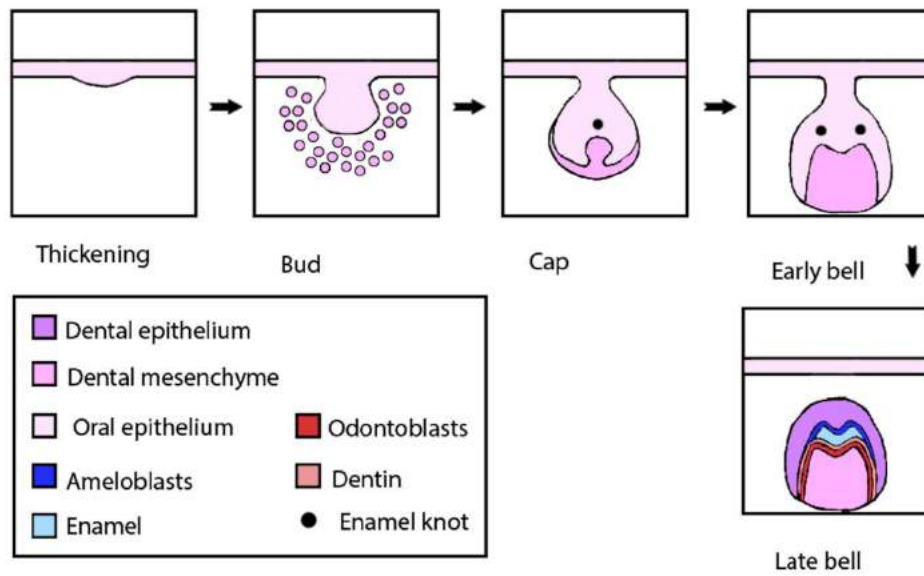


Figure 6. Upper: tooth anatomy. Lower: Stages of odontogenesis.

3.1.2 Dental nonmetrics

Dental morphological traits, also called dental nonmetric, discrete, discontinuous or epigenetic traits, are described by accessory ridges, tubercles, styles, accessory cusps in crowns and deviations in root numbers (Scott and Turner 1988, p. 100). Like the rest of the field, dental morphology studies shifted away from typology after WWII (Dahlberg 1945, 1951, Kraus 1951, 1959, Lasker 1950). At the Arizona State University, Dahlberg (1956) made a great leap by developing the first series of plaques depicting morphological variation, beginning the standardisation process of dental (nonmetric) trait recording. Spurred on by his work and the increasing number of discovered dental traits, dental morphology became utilized in biological distance analyses of various scales (Scott 1973, Scott and Dahlberg 1982, Turner 1986). In the 1980s, nonmetric trait frequencies and odontometrics were extended to the study of australopithecines and early hominins (Freyer 1977, Wood et al. 1987, 1988).

The traits deemed most useful were compiled in a journal publication by Turner et al. (1991) to what is now known as the Arizona State University Dental Anthropology System (ASUDAS, list of traits in table 3 and a more extensive table with descriptions is available in the appendix A5). The traits were selected because of their durability against moderate attrition, easy identification, high recording repeatability, observed heritability and little to no sexual dimorphism (Scott 1973, Hanihara 1992, Hubbard et al. 2015, Irish 1993, Larsen 1997, Scott and Turner 1997, Turner et al. 1991). The publication was supplemented by Scott and Turner (1997) in a seminal book titled *The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations*. In addition to more elaborate trait descriptions and photographic examples, the publication included global frequencies for geographically distinct groupings. Since then, several other works have been published (e.g. Irish and Scott 2016, Scott and Irish 2013), including most recently, the ASUDAS manual by Scott and Irish (2017) adding to the previous studies with a comprehensive photographic catalogue of dental nonmetric traits.

Table 3. List of dental traits, the primary tooth to observe the trait from, abbreviation (used later in chapter 6) and breakpoints used to dichotomise data.

Trait	Primary tooth	Abbreviation	Breakpoint (present)
Winging	UI1	W	1
Labial convexity	UI1	LC	2-4
Palatine torus		PT	2-3
Shoveling	UI1	S	2-6
Double-shoveling	UI1	DS	2-6
Interruption groove	UI2	IG	p
Tuberculum dentale	UI2	TD	2-6
Pegged of reduced incisor	UI2	I2V	p
Mesial accessory ridge	UC	MAR	1-3
Distal accessory ridge	UC	DAR	2-5
Premolar accessory ridges	UP2	PAR	2-4
Accessory cusps	UP1	AC	p
Metacone size	UM3	M	4-5
Hypocone size	UM2	H	3-5
Bifurcated hypocone	UM2	BH	p
Cusp 5	UM1	C5UM	2-5
Marginal ridge tubercles	UM1	MRT	1
Carabelli cusp	UM1	CC	2-7
Parastyle	UM3	PUM3	1-5
Enamel extensions	UM1	EE	1-3
Root number	UP1	RUP	2+
Root number	UM2	RUM	3+
Congenital absence	UM3	M3V	p
Odotome	UP1	O	p
Tome's root	LP1	TR	3-5
Cusp number	LP2	CLP	2-9
Anterior fovea	LM1	AF	2-4
Mandibular torus		MT	2-3
Groove pattern	LM2	GP	y
Rocker jaw		RJ	1-2
Cusp number	LM2	C5LM	5+
Cusp number	LM1	C6	6+
Cusp 7 size	LM1	C7	2-4
Deflecting wrinkle	LM1	DW	2-3
C1-C2 crest	LM1	MDTC	p
Protostylid	LM1	PRLM	1-6
Root number	LC	RLC	2+
Root number	LM1	RLM1	3+
Root number	LM2	RLM2	2+
Torsomolar angle	LM3	TA	p
Midline diastema		MID	>0.5

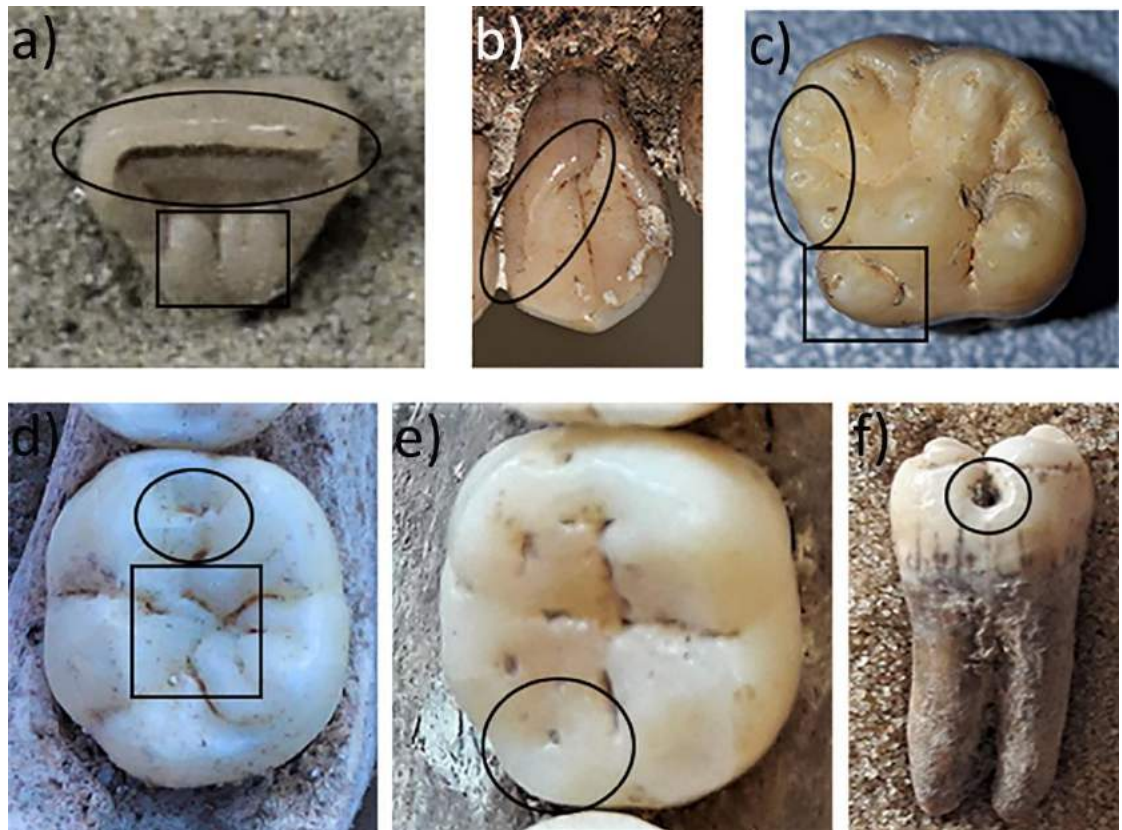


Figure 7. Examples of dental traits observed from the samples: a) shovelling (circle) and tuberculum dentale (square) on upper first incisor, b) mesial accessory ridge (circle) and slight distal accessory ridge on the opposite margin of upper canine, c) marginal ridge tubercles (circle) and Carabelli's cusp (square) on upper first molar, d) anterior fovea (circle) and Y-groove pattern (square) on lower first molar, e) worn but still visible cusp 5 (circle) on lower second molar, f) protostylid (circle) on lower second molar (with possible caries lesion in the pit).

Table 4. Development of studies in dental morphology.

Reference	Description
Azoulay and Regnault 1893	Comparative work on primate incisors with a strong racial undertone.
Brothwell 1963	Landmark work presenting papers on primate, hominin and modern human teeth.
Dahlberg 1951, 1956	First large leap in the standardisation of trait recording, and the creation of casts.
Hanihara 1954, 1955	Dental nonmetric traits for deciduous teeth.
Hrdlička 1920, 1921	First comprehensive descriptions of nonmetric traits, such as the shovel-shaped incisors, and the use of a graded system.
Lasker 1945	The study on dentition from China and Chinese immigrants in the US was part of the genetic foundation of dental morphology.
Nichol 1990	Seminal work analysing the relationship between dental morphology and genetics among indigenous American populations.
Owen 1840	Comparative work on the dentition of fish, reptiles and mammals.
Pedersen 1949	Description and analysis of East Greenland Eskimos, focusing particularly on molars
Scott 1973	Seminal work analysing the relationship between dental morphology and genetics among indigenous American populations.
Scott and Turner 1997	A classic work describing the study of dental morphology.
Thompson 1903	An analysis on the teeth of 'Inca Peruvians' led to the recognition of population variability in subsequent studies.
Turner et al. 1991	Extension to the standardisation process begun by Washburn.
von Carabelli 1842	The publication included the first description of the Carabelli cusp.

Both theoretical and practical issues have been raised in regard to dental nonmetric traits. According to Hubbard (2012, p. 25), the use of dental nonmetrics as a measure of biological distance assumes that changes in allele frequencies are reflected in phenotypic appearance, that the biodistance measure is reflective of a real biological process, and that the relationship between genetic and phenotypic frequencies is simple. No dental trait, excluding certain rare abnormalities, has a simple mode of inheritance. Twin and familial studies have been used to estimate the influence of genetic, epigenetic and environmental factors to phenotypic appearance (table 5).

Generally, these studies suggest that the correlation of genetic variation and phenotypic variation of dental traits is moderate to high, but environmental and epigenetic factors do influence the morphology in varying

degrees (Townsend et al 2009, 2012). The varying success of the early studies could be due to the lack of standards at the time to help with the recording process (e.g. Brewer-Carias et al. 1976, Sofaer et al. 1972). The most recent studies, comparing genetic data and dental nonmetric traits collected using ASUDAS standards, have found significant and meaningful correlations between dental nonmetric and aDNA biodistance analyses (Delgado et al. 2019, Hubbard et al. 2015). An additional interesting point was raised by Delgado et al. (2019). For their sample, admixture present in the current population made it more challenging to investigate individuals. This is a factor which may also affect the eastern Mediterranean population that were extremely mobile during the period under investigation.

The ongoing development of ancient DNA (aDNA) techniques has begun to transform the field of biodistance analyses, visible even in the comparative studies presented in table 5. They provide a more in-depth view into individuals and populations, providing information on ancestry and even kinship, among a plethora of other aspects (Maaranen et al. 2019b). The results are, however, reliant on moderate to good preservation, and the costs, though considerably decreased, may still make them unattainable. Both factors have a severe effect on sample sizes, which can be argued to limit the interpretations from populations to individuals. In these cases, it becomes pertinent to also reflect the information value gained from an aDNA study, as opposed to a non-destructive study likely utilising a much larger dataset. The destructive nature of the analysis also raises ethical issues that must be considered (discussed further in section 3.3). Regardless of the issues, and the other available methods for recording dental nonmetrics (e.g. see Alt and Vach 1991, 1998, Zubov 1977), ASUDAS is by far the most utilised method in dental biodistance analyses (e.g. Hanihara 2008, Irish 2005, 2015, Scott and Turner 1997). Scott and Turner (1997) divided studies into six geographic scales: individual, familial, local, regional, continental and global. While the theoretical issues regarding large temporal considerations create controversy for the use of dental nonmetrics in regional and local scales, the majority of morphological studies and practically all archaeological ones, focus on these. It is pertinent to acknowledge not only the spatial but temporal aspect of phenetic change, distinguishing between a synchronic and diachronic

question. The issue highlights the importance of associating the biological data with historical, linguistic and cultural information to produce meaningful results (Scott and Turner 1988, p. 103).

Dental nonmetric studies using ASUDAS, specific to the Near East, have been collected in table 6. The vast majority of studies report continuation, both locally and regionally (e.g. Dicke-Toupin 2012, Elias 2016, Irish 2006, Lovell and Haddow 2006, Roler 1992, Sołtysiak and Bialon 2013). Parras (2004) even observed some inter-regional similarities between Cyprus and Syria. Only the study by Machiarelli (1989), dating to the 5th and 4th millennia BCE, shows more prominent differences. The continuation is further supported by the archaeological record, showing both regional and inter-regional movement (e.g. see section 2.1 and chapter 4).

The observation of continuum is not surprising considering the wide timeframes in some studies, making the comparative samples less synchronic. The wider the comparable time periods are in site-by-site studies, the greater the loss of details. In some cases there is no alternative due to small sample sizes, which is often the case with the numerous, but moderately sized, archaeological sites of the region. Ancient DNA could provide a tool for acquiring data even from small samples, but the tests are only invariably successful due to preservation (e.g. see Sołtysiak and Bialon 2013). There is great potential for further work in the region, and the number of researchers interested in dental nonmetrics is steadily increasing.

Table 5. Studies investigating the hereditary pathways of dental nonmetric traits. Though there are much more, the ones presented here either work directly with genetic data or employ powerful statistical tools that have risen from genetic research.

	Reference	Description
DNA	Brewer-Carias et al. 1976	Promising, though problematic results due to the use of Pearson's coefficient of racial likeness, meant for continuous data.
	Corruccini et al. 1982	Comparison of genetic and odontometric and nonmetric data noted deviations in heritability due to environmental noise.
	Delgado et al. 2019	Comparison of admixed Colombian Latin Americans. Dental trait frequencies provided reasonable average estimates of ancestry for groups but low accuracy for individuals, likely due to the genetic mixture from European, Native American and African origin.
	Hubbard et al. 2015	Both genetic and dental nonmetric datasets were capable of identifying the known ethnic grouping used in the study.
	Hunter et al. 2010	By building on the cascade model by Jernvall and Jung (2000), the study predicted the size, shape and location of Carabelli's cusp in relation to other cusps on UM1.
	Sofaer et al. 1972	Compared the raw biodistances calculated using the square root of Sanghvi's χ^2 distance (Sanghvi, 1953). Genetic and biodistance estimates increased after the exclusion of traits with higher than 20% intra-observer error rate.
TWIN AND FAMILY	Paul and Stojanowski 2017	The analysis of twins and families presented reasonably good results when using permanent dentition, but the deciduous teeth performed better.
	Townsend et al. 2009, 2012	The study gathered genetic and phenotypic data (tooth size, number and shape), concluding a co-occurrence of genetic, epigenetic and the environmental factors.

Table 6. Biodistance studies on Western Asian and ancient Egyptian populations using ASUDAS.

Reference	Location	Dating	N	Description
Bentley 1987	Bab edh-Dhra'	3150-3050 BCE	ca 300	Dental traits clustered by chamber, suggesting tombs were shared by family members.
Dicke-Toupin 2012	Lachish	4000-332 BCE	942	Results indicate biological continuity between Bronze Age and Iron Age.
Elias 2016	Beirut and Batroun	0-300 CE	213	Variation was detected between sexes, age groups as well as between phases, reflecting the city's history as a Roman colony.
Irish 2006	Egypt	Predynastic-Ptolemaic	996	Overall homogeneity suggesting population continuity. The distinctiveness of the Lisht population could be exclusive marriage practices among the (potentially Upper Egyptian) group or genetic drift.
Lovell and Haddow 2006	Tell Leilan	2500 BCE	21	The intramural burial individuals share frequencies with other Canaanite samples, though results are tentative due to the small sample size.
Machiarelli 1989	Ra's el-Hamra	5th-4th millennia BCE	49	The within-group variation suggests a prolonged period of genetic isolation, leading to microdifferentiation. The number of observable traits was not high enough for comparative statistical analysis.

Table 5 cont'd. Biodistance studies on Western Asian and ancient Egyptian populations using ASUDAS.

Reference	Location	Dating	N	Description
Nassar 2010	Mari	2950-1760 BCE	ca 30 (total ca 300)	Neither dental and skeletal metric and nonmetric analyses revealed differences within the site (occupation continuum) or between Mari, Tell Leilan and Jerblus Tahtani.
Nassar, in press	Tell 'Arqa	Circa 2500-1200 BCE	48	Tell 'Arqa showed no breaks between occupation layers 15-12.
Parras 2004	Souskiou-Vathyrkakas, Lemba-Lakkous, Kissonerga-Mosphilia, Enkomi, Ayios Iakovos, Lerna, Asine, Jerablus-Tahtani (JT)	3500-2400 BCE	JT ca 123 (total 786)	Comparison of Chalcolithic and MB sites. Southwest Cypriot sites share close biological affinities to one another and some similarities with the EBA Syrian Jerablus-Tahtani site.
Randl and Großschmidt 2002	Tell el-Dab'a	1650-1550 BCE	37	The Tell el-Dab'a had the best agreement with North Africa using frequency comparisons.
Roler 1992	Ain Ghazal, Wadi Shu'eib, Bab edh-Dhra', modern Lejjun	6600 BCE-modern	121	Though some studies had been published prior to modern standards, Bab edh-Dhra' showed biological similarity to Mirgissa and Tall Sukas.
Softysiak and Bialon 2013	Tell Ashara (Terqa), Tell Masaikh, Jebel Mashtale	3000 BCE-modern	350	MMD results indicated homogeneity and population continuity during the 3 rd and 2 nd millennium BCE. Only the modern sample was markedly different, explained by the depopulation after the Mongolian invasion and population by Bedouin tribes.

3.1.3 Geometric morphometrics

Geometric Morphometrics (GM) has been called a 'revolution in morphometrics' (Rohlf and Marcus 1993), consisting of a host of approaches for the analysis and visualization of shape data, represented by Cartesian coordinates (x, y and z). The theoretical foundation of geometric morphometrics lies in 19th century biometry (Bookstein 1998) that spurred the development of the theory of allometry, the analysis of body size and shape (Huxley 1932), and various multivariate statistics (e.g. Bookstein 1985, Pearson 1926, Pimentel 1979, Reyment et al. 1984, Sneath and Sokal 1973). The first "digitisation" of a human skull was an awkward affair with a high error estimate, conducted with sliding callipers (Benfer 1977). The current theoretical and methodological framework took form after increase in computing power (Bookstein 1991, 1996, 1998, Dryden and Mardia 1998, 2016, Kendall et al. 1999, Klingenberg 2010, Rohlf and Marcus 1993, Small 1996). A more detailed description of methodology is presented in section 5.4.

Geometric morphometrics have been widely adopted in skeletal biology, evaluating sexual dimorphism (Betti et al. 2013, Bigoni et al. 2010, Bytheway and Ross 2010, Franklin et al. 2007, Kimmerle et al. 2008), population structure and history (see table 7), growth and development (Gonzalez et al. 2010, Stark et al. 2017), continuous population change (Wescott and Jantz 2005, Weisensee and Jantz 2011) and forensic cases (Kenyhercz et al. 2014, Sholts et al. 2011). Studies conducted on nonhuman primates and palaeoanthropology are even more extensive (e.g. Gomez-Robles and Polly 2012, Gomez-Robles et al. 2007, Hlusko et al. 2002, Kupczik 2009, Rizk et al. 2013, Zanolli et al 2018).

Most common applications concern organismal shape (Bookstein 1991, 1996, Claude 2008, Lele and Richtsmeier 2001, Rohlf and Slice 1990, Zelditch et al. 2012), though the analysis can be applied to any shape of any object. Though it is hard to think of a field where geometric morphometrics has not found application potential, adapting concepts to foreign fields carry challenges. In archaeology, both benefits and challenges have become apparent in applications to material culture (e.g. see Doyon 2019, MacLeod 2018, Okumura and Araujo 2019, Thulman 2012). Geometric morphometrics offer a less subjective approach to artefact analysis by transforming the object

into a collection of landmarks. However, the theoretical foundation of the method assumes shape as an indication of closeness (which is not necessarily the case in material culture)

Table 7. Geometric morphometric studies focussing on population structure and history and GM methodological studies using archaeological material.

Reference	Element	Data type	Description
Bernal 2007	upper second molar	2D landmarks and semilandmarks	35 individuals from archaeological collections were used in a methodology test on measurement techniques (linear measurements, landmarks and semilandmarks) were highly correlated. Landmarks improve retained information on tooth contour.
Cramon-Taubadel 2009	cranial bones	3D landmarks and DNA	15 modern human samples were used to test the temporal bone against other cranial bones. Results show that the temporal, sphenoid, frontal and parietal bones show correlations with molecular data.
Martinez-Abadias et al. 2012	cranium	3D landmarks	Individuals from the Hallstatt ossuary were used. The face, cranial base and vault are strongly integrated, suggesting the cranium should be seen as a composite.
Noback et al. 2011	bony nasal cavity	3D landmarks	10 modern human populations were used to analyse the correlation between nasal cavity and climate. The results indicate the morphology is mostly related to temperature, while nasopharynx is associated with humidity. The nasal aperture is higher and narrower in colder climates.
Perez et al. 2006	craniofacial bones and upper first molar	2D landmarks and semilandmarks	60 individuals from archaeological collections were used in a methodology test on Procrustes distance (D) and bending energy (BE) sliding methods. Results indicate the two techniques produce similar classifications but the discrimination scores differ. However, the visual representation of the data exhibits similar overlap between same groups.
Perez et al. 2009	craniofacial bones	2D and aDNA	Holocene remains from Argentina were analysed , but no concordance between craniofacial and molecular data.
Smith et al. 2007	temporal bone	3D landmarks and DNA	Analysis of 11 modern groups suggested that while there was a strong correlation with climate (temperature and latitude), the temporal bone was correalted with geographical location and correct classification was good overall.

3.2 Current concepts in migration studies

At the abating of processualism, migration studies returned to archaeology and were able to acquire models from the other social sciences that had maintained interest in the topic (Burmeister 2000, Dommelen 2014, Kelly 1992). The current field of migration studies has formed into a multidisciplinary network of anthropologists, historians, archaeologists, demographers, sociologists, geographers and political scientists. Migration is currently viewed more as a social mixer rather than cultural replacer (Clark 2011, pp. 85-6, Tsuda and Baker 2015, p. 311).

Despite strides forward, a conceptual rift has remained between scholars investigating contemporary and past migration, with the assumption that current patterns are too radically different for comparison. Diner (2008) has commented on the tendency of historical studies to skew theory by shifting focus from the migration process to the narrative of the migrants. The shift assigns agency to the individual migrant and detaches them from the influences of social structures which act in the centre of social sciences studies (Brettel and Hollifield 2008, p. 4). The assumption also affects the understanding of emigration and immigration impacts on social relations between groups/groupings, such as males and females or kinship. Archaeological studies are not synonymous with historical studies, but the need to distinguish a group based on an observed feature is a process which inherently assigns agency.

It is believed that fundamental causes for migration have not changed, merely the scale and scope (Anthony 1990: 898, Burmeister 2000: 543, O'Rourke 2012). To bridge the theoretical gap between archaeology and modern migration studies, Tsuda et al. (2015) developed shared definitions and concepts that could provide meaningful information for both. A key element was established at the identification and interpretation of disruptions, defined as "substantial interruptions that disturb the accustomed activities of a society and have significant structural impact from the macro level of civilisations, nations, and cities to the meso level of ethnic groups/tribes, institutions, and families" (Tsuda et al. 2015, p. 17). Disruptions, potentially visible even in an incomplete archaeological record, take place in both source (sending) and target (receiving) communities.

Disruptions are categorised as either environmental or social, often intertwining, affecting social groups differently based on their socioeconomic, political and cultural resources (Tsuda et al. 2015). Sufficient resources increase resilience, but, on the other hand, the lack of these resources can create barriers that prevent migration, even when faced with substantial disruptions. Tsuda et al. (2015, p. 18) have divided the disruptions into further groupings:

Environmental

- Natural processes: droughts, floods, hurricanes, earthquakes, tornados, tsunamis
- Pathogens and pests affecting livestock, crops

Social

- Social structures: kinship, ethnicity, class, gender systems
- Cultural systems: ideologies, belief/symbolic systems, religions, languages, identities
- Political and economic systems: governance, warfare, invasion/conquest

Environmental disruptions do not include events so catastrophic they halt migration completely, though they do include severe events such as the climate change of 4.2 kiloyear event (Clarke et al. 2016, Staubwasser et al. 2003, Wiener 2013). Social disruptions are more complex, acting as cause and effect, influencing the source, target and the migrating community. The magnitude of the disruption is dependent on its size and scale, duration and frequency as well as on the resilience of the target society (Tsuda and Baker 2015, p. 310). The outcome is a dynamic combination of the different factors. In addition, the magnitude of the actual or perceived differences between the two entities can affect the magnitude of the disruption. For archaeological contexts, deciphering perceptions can be challenging due to incompleteness of records as well as potential later reinterpretations (Zakrzewski 2015). Factors that influence the magnitude of the disruption are (Tsuda and Baker 2015, p. 310):

- Size and cohesion: larger and cohesive groups assimilate slower

- Segregation socially, economically or physically: hinders the adoption of majority cultural norms
- Strong minority identities: may be reactionary to marginalisation or segregation

This resembles Berry's (1997) list of the psychological aspects of the acculturation process. The size, ethnic identity and experience within the target community form a process which may be visible archaeologically. The size and unity of the migrant population can result in the formation of an ethnic enclave which is economically, linguistically and socially self-contained (Massey 1999, Tsuda and Baker 2015, p. 310). In modern studies, they are seen to have certain occupational and immigrant social structures that have a degree of marginality (Low 1997). The enclaves, as ethnic collectives, also promote group member identity, particularly if the group is historically or ethnically distinct from the target population and/or experiences discrimination (Low 1997, Tsuda and Baker 2015, p. 310). Ethnic identity or ethnicity exists both internally and externally, as "it is created, preserved, reaffirmed and even rejected through a continuous set of contrasts between one's own group and others" (Tseng 2002, p. 386). It is a common occurrence in anthropological studies, and fluctuates according to various parameters (Brettel 2008, p. 132). Marginalisation and discrimination can also promote the generation of distinct ethnic identities, also called 'reactive ethnicities' (Tsuda and Baker 2015, p. 310).

In archaeological contexts, migration is tracked by identifying sudden changes in material culture, settlement patterns or funerary practices (Anthony 1990, Burmeister 2000). It is believed that cultural values and lifestyles of migrants are better preserved in homes than the public domain and reflects the chosen acculturation strategies (Bader 2012). Burmeister (2000, p. 542) calls this the dichotomy of public sphere and internal domain - while domestic assemblages are the last to be transformed by interaction and emulation of popular styles, they are the first to demonstrate a new symbolic system. The so-called "push and pull" factors, described by Anthony (1990, p. 899, 1997, p. 22), have been used extensively to understand the causes of migration events (e.g. Barako 2000, Gilboa 2005, Mourad 2018, forthcoming, Priglinger in press, Yasur-Landau 2010).

A model particularly interesting for the Mediterranean environment is the so-called Port Power model, introduced by Stager (2001), which “visualises the organisation of societies on commercial networks grouped around natural transport systems” (Cohen 2002, p. 26). The model shifts power away from polities to the entities participating in trade, recognising the influence of not only port cities but the technocomplexes producing commodities for trade. The decentralised system of exchange generates networks on local and regional levels, making economic gain the main driving force of interaction (Cohen 2002, p. 26). These networks create a dendritic pattern, beginning from larger trade hubs and gradually progressing into smaller sites further away.

The archaeological record cannot identify groups who do not present their difference via material culture, which can be due to a plethora of reasons regarding the size and status of the moving body. Slaves, though involuntary migrants, are often invisible in the archaeological and textual record due to assimilation and re-naming, even in relatively well-sized groups (e.g. see section 2.1). This is due to the resilience of the target community, negating any effect a migrant element may have had. For the target community, disruptions can be (1) temporary with no long-term effect, (2) short-term that results in nondisruptive change, or (3) repetitive and persistent enough to cause system collapse (Buzon and Simonetti 2013, Morkot 2000, Smith 2003, Tsuda et al. 2015, p. 24-5).

The development of biodistance methods in bioarchaeology has not only enabled a novel way of detecting migration but opened new avenues of research by truly engaging with the archaeological record. Kinship studies have expanded beyond biological models of group formation as a response to criticism on their normative Eurocentric conceptions of relatedness (Collier and Yanagisako 1987, Johnson and Paul 2016, MacCormack and Strathern 1980, Schneider 1972, 1984). Ethnogenesis, “the establishment of group distinctiveness” (Sturtevant 1971, p. 92), studies the ways group identity can be formed through phenomena such as class, ethnicity, community, nationality, religion or political affiliation (Stojanowski 2013). The boundaries formed by these aspects are fluent and overlapping, resulting in the

decoupling of “biological and social identities in evolutionary time and defy simple reification” (Stojanowski 2013, p. 72).

The ongoing development in aDNA studies continues to provide new aspects in migration not only in identifying movers but understanding why they moved. Genetic research suggests certain genes, together with external factors, may also affect behaviour and increase the likelihood of migration (Campbell and Barone 2012). Genes affecting personality traits, such as novelty-seeking, neuroticism and extraversion, as well as lower levels of dopaminergic genes (making habitual activity less rewarding), exhibit occurring (though not ubiquitous) patterns among migrating individuals (Campbell and Barone 2012, p. 55). It also appears males and females exhibit different patterns of decision-making, generally sharing only the gene *TaqA1+*, connected to low neuroticism (in males), low dopamine binding and extraversion – males tend to migrate when habitual behaviour is less rewarding, while females need to also be somatically endangered (e.g. low on resources) (Campbell and Barone 2012, pp. 57-9).

The study results tend to vary depending on the sample, the question (e.g. how far the move took place) and the gene(s) under investigation, confirming that migration (particularly in populations with no real necessity) is a multifactorial process to the very core. For females, kinship was also a factor in decision-making, as leaving kin behind appeared to have been more genetically propelled, while leaving *for* kin dominated over genetic makeup (Campbell and Barone 2012, pp. 45-64). Anthropological research has found that local networks, an integral aspect of local mercantile connections and gift exchange, are often initiated and maintained by migrant women (Brettel 2008). These social networks, along with trade routes and seasonal movement, were integral in providing past migrants with knowledge of target areas (Tsuda and Baker 2015).

3.3 Summary

Social sciences are in a constant cycle of theoretical re-invention to maintain currency with the ever-changing landscape of human migration. The revolution in transportation has changed the scale and scope of migration and

mobility, causing constant and accumulative transformations in societies. It has also provided a new perspective into migration theory that has previously considered the nation-state as the constant to which migration occurs via different modes. In this model, the people moving are the focus, the anomaly, despite the acknowledgement that movement across space is the norm. It has highlighted the act of restricting mobility by creating borders as the abnormal, drawing attention to the new artificially stable unit of a nation-state (Favell 2008, p. 271). As a response, migration studies are leaning towards becoming a part of spatial mobility studies and assuming a global (decentered) perspective. Favell (2008, p. 275) argues that the conceptual tools “we have inherited from scientific disciplines are not sensitive to this need”, as the disciplines themselves are rooted in nation-states.

The colonial history of anthropology is particularly prominent in the developmental history of biodistance analysis and should be acknowledged to ensure ethical standards remain current with the development of the field. The discussion of ethical conduct and generation of standards has been active in bioanthropology (e.g. Mitchell and Brickley 2017, the AAA code of ethics), and similar discipline-wide protocols have recently begun emerging for aDNA and 3D geometric morphometrics research as well (e.g. Hirst et al. 2018, Kaestle and Horsburgh 2002, Prendergast and Sawchuk 2018).

There has been a debate whether modern bioanthropology research has moved forward from the “Neumann ideology” of typing. The issue was raised by Armelagos and van Gerven (2003) after noticing a methodological stagnation in journal publications. Though some had more positive views on the state of research (e.g. Konigsberg 2006, p. 266, Knudson and Stojanowski 2008, Stojanowski and Buikstra 2005), the criticism may have ultimately spurred on further research.

Biochemical analyses (stable isotopes, aDNA) are becoming increasingly popular, and affordable, for studies investigating mobility (stable isotopes) and migration (aDNA). There may be, however, practical and potential ethical issues which promote the continued usefulness of non-invasive techniques. Though the decreased prices of biochemical analyses have allowed for larger sample sizes, successful tests continue to be reliant on good preservation. The risk of destroying the material may in some cases

make collection holders more persuasive for non-destructive methods which can also generate larger datasets in some cases.

The field of dental anthropology has developed into a prolific field, continuously pursuing improvement in its methodology and theoretical framework. This also holds true for the study of dental nonmetric trait analysis which has progressed from Dahlberg's first casts to current photographic manuals (e.g. Scott and Irish 2018). The increasing computational power and array of multivariate statistical analyses allow new venues of research within the field as well as in multidisciplinary approaches. These are discussed further in chapter 5.

Methodology is only as good as the theory behind it. In biodistance analysis, the impact of condensing groups into cladistic taxonomic models has been realised to represent only a small aspect of a community and its identity. The understanding of archaeological cultures as models, constructed from the available physical and textual evidence, has highlighted the relevance of multidisciplinary approaches. In order to provide a meaningful interpretation of the Tell el-Dab'a community and network, the bioanthropological data was considered in conjunction with archaeological finds. This includes understanding changes in settlement structure, material culture and behavioural patterns (i.e. customs). These are discussed further in chapter 4.

4. Material

The thesis focused on collecting data from Middle Bronze Age Egypt and the Eastern Mediterranean. These areas have been proven relevant for the study by decades of previous research (e.g. Bietak 1996, 2007, 2010). Data used in this analysis has been acquired by three pathways: fieldwork (1), receiving unpublished data from other researchers (2) and compiling appropriate data from published sources (3).

Because of the special interest in the Levant and Mesopotamia, efforts were focused on accumulating new data from this area (table 8, figure 8). In addition to sample names, table 8 includes information on collection locations, the number of individuals (or the minimum number of individuals, MNI), the number of teeth that attributed towards the MMD analysis from those individuals (duplicates were not included), dating of the sample and whether any equid or weapon burials have been identified from the sites. All sites where data was collected from had at least some evidence of contact with Egypt, either before or after the Hyksos period (further details in site descriptions).

Dental nonmetric data from the Near East has been scarce, though efforts have been made to correct this (e.g. see Elias 2016, Nassar 2010, Sołtysiak and Bialon 2013). When published, the study will provide a new cache of information for further research in migration and kinship in Egypt and across the Eastern Mediterranean.

Unfortunately, the amount of available data from some sites (Umm el-Marra, el-Kubanieh, Ermenne) was too small to allow for statistical analysis. To generate possibilities for further research, these sites were still included in the frequency tables in appendices (A11). Because the sites were not considered further in this work, no site descriptions were produced. However, the reader is directed to the work of Schwartz (2000, Schwartz et al. 2006) for Umm el-Marra, and Junker (1920, 1925) for el-Kubanieh and Ermenne.

The project used skeletal human remains from archaeological contexts for research purposes. The ethical issue rises from the lack of permission

from the individuals themselves, which was reconciled by assuring the research serves a purpose and produces results which could not be attained otherwise. All the techniques were also non-invasive by nature. Guidelines have been issued by several relevant institutions and parties to ensure respectful and professional treatment of the human remains, such as by BABAO (British Association for Biological Anthropology). The guidelines were followed to ensure the highest level of professionalism and respect when treating the remains. When conducting the research abroad, the same guidelines as well as local standards will be followed. The Online Ethics Courses and the Online Ethics Checklist provided by Bournemouth University were passed prior to beginning data collection (appendix A18).

4.1 Data context

Data from unpublished sites (table 8) is pointed out clearly and has been treated differently in the appendices. In order not to hinder other publication work, details of these sites have been omitted, whereas the data from sites observed by the author has been included with all the contextual information that was available. For the published sites, data collected by the original investigator was primarily consulted. The latter group was scarce for the Eastern Mediterranean but a wealth of published data from Egyptian sites was readily available, namely from publications by Irish (2006).

Raw data was received from Ashara (ancient Terqa), however the site has also been published together with other near-by sites (see table 8). To include a larger number of sites, and to give the reader an opportunity to look up published information, the latter was used in further analyses.

Two different relative chronologies were used in this work, the Egyptian dynasties (dyn) and the Levantine archaeological periods from Early Bronze Age to Iron Age (see figure 10). Material was included in the analysis only if dating could be ascertained to the time period of interest, the Levantine Bronze Age. Though the focus was the Middle Bronze Age II (MBAII/MBII) period, data was included from individuals dating from the Early Bronze Age (EBA/EB, also EBIV/MBI) to the Late Bronze Age (LBA/LB). The chronological

window was extended to ensure a truer interpretation of the migration movement, as the timing of “the Hyksos invasion” was uncertain.

Determining absolute chronology and synchronising periods between sites is one of the most challenging tasks in archaeology, evident from the ongoing discussions (Bietak 1984, 1989, Dever 1991, Hölfmayer et al. 2016). It is not the aim of this work to attempt the synchronisation of the relative and absolute chronologies across the Eastern Mediterranean and Egypt or offer any other input. This task is currently being discussed by numerous other researchers, devoted to the topic, and they are much more enlightened. The dates presented in this work have been collected from publications by primary investigators and were used when the dating appeared confident.

Table 8. Collected and unpublished data from other researchers. Na= sample size for geometric morphometrics, Nb=sample size (MNI or individuals) for dental nonmetrics, T=number of teeth attributing to the MMD analysis (given for sites recorded by author), D=Dating, WB=weapon burials, EB= equid burials. Dating abbreviations include EBA=Early Bronze Age, MBA=Middle Bronze Age, LBA=Late Bronze Age, IA=Iron Age. Sites marked with and asterisk (*) have additional information included in appendices A6-10.

	Site	Collection location/reference	Na	Nb	T	D	WB	EB
Collected data	Jericho*	Nicholson Museum (Sydney), Australian Institute of Archaeology (Melbourne), Duckworth Laboratory (Cambridge), British Museum (London)	4	69	664	MBA	X	X
	Pella	Pella in Jordan project (Sydney)	8	33	554	LBA	X	
	Sidon*	Sidon project (Sidon) and Bournemouth University	21	104	1614	MBA	X	
	Tell Sukas	Panum Institute (University of Copenhagen)	1	11	189	MBA	X	
	Tell el-'Ajjul*	Duckworth Laboratory (Cambridge)		17	129	MBA-LB/IA		
	Tell el-Burak (Sidon)	Pompeu Fabra (Barcelona)		4	72	MBA		
	Tell Fadous-Kfarabida	Tell Fadous-Kfarabida project (American University of Beirut)	1	6	79	MBA		
	Tell el-Far'ah South*	Duckworth Laboratory (Cambridge)		20	77	LBA	X	
	Dra Abu el-Naga (Thebes)	Musée de l'homme		43	483	17th dynasty		
	Ugarit (Ras Shamra and Minet el-Beida)*	Musée de l'homme		42	652	MBA	X	X
	Tell el-Dab'a*	University of Vienna, Medical University of Vienna, Natural History Museum (Vienna)	12	96	953	MBA		
	Ashara			87	-	EBA-MBA	X	X
	Barri	Courtesy of Prof Arkadiusz Sołtysiak and Jessica Walker		28	-	EBA-MBA	X	
Data received	Tell Arbid			31	-	EBA-LBA	X	X
	Tell Brak			34	-	EBA		X
	Lachish	Dicke-Toupin (2012)		70	-	LBA-IA	X	
	Tell Mozan	Kharobi (in press)	2	26	-	MBA	X	

Table 7 cont'd. Data collected from publications. Nb=sample size (MNI or individuals) for dental nonmetrics, T=number of teeth attributing to the MMD analysis (given for sites recorded by author), D=dating, WB=weapon burials, EB= equid burials. Dating abbreviations include EBA=Early Bronze Age, MBA=Middle Bronze Age, LBA=Late Bronze Age, IA=Iron Age.

	Site	Collection location/reference	Na	Nb	D	WB	EB
Data from publications	Arqa	Nassar (in press)	8	93	EBA-LBA	X	
	Tell Leilan	Lovell and Haddow 2006		21	EBA		
	Lisht	Irish 2006		61	EBA-MBA		
	Thebes	Irish 2006		54	EBA		
	Qurna (Thebes)	Irish 2006		67	LBA		
	Mari	Nassar 2010		30	MBA	X	
	Ashara, Tell Masaikh, Jebel Mashtale	Sołtysiak and Bialon 2013		48	MBA-LBA	X	X

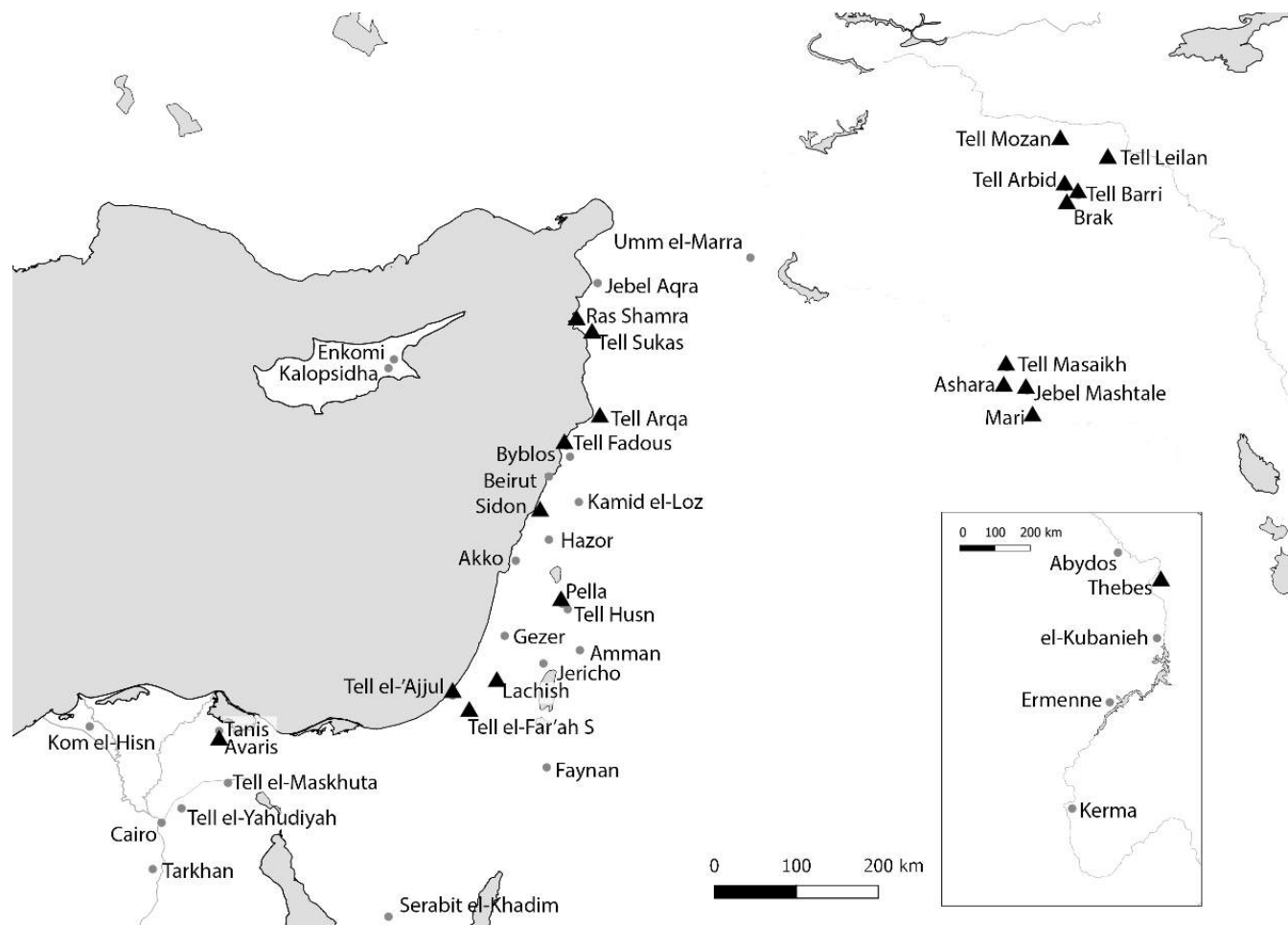


Figure 8. Map of sites mentioned. Sites used in the biodiversity analysis are marked by a triangle. Avaris also marks the location for Qantir (Pi-Ramesse), Thebes also marks Deir el-Bahri, Dra' Abu el-Naga', Karnak and Qurna.

4.2 Tell el-Dab'a

Avaris, located in the modern town of Tell el-Dab'a, resides circa 105 km North-East from Cairo. Naville undertook soundings in the area in 1885 for the Egypt Exploration Fund but the site was not identified as Avaris at the time (Naville 1887, pp. 21-3). Instead, locations such as Tanis, Tel el-Yahudiyah and Heliopolis were suggested (Gardiner 1916, pp. 173-4, Petrie 1906, pp. 9-10, Weill 1953). Gardiner (1916, pp. 100-1) made the connection between Seth of Avaris and Seth of Pi-Ramesse, suggesting the city must have resided close by if not under the Ramesside capital. In 1928, Mahmoud Hamza excavated in Qantir, north of the Tell el-Dab'a, identifying the place with Pi-Ramesse. Labib Habachi excavated in the area in 1941-42 and supported Hamza's proposition, further suggesting that Tell el-Dab'a should be identified as Avaris (Habachi 2001). The identification of Tell el-Dab'a as Avaris was finally confirmed by the excavations led by the Austrian Archaeological Institute in Cairo, and the Institute of Egyptology at the University of Vienna. The two institutes have been excavating at the site 1966-1969 and from 1975 to the present.

The following sections present Tell el-Dab'a excavation areas, giving particular attention to the ones where skeletal material was available from. To understand the Tell el-Dab'a network as it appears via the archaeological record, material culture and burial customs were regarded in local (Egyptian) and region-wide context. This was focused on aspects of material culture and customs with extensive prior research, both from Tell el-Dab'a and the eastern Mediterranean.

4.2.1 Excavation areas

Though the site is covered by modern agriculture, boreholes have enabled the identification of *tells* which stayed above water during inundation (Tronchère et al. 2012). These tells are referred to in the literature as A/I-A/V, F/I-II, R/I, R/III and H/I-VI (figure 9). The areas follow two stratigraphic sequences, marked by capital and lower-case letters, visible in figure 10.

The most excavated and published area in Tell el-Dab'a is A/II which also the source for the majority of burials available for osteological analysis.

The second-largest selection comes from the area F/I with only nine individuals dating to the Middle Bronze Age. The following description is focused on these areas however an overview of the whole site is provided in table 9, compiled from the research by Mourad (2018).

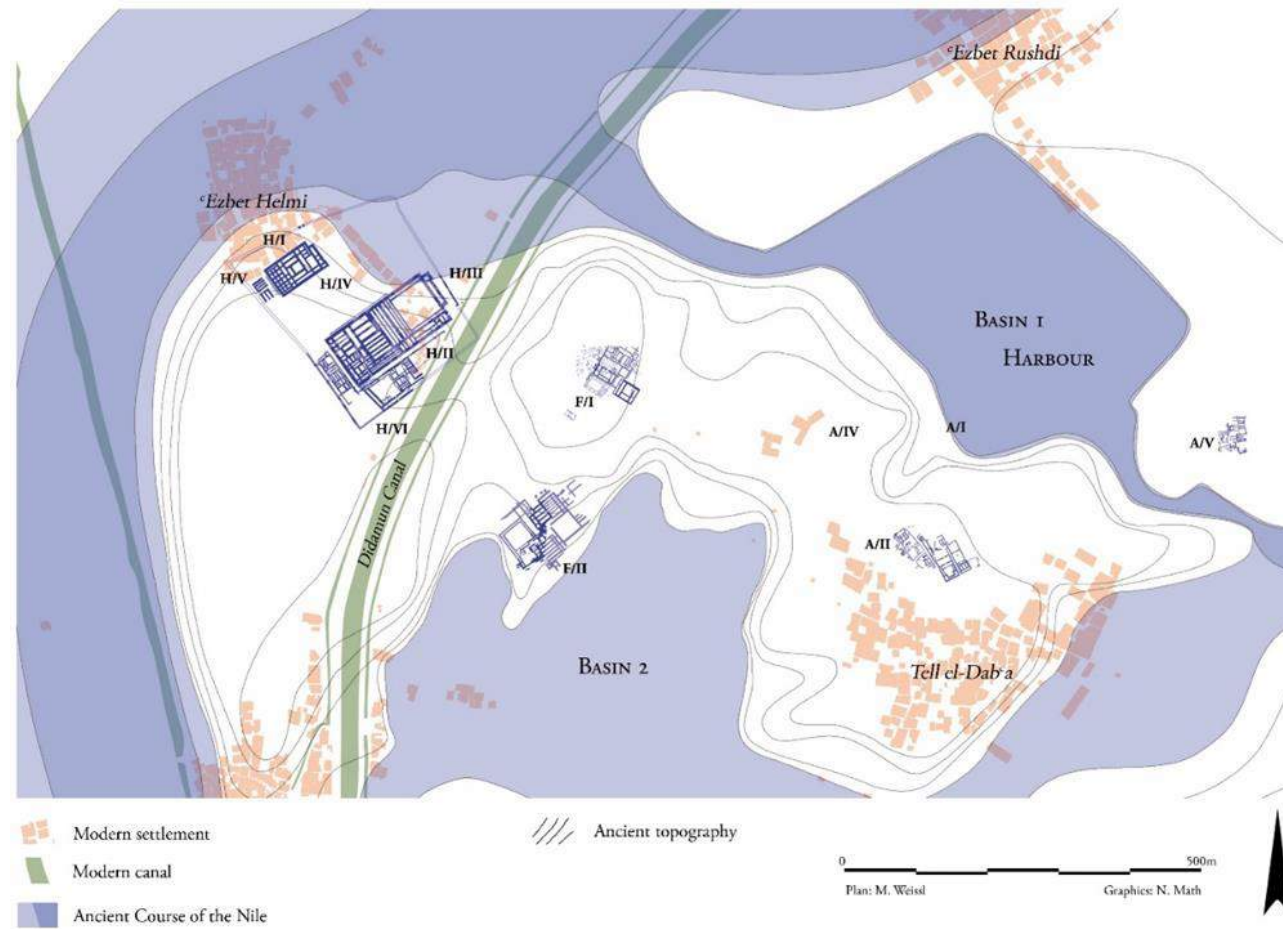


Figure 9. Map of Tell el-Dab'a excavation areas. Image courtesy by the Hyksos Enigma project, map created by Weissl and Math.

MB-PHASES	B.C.	EGYPT RELATIVE CHRONOLOGY	TELL EL-DAB ^c A					GENERAL STRATIGRAPHY
			TOWN CENTRE (Middle Kingdom) ‘Ezbet Rushdi	NEW CENTRE MB-Population	EASTERN TOWN	NORTHEASTERN TOWN	PALACE DISTRICT ‘Ezbet Helmi	
			R/I	F/I	A/I-IV	A/V	H/I-VI	
LB I	1410	Dyn. AII	H I A T U S					Amenhotep II
	1440							C/2
	1470	XVIII H TIII TII TI						C/3
	1500	AI						Ahmosé D/1
MB II C	1530	AHMOSE	DENUDED a PITS	a/2 b/1	D/2	D/2	e/2-f	D/2
	1560				D/3	D/3	g	Khayan D/3
MB II B	1590	XV HYKSOS			E/1	E/1		E/1
	1620				E/2	E/2		E/2
MB II A-B	1650				E/3			E/3
	1680	KINGDOM OF AVARIS NEHSY	DENUDED a STORAGE PITS	b/2	F			F
MB II A	1710			b/3				G
	1740	XIII		EPIDEMIC c H I A T U S	G/1-3			G/4
	1770			d/1	G/4			H
	1800	So AIV		d/2 d/2a d/2b	H			I K Senwosret III, year 5
	1830	AIII	H I A T U S					L
MB I	1860	XII SIII Senwosret III, year 5 d						M H I A T U S
	1890	SII AI		e/1-4				N/1
	1920	SI		f				N/2-3
	1950	AI		?	e/1			
	1980				e/2-3			
MB I	2000	XI	?					
	2050	X		HERACLEO- POLITAN FOUNDATION				

© M.Bietak (2008)

Figure 10. Chronology comparing Avaris, Egypt and the Levant. Tell el-Dab'a stratigraphical layers have been separated according to excavation area. The relative chronologies of the Middle East (MB-phases), ancient Egypt and the Tell el-Dab'a site are aligned, while datum lines represent available radiocarbon dates from the site. Chronology courtesy by Bietak (2010, figure 1, p. 140).

Some traditions are so common in the Tell el-Dab'a material and cultural corpus that it is worth describing them further as they reflect the relations the Hyksos had to the region. This is not done to equate “pots with people” but to better understand the fluctuations that took place in this trade hub and how they may have influenced the people. The traditions are a combination of artefacts and customs observed in Tell el-Dab'a in both mortuary and occupational levels and illustrate fluctuating patterns of contact. Because of the poor preservation of organic material (figure 11), the most prominent sources alluding to Hyksos connections are osteological material (though the organic portion of bones has suffered as well), pottery and metal objects (Aston and Bietak 2004, Phillips 1995, 2006, Maguire 2009).

The preservation and incomplete nature of the available Tell el-Dab'a human remains was also a driving factor in the selection of methods. Dentition was by far the best-preserved material and most often available, though at times degenerated and in incomplete sets, and resulted in the focus of dental morphology and associated analyses (discussed further in chapters 3 and 5).



Figure 11. Tell el-Dab'a skull with signs of crushing, skewing and cortical bone flaking.

Table 9. Development of Tell el-Dab'a as described by Mourad (2018).

Stratum	Description
N: foundation	Egyptian settlement in F/I, relocated to 'Ezbet Rushdi. Ceramic corpus contained small numbers of handmade little MBI cooking pots.
H: Rise	Reoccupation of F/I (rectangular mud-brick houses), with a marginal settlement in A/II, a domestic sector in A/IV, a temple in 'Ezbet Rushdi. Structures: Breitraumhaus (broad-room), Mittelsaalhaus (central hall house) has comparatives in Arad, Meser, Tell Brak, Byblos and Mari. MBIIA pottery increased 20%, predominantly from Northern Levant. Foreign funerary customs emerged: weapons, silver artefacts, animal offerings, equid burials.
G/4: Growing independence	Trade with Northern Levant continued. Egyptian-style administrative complex rose at F/I during stratum d/I, above the Mittelsaalhaus. The tombs in the building's garden probably belonged to officials. Cylinder seal with Ba'al was found from palace.
G: Administrative shift	Stratum d/1(=G/4) in F/I ended with the abandonment of the administrative building, sealing doors and destroying the Asiatic statue. In F/II, a complete horse burial, two pits with 14 right severed hands (c/2-1) and a fragment of an Akkadian cuneiform tablet (c/2-1) was found. A/II continued to develop. Another 20% increase in MBIIA-B pottery. Stratum c(=G/1-3) was marked by a higher mortality rate in F/I and A/II with numerous shallow graves possibly indicating conflict/disease/influx of people.
F-E/3: Rise	Greater social differentiation in F/I (villas similar to el-Lahun). The seal impression 'ruler of Retjenu' was found from F/II palatial complex. New settlement in A/II with an Egyptian style chapels and mortuary temples, temple III (Breitraum), temple II (Breitraum, bent-axis). Servant burials appeared in F/I and A/II. Another increase in MBIIA-B (local, Northern and Southern Levant) ware, and fragments of Nubian and Cypriot ware.
E/2-D/2: growth and independence	Temples were built in F/I, A/IV (for Seth), A/II (temple I, similar to Hazor LBA temple, libation pipes near entrance). 'Ritual banqueting' took place near the F/I temple. Temple II-III in A/II continued in use. F/II settlement was destroyed by fire, new palatial complex rose in its place; pits were excavated with with pottery (Nubian, Levantine, Cypriot, Memphite), animal bones and Egyptian- and Near Eastern-style sealings (though could date to F-E/3). Local pottery industry produced imitations of Cypriot and Levantine wares. Settlements were built in R/III and A/V. Some new and existing eastern Delta sites (e.g. Tell el-Hebwa I, Tell el-Maskhuta, Tell el-Yahudiayh) appear with shared cultural elements.
D/2-1: Abandonment and continuation	Abandonment with no signs of destruction. Limited activity in A/V, temple in A/IV remained in use. A/II was abandoned and not reoccupied until the Late Period. Area H/I was used for magazines, silos and burials. Previous pottery types were still in use. Area H/III had burials of young men with signs of injury, horses and other equids (part of SIP/NK military camp). A palace was built during the Tuthmosid period.

4.2.1.1 Area F/I

The earliest occupation in area F/I dates to the 12th dynasty, strata e/2-3 (Czerny 1999), followed by a short hiatus. The succeeding strata d/1-2 (contemporary with strata H-G/4) have been published by Bietak (1991) and Schiestl (2009). Strata d/1-2 exhibit tomb types not witnessed beyond the area or these periods (elaborated in section 4.2.2). Stratum d/2 already has examples of non-local customs, such as the so-called Mittelsaalhaus buildings, Levantine Painted Ware and burials with Near Eastern style metalwork (Philip 2006, p. 26). Stratum d/1 (=G/4) featured a palace building and associated burials in its garden. The barrel-vaulted mudbrick chambers were accompanied by pairs of donkey burials at the entrance. Both internal and external measurements of the layout followed the Egyptian measure of cubit, equalling to circa 52 centimetres. The tombs were cut into the existing palace garden, mirroring the layout of an Egyptian bedroom (Schiestl 2009, p. 250).

In stratum c (=G/1-3), burial locations showed variation. Graves were placed under house floors or associated courtyards, in structures attached to houses and in small cemeteries. Some of the graves included weapons, and moulds used for metallurgy were found. The end of stratum c is characterised by shallow pit burials, believed to have been dug in haste (possibly due to an epidemic). Regular burials were resumed in stratum b/3 (str F). (Schiestl 2009, p. 86) New villa type houses were built during stratum b/3 and became larger in the succeeding period strata b/2-1 (=E/3-2), and burials were again placed in courtyards (Schiestl 2009, p. 480). Subsequent strata have been mostly destroyed due to recent agricultural activity.

One of the most intriguing finds from F/I are the fragments of a limestone statue, discovered across the south-eastern part of the cemetery. The reconstruction of the statue has revealed a depiction of a high dignitary with Asiatic cultural markers – yellow skin and a mushroom-shaped hairdo with a long black-and-red dress (possibly a cloak), holding a curved instrument (Schiestl 2009, pp. 77-84). Though the statue was an Egyptian representation of an Asiatic, some features have been found from Near Eastern contexts. The hairdo has parallels from statues in Alalakh (though not exact) and from a MBII statue fragment from Pella (Schiestl 2009, p. 87). The

terminus ante quem for the destruction of the statue is just before the Hyksos period (Schiestl 2009, pp. 85-6). Based on the craftsmanship of the statue it may have been produced by the sculptors working or trained by the workshop of Amenemhat III (Arnold 2010, p. 192). Curiously, no other statues have been found depicting the upper class.

Nine burials of varying states of preservation were available for analysis from F/I, dating mostly to stratum c and b/3 (G and F). Burials in this area dated to the Late period and even Hellenistic period were excluded from further analysis. Unfortunately, only dating information was available for these burials as the publication is still ongoing. The portion of the material used in this study was part of a larger analysis produced by Randl-Gadora and Großschmidt (2002a-b).

4.2.1.2 Area A/II

Occupation in Area A/II began with small scale settlement activity throughout strata H-G/1 (Brink 1982, p. 3). A marked change takes place in stratum F when the previously built small houses were replaced by Temple III, a building with parallels in western Asia (Bietak 1991). More monumental buildings, a Near Eastern type Temple II and Egyptian mortuary Temple V, were constructed in the succeeding stratum E/3 (Mourad 2018). Mortuary activity continued to develop in stratum E/2 and Temple I was constructed. Small domestic structures appeared in the area in stratum E/1. In stratum D/3, large offering pits were found in front of Temple III and Temple V, containing charred bones (cattle) and broken pottery (Forstner-Müller 2010, p. 132). By D/3, the domestic building covered the previous cemetery west of the temples, graves now dug into the house floors, and continued to expand in strata D/3 and D/2. Stratum D/2 indicates the last evidence of occupation in D/2. (Mourad 2018)

According to Forstner-Müller (2010, p. 128), four main phases can be recognised in the development of funerary culture (table 10): early Thirteenth Dynasty (1), late Thirteenth Dynasty (2), early Hyksos period (3) and late Hyksos period (4). During this time, the area changed from a living settlement to a funerary site, with a large temple area surrounded by a cemetery, until

the town's living quarters expanded over the cemetery and the smaller funerary structures.

The temples and burials seen in A/II combine a mixture of both Egyptian and Near Eastern traditions which gradually transform into the uniquely Eastern Delta culture visible in the later phases. Phase three is marked by the appearance of a distinctive Delta material culture that exhibits both Egyptian and Syro-Palestinian traditions and even further changes can be observed from the funerary evidence from phase four (Forstner-Müller 2010, pp. 128-9). The most notable pieces of continuation however are Temple III (figure 12), used from the late thirteenth to the early eighteenth dynasty, and land plots that remained the same throughout the period, suggesting some continuation in land ownership as well (Forstner-Müller 2010, pp. 127-9).

Table 10. Development of area A/II as described by Forstner-Müller (2010). Occupation and material culture development phases are aligned with the appropriate stratigraphic layers (Str), dynasties (Dyn) and the Middle Bronze Age chronology (MB). The function and material culture of area A/II exhibits great diversity throughout its occupation history.

Phase	Str	Dyn	MB	Changes in occupation and material culture	Orientation of tombs
1	G	13	MBIIA	Settlement area with tombs constructed nearby or in domestic courtyards. Donkey burials, toggle pins and weapon burials appear.	no pattern
2	F	13	MBIIA-B	The area is redistributed and partially sectioned to plots. The temple precinct became prominent with Temple III in the center with smaller NE structures and Egyptian mortuary chapels were built around it. Cemeteries moved to the margins of the area	aligned with Temple III either SSE or SE, very little variation
2	E/3	13	MBIIB		greater flexibility but little change
2 to 3	E/2	13-14	MBIIB		
3	E/1	14	MBIIB	Living quarters expanded over tombs and chapels but the plots stayed the same (same owners). New Eastern Delta material culture emerged and the amount of Cypriot imports increased. Weapons changed from copper to bronze and begun to disappear from funerary deposits (does not happen in the rest of Levant until LBA).	
3	D/3	14	MBIIC		
4	D/2	15	MBIIC	New tomb architecture (large shaft tombs connected to house architecture with both men and women, perhaps family tombs). Very little to no Syro-Palestinian imports, instead concentration is on Cypriot imports. Weapons have disappeared from burials.	



Figure 12. Area A/II burials mapped out. Temple III included for reference.

Several small building types of Egyptian style have been found near the burials that were never used beyond one stratum. Their function is not clear, but a connection has been suggested to funerary cults such as ritual dining (Forstner-Müller 2010, p. 130, Forstner-Müller 2001, Bietak 2003). Larger pits have accommodated offering meals in the cemetery, containing often smashed pottery and cattle bones (Forstner-Müller 2010, p. 132). Remains of pigs have been found near the Egyptian-style chapels, but never near Temple III (Forstner-Müller 2010, pp. 133-134). The custom of enjoying offering meals is well-documented from the Levant, conducted both as a stately, formal performance and as a familial, private affair (Way 2010). The public and private aspects of ritual feasting maintained a system that was sacred in both institutional and personal spheres (Bergquist 1993, 55).

Burial types used throughout the area included simple pit burials, jar burials and various forms of mudbrick and stone tomb burials (elaborated further in section 4.2.2). Superstructures were rare in general and completely absent in area A/II. The most popular burial position was supine, sometimes with a brick placed under the head. Grave goods, when present, usually followed similar patterns. Weapons were placed on the person, toggle pins on the left shoulder, bowls and dishes near the left shoulder or the head, smaller containers close to the body and large vessels close to the entrance. (Forstner-Müller 2010, pp. 130-4)

The available Hyksos skeletal sample was excavated during the 1966-1969 and 1975-1983 campaigns. The collection was then transported to Vienna, Austria, where it is curated by the Department of Anthropology at the University of Vienna, the Medical University of Vienna and the Natural History Museum of Vienna. Preliminary reporting was conducted by Jungwirth (1968, 1969, 1970) on the material that reached the Natural History Museum, however the main body of work was conducted by Eike-Meinrad Winkler and Harald Wilfing (1991), recording age, sex and ancestry, as well as dental, cranial and post-cranial metric and non-metric information. The current preservation of the material is extremely poor and fragmented, suggesting a good portion of the osteological analysis must have taken place prior to lifting (Harald Wilfing was part of the excavation team).

Winkler and Wilfing (1991) performed age- and sex assessments using tooth development and attrition patterns, joint fusion and bone length and bone degeneration (Winkler and Wilfing 1991, pp. 16-18). Individuals were divided into age categories (Fetus, Infans I, Infans II, Juvenil, Adult, Matur, Senil and their own 'young adult', Frühadult). Sex of the individuals was assessed from available cranial and postcranial elements and tooth size, and scored on a five-point system (Winkler and Wilfing 1991, pp. 17-8). The assessed median life expectancy was 18.6 years, with a mean of 34.4 and 29.7 years for the males and females (respectively) that survived to adulthood (Winkler and Wilfing 1991, p. 140, Bietak 1996, pp. 35-6). The original age and sex estimations were utilised in this study due to the state of preservation.

Winkler and Wilfing (1991) conducted a hierarchical cluster analysis on both cranial and dental metric and nonmetric information. The results separated the Tell el-Dab'a males from the local Egyptian population, tying them more closely to the Levantine area and especially to the individuals in the Iron Age cemetery of Kamid el-Loz (Winkler and Wilfing 1991, p. 95). However, at the time of analysis, the modern standard of dental nonmetric analysis was not in place and as such was not used in the study (see used traits in table 11). An analysis on dental nonmetrics, using the ASUDAS, was conducted later by Randl and Großschmidt (2002) on 37 subadults from the site but the publication does not mention the absolute observation counts for traits. The available teeth were recorded again using the modern standard.

Table 11. Dental features recorded by Winkler and Wilfing (1991).

Winkler and Wilfing 1991	Translation
Schmelzvarianten	Incisor shape variation
Incisivenengstand	Crowding
Linguale Fissuren	Lingual fissure pattern
Tuberculum Carabelli	Carabelli cusp
Rhomboider	Rhomboid form
Verschmelzung	Malocclusion
Schmelzperle	Enamel pearl
Schmelzzunge	Enamel extension
Hypoplasie	Hypoplasia
M3 nicht angelegt	Congenital absence of M3
Druckatrophien	Pressure atrophy (from forceful chewing)
Foramen caecum molare	Buccal pit
Wurzelform der Molaren	Root form
Okklusale Fissuren	Occlusal fissure pattern
Protostylid	Protostylid
Zahnstein	Calculus
Usuren	Wear
Bißform	Bite

4.2.2 Burial types

Tell el-Dab'a funerary customs can be roughly divided into two main categories, Near Eastern and Egyptian (Schiestl 2008, p. 243). Due to the high water tables, Tell el-Dab'a tombs were set in pits just deep enough for the burials, and the building material was mudbrick (Schiestl 2008, p. 245). The vault structures began to show characteristic features in strata d/1 and d/2 of F/I, with one of the distinct features being diversity. One of these were small cist tombs built for subadults, varying from oval to rectangular in shape (Schiestl 2008, p. 246). Barrel vaults, sloping structures covering the tombs' long axis in a right angle by bricks, were most common during d/1-2, which has only been documented from the Egyptian Nile Delta - according to Schiestl (2008, pp. 245, 247), despite the scarcity of descriptions in site reports in both Egypt and the Near East, it was most likely a part of local tradition. Domical structures, flattened domes constructed of antithetic rings of bricks joining in the middle, were also restricted to d/1-2 (Schiestl 2008, p. 249-50).

A curious set of burials took place at the very end of the 13th dynasty (strata G-F, transition MBII B-C) when a small number of servant burials appeared in areas A/II and F/I, located at the entrance of large structured burials (Bietak 1989a, p. 30). The burials have no offerings, and the adult individuals were assessed as young females (Bietak 1989a, p. 39). Though some parallels are known from Early Dynastic Period and 3rd dynasty Ur, neither of the cases overlap periodically with the servant burials from Tell el-Dab'a. However, some cases have been observed from the contemporary Kerma culture in modern Sudan where the custom was carried out longer than in Tell el-Dab'a. (Bietak 1989a, pp. 40-1) It is difficult to determine whether the servant burials indicate the presence of high Kush dignitaries in Tell el-Dab'a at the end of the Middle Kingdom, but it cannot be ruled out either as the sovereigns maintained a connection even during the Hyksos period (e.g. Kubisch 2010).

During the Second Intermediate Period, architectural features become reduced to three main types, single vaulted tombs (2 subtypes), double-vaulted tomb (3 subtypes) and the vaulted chamber tombs with brick-lined shaft (table 12) (Forstner-Müller 2008, pp. 25-34, Schiestl 2008, p. 245). The

cist tombs, common for young subadults in the earlier phases (F/I d/1-2), were replaced by jar burials (Schiestl 2008, p. 245-6). Infant jar burials are widespread custom in the Near East, spanning from the Neolithic to Iron Age (Al-Shorman and Khwaileh 2011, p. 94, Birney and Doak 2011, Bloch-Smith 2013, p. 257, Gonen 1992, Hallote 1995, Ilan 1996). The earliest cases to date come from late 4th millennium BCE Mesopotamia, spreading to Syria in the course of 3rd and 2nd millenia BCE (Orrelle 2008, p. 71).

The publications by Bietak (1991), Brink (1982), Forstner-Müller (2008) and Schiestl (2009) are recommended for further details on burials structures and subtypes. Changes in the terminology did not allow for an automatic merging of reports. To avoid mislabelling, burials were categorised as pit burials, jar burials and chamber burials.

Table 12. Main burial types during the Hyksos period (Forstner-Müller 2008).

Burial types	Description
Pit graves	simple cuts with no structure or with few mudbrick
Jar burials	child burials in large Levantine amphoras (often) or Egyptian Nile silt vessels (seldom)
Small rectangular tomb chambers	burial chamber was built around the deceased, either over the burial or around it
Simple ring vault tombs	mudbrick chamber covered by a semi-circular vault (not used in traditional ancient Egyptian architecture)
Double-ring vault tombs	similar to single-vaulted tombs but two layers that was used for larger tombs
Vaulted shaft tombs	Vaulted tomb chambers with mudbrick shaft leading to an entrance

4.2.3 Weapons burials (warrior burials)

Weapon burials, also referred to as warrior burials, spanned throughout Bronze Age. In her analysis of weapon burials, Prell (in press) has noted an interesting pattern of customs first appearing in Mesopotamia and northern Syria in EBI-II, spreading to the Levantine coast by EBIII-IV. Customs continued during MBIIA (reaching also the Nile Delta) while mostly disappearing from northern Syria. The most classic form of the weapon burial takes place in the Middle Bronze Age, when a bronze or copper dagger and an axe appear as a set (Philip 1995b, p. 67). Warrior burials have traditionally been associated with the influence and movement of the so-called Amorites, a nomadic people from the Euphrates river valley but the accumulating findings showing local manufacture has been suggested to reflect shared ideology instead (Homsher and Cradic 2018). Tell el-Dab'a weapons exhibit local manufacture, accompanied by stylistic changes that begun before MBI. The wide dispersal and variation of the weapon burials likely make them a pan-Near Eastern cultural feature. (Philip 2006, p. 231-4)

Earliest representatives of West-Asian style weaponry in Egypt are from tombs dated to the First Intermediate period and early Middle Kingdom (Brunton 1947, Orel 2000, p. 40). In Egypt, copper and silver torques, an element of the West-Asian burial assemblage, have only been found from Middle Kingdom and Second Intermediate period burials from Kom el-Hisn and Tell el-Maskhuta (Hamada and El-Amir 1947, p. 108, pl. 32, Hamada and Farid 1947, pp. 201–20, Holladay 1982, p. 45).

Weapons from Tell el-Dab'a found from strata H and F have parallels particularly on the Levantine coast (Philip 1995a, Schiestl 2008, p. 244). Fenestrated axes, often referred to as duckbill axes, along with Philip's (2006) type 12 daggers and decorative metal belts, not meant for wear, have been found from only from these periods (Philip 2006, p. 153). Fenestrated axes have been found from a wide area, even as north as Anatolia, but they are concentrated on the Levantine coast (Gernez 2007). Other artefact types, such as crescent-shaped pommels, socketed axes, toggle pins and tweezers, were part of the burial customs in the Euphrates river valley during the 3rd millennium BCE (Philip 2006, pp. 231-2).

Dagger types 12 and 13 have been found from contexts in Syria, Palestine and the Delta (and their variations in Crete, Cyprus and Kerma). Fenestrated axes were replaced by narrow-bladed type 1 and 2 axes in stratum G/4, and spearheads became less frequent around the same time in stratum F. (Philip 2006, p. 232) According to Philip (2006, p. 232), the synchronistic changes in weapon types throughout the region “*implies that the key styles were familiar and meaningful to both producers and consumer [...pointing to] weapons as having an important role in terms of symbolic communication.*”

A new dagger type, Philip's (2006) type 17 occurs from strata E/1-2 onwards. Contemporary with the type 17 daggers is the type 2 narrow-bladed axe. These and other weapon types emerging in stratum E/3 and later have parallels only in Southern Levantine sites (Philip 2006, p. 151). Pin styles show a similar shift (Philip 2006, p. 233). Weapons were not frequent grave finds and became even rarer towards the end of the Middle Bronze Age, possibly marking a shift in idea of “high male status” (Hallote 1999, pp. 112-113, Philip 1995b). The weapon burial custom was replaced by chariots, composite bows and armours during the Late Bronze Age (Philip 1995b, p. 74, 2006, p. 233).

4.2.4 Animal offerings

Animal offerings or sacrifices are a well-attested custom throughout the Near East, beginning from Mesopotamia and spreading to the rest of the Levant via the north (Philip 1995a, p. 153). Despite the pervasiveness of the custom, very little sources go into its function or the exact preparation process (Vila 2013). Ugaritic texts describe long lists of sacrifices performed on certain cycles, but even then there is no clear association between mythological and ritual texts (Pardee 2002). Offerings are placed in both tombs and public (communal) spaces, though both groups exhibit great diversity and overlap. Here, emphasis is given to three types most often referred to in literature; the meat offerings placed in burials, high status equid burials and offering pits which existed in both personal and communal space.

Meat offerings were animals and fish placed in burials, either in portions or as whole carcasses. The offering, ranging from poor to rich in meat, was often placed on a container near the deceased in varying locations (Horwitz 2001). There seems to have been some selection on the type of offering. A Mesopotamian text of the death of Ur Nammu describes the king offering bovines, sheep and lambs to the gods in the afterlife (Kramer 1967). In Middle Bronze Age Levant, offerings were most often, though not exclusively, immature caprines (Vila 2013). Horwitz (2001) notes an increase in the funerary offering at the end of the Middle Bronze Age in the Southern Levant. If the preference extends to the entire Eastern Mediterranean, it could explain the wide selection of sacrificial animals recorded in the LBA Ugaritic texts (Pardee 2002).

Another type of animal sacrifice, often discussed separately, are equid burials. Equid refers to the family of mammals consisting of horses, donkeys, zebras and other related animals. Literature often distinguishes between donkey and horse burials, but due to lack of detail in older excavation reports, the umbrella term is chosen following the research by Prell (in press). It is also worth noting that the identification of equid species is difficult unless an entire skeleton or a diagnostic piece is present (Hanot et al. 2017).

Equid (most often synonymous with donkeys) burials are animal burials that appear in both domestic and funerary contexts (Way 2010). When associated with burials, the equid(s) were usually buried at the entrance of the tomb. The earliest ritualistic burials of donkeys are known from the 3rd millennium BCE Mesopotamia, though an even earlier example may come from the Neolithic Arabian Peninsula, from where they spread to the rest of the Eastern Mediterranean via Syria (Bietak 1996, p. 25, Silver 2014, p. 340). Sacrificing donkeys is known from Mari and Ugaritic texts (Bietak 1996, p. 40, Pardee 2002).

Tell el-Dab'a equid burials had a strong association with weapon burials (Prell, in press). A varying number of equids were buried in front of the tomb entrance of both single and multiple inhumation tombs. Together they seem to indicate high male status, depicted also in the Beni Hassan tomb of Khnumhotep II and in the inscriptions of Serabit el-Khadim (discussed in section 2.1). Philip (2006, pp. 238-9) elevates this as a key element of the

burial practice in the Nile Delta; equid burials may have been a custom across the Near East, but it gained a unique meaning in the Egyptian context, probably due to the importance of the Sinai trade route. Equid burials, though unrelated to human burials, are already known from Early dynastic contexts in Abydos and Tarkhan (Silver 2014, p. 340). Equid burials are continued beyond the Palace Cemetery, suggesting their association with high status was an integral part of the local community (Philip 2006, p. 239).

Offering pits can be associated with specific burials or the cemetery. Sites such as Sidon and Tell el-Dab'a have reported food offerings performed outside the burials in both private and communal settings (Doumet-Serhal 2009, Forstner-Müller 2010). These have been interpreted as offering meals (Forstner-Müller 2010, p. 132) and ritual feasts for the dead (Doumet-Serhal 2009). Equids were part of the "communal offering pits", containing remnants of pottery sherds and other animal bones (sheep or goat) - the offering pits found from areas A/II and F/I have been interpreted as remnants of cultic meals (Schiestl 2009, p. 331, Forstner-Müller 2002, p. 271). Way (2010, p. 214) has suggested a connection with the sacrifices in Ugaritic texts, describing offerings made for Ba'al's funeral (Smith 1997, pp. 108-80). The equid burials in the Southern Levant (aside from Tell Jemmeh) were most associated with human burials. In Tell el-'Ajjul, most of the burials were incomplete animals, which has been proposed to reflect combining ritual sacrifice with a funerary offering, appeasing both god and the deceased, respectively (Wapnish 1997, pp. 258-9).

Animal offerings (or sacrifices) can be interpreted as gifts to gods, as a communal cultic meal, as commemoration of the dead or as a sign of covenant (Horwitz 2001). As the nature of offerings seems to vary between sites as well as within sites, synchronically and diachronically, all these interpretations can be considered equally valid. Though no written sources have been recovered from the Levant describing ritual activity, the archaeological record has revealed fluctuations from private to communal practices across the region (e.g. see Doumet-Serhal 2009, Doumet-Serhal and Shahud 2013, Lev-Tov and McGeough 2007).

In the Egyptian belief system, even a non-royal person could merge with the god Osiris, and the hazards of life and death could be managed with

magic. Neither aspect is visible from Tell el-Dab'a burials (Arnold 2010, p. 187). The funerary practices observed from Tell el-Dab'a are challenging to interpret due to the lack of epigraphic sources as the only written sources inside burials were scarabs (Forstner-Müller 2010, p. 134).

Both pre- and post-burial ritual activity has been noted in Tell el-Dab'a, of which at least some took place at the burial location. A distinction has been made in the composition of the goods used to perform ceremonies both outside and inside the grave, the former mostly consisting of Egyptian material while the former was MBA forms. (Forstner-Müller 2010: 131-132) Offerings also included meat (mostly goat and sheep), deposited near the entrance. Burnt animal bones were sometimes placed within the grave, a custom known in a more meticulous form from Egypt (Forstner-Müller 2010, p. 132).

From strata E/3 onwards, few offering pits have been found associated with burials, regardless of type. According to Forstner-Müller (2010), ritualistic behaviour in area A/II was defined within the strata despite the lack of changes in land plots. This does not follow the usual religious behaviour of either Egypt or the Levant in which continuous cult practices were important.

4.2.5 Tell el-Yahudiyah ware

Tell el-Yahudiyah ware is characterised by geometric designs (lines, stripes, triangles, squares and occasionally circles) created by perforating the vessel surface with a sharp object. The vessels generally have a dark surface and the holes were filled with chalk or lime for contrast. Decoration styles varied not only geographically but also chronologically, making them useful for dating (Aston and Bietak 2004, p. 556).

Though most abundant in Egypt, the primary development of Tell el-Yahudiyah ware resides outside Egypt. Aston and Bietak (2004, pp. 57-8) have divided the development of Tell el-Yahudiyah ware into several branches, with Palestinian and Levanto-Egyptian branches as the main lines. Tell el-Yahudiyah ware occurs in Tell el-Dab'a as early as stratum G/4 (early 13th dynasty) and has one parallel from Byblos (Aston and Bietak 2004, p. 57). Neutron Activation Analyses (NAA) conducted on the earliest Tell el-Dab'a pieces indicate a Northern Levantine origin, spreading to Syria,

Palestine, Egypt and Cyprus (Bietak 1996, pp. 59-60). Trade between the Levant and Egypt in the early 13th dynasty led to the import and imitation of Early Levantine Tell el-Yahudiyah ware (branch I) in Egypt, and it was the most abundant group from the MBIIA vessels. (Aston and Bietak, p. 552). During MBIIIB, branch I developed into the local Tell el-Yahudiyah ware branch L, contemporaneous to the branch D produced in Palestine. Contact with the Southern Levant brought about a hybrid type, branch M, which was produced locally in the Southern Levant (Aston and Bietak 2004, p. 295).

Tell el-Yahudiyah juglets were most likely used for precious liquids, such as perfumed oils and ointments, if not opium. Analyses on the contents of juglets from Tell el-Dab'a have identified mixtures of plant and animal fats but no narcotics (Aston and Bietak, p. 558). Most of the early Tell el-Yahudiyah ware came from burials contexts (when *in situ*) but in the Hyksos period Tell el-Yahudiyah ware became more numerous, and larger vessels are found also from settlement strata (Aston and Bietak, p. 558). Excavations at 'Ezbet Helmi have produced Tell el-Yahudiyah ware made in the 18th dynasty (type L.5-8) (Aston and Bietak, p. 556).

4.2.6 Cypriot ware

The first signs of Cypriot influence in Tell el-Dab'a come from the 13th dynasty, when imitation Cypriot ware, handmade globular juglets with distinctive Cypriot plug handles, was produced at the site, suggesting the presence of non-locals living at the site to produce or instruct the manufacturing of the vessels (Aston and Bietak, p. 58, Maguire 2009, p. 21). Tell el-Dab'a has produced the largest selection of Cypriot MBA pottery outside the island to date, with other large deposits found from Ras Shamra and Akko (Maguire 2009, p. 13). The pottery has been found from burials as well as settlement layers.

Cypriot pottery has been found from over forty sites across the Eastern Mediterranean, particularly along the coastal line, and its role as an intermediary should not be underestimated. The vessel types suggest trade was conducted in both precious and bulk items and may have been particularly associated with the circulation of Cypriot copper (Maguire 2009,

pp. 66-7, 86-7). In the Early Bronze Age copper production in Cyprus was likely able to satisfy local demand (Kassianidou 2014, p. 261). In the Middle Bronze Age, both the Cyclades and the Jordanian Faynan region had ceased to produce copper while activity in Cyprus was becoming substantial enough for exportation (Bassiakos and Tselios 2012, p. 160, Hauptmann 2007, p. 153, Kassianidou 2008, pp. 251-6, Véron et al. 2011/2012). Copper production was divided across several centres in Cyprus, but the most extensive workshop has been found in Enkomi (Kassianidou 2014, p. 262). Mari texts mention trade products such as tin, gold, silver, textiles, wine, oil, wood and slaves (Leemans 1960, pp. 110-29).

The Late Egyptian Tell el-Yahudiyah ware distribution pattern of Cyprus, Southern Palestine and Ras Shamra is parallel to the contemporary circulation of Cypriot pottery (Maguire 2009, p. 55). Cypriot Red Polished and Burnished Wares are related, appearing particularly in Palestine and Syria, respectively. The Red Polished piriform juglets appear particularly in Palestine and the Nile Delta. Over 200 Red Polished piriform and cylindrical vessels have been found MB tombs in Jericho (Kenyon 1960, p. 264), despite Tell el-'Ajjul, Lachish and Gezer being larger in occupation size at the time (Gonen 1984, pp. 63-5). A specific type of Cypriot ware, named Proto White Slip ware (PWS), appeared in Tell el-Dab'a and Tell el-'Ajjul before the end of the Hyksos Period (Maguire 2009, pp. 86-7). Red Burnished Ware is mostly confined to sites in Cyprus and coastal Syria, with over 30 instances in Ras Shamra, with examples in either the Southern Levant or Egypt (Maguire 2009, p. 59). Related to the Red Burnished Ware is a Cypriot class WP V Eyelet style which combined both local and Syrian attributes, has been found in small quantities in Ras Shamra and even smaller quantities along in Syro-Palestine and Egypt (Maguire 2009, p. 55)

The abandonment of Tell el-Dab'a halted local pottery production in trade purposes, and most of the Red Burnished and Polished Ware disappeared as well, leaving Cyprus to assume near complete monopoly of small trade containers (Maguire 2009, pp. 62, 66). In Cyprus, Enkomi increased prominence over Kalopsidha and foreign material became more frequent in the archaeological record. Socketed axes and belts, Tell el-Yahudiyah ware and its imitations and Red Burnished Ware have been found

from burials (Maguire 2009, p. 66). Cypriot copper production continues to grow, reaching its peak in the Late Bronze Age (Kassianidou 2014, p. 262).

4.3 Dra Abu el-Naga (Thebes)

The Egyptian necropolis of Dra' Abu el-Naga' is located on the West Bank of the Nile, close to the Deir el-Bahri mortuary complex and the necropolis in el-Assasif (the map location for the site is Thebes, the modern city of Luxor). The necropolis appears to date between the Middle Kingdom and New Kingdom, though excavations at the area are still ongoing (Polz et al. 2012). The site was originally excavated by Mariette, but the exact timing and documentation is ambiguous. Mariette does not give many details of the burials in his publications, only mentioning: "Unfortunately, there is not a single tomb in Drah-abou'l-neggah which is worthy of a visit." (Mariette 1890, p. 215).

Mariette was not working in Thebes himself, but employed assistants to carry out excavations, namely Luigi Vassalli who is known to have found burials at least in 1862. These burials have been dated to the late 17th and early 18th dynasties, and not the 11th dynasty (Polz et al. 2012). It is strongly believed that the skulls marked for the 11th dynasty, may in fact date to the 17th-18th dynasties. The reason for the confusion is suspected to be mainly the result of mixing the 11th and 17th dynasty rulers when dating, both called Intef (Polz, pers comm). The first tombs that can be certainly dated to the 11th dynasty were found in 1995 (Polz et al. 2012).

For comparative purposes, skulls from the Theban cemetery in Dra' Abu el-Naga' were included in the analysis. The original dating estimation by Mariette, marked on the skulls, indicates Middle Kingdom 11th dynasty. These were ignored in favour of the more recent estimation by Polz, though both dates (Middle Kingdom versus 17th dynasty) fall within the dating parameters set for the analysis. The skulls were part of the World exhibition (*Exposition Universelle*) of 1867, where the Egyptian pavilions contained the remains of circa 500 individuals in chronological order (Mariette 1867 vol V-VI). The skulls are assumed to have been a donation to the exhibition by the Egyptian viceroy, Ismail Pasha (Reid 2002, p. 128). A selection of the skulls, the ones

already originally assigned to the 17th dynasty, have been published by Komáry and Fóthi (2013).

4.4 Arqa (Tell 'Arqa)

Arqa is located in northern Lebanon on the Akkar plain. It was excavated by a Franco-Lebanese expedition in 1972-96, with a hiatus during the Lebanese civil war (Thalmann 2000). Occupation at the site dates back to the Natufian period, however the best known occupation period is the Bronze Age (Thalmann 2010). During EBI, the trade network was mostly local, reaching sites such as Byblos, Sidon and Tell Fadous. In EBII, however, the ceramic corpus finds its parallels from the Southern Levant with little contact to the northern regions (such as Ras Shamra/Ugarit). EBIV is marked by a change in the area, as the ceramic, lithic and metalwork corpus takes on the appearance of northern and central Syria. (Thalmann 2010) A similar shift has been recorded from Byblos at the time (Thalmann 2010). Thalmann (2010) identifies parallel funerary architecture from the northern Syrian site of Umm el-Marra.

Weapon burials have been discovered from the Middle Bronze Age layers, including daggers and axes. Circa fifty intramural jar burials were dated to the MBII period (Gernez 2008). Typology analysis of the metal artefacts found parallels throughout the region, beginning from northern and central Syria and Mesopotamia and shifting to the Southern Levant by MBI (Gernez 2008). The Middle Bronze Age was a period of rapid growth, which quickly reduced in size by the beginning of the Late Bronze Age. The site was later mentioned in the Amarna letters (Irrata in Amarna letter EA 100), and during the Crusader period it was utilised because of its strategic location at the foot of Mount Lebanon (Charaf 2016, Thalmann 2010).

Individuals dating to the Bronze Age (local phasing K-R) were selected for analysis. As dental nonmetrics have recently been recoded from the Arqa material (Nassar, in press), data collection was focused on individuals with first molars with little to no wear for the geometric morphometrics analysis.

4.5 Tell Mozan

Tell Mozan is located in the Syrian Khabur plain, close to sites such as Tell Arbid, Brak and Barri. Soundings and small trenches were conducted at the site by Mallowan in 1934 who mistook the site as Roman. In 1984, excavations were initiated by Giorgio Buccellati and Marilyn Kelly-Buccellati under UCLA and California State University, respectively, but the excavations were halted by the Syrian civil war in 2011 (Buccellati and Kelly-Buccellati 1997).

The site has been identified as ancient Urkesh, founded around the 4th millennium BCE, and the site, along with the whole Khabur basin, became the heart of the Hurrian cultural region in the 3rd millennium BCE (Buccellati and Kelly-Buccellati 1997). Hundreds of clay seals have been found, describing daily, ritual and royal activities in the town. A large cultic structure (*âbi*), dug deep into the ground and with complete dog skeletons at the bottom, has been identified from the contemporary texts as a means to communicate with the underworld (Kharobi, pers comm). Dog burials have been found on several sites along the Euphrates-Tigris river valley (including the close-by Tell Leilan), but in a much more distinct area compared to the equid burials (Wygnańska 2017). A similar structure has been excavated from Tell el-Dab'a (Bietak, pers comm), but aside from singular bone finds from settlement layers, no dog burials have been recorded from the site (Prell, pers comm).

During the 2nd millennium BCE, Urkesh became a vassal state to the Amorite kingdom of Mari, until falling under the rule of Babylonians (circa 1900-1600 BCE), and suddenly abandoned in 1350 BCE (Buccellati and Kelly-Buccellati 1997). A total of 159 burials have been found, dating to the Middle Bronze Age (Kharobi et al. 2014). Eight burials with either young children or adult females had additional “fire rituals”, or *kipsum*. Contemporary texts reveal the underworld as a sinister place which could turn the spirit malicious if not fed (Cohen 2005). To appease the spirit, family members conducted fire rituals, offering food and drink, while invoking the deceased's name. Burnt animal bones have been found from the Mozan fire pits, offering further support for the texts (Kharobi et al. 2014).

Only a small portion of loose teeth have been transported out of the country for further research (and were thus available). These teeth, as well as

the Tell Mozan burials, have been thoroughly analysed by Kharobi et al. (2014, in press), whose dental nonmetric trait data was used in conjunction with the other sites from the Khabur basin. New data was acquired by photographing first molars with little to no attrition for the geometric morphometrics analysis.

4.6 Ugarit (Ras Shamra and Minet el-Beida)

Ugarit was an ancient kingdom on the Levantine coast, on the mound of Ras Shamra, circled by two seasonal streams that joined circa one kilometre away in Minet el-Beida. Both Ras Shamra and Minet el-Beida are sometimes used when referring to a specific location, and the former often seems synonymous to Ugarit in vernacular. Minet el-Beida may be the ancient port Ma'hadu (Greek Leukos Limen, Crusaders' White Port). On the northern horizon, 30 kilometres away, is Jebel Aqra, ancient Mount Sapan, at whose peak the storm god Ba'al resides with his sister 'Anat. (Yon 1997, p. 255) The discovery of the site was the result of an accidental discovery of a tomb in Minet el-Beida in 1928, leading to a full-blown excavation in Minet el-Beida and Ras Shamra by the *Mission Archéologique Française*. Excavations have been carried out for decades by several directors; Claude Schaffer (1929-1970), Henri de Contenson (1971-1974), Jean Margueron (1975-1977) and Marguerite Yon (1978) (Pardee 2002, Yon 1997). Occupation history begins in the Neolithic (circa 8000 BCE) but excavations have mostly revealed the Late Bronze Age period. Surveys suggest only one sixth of the site has been uncovered (Pardee 2002).

Ceramic finds reveal contact with other contemporary Eastern Mediterranean sites, beginning in the Early Bronze Age, briefly abandoned circa 2000 BCE and then reoccupied at the beginning of the Middle Bronze Age (Yon 1997). The MBA city, surrounded by ramparts, has produced tools and resources indicating a high level of craftsmanship in metalwork, pottery, stone, ivory and faience (Yon 1997). Trade can be attested by imports from Egypt, the Levant and Cyprus, a combination that is most reminiscent of Tell el-'Ajjul in the south (Kempinski 1997, p. 328). The Mari texts mention Ugarit in tin trade (Muhly 1985), and the archaeological finds from the MBA layers

point to prolific local bronze artefact production (Buck 2018, p. 136, Yon 1997).

A collection of texts were uncovered from Ras Shamra in 1929, written in several languages and dating mainly to the 14th-13th century BCE (Yon 1997). A large portion of the texts were written in Akkadian, the *lingua franca* till the end of the Late Bronze Age (Pardee 2002). Among the tablets was also Ugaritic, a previously unknown language inscribed in cuneiforms using an alphabetic system. From the texts, the site was identified as Ugarit, mentioned in 1800 BCE Mari texts and 1400 BCE Amarna letters (Pardee 2002). Though the texts date to circa 1200 BCE, they are believed to describe a longer tradition, covering topics from magical texts, myths and incantations to medical texts, contracts and letters (Pardee 2002). Most of the texts center around the cultic activity of animal sacrifices that were offered to deities, following a lunar cycle. The texts also describe the Ba'al cycle, a collection of stories recounting the life of Ba'al and his struggle against Yam and Mot, allegories against drought, chaos, death and infertility (Angi 1971). Ba'al (Semitic for "lord") is considered identical to the Mesopotamian fertility and storm god Hadad, and the god sometimes appears in the form Ba'al-Hadad (Ayali-Darshan 2013, p. 652, Hermann 1991, p. 132).

Much like Tell el-Dab'a, several theories have been proposed for the origin of the Ugaritic polity, most commonly proposing a Hurrian, Amorite or Canaanite connection (Buck 2018, pp. 8-14). The first theory assigns the emergence of Ugarit with the arrival of Hurrians. No clear evidence of a Hurrian presence in Ugarit exists during the MBA, and the introduction of Hurrians may not have taken place before LBI (Buck 2018, p. 298). Another theory, supported by archaeological, literary and linguistic evidence, draws a connection between Ugarit and its "Amorite" neighbors. Buck (2018, p. 316) has proposed a hybrid model, suggesting that Amorite groups moved into the Levantine area, occupying sites abandoned during EBIV-MBI, bringing with them "key elements of their material assemblage that reflected unique aspects of social complexity, religious expression, and administrative practices" (Buck 2018, p. 316). The final theory has proposed a close affinity between Ugaritic and Canaanite populations, based on close lingual relationship. The theory

also lends support to the material continuity between the EBA and MBA and is considered as one of the most likely scenarios (Buck 2018, pp. 125-6).

Burials have been found from Ras Shamra and Minet el-Beida, dating from the Bronze Age to the Roman period. Schaeffer (1962, p. xxxiii) made two major distinctions in tomb styles, referring to them as “Hyksos tombs” or Cretan-style tombs. The former were distinguished by intramural burials, accompanied by weapons, Tell el-Yahudiayh ware and animal offerings of sheep or goat (Schaeffer 1938). The latter were dated to the 15th-14th century BCE. The human remains available for analysis were excavated by Schaeffer and published in *Ugaritica IV* by Charles (1962, pp. 521-64), Vallois and Ferembach (1962, pp. 565-622) and Dastugue (1962, pp. 623-30). The collection, currently hosted by the Musée de l’homme, was recorded in its entirety but only individuals dating to the Bronze Age were retained for further analysis.

4.7 Tell Sukas

Tell Sukas, circa 35 kilometres south of Ras Shamra, is believed to have been part of the Ugaritic kingdom. The town’s ancient name Su-uk-su (Suksa) has been recorded from Egyptian, Ugaritic and Hittite documents (Assaf 1997, p. 90). Emil Forrer conducted soundings in the area in 1934 on behalf of the Bryn Mawr College Expedition. A Danish Expedition, funded by the Carlsberg Foundation, excavated parts of the mound under Professor P.J. Riis in 1958-64 (Assaf 1997, p. 90). Occupation at the site goes all the way back to the Neolithic (circa 6500-4800 BCE) with a short hiatus taking place between the Neolithic and the Chalcolithic period (Assaf 1997, pp. 90-1).

The Middle and Late Bronze Age were highly disturbed by building activity during the Neo-Phoenician period (380-140 BCE), Riis’ period F (Assaf 1997, p. 91). The most notable remnants from the MB period were house foundations and a large collective pit burial from area G11 from MBII (1900-1700 BCE), excavated and published by Thrane (1978). Grave goods included pottery, jugs, lamps, bronze weapons and silver jewellery; similar “melon-headed” pins have been found from Ras Shamra, Jericho, Megiddo and Lachish (Thrane 1978, p. 39). The bronze shaft-hole axe has been found

from Megiddo (Thrane 1978, p. 38). The most common comparisons for pottery come from Ras Shamra, Megiddo and Jericho, with some mentions of Yabrud, Hazor and Tell el-'Ajjul (Thrane 1978, pp. 40-47).

The burial contained the disturbed and undisturbed articulated (skeleton I, II, IV-VII, IX, XI-XVII) and disarticulated (skeleton group III, VIII, X) remains of circa 41 individuals (MNI using crania). Skeletal elements were in 3 levels, with articulated remains lying on top of disarticulated ones. When fully decayed, the skeletal elements were placed along the edge of the pit to free up space for a new interment. Some skeletal elements were left unmoved, however, which Thrane (1978, p. 49) suggests could be due to an unfinished decomposition process. Ten crania were uncovered from level 1, two from level 2 and 25 from level 4.

Only the articulated remains were analysed. From these 6 adults, one juvenile and four children (6-12 years) were distinguished. No infants were found in the burial, suggesting they may have been buried elsewhere (Thrane 1978, p. 50). The fragmented cranial elements and teeth were taken to the Anthropological Laboratory at the University of Copenhagen. Due to the preservation of the material Aleksandersen (1978) focused his efforts on conducting an odontological study. The MNI according to teeth was 31 (left first molar). The total was 88 deciduous teeth and 635 permanent teeth. Age was estimated according to development and amount of attrition (Miles 1963). However, Alexandersen (1978, p. 6) notes that teeth appear to erupt later in the Sukas collection than in the Anglo-Saxon collection (Miles 1963).

Alexandersen (1978, pp. 15-35) conducted morphological and metrical analyses of the Tell Sukas teeth using modified Smith's MMD. Most distances were non-significant, the only significant distances are between Tell Sukas and Anatolia (Alexandersen 1978, p. 35). There was a great similarity between Tell Sukas and Chalcolithic Byblos, despite the temporal difference (Alexandersen 1978, p. 35, p. 44). Though the sample sizes were sufficient for the MMD analysis (>10 observations/trait), only seven traits, likely highly correlated (e.g. the Y-pattern of first and second lower molar), were used. The data was collected again for the current analysis.

4.8 Tell Fadous-Kfarabida

Tell Fadous was a coastal site, located in the modern village of Kfarabida. The site was discovered during construction work, and led to the initiation of archaeological excavations by the Department of History and Archaeology at the American University of Beirut (AUB) in 2004 (Genz 2014-15). The site covers circa 1.5 hectares. Six phases have been recognised, ranging from the early 4th to the 2nd millennia BCE and declining in activity by the end of the 3rd millenium. Excavations have revealed domestic buildings and a fortification wall, but signs of activity during MBA are currently only represented by phase V pits and three MBI/MBIIA (phase VI) burials in area II. (Genz 2014-15)

Phase I (EBA) contained two subadult burials (FAD15.260/325 and 260/320). The MB burials 402, 637 and 736 were individual adult burials. A scarab found from the burial 736 dates to the Egyptian 12-13th dynasty (Genz 2014-2015). The associated pottery has parallels in Byblos and Sidon (Genz 2014-2015, Doumet-Serhal 2004, Tufnell 1969). Tell el-Yahudiyah juglets were also discovered, belonging to the piriform type 1 of the Levanto-Egyptian group L, typical in Tell el-Dab'a strata G and F (Aston 2008). All individuals were included in the analysis as a commingled dataset, as the burials were disturbed and the skeletal material severely fragmented.

4.9 Sidon

The ancient city of Sidon, modern Saida, is located circa 40 kilometres south of Beirut on the coast of Lebanon. The continuous occupation in Sidon has not allowed for systematic excavations, but the earliest settlement occurs in the third Millennium BCE (Doumet-Serhal 2008). The Roman historian Justin claimed that the settlement was founded due to abundance of fish in the area, and Sidon and Sidonians were often used to refer to the sea-faring Phoenicians of the Late Bronze Age and Iron Age (Eiselen 1907). Though several excavations have taken place in the immediate vicinity of Sidon, a project in the city proper was possible after the Lebanese Department of Antiquities appropriated the site in 1960 for the sole purpose of research. Buildings erected on the land were used for the Gerard Institute for boys, the American Protestant Mission College and the Marist College, until demolished between 1959 and 1961. The plots remained untouched till 1998 when the

British Museum initiated a project under the auspices of the Department of Antiquities. The site is still referred to by the last phase of modern use as Sidon College site, with foundation pillars still partially standing in the excavation site. (Doumet-Serhal 2013)

Evidence from the site suggests continuous occupation at least since the Chalcolithic, though the settlement centre appears to have shifted momentarily closer to the harbour during Early Bronze Age (Doumet-Serhal 2006, 2010). Sidon, like Tyre and Beirut, was a natural harbour with partially drowned sandstone islets that gave it protection. During the Early Bronze Age, larger vessels were anchored offshore in bays and coves and the rest of the journey to land was covered in smaller boats (Marriner et al. 2014). At the end of the Middle Bronze Age, the increase in trade created a necessity to ensure safe docking during all seasons and the natural harbour was modified with carved installations into the sheltered coves (Carayon et al. 2011, Marriner et al. 2014).

After the brief abandonment of the site from the end of Early Bronze Age to the beginning of Middle Bronze Age, occupation returned and the area was covered with a deposit of sand of circa 1.4 metres thick, ending its function as a domestic quarter (Doumet-Serhal 2013). The area seems to have become a religious centre, with a large MB temple and densely packed burial ground. Many of the burials have been seemingly accidentally cut in antiquity (Doumet-Serhal 2004). Tannurs (bread ovens) were used for rituals, meat offerings were deposited in the graves and meals were consumed close to the graves (Doumet-Serhal 2009). Around 1600-1650 BCE a channel was used to symbolically mark the transition from the living to the dead, referred to Mesopotamian texts as “the slaughter and liberation of animals in the channel”, making the rites a public exercise (Doumet-Serhal 2009, 241). By circa 1500 BCE the funerary banquet had moved from the graves to the temple where ritual destruction of objects (mostly plates) and offering of meat took place (Doumet-Serhal 2013).

The large MBA temple, though only partially available for excavation and disturbed by later activity, revealed faunal remains indicative of ritual feasting in the temple (Doumet-Serhal and Shahud 2013). The majority of the remains were young caprine (sheep or goat), the predominant offering fauna

during the time period in the Levant (Doumet-Serhal and Shahud 2013, Horwitz 2001, p. 81). Caprine and cattle bones are attested in Neo-Babylonian sacrificial texts (Joannés 2000, p. 335). Refuse-pit remains related to feasting or special meals are attested in MBA Ebla and Tell Dab'a and late MBA in the Southern Levant (Marchetti and Nigro 1997, pp. 36-7, Forstner-Müller 2008, pp. 278-9, 282). In LBA Hazor, the feast has been interpreted as part of a communal identity formation and reification, where societal roles were reinforced both symbolically and practically (Lev-Tov and McGeough 2007).

Burial goods from the Middle Bronze Age place the site firmly in the Levantine cultural sphere of the 2nd millennium BCE and the “warrior culture” (Doumet-Serhal 2008, Doumet-Serhal and Kopetzky 2011, Philip 1995b). Particularly interesting is a scarab, dated to the MBIIB (Hyksos period), with the inscription “Dd-kA-ra, beloved of Seth/Ba'al, lord of iAy” (Loffet 2006, pp. 78-9). Iay (iAy) is also known from other sources (see section 2.1), but its exact location has remained ambiguous. Analysis of the trace and major element concentration patterns in bronze weapons indicated copper provenance from the Oman region, Cyprus and to a lesser extent from Crete. Surprisingly, evidence pointing to either the Northern or Southern Levant was scarce (Véron et al. 2011/2012).

Archaeological finds from the site suggest that commercial connections between Sidon and Egypt were in place throughout the time period and were particularly intense during the 2nd millennium BCE (Doumet-Serhal 2013). Sidon pottery, likely containing wine and oil, has been discovered from tombs in Saqqara and Abydos. Scarabs and seal impressions, imported and locally made, have been found throughout the period (Doumet-Serhal 2013). A cuneiform tablet dated to 1400 BCE mentions an order for wood objects, and cedar and pine are known to have been major trade products (Doumet-Serhal 2013). Sidon is mentioned in the Amarna letters from the same time period, describing unrest that required military assistance (Moran 1992).

As the Sidon excavation is still ongoing, the number of exhumed burials is still increasing. During the time of this publication, 170 burial numbers had been given, indicating both individuals, secondary finds of human remains as well as commingled burials. Consequently, only

preliminary reports and stand-alone publications have been generated from the skeletal material (Haber et al. 2017, 2019, Kharobi et al. 2019a, 2019b, Mikulski et al. 2018, Ogden and Schutkowski 2004, Ogden et al. 2011, Stantis et al. 2018, 2019, Schutkowski and Ogden 2011-2012). Recently published DNA study of 99 modern Lebanese and five individuals from the MBA suggested population continuity, at least from the MBA onwards (Haber et al. 2017). The full genome analysis also reported that the phenotypic appearance of the MBA individuals was close to the modern Lebanese population.

4.10 Tell el-Burak

Tell el-Burak is located 9 kilometres south of Sidon. Occupation activity ranged from the Early Bronze Age to the Mamluk/Ottoman period, focussing on the Middle Bronze Age (Sader 2008). The site is believed to have been a stronghold for the larger harbour town Sidon (Sader and Kamlah 2010). Excavations were a joint expedition by the American University of Beirut and the University of Tübingen that took place 2001-2011 (Sader 2008).

The MBA layer revealed the remains of a large revetment wall and a palace building of Mesopotamian influence and wall paintings with Egyptian motifs, similar to paintings from the Middle Kingdom tombs of Beni Hassan (e.g. black-and-white-checkered ceilings) (Sader and Kamlah 2010). The remnants of a tomb were uncovered near the western corner of the building, containing MBIIIB juglets and the poorly preserved commingled remains of five individuals (Genz and Sader 2007/2008, p. 270, Sader and Kamlah 2010). The ceramic material had strong parallels with Sidon and northern Palestine (Badreshany and Kamlah 2011). Some Tell el-Yahudiyah juglets with parallels from Tell el-Dab'a layers E/3-2 were found from settlement layers (Badreshany and Kamlah 2011). The material corpus suggested contact especially with Egypt and to a lesser extent with the Northern Levant and Cyprus (Sader 2008).

The human remains were accessed at the Pompeu Fabra University in Barcelona. The dataset was recorded as commingled, trait frequencies were established by highest FDI number and the resulting dataset merged with the Sidon dataset. The preliminary analysis of the remains has been conducted

by Dr Laura Trelliso, and the results are published as part of the archaeological reports (Sader 2008, Sader and Kamlah 2010). According to dentition, all individuals were adults.

4.11 Jericho

Jericho, modern Tell es-Sultan, resides in the Jordan Valley, circa 40 km West-Nort-West from Amman. It was confirmed as Jericho by Robinson and Smith (1841). The origin of the toponym Jericho has been proposed to come from the ancient West Semitic word yerakh ('moon'), after a contemporary deity (Nigro 2013). Archaeological work has been conducted in Jericho on several occasions, most prominently by Kathleen Kenyon (1952-58) and then later by an Italian-Palestinian Expedition (1997-2015) which has revised some of Kenyon's work (Nigro et al. 2011).

First archaeological evidence is made by local hunter-gatherers camped around the natural spring circa 12000 BCE (Kenyon 1981), marking the beginning of Jericho as a settlement. Despite short periods of vacancy, the site grew steadily throughout the Epipaleolithic/Neolithic period. The beginning of the Early Bronze Age (3500-3000 BCE), EBI or Kenyon's proto-urban, is marked by the appearance of new material culture. Trade networks were already expanding well beyond the surrounding areas, and imports came from Turkey, Syria and Egypt (Holland 1997, pp. 221-2).

After a period of vacancy, Jericho was occupied again during Kenyon's Intermediate EB-MB (circa 2100-1950 BCE), Nigro's (2013) MBI (2250-1950 BCE). Kenyon identified this group as "Amorites" using a pottery type which has parallels in northern Syria (Kenyon 1981, figure 12). The new tomb type had a vertical shaft leading to rock-cut chambers, but Kenyon (1960, 1965) also sub-classified burials according to burial goods: dagger (1), pottery (2), dagger/pottery (3), outsize (4), bead (5), composite (6), and multiple burial (7). The city was destroyed in a fire at the end of EBIIIB (circa 2250 BCE) (Nigro 2013). Ramparts have been identified around Jericho dating to the MBIIA and MBIIC (Marchetti 2000).

Archaeological material from Jericho contains Egyptian imports from the late MBIIA or transitional MBIIA-B onwards. These first finds are mainly

scarabs which were also imitated locally, and the trend of imitating Egyptian designs in locally made products continues to become even more established during the MBII B (Kenyon 1960, Mourad 2014, p. 284, Sagona 1980). Among the Middle Bronze Age burials are also weapon burials. Altogether 17 daggers and a socketed axe have been found from Jericho (Kenyon 1965, p. 285 figure 103, 6, 7, 323, figure 103, 10, 11, Garstang 1932, pp. 46-7).

The Middle Bronze Age period was brought to an end circa 1550 BCE (according to Kenyon's dating) either due to an earthquake or an attack, leading to the destruction of the city. No significant occupation activity seems to have taken place until the Iron Age (Burke 2008, p. 282, Bienkowski 1986, pp. 71, 90, 102), after which occupation carried on until the Babylonian Exile in 587 BCE. Due to erosion, evidence of occupation after Iron Age is scarce, though some evidence remains to suggest at least the sporadic presence of Persians, Hellenistic people and Romans (Bartlett 1982, p. 542, Holland 1997, p. 224, Kenyon and Holland 1982, p. 569).

Part of Kenyon's work at Jericho included the excavation of over 507 tombs around the tell site of Jericho, with the main agenda of obtaining complete or near-complete references for the pottery corpus (Kenyon 1965, p. vi). Material from the excavation has been sent to excavation funders around the world including Australia, Canada, Holland, Sweden, the UK, and the USA (Kenyon 1965, p. v). Table 13 presents a list of receiving institutions, though some of the material has since been relocated. For the current study, material was accessed at the University of Sydney (Nicholson Museum), the Australian Institute of Archaeology, the Duckworth Laboratory and the British Museum. Aside from burial B35 at the Nicholson Museum, the material consisted of individual skeletons. While hundreds of tombs have been excavated at Jericho, publications of the osteological findings are minimal (e.g., Lisowski et al. 1957, Brothwell 1965, Hughes 1965).

Tomb B35 was a rich commingled burial (Kenyon 1960, pp. 371–92). Apart for some cranial material, which was given an individual label and bagged separately, the majority of skeletal remains were collectively stored with no record of excavation layer number. The material was packed and sent to Sydney, where the material was cleaned and catalogued (Blau 2006). Kenyon estimated that there were approximately forty-five individuals (adult

and immature) buried in B35 (Kenyon 1960, p. 264, Kenyon 1965, p. 550). The assessment by Blau (2006) resulted in same MNI using post-cranial elements. Cranial elements of five individuals were accessed at the Australian Institute of Archaeology, but the teeth had not preserved well enough for recording.

Table 13. List of locations where the Jericho material was sent to by Kenyon. List is not contemporary as material has moved between institutions ever since the first dispatch. Material was accessed in bolded the institutes.

Institute	Location
National Museum	Amman
Emory Museum	Atlanta
Birmingham Museum and Art Gallery	Birmingham
University Museum	Cambridge
Duckworth Laboratory	Cambridge
Trinity College	Dublin
University of Durham	Durham
American School of Oriental Research	Jerusalem
Ecole Biblique	Jerusalem
Rockefeller Museum	Jerusalem
University Museum	Leeds
Oudheikundig Museum	Leiden
University Institute of Archaeology	Liverpool
British Museum	London
University Institute of Archaeology	London
Australian Institute of Archaeology	Melbourne
Ashmolean Museum	Oxford
University Museum	St. Andrews
Nicholson Museum	Sydney
Royal Ontario Museum	Toronto

The other large assemblage was accessed at the Duckworth Laboratory and the British Museum. The accessed burials were excavated during 1952-58 and arrived at the Duckworth in several waves. P19 was expected to be part of this collection but it was not received. Instead, burial P19 is currently curated by the British Museum and can be partially viewed as part of the exhibition, while the three subadults (accessed for this project) have remained in storage. The most published portion of these remains was

excavated in 1957-8 and has been dated to the Early or Middle Bronze Age (Brothwell 1965, Hughes 1965, Lisowski et al. 1975). Unfortunately, due to time restrictions, the skeletal assemblage was not engaged in its entirety, and so these publications are recommended for an overall view of the collection.

4.12 Pella

Pella of Decapolis, modern Tabaqat Fahl, rests on the Eastern foothills of the Jordan Valley, 5 km from the river Jordan. Pella was an ideal site for occupation because of its soil and rainfall, making it optimal for agriculture, and its access to the Eastern ascending hills and the Western Jordan Valley (Hennessy and Smith 1997, p. 257). The main settlement site was circa 8 hectares. First archaeological investigations took place in 1958 when the American School of Oriental Research (ASOR) conducted soundings in the area. Afterwards, the Jordanian Department of Antiquities (1963-4) conducted an emergency excavation at Tell el-Husn. Circa fifteen rich tombs, dating to the 13th-14th centuries BCE (Smith 1973, 13f), were discovered but the material was mostly misplaced during the political turmoil of 1970-71 (Bourke and Sparks 1995, p. 151).

Robert Houston Smith, under the College of Wooster, excavated at the site for a season before the beginning of the June war of 1967. After conditions normalised, Smith returned with Basil Hennessy from the University of Sydney, forming the Sydney-Wooster Expedition which began its work 1979 and carried on till 1985, after which work was continued by the University of Sydney in collaboration with the Jordanian Department of Antiquities (Hennessy and Smith 1997, p. 257). In 1994, work was continued by Professor Stephen Bourke (University of Sydney), who also granted access to the material held at the University of Sydney (Bourke 2013).

Occupation history ranges from the Neolithic (circa 6500 BCE) to the modern day. Small pockets of Neolithic houses with domesticated animals (sheep, goat, cattle, pig) and plants (wheat, barley, legumes) but lacking in imported goods suggests Pella started as a small insular agrarian community (Bourke 2013). The end of the Chalcolithic period (3900 BCE) is marked by a short hiatus in occupation, lasting circa 400 years. When occupation returned

no later than 3500 BCE, it extended to the main mound as well as Tell Husn. Both mounds have fortification walls dating around the same EBA period (3200 BCE) (Gibbins 2001). A large fortified building on Husn has been identified as a civic/administrative 'acropolis', and metal object found from the mound come from several known production centres in Cyprus, Anatolia, Sinai and Jordan (Bourke 2013). A severe earthquake has been speculated to have caused the destruction of several sites in the area circa 2900-2800 BCE, and Pella was not re-inhabited until a millennium later (Hennessy and Smith 1997, pp. 257-8).

The Middle Bronze Age settlement was heavily fortified during MBII. The site was also mentioned in the Egyptian Execration Text Brussels E8, dating to the Middle Kingdom and listing the pharaoh's enemies, suggesting it was noteworthy (and troublesome) enough to garner mention (Smith 1973, p. 23, Smith and Potts 1992, p. 35). Pella may have benefited from the trade growth of Tell el-'Ajjul, where the best comparative materials for the Pella corpus are known from, be it pottery (Eriksson 2001), stoneware, metalwork (Bourke et al. 2006) or seals (Richards 1992, pp. 43-4). The archaeological evidence from Tell el-'Ajjul is enough to establish the site strongly within the Middle Bronze Age and Second Intermediate Period trade network. The sheer quantity of material could have easily trickled over to Pella, the luxury items finding homes among the local elite.

Finds exhibiting contact between Egypt and Pella all seem to be items used personally (perfumes, unguents, weapons and jewellery) or displayed (Tell el-Yahudiyeh ware and ivory boxes), exhibiting limited access to elite objects and not mass circulation of common types (Bourke et al. 2006). Two scarabs were found in Wooster tomb 1 and interpreted as formal political allegiance and connection between Upper Egypt and the site during Second Intermediate Period (Smith 1973, p. 210), though the tomb may also date to the New Kingdom (Bourke and Eriksson 2009). Nearly 90% (66 of 76) of the scarabs found in Pella come from burial contexts, while the rest are found in purely occupational contexts (Bourke and Eriksson 2009).

New Kingdom Egypt clearly had interests in Pella, visible in the architecture of the so-called Fortress Temple. Dated from MBI to IAIIA, the temple had six phases (Bourke 2004, 2013). The temple was destroyed circa

1350 BCE, and the new construction takes in Egyptian architectural influences by including an internal columned hall and the sanctum itself was re-centred during phase 5 in LBII (Bourke 2013). Votive offerings include Egyptian stone statues and Egyptianising pottery, gold, silver and lapis jewellery as well as Mycenaean and Cypriot pottery (Bourke 2004).

Fragments of cuneiform tablets have been found from the LBI layers, and the Amarna letters mention a “Mut-bal’lu of Pella” (Hennessy and Smith 1997, p. 258). There are no marked changes between LBI and LBII, possibly due to the smaller active occupation area of the time. Rich burials are known from LBI-II, though the following Iron Age town presents itself less prominent in the archaeological record (Hennessy 1997, p. 258). In the Ramesside and post-Ramesside period, papyrus Anastasi IV identifies Pella (Pher) as the supplier of specialised wooden chariot spokes (Smith 1973, p. 32).

Human remains from Pella were accessed at the University of Sydney. These included the MB burials P3, P28 (XXVIII), 27, 106 and the large commingled Tomb 62, dating to MBA-LBA. Burials 27 and 28 were in the same tomb, containing the remains of circa 15 individuals. The skeletal material was highly fragmentary due to water damage and crushing, caused by the partial collapse of the tomb. The preliminary analysis of skeletal remains was conducted by Bourke (1992), estimating an MNI of circa 100-150 individuals. Most of the remains (and dentition) belonged to adults. Only a portion of the teeth were in good enough condition for dental nonmetric analysis, often either too worn or destroyed due to taphonomy to even assign an FDI identifier.

4.13 Tell el-‘Ajjul

Tell el-‘Ajjul resided circa 150 kilometres southwest from Amman along the Levantine coast. Occupation was at its largest during the Bronze Age, however some Iron Age II burials and later material finds have been made (Dessel 1997, p. 38). The most extensive excavation was conducted by WM Flinders Petrie and his associates between 1930 and 1938 (Petrie 1931, 1932, 1933, 1934, Mackay and Murray 1952). Excavations were renewed in 1999 and 2000 by Fischer and Sadeq but came to a halt due to political circumstances (Fischer 2009). Due to limited access to the site, much of the

current research is re-evaluations of Petrie's original work (e.g. Kennedy 2015, Sparks 2005, Winter 2018).

Tell el-'Ajjul may have been the southernmost buffer town for Ashkelon, a major harbour town during the Middle Bronze Age, and the first major settlement encountered when approaching Ashkelon from Egypt (Burke 2008, p. 132). Kempinski (1992, p. 125) regarded 'Ajjul's orthogonal layout to suggest the site was a planned settlement rather than an organically formed one. During the Middle Bronze Age, higher water levels allowed smaller vessels to enter Tell el-'Ajjul through the wadi (Burke 2008, p. 233). The Cypriot ware found in Tell el-'Ajjul is the most diverse outside of Cyprus (Bourke and Eriksson 2009, Maguire 2009, p. 87). Neutron Activation Analysis (NAA) conducted on over 200 Canaanite jars from Tell el-Dab'a indicated a Southern Levantine origin, most likely from Gaza, Ashkelon or Tell el-'Ajjul (McGovern 1997, pp. 151-2). The evidence has led some researchers to assign Tell el-'Ajjul as the ancient Sharuhén, the last Hyksos stronghold (e.g. Kempinski 1974).

Several cemeteries have been found from Tell el-'Ajjul. Cemetery 1500, also known as Copper Age cemetery, dates to the 3rd millennium BCE (Kennedy 2015). From cemetery 100-200 a total of 48 tombs were excavated, dating to the EB IV. The earliest material comes from the Courtyard cemetery with tombs cut into the soft marl and a total of 25 human burials and 80 animal burials. Three large cemeteries emerged during the Late Bronze Age; the northern cemetery, the 18th dynasty cemetery, and the eastern cemetery of over 300 pit burials. The LBA pit burials contained a high number of Cypriot pottery, Mycenaean pottery, gold and bronze jewellery and Egyptian artefacts (Dessel 1997, pp. 38-9, Sparks 2002/3). Both equid and warrior burials are well-attested from Tell el-'Ajjul (Prell, in press).

Petrie mentions only one occasion of sending skeletal material (particularly skulls) to the Galton Laboratory, founded in 1904, for craniometric studies: "The skulls have been placed in the collection of crania, Eugenics Department, University College" (Petrie 1932, p. 5). During this time, the lab was directed by Karl Pearson (1911-33). Petrie had begun working with Francis Galton and Karl Pearson already in the 1880's, sending the UCL thousands of skulls and even fully articulated skeletons. Later these

collections, known also as the Pearson Collection, were housed by the Duckworth Laboratory (Sheppard 2010).

Individuals curated at the Duckworth spread throughout the cemeteries, ranging from Middle to Late Bronze Age (and possibly Iron Age). Very little contextual information has remained with the material, but thanks to the investigative work by Dr Rachael Sparks (pers comm) some of the material could be assigned to burials and dated. Only material with known dating was included in the final analysis to avoid unaccounted uncertainty in the results.

4.14 Tell el-Far'ah (South)

Located 22 km south of Gaza, Tell el-Far'ah South was excavated by WMF Petrie in 1928-29 and published by Petrie (1930), Starkey and Harding (1932), and Price Williams (1977). Additional soundings were conducted in 1976, 1999 and 2000 (Cohen 1977, Lehmann and Schneider 2000). Tell el-Far'ah is one of the sites suggested as the ancient Sharuhin (Rainey 1993, Weinstein 1991, Kempinski 1974).

Occupation began at the MBII-III period, surrounded by defence walls. The site was abandoned momentarily circa 16th century BC and reoccupied circa 14th century BCE. Both abandonment and reoccupation have been suggested to be connected to Egyptian interests in the area. During the 13th century BCE, a large building connected to Egyptian administrative and military activity was built on top of the MBII rampart (Braunstein 2011). Petrie's excavations uncovered several cemeteries (cemetery 100, 200, 500, 600, 700, 800 and 900), dating from the MBA to the Persian period, that are only briefly described in the publications (Braunstein 2011). Later, these cemeteries have become a focus of more recent research. Warrior and equid burials are known, concentrating on the MB cemetery 500 (Braunstein 1998, 2011, Laemmel 2003, Lehmann et al. 2019, McClellan 1979, Price Williams 1977, Stiebing 1970, Waldbaum 1966, Wright 1959).

Most of the material in the sample comes from cemetery 900, dug into the Western marl slopes of the trench constructed during the Middle Bronze Age (Petrie 1930, p. 16, Macdonald et al. 1932, p. 22). The cemetery contained numerous Egyptian artefacts, including pottery, coffins, scarabs,

amulets as well as royal and divine iconography. The high number of amulets from Tell el-Far'ah S (circa 250) makes it unique in this aspect (Braunstein 2011). A cluster analysis by Braunstein (2011) on the burial assemblages of the 900 cemetery revealed no distinct groups associated with Egyptian artefacts but that the Egyptian-style artefacts were integrated into the whole community. Aside from the Egyptian-style artefacts, burial customs were Canaanite. It is unlikely, though not impossible, that these individuals were other than locals.

Material from cemetery 900 was accessed at the Duckworth Laboratory where it was transported to, together with the Tell el-'Ajjul material, under the same auspices. However, the Tell el-Far'ah material earliest dates are the Late Bronze Age, with some individuals dating to the Iron Age and Persian period. Material dating to the Late Bronze Age and the beginning of Iron Age were kept in the analysis but the Persian material was excluded.

4.15. Summary

The information presented in this chapter was to provide sufficient background into politics and relations of the Middle Bronze Age. Focus was directed to material that has been extensively analysed and published throughout the region. Scarabs, though abundant in archaeological contexts during the period, were only discussed in conjunction with other material. This was done to avoid dating and provenance uncertainties that often follow these materials (Prell, pers comm).

The material and site descriptions reflect the emerging MBA network. Technological advancements, particularly in metalwork, promoted the formation of a network that expanded throughout the coastal line and further inland via different mediators. Stager (2001) has described this as the Port Power model where settlements concentrate on areas with easy access and connection to other sites. In this network, Tell el-Dab'a was a trade hub between north and south, benefiting from the transactions taking place through it.

Bronze Age occupation and trade relations took place against the backdrop of several periods of fluctuating environmental conditions

(Palmisano et al. 2019). The worry of drought is evident even in the Late Bronze Age Ugaritic texts describing Ba'al's struggle against Mot, representing death and drought (Smith and Pitard 2009, p. 683). Pollen records have indicated lowered precipitation levels circa 2300-2000 BCE and circa 2000-1800 BCE, the latter coinciding with the Egyptian 12th Dynasty (Finkelstein and Langgut 2014, Wiener 2013). Because of the difficulties in chronological synchronisation, these events are placed under EBIV/MBI, MBI or MBIIA periods, depending on the researcher.

The material information is key not only for the contextualisation of results but in the formulation of data collection protocols, the appropriate methods and subsequent statistical analyses. The methods presented in chapter 5 were selected according to the content and state of preservation of the material to assure the most successful possible outcome.

5. Methods

This chapter presents the methods used to collect and analyse data. Data collection focused on three aspects; maturity level (adult versus subadult), sex (assessed only from adults) and tooth morphology. The two former aspects were utilised in the intra-site analysis of Tell el-Dab'a, but not in inter-site analysis due to small sample sizes and the commingled content of some of the comparative sites (such as Pella). Maturity levels (adult versus subadult) and sexes of adult skeletons have been included in the supplementary material. These were assessed either by the author or consulted from a primary publication (distinction made in the supplementary material).

The following sections (5.1 and 5.2) give a short account of the age and sex estimation methods used by the author. The following sections (5.3-5.4) present the tools used to collect and analyse the dental morphology data. The model-free and model-bound approaches in section 5.3 present statistical tools used to explore the dental nonmetric data, while 5.4 focuses on geometric morphometrics.

5.1 Age-at-death

Age-related skeletal changes are governed by developmental or degenerative processes, caused by either intrinsic (e.g. genetic) or extrinsic (such as environmental) factors (Uhl 2013, p. 64, White et al. 2012, pp. 25-8). The skeletal development of subadults is more tightly controlled by the former, enabling age estimations for young adults and younger subadults that are both precise (estimations are close to the true age) and accurate (true age falls within the estimation range).

Morphological appearance of bone is affected not only by genes but health, status, occupation, lifestyle, nutrition and endocrine function which all vary not only between individuals and populations but within individuals (Cox and Mays 2000, p. 64). The lack of a perfect indicator causes methods to balance between precision and accuracy, with the accumulation of extrinsic factors expanding age ranges with increasing age (Buckberry 2015, Uhl 2013,

p. 64). The increasing uncertainty is made worse by using methods that do not take into account age mimicry where the method averages and ranges follow the reference sample's age-at-death distribution (Buckberry 2015).

For the current study, most collections consisted only of skulls which are notoriously bad for age estimation (Herskovitz et al. 1997, Milner and Boldsen 2012). To bring cohesion into the dataset, individuals were assessed as adult or subadult using available skeletal elements (AlQahtani et al. 2010, Schaefer et al. 2009).

5.2 Sex estimation

Ideally sex assessments were based on the dimorphic features of the ossa coxae and when possible a combined estimation using both pelvic and cranial features was conducted to improve certainty (Cox and Mays, p. 120). Several of the features were observed on a five-point scoring system that assesses the appearance from highly female to highly male. Features noted by Phenice (1969) are widely regarded as accurate (Buikstra and Ubelaker 1994) though there is some criticism regarding the subjectivity of grading (Moore 2013, p. 96).

As mentioned before (section 5.1), the available study material most often consisted only of the skull. Furthermore, ossa coxae are often highly fragmented in the Middle Bronze Age material. As a secondary source of information, morphological features of the cranium and mandible were assessed using the Ascádi and Nemeskéri method (1970) presented in the standards published by Buikstra and Ubelaker (1994). The mastoid process and the supra-orbital ridge have been reported most accurate (Williams and Rogers 2006) whereas the nuchal crest is the least accurate (Garvin et al. 2012). Cranial features exhibit more population-specific variation (Walker 2008), such as the inflated size of mastoid processes on ancient Egyptian females (Zakrzewski 2007), so that any assessment made using cranial features is much more tentative. As with pelvic features, the cranial features were assessed on a scoring system and individuals were assessed as tentative male, tentative female or indeterminate. The scores are available from the author upon request.

The importance of using a grading system for recording is enhanced by the unfamiliar variation in sexual dimorphism within and between the Levantine populations under assessment. Recent studies suggest there is more global shape variation than current methods, based on averages, can account for. This was made particularly evident with the variation observed in the female pelvic inlet (Betti 2017, Betti and Manica 2018, Betti et al. 2013).

5.3 Model-free and model-bound approaches used for dental nonmetrics

Current biodistance techniques divide into model-free and model-bound approaches. The former describes data patterns using contextual data (i.e. population history) while model-bound approaches use population genetics (Relethford and Harpending 1994). The earliest biological distance studies were largely model-free approaches that focused on the overall similarities among groups. Later studies applied a population genetic framework for analysing quantitative traits (e.g., Relethford and Blangero 1990, Roseman 2004, Smith 2011). These model-bound approaches allowed the estimation of microevolutionary processes such as gene flow and genetic drift (Pietrusewsky 2014). The Relethford-Blangero (1990) model estimates population distances and within-group variation. It is based around an R-matrix, estimated from quantitative traits. The diagonal of the R-matrix is the standardised distance of each population to an imaginary group in the centroid. The populations have a summary measure of additive genetic variance, related negatively to the centroid distance, i.e. internal variation decreases with distance from centroid. The R-matrix can be calculated from a distance matrix, while the full Relethford-Blangero (1990) model estimating within-group variance requires variance-covariance matrices as well. This study uses a combination of model-free and model-bound approaches. The grouping and analysis of data according to contextual information is a model-free approach, but the inclusion of statistics (such as comparing group variation), helps create population parameters.

The theoretical foundation of studies concerning spatial and temporal developments (together) is not well-developed for the moment (Konigsberg 2006, p. 274, Stojanowski and Schillaci 2006). The research parameters must acknowledge the issues of in situ population development versus

replacement, making it apparent whether the study is utilising synchronic or diachronic data and accounting for the potential effect of sample sizes, even if there is no clear solution (Konigsberg 2006, p. 274).

5.3.1 Mean measure of divergence (MMD)

Among the most commonly used methods for biodistance analysis is the C.A.B. Smith's (1972) modified mean measure of divergence (MMD). The statistic was first developed to compare changes in mice (Grewal 1962) but was soon applied to cranial nonmetrics by Berry and Berry (1967). MMD uses summary data to compare trait frequencies across groups, allowing it to cope with missing data, which has made the method extremely useful for material from archaeological contexts (e.g. Irish 2005, 2006).

MMD is a multivariate statistical method. It calculates distances between groups by using the number of positive and overall observations of traits together, combining the individual trait distances into one overall value between the groups. An increase in the distance value indicates increasing distance or dissimilarity between groups. The mathematical definition of MMD is:

$$MMD = \frac{\sum_{k=1}^c (\theta_{ik} - \theta_{jk})^2 - (1/(n_{ik} + \frac{1}{2}) + 1/(n_{jk} + \frac{1}{2}))}{c}$$

where θ equals

$$\frac{1}{2} \arcsin(1 - \frac{2r}{n+1}) + \frac{1}{2} \arcsin(\frac{2r+2}{n+1})$$

(Freeman and Tukey 1950, Santos 2016)

i and j are the number of positive observations for trait k

n is the number of individuals observed for trait k

c is the number of traits used

θ is the angular transformation which corrects for low (≤ 0.05) and high (≥ 0.95) trait frequencies and traits with as little observations as 10. The r is the

number of positive observations for the trait, while n is the total number of observations.

If there is no difference between samples, MMD will resemble a normal distribution with a mean of 0, though an artificial negative value is possible (discussed further below). The upper value is less than circa 9.6 (Harris and Sjøvold 2004). There are several variance formulas (e.g. Green et 1979, Sjøvold 1973), here the formula (Harris and Sjøvold 2004, Sjøvold 1977), preferred by (Santos 2018) is used:

$$var(MMD) = \frac{2 \sum_{k=1}^c (1/n_{ik} + 1/n_{jk})^2}{c^2}$$

If the $MMD > \sqrt{var(MMD)}$ then the null hypothesis (groups are same) can be rejected at a 0.025 level (Sjøvold 1977).

Variables with shared informational content can inflate MMD values. Variables can also be correlated by chance alone. By including correlated nonmetric traits, traits that have been selected for the analysis in the first place because they exhibit variation between groups, enhanced differences could result in false positives (Harris and Sjøvold 2004). To avoid inflated MMD values, a simple bivariate correlation test can be conducted.

Small samples have some issues that must be pointed out. The variance of a trait in a sample is pq/n (Sokal and Rohlf 1995, p. 419) where trait presence p is multiplied by trait absence q and divided by sample number size n . The association of p and n is nonlinear, which creates distortion in small samples. Because analyses focus on within-species samples, the variation is limited to begin with. The calculation $(\theta_{ik} - \theta_{jk})^2$ can produce a negative overall value in small samples. The value is wholly artificial, resulting from small differences between trait frequencies or small sample sizes. However, larger differences between groups can correct for small sample sizes and render positive distance values. Harris and Sjøvold (2004) have noted that in cases with less than 20 observations, the difference between

samples must be at least 15 percent. If the difference is 10 or 5 percent, $n=40$ or $n=200$, respectively. Negative values have been corrected to zero by investigators but this may overestimate population differences. Instead, a winnowing process, where variables resulting in individual negative values are excluded, has been recommended (Harris and Sjøvold 2004). In essence, the test is as good as the data. The result is relative to the variables and samples used and will change with every new configuration.

Another issue concerns the use of dichotomised data. The phenetic appearance of dental traits can be either discrete/dichotomous, scored present or absent, or quasi-continuous (e.g. the number of roots), scored on a scale marking the degree/strength of the expression (Scott and Turner 1988, p. 100). MMD cannot use this raw data to create the distance matrix, but instead the data must first be collapsed into frequencies by groups.

To create a frequency table, values must first be dichotomised into present (1) and absent (0) according to breakpoints set by the investigator. Breakpoints may not begin from complete absence but in some cases exclude weak expressions to differentiate between individuals exhibiting strong trait expressions. The use of breakpoints has the benefit of decreasing inter- and intra-observer error by excluding weaker (and something difficult to see) expressions, but it does come with the drawback of limiting inter-study comparisons (potentially resulting in a comparison between “pears and apples”). The appropriate breakpoints could also vary depending on the samples and the specific research questions – e.g. is the aim to understand divergence based on expression grades common for a region or is the focus solely on the samples, regardless of other factors.

Since traits with different breakpoints are not comparable, several researchers have opted on using recommended standard breakpoints. The breakpoints used in this study follow the morphological thresholds that have been assessed and determined by prior research dedicated to the matter (e.g. Haeussler et al 1988 Nichol 1990, Scott 1973, Turner 1987). This also aligned the dichotomised data with Irish (2006) who has extensive knowledge of the dental morphology (and appropriate breakpoints) of the region.

5.3.2 Multidimensional scaling (MDS)

Patterns can be visualised with multidimensional scaling (MDS), also referred to as principal coordinate analysis (PCoA), which creates a spatial representation of 1-to-n dimensions. It is a nonlinear dimension reduction technique that attempts to maintain the best dissimilarity between points in 2 or 3-dimensional space by assigning different points for several iterations until the best solution is found. The goodness of fit is measured by stress, based off the differences between the actual and expected distance values, where values close to zero are best. Kruskal (1964) has suggested that values between 0-0.025 are perfect to excellent, 0.05 is good, 0.1 fair and 0.2 or higher is poor.

There are two general methods for MDS, the metric or classical MDS and the nonmetric MDS that are used for continuous and rank data, respectively. The classic MDS has been employed most in dental nonmetric analyses as the high number of variables approximates continuous data (e.g. see Irish 2005, 2006).

5.3.3 Fixation index (F_{ST}) from MMD and MDS

The Fixation index (F_{ST}) measures population (genetic) differentiation and is defined as the correlation of gametes between subgroups, relative to gametes drawn randomly from the whole group. The values range from 0 to 1, where the increase in value indicates population divergence. The value varies greatly by chosen populations, and geographic and ethnic similarity often translates to population closeness. The expression “isolation-by-distance” (Wright 1943, 1946) refers to a theory of populations exhibiting greater genetic affinity with geographically closer populations. F_{ST} values with ranges from 0.1 to 0.3 are the most divergent populations (Cavalli-Sforza 1994).

F_{ST} values can be calculated from a Euclidean distance matrix, such as Mahalanobis D^2 distance matrix. MMD distances, however, are based on the average squared differenced of the angles θ . An analogous measure has been suggested by calculating a mean distance to the centroid using MDS (Irish 2010, 2016, Schillaci et al. 2009). The procedure is considered valid because D^2 and MMD distance matrices are correlated, MDS transforms the

values into Euclidean distances and the resulting R-matrix has been proven proportionate to the matrix acquired from a D^2 matrix (Irish 2016).

5.3.4 Correspondence Analysis (CA)

Correspondence Analysis (Hirschfeld 1935, Benzécri 1973) is a form of principal component analysis that can be used to measure variation among samples. It creates a chi-square distance matrix of the discrete data, revealing the variables that carry the most variation. The visualisation of CA values is very close to the MDS diagram (Irish 2006).

The analysis is often produced using either frequencies or percentages of variable counts, which are used to weigh the rows and columns. The latter has been preferred in dental studies to minimise the effects of varying sample sizes (Irish 2005, 2006). The statistic plots for rows, columns and row*columns, to exhibit variation. The dimension with the greatest variation (or inertia) of the overall chi-square test value is plotted on the x-axis. Like in principal component analysis, the following dimensions explain less of the variation/inertia in the dataset.

5.3.5 Gower distance analysis

Because of the missing data in this study, the statistical methods had to be able to produce distance matrices from tables with missing values. Where mean measure of divergence (described in section 5.3.1) uses dichotomised data and group frequencies, Gower distance analysis can generate a distance matrix from non-dichotomised raw data. This allows the investigator to compare not only groups but individuals as well. Currently, there are relatively few examples of this method being used for biodistance analyses (e.g. Gamble et al. 2001, McClelland 2003, Paul et al. 2013), but this may change because of the increased supply of available statistical tools.

Gower distance can be used to create distance matrices of mixed data sets. The R package cluster, used in this study, allows the user to define the type of data in each variable (Maehler et al. 2018). It measures the difference between observations, beginning by computing the distance between pairs and then combining the distances into a single value per record-pair (Gower

1971). The distance is non-euclidean and non-metric by nature, discarding further analysis using methods such as PCA. The Gower distance matrix was generated using the function `daisy` in R package `cluster`.

Maehler et al. (2018) define Gower dissimilarity as “the dissimilarity between two rows is the weighted mean of the contributions of each variable”. They use the extension proposed by Kaufman and Rousseeuw (1990):

$$d_{ij} = d(i, j) = \frac{\sum_{k=1}^p w_k \delta_{ij}^{(k)} d_{ij}^{(k)}}{\sum_{k=1}^p w_k \delta_{ij}^{(k)}}$$

d_{ij} is the weighted mean of $d_{ij}^{(k)}$

w_k is the weight assigned to variable k (default = 1)

$\delta_{ij}^{(k)}$ is the weight, becomes 0 when the variable k is missing in row i and/or j , or when both values are asymmetric binary and equal 0.

$d_{ij}^{(k)}$ is the distance between rows i and j considering variable (column) k . Equals zero if both values are nominal/binary and same. Distance depends on the variable:

- Logical columns/variables are considered asymmetric binary variables. When $x_{ik}=x_{jk}=\text{TRUE}$, then $d_{ij}^{(k)}=0$, in other cases $d_{ij}^{(k)}=1$.
- Factor or character columns/variables are considered categorical nominal variables. When $x_{ik}=x_{jk}$, then $d_{ij}^{(k)}=0$.
- Ordered columns are considered categorical ordinal variables where values are substituted with corresponding value in a factor level.
- Numeric columns are considered interval-scaled variables where $d_{ij}^{(k)} = (x_{ik} - x_{jk})/R_k$. R_k =the range of values for variable k .

The values are scaled (standardised) to fall between 0 and 1, ranging from identical to maximally dissimilar, respectively. (Maehler et al. 2018) Additional transformations are specified using the `type` argument, such as binary values, otherwise the function treats them as interval (continuous).

5.3.6 Cluster analysis

Partitioning around medoids (PAM) is a clustering technique for nonparametric data. The function `pam` can be used from R package `cluster` to create clusters from data and distance matrices. PAM attempts to minimise the overall dissimilarity between observations in each cluster (medoid).

The optimal number of clusters was assessed using the Silhouette Width method (Kaufman and Rousseeuw 1990, pp. 87-8). The silhouette coefficient measures the distance of each point in a cluster to points in neighbouring clusters, the output ranging from -1 to 1 with 0 indicating that clusters are close to the decision boundary (Rousseeuw 1987). The strength of the overall partitioning can be observed from similar coefficients. According to Kaufman and Rousseeuw (1990), the coefficients can be interpreted as follows:

- 0.71-1.0: A strong structure has been found
- 0.51-0.70: A reasonable structure has been found
- 0.26-0.50: The structure is weak and could be artificial.
- < 0.25: No substantial structure has been found

5.3.7 Statistical analysis

Multivariate analysis of variance from nonparametric distance measurements requires different statistical tools. Here, PERMANOVA and PERMDISP tests designed for non-Euclidean data were utilised. PERMANOVA (permutational MANOVA) can detect differences in group mean location (or direction) and group dispersion (spread). It is distribution-free, less sensitive to differences in group variances, insensitive to correlation among variables and zeros in the data matrix, and the number of variables (columns) can exceed samples (rows). It does, however, require equal spread of datapoints (a balanced design) for the groups under analysis to avoid false positives. PERMDISP, on the other hand, measures the multivariate dispersions of the nonparametric distance matrix by comparing within-group and between-group distances using group centroids. It performs a principal coordinate analysis (PCoA) on the distance data, generating vectors (PCo values), eigenvalues (that explain the amount of variation) and the centroid distances by the selected grouping.

PERMDISP only regards spread, not the direction of the values. (Anderson 2006). A significant PERMANOVA test can result from a difference in the location of the samples (average community composition), dispersion of the samples (variability in community composition) or both. In cases of significance, PERMDISP distinguishes between the options. However, PERMANOVA is not as effective for distinguishing differences in spread as PERMDISP.

5.3.8 t-distributed Stochastic Neighbour Embedding

The Gower cluster data was visualised using t-distributed Stochastic Neighbour Embedding (t-SNE). It reduces high-dimensional data by constructing a probability distribution over pairs of high-dimensional observations and then transforming them into a similar probability distribution for a 2- or 3-dimensional graph (Maaten and Hinton 2008). Though the original algorithm uses Euclidean distance to calculate probabilities, it can accommodate custom distance matrices such as the one created by GD (Maaten and Hinton 2008). Because of the way t-SNE reduces dimensionality, it does not generate values explaining the amount of variation by dimension like PCA or PCoA.

T-SNE uses perplexity as a measure of how well the probability model predicts the sample, and it can be manually altered in the function. Perplexity is the effective number of nearest neighbours for each point which attempts to equalise group sizes to prevent any individual point from overinfluencing its assigned group (Cao and Wang 2017). The perplexity measure must be smaller than the number of data points in the sample but still large enough to limit local variation. Any perplexity measure between 5 and 50 is believed to produce a satisfactory visual output of the data, and often the recommendation is to run several tests to find the best visualisation.

5.4 Geometric morphometrics

Shapes are captured using landmarks, features in objects and specimens that are easily identifiable across the sample. The object becomes represented by the landmarks, and the resulting coordinate shape is referred to as a

configuration. Landmarks can be recorded from photographs, scans (such as a CT or MRI scans) and with three-dimensional digitisers, and the resulting coordinate information can be processed in various software. An example of a widely used program in osteological studies is 3Skull (<http://math.mercyhurst.edu/~sousley/Software>, accessed July 4, 2019), designed specifically to digitise skulls in 3-dimensional space with a digitiser. There is numerous freely available software for analysing (any) other structure, such as tpsDig (Rohlf 2017), ImageJ (Rueden et al. 2017), the geomorph package in R (Adams and Otárola-Castillo 2013) and MorphoJ (Klingenberg 2011). To retain only shape information, size and positioning information can be removed by a number of superimposition techniques, such as two-point registration or generalized resistant fit superimposition (for overview see Zelditch et al. 2004). The most preferred method is the generalized Procrustes analysis (GPA).

5.4.1 Landmarks and semilandmarks

Analysis of tooth morphology using 2D information has been especially used in the study of hominins (Gómez-Robles et al. 2007, Gómez-Robles et al. 2008, Gómez -Robles and Polly 2012, Bauer et al. 2016) with, thus far, only a handful of examples from archaeological contexts (Perez et al. 2006, Bernal 2007). What is evident from these prior studies, is that though the data manipulation process is well understood and follows an accepted theoretical framework, there is no set standard for the selection of landmarks or the best course of action regarding the use of semilandmarks.

When the organism has been digitised, it will only exist in the form of selected landmarks, referred to as a configuration. While this is necessary to reduce the complexity of the shape, reduce 'noise', any further analysis is only meaningful if the selected landmarks are truly representative of the shape variation. As a result, landmarks should be easily located, exhibit clear correspondence between samples and take into account the whole aspect used in the analysis (McKeown and Schmidt 2013, p. 331). To communicate the 'goodness' of landmarks, Bookstein (1991, p. 63) has divided them into types according to the precision in which they could be placed on the organism. Type I landmarks are intersections between boundaries, type II

landmarks are maximum points of curvature and type III landmarks are extreme points (relative to the position of the object and as such not purely local) (Bookstein 1991, p. 63). In previous 2D dental GM studies, chosen landmarks have been a combination of cusp tips (type II landmarks) and intersections between cusps (type I landmarks).

Sometimes shape can be a contour or an outline that cannot be defined using location-specific landmarks, but which still carries important information of the organism (like silhouettes). In these cases, the outline can be analysed either by itself (using Fourier or eigenshape analysis) or by combining landmarks with semilandmarks (Gunz et al. 2005, Gunz and Mitteroecker 2013). Unlike landmarks, which are precisely located with two or three coordinates, semilandmarks have only one known coordinate, perpendicular to the outline direction, allowing them to slide along the outline until they reach a correspondence with the other semilandmarks.

5.4.2 General Procrustes superimposition

To investigate only the shape of the organism, size, location and orientation must be excluded from the analysis. With teeth, this means the removal of orientation and location of the tooth in the image, as well as any size difference between teeth. In practice, this is achieved using partial or generalised Procrustes superimposition, where shapes are 'fitted' by minimising the difference between corresponding landmarks by rotating them to the origo and rescaling the configurations to a size 1 (Webster and Sheets 2010). The square root of the sum of these least-squared distances is called Procrustes distance or centroid size (Rohlf and Slice 1990, Goodall 1991). The resulting Procrustes distances exist in Kendall shape space, a "mathematical space induced by the shape coordinates" (Mitteroecker and Gunz 2009, p. 235). It is often demonstrated as a sphere, defined by a configuration with three (and only three) coordinate points. When the number of coordinate points increases, the space becomes a higher-dimensional space that is impossible to visualize. Furthermore, Kendall's shape space is non-linear (non-Euclidean), preventing the use of statistical analyses based on linear relationships. However, the Kendall shape space is approximated by a Euclidean tangent space, the same way a map in a localised coordinate

system can be used to represent the surface of the earth (Webster and Sheets 2010).

Each of the landmarks represents a dimension and a degree of freedom, which together form the minimum number of free observations needed to reproduce the shape. Because the configurations have been aligned by fixing their position and rescaling them, some of the freedom is lost. Procrustes superimposition causes a loss of 4 degrees of freedom in 2D configurations and 7 in 3D, meaning the number of landmarks should exceed the number of lost degrees of freedom (Zelditch et al. 2004, pp. 97-8).

Previous studies have shown that sliding the landmarks gives the best results (Gunz et al. 2005), and there are two ways to do this. Bending energy (Bookstein 1997), known from the thin-plate spline technique, determines semilandmark placement by mapping the 'path of least resistance' between neighbouring landmarks. It has been widely used in semilandmark studies though some concerns have been raised due to the loss of variation it proposes (Perez et al. 2006). The other method, called the minimum Procrustes distance, aims to minimise the distance between adjacent semilandmarks (Rohlf 2010) after an initial Procrustes fit has already been performed on the landmarks (this helps orientate the semilandmarks). Both techniques still carry the inherent issue of correspondence between landmarks, and thus may cause issues in comparative studies (Perez et al. 2006).

5.4.3 Thin-plate spline

After Procrustes fit, the data can be explored for variation and the relationships between landmarks changes. Thin-plate spline is often used to visualise shape changes on a non-uniform transformation grid (where grid lines are allowed to change shape), thereby showing the different levels of distortion depending on the abruptness of the change (McKeown and Schmidt 2013, p. 244-5). The amount of change is defined by the amount of bending energy, where high values indicate change is localised and abrupt while low values tell the change is smooth over a large area. The change can be measured with principal, partial and relative warps. Principal warps describe

movement but not direction and are used to calculate partial warps which can indicate the direction of the movement. Relative warps can be calculated from partial warps (they are principal components of partial warp scores), Procrustes residuals or principal components (PCs). (Rohlf 1993, pp. 135-43, Webster and Sheets, 2010)

5.4.4 Statistical analysis

Principal component analysis (PCA) transforms the values into uncorrelated principal components that account for the largest amount of variation in the sample. It is computed from the covariance matrix, a table of variables describing the differences (amount and direction) of points in relation to the mean value by centring the data cloud (subtracting each value of the overall mean) and rotating it so the longest axis is parallel to the x-axis. Principal components have vectors of PC coefficients which indicate the change between the original and rotated value. The first principal component (PC1) describes the line of best fit, and usually most of the variation in the sample can be explained with the first few PC values. It is common to compare groups by plotting PC scores against one another in a scatterplot. Though PCA is meant for the analysis of a single group, it can help reveal subgroups through clustering of PC scores. Relative warp analysis is a form of PCA that does not include weighting (which describes the angle between rotated and original axis). (Webster and Sheets 2010)

An analysis of variance (ANOVA) test, designed for continuous/interval data, compares variation among and within groups to determine how different they are. Another way to test between-group/within-group variation is by disparity, the extent of group variation within morphospace. The homogeneity of multivariate group dispersions is measured from the dissimilarity matrix by calculating distances between group members and the group centroids from the principal component axes.

5.5 Protocol

5.5.1 Age

- Maturation level was assessed from tooth formation and eruption (AlQahtani et al. 2010) and epiphyseal fusion (Schaefer et al. 2009).

5.5.2 Sex

- Sex was assessed only for adults (assessed from molar eruption and epiphyseal fusion).
- From the pelvis: pubic symphysis, the greater sciatic notch and the preauricular sulcus were recorded and scored following Buikstra and Ubelaker (1994).
- From the skull: nuchal crest, mastoid process, supraorbital margin, supraorbital ridge and mental eminence were assessed and scored following Buikstra and Ubelaker (1994).
- More information on individual scores can be requested from the author.

5.5.3 Arizona State University Dental Anthropology System (ASUDAS)

- Dental nonmetric traits were recorded either as present/absent or as a grade from absent to full expression. Each tooth expressing the feature was recorded, but only one tooth member expressing a specific trait was carried over to the final analysis. All data was recorded and stored in Microsoft Access.
- Generally, only one member from a cohort was carried over to the final analysis due to the correlation within tooth classes as well the subsequent redundancy of information (Nichol 1990, Irish 2005).
- Only one antimer was selected per individual to avoid duplication and skewing of data. Some have chosen a side prior to observation (e.g. Hauessler et al. 1988) but the more usual practice is to record the tooth with the stronger expression (Irish 2005). For this study, two different strategies were selected.

- For individuals, the antimere with the strongest expression was selected for further analysis.
- In cases where teeth were commingled, the side with the highest recorded sample number was selected.
- Teeth were recorded using the FDI (*Fédération Dentaire Internationale*) Dental Numbering System, included in appendix A4.
- Tooth members for trait comparisons and breakpoints were chosen according to recommendations by Scott and Irish (2017) and used by comparative studies (Irish 2005, 2006, Sołtysiak and Bialon 2013). Traits with different breakpoints were not utilised.

5.5.4 Repeatability

- **Intra-observer error** was analysed using 24 individuals with Spearman's rho (for non-Gaussian data)
- **Inter-observer error** was performed with Prof. Joel Irish on a non-related sample ($n = 9$ individuals) to ensure reliability for cross-examiner studies.
- **Low count** traits (<10 observations/trait) were excluded.
- **Inter-trait correlation** was analysed using Kendall's tau-b, designed to test the monotonic relationship between variables in ordinal or continuous datasets. The non-dichotomised data was tested for bivariate correlations using Kendall's tau-b in SPSS. Tooth members exhibiting strong correlations ($b \Rightarrow .0.5$) between traits were excluded from further analysis.

5.5.5 MMD, MDS and CA

- After traits frequencies were generated, data was submitted to the R package AnthroMMD (Santos 2018). The Freeman and Tukey (1950) formula was selected for angular transformation and traits with negative overall MD values were excluded. The package allows the user to determine the minimum number of observations/trait that leads to exclusion (with a default at 10).

- Correspondence Analysis: Sites were rows, traits were columns. The dataset was weighted prior to analysis with trait percentages.
- Geographically close sites with small sample sizes were clustered for MMD analyses to increase observations/trait. First only individuals from the same period were selected, but in most cases sample sizes were still too small and all data had to be pooled:
 - MABB = Tell Arbid, Barri, Tell Brak, Tell Mozan
 - SUKUG = Ugarit, Tell Sukas
 - AJJFL = Lachish, Tell el-'Ajjul, Tell el-Far'ah
 - JP = Jericho, Pella
- The MMD dissimilarity matrix was submitted to SPSS 25.0 procedure ALSCAL and the best (smaller stress value) graphic output (2D versus 3D) was selected.
- To obtain the values, MDS coordinates (3-dimensional x, y, z) were submitted to SPSS procedure Linear Regression as independent variables (dependent variables were random numbers) and the new distances can be saved as squared Mahalanobis distances. The stress testing parameters were kept at default (s-stress convergence 0.001, min stress value 0.005, max iterations 30). The acquired distances imitate the diagonal of C- and R-matrices but they are not directly comparable (Irish 2010, p. 387).

5.5.6 Gower analysis

- Missing data pattern analysed, circa 70% of values must be present for the function to generate a dissimilarity matrix without missing values.
- The Gower dissimilarity matrix was created using R package cluster. To assess the optimal number of clusters for the nonmetric data, the function pam() and a silhouette method were used from the same package.
- For visualisation t-distributed Stochastic Neighbor Embedding (t-SNE) was utilised using R package Rtsne.
- Function adonis2() from R package vegan was used for multivariate analysis of variance (PERMANOVA).
- Function betadisper() from R package vegan was used to analyse homogeneity of group dispersions (PERMDISP). The function is meant

for non-Euclidean data, it reduces the original object and group distances into principal coordinates (multidimensional scaling).

- Contextual data collected from Tell el-Dab'a area A/II was submitted to a separate Gower distance analysis test to explore whether contextual data exhibits any concernable patterns.

5.5.7 Geometric morphometrics

- The first lower molar was selected for its stability in shape and development. The role of the first molar in mastication, maintaining proper occlusion and facial development highlight the importance of consistent phenotypic expression (Gomez-Robles and Polly 2012). Their stability makes them better for biodistance analyses than second or third molars, as changes in the shape are more likely due to genetics rather than epigenetic or environmental factors.
- 2D data collection was selected for its portability and recording speed. This only requires a camera, a stand (either a quadrapod or a copy stand) and decent lighting.
- Photographs were taken on the occlusal surfaces using a Nikon D5300 fitted with A-FS Nikkor 85 mm f/1.4G. Field depth was maximised using a large aperture (f/28). The camera was placed on the quadrapod Pro Elite and at least two light sources were used to minimise shade. Teeth were oriented buccal side towards the top of the image, occlusal surface towards the camera lens and running parallel to it. A scale was placed on the same level with the occlusal surface.
- There is currently no standard for selecting landmarks and semilandmarks from teeth, so a combination of previously used landmarks (Gòmez-Robles and Polly 2012) was chosen (figure 13).
 - The landmarks (LM1-5) fall between type I and type II as although they are points of extreme curvature (type II), the restriction of samples to teeth with no wear made the point unambiguous (type I). Landmarks were placed on each cusp tip, beginning from cusp one and always moving in the same order.

- Semilandmarks were placed along the tooth outline, beginning from the mesial aspect where cusp one and two meet and moving in the same direction.
- Photos were digitised using R package Stereomorph. Each photo was scaled and marked manually. Three ruler points were established from the scale, 1 mm apart. The measurement is slightly arbitrary as the current analysis did not attempt to re-introduce size information back into the analysis later. Nevertheless, the scale was always placed as accurately as possible.

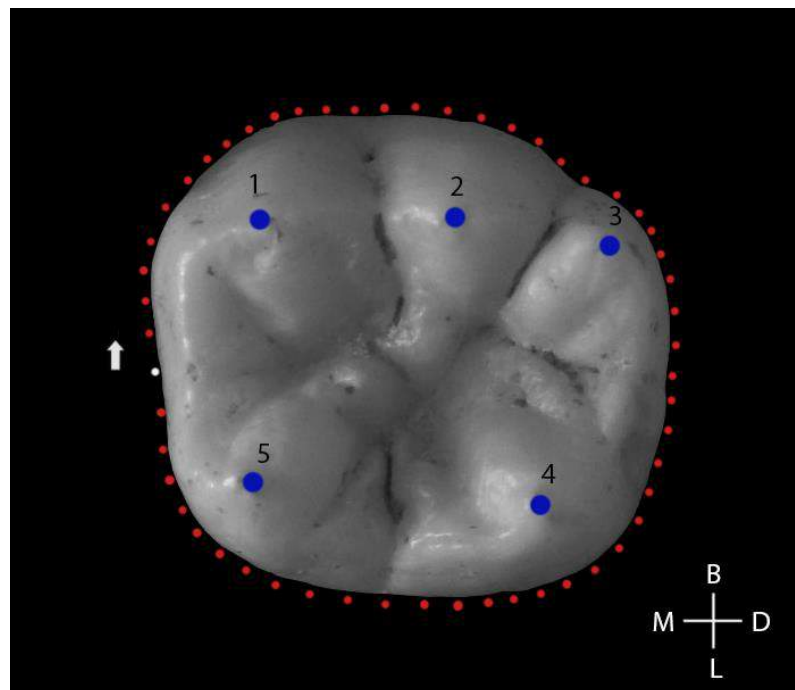


Figure 13. Landmarks (blue) and semilandmarks (red) on first lower molar. Numbers indicate placement order of landmarks, the arrow the direction in which semilandmarks were placed.

- Data was treated and analysed in R package geomorph.
 - Function `gpagen()` performed a generalised Procrustes analysis on the landmarks and semilandmarks. The latter must be specified using “`curves=`” option.
 - Function `plotAllSpecimens()` was used to plot the coordinate shape of all specimens with their mean shape.

- Function `plotTangentSpace()` PCA of shape variation and plots PC1 and PC2 in tangent space. Outliers were analysed with function `plotOutliers()`, specifying sites.
- Function `plotReftoTarget()` was used to visualise shape differences, specifying `method="vector"` generates arrows into the plot visualising direction of change.
- ANOVA and a disparity test were conducted using functions `advanced.procD.lm()` and `morphol.disparity()`, respectively, with 1000 iterations.

6. Results

Results have been organised from micro to macro, beginning with the intra-cemetery analysis in Tell el-Dab'a and progressing to inter-site analyses. The confidence level is maintained at 95% throughout the study, meaning values <0.05 were considered significant. Sex and maturity have only been regarded in the intra-site analysis of Tell el-Dab'a due to the limitations on sample sizes and the commingled nature of the some of the main comparative sites.

The following sections offer frequency tables (either in text or in the appendices) and the raw data used for the intra-site analysis of Tell el-Dab'a, but some raw data has not been included. Some of the data received from colleagues is currently unpublished, and so was omitted. Any data, not included in the work, can be requested from the author.

6.1 Tell el-Dab'a dental nonmetrics

Table 14 exhibits trait frequencies in Tell el-Dab'a, divided by sex (indeterminate, male and female) and by period. The 14th dynasty was likely partially contemporary to the Middle Kingdom 13th dynasty. Very few traits exhibit stronger expressions. The subsamples do not support meaningful statistical analyses of the trait frequencies by dynasties or males and females, but some descriptive comments can be made.

The differences between dynasties 13-14 and 15 are small (under 0.76 apart from Tomes root which increased in expression from 13/14th to the 15th dynasty). The absolute difference between 13-14th dynasty and the 15th dynasty was 0.28 with a standard deviation of 0.3. The overall differences between males and females are similar with an absolute mean difference of 0.28 and SD 0.37. Again, the absolute mean difference in trait expression is fairly low (mean absolute difference of 0-0.67) with four traits showing slightly stronger differences. Males have a larger upper first molar cusp 5, palatine torus and lower second molar cusp 5, whereas females have a larger upper first molar Carabelli cusp.

Abbreviations in table 14 correspond with the following traits: W=Winging, LC=labial convexity, PT=palatine torus, S=shoveling, DS=double-shoveling, IG=interruption groove, TD=tuberculum dentale, MAR=mesial accessory ridge, DAR=distal accessory ridge, M=metacone size, H=hypocone size, BH=bifurcated hypocone, C5UM=upper molar cusp 5, MRT=marginal ridge tubercles, CC=Carabelli's cusp, PUM3=parastyle, EE=enamel extension, RUP1=upper premolar root number, I2V=reduced or peg-shaped upper second incisor, M3V= reduced or peg-shaped third molar, O=odontome, MID=midline diastema, CLP=premolar cusp number, AF=anterior fovea, MT=mandibular torus, GP=groove pattern, RJ=rocker jaw, C5LM2= lower molar cusp 5, DW=deflecting wrinkle, MDTC=mesial and distal trigonid crest, PLM1=protostylid, C6=Cusp 6, C7=Cusp 7, TR=Tome's root, RC=lower canine root number, RLM1=lower first molar root number, RLM2= lower second molar root number, TA=torsomolar angle.

Table 14. Frequencies of Tell el-Dab'a dental traits by sex and period. Frequencies are given in decimals, not percentage points. Not all individuals could be assigned to a specific dynasty.

Trait		indeterminate	male	female	total	13-14 th Dyn	15 th Dyn
W	n		1	3	4	4	
	%		0.00	0.00	0.00	0.00	
LC	n	10	7	10	27	25	2
	%	0.00	0.43	0.40	0.28	0.28	0.00
PT	n		1	3	4	4	
	%		0.00	0.00	0.00	0.00	
S	n	10	4	6	20	16	4
	%	0.60	0.50	0.33	0.52	0.44	0.75
DS	n	12	4	9	25	22	3
	%	0.00	0.00	0.00	0.00	0.00	0.00
IG	n	8	3	8	19	17	2
	%	0.25	0.00	0.63	0.37	0.29	1.00
TD	n	10	2	7	19	17	2
	%	0.40	0.50	0.29	0.37	0.41	1.00
MAR	n	11	3	6	20	8	10
	%	0.18	0.33	0.17	0.20	0.25	0.2
DAR	n	12	1	3	16	6	8
	%	0.58	1.00	1.00	0.69	0.67	0.63
PAR	n	8	3	5	16	5	10
	%	0.75	0.67	0.60	0.69	0.60	0.7
AC	n	13	3	6	22	10	10
	%	0.39	0.33	0	0.27	0.40	0.20
M	n	6	11	17	34	16	16
	%	1	0.82	0.82	0.85	0.94	0.75
H	n	14	11	17	42	20	21
	%	0.86	0.73	0.88	0.83	0.85	0.81
BH	n	10	5	13	28	15	12
	%	0.20	0.00	0.08	0.11	0.13	0.08
C5UM	n	21	1	1	23	9	11
	%	0.43	1.00	1.00	0.48	0.44	0.55
MRT	n	20		1	21	8	10
	%	0.85		1.00	0.86	1.00	0.70
CC	n	20	5	11	36	18	14
	%	0.85	1.00	1.00	0.92	1.00	0.86
PUM3	n	4	8	10	22	9	12
	%	0	0.13	0.00	0.05	0.00	0.08
EE	n	9	6	9	24	10	12
	%	0.11	0.50	0.33	0.29	0.40	0.17
RUP1	n	5	3	4	12	4	7
	%	0.8	0.33	0.75	0.67	0.50	0.71
RUM2	n	1	5	5	11	6	5
	%	1	0.80	1.00	0.91	1.00	0.80

Table 13 cont'd. Frequencies of Tell el-Dab'a dental traits by sex and period. Frequencies are given in decimals, not percentage points. Not all individuals could be assigned to a specific dynasty.

Trait		indeterminate	male	female	total	13-14th Dyn	15th Dyn
I2V	n	10	5	11	26	13	12
	%	0.00	0.20	0.00	0.04	0.00	0.08
M3V	n	14	12	18	44	24	17
	%	0.14	0.08	0.06	0.09	0.08	0.12
O	n	19	5	12	36	16	17
	%	0.00	0.00	0.00	0.00	0.00	0.00
MID	n	1	1		2	1	1
	%	0.00	0.00		0.00	0.00	0.00
CLP	n	11	8	10	29	13	14
	%	0.91	0.88	1.00	0.93	1.00	0.86
AF	n	14	3	7	24	12	10
	%	0.64	1.00	1.00	0.79	0.75	0.90
MT	n	3	3	13	19	13	4
	%	0.00	0.00	0	0	0.00	0.00
GP	n	17	9	21	47	20	24
	%	0.24	0.33	0.38	0.32	0.35	0.25
RJ	n	4	3	12	19	13	4
	%	0.00	0.00	0.083	0.05	0.08	0.00
C5LM2	n	12	3	6	21	8	12
	%	0.25	0.67	0.33	0.33	0.5	0.25
DW	n	16		3	19	7	10
	%	0.63		1.00	0.68	0.86	0.60
MDTC	n	18	3	5	26	11	12
	%	0.056	0.33	0.00	0.08	0.09	0.08
PLM1	n	14	3	7	24	12	10
	%	0.64	0.67	0.57	0.63	0.83	0.40
C6	n	18	2		20	8	10
	%	0.11	0.00		0.1	0.13	0.10
C7	n	21	4	4	29	14	13
	%	0.14	0.00	0.00	0.10	0.14	0.08
TR	n	2		3	5	3	2
	%	0.50		0.00	0.20	0.00	0.50
RC	n	2	2	4	8	4	4
	%	0.00	0.00	0.00	0.00	0.00	0.00
RLM1	n	7	4	4	15	7	7
	%	0.00	0.00	0.00	0.00	0.00	0.00
RLM2	n	4	5	6	15	5	9
	%	1.00	0.80	1.00	0.93	1.00	0.89
TA	n	3	4	11	18	12	3
	%	0.33	0.25	0.27	0.28	0.33	0.33

6.2 Correspondence analysis

Nine sites and 28 traits were submitted in a correspondence analysis to understand the traits with most variation (inertia) in the sample. However, the chi-square test indicated that the rows (sites) and columns (traits) were not related ($\chi^2 = 16.337$, $p = 1.00$, $df = 216$, see table 15). This may be a product of relatively low variation among the sties. Instead, focus was directed to only observing the traits (columns) to establish which traits accounted for most of the variation (inertia) in the dataset. The column scores are the weighted average of the row scores (standardised), maximising the distances between column categories (figure 14).

Table 15. Correspondence analysis summary table.

Dimension	Inertia	Chi Square	Sig.	Proportion of Inertia	
				Accounted for	Cumulative
1	0.056			0.270	0.270
2	0.051			0.248	0.519
3	0.032			0.155	0.674
4	0.025			0.123	0.797
5	0.020			0.095	0.891
6	0.010			0.050	0.941
7	0.009			0.042	0.983
8	0.004			0.017	1.000
Total	0.207	16.337	1.000 ^a	1.000	1.000
a. 216 degrees of freedom					

Traits exhibiting the most inertia are:

- First dimension: Traits shoveling (0.28), deflecting wrinkle (0.15) and distal accessory ridge (0.13) explain most of the variation in the first dimension.
- Second dimension: Traits cusp 6 (0.11) and hypocone (0.11) explain most of the variation in the second dimension.
- Third dimension: Traits protostylid (0.25) and distal accessory ridge (0.1) explain most of the inertia in the third dimension as well.

The first dimension explains 27% of the variation, the second 24.8%, the third 15.5%.

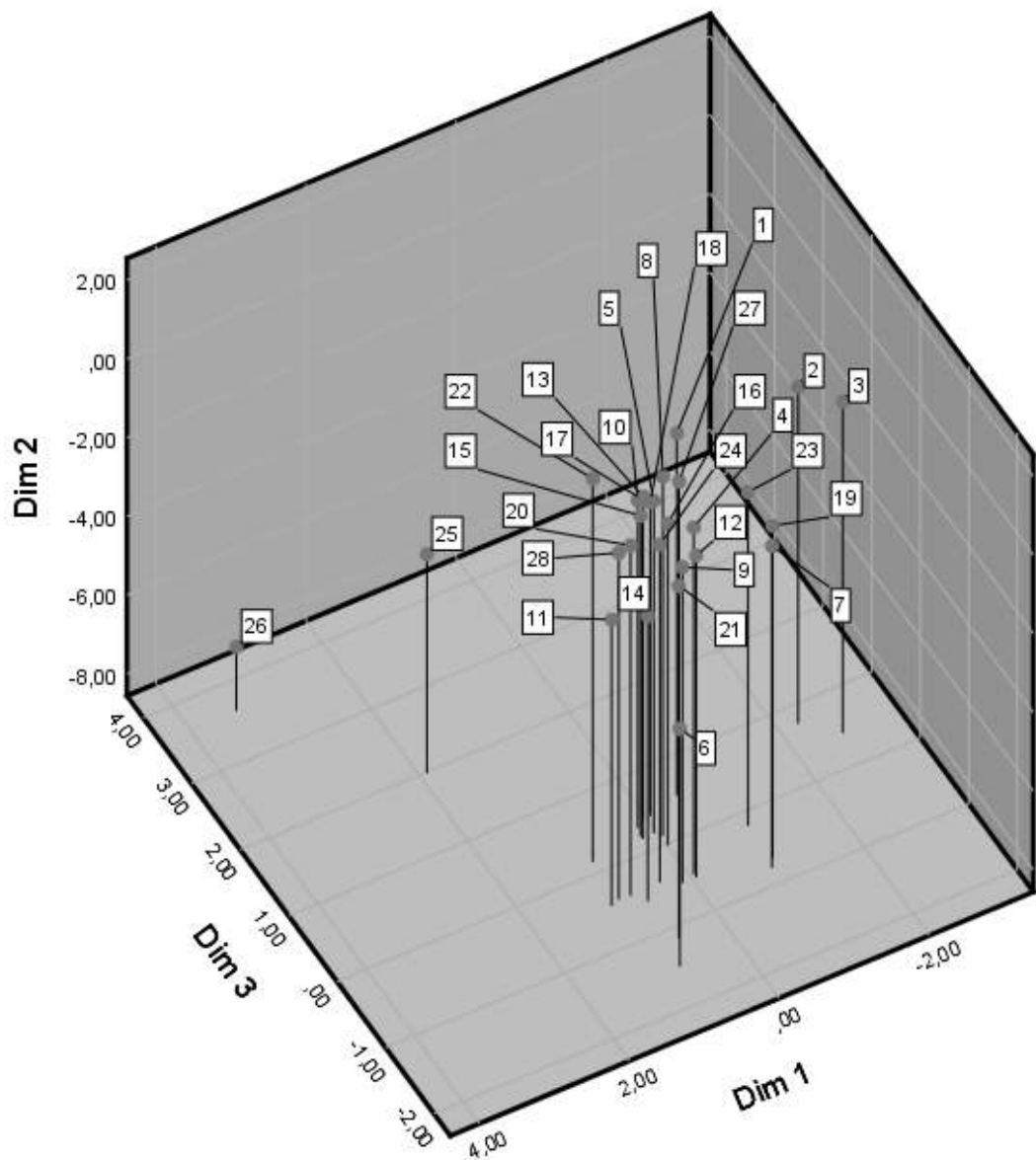


Figure 14. Correspondence analysis column plot based on symmetrical normalisation of 28 dental traits. Clustering exhibits how traits correspond with one another within the dataset. 1=Labial convexity, 2=shoveling, 3=double-shoveling, 4=interruption groove, 5=tuberculum dentale, 6=mesial accessory ridge, 7=distal accessory ridge, 8=hypocone size, 9=upper molar cusp 5, 10=Carabelli's cusp, 11=parastyle, 12=enamel extension, 13=upper premolar root number, 14=reduced or peg-shaped upper second incisor, 15=premolar cusp number, 16=anterior fovea, 17=groove pattern, 18= lower molar cusp 5, 19=deflecting wrinkle, 20=mesial and distal trigonid crest, 21=protostylid, 22=C6, 23=C7, 24=Tome's root, 25=lower canine root number, 26=lower first molar root number, 27= lower second molar root number, 28=torsomolar angle.

The inertia is visualised in figure 14 and the full table for column inertia overview is available in appendix A12. From the traits exhibiting most inertia none were present in dataset 1 and only shoveling and distal accessory ridge were present in dataset 2, while traits present in dataset 3 were shovelling and deflecting wrinkle. This could potentially hide some of the variation between samples, particularly in the dataset 1. What must be noted, however,

is that because CA weighs the cases by frequency (%), it does not take into account small sample sizes, which could potentially hinder the effectiveness of the test. This could be the case with traits such as deflecting wrinkle, ranging widely in the number of observation events between sites (e.g. 2 observations from Tell Fadous-Kfarabida versus 37 observations from Sidon).

6.3 Intra-site analysis

For the intra-observer error test 24 individuals from the Tel el-Dab'a collection was recoded twice, one year apart. The absolute maximum difference between observation events was 1 grade. Agreement between observation events was analysed using Spearman's rho (for non-Gaussian data) which confirmed that scoring was consistent ($r=0.978$, $p<0.001$, $N=216$ observations).

6.3.1 MMD analysis

One of the questions regarded continuity at the site. Archaeologically, no major disruptions have been recorded, though some of the administrative buildings were sealed off around the time of the shift. A simple MMD analysis was conducted on the Tell el-Dab'a material, dividing the sample to the (at least) partially contemporary 13th and 14th dynasties and the 15th (Hyksos) dynasty.

When divided according to period, the number of observations per trait decreased significantly, dropping some under the threshold of ten observations/trait. The frequencies are exhibited in the table 14 above. Fourteen traits remained available for MMD analysis, but when the test was run only lower first molar protostylid (PLM1) had a positive distance value (0.13) whereas all the rest produced an overall negative MD (caused by lack of variation between samples). To observe the values, exclusion strategy was deselected and the test run again with a result of $MMD=0.007$, $2SD=0.116$. The MMD test did not reveal any differences between the earlier 13th and 14th dynasties and the 15th dynasty. The sample sizes for males and females were too small (<10) to attempt an MMD analysis.

6.3.2 Gower distance analysis

The frequency of missing data was decreased by eliminating both rows (individuals) and columns (variables) until the individuals had >60% valid cases. A maximum of 110 traits were possible to record per person. To maximise the sample and variable number, all teeth were included in the missing data pattern analysis. If there were still multiple members of the same cohort, these were then excluded and the inter-trait correlation test was used to eliminate any potentially correlated traits. The final dataset contained only 31 individuals and 27 variables (table 16, appendix A14). Duplicates were omitted (except for the differing groove patterns of LM1 and LM2) and the remaining variables were tested for inter-trait correlation, leading to the selection of 18 traits (table 17).

After traits were chosen, the data was analysed. Some of the traits are binary by nature (present/absent), such as the bifurcated hypocone and groove patterns, however some of the ordinally recordable traits had only expressions of 0 and 1 (such as the UI2 double-shoveling and UM3 parastyle). These traits were treated as binary, as recommended by the cluster package guideline (Maechler et al. 2018).

One modification was made to the trait marking groove pattern. Usually, the y-pattern is scored on the second lower molar (where it is more infrequent), however the opposite x and plus-patterns were exhibited equally infrequently (and randomly) on the first lower molar. As the groove patterns were presented in different members of the cohort and exhibited different random (and non-correlated) events on separate groups of individuals, they were both included in the analysis to increase dimensionality.

Table 16. Tell el-Dab'a individuals used to create the Gower distance matrix. Age: SA=subadult, A=adult. Sex: I=indeterminate, F=female, M=male. Str= excavation stratum, Ph=phase. D=Dynasty, W=weapon burials, TeyI= Tell el-Yahudiyah ware (north Levantine tradition), TeyL= Tell el-Yahudiyah ware (local production), TeyD= Tell el-Yahudiyah ware (Palestinian tradition), C=Cypriot ware.

Individual	A	S	Str	D	W	Tey I	Tey L	Tey D	C
All-k/14 Grave 4	SA	I	F	13-14					
All-k/14 Grave 8	SA	I	E/2	13-14			X		
All-l/11 Grave 1 Burial 2	SA	I	F-G	13-14					
All-l/11 Grave 3 Burial 1	A	F	F	13-14					
All-l/12 Grave 4	A	F	F-G	13-14					
All-l/12 Grave 5 Burial 3	SA	I	F	13-14					
All-l/16 Grave 4 Burial 1	A	M	F	13-14	X				
All-l/17 Grave 5 Burial 1	SA	I	D/3	13-14					X
All-l/17 Grave 5 Burial 3	SA	I	D/3	13-14					X
All-m/10 Grave 7 Burial 2	A	F	E/1	13-14					
All-m/10 Grave 8 Burial 1	A	M	F	13-14	X	X			
All-m/11 Grave 1	SA	I	D/2	15					X
All-m/12 Grave 12/13 Burial 1	A	F	E/2	13-14					
All-m/13 Grave 13 Burial 2	A	F	E/3	13-14		X			
All-m/15 Grave 11	A	F	G	13-14					
All-m/15 Grave 9 Burial 1	A	M	G	13-14	X				
All-m/15 Grave 9 Burial 2	SA	I	G	13-14					
All-m/16 Grave 2 Burial 2	A	F	F	13-14					
All-m/16 Grave 3 Burial 1	A	F	F	13-14				X	
All-m/16 Grave 3 Burial 2	A	F	F	13-14				X	
All-m/16 Grave 3 Burial 3	A	F	F	13-14				X	
All-m/17 Grave 1	SA	I	D/2	15					
All-m/17 Grave 3 Burial 10	SA	I	D/2	15			X		
All-m/17 Grave 3 Burial 14	A	F	D/2	15			X		
All-m/17 Grave 3 Burial 6	A	F	D/2	15			X		
All-m/17 Grave 3 Burial 7	A	M	D/2	15			X		
All-m/17 Grave 5	A	M	E/1	13-14					
All-n/13 Grave 8 Burial 2	A	F	D/3	13-14		X			
All-n/15 Grave 1 Burial 2	A	M	D/3	13-14	X				
All-n/19 Grave 4 Burial 3	SA	I	F-E/3	13-14		X			
All-o/21 Grave 3	A	F	F-E/3	13-14					

Table 17. Traits selected for kinship analysis. Column 'type' indicates how data was treated in the statistical analysis.

Trait	Type
Shoveling UI2	ordinal
Double-shoveling UI2	binary
Bushman canine UC	ordinal
Distal accessory ridge LC	ordinal
Accessory ridges UP1	ordinal
Metacone UM3	ordinal
Hypocone UM3	ordinal
Bifurcated hypocone UM2	binary
Cusp 5 UM2	ordinal
Carabelli cusp UM1	ordinal
Parastyle UM3	binary
Reduced or absent UM3	ordinal
Lingual cusp number LP2	ordinal
Anterior fovea LM2	ordinal
Groove pattern x LM1	binary
Groove pattern y LM2	binary
5-cusped LM3	ordinal

6.3.2.1 Group analysis from distance matrix

The Gower distance matrix was analysed for homogeneity of multivariate dispersions using the `betadisper()` function in R package `vegan`, grouped by eras (pre-Hyksos and Hyksos), phases (1-4) identified by Forstner-Müller (2010) and sexes (males vs females). PERMANOVA test revealed no significant differences between eras, phases or sexes (table 18), whereas PERMDISP showed all to be significantly different (table 19). This means that while the spread of groups was different, the direction was not (exhibited with PCoA plots in figures 15-16 and boxplots in figures 17-18). Comparison of males (n=6), females (n=14) and indeterminate subadults (n=11) showed significant differences between males and females and males and indeterminate subadults (table 20). Females and indeterminate subadults were not significantly different in spread.

Table 18. PERMANOVA test results comparing eras (1), phases (2), sexes (3) and sex and era together (4). Df=degrees of freedom, SS=sum of squared distances, MS= mean of squared distances, Per= number of permutations.

		Df	SS	R²	F	p
1	Era	1	-0.028	-0.018	-0.505	0.922
	Residual	29	1.635	1.018		
	Total	30	1.607	1.000		
2	Phase	5	0.203	0.126	0.721	0.708
	Residual	25	1.404	0.874		
	Total	30	1.607	1.000		
3	Sex	2	0.147	0.091	1.405	0.333
	Residual	28	1.460	0.909		
	Total	30	1.607	1.000		
4	Era*sex	2	0.231	0.144	2.247	0.090
	Residual	25	1.287	0.801		
	Total	30	1.607	1.000		

Table 19. PERMDISP test results comparing eras (1), phases (2) and sexes (3). Df=degrees of freedom, SS=sum of squared distances, MS= mean of squared distances, Per= number of permutations. Significant values bolded.

		Df	SS	MS	F	Per	p
1	Groups	1	0.010	0.010	5.403	999	0.023
	Residuals	29	0.053	0.002			
2	Groups	5	0.120	0.024	11.071	999	0.001
	Residuals	25	0.054	0.002			
3	Groups	2	0.008	0.004	4.167	999	0.030
	Residuals	28	0.027	0.001			

Table 20. Pairwise permutation test of centroid distances by sex. All indeterminates were subadults. Observed p-value below diagonal, permuted p-value above diagonal.

	Male	Female	Indeterminate
Male		0.017	0.015
Female	0.018		0.928
Indeterminate	0.013	0.935	

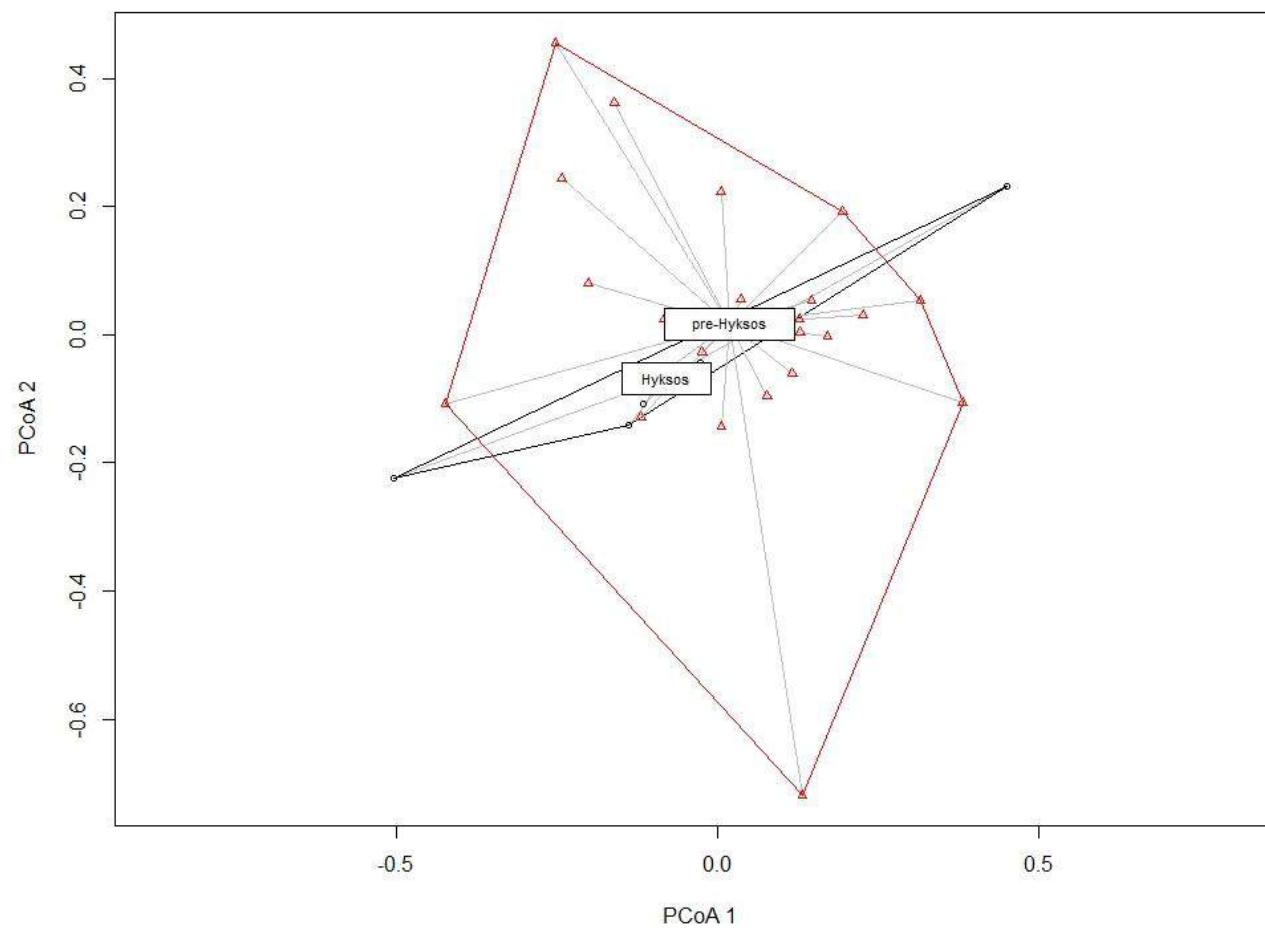


Figure 15. PCoA plot of PERMDISP test values according to period (pre-Hyksos=13-14th Dynasty, Hyksos=15th Dynasty). The distribution exhibits the change in spread but not direction which could be due to low sample sizes.

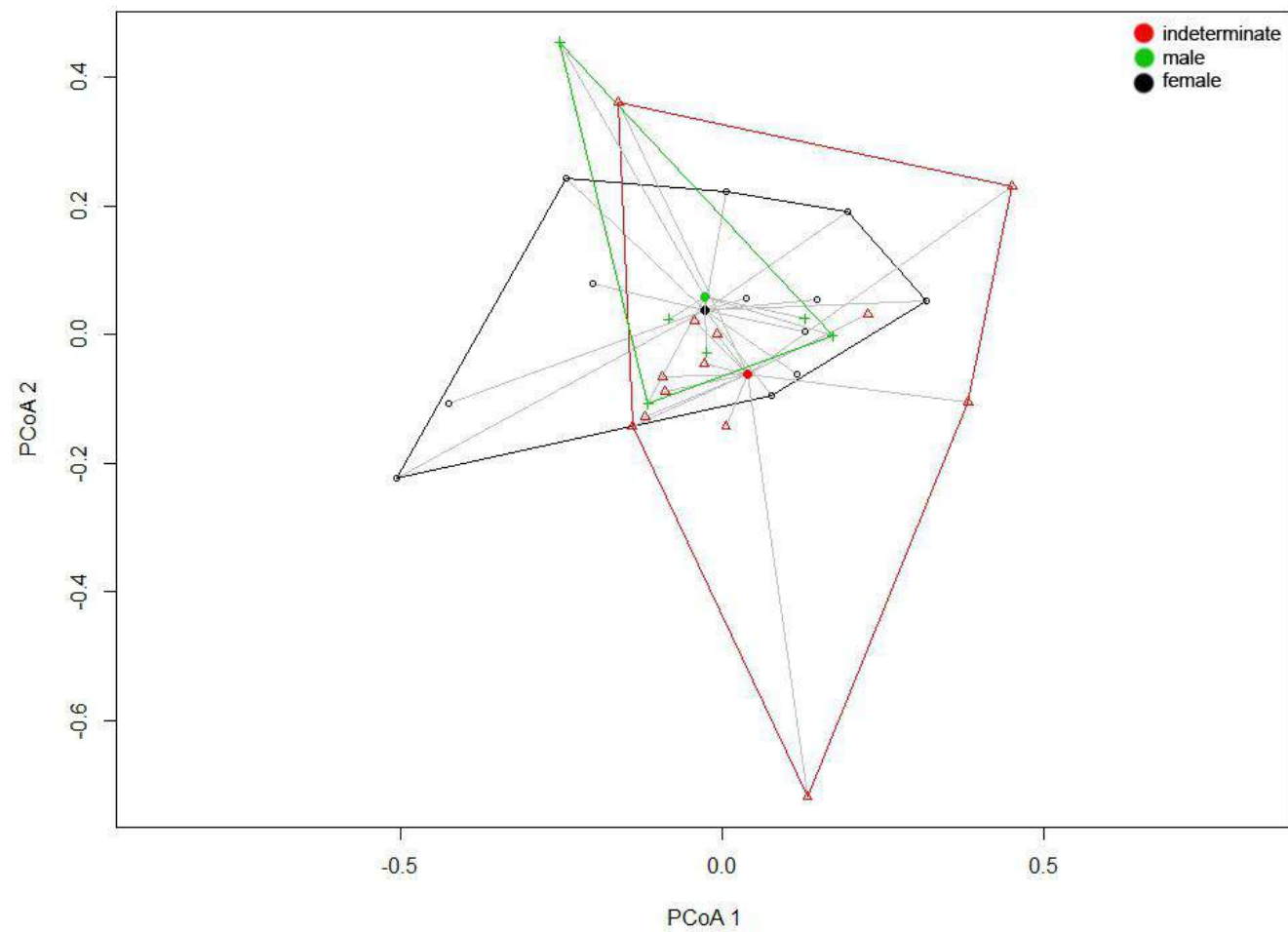


Figure 16. PCoA plot by sex. Both spread and direction are very similar, suggesting little difference between sexes.

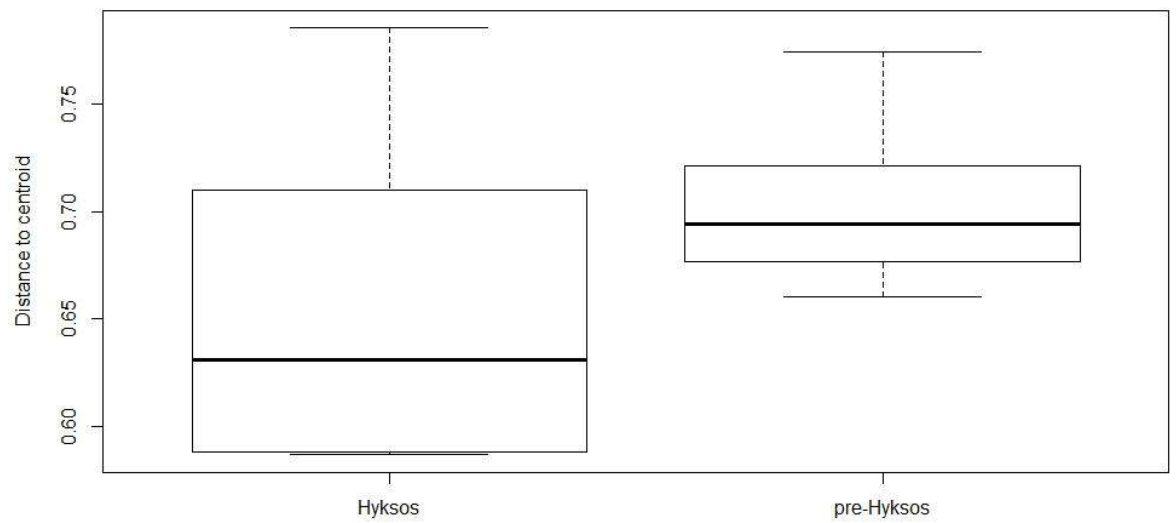


Figure 17. Boxplot of distances to group centroids by periods (pre-Hyksos=13-14th Dynasty, Hyksos=15th Dynasty).

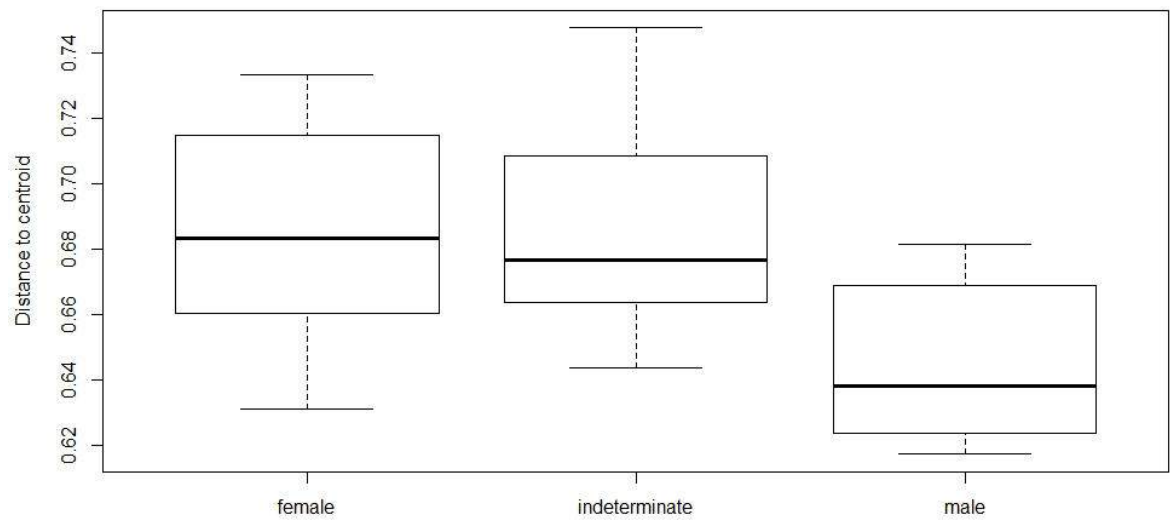


Figure 18. Boxplot of distances to group centroids by sex. All indeterminate individuals were subadults (3-16-year-olds).

6.3.2.2 Cluster analysis from distance matrix

The Silhouette method indicated that the best division of clusters was 2 and 6 (figure 19). According to Kaufman and Rousseeuw (1990), the second partitioning (SG1-6) does not generate any substantial partitioning (Silhouette Width < 0.25). Considering the nature of the sample, both groupings were retained for further analysis. Not only are the individuals all the same species, they were temporally and spatially similar as well. Any changes in dental nonmetrics would be minute. The former were referred to as groups 1 and 2 (G1 and G2) and the latter as subgroups 1-6 (SG1-6) to avoid confusion. Aside from SG3, these subgroups fall completely under either G1 or G2 (figure 20). Table 21 exhibits the grouping data together with contextual information, and figure 21 exhibits the subgroupings across the burial site.

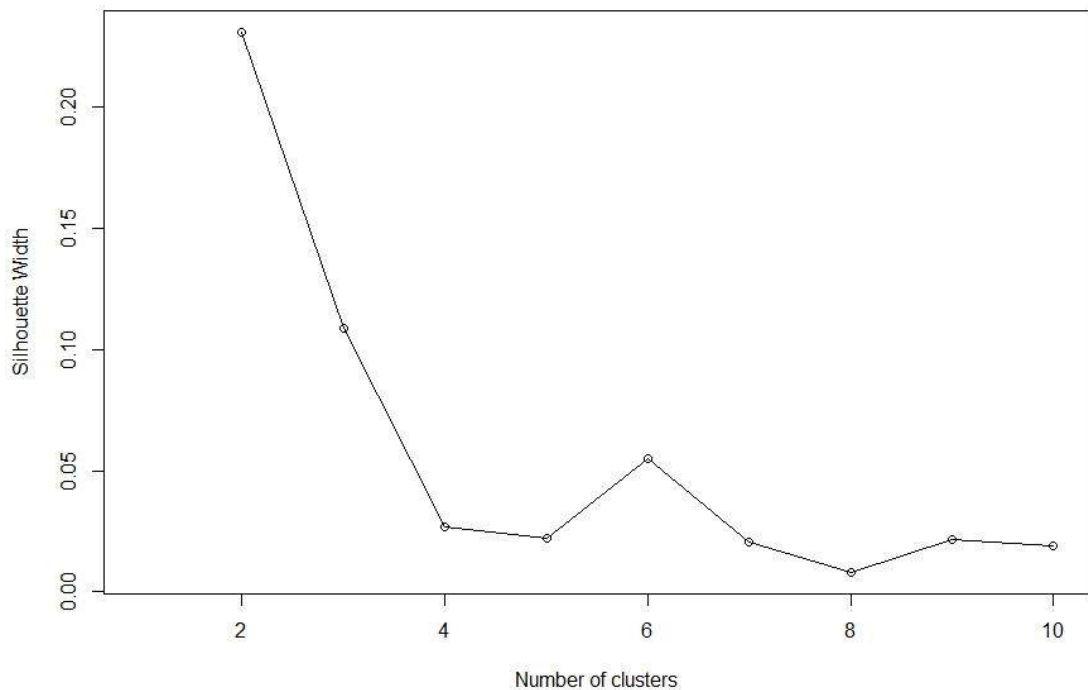


Figure 19. Graph exhibiting the optimal number of groups (clusters) according to Tell el-Dab'a dental traits. Coefficient (SC) values on the y-axis.

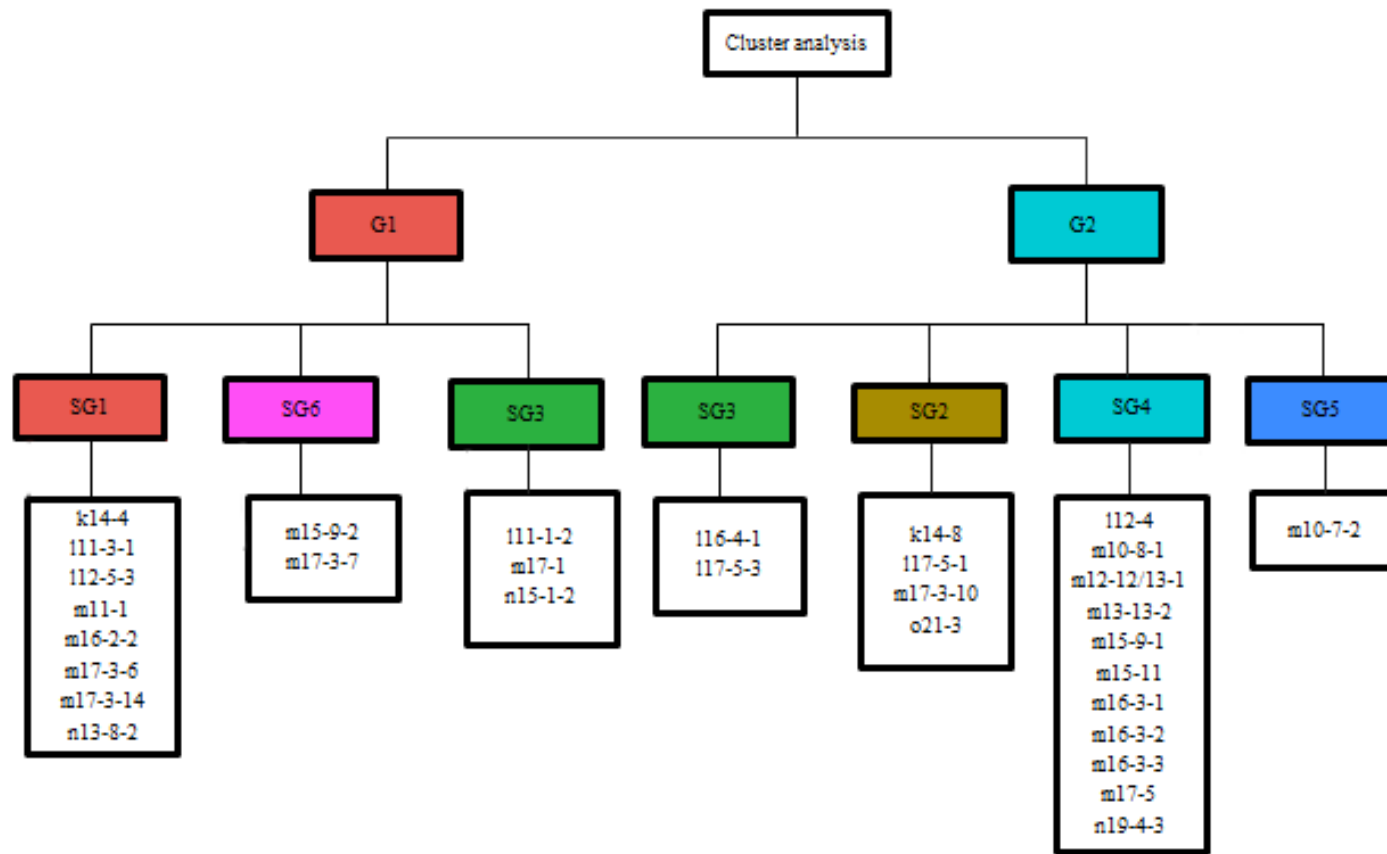


Figure 20. Individuals by morphological clusters. Best division was between two groups (G1-2), the second-best between six (SG1-6). SG1 and SG6 fell completely under the larger grouping G1, while SG2, SG4 and SG5 fell within G2. Individuals from SG3 were divided between the two.

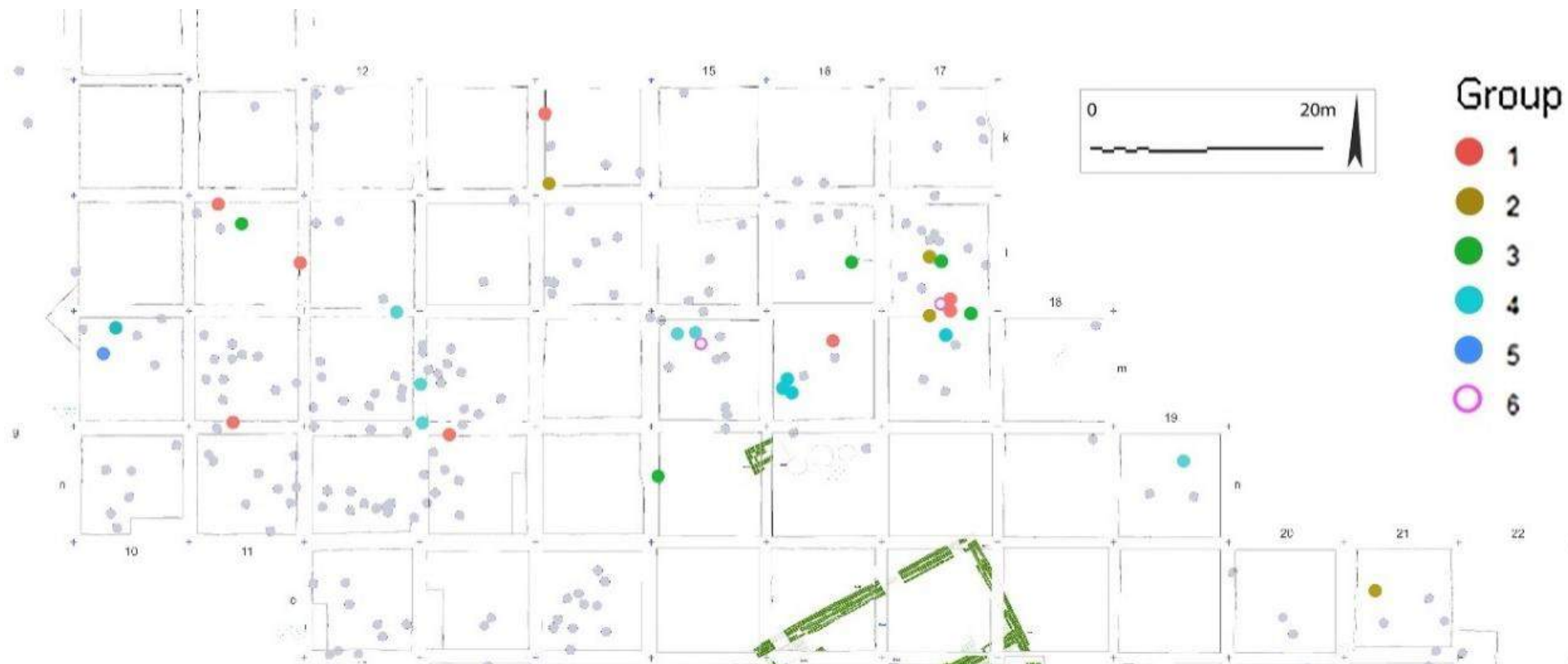


Figure 21. Burial locations of individuals ($n=31$) according to subgroups (all time periods). Grey points are burials not available for analysis. The three clustering individuals in m/16 are the three females from m/16-grave 3.

Table 21. Main contextual information according to groups (G) and subgroups (SG). TeY branch D= Tell el-Yahudiyah ware (Palestinian line), TeY branch I= Tell el-Yahudiyah (Northern Levantine line), TeY branch L= Tell el-Yahudiyah ware (local line), Cypriot= imported Cypriot ware.

		Group		Subgroup					
		1	2	1	2	3	4	5	6
Sex	Males (n/total)	2/13	4/18	0/8	0/4	2/5	3/11	0/1	1/2
	Females (n/total)	5/13	9/18	5/8	1/4	0/5	7/11	1/1	0/2
Stratum	D/2	5	1	3	1	1			1
	D/3	2	2	1	1	2			
	E/1		2				1	1	
	E/2		2		1		1		
	E/3		1	4	1		1		
	E/3-F				1		1		
	F	4	5			1	4		
	F-G					1			
	G	1	2				2		1
	Weapon burial	1	3			2	2		
Pottery	TeY branch D		1				1		
	TeY branch I		1				1		
	TeY branch L		1		1				
	Cypriot	1	1	1	1				

There was no isolation between groups or subgroups, but the groups did not completely overlap either. The Gower distance matrix was analysed using PERMANOVA AND PERMDISP2, the function `adonis2()` and `betadisper()`, respectively. Due to the uneven sample sizes in subgrouping (cluster 1-6), PERMANOVA was not conducted. The test requires a balanced design for small samples to render meaningful results. This could be corrected by bootstrapping the groups, but in the case of subgrouping, the individual cluster size dropped as small to as one individual (cluster 5 in table 21). PERMANOVA was focused on the larger grouping (clusters 1-2).

Observing the descriptive data (table 21) alone suggests the groups or subgroups do not focus on certain eras, phases or sequential strata. The lack of individuals at certain strata is likely artificial, caused by the small sample

size. As a result, seeking correlation between biological groups and time was hindered. Morphological data showed some correlation between subgroup (SG1-6) and sex. Only males were recorded from subgroups three and six and only females from subgroups one, two and five. Subgroup four exhibited a combination of males and females. However, all subgroups (except SG5 with only one individual) had both adults and unsexed subadults.

A PERMANOVA test was conducted by constricting the permutations by grouping (cluster 1-2) so randomisations occurred only within groups and not across both groups. The spread and direction of clusters did not differ significantly by eras, phases or sex or in the interaction of factors (table 22).

BERMDISP analysis only allows for pairwise analysis (grouping with one variable). A permutational group-wise comparison was conducted on both groupings and subgroupings. The groups G1-2 did not differ significantly in their dispersion ($F(1,29)=0.0651$, $p=0.79$) but the subgroupings did show significant differences ($F(5,25)=86.455$, $p=0.001$). A pairwise comparison suggests that all groups aside from SG1 versus SG4 and SG2 versus SG3 were significantly different in their spread (table 23). However, though the p-values were permutational (999 permutations), the small sample sizes particularly in SG3 and SG5-6 may cause false positives.

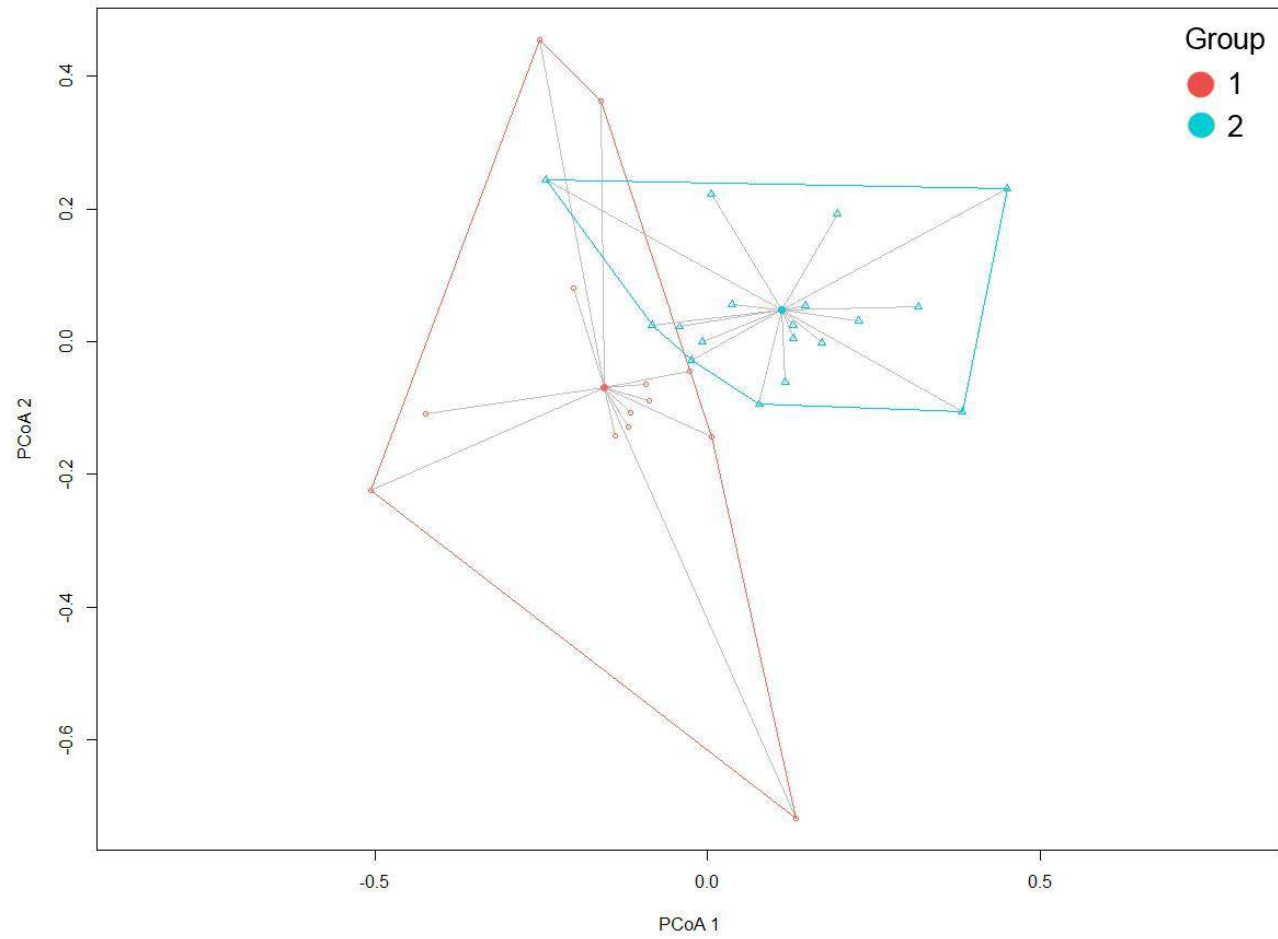
The differences in group and subgroup spread were visualised by plotting the centroid distances along principal coordinates (figures 22 and 23). Subgroup four, though largest of the subgroups, still had relatively little variation within the dispersion of the individuals (figure 24 and 25). However, the PCoA axes explain only circa 17% of the variation in the dataset, making the two-dimensional groups appear much more separate than they are. Another dimension-reduction technique, t-SNE, was employed to visualise the distance matrix (figures 26 and 27). T-SNE plots do not exhibit as clear separations between groups as PCoA which, considering the low variation percentage caught by the PCoA, could be a truer representation of the multidimensional data.

Table 22. PERMANOVA test on era, phase and sex and their interaction (era*sex, phase*sex) according to grouping (cluster 1-2).

	Df	SS	R2	F	p
Era	1	-0.028	-0.018	-0.553	0.913
Sex	2	0.116	0.072	1.128	0.448
Era~sex	2	0.231	0.144	2.247	0.081
Residual	25	1.287	0.801		
Total	30	1.607	1.000		
Phase	5	0.203	0.126	0.649	0.713
Sex	2	0.096	0.060	0.770	0.567
Phase~sex	8	0.372	0.231	0.744	0.717
Residual	15	0.936	0.583		
Total	30	1.607	1.000		

Table 23. Permutational pairwise comparison of subgroup multivariate dispersions. Subgroup 5 was not estimated as it only has one individual (A/II-m/10 Grave 7 burial 2).

Comparison	p
1-2	0.028
1-3	0.036
1-4	0.952
1-6	0.005
2-3	0.431
2-4	0.001
2-6	0.005
3-4	0.001
3-6	0.001
4-6	0.001



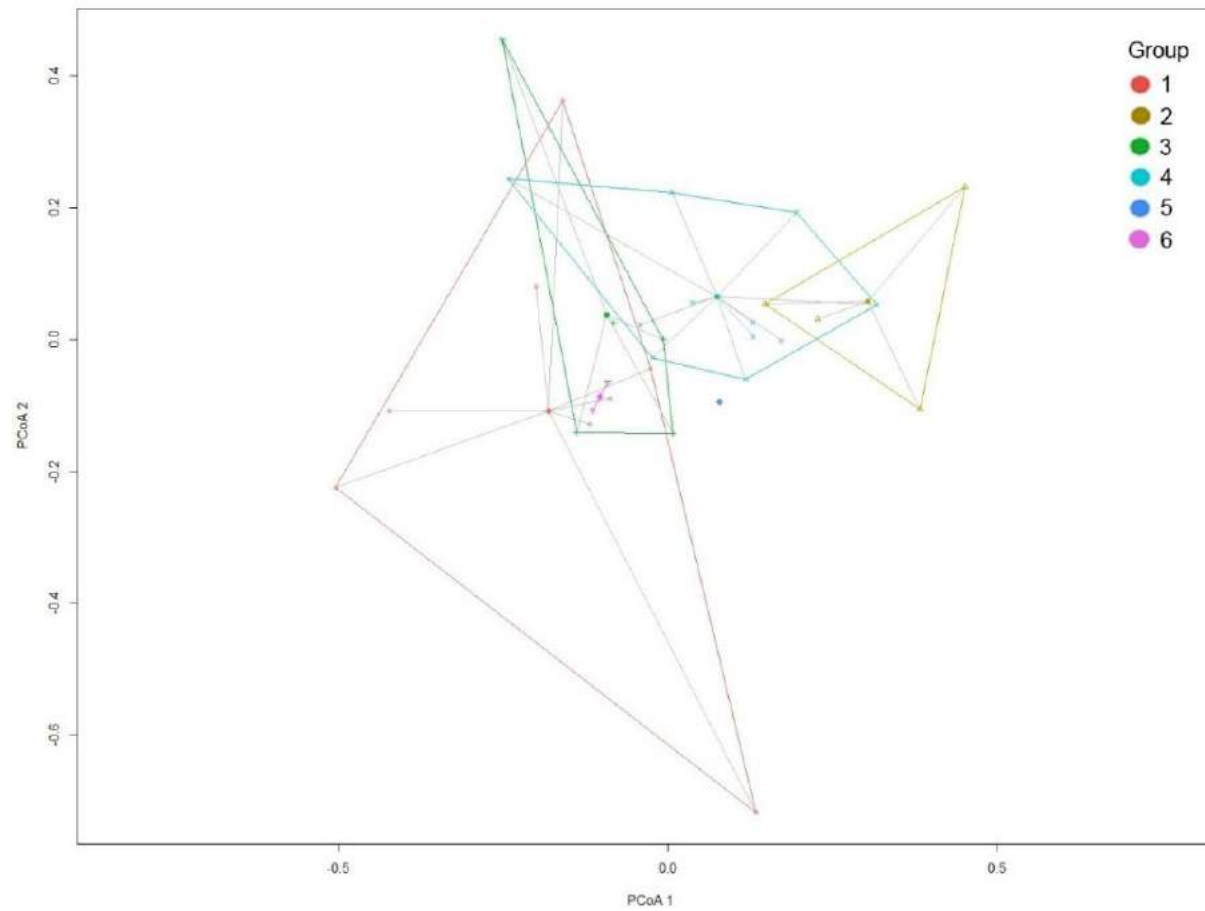


Figure 23. PCoA plot of 6 clusters visualising spread. Individuals in groups 1,2 and 5 are all females. Individuals in groups 3 and 6 are all males. Group 4 is a mixture of males and females.

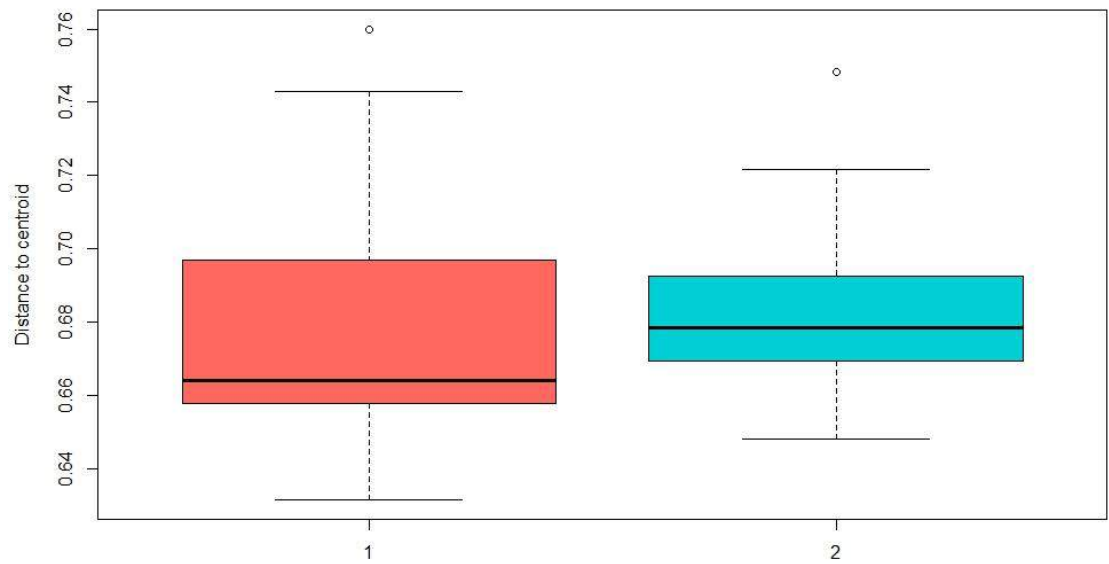


Figure 24. Boxplot of group (G1-2) centroid distances. G1 outlier is A/II-k/14 Grave 4, G2 outlier is A/II-m/15 Grave 9 burial 1.

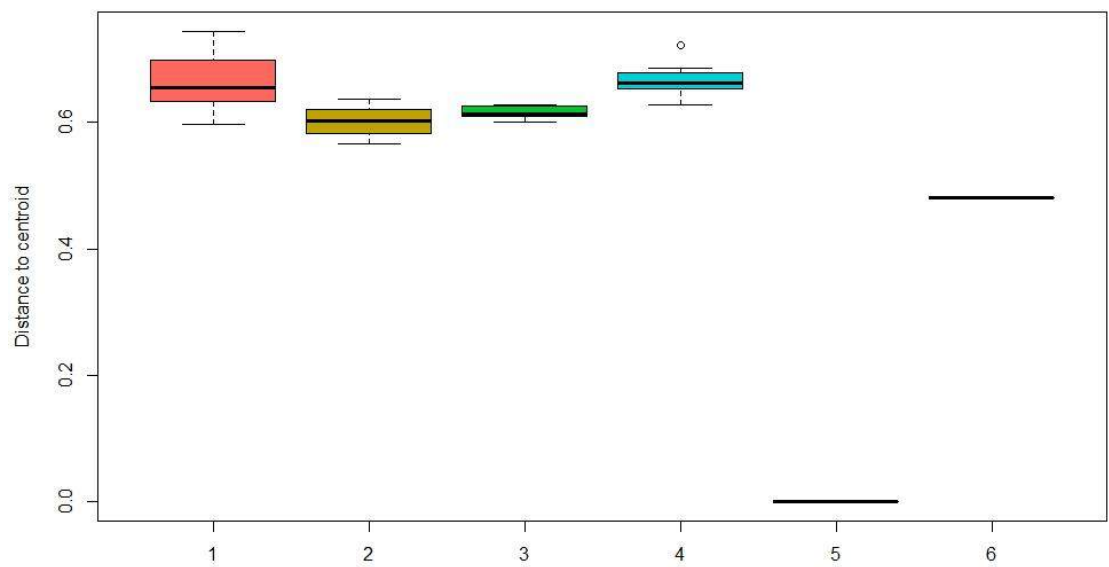


Figure 25. Boxplot of group (SG1-6) centroid distances. SG4 outlier is A/II-m/15 Grave 9 burial 1. SG5 has two individuals, SG6 has only one.

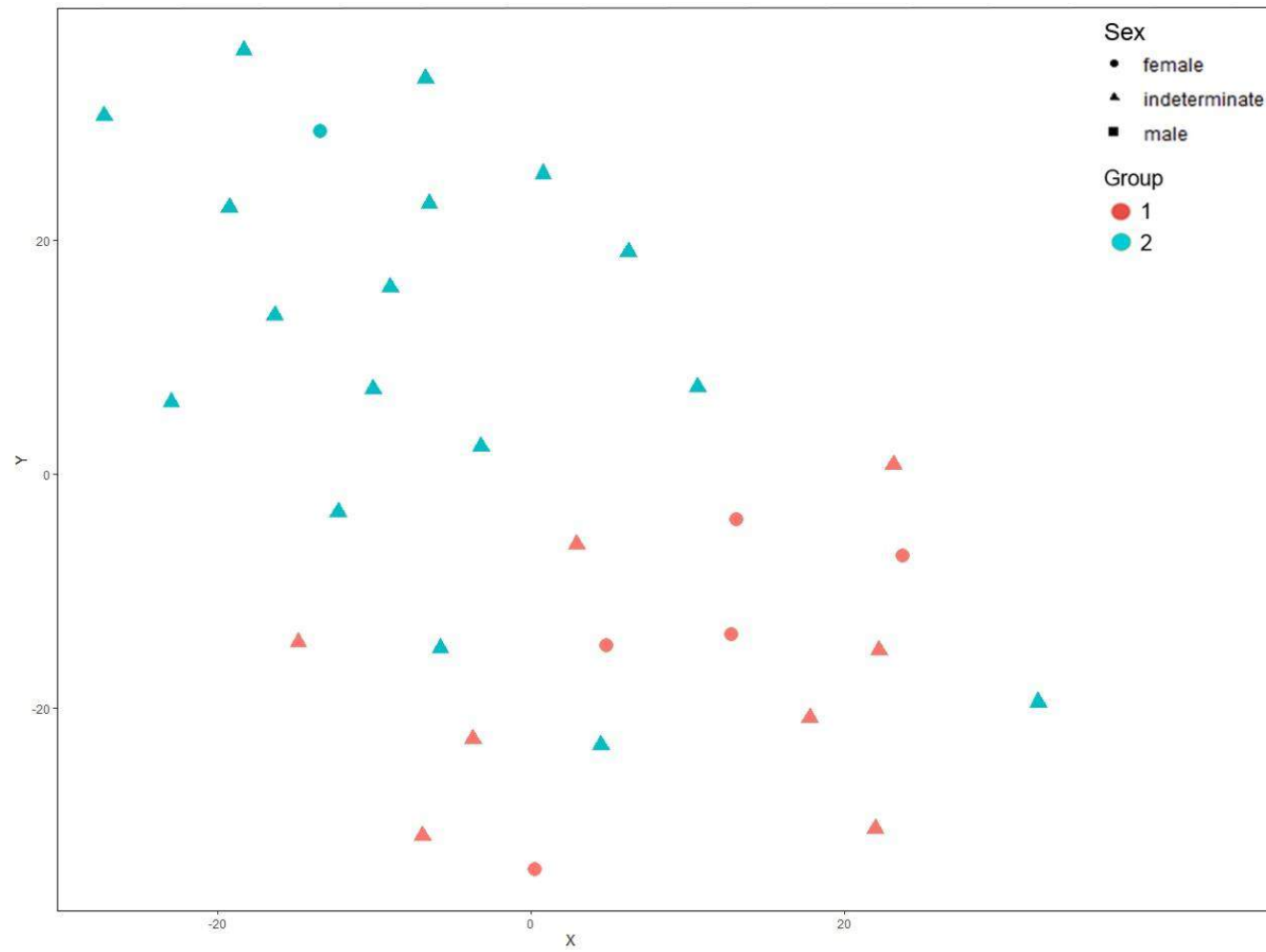


Figure 26. T-SNE plot of G1-2 according to sex.

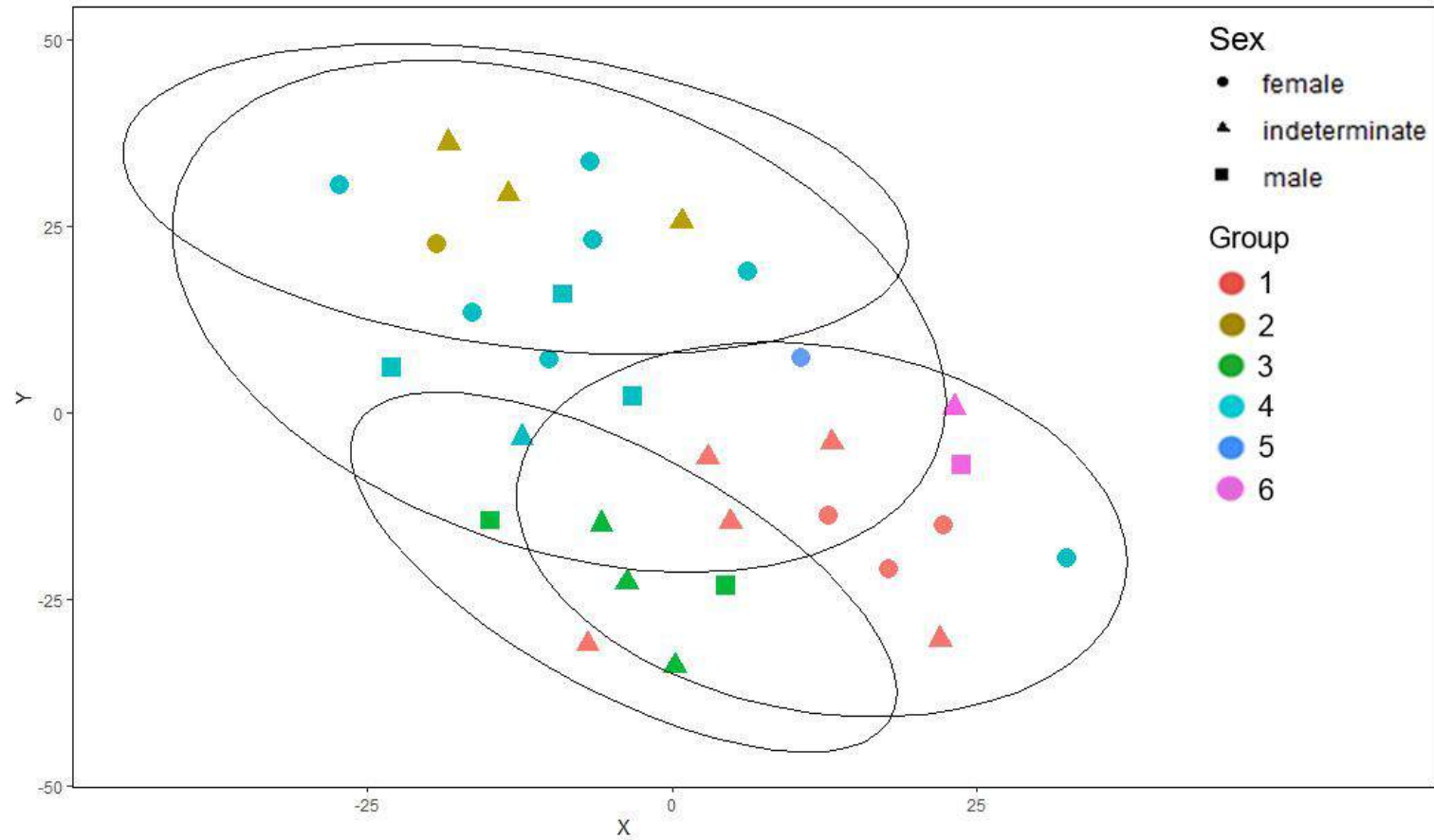


Figure 27. T-SNE plot of SG1-6 according to sex. Ellipses define subgroups with a 95% confidence level, SG5-6 could not be drawn due to low observation count.

6.3.2.3 Comparing spatial and contextual information

Mortuary data available from area A/II was utilised together with biological data. Spatial and contextual data also enabled an analysis with a larger sample size (n=367) which was collected from the sources presented in the chapter 4. The comparative clusters were generated by dividing the dataset into three different contexts (table 24).

Burial locations were mapped into an arbitrary coordinate system (defined by author) in QGIS, generating unique coordinate points for every grave in context 1. The available maps did not always include locations of individual burials. In order to incorporate individual information (such as age, sex or grave goods) for context 2, coordinate points were placed randomly within the grave structure to represent individuals. As mentioned, the coordinates were not tied to any actual projections but merely provide the relative distance between burials. Spatial data was dropped completely for context 3.

Table 24. Contextual, spatial and osteological data used in cluster analysis.

Context 1

y- and x coordinates, stratum

Context 2

y- and x coordinates, stratum, burial position, body position, skull facing, associated equid burials, warrior burials, associated servant burials, servants, jewellery (beads), rings, earrings, pins, other precious metal jewelley and artefacts, Tell el-Yahudiyah ware (Levantine origin), Tell el-Yahudiyah ware (Palestinian origin), Tell el-Yahudiyah ware (handmade globular), Tell el-Yahudiyah ware (hybrids), Cypriot ware, Cypriot ware (imitation), age, sex

Context 3

burial position, body position, skull facing, associated equid burials, warrior burials, associated servant burials, servants, jewellery (beads), rings, earrings, pins, other precious metal jewelley and artefacts, Tell el-Yahudiyah ware (Levantine origin), Tell el-Yahudiyah ware (Palestinian origin), Tell el-Yahudiyah ware (handmade globular), Tell el-Yahudiyah ware (hybrids), Cypriot ware, Cypriot ware (imitation), age, sex

Spatial analysis, using only continuous variables with no missing data, was analysed using k-means cluster analysis (KCA). KCA aims to divide the observations into groups with the nearest mean, meaning it is designed for continuous data with a Gaussian distribution. It cannot accommodate missing values and values from different origins must be scaled (standardised) prior to analysis. The optimal number of clusters was assessed using NbClust() in R. NbClust package provides 30 indices for determining the number of clusters and proposes to use the best clustering scheme from the different results obtained by varying all combinations of number of clusters, distance measures, and clustering methods. For spatial data (x, y, z), the best number of clusters was three.

The combined contextual and spatial data of context 2 and only contextual data of context 3 were analysed similarly to the nonmetric data in section 6.3.2.2. The best number of clusters for both contexts 2 and 3 was two. However, the SC (Silhouette coefficient) values were 0.15 and -0.1, respectively, indicating no substantial structure for either and potential overall bad cluster assignment for the latter. To visualise the extreme overlap of data, figure 28 exhibits the t-SNE graph of Context 2 with the optimal number of clusters.

Biological groupings G and SG were compared to the Context 1 and 2 groupings using crosstabulation and Fisher's Exact test, designed for small sample sizes (figure 24). Context 3 was omitted for further analysis altogether due to the poor assigning of the data. Spatiotemporal data was not significantly correlated with groups or subgroups, even when divided by sex (tables 25 and 26).

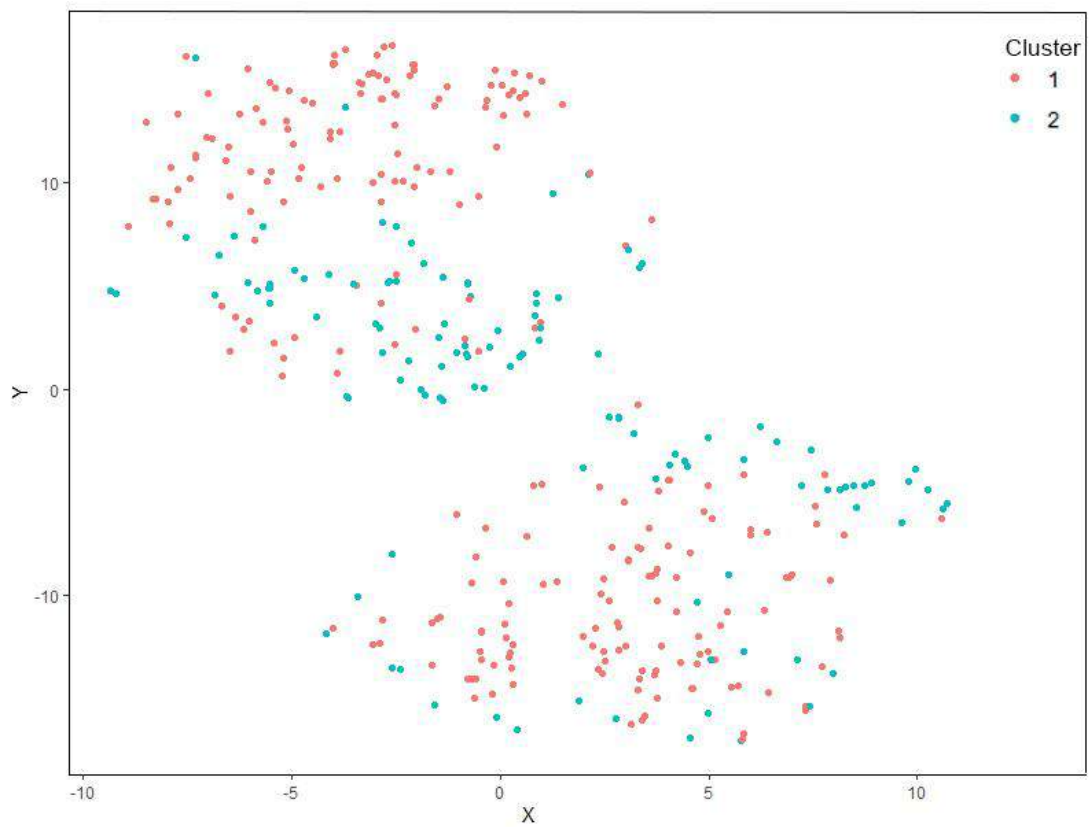


Figure 28. Cluster analysis according to spatial and contextual data did not produce isolated groups.

Table 25. Crosstabulation of contexts and groups and subgroups, divided by sex.

	Sex	N	Fisher's Exact	p (2-sided)	p (1-sided)
Group * Context 1	male	6		0.40	0.20
	female	14	1.29	0.74	
	indeterminate	11	5.19	0.06	
Group * Context 2	male	6		0.47	0.40
	female	14		1.00	0.66
	indeterminate	11		0.24	0.20
Subgroup * Context 1	male	6	1.50	1.00	
	female	14	9.16	0.12	
	indeterminate	11	10.66	0.24	
Subgroup * Context 2	male	6	1.16	1.00	
	female	14	2.09	1.00	
	indeterminate	11	4.81	0.59	

Table 26. Crosstabulation of contexts and sexes, divided by groups and subgroups. Subgroups 5 and 6 did not yield values.

	Grouping	N	Fisher's Exact	p (2-sided)
Context 1*sex	G1	13	2.45	0.48
	G2	18	6.23	0.17
Context 2* sex	G1	13	1.38	0.74
	G2	18	0.52	1.00
Context 1*sex	SG1	8		1.00
	SG2	4		0.25
	SG3	5		1.00
	SG4	11	5.74	0.21
Context 2*sex	SG1	8		0.46
	SG2	4		1.00
	SG3	5		1.00
	SG4	11	1.43	1.00

6.3.3 Intra-site analysis summary

Intra-site analysis did not indicate significant changes between the partially contemporary 13-14th dynasties and the 15th dynasty. This was indicated by the MMD analysis (MMD=0.007, 2SD=0.116) comparing entire groups and the Gower distance analysis comparing a smaller subset of individuals from Area A/II (see tables 18-19 and figure 15).

Comparison of sexes was not possible in the MMD analysis due to small sample numbers (<10 observations/trait). Males (n=6), females (n=14) and individuals of indeterminate sex (n=11) could be compared in the Gower distance analysis, however the sample sizes were still small, suggesting the results are best regarded as tentative. Pairwise permutation test of centroid distances by sex (table 20) did indicate differences between males and females and males and indeterminate subadults. Coupled with the results from the PERMANOVA (table 18) and PERMDISP tests (table 19), this could indicate slight differences between males and females which may be teetering on the line of being significant.

The Gower distance analysis dataset was subjected to further testing by performing a cluster analysis, dividing the smaller subset of individuals into groups defined dental morphology (dental nonmetric traits). The data was

considered in two levels, groups (G) and subgroups (SG) (figure 20). In this instance, the term 'subgroup' does not imply a subordinate relation to 'group', as both divisions have been created independent from one another. The term was utilised to keep track of the divisions in text. The former offered stronger division into two clusters, while the latter represented a weaker division into six clusters (figure 19). Neither groups nor subgroups formed isolated clusters, indicating small differences within the dataset.

The groups or subgroups did not reveal any temporal trends (table 21), following prior results. Subgroups showed some clustering according to sex (table 21), with males in subgroups three (SG3) and six (SG6) and females in one (SG1), two (SG2) and five (SG5). The trend could be caused by small sample sizes. Furthermore, the largest subgroup four had both males and females.

Further comparisons between individuals and contextual information indicated neither morphologically defined groups (table 25) nor sexes (table 25-26) had significant connections to burial location or other burial information. The analysis was conducted solely on the Area A/II and the small subsample (appendix A14).

6.4 Inter-site analysis

6.4.1 MMD

An inter-observer error test was performed with Professor. Joel Irish on a non-related sample ($n = 9$ individuals) to ensure reliability for cross-examiner studies. The test was conducted on dichotomised data. Agreement between examiners was high ($n = 281$ variables, Cohen's kappa = 0.8, $p=0.000$), allowing for further analysis. Disagreement in dichotomised values according to trait took place once or not at all.

Due to its robustness, MMD analysis could utilise the highest amount of data. Dental nonmetric traits were recorded from Egyptian and Near Eastern sites, collected from reliable publications (e.g. Bialon and Sołtysiak, Irish 2006) and received directly from colleagues (table 8 in section 4.1). However, despite relying on frequency tables, the requirements for MMD (large enough sample sizes, exclusion of correlated variables and variable variation among cases) did not allow for all data to be simultaneously employed. Because of this, the dataset was divided into smaller datasets and pooling geographically close sites (assuming positive correlation between biodistance and geographic distance) in order to explore Tell el-Dab'a affinity without drastically decreasing the number of informative variables:

- Dataset 1: el-Lachish,(L), Qurna (Q), Thebes (T), Tell el-Dab'a (TeD), Sidon (S), Jericho and Pella (JP), Euphrates (E=Mari, Ashara, Jebel Mashtale, Tell Masaikh), Khabur basin (KB=Tell Mozan, Tell Arbid, Tell Brak, Barri), Ugarit (U)
- Dataset 2: LBA Southern Levant (AFL=Tell el-'Ajjul, Tell el-Far'ah, Lachish), el-Lisht,(L), Qurna (Q), Thebes (T), Tell el-Dab'a (TeD), Sidon (S), Jericho and Pella (JP), Ugarit
- Dataset 3: Tell el-Dab'a (TeD), Sidon (S), Jericho (J), Pella (P), Ugarit (U)

The Freeman-Tukey (1950) angular transformation was selected as correction methods from the R package AnthroMMD. Furthermore, traits with negative overall MD were omitted from the analysis to avoid biasing the results.

6.4.1.1 Inter-trait correlation

Inter-trait correlation test (Kendall's tau-b) was conducted on the non-dichotomised (raw values) dataset with collected and received data (table 27). All correlation values remained well under $b \Rightarrow 0.5$. All values were retained.

Table 27. Inter-trait correlations.

Trait	Tau-b	sig	N
LC*DS	-0.215	0.005	130
MAR*DAR	0.174	0.030	125
H*BH	-0.154	0.043	143
C5UM*CC	0.185	0.002	186
MRT*CC	0.256	0.000	148
AF*DW	0.286	0.000	127
C6*C7	0.206	0.005	177

Correlations are so low no traits needed to be omitted from the data set. However, sites acquired from other publications mentioned the following significant inter-trait correlations:

- Dicke-Toupin (2012) found correlation among samples for traits: labial convexity, deflecting wrinkle, mesial and distal trigonid crest, protostylid
- Irish (2006) found correlation: labial convexity/shoveling, shoveling /double- shoveling, mesial and distal trigonid crest/anterior fovea, deflecting wrinkle/cusp 6
- Soltysiak and Bialon (2013) reported no strong correlations (>0.5)

6.4.1.2 Dataset 1

Geographically close sites were grouped together to increase observations to a minimum of 10 observations/trait. The samples used in the study were limited temporally as much as possible. Further traits were omitted when the number of observations was under 10 ($n < 10$).

Table 28 exhibits the traits and frequencies used in the MMD analysis. Traits exhibiting most of the variation were upper first premolar root number (27.87), hypocone size (26.95), lower premolar cusp number (20.36), upper second molar root number (16.14), lower first molar protostylid (13.69) and Carabelli's cusp (13.21).

Tell el-Dab'a showed significant difference to most sites ($MMD > 2SD = 2 \times \text{standard deviations}$). The difference between Tell el-Dab'a and Ugarit ($MMD = 0.052$, $2SD = 0.076$) and Tell el-Dab'a and the grouped Pella-Jericho ($MMD = 0.031$, $2SD = 0.062$) fell within the two standard deviation mark, indicating closer biological affinity between sites. Ugarit and Pella-Jericho even showed close affinity to one another ($MMD = 0.000$, $2SD = 0.064$).

Table 28. Trait frequencies for Near Eastern and Egyptian sites. Abbreviations in appendix A5. Frequencies are given in decimals not percentages. L=Lachish, Q=Qurna, T=Thebes, TeD= Thebes, S=Sidon, JP= Jericho and Pella, E= Euphrates (Tell Ashara, Jebel Mashtale, Tell Masaikh, Mari), KB=Khabur basin (Arbid, Barri, Brak, Mozan), U=Ugarit (Ras Shamra, Minet el-Beida, Tell Sukas).

		L	Q	T	TeD	S	JP	E	KB	U
IG	N	34	27	24	19	40	28	39	34	15
	%	0.06	0.04	0.21	0.37	0.45	0.39	0.21	0.44	0.20
MAR	N	41	31	33	20	49	38	32	11	15
	%	0.07	0.00	0.03	0.20	0.00	0.00	0.03	0.27	0.00
H	N	57	46	42	42	57	46	41	42	27
	%	0.04	0.87	0.86	0.83	0.79	0.72	0.54	0.86	0.85
C5UM	N	42	38	28	23	52	34	17	44	11
	%	0.21	0.05	0.14	0.48	0.25	0.29	0.06	0.20	0.36
CC	N	41	34	28	36	71	48	17	45	21
	%	0.73	0.71	1.00	0.92	0.68	0.81	0.35	0.58	0.71
EE	N	64	51	42	24	46	34	27	38	24
	%	0.08	0.10	0.05	0.29	0.07	0.12	0.26	0.18	0.08
RUP1	N	33	34	34	12	35	25	29	30	20
	%	0.00	0.71	0.85	0.67	0.66	0.72	0.28	0.43	0.75
RUM2	N	20	30	32	11	25	24	11	23	21
	%	0.80	0.70	0.81	0.91	0.88	0.88	0.09	0.61	0.81
CLP	N	49	35	37	29	43	34	15	25	24
	%	0.80	0.54	0.70	0.93	0.77	0.82	0.07	0.68	0.88
GP	N	70	50	48	47	49	50	42	15	42
	%	0.34	0.20	0.25	0.32	0.10	0.30	0.26	0.20	0.33
C5LM2	N	54	40	38	21	36	30	17	12	17
	%	0.37	0.23	0.26	0.33	0.25	0.33	0.06	0.17	0.53
PLM1	N	58	32	41	24	48	25	13	52	24
	%	0.03	0.06	0.12	0.63	0.23	0.44	0.54	0.31	0.33
C7	N	67	36	44	29	59	36	42	70	34
	%	0.00	0.06	0.07	0.10	0.07	0.08	0.07	0.01	0.03

Table 29. MMD values (upper triangular) and SD values (lower triangular). Most distances were significantly different. For convenience's sake, significant values were bolded, insignificant values were marked with an asterisk (*). The distance between U and JP generated a negative value and has been corrected to zero. L= Lachish, Q=Qurna, T=Thebes, TeD= Thebes, S=Sidon, JP= Jericho and Pella, E= Euphrates (Tell Ashara, Jebel Mashtale, Tell Masaikh, Mari), Kh=Khabur basin (Arbid, Barri, Brak, Mozan), U=Ugarit (Ras Shamra, Minet el-Beida, Tell Sukas).

	L	Q	T	TeD	S	JP	E	Kh	U	D ²
L	0	0.584	0.710	0.741	0.578	0.582	0.739	0.537	0.586	6.986
Q	0.020	0	0.078	0.368	0.110	0.165	0.412	0.173	0.115	2.844
T	0.021	0.022	0	0.187	0.099	0.079	0.722	0.223	0.082	2.646
TeD	0.028	0.029	0.030	0	0.150	0.031*	0.760	0.135	0.052*	3.450
S	0.019	0.020	0.020	0.028	0	0.000*	0.549	0.094	0.022*	0.285
JP	0.021	0.023	0.023	0.031	0.021	0	0.573	0.126	0.000*	0.562
E	0.029	0.030	0.030	0.038	0.028	0.031	0	0.299	0.618	5.811
Kh	0.026	0.027	0.028	0.035	0.026	0.028	0.035	0	0.120	1.020
U	0.029	0.031	0.031	0.038	0.029	0.032	0.039	0.036	0	0.396

Multidimensional scaling (MDS) using the SPSS procedure ALSCAL was used to reduce the dimensionality of the multidimensional distance matrix and plot it. The function tested both two- and three-dimensional models to find the best fit. Three-dimensional representation (figure 24) resulted in better representation of the data (Kruskal's stress=0.001, RSQ=0.97725). The close relationship of Tell el-Dab'a and JP (Jericho and Pella) and Ugarit (Ras Shamra, Minet el-Beida and Tell Sukas) is evident in the figure 24. The sites cluster close together in each dimension, demonstrating the close affinity observed in the MMD analysis. Sidon hovers close to Tell el-Dab'a and even closer to Jericho-Pella and Ugarit. Beyond this were the Egyptian sites Qurna and Thebes, close to one another but not the Levantine sites. The furthest sites from Tell el-Dab'a were the Euphrates sites, Lachish and the Khabur basin sites.

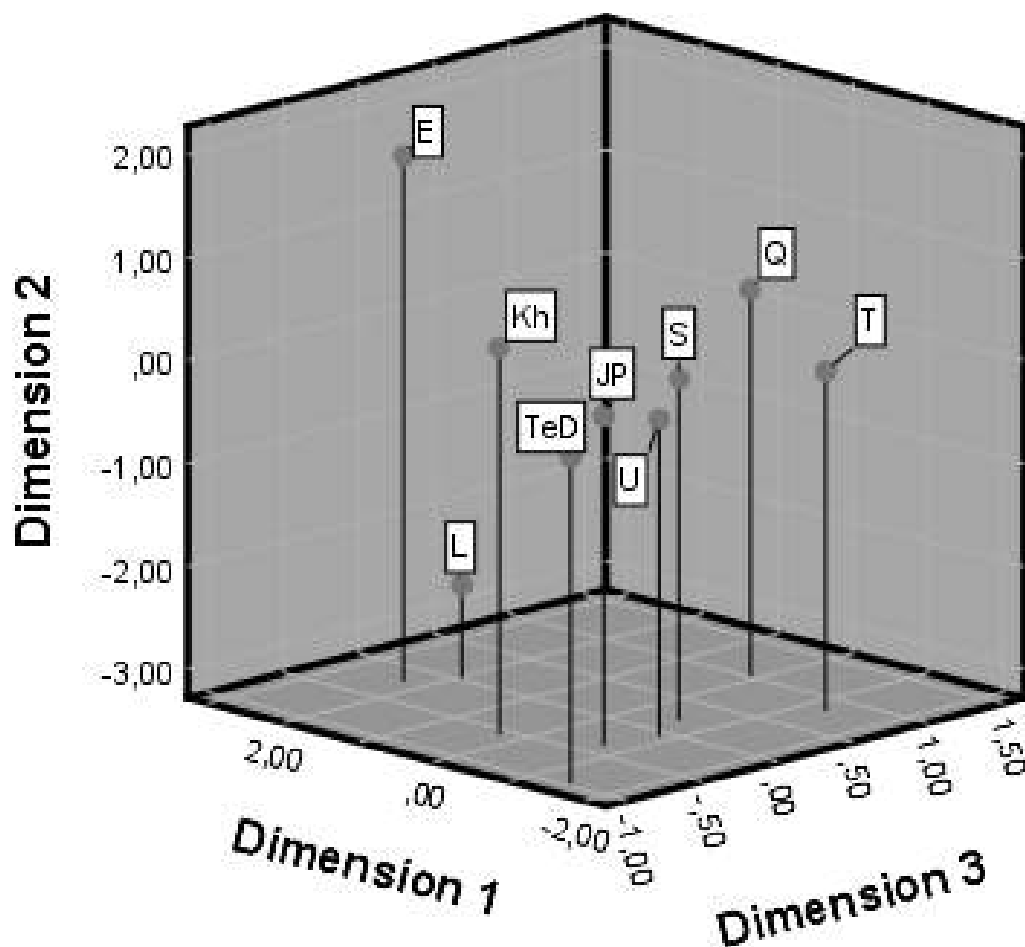


Figure 29. MDS plot of MMD values. Dimension 1 explains most of the variation. The SPSS procedure ALSCAL does not calculate overall importance of dimensions without weighting the proximities, which could not be provided for the current analysis. L=Lachish, Q=Qurna, T=Thebes, TeD= Thebes, S=Sidon, JP= Jericho and Pella, E= Euphrates (Tell Ashara, Jebel Mashtale, Tell Masaikh, Mari), KB=Khabur basin (Arbid, Barri, Brak, Mozan), U=Ugarit (Ras Shamra, Minet el-Beida, Tell Sukas).

The Mahalanobis distance (D^2) values in table 29 are the “gross measure of group diversity” (Schillaci et al. 2009, p. 239), calculated from the regional centroid of the sites. The mean D^2 was 2.667.

Sidon was closest to the centroid (0.28), followed by Ugarit (0.40), consisting of the archaeological sites of Ras Shamra, Minet el-Beida (practically a part of Ras Shamra) and Tell Sukas. They were followed by the combined sites of Jericho and Pella (0.56). Sites from the Syrian Khabur basin, combining the EBA-MBA samples from Tell Arbid, Tell Brak, Tell Barri, Tell Mozan and Tell Leilan, begin to place further away from the centroid

(1.02). The Egyptian sites Thebes and Qurna, which are in essence the same site, were close to the mean value.

The Tell el-Dab'a sample value was above average (3.45). The combined MBA-LBA sites along the Euphrates River, Tell Ashara (ancient Terqa), Tell Masaikh, Jebel Mashtale and Mari, lie far away from the centroid and well above the mean value of 2.667. Lachish lies furthest from the centroid (6.99), distinctly separate from the other Levantine sites.

6.4.1.3 Dataset 2

Another theoretical point, mentioned already in chapter 5.3, is that the results are relative, dependent on the combination of sites (cases) and traits (variables). The data was tested again with a different combination of sites to increase the number of dental traits (table 30 and 31). Now, the traits to capture most of the variation were second lower molar root number (40.91), hypocone size (24.34), upper canine distal accessory ridge (23.78) and upper premolar root number (22.92). The results remained relatively similar (order of sites according to diversity measure was correlated, $r=0.86$, $p=0.014$) though Pella and Jericho were just above $2*SD$ ($2SD=0.058$, $MMD=0.073$). The distance between Ugarit and Tell el-Dab'a remained nonsignificant ($MMD=0.024$, $2SD=0.076$).

Table 30. Frequency table of traits. Frequencies are decimals, not percentages. Shoveling was retained in the list as it was correlated to LC and DS which were omitted from the dataset.

Trait		AFL	Q	T	Li	TeD	S	JP	U
S	N	22	17	19	10	25	54	22	10
	%	0.00	0.00	0.16	0.00	0.00	0.17	0.27	0.20
IG	N	37	27	24	19	19	40	28	15
	%	0.05	0.04	0.21	0.32	0.37	0.45	0.39	0.20
MAR	N	42	31	33	27	20	49	38	15
	%	0.07	0.00	0.03	0.00	0.20	0.00	0.00	0.00
DAR	N	28	23	19	23	16	34	24	10
	%	0.07	0.09	0.11	0.00	0.69	0.32	0.63	0.70
H	N	63	46	42	42	42	57	46	27
	%	0.03	0.87	0.86	0.88	0.83	0.79	0.72	0.85
C5UM	N	43	38	28	26	23	52	34	11
	%	0.21	0.05	0.14	0.15	0.48	0.25	0.29	0.36
CC	N	47	34	28	23	36	71	48	21
	%	0.64	0.71	1.00	0.61	0.92	0.68	0.81	0.71
EE	N	65	51	42	47	24	46	34	24
	%	0.08	0.10	0.05	0.15	0.29	0.07	0.12	0.08
RUP1	N	40	34	34	42	12	35	25	20
	%	0.00	0.71	0.85	0.62	0.67	0.66	0.72	0.75
CLP	N	50	35	37	12	29	43	34	24
	%	0.78	0.54	0.70	0.67	0.93	0.77	0.82	0.88
GP	N	74	50	48	24	47	49	50	42
	%	0.32	0.20	0.25	0.38	0.32	0.10	0.30	0.33
C5LM2	N	56	40	38	24	21	36	30	17
	%	0.36	0.23	0.26	0.21	0.33	0.25	0.33	0.53
C7	N	67	36	44	23	29	59	36	34
	%	0.00	0.06	0.07	0.00	0.10	0.07	0.08	0.03
RLM2	N	46	28	36	29	15	26	26	20
	%	0.00	0.86	0.92	0.86	0.93	1.00	0.96	0.95
TA	N	58	37	40	26	18	25	15	27
	%	0.14	0.03	0.23	0.31	0.28	0.44	0.47	0.26

Table 31. MMD (upper) and SD (lower) values. Significant values were bolded, insignificant values were marked with an asterisk *.

	AFL	Q	T	L	TeD	S	JP	U	D²
AFL	0	0.825	1.041	0.791	1.157	1.082	1.053	1.033	5.915
Q	0.020	0	0.101	0.054*	0.452	0.206	0.296	0.231	2.672
T	0.020	0.023	0	0.108	0.202	0.111	0.122	0.137	2.532
L	0.026	0.029	0.029	0	0.389	0.109	0.217	0.218	1.882
TeD	0.026	0.029	0.029	0.033	0	0.163	0.029	0.024*	3.055
S	0.017	0.020	0.020	0.025	0.026	0	0.009	0.049*	2.503
JP	0.021	0.024	0.024	0.029	0.030	0.022	0	-0.036*	1.434
U	0.030	0.033	0.033	0.038	0.038	0.030	0.033	0	1.008

When examining the list of traits explaining most of the variation, it is clear the slight shift was caused by the inclusion of additional traits in the list that resulted in explaining most of the variation in the dataset. Unsurprising, the exclusion of traits has an impairing effect on the results as the method is unable to measure difference between the samples to its full capacity. The Mahalanobis distances were calculated again for the new dataset from 3D MDS values (table 31). The MDS plot (figure 30) and Mahalanobis distances have remained similar but also perpetuate the importance of retaining the maximum number of traits. The MDS values were a good fit (stress= 0.034, SQR=0.99). Mahalanobis mean distance measuring group diversity was 2.625. When sites present in both dataset 1 and 2 were placed in order according to the D² values, the order was strongly correlated (r=0.86, p=0.014).

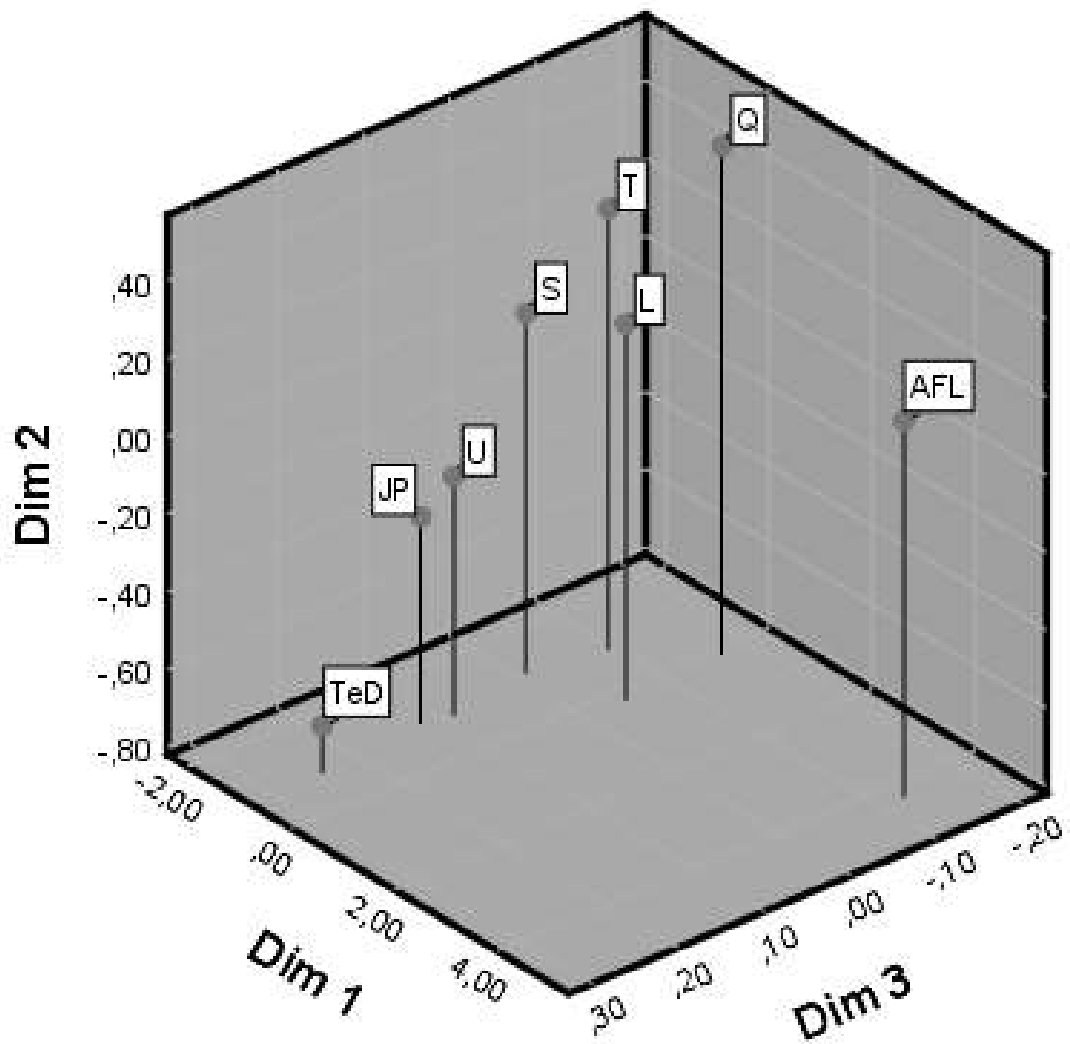


Figure 30. MDS plot of MMD values. The inclusion of traits caused Tell el-Dab'a to isolate more, though still clustering most with JP and Ugarit. Unlike before, Lisht is clustering with the other Egyptian sites, while the Southern Levantine sites AFL (Tell el-Ajjul, Tell el-Far'ah and Lachish) isolate from the others.

6.4.1.4 Dataset 3

One last analysis was conducted on a smaller group of sites (Tell el-Dab'a, Sidon, Pella, Jericho, Ugarit) in order to increase the number of traits and separate Jericho and Pella into their own entities. The data was treated similarly as before, excluding traits indicating no variation among sites and <10 observations per trait (table 32). The MMD results indicated significant differences between Tell el-Dab'a and Ugarit and Sidon, but not between Tell el-Dab'a and Pella (table 33).

Ugarit, consisting of Tell Sukas and Ugarit (modern Ras Shamra and Minet el-Beida), were similar to Sidon and more curiously to Pella. This was observed also in previous analyses in datasets 1 and 2. Traits exhibiting the highest amount of variation within the dataset were lower first molar deflecting wrinkle (6.376), central upper incisor shoveling (4.330), first upper premolar accessory cusp (2.160) and lingual convexity (2.000). When compared to the MD values derived from the first and second dataset, the elimination of so-called outsiders from the analysis caused variation to become much more muted.

MDS analysis of the MMD matrix suggested the data was equally well-represented by two and three dimensions (stress=0.06). The Mahalanobis distances were calculated again for the new dataset from 3D MDS values (the MDS model fit well, stress= 0.00, RSQ=0.99). The Mahalanobis distances were included in table 33, the mean distance was 2.40. Aside from Ugarit, the sites appeared to exhibit similar amounts of divergence from centroid.

Table 32. Frequency tables for the traits with positive overall MD. TeD= Tell el-Dab'a, Ugarit= Ras Shamra, Minet el-Beida, Tell Sukas.

Trait		TeD	Sidon	Pella	Jericho	Ugarit
LC	N	27	51	12	16	13
	%	0.26	0.26	0.50	0.06	0.46
S	N	20	54	12	10	10
	%	0.50	0.17	0.50	0.00	0.20
MAR	N	20	49	22	16	15
	%	0.20	0.00	0.00	0.00	0.00
AC	N	22	46	17	15	15
	%	0.27	0.26	0.24	0.00	0.33
CC	N	36	71	27	21	21
	%	0.92	0.68	0.78	0.86	0.71
GP	N	47	49	23	27	42
	%	0.32	0.10	0.44	0.19	0.33
DW	N	19	37	10	12	11
	%	0.68	0.08	0.80	0.33	0.27

Table 33. MMD (upper) and SD (lower) values. Significant values are bolded and, insignificant are marked with an asterisk *. TeD= Tell el-Dab'a, Ugarit= Ras Shamra, Minet el-Beida, Tell Sukas.

	TeD	Sidon	Pella	Jericho	Ugarit	D ²
TeD	0	0.469	0.043*	0.499	0.165	3.200
Sidon	0.037	0	0.532	0.196	0.050*	2.408
Pella	0.064	0.052	0	0.577	0.108*	2.607
Jericho	0.064	0.052	0.079	0	0.266	3.199
Ugarit	0.066	0.053	0.081	0.081	0	0.586

Pella's continuous closeness to Tell el-Dab'a was investigated further by subsetting the data to include only individuals from Tomb 62. Unfortunately, there was not enough data from other Pella burials for a joint comparison, but instead two different tests were performed. First, Tell el-Dab'a was compared to only Pella and then only to material from Tomb 62. To exhibit the small variation captured by the traits, the test was allowed perform even with negative overall trait MD values. Excluding the other burials did not have significant effects on the results:

- Pella (full dataset): MMD=0.018, 2SD=0.069, MAR 0.471, PAR 0.126, LC 0.117,
- Tomb 62: MMD=0.016, 2SD=0.068, MAR 0.430, PAR 0.231, CC 0.151

In both cases, the two standard deviation value was circa 4 times the MMD value. The variation grasped by the primary three traits was minimal compared to the first datasets. In addition to the four traits mentioned above, 15 other traits were included in the analysis (C5UM, C6, MDTC, AF, H, CLP, GP, I2V, EE, C5LM2, C7, AC, DW, IG, S).

6.4.2 Gower distance analysis

To explore the biological affinities of individuals, nondichotomised values were utilised. The sheer volume of missing data prevented the use of the classic Mahalanobis distance (D^2) and caused the culling of traits and individuals for the Gower analysis. To retain as many individuals and traits as possible, missing values patterns were explored with SPSS procedure “Analyze Patterns”.

The final dataset that was able to produce a Gower distance data matrix (with no missing values) had circa 30% missing values and a total of 124 individuals across eight sites (table 34) and 15 dental traits (UI1 interruption groove, UM2 metacone size, UM2 hypocone size, UM2 bifurcated hypocone, UM2 cusp 5, UM1 Carabelli’s cusp, UM1 enamel extension, peg-shaped or reduced third, LP2 lingual cusp number, LM2 anterior fovea, LM1 groove pattern x, LM2 groove pattern y, LM1 cusp 5 size, LM2 protostylid, LM1 cusp 7). Inter-trait correlation test indicated no correlations of traits within tooth members.

Some of the traits are binary by nature (present/absent), such as the bifurcated hypocone and groove patterns, however some of the ordinaly recordable traits had only expressions of 0 and 1 (such as the UI1 interruption groove). These traits were treated as binary, as recommended by the cluster package guideline (Maechler et al. 2018).

6.4.2.1 Group analysis from distance matrix

PERMANOVA and PERMDISP2 tests were conducted on the dataset, grouping the data by sites as well as geographically distinct regions:

- Group 1: Dra’ Abu el-Naga’ (n=5)
- Group 2: Jericho (n=15), Pella (n=3), Tell el-‘Ajjul (n=5), Tell el-Far’ah (n=1)
- Group 3: Sidon (n=50)
- Group 4: Tell el-Dab’a (n=33)
- Group 5: Ras Shamra, Minet el-Beida, Tell Sukas (n=12)

Prior to analysis, the balance of the groups was observed visually by creating an ordination plot (figure 31) which exhibits the spread and location of the

data. Grouping by region was more balanced than by site, which was expected due to the small sample sizes in some sites. On the basis of the plot, PERMANOVA was conducted on regional level but not by site.

According to PERMANOVA, there was no difference between regions ($F(4,119)=1.967$, $p=0.08$), which is interesting considering the sample also includes individuals from southern Egypt (Dra' Abu el-Naga' = DAN). When compared to the distinct differences revealed by the MMD analysis (tables 29 and 31), which is very robust, the lack of difference when using the raw data could be due to small sample sizes or the uninformative selection of traits.

Differences in the spread of data points and distance from centroid by site was visualised in figures 32 and 33. The dispersions were significantly different ($F(4,119)=21.065$, $p=0.001$). Pairwise permutation test on centroid distances (table 34) indicated most sites to be significantly different from one another ($p<0.05$). Distances were nonsignificant between Ugarit and Jericho (permutation $p=0.085$) and between Tell el-'Ajjul and Pella (permutation $p=0.051$) and between Tell el-'Ajjul and Dra' Abu el-Naga' (permutation $p=0.310$).

Tell el-Dab'a and Sidon, the largest samples, also exhibited the greatest amount of dispersion (figure 32). The data was subset to Tell el-Dab'a males and females to for further visualisation (figures 34 and 35). Tell el-Dab'a females had a wider range of variation (spread) than males, however the two also varied by sample size.

Table 34. Pairwise permutation test of centroid distances by site. Observed p-value below diagonal, permuted p-value above diagonal. DAN= Dra' Abu el-Naga', TeA= Tell el-'Ajjul, TeD= Tell el-Dab'a.

	DAN	Jericho	Pella	Sidon	TeA	TeD	Ugarit
DAN		0.001	0.035	0.001	0.310	0.001	0.001
Jericho	<0.000		0.001	0.008	0.003	0.001	0.085
Pella	0.041	<0.000		0.001	0.051	0.001	0.001
Sidon	<0.000	0.010	<0.000		0.001	0.036	0.001
TeA	0.300	0.002	0.051	<0.000		0.001	0.025
TeD	<0.000	0.001	<0.000	0.069	<0.000		0.001
Ugarit	<0.000	0.108	<0.000	<0.000	0.024	<0.000	

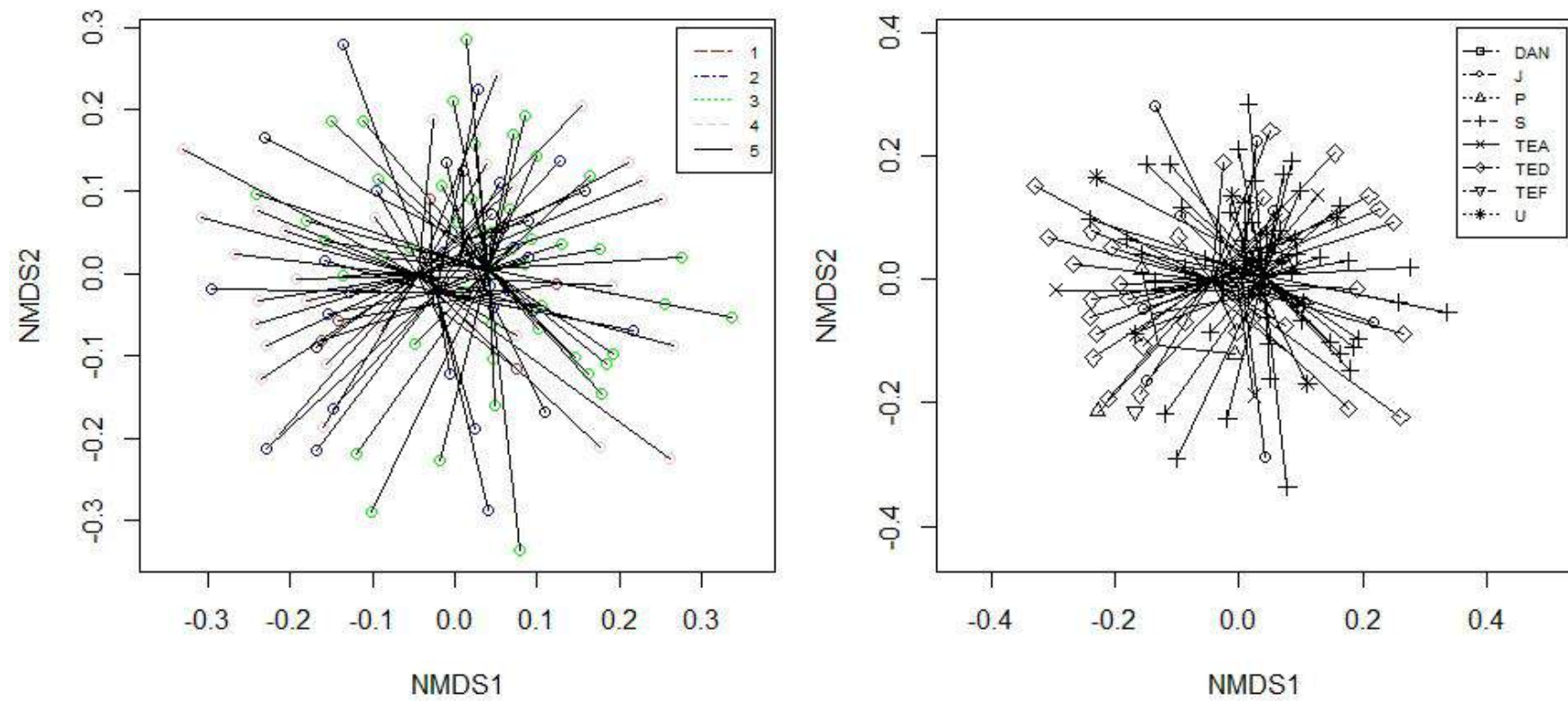


Figure 31. Ordination plot of group dispersions. Regional (left) dispersions appear more balanced than site (right) dispersions.

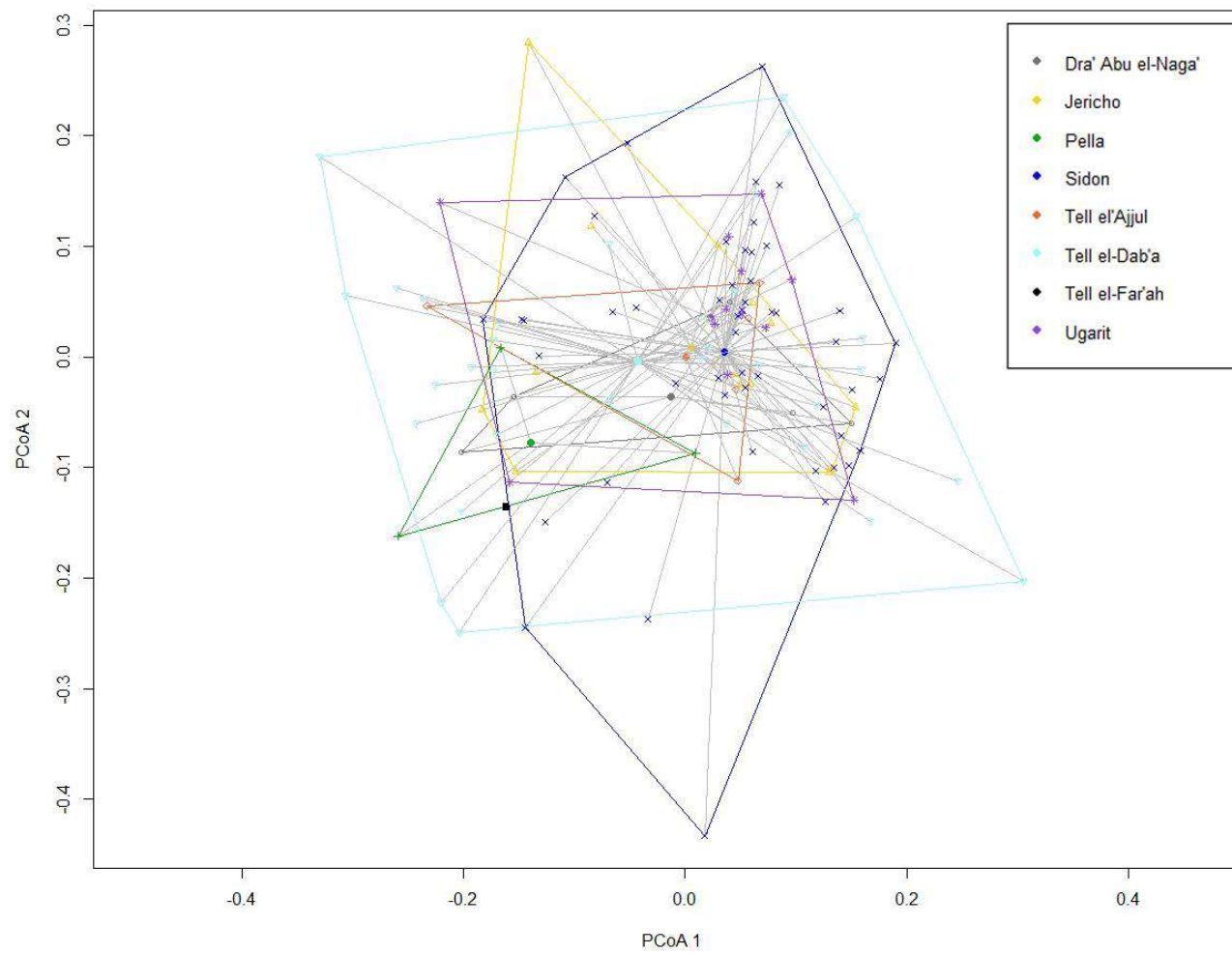


Figure 32. PCoA plot of site dispersions.

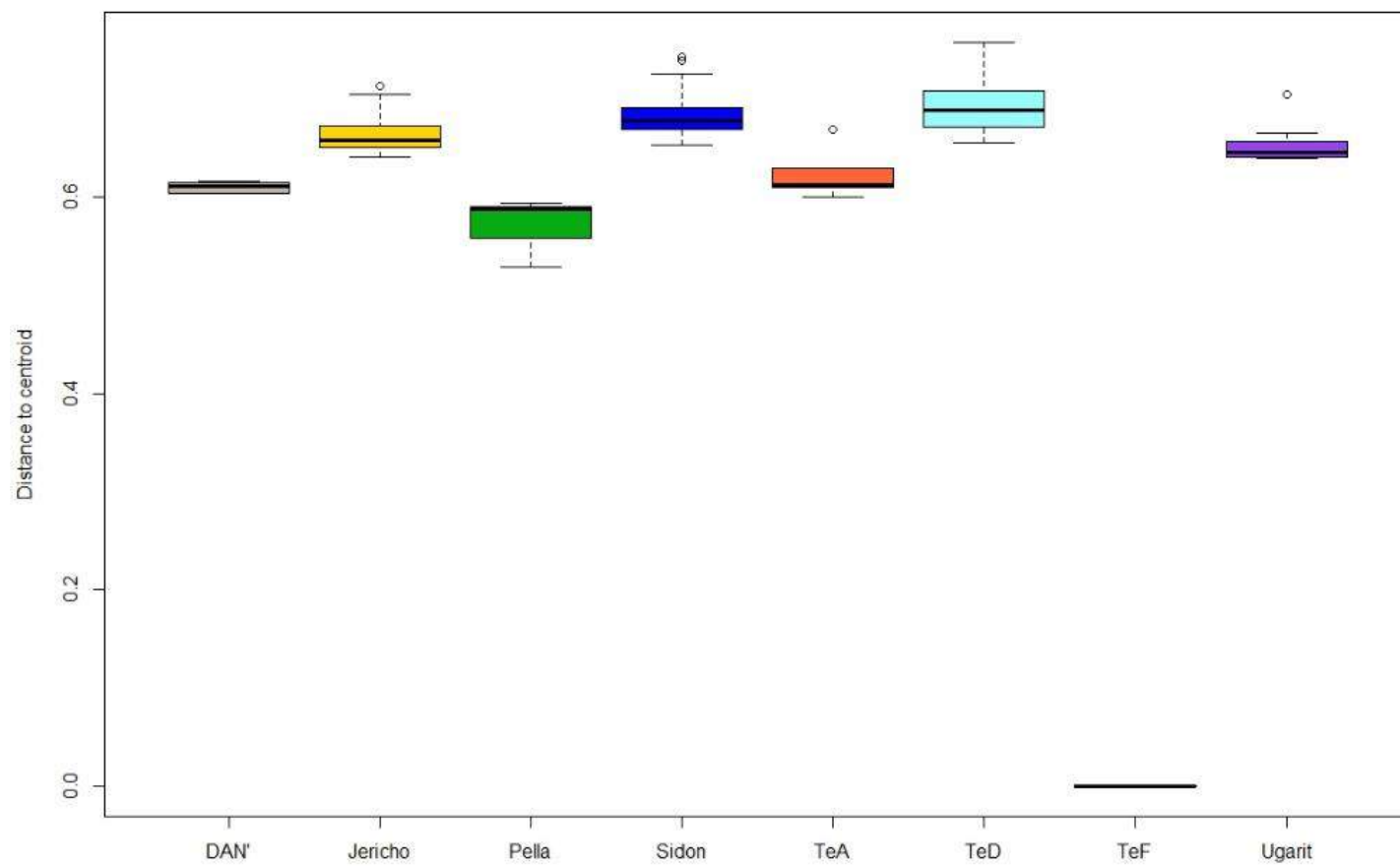


Figure 33. Boxplot of site centroid distances. DAN= Dra' Abu el-Naga', TeA= Tell el-'Ajjul, TeD= Tell el-Dab'a, TeF=Tell el-Far'ah centroid distance could not be calculated (n=1).

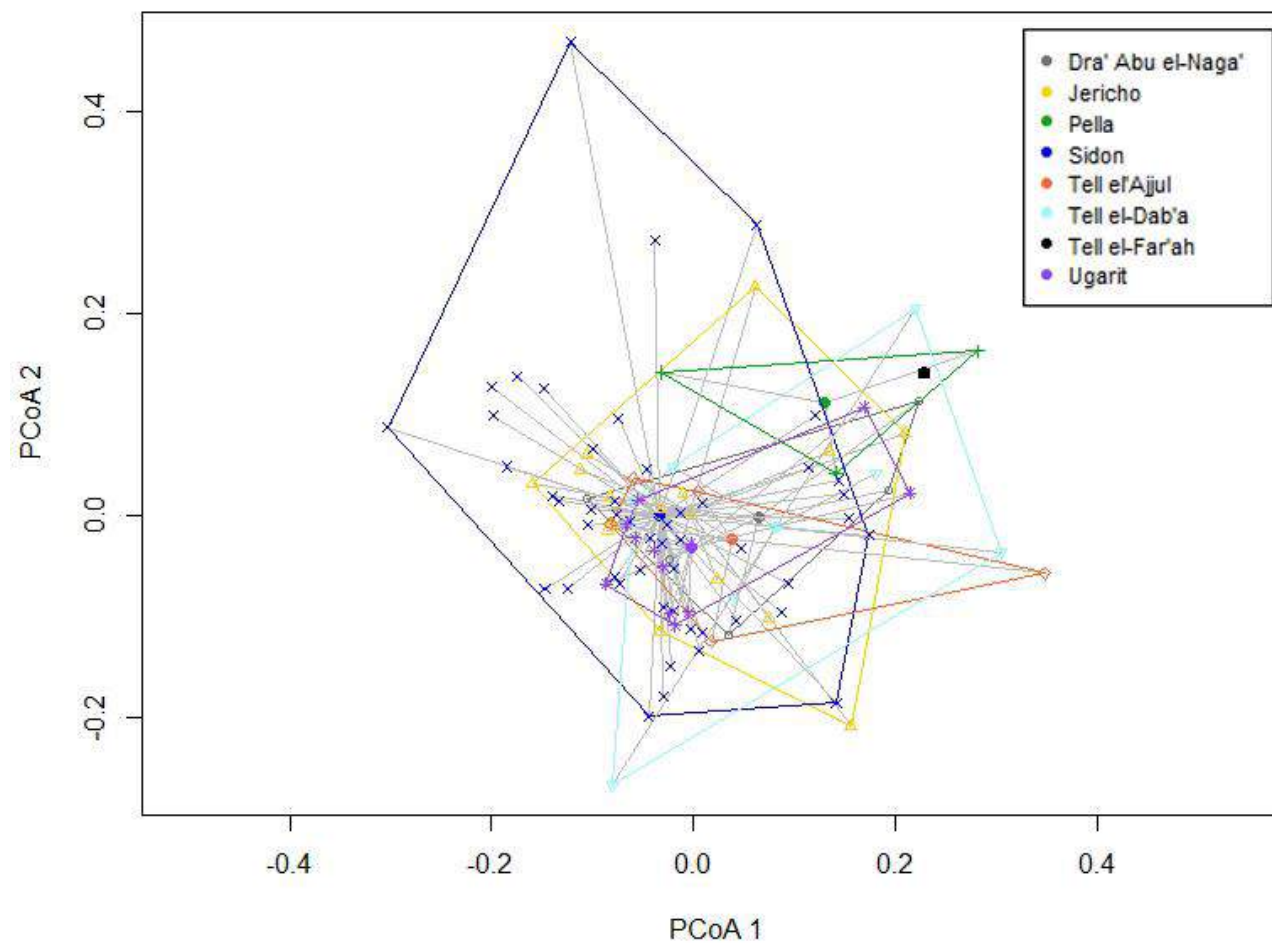


Figure 34. PCoA plot of dispersion among Tell el-Dab'a males in comparison to other sites.

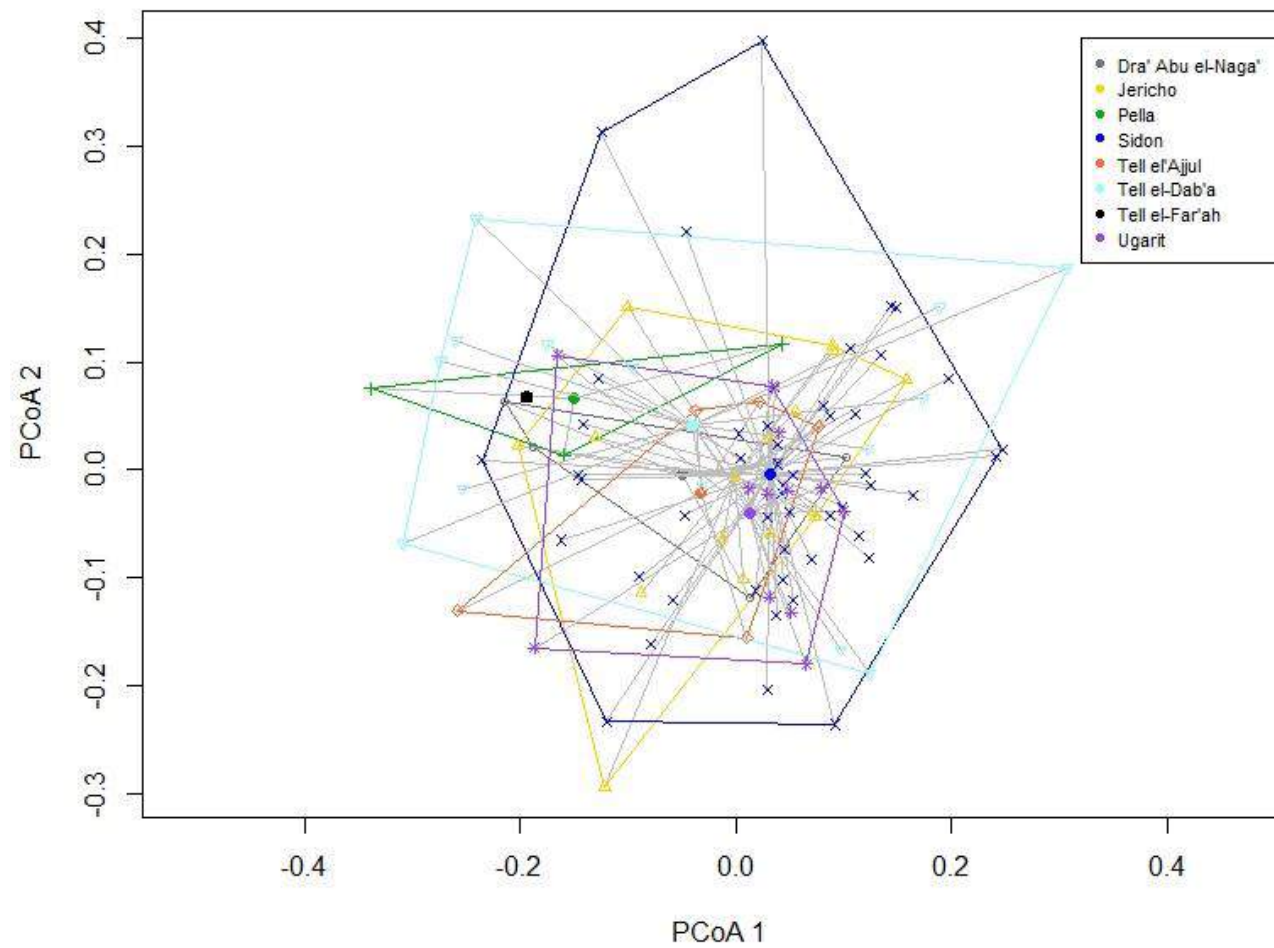


Figure 35. PCoA plot of dispersion among Tell el-Dab'a females in comparison to other sites.

6.4.2.2 Cluster analysis from distance matrix

The optimal number of clusters (figure 36) was two and to a lower degree three. Again, there was no isolation of clusters, visible in figures 37 and 38. However, though the overall division of individuals from different sites did not produce overall distinct results, sites seem to slightly focus on one cluster over another (table 35). Data was visualised using t-SNE.

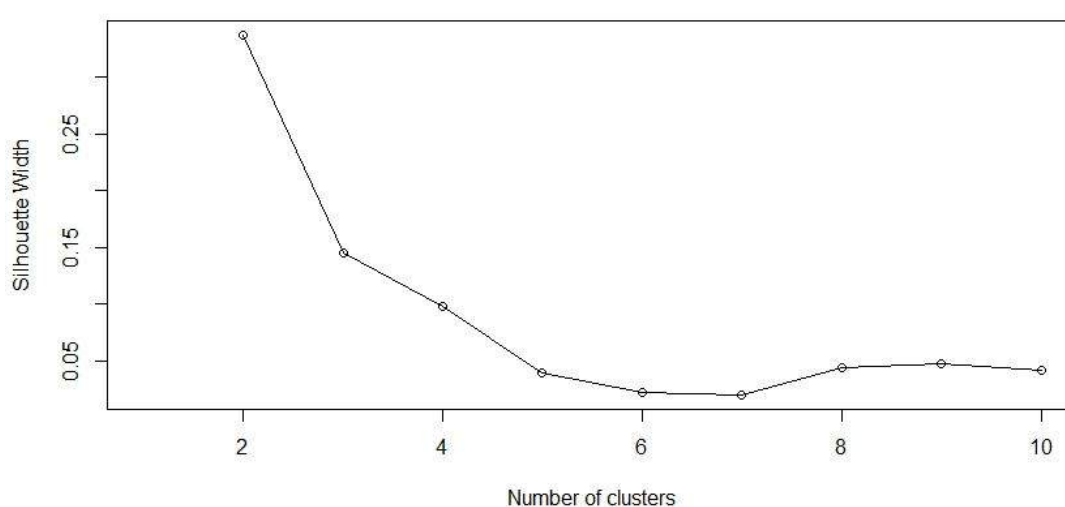


Figure 36. Optimal number of clusters for the eight sites.

Table 35. Frequencies (percentage in decimals not percentage units) by sites.

	Clustering into 2		Second clustering into 3			Total n
	C1	C2	SC1	SC2	SC3	
Dra' Abu el-Naga'	0.60	0.40	0.60	0.20	0.20	5
Jericho	0.73	0.27	0.67	0.20	0.13	15
Pella	0.33	0.67	0.33	0.00	0.67	3
Sidon	0.84	0.16	0.70	0.16	0.14	50
Tell el-'Ajjul	0.80	0.20	0.60	0.20	0.20	5
Tell el-Dab'a	0.52	0.48	0.39	0.36	0.24	33
Tell el-Far'ah S	0.00	1.00	0.00	1.00	0.00	1
Ugarit	0.83	0.17	0.58	0.33	0.08	12

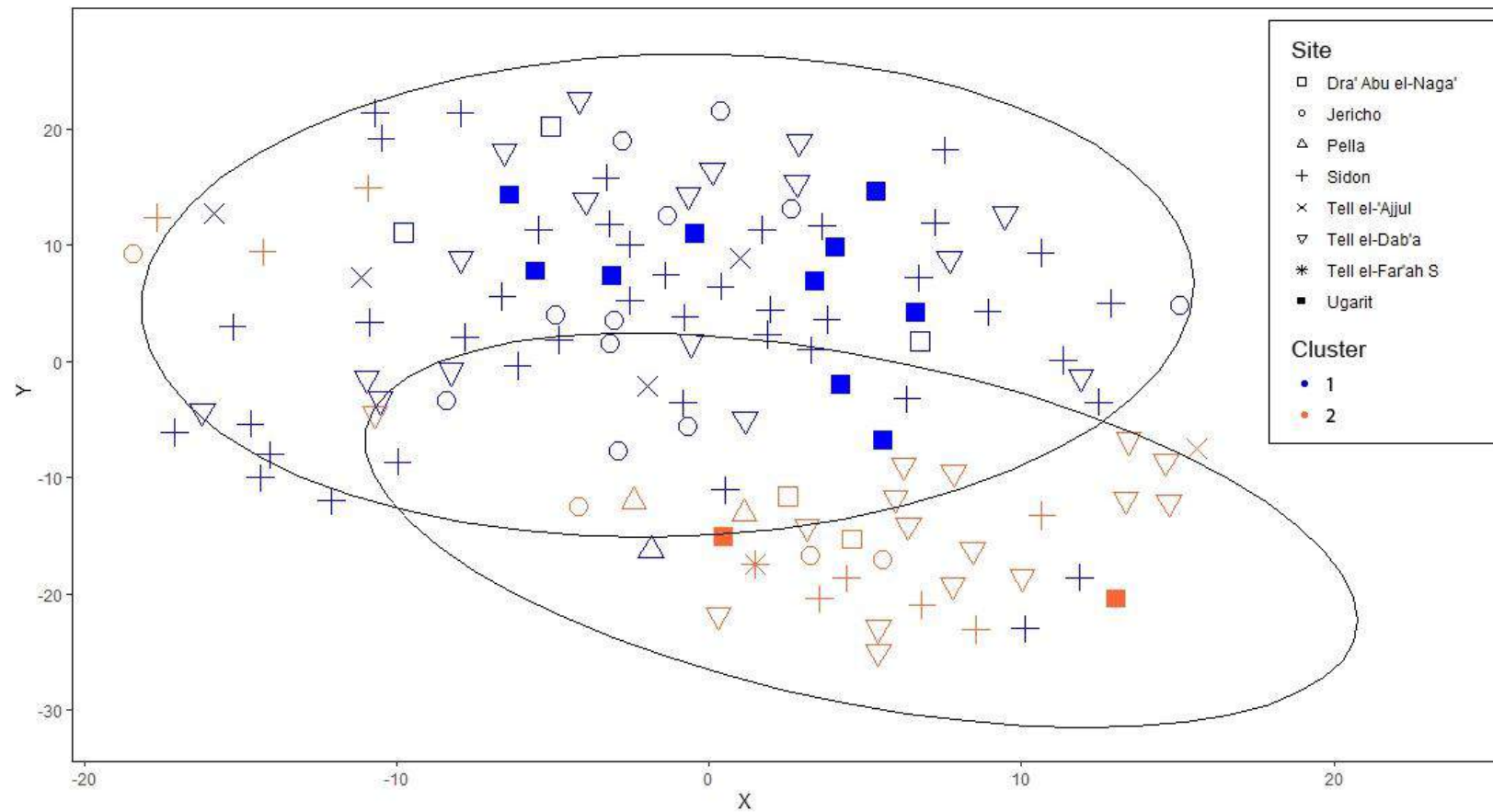


Figure 37. Cluster plot of sites. Ellipse drawn around clusters with 95% confidence level.

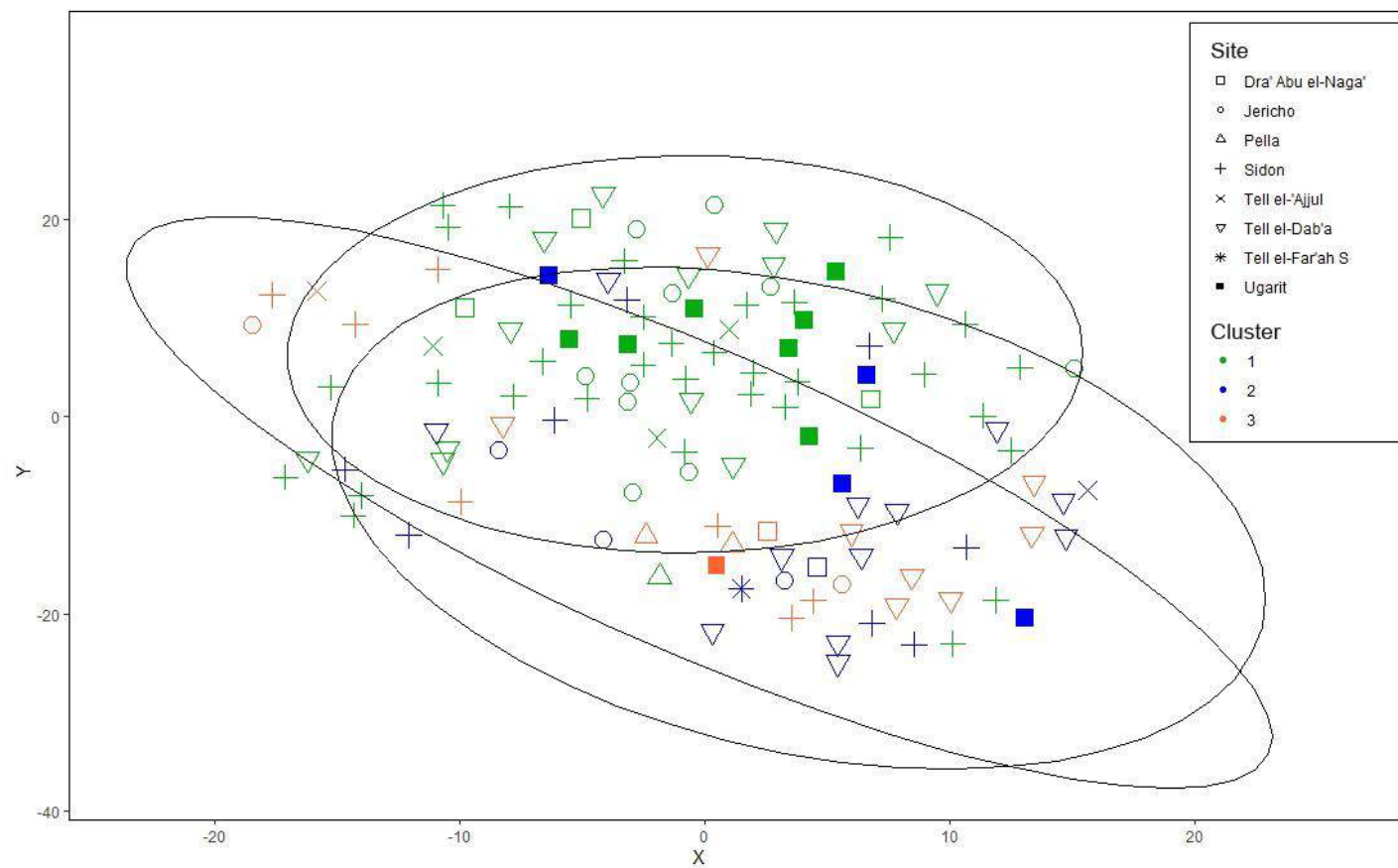


Figure 38. Cluster plot of sites. Ellipse drawn around clusters with 95% confidence level.

Clusters derived from Tell el-Dab'a intra-site analysis were included in further analysis. Due to the small sample numbers, statistical analyses were not valid, but some observations were made from the cross-tabulated groupings (table 36 and 37). All G1 individuals were in C1 but G2 individuals were dispersed between C1 and C2. G1 individuals were a mixture of males, females and subadults. 80% or more of individuals from Sidon, Tell el-'Ajjul and Ugarit belonged to C1 as well. When divided into secondary clustering (SC1-3), G1 and G2 spread equally across clusters.

Subgroups identified in section 6.3.2.2 exhibited some division by sex – SG3 and SG6 were all males, whereas SG1 and SG5 were all females. Male SG3 and SG6 individuals as well as female SG1 and SG5 individuals were in all in C1. All female SG2 individuals fell in C2. SG4 males and females fell across secondary clusters (SC1-3). SG2 burials had Tell el-Yahudiyah ware (local tradition) and Cypriot imports. Only Pella showed greater emphasis on C2 (67%, n=3). The spread is further illustrated by figure 39, where sites were plotted with the two clusters and an additional layer of information was added by coloring the placement of the male and female groups acquired from the intra-site analysis.

Table 36. Tell el-Dab'a G1-2 and SG1-6 males and females by clustering into two.

		C1 n	C2 n	Total n	%1	%2
G (all)	1	10	0	10	1.00	0.00
	2	6	12	18	0.33	0.67
SG males	3	2	0	2	1.00	0.00
	4	1	2	3	0.33	0.67
	6	1	0	1	1.00	0.00
SG females	1	4	0	4	1.00	0.00
	2	0	4	1	0.00	4.00
	4	2	6	8	0.25	0.75
	5	1	0	1	1.00	0.00

Table 37. Tell el-Dab'a G1-2 and SG1-6 males and females by secondary clustering into three.

		SC1	SC2	SC3	Total	%1	%2	%3
G (all)	1	6	2	2	10	0.60	0.20	0.20
	2	7	7	4	18	0.39	0.39	0.22
SG males	3	1	1	0	2	0.50	0.50	0.00
	4	1	1	1	3	0.33	0.33	0.33
	6	0	1	0	1	0.00	1.00	0.00
SG females	1	3	0	1	4	0.75	0.00	0.25
	2	0	3	1	4	0.00	0.75	0.25
	4	3	3	2	8	0.38	0.38	0.25
	5	1	0	0	1	1.00	0.00	0.00

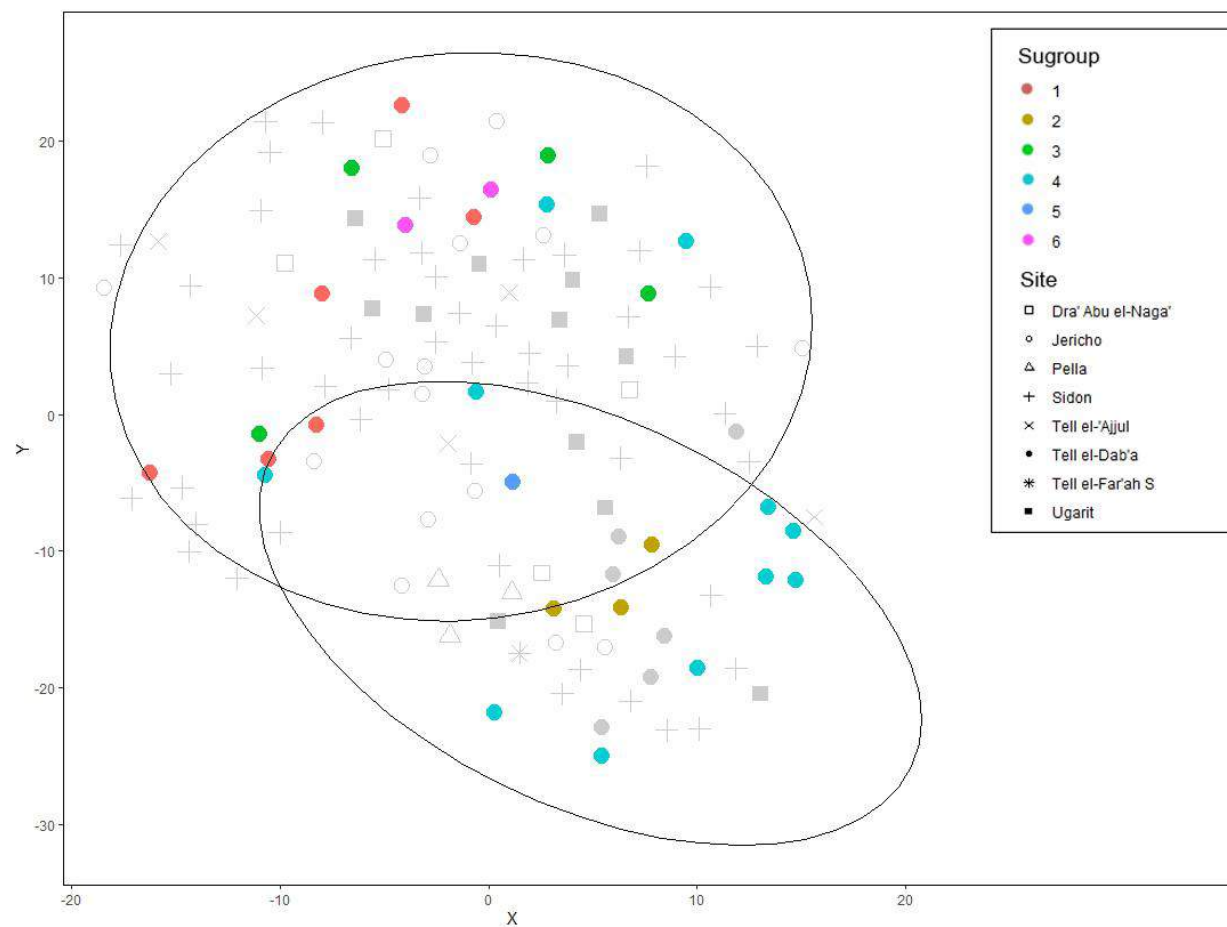


Figure 39. T-SNE plot of C1-2 clusters by sites. The colours, however, match the male and female subgroups generated in the intra-site analysis of Tell el-Dab'a. Ellipse drawn at 95% confidence level around C1 (upper) and C2 (lower). Grey points indicate Tell el-Dab'a subadults and sites other than Tell el-Dab'a.

6.4.3 Geometric morphometrics

6.4.3.1 Repeatability

Landmark and semilandmark repeatability was tested by digitising five teeth twice, and conducting GPA and PCA. The Pearson correlation coefficient indicated high repeatability between observations ($r=0.967$). The first four PC values of each individual were also plotted in a simple scatterplot (figure 40), and a coefficient of determination (R^2) has been given to exhibit goodness-of-fit for the linear model. Both r and R^2 are strong, suggesting observations one and two produce similar results.

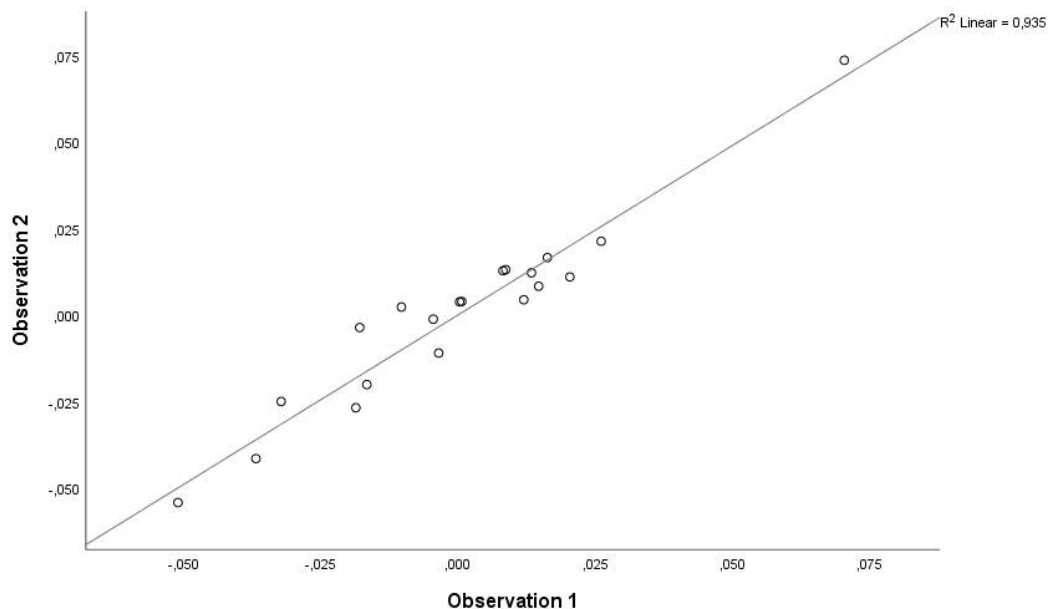


Figure 40. Scatterplot measuring the results of PC1 and PC2 between observation events one and two.

6.4.3.2 GPA and statistical analysis

After digitisation, general Procrustes superimposition was conducted on the selected teeth (appendix A16). Only individuals were considered for the analysis to avoid duplication. The analysis was conducted on the left lower first molars, all right side first lower molars were mirrored to ease digitisation. Because of the heavy attrition, often beginning as early as eight years old, all teeth belonged to subadults.

GPA centres, rotates and scales the configurations, eliminating any information related to location or size (figure 41). Cusp tip three and five exhibited the most variation, moving towards the buccodistal aspect of the molar (figure 41). Cup tips one and two moved towards the distal aspect. There was little change in the outline shape around cusp four and five. There was more change on the buccal and lingual aspects, cusp one outline extending buccally, while the outline of cusp three and margin of cusp two and four moved inwardly.

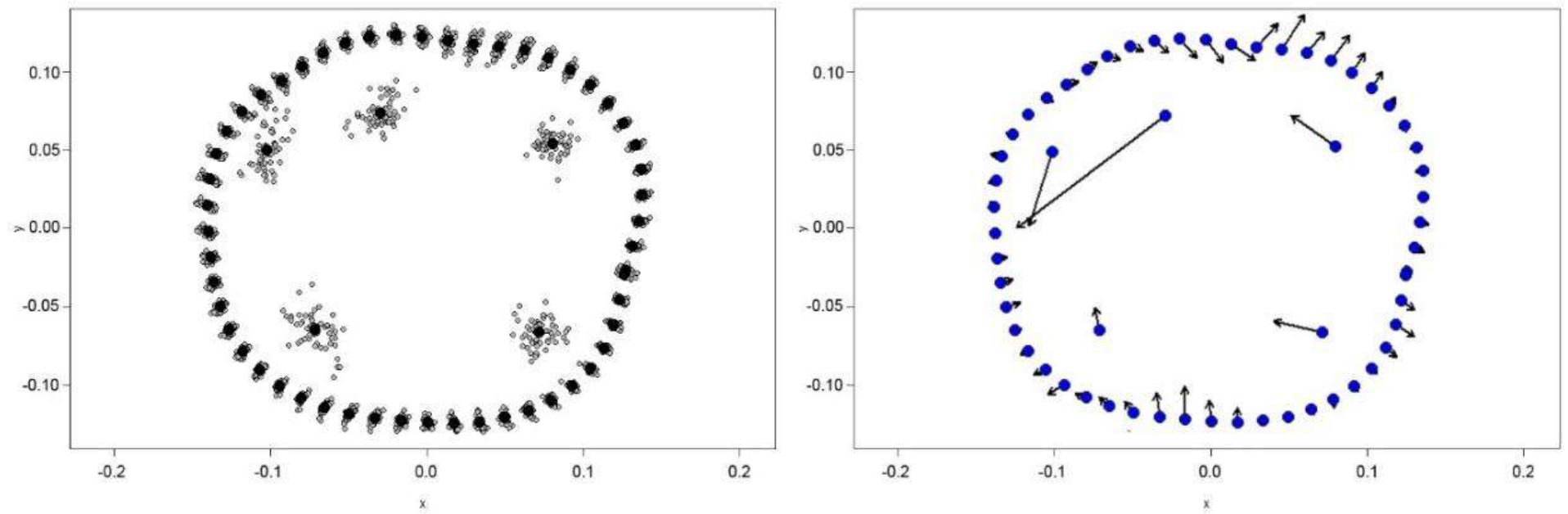


Figure 41. Left: plot of sample teeth (grey) and average (black) shape coordinates. Right: plot exhibiting the direction of shape change.

One-factor MANOVA test with 2000 permutations was performed on the GPA data. A barely significant difference was identified from the data ($F(7,45)=1.364$, $p=0.048$). Further pairwise analysis by sites, using least squared distances, indicated that the only groups with significant difference were Sidon versus Arqa ($p=0.02$, $Z=1.94$) and Tell el-Dab'a versus Jericho ($p=0.03$, $Z=1.98$, table 38). PCA was performed on the MANOVA distance matrix comparing sites, explaining 60% of the variation (figure 42). The scatter was similar to the PCA plotted directly from the GPA data (figure 43). Scatter by site was wide in both cases.

Pairwise disparity test was performed on the Procrustes distances using function `morphol.disparity()` from the `geomorph` package. According to the test, there was no significant differences in disparity between subadults of pre-Hyksos and Hyksos periods ($p=0.737$).

Table 38. LS (least squares) distance matrix (upper) effect sizes or Z-scores (lower). Significant distances are bolded and marked with an asterisk *. Effect sizes close to 2.0 resulted in significant values.

Site	N	Arqa	Jericho	Pella	Sidon	TeD	Fadous	Mozan	Sukas
Arqa	8	0	0.03	0.01	0.02*	0.02	0.05	0.02	0.04
Jericho	4	1.24	0	0.03	0.03	0.03*	0.05	0.04	0.03
Pella	8	-1.18	1.69	0	0.02	0.02	0.04	0.02	0.03
Sidon	21	1.94	1.40	1.55	0	0.02	0.04	0.03	0.03
TeD	12	0.77	1.98	0.09	1.49	0	0.04	0.03	0.04
Fadous	1	1.27	0.60	0.70	0.25	0.20	0	0.06	0.05
Mozan	2	-1.17	0.80	-0.73	0.23	0.10	1.14	0	0.04
Sukas	1	-0.09	-1.21	-0.30	-0.16	-0.21	-0.24	-0.43	0

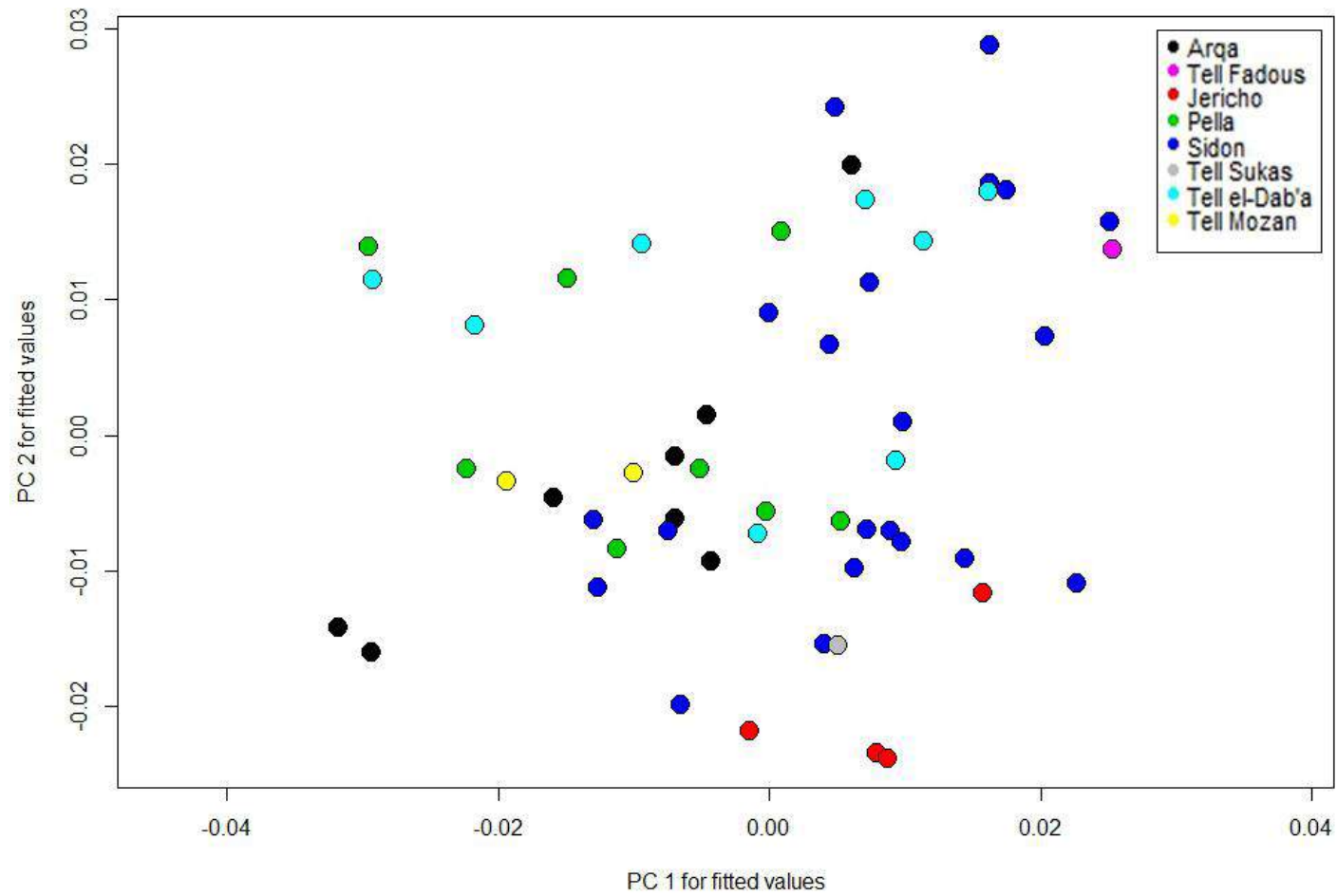


Figure 42. PCA plot of MANOVA fitted values according to sites. PC1 explains 36% of the variation, PC2 explains 24%.

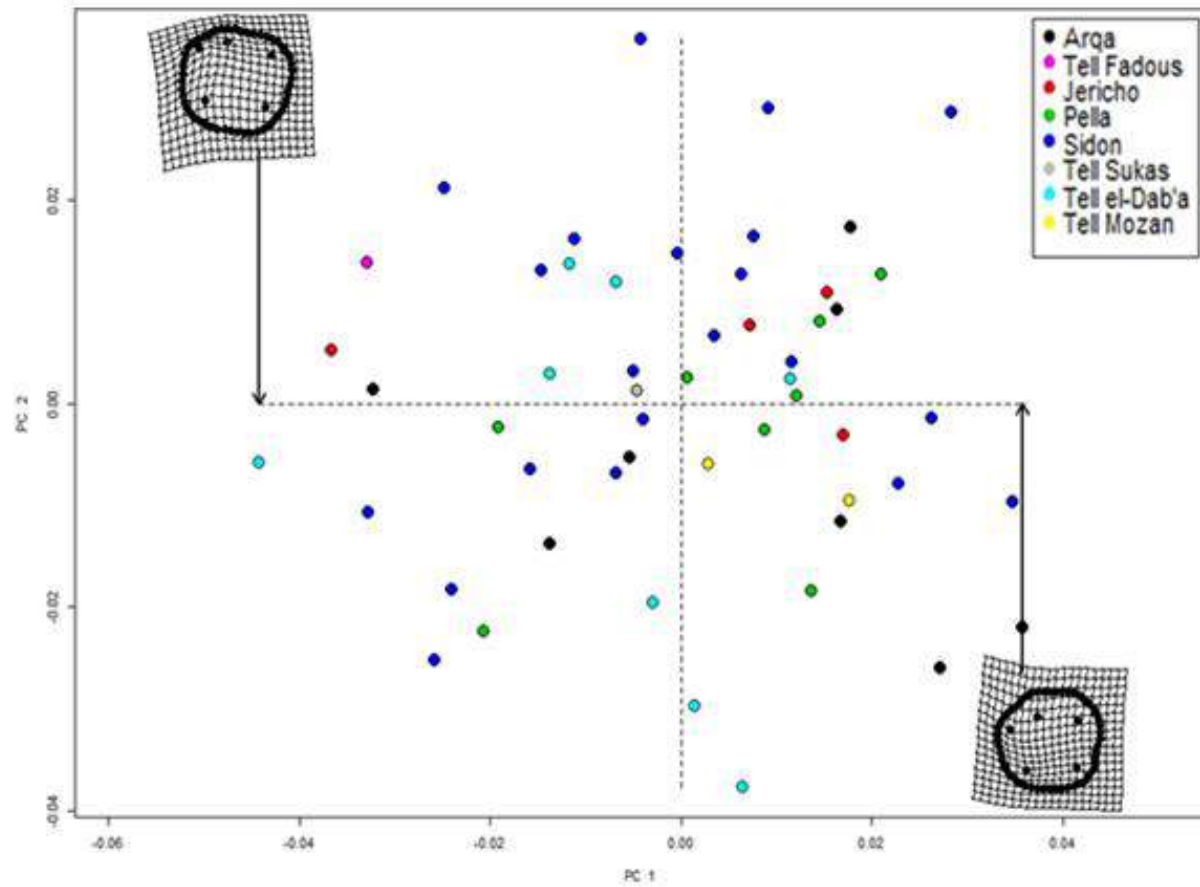


Figure 43. PCA plot of MANOVA fitted values according to sites. PC1 explains 27% of the variation, PC2 explains 18%. Transformation grids in the upper left and lower right corners demonstrate the direction of change in shape.

One of the Tell el-Dab'a individuals, A/II-p/21 Grave 12 was flagged as an outlier (figure 44). Unfortunately, there was very little contextual information from this grave. The subadult was circa 3-4 years of age, buried in a chamber tomb during the pre-Hyksos period (stratum F or E/3). Both F/I individuals clustered with A/II. When sites were pooled, the only outliers were the single individuals from Tell Fadous and Tell Sukas (figure 45).

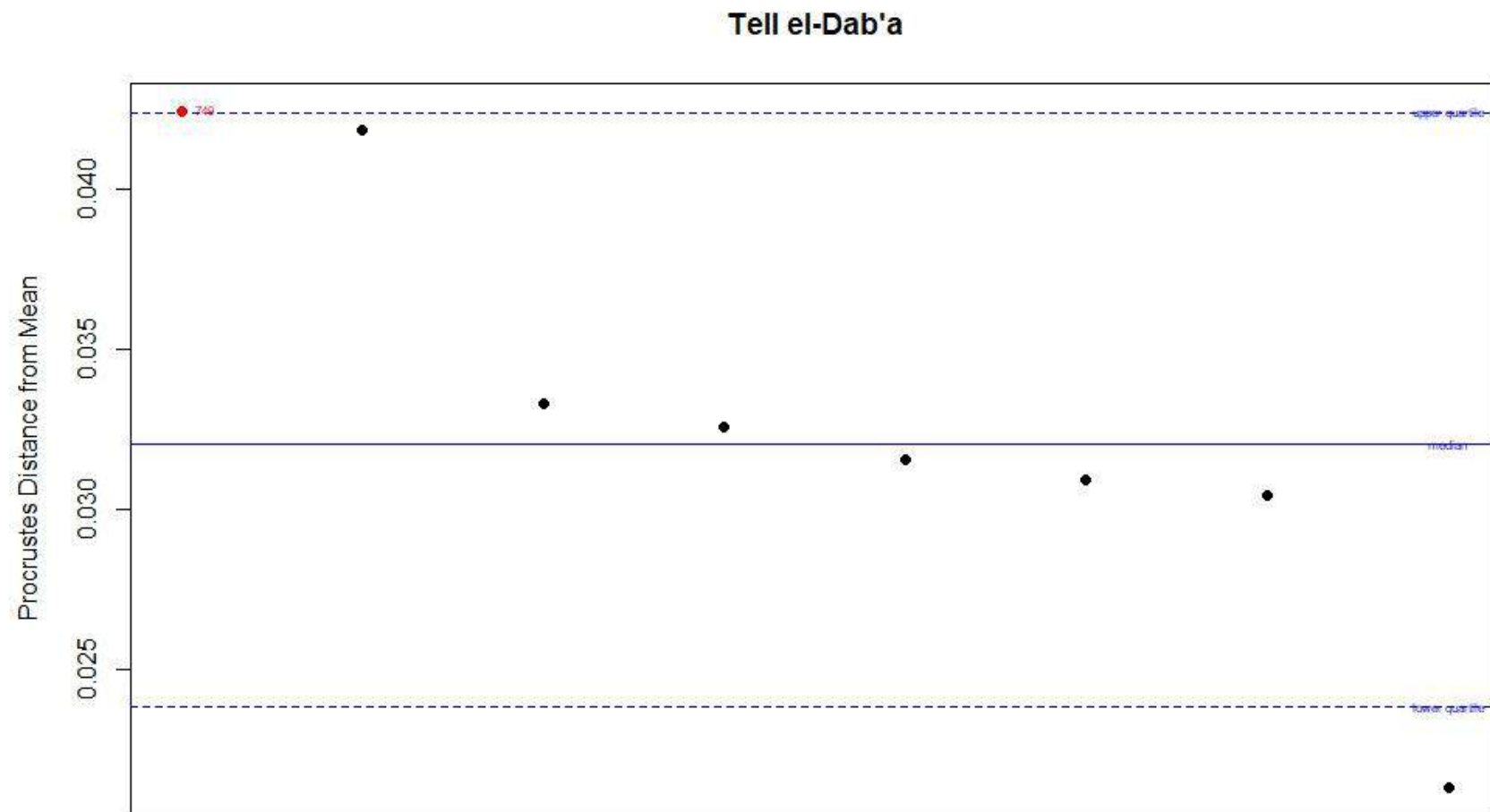


Figure 44. Tell el-Dab'a outlier specimen 749 (upper left corner) correlates with individual A/II-p/21 grave 12.

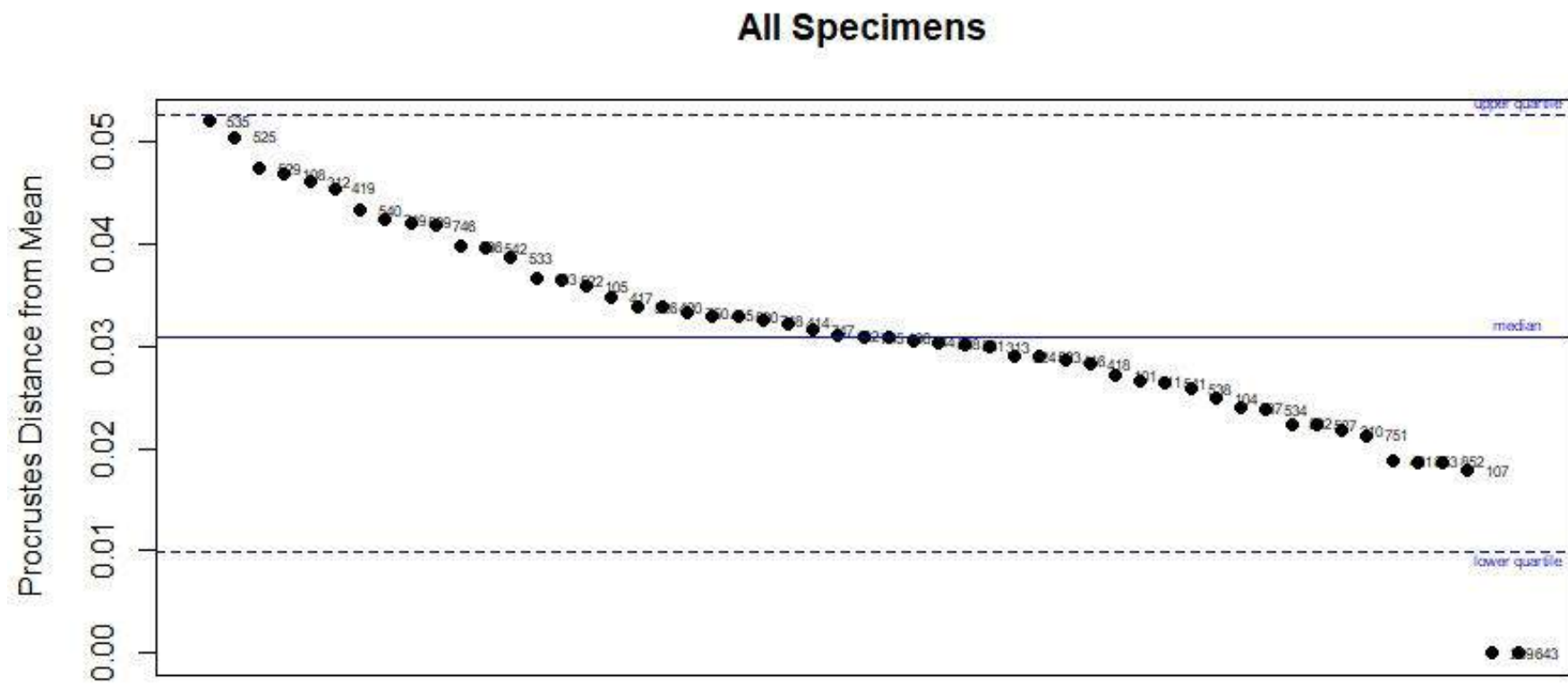


Figure 45. Outliers when sites were pooled.

6.4.4 Inter-site analysis summary

Inter-site analysis had three main avenues of investigation; mean measure of divergence (MMD) analysis, Gower distance analysis (GDA) and geometric morphometrics (GM). The former two, MMD and GDA, utilised the same dental nonmetric trait datasets, albeit in different contents, while GM generated a separate dataset using landmark information.

Three different datasets were created for the MMD analysis to maximise not only the number of sites and regions but the number of traits exhibiting variation. To minimise bias, strongly ($b > 0.5$) correlated traits and traits with negative MD values and less than ten observations per trait, were excluded from tests.

Based on dataset 1, Tell el-Dab'a indicated biological closeness to both northern (Ugarit) and southern Levantine (Jericho-Pella) sites. Aside from Lachish, the Levantine sites (Sidon, Ugarit, Pella, Jericho) clustered together (table 29, figure 29). Khabur basin sites (Tell Mozan, Tell Arbid, Tell Brak, Barri) hovered close to the Levantine sites. The Egyptian sites of Qurna and Thebes stood apart from the Levantine and northern Syrian sites, while the sites along the Euphrates (Mari, Ashara, Jebel Mashtale, Tell Masaikh) stood apart from all other sites.

On the basis of dataset 1 results, sites in the Khabur basin and along the Euphrates were removed from further testing. The exclusion allowed for the inclusion of Tell el-'Ajjul, Tell el-Far'ah (S) and Lisht which created a slight trade-off in traits available for testing (table 30). Due to the small sample size of Tell el-'Ajjul and Tell el-Far'ah (S), the sites were grouped with Bronze Age Lachish material. The results indicated similar distances than before (order of sites according to diversity measure was correlated, $r=0.86$, $p=0.014$), with Ugarit placing closest to Tell el-Dab'a (MMD=0.024, 2SD=0.076). The inclusion of traits increased the difference between Jericho-Pella and Tell el-Dab'a beyond two standard deviations (2SD=0.058, MMD=0.073). Aside from the grouped sites of Tell el-'Ajjul, Tell el-Far'ah (S) and Lachish, sites (including the Egyptian sites) appeared to show some clustering in dataset 2.

Dataset 3 was focused solely on sites that had indicated stronger biological affinity to Tell el-Dab'a; Sidon, Pella, Jericho and Ugarit. The further

exclusion of sites enabled the separation of Jericho and Pella without significant loss to available variables. The exclusion of traits with negative MD values (showing no variation between sites) left only few traits in the final analysis, highlighting the close biological affinity between the sites. For the first time, the results showed significant difference between Tell el-Dab'a and Ugarit, consisting of Tell Sukas, Minet el-Beida and Ras Shamra (MMD=0.165, 2SD=0.132). The separation of Pella and Jericho resulted in an interesting shift in results, indicating Tell el-Dab'a's close affinity to Pella (MMD=0.043, 2SD=0.128) and further distance to Jericho (MMD=0.499, 2SD=0.128). Jericho was significantly different from all other sites (table 33).

Gower distance analysis was tested on a subsample of 124 individuals across eight sites and 15 dental traits. Unlike MMD analysis, the test utilised non-dichotomised values instead. Comparison according to sites created small sample sizes which may have affected the statistical analysis. Tell el-'Ajjul and Dra' Abu el-Naga', two sites with small sample sizes, had similar centroid distances, while Tell el-Dab'a and Sidon, the largest samples, exhibited the greatest amount of variation (figure 32). Cluster analysis, grouping the individuals according to dental trait variation, indicated best division into two clusters (silhouette width value 0.35). None of the sites fell within either group completely, though slight preferences could be observed in percentages (table 35, figure 37). The "preferences" were not regionally consistent.

Further comparison was made between the intra-site (Tell el-Dab'a) and inter-site Gower distance analysis. This was done by comparing the groups and subgroups from the intra-site analysis to the clustering derived from the inter-site analysis. The purpose was to observe whether any group (G1-2) or subgroup (SG1-6) individuals would cluster with specific sites.

All G1 individuals were in C1 but G2 individuals were dispersed between C1 and C2 (table 36). G1 individuals were a mixture of males, females and subadults. 80% or more of individuals from Sidon, Tell el-'Ajjul and Ugarit belonged to C1 as well (table 35). Male SG3 and SG6 individuals as well as female SG1 and SG5 individuals were in all in C1. All female SG2 individuals fell in C2. SG2 burials had Tell el-Yahudiyah ware (local tradition) and Cypriot imports (table 21). Only Pella showed greater emphasis on C2

(67%, n=3). Statistical analyses were not conducted due to small sample sizes.

Finally, geometric morphometrics was tested on lower first permanent molars from Arqa, Jericho, Pella, Sidon, Tell el-Dab'a, Tell Fadous-Kfarabida, Tell Mozan and Tell Sukas. The only groups with significant differences were Sidon versus Arqa ($p=0.02$, $Z=1.94$) and Tell el-Dab'a versus Jericho ($p=0.03$, $Z=1.98$, table 38). According to the PCA plot of MANOVA fitted values (figure 42-43), Jericho individuals appeared to show any clustering while the other sites showed wide dispersal and overlap.

6.5 Summary

Correspondence analysis suggests most of the variation in the dataset was presented by upper first incisor shoveling (0.28), lower first molar deflecting wrinkle (0.15) and upper canine distal accessory ridge (0.13). The traits were invariably present in the analyses, depending on the samples. What must be noted, however, is that because correspondence analysis weighs the cases by frequency (%), it does not take into account small sample sizes.

Intra-site analysis did not indicate significant changes between the partially contemporary 13th-14th dynasties and the 15th dynasty. This was indicated by the MMD analysis (MMD=0.007, 2SD=0.116) comparing entire groups and the Gower distance analysis comparing a smaller subset of individuals from Area A/II (see tables 18-19 and figure 15).

Inter-site analysis was conducted using mean measure of divergence (MMD) analysis, Gower distance analysis and geometric morphometrics. From the three methods, MMD was able to retain the highest amount of variables (and thus information). MMD analysis was conducted in several steps to maximise the number of sites and dental traits, slowly narrowing down to sites exhibiting closer biological distance. Ultimately, Tell el-Dab'a appeared to cluster with Levantine sites (figure 46), particularly Pella (MMD=0.043, 2SD=0.128). Comparison of sexes or other contextual information was not possible in the MMD analysis due to small sample numbers (<10 observations/trait).

Gower distance analysis of the non-dichotomised (raw) data showed little distinction between sites (figures 32 and 37), highlighted further by the cluster analysis (section 6.4.2.2). The number of traits available for the analysis was smaller (15 traits) and did not include the traits identified by the correspondence analysis as most informative. The overlap of sites in the test may thus be a combination of lack of most informative variables and the close overall similarity of the eastern Mediterranean sites suggested also by the MMD analysis as well.

Geometric morphometrics analysis on the lower first molar cusp tip location and outline did not generate distinct groupings either and Tell el-Dab'a subadults were significantly different only from the Jericho subadults. Though PCA of the GPA was able to retain most of the variation within the first two PC values, the information itself in the 2D configuration was not unique enough to produce site-specific information, at least not for sites so closely affiliated. The method offers contrast to the hominin studies (Gomez-Robles and Polly 2012, Gomez-Robles et al. 2007) which show much more variation. A potential hinderance may have also been the loss of degrees of freedom (four in two-dimensional data), leaving only one degree of freedom.

7. Discussion

In the beginning of this work, three main research questions were raised; who were the Hyksos, where did they come from and where did they go. These questions were approached from the perspective of skeletal and dental information (section 7.2) and contextualised using the available archaeological record (sections 7.3-7.7). First, however, it is pertinent to discuss the limitations posed on the study by the material and analytical tools (section 7.1).

7.1 Material and methodological considerations

There are two considerations that must be taken account in the current study; regardless of the method, the results are representative of the *samples and their relation (1)* as well as the *informativeness (2)* of the variables used in the analysis. The sample limitations, together with methodological limitations, must be taken into account when interpreting the results.

In the very beginning of this thesis, for the sake of the analysis, the investigation of the “Hyksos population” was extended to all the inhabitants of Tell el-Dab’a from the Middle Bronze Age. Now, a distinction must be made to fully understand the results and its limitations. The majority of Tell el-Dab’a samples in this study derived from the Area A/II. Despite having some wealthy burials (including equid and weapon burials), it has been regarded as a non-elite burial ground (Mourad 2018). Only few individuals from Area F/I, the suspected higher status burial ground, were appropriate for analysis, but the volume of missing data prevented any meaningful statistical analysis comparing it to Area A/II or other sites.

Though Area A/II represents the largest cemetery at the site, it is by no means the only one. Previous researchers have argued that the different tells should be considered separately (Priglinger, in press). There is no way of knowing whether the tells represent (minorly) different ethnic enclaves with potentially different migration backgrounds without acquiring a large enough sample size from all the tells.

There is also a lack of data from other Eastern Delta sites with similar shared cultural characteristics. Serious efforts were made in the current study to include other sites to the analysis, but bureaucratic and logistic requirements were insurmountable. If dental nonmetric data ever becomes available from other Second Intermediate Eastern Delta sites, the current data from the Hyksos capital could be expanded into an analysis of the Hyksos kingdom population structure.

Another unfortunate gap in the dataset was the lack of material from some of the major Middle Bronze Age sites, including Byblos, a key trade partner with Egypt throughout the Pharaonic era. After extensive inquiries, it was clear that the material no longer existed and had in fact been disposed by the original excavator. Until new burials from this time period are found from Byblos, the question of Byblos' involvement with Avaris will remain open from a biodistance perspective. Other sites, such as Kamid el-Loz (identified by Winkler and Wilfing 1991), Ashkelon and Kabri may become available for biodistance analyses in the near future.

In addition to missing sites, it is also important to acknowledge the content of the acquired sites, i.e. who in the community does the sample represent. This study contained samples of all sizes, consisting of few (elite and non-elite) burials to full cemetery samples (namely, Sidon). Samples create distinct groups not only on the basis of anthropological but also temporal and geographical differences. An entirely synchronic assessment of sites, narrowing the comparison only to MBII, was not possible or necessarily appropriate for the current research questions. Assigning specific dates to burials can be challenging, requiring radiocarbon or other absolute dating, if not completely impossible in some cases. It would have left very little comparative material, as well as placed the selected material under further scrutiny due to the issues in chronological synchronisation. Furthermore, limiting the time period too precisely would not have served the current line of questioning, regarding provenance and potential relocation destinations. The expansion to cover Bronze Age from EBA to LBA can explore this process and still retain meaningful synchronic information of the relationships between sites.

Missing data was a considerable issue in this study. When recording features from the whole dentition (not just the main teeth used for statistical analysis), missing data accounted for circa 90% of the dataset. The selection of mean measure of divergence (MMD) as the main statistical tool was able to combat the issue by employing frequency tables, but even this method has pre-requisites, regarding inter-trait correlation and observation counts (more than ten per trait). In the latter case, a decision had to be made whether to omit the variable with too few observations, omit the site or to pool close-by sites to retain both sites and variables. The former options left very little material available for analysis (see appendix A11 for a site-specific frequency table), making the last option the only viable one. In some cases, the original data had been published using different breakpoints and alternatives were not accessible.

The Gower method can generate a distance matrix even when the original dataset has large number of missing values. However, when missing data are too prominent in the original dataset, the resulting distance matrix can also contain missing values, preventing the application of some statistical tests from running, including partitioning around medoids. In the author's experience, the dataset could generate a complete (no NAs) distance matrix when under 30% of the values were missing. Though not the ideal circumstance, having to omit large portions of data, the method did enable at least a partial investigation of the sites.

Geometric morphometrics, on the other hand, cannot account for any missing data. Individual coordinate points can be estimated for fragmentary specimens but the configurations can only regard features that are shared by all specimens. The result is wholly dependent on the configuration. For the current study, geometric morphometrics did not produce distinct groups. Together with the Gower distance coefficients and MMD, the analyses highlight the high degree of similarity shared by the different populations and the importance of creating and retaining informative variables to make meaningful distinctions.

The biodistance analysis, therefore, can only comment on the provenance and structure of the Tell el-Dab'a population in light of the populace of Area A/II. Even for this interpretation, the sample size was fairly

limited (n=80), considering the nearly four hundred burials published from A/II alone. Fortunately, the sample was random, representing all demographics from all time periods and thus making it possible to regard it as representative of the cemetery. Though limited, the joint consideration of archaeological and dental nonmetric data did produce interesting results, shedding further light on the emerging eastern Mediterranean network.

7.2 Biolodistance evidence

The first biodistance analysis on Tell el-Dab'a was conducted by Winkler and Wilfing (1991) reported a connection between Tell el-Dab'a males and the Iron Age Kamid el-Loz (Winkler and Wilfing 1991, p. 95). Due to the preservation of Tell el-Dab'a material and the availability of comparative samples from the region, the Tell el-Dab'a sample was small and the comparative sites ranged widely in their dating. Despite the temporal discrepancy between Tell el-Dab'a and the Kamid el-Loz sample, circa thousand years apart, the result likely represents a true similarity between Tell el-Dab'a and the Levantine region, seen also in this study employing contemporary sites. When Randl and Großschmidt (2002) conducted their study on 37 subadults using ASUDAS, there was little dental nonmetric trait information available from contemporary eastern Mediterranean sites for a comparative, multivariate study. As a result, the study found the closest connection between Tell el-Dab'a and northern Africa and West Europe looking at agreement between frequencies. No sites from the eastern Mediterranean were included in the comparison.

The current study found no significant changes between the 13th and 14th dynasties and the 15th dynasty. The result was acquired not only from the robust MMD analysis (MMD=0.007, 2SD=0.116), considering trait frequencies, but also from the Gower distance analysis which regarded the Area A/II individuals according to the raw (non-dichotomised) data (tables 18-19, figure 15). The find supports the archaeological interpretation of site continuum, at least from the Middle Kingdom stratum G to the Hyksos period stratum D/2.

Morphologically, the individuals exhibited no preference by burial location, time period, phase or stratum (tables 25-26). There was a potential division by sex, as males and females appeared to fall into different groupings (table 21). However, the division could be coincidental due to small sample sizes ($n=1-11$) and should be regarded with caution. The largest subgroup, SG4, contained both males and females, and subgroups also had subadults.

A comparison between Tell el-Dab'a and contemporary Egyptian sites (table 29, figure 29) suggests the former to be significantly different from the latter. The result was further supported by the stable isotopes results, identifying a large number of Tell el-Dab'a individuals, and a statistically significant portion of females, as non-locals (Stantis and Schutkowski 2019). The stable isotopes results, together with the tentative distinctions observed in the intra-site cluster analysis, could suggest different migration strategies for Tell el-Dab'a males and females. Differences in migration strategies between males and females have been reported before in both genetic and anthropological studies (Brettel 2008, Campbell and Barone 2012).

The data collected not only from Tell el-Dab'a but comparative sites enabled an exploration of migration and movement in the Near East during Middle Bronze Age. Inter-site MMD results placed Tell el-Dab'a individuals close to the Levantine sites (tables 29, 31 and 33, figure 29), particularly Ugarit and Pella. When analysis was focussed on sites showing greatest potential, the mean divergence by traits dropped very low in comparison to the other tests, suggesting little variation between the sites. In this case, the analysis found a remarkable similarity between Tell el-Dab'a and Pella (table 33), the latter consisting mostly of dental material from the MBA-LBA Tomb 62. Further testing showed that excluding the few other MB burials from the Pella dataset (leaving only Tomb 62) did not change the results.

When moving from MMD group analysis to comparing sites by individuals using the Gower distance matrix, did not find as distinct differences between sites (table 34, figure 32). Further cluster analysis divided the data into two morphological groups which could not be defined with specific regions, which could suggest population mixture in the Levantine area and potentially along very specific trade routes (table 35, figure 37). The majority of Tell el-'Ajjul individuals cluster with the majority of Sidon, Jericho and Ugarit

individuals (from Ras Shamra and Minet el-Beida). Further analysis could have looked into more time-sensitive changes (tracking movement from MBIIA to MBIIIC) but this would need more samples from very secure dating conditions. The close connection between Tell el-‘Ajjul and Dra’ Abu el-Naga’ cannot be explained without further investigation, but due to the lack of documentation by Petrie and Mariette the enormity of the task falls outside the scope of this study.

The incompleteness of the data did not allow for an in-depth exploration of individuals. The strong overlap of sites in the principal coordinate analysis (PCoA) conducted on the Gower distance matrix likely resulted from this issue and the involuntary exclusion of dental traits (figure 32). Due to the volume of missing data this project had to manage, the retained traits were visible even in heavily destroyed teeth and consequently often the most common structures, observed in every individual to some degree. The most informative traits were often unobservable, causing a severe limitation to the analysis relying on variation. PERMANOVA and PERMDISP2 results may have been affected by small group sizes which limit the spread (dispersion) of the groups, particularly for eras and phases. The PCoA plot of the 13-14th dynasties and the 15th dynasty (figure 14) demonstrated the issue, as the lack of data points from the 15th dynasty Hyksos period may have caused the group to spread as wide (or wider) along the PCo1 axis as the earlier group but not along the PCo2.

An interesting consideration, potentially useful to the current study as well, was the observation made by Delgado et al. (2019) when comparing the DNA and dental nonmetric trait data of admixed Colombians (section 3.1.2, table 5). When regarding groups, the MMD analysis used by the project was fairly accurate but did not apply to individuals to the same degree of success. If dental nonmetric traits lose some of their effectiveness on an individual level in samples with potentially high levels of admixture, it could be another compounding factor in the amount of overlap seen in the Gower distance PCoA plots comparing the Levantine sites (figures 32 and 37).

Though the study was focused on Tell el-Dab’a and its position in the eastern Mediterranean network, some observations could be made on the comparative sites based on the biodistance analysis. Regions further from the

Levant were also more distinct from the rest in the MMD analysis (table 29). Neither the Middle Bronze Age material from the Khabur basin (Barri, Tell Arbid, Tell Brak, Tell Mozan) nor the Middle Bronze Age – Late Bronze Age material from the Euphrates river valley (Mari, Ashara, Tell Masaikh and Jebel Mashtale) showed close affiliation to other sites in the analysis.

The Mari texts represent a wide commercial network, trading both locally (agricultural products and crafts work such as oils and wine) and regionally (exporting local products and lapis lazuli, controlling the distribution of tin and importing copper) (Alexander and Violet 2015, Leemans 1960). An mtDNA study carried out on four individuals from Tell Masaikh and Tell Ashara carried haplotypes found in modern populations in Tibet, the Himalayas, India and Pakistan but not in modern Syrian populations (Witas et al. 2013). The dating of these remains was wide, from Early Bronze Age to the Roman period (circa 2500 BCE – 500 CE). The dating limits interpretations for the current study but does emphasise the region's continuous status as a recipient of migrants. A dental nonmetric trait analysis comparing time periods (Early Bronze Age, Middle Bronze Age, Early Iron Age with Neo-Assyrian period, Classical-Late Antiquity, Early Islamic period and Modern period) in Tell Ashara, Tell Masaikh and Jebel Mashtale did not present any significant changes in the population structure until the Modern Period (Sołtysiak and Bialon 2013). The results from the mtDNA study together with the dental nonmetric studies (both this and the one by Sołtysiak and Bialon 2013) suggest less migration from the Euphrates sites to the Levantine area, at least during the Middle Bronze Age. Unfortunately, there was no satisfying way to divide these sites into separate entities without drastic loss of traits, making the statistical analysis non-informative.

The significant divergence of the Euphrates and Khabur basin sites has further implications for Ugarit as well, another site with a much-discussed population provenance issue (section 4.6). The dental nonmetric trait analysis of the Ugaritic Middle Bronze Age population clusters with the other Levantine sites, supporting the Canaanite theory as the biological “origin”. The sample size (n=53) was fairly small, however, and only a portion of the site has been excavated (Pardee 2002).

Surprisingly, Lachish showed no close biological affinity to the other geographically close sites (table 29). The current debate of Lachish concerns the very issue of population ethnicity and provenance (Ullinger et al. 2005). Archaeological evidence has been reported to record a disruption in the transition from the Bronze Age to the Iron Age (Dever 1990), but its nature has remained elusive. The high diversity count could be a consequence of pooling data from both Bronze Age and Iron Age to gain a large enough sample size. However, a previous study on the Lachish Bronze Age – Iron Age transition using ASUDAS was conducted by Dicke-Toupin (2012) who found no biological difference between the time periods. Further excavations are currently underway in Lachish, pursuing to shed more light into the population history of the site.

The results of the intra-site and inter-site analyses, presented in this section, have begun building the narrative of Middle Bronze Age movement and its connection to the occupation of Tell el-Dab'a. The following sections consider the archaeological evidence even further, as seen through the results of the biodistance analyses.

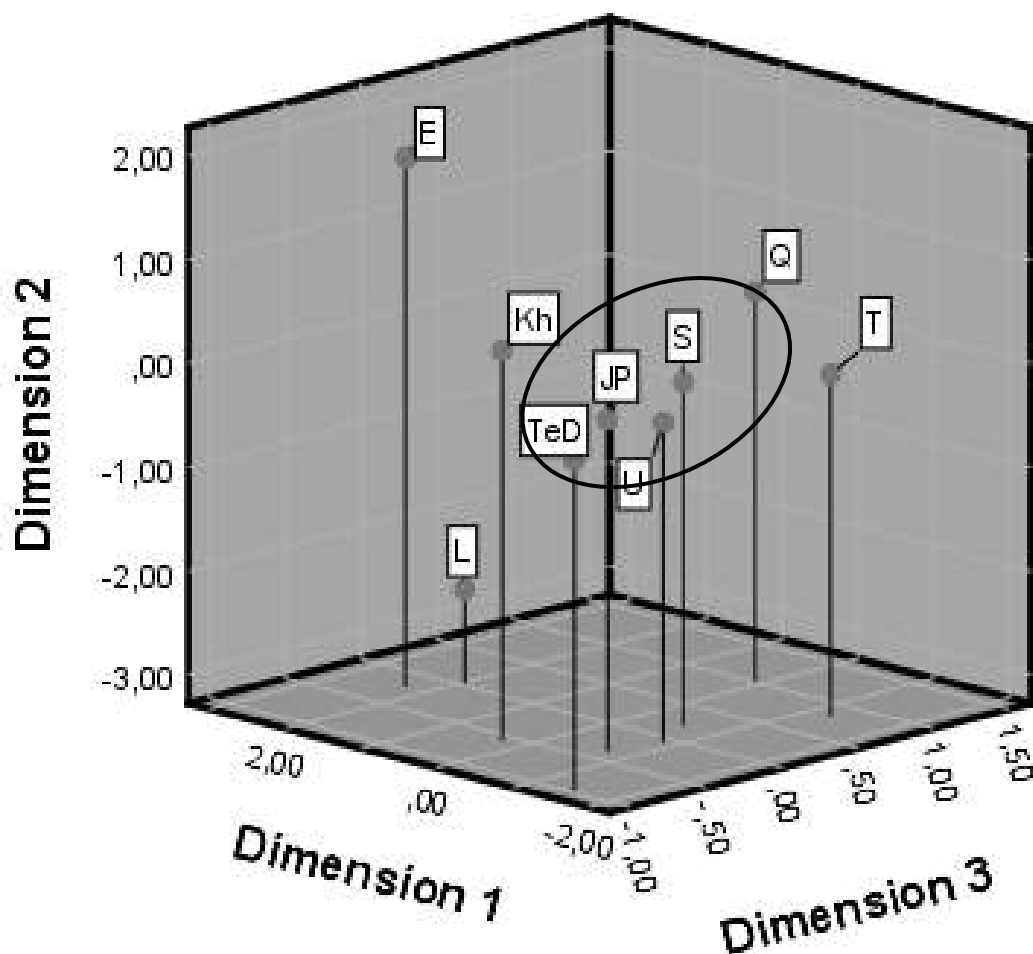


Figure 46. MDS plot of MMD values. Dimension 1 explains most of the variation. The SPSS procedure ALSCAL does not calculate overall importance of dimensions without weighting the proximities, which could not be provided for the current analysis..L= Lachish, Q=Qurna, T=Thebes, TeD= Thebes, S=Sidon, JP= Jericho and Pella, E= Euphrates (Tell Ashara, Jebel Mashtale, Tell Masaikh, Mari), KB=Khabur basin (Arbid, Barri, Brak, Mozan), U=Ugarit (Ras Shamra, Minet el-Beida, Tell Sukas).

7.3 The rise of Avaris

Disruption events in the archaeological record are identified as sudden changes in material culture, customs or settlement structures (including any sudden abandonment or destruction) (Tsuda et al. 2015). Mourad (2018) has identified key periods of change in Tell el-Dab'a, most evident in stratum G. An Egyptian-style administrative building (and the associated garden tombs) was constructed in Area F/I during stratum d/1 (=G/4) but quickly abandoned at the end of the same stratum. From the building, a cylinder seal depicting the storm god Ba'al was found. The destruction of the Asiatic statue (elaborated further in chapter 4) also likely happened by the end of stratum G.

A building complex in F/II was destroyed by fire circa strata d-c/2 (=G), though the reason behind the fire cannot be discerned. The period also marks a unification of burial customs, decreasing from the diversity observed in strata d/1-2 (=H-G/4). Pits discovered at the palatial complex of Area F/II contained the remains of severed hands, a fragment of an Akkadian cuneiform tablet and the earliest evidence of a full horse burial, dating to stratum c/2-1 (=G/1-3). The end of stratum was marked by shallow pit burials, viewed as potential evidence of an epidemic (Bietak 1996, p. 35).

Strata b/2-3 (=F-E/3) exhibit greater social differentiation in Area F/I. A seal impression with the title “ruler of Retjenu” was discovered from the F/II palatial complex. Temple III, dedicated to a god worshipped in Near Eastern customs, was built in Area A/II and remained in use until the end of the Hyksos period (Forstner-Müller 2010, Mourad 2018). The space became a sacred precinct and a cemetery, though the latter was covered by settlement structures due to the expanding housing requirements later. MBA pottery finds continued to gradually increase along the settlement size and the local Levanto-Egyptian (Bietak and Aston’s 2004 branch L) emerged.

The archaeological record could be interpreted as signs of disruption in stratum G, causing notable changes particularly in Areas F/I and F/II, while the transition to the Hyksos period indicated no drastic changes (Mourad 2018). If there ever was a sudden introduction of larger numbers of foreigners, this may have been the time it took place. Migration can also cause disease outbreaks in the migrating and target communities by experiencing lowered immunity due to stress factors in the former and by introducing new pathogens for the latter (Burmeister 2000). Immigration stress, in conjunction with a possible disease outbreak and the increased population density (also adding to the efficacy of disease spread) may have caused the shallow pit burials discovered from stratum c (=G).

Unfortunately, the number of individuals from stratum G was limited and non-existent from earlier strata, making statistical analysis impossible. The few individuals available for Gower distance analysis clustered with individuals from other time periods, suggesting continuity from stratum G onwards (table 21). The sample numbers were sufficiently large to compare the 13th and 14th dynasties with the 15th dynasty and then compare the site

with other ancient Egyptian populations. The dental nonmetric data supports the archaeological evidence of uninterrupted occupation by people who were not of local origin (table 29). The contemporary Egyptian sources from Upper Egypt and el-Lisht were drastically different from the Tell el-Dab'a sample which instead showed closer affinity to Eastern Mediterranean sites. Strontium isotope results from the same samples recorded a high frequency of non-local signatures during both pre-Hyksos and Hyksos periods, particularly among females (Stantis et al. 2019). Though the isotope analysis could not tease out more detailed results (due to the homogenous bedrock in the region), the parallel results produced by the different lines of questioning offer strong evidence for the presence of a migrant population which was already in place during the Middle Kingdom and continued to receive individuals from similar (or same) source populations.

Whether the first occupiers prior to stratum G were Egyptianised Asiatics, moving in to Tell el-Dab'a from other Egyptian sites, or first-generation movers from different areas of the Eastern Mediterranean, cannot be estimated without further material from the very early stages of the 12th Dynasty. What can be discerned is that from stratum G onwards, the beginning of the 13th dynasty, non-locals were taking residence at the site and were free enough to maintain their own cultural markers.

The Asiatics in el-Lisht provide an interesting contrast. They formed a smaller, subordinate group that was effectively assimilated into the local populace, making them nearly invisible in the archaeological record. The most notable signs of Asiatics working in the 12th dynasty town are onomastic sources and the indirect evidence presented by the imported goods (discussed in chapter 2). Meanwhile in Tell el-Dab'a, small numbers of handmade MBI cooking pots, used in local food production (Bader 2012, Mourad 2018), have been found from 12th dynasty layers and reflect a certain level of freedom to continue non-local traditions. The ability to maintain identity through material culture is connected to the size of the population and the level of control practiced over it. The Asiatics of el-Lisht and Tell el-Dab'a may have been partially contemporary but acted under different realities.

7.4 The movers and the shakers - reconstructing the network

In regions where textual evidence has been abundant, mobility and migration studies have played a minor role in archaeological investigations (Bader 2008, Dommelen 2014). However, written sources are challenging as potentially misleading, both intentionally and unintentionally. In the case of the Hyksos, there is little available textual evidence produced by the rulers themselves. Instead, the majority of known written sources are *etic*, deriving from the Egyptian perspective, and the implications of this rhetoric have not always been considered enough (Ryholt 1997: 147-9, Leprohon 2014: 309-11).

The many theories of Hyksos provenance were briefly touched upon in chapter 2, ranging from ethnic assignments given by Josephus to the more recent speculations. The description was kept short to avoid over-saturating the following chapters with various theories, leaving a more in-depth commentary for the final discussion. As mentioned previously, the discussion of the Hyksos identity has often been temporally ambiguous, mixing entities and polities from Early Bronze Age to Late Bronze Age. Here the theories are limited to ethnic groups that existed during Early Bronze Age – Middle Bronze Age in order to answer the question who the Hyksos *were*, not who they *became*. There are few common propositions for the Hyksos provenance, regarding Amorites, Hurrians and Canaanites (Levantine populations).

The Hurrians were a group from northeastern Mesopotamia, speaking Hurrian language, who migrated to northern Syria and Anatolia circa 2000 BCE and possibly further along the Mediterranean coast later (Stein 1997, p. 126). The Hurrian heartland resided in the Khabur river valley in northern Syria, in cities such as Urkesh (circa 4th millennium-1350 BCE). Later, Hurrians and Amorites formed the kingdom of Yamhad (circa 1800-1500 BCE) around Aleppo. Little is known of the extent of the Middle Bronze Age Yamhad but together with the kingdom of Qatna, it covered the whole of Western Syria (Pitard 1998, p. 40, Thuesen 2000, p. 60).

The sites from the Syrian Khabur basin, used in this study, combined the Early Bronze Age – Middle Bronze Age samples from Tell Arbid, Tell Brak, Tell Barri, Tell Mozan (ancient Urkesh) and Tell Leilan for statistical analysis. The sites exhibited significant divergence from the other samples (table 29). This suggests that the ethnic distinctiveness of the Hurrian culture also

extended to biological closeness, at least relative to the samples (and dental traits) used in this study.

The Amorites were a Semitic-speaking people from Syria and northern Mesopotamia, mentioned first in Sumerian texts circa 2600 BCE, who spoke a northwest Semitic language (Silver 2000, p. 41, Streck 2011, p. 452). Sumer, Akkad and Assyria described the Amorites as nomads, residing west of the river Euphrates though the exact borders of the Amorite influence are unknown (Buccellati 1997, p. 108). Amorite chieftains were able to take down city-states and establish new ones, such as Mari, Yamhad and Qatna (Buccellati 1997, p. 108, Buck 2018, p. 309). The Amorites disappear from historical records circa 1200 BCE (Streck 2011, p. 452).

The combined samples from sites along the Euphrates river, Tell Ashara (ancient Terqa), Tell Masaikh, Jebel Mashtale and Mari (Nassar 2010, Sołtysiak and Bialon 2013), exhibited significant divergence from the rest of the comparative sites (table 29). This result, together with the mtDNA analysis conducted by Witas et al. (2013), suggests the population likely contained elements not present in the other samples closer to the Mediterranean coast.

Lastly, are the so-called Canaanites which refer to several smaller populations along the Eastern Mediterranean coastal region. Other terms are intermittently used, such as the Levantine area or the Syro-Palestinian area. Here, the term Levant/Levantine is used to avoid the more specific regional and ethnic associations connected to the term Canaan/Canaanite. Though there are no clear boundaries marking the Levantine cultural area, it has been estimated to have spread from the southern Wadi al-'Arish north of the Lebanese mountain range and to Jordan in the east (western margin being defined by the Mediterranean) (Hackett 1997, p. 409). Levantine culture had taken shape by the beginning of the Middle Bronze Age (2nd millennium BCE), and the region was first mentioned in Mari texts and in Egyptian Execration texts circa 19th-18th century BCE (Na'aman 2005, p. 111, 178). These Levantine populations belonged to the northwest Semitic language family and used several writing systems, among them the Late Bronze Age linear alphabet, which developed from Proto-Sinaitic and -Canaanite iconic scripts and has been found in both forms from Lachish and the Sinai mining sites (Goldwasser 2016, p. 119).

This study used comparative data from several sites from the Levantine region, including Ras Shamra, Minet el-Beida, Tell Sukas, Arqa, Tell el-Fadous, Sidon, Jericho, Pella, Lachish, Tell el-'Ajjul and Tell el-Far'ah. Some of the sites had low sample sizes, hindering statistical analyses, but all sites were present in some step of the investigation. The archaeological evidence presented from Tell el-Dab'a (chapter 2 and 4) alone makes a strong case for a Levantine origin for the population, though no consensus has been reached over the exact provenance of the Tell el-Dab'a population. Compelling arguments have promoted both northern and southern Levantine origins (e.g. Ben-Tor 2007, 2010, Bietak 2010, Kopetzky 2012).

Based on the material available mainly from Area A/II and to a lesser extent from F/I and ranging from stratum G to D/2, Tell el-Dab'a shows the greatest biological affinity to Pella in the southern Levant (table 29 and 33). The combined Ugaritic sites (Ras Shamra, Minet el-Beida and Tell Sukas) also suggested close affinity with a more limited group of traits in the larger pool of samples (table 29). The visualised distances between sites (figures 29 and 46) shows Tell el-Dab'a clustering with Pella, Ugarit and Sidon, the latter two falling far enough to be considered significantly different in the later analyses with a larger set of dental traits (table 33).

The majority of the Pella sample data (circa 80%) derives from one tomb, dated to MBII-LBI (late Middle Bronze Age – early Late Bronze Age). Tomb 62 is the richest Pella tomb to date, with a count of 1200 vessels, including a collection of the Southern Levantine Chocolate on White ware (produced during MBII-B-LBIB) and three Cypriot vessels, as well as stone vessels, bone inlaid boxes, bronze weapons and jewellery and other personal items (Smith and Potts 1992, p. 70). The tomb also had over 50 scarabs attested to the so-called Hyksos design, defined by swirling patterns and stylised hieroglyphs. Three of the scarabs contained the cartouches of the Hyksos king Apophis Aawoserre, Ya'ammu Nubwoserre (whose dating is currently uncertain, see Beckerath 1964, p. 139, Ben-Tor et al. 1999, p. 58, Ryholt 1997, p. 200, Tufnell 1984). The third scarab was assigned to the last ruler of the 17th Dynasty Thebes, Kamose Wadjkheperre, though more recent publications have suggested alternative readings (see Boschloos 2014). Due to lack of precious items, despite the large quantity of pottery, Smith and Potts

(1992, p. 70-1) have suggested that the tomb may have been a secondary burial site into which smaller tombs from the site were moved. Commingled multiple interments have been recorded from sites across the Levant and formed a special mortuary practice (e.g. Kurth 1962, McGovern 1986, Sheridan et al. 2014, Spronk 1986, Ullinger et al. 2005). The archaeological record of the MBA/LBA Pella is obscure due to the removal of deposits during the early LBA to make room for a large building, identified as an Egyptian Governor's Residence (Bourke and Eriksson 2006).

The strong material connections between the 15th dynasty and the southern Levant do not appear to extend to Pella, and yet the current analysis distinguished the site from all other Southern Levantine sites. The most likely explanation would be to assume a specific route of movement, invisible due to a gap in the dataset. The dating of Tomb 62 limits the reconstruction of a series of events but based on the archaeological and biological data as a whole, it is possible to make some suggestions.

The study of the archaeological record draws a reoccurring pattern between Cyprus, the northern Levant (specifically, Ugarit), the Southern Levant and Tell el-Dab'a. The similar patterns created by Cypriot and Tell el-Yahudiyah ware types suggests the two elements were intertwined in trade, possibly due to their role in copper (and tin?) trade. Trade connections to the north-eastern Mediterranean increased during the Middle Kingdom. Ugarit's intermediary role between the Syrian inland and the Mediterranean trade networks are also visible in the earliest ceramic imports in the Southern Levant (Van Seters 1966, p. 22). Fueled by trade, and possibly the manufacturing of bronze and bronze objects, Ugarit's influence has been noted from Cyprus, the Levant and Tell el-Dab'a (Kempinski 1997, p. 328). Evidence from Ras Shamra suggests the site was already manufacturing finished bronze artefacts during MBIIA (Yon 2006, 16), coinciding with the Egyptian 12th dynasty. Tombs and settlement layers from Ras Shamra have yielded precious Egyptian artefacts, including two fragmentary sphinges of Amenemhat III from the foundation deposit of a temple dedicated to Ba'al (Buck 2018, p. 122). The changes observed from Tell el-Dab'a material culture, architecture and spatial organization during stratum G suggest an early emphasis on northern connections (Bietak 1996, p. 59).

During the MBIIA, southern Levantine occupation began with sites along the coast, the most conducive areas for communication, trade and agriculture, before spreading further inland, particularly in the Jezreel Valley and the southern wadi systems (Cohen 2002, p. 137, Oren 1997, pp. 255-7). In the following MBIIA-B, the number of smaller settlements began to increase. Statistical analysis of the settlement types by Falconer and Savage (2009, p. 135-6) showed the Southern Levantine settlements to consist mostly of modestly hierarchical local polities that “were fueled primarily by ever-shifting rural settlements in a dynamic countryside” (Falconer and Savage 2009, p. 151). Instead of centralized polities, network formation may have been guided by market exchange, forming a dendritic system where the strongest exchange partner was the closest node in the system (Cohen 2002, p. 24, Stager 2001). Fortifications at sites along the Jordan Valley, such as Pella, reflect the use of these routes (Cohen 2002, p. 137).

Sedentary settlement formation continued to increase in number, though not in size during the Middle Bronze Age and Late Bronze Age (Falconer and Savage 2009). In the coastal area, this result is consistent with out-migration, and the proliferation of coastal towns may support the theories regarding maritime trade between Egypt and other towns north along the Levantine coast. Falconer and Savage (2009, p. 130) believed the periods of prosperity in the southern Levant were promoted by political uncertainty in Egypt. Indeed, the lack of large organized campaigns by the Egyptian military may very well have made the area more stable for the local occupants. The Port Power model introduced by Stager (2001) and explored further by Cohen (2002, p. 137-8), suggests coastal network formation was organised around natural transport systems and promoted into further urbanization and independence because of intensified trade networks. Wealth from these ports spread along trade routes further inland, following the dendritic system.

At the start of the 15th dynasty Hyksos period, MBII-B-C, the imported and exported material corpus shifts to Southern Levant. Similar distribution patterns have been proposed for weapon types, 14th dynasty scarabs and ceramics for the Southern Levant and the Nile Delta (Philip 2006, p. 233, Ryholt 1997, p. 115, McGovern 2000). Philip (2006, p. 233) connects the stylistic developments with periods of economic growth. The locally produced

Tell el-Yahudiyah ware (branch L by Aston and Bietak 2004) has been found from sites along the Nile River, in the Southern Levant and Cyprus (Bietak 1997, p. 96 figure 4.7). The hybrid shape (branch M by Aston and Bietak 2004), born from contact between Tell el-Dab'a and the Southern Levant, has only been discovered from few sites to date, including Jericho, Lachish, Megiddo, Ashkelon and Tell el-'Ajjul (Aston and Bietak 2004).

Ras Shamra also entered a new phase of urban development which Schaeffer (1938, p. 197) has described as "the invasion of the Hyksos" due to the shared material culture and glyptic motifs. Although ideas have been updated since, it does demonstrate that cultural contacts were already in place during the Middle Kingdom and continued in some form even during the Hyksos period. Ugaritic fortifications, dating to the MBII B-C, resemble other contemporary coastal towns, such as Byblos, Beirut and Ashkelon (Burke 2008, p. 223). Though relations between Tell el-Dab'a and Ugarit waned during the Hyksos period, in light of morphological evidence, Ugarit's connections to the Levantine coast appear to have remained intact. The network also provides a model for interpreting the unusual connection between Tell el-Dab'a and Pella.

Shared material culture between Tell el-Dab'a and Pella is scarce, consisting most abundantly of the finds from Tomb 62, described as "a view from the margins" (Bourke and Eriksson 2006, p. 339). In addition to the material evidence, Pella has not generated any evidence of equid burials; these have been considered one of the key markers of the Tell el-Dab'a elite (Philip 2006). On the other hand, the majority of the comparative Tell el-Dab'a sample comes from the Area A/II, not considered an elite cemetery (despite having some associated weapon and equid burials).

Pella shares material culture particularly with Tell el-'Ajjul (Bourke et al. 2006, Eriksson 2001, Richards 1992, pp. 43-4), one of the potential locations for the fabled Sharuhén, the last Hyksos stronghold conquered by the Theban king Ahmose (Bourriau 2000, p. 197). Tell el-'Ajjul's position next to the Wadi Gaza allowed an ancient harbour and small vessels to reach the city (Fischer and Sadeq 2000). The goldwork and other luxury items found at the site together with the vast amount of Cypriot imports allude to its position as a main trading centre in the southern Levant (Fischer 2003, p. 290). If Pella was

closely affiliated with the ancient Sharuhen, it could explain the Egyptian presence at the site during the Late Bronze Age mainly visible in the Egyptian-style administrative building and the Fortress Temple.

Tell el-'Ajjul, founded during MBIIA and fortified in MBIIIB, is believed to have been one of the buffer towns to the coastal site of Ashkelon, a major harbour town during the Bronze Age (Burke 2008, p. 132). Kempinski (1992, p. 125) regarded 'Ajjul's orthogonal layout to suggest the site was a planned settlement rather than an organically formed one. Sealing finds from Ashkelon have been interpreted to reflect contacts with Tell el-Dab'a, and some attempts have been made to synchronise the chronologies from Ashkelon and Tell el-Dab'a (Bietak et al. 2008). Tell el-'Ajjul was not only the southernmost of Ashkelon's secondary fortified settlements (Burke 2008, p. 132) but also the first major settlement encountered when approaching Ashkelon from Egypt along the Road of Horus, the ancient highway connecting Egypt and the Levant (Hoffmeier and Moshier 2013, p. 488). Its location along two important transportation routes may have given Tell el-'Ajjul an additional advantage when conducting trade.

The site was an active trade centre during the MBIIIC-B. The Cypriot ware found from Tell el-'Ajjul is the most diverse outside of Cyprus (Bourke and Eriksson 2009). Both weapon and equid burials are well-attested from the archaeological record of Tell el-'Ajjul (Prell, in press, Wapnish 1997, p. 349-50), as well as some of the more unique forms of pottery shared particularly between Tell el-Dab'a and Tell el-'Ajjul. A Neutron Activation Analysis (NAA) conducted on over 200 Canaanite jars indicated a Southern Levantine origin, most likely from Gaza, Ashkelon or Tell el-'Ajjul (McGovern 1997, pp. 151-2). Maguire has raised particular interest in the Proto White Slip ware that appears in Tell el-'Ajjul and Tell el-Dab'a before the end of the Hyksos period, suggesting there could have been a more direct line of trade between the loci (Maguire 2009, p. 87).

Drawing from the dendritic system model, the close material evidence between Pella and Tell el-'Ajjul could suggest the two were part of the same network where the former represented the tail end, "a view from the margins". Then, in align with the Port Power model, Tell el-'Ajjul, either directly or via Ashkelon, was able to increase its influence in the network, facilitated by the

movement of people and commodities. The movement of people, facilitated by trade and kin connections, along the trade route could explain how two groups with little shared cultural features share a morphological connection. The numerous points of contact between Tell el-Dab'a and Tell el-'Ajjul could also indicate a movement of people. Unfortunately, the small sample sizes and the amount of missing data from Tell el-'Ajjul limited the possible analyses, but these are opportunities for future research.

7.5 Tell el-Dab'a social organisation

The rich mortuary data provided an opportunity to combine material culture, burial practices, spatial organization and morphology to assess social organization and how the local social collective was generated and maintained. The question was approached from an ethnogenesis perspective, in which biological closeness is only one tool among many to assess kinship and negotiation of ethnic identity. Because the morphological analysis was conducted with a small sample size ($n=31$), the results should be considered tentative.

A slight connection between sex, morphology and weapon burials was noted. Philip (1995, 2006) has attempted to understand the Hyksos symbolic communication transmitted by weapons and "warrior" burials and their gradual disappearance. The first appearance of weapon burials in Tell el-Dab'a is linked to the wide regional concept of "warrior" leaders and unity of the social elite that becomes restricted to the Southern Levant in the Second Intermediate Period (Middle Bronze Age period MBII-B-C). Weapon burials are said to reflect status rather than true warriorhood which could explain, in its broadest definition possible, the potential 'familial' descent of the custom in Area A/II individuals l/16-4-1 and n/15-1-2 and m/10-8-1 and m/15-9-1 (table 21).

Despite the distinction between Tell el-Dab'a males and females, overall the differences were minimal, evident also in the overall MD values derived from the MMD analysis (section 6.4.1). Furthermore, the analysis did not detect any statistically significant patterns connecting morphology, material culture, burial practices or spatial organization.

To summarise, the A/II population was a homogenous group that did not cluster following any available biological or ethnic marker. It is possible the markers used in the analysis were *too common*, considering the morphological (and subsequent geographical) closeness of the sample under investigation. How was social unity generated and maintained in Tell el-Dab'a, particularly when the community was going through constant transformations?

The growth of Tell el-Dab'a led to transformed concepts of status, power and ritual (Mourad 2018). Ritual has been employed particularly by political leaders during times of change as it can affirm legitimacy during such periods of transitional stresses and be transformed into traditions that promote the new social order. The different ways of legitimising and maintaining group identity have been described as "short-term and long-term strategies" (Faulseit 2016, p. 7), with a plethora of modes identified by Mourad (2018) in her study of the Hyksos. The Hyksos may have enforced collective group identity through cultural customs, visible in the archaeological record in the shared mortuary customs.

A notable aspect is also the emergence of the local hybrid deity, Seth/Ba'al. The first evidence of the Near Eastern storm god Ba'al Zephon in Tell el-Dab'a is from a cylinder seal found in the palace quarters of area F/I (stratum d/1) (Mourad 2018). Later, the storm god became merged with the local Egyptian god Seth, providing the inhabitants with a common object of worship (Bietak 2007). The significance of religion in place-making community building has been noted across all fields (Brettel 2008, p. 134). The building of Near Eastern temple types and introducing new deities convey the ability to express identity, negotiated particularly through the religious sphere on a grand scale. The pan-Asiatic culture described by Philip (2006) and the widely spread worship of Ba'al across the Eastern Mediterranean suggest that identity could be generated and maintained even without site-specific shared customs.

Equid burials, discovered from Mesopotamia to Egypt, carry important information about the communities' customs. The diversity in the types of donkey burials (partial vs complete, with vs without associated human burial, foundation deposit, part of meat offering, etc) suggests that the donkey could be used to convey a variety of meanings. "Equids were animals of singular

importance, mediating some special role that even the more symbolically potent bull did not fulfil" (Wapnish 1997, 359).

Philip (2006, p. 238) believes equids had a particularly integral part in expressing status and leadership in the Nile Delta. Equids were a crucial part of mining and trading expeditions to the Sinai and Southern Levant. Tell el-Dab'a would have played part facilitating these excursions, making donkeys particularly prominent for local development and success. The donkey burial practice in Tell el-Dab'a even extended beyond mining activities, reflecting transformations in local concepts of elite status (Philip 2006, p. 239). Way (2010, p. 213) has expanded on Philip's notion, believing the quantity to imply a religious or ceremonial element. The donkeys may have been meant for use in the afterlife and perhaps even acted as the vehicles with which the journey was made. The cemetery pits with equid remains have been interpreted as communal offering pits for either clustering tombs or entire cemeteries by Schiestl (2009, p. 331) and Forstner-Müller (2008, p. 271). The earliest equid burials from Tell el-Dab'a, associated with I/12 Grave 5 and p/14 Grave 18 from Area A/II (stratum F, MBIIA-B), are contemporary or slightly later than the Tell el-'Ajjul equid burials (Wapnish 1997, p. 360). Wapnish (1997, p. 360) has suggested that the custom was transferred from Southern Levant and further influenced by local traditions.

Way (2010, p. 214) has sought parallels from Ugaritic texts describing grand sacrifices, including as many as 70 donkeys, for the funeral of Ba'al. The storm god may also provide an explanation for the incomplete equid burials associated with tombs, found in Tell el-'Ajjul, Tell Brak, Lachish and Jericho (Way 2010), as well as the offerings conducted near the Tell el-Dab'a temples (Forstner-Müller 2010, p. 132). Though the Ugaritic texts are from the Late Bronze Age, the traditions described by the texts have been assumed much older, mentioned already in Mari texts and centuries before (Pardee 2002). The southern Levantine equid burials were most often incomplete but still associated with specific human burials, possibly reflecting an offering made for both god and the deceased (Wapnish 1997, p. 359). The close archaeological (and potentially biological) connection between Ugarit and Tell el-'Ajjul could also imply a transference of ideologies and customs, adjusting to the pre-existing local community.

Another interesting feature is worth noting from Ugaritic mortuary practices. Angi (1971, pp. 80-1) draws a distinction between Northern and Southern Levantine burial customs. In the Ugaritic sphere, all men became objects of worship after death, maintained by the family unit through offerings (Angi 1971, p. 85). In the Southern Levant, though paralleling the Ugaritic tradition, ancestor cult distinguished special members of the community who could be venerated for generations (Angi 1971, p. 81). The lack of an ancestor cult in Tell el-Dab'a (Forstner-Müller 2010, p. 132-3) could potentially align with concepts from the Ugaritic tradition of family-focused worship, only practiced for a limited timeframe.

As A/II cemetery was meant for a more general populace rather than the ruling class, it is likely that this social collective was maintained by a (potentially more heavily unified) higher class buried elsewhere. Arnold (2010, p. 209) has suggested that the Semitic character of the rulers' names and the lack of statuary might indicate a rejection of previous attempts for a separate but essentially Egyptian east Delta identity. Interesting is also the designation, HKAw xAswt, used most prominently by the rulers themselves during the Second Intermediate Period (Candelora 2017). Candelora (2017) has hypothesised that the adoption of the term was a conscious effort to stand apart but also negotiate identity using familiar concepts, following the same reasoning as the stately acknowledgement of the Seth/Ba'al hybrid deity.

7.6 The landscape of Middle Bronze Age migration

What propelled people to migrate from the Levant? The high proportion of non-locals, even as first-generation movers (e.g. Stantis et al. 2019), in Area A/II suggest a constant flow of people from the Levant, from the very oldest to the most recent samples. Trade and migration form a dynamic process in which one promotes the other, but there are also other factors to consider, such as environmental changes and political turmoil (Tsuda et al. 2015).

The intra-cemetery analysis of Tell el-Dab'a individuals from Area A/II divided males and females into various groupings (both separate and joint groups), possibly indicating different migration strategies. Bietak (2010) has considered the migrating males as merchants, sailors and skilled workers,

moving along trade hubs. The continuous movement between Tell el-Dab'a and the Levantine sites generated kin networks which promoted further movement. From an anthropological and genetic perspective, these networks were often generated and maintained by women (Brettell 2008, pp. 125-6, Campbell and Barone 2012, p. 59). This could potentially explain the high number of migrating females detected by Stantis et al. (2019).

Site destruction or abandonment has been used to infer more about the events that took place during the Middle Bronze Age. According to Burke (2008, p. 101), northern Levantine military and political development was tied to Mesopotamia (clear also in the analysis of material culture), the latter posing a constant threat to the former, along with Yamhad and Qatna, from circa 2300 BCE onwards. The lack of competition between Levantine polities has been regarded as evidence of sufficient environmental resources, capable of accommodating the growing population (Burke 2008, p. 101). In the south, periods of destruction have been identified from MBIIA and MBIIIC-LBIA (Burke 2008, p. 98). There is no evidence of extensive Egyptian influence in the Levantine area during MBA: instead the archaeological and historical evidence suggested Egypt's presence was mostly trade relations and raid campaigns (Burke 2008, p. 100). The fortification of Southern (and northern) Levantine sites has been connected to the threat posed by closer sovereigns, such as Yamhad, Qatna, Hazor, Larsa, Eshnunna and Babylon (Burke 2008, p. 100).

The restlessness of the Mesopotamian region and the wide-spread abandonment of sites in the Near East during EBIV/MBI has been connected to the 4.2 ka event, though there is no full agreement among researchers (Clarke et al. 2016, Finkelstein and Langgut 2014, Kaniewski et al. 2008, Roberts et al. 2011, Rosen 2007, Staubwasser and Weiss 2006, Weiss et al. 1993). The 4.2 kiloyear event was one of the most drastic climate-related environmental changes of the Holocene, causing extreme draught in the entire region (deMenocal 2001, Wiener 2014). Though perhaps not directly, climate change may have been the instigator for wider fluctuation in polities, networks and movement of people. Local resource competition in Mesopotamia and population movement beyond the area may have created a domino effect that then swept across the Eastern Mediterranean, creating a

considerable “push” factor to seek economic and social stability elsewhere (Priglinger, in press).

Finkelstein and Langgut (2014) noted a change in precipitation levels during circa 2000-1800 BCE (referred by the authors as MBI) using pollen records from the Sea of Galilee and western shore of the Dead Sea, resulting in more arid climate conditions in both Northern and Southern Levant. The population depletion visible in the Levantine record coincided with the emergence of Asiatics in the Eastern Nile Delta (Finkelstein and Langgut 2014). In MBII-III, increased precipitation levels in the Levant helped local systems to recover and expand, particularly in the Southern Levant (Finkelstein and Langgut 2014). By this time, the connection between the Levantine sites and Egypt had been established.

Burke (2008, p. 100-1) has considered the emergence of small, unfortified settlements in the MBII-B-C southern Levant as some modicum of peace, allowing people to feel comfortable enough to settle beyond fortified large urban centres, despite the evidence of a “fragmented political landscape” (Falconer 2001, p. 282). Burke’s view holds well particularly when contrasted against the events of MBII-C-LBIA, when destruction (and sometimes abandonment) includes a vast number of major sites such as Dan, Hazor, Shechem, Beit Mirsim, Lachish, Tell el-‘Ajjul, Ashkelon, Gezer and Kabri (Burke 2008, p. 101).

Migration can also be an adaptive strategy by circulating resources, and “a migration mentality” can be so inherent that traditions, rituals and customs become associated with it (Tsuda and Baker 2015). For the Tell el-Dab’a population, migration was a familiar affair, invoked again by the siege and abandonment of the town. The tentative evidence of different immigration strategies could suggest emigration also took several forms. Some individuals possibly left for the Southern Levant, either by land or sea or both. Some may have left for other ports, which could be one potential theory (among many) for the appearance of Levantine burial customs in Cyprus at this period (Maguire 2009, p. 66). There is also the contemporary evidence to consider, alluding to at least some of the Asiatics remaining in Egypt. The biography of Ahmose, son of Ibana, mentions the receiving of slaves for his services to the Theban ruler (Breasted 1906, p. 7), and there is no need to assume he was a

unique case. A diverse vocabulary of Semitic words emerged in the beginning of the New Kingdom and is considered too banal to merely reflect mercantile connections (Hoch 1994).

7.7 Manetho in context

The sociocultural context of Manetho has been considered from an archaeological and historical perspective (Redford 1970), but the morphological information allows for an updated reflection of key elements of the account. Three passages, regarding origin, timing and exile, are remarked upon. The first passage (Waddell 1940, p. 79) from Josephus translates as:

"Tutimaeus [Dedumose II?]. In his reign, for what cause I know not, a blast of God smote us; and unexpectedly, from the regions of the East, invaders of obscure race marched in confidence of victory against our land."

Different interpretations have been considered on Josephus' wording, particularly regarding "obscure race". Van Seters (1966, p. 124) has regarded the phrase in literal terms, referring to unknown origin. The morphological and biomolecular analyses suggest Egyptians were well aware of the Asiatic elements prior to the collapse of the Middle Kingdom rule. This was also evident from the mercantile and military campaigns conducted along the Levantine coast, the Southern Levant and the Sinai (Bietak 1996, p. 19). Though mostly visible via onomastic evidence in historical records, Asiatics were employed in different positions in the Egyptian society (Bietak 2007, p. 421, Posener 1957, p. 152, Luft 1992, Schneider 2003, pp. 335-6). Egyptian luxury items have been found from foreign courts as tributary gifts (Buck 2018, p. 122, Dunand 1937/1939, p. 26-7), demonstrating the importance of trade for items such as wood and bronze.

There are also non-literal interpretations, instead suggesting a denominative meaning, aligning with the other pejoratives used for foreign leaders, such as vile (xsi) (Redford 1970). However, the "obscure race" is only mentioned in Josephus' version of the Hyksos invasion, whereas the two later historians Africanus and Eusebius merely state "they were foreign kings from Phoenicia" (Waddell 1940, p. 67). Josephus carries on (Waddell 1940, p. 79):

“By main force they easily seized it without striking a blow; and having overpowered the rulers of the land, they then burned our cities ruthlessly, razed to the ground the temples of the gods, and treated all the natives with a cruel hostility, massacring some and leading into slavery the wives and children of others. Finally, they appointed as king one of their number whose name was Salitis. He had his seat at Memphis, levying tribute from Upper and Lower Egypt.”

Though all accounts mention the seize of Memphis, only Josephus mentions a sudden invasion. The clear continuation observed in Tell el-Dab’a, together with the archaeological evidence from Memphis (discussed in chapter 2), place Manetho’s account of an invading population under further criticism. The magnitude of such an event would have surely been evident even in the Area A/II which had no interruptions in settlement, temple or burial activity. The changes visible in stratum G in Tell el-Dab’a also coincide with the 13th Dynasty when the Egyptian government began to exhibit signs of weakening control. The slack in governance allowed the town to develop more freely, as seen in the other regional centres across Egypt, with the eventual collapse of government sweeping away the last of the constraints.

Redford (1970) has seen the description as analogy, created by the invasions of Egypt which occurred closer to Manetho’s birth, such as the Ethiopian invasion in the 25th dynasty, the Assyrian and Persian invasions, and ultimately the conquest by Alexander the Great in 332 BCE. These were sudden military incursions, much like the described Hyksos invasion (Alt 1954). The folk tales, such as the Osarsiph Legend, the Apology of the Potter, Nectanebo and Alexander and the myth of Horus of Edfu, all follow an “invasion and liberation” formula which was in place at the time of Manetho (Redford 1970). Lastly, Manetho describes the exile (Waddell 1940, pp. 87-9):

“Thummosis, the son of Misphragmuthosis (he continues), attempted by siege to force them to surrender, blockading the fortress with an army of 480,000 men. Finally, giving up the siege in despair, he concluded a treaty by which they should all depart from Egypt and go unmolested where they pleased.”

The mention of a New Kingdom Pharaoh, Tuthmosis III further highlights the diffusion of unrelated events. Redford (1970) has argued that the texts of

Tuthmosis III have been heavily “borrowed” from Tuthmosis I, wanting to make his reign appear more innovative - his siege of Megiddo became Avaris, and the Levantine princes became the Hyksos and the people were allowed to leave safely (Redford 1970). Late 18th- early 19th dynasties omitted the Hyksos from official records, though the stories remained in oral history.

The Hyksos hovered just beyond the Egyptian politics but contributed to the motifs of invasion and provided a classical archetype of vile invaders. The foreigners were topoi for disorder and chaos, whose ritual killing by the Pharaoh maintained *maat*, order, and acted as legitimisation of power (Loprieno 1988, Riggs and Baines 2012). During the 18th Dynasty, the tradition shifted from vile Asiatics to vile Hyksos, coinciding with the introduction of Semitic words (Hoch 1994, Redford 1970).

7.8 Summary

The aim of this PhD was to assess Hyksos provenance and potential migration pathways using morphological data together with research conducted on the archaeological record. Three main research questions were posed for the study:

(1) Who were the Hyksos? There was no indication of change in population structure between the pre-Hyksos (13th and 14th dynasties) and the Hyksos period (15th dynasty), despite the individuals appearing different from contemporary Egyptians. The site appears to have received non-locals from across the region throughout its existence, exhibited also by the preliminary finds from stable isotopes studies (Stantis and Schutkowski 2019). The result was acquired from the robust MMD analysis and the Gower distance analysis. The latter test also suggested potential slight differences between males and females, but the differences were very weak and the sample sizes were small (n=1-11). The low sample size prevented comparing males and females using MMD.

(2) *Where did they come from?* According to the MMD analysis, Tell el-Dab'a individuals appeared close to Levantine populations (table 29, figure 29), particularly Pella (MMD=0.043, 2SD=0.128 in table 33). Pella material consisted mostly of material from Tomb 62 where also royal Hyksos scarabs were found (Bourke and Eriksson 2006). The connection between Tell el-Dab'a and Pella may have been direct, via the landroute discussed in chapter 2, or indirect, via a port town connecting the two into the same network. Despite Tomb 62, evidence of shared material culture is relatively low (discussed further in section 7.4). Furthermore, Tomb 62 appears to be a secondary deposition dating either to the end of the Middle Bronze Age or the beginning of the Late Bronze Age. The analysis focused on sites as a whole as samples were not large enough to support analyses by sex or other contextual information.

(3) *Where did they go?* The fate of the Tell el-Dab'a population remains uncertain even after this analysis, mostly due to material limitations. Particularly the dating of the Pella material places the site at a turning point in history, depicting either the Hyksos period or the time shortly after (discussed in section 7.4). Further research on both Pella and Late Bronze Age sites in the region are required for a reliable bioarchaeological interpretation. If the Tell el-Dab'a population followed several migration strategies when occupying the site, it is possible the dispersal after the attack and siege by Ahmose followed equally diverse routes. Considering the archaeological evidence from post-Hyksos Tell el-Dab'a and New Kingdom Egypt, at least some may have stayed (Hoch 1994, Redford 1970)

Four objectives were set to achieve the aim; (1) establishing comparative sites, (2) examining human remains from Tell el-Dab'a, (3) Recording and analysing biological distance and (4) pooling and synergizing results.

(1) Comparative sites were acquired across the region by accessing material curated by museums and projects or acquiring data from

published and unpublished sources. Though the current study was able to collect data from multiple sites along the Levantine coast and further inland, the list represents only a fraction of all the excavated Middle Bronze Age settlements. The incorporation of sites such as Byblos, Kamid el-Loz and Ashkelon, to name a few, into further comparative studies (by the author or future researchers) will shed more light on migration in the Levantine coast. The current study also did not have any comparative material from contemporary Cyprus. Though some assessments have been made incorporating Cypriot sites in temporally wider studies (Parras 2004), future comparisons focusing on the Middle Bronze Age trade hubs could offer further perspective into region-wide activities as well.

- (2) The human remains from Tell el-Dab'a were examined for dental nonmetrics. Any further biological information was acquired from the publications by Bietak (1991), Brink (1982), Forstner-Müller (2010) and Winkler and Wilfing (1991). The available material did not represent full skeletons, and due to taphonomic processes, state of preservation was poor. Bones (when present) were often not only fragmented but flaked and distorted, caused by the fluctuating water levels and soil pressure. The effects are not merely cosmetic but affect the biochemically as well, decreasing the success of collagen-extraction.
- (3) The preservation also affected the dental nonmetric traits – when every Tell el-Dab'a tooth was recorded for the each possible trait, the final dataset had circa 90 percent of missing values. Mean measure of divergence (MMD) was the obvious choice for statistical analysis because of its ability to accommodate missing values (through the use of frequency tables). The Gower distance analysis and 2D geometric morphometrics were unable to achieve the same of efficacy, caused by the missing data (former) and lack of sufficiently informative (remaining) features (former and latter). Furthermore, because the study worked with a narrowed timeframe (EBA-BA), differences between the closely-knit populations,

particularly along the Levantine cultural area, were slight to begin with.

- (4) The archaeological record was utilised throughout the study to understand the interplay between the primary (material) and secondary (written) sources, to help identify appropriate comparative samples and to contextualise the results. Osteological analysis by itself does not provide any more definitive answers than any other technique employed by archaeologists. Without context, they are as meaningless as any singular analysis.

Research on Tell el-Dab'a has shown the inter-connectedness of the Eastern Mediterranean region, including Egypt (Bietak 2007, p. 417). Towns were formed around natural harbours and wadi systems capable of receiving small vessels, spreading commodities further inland along trade routes (Cohen 2002, p. 137). Urbanisation and inter-site trade rose to levels unprecedented for the area, and along these networks travelled not only commodities but people as well.

The largest communities along the Levantine coastline were harbour towns with access to other trade centres along land routes (Cohen 2002, p. 137). The Middle Bronze Age trade network may have been initiated by the northern regions (northern Syria and southern Anatolia), spreading across the Eastern Mediterranean (Kempinski 1997, p. 328, Van Seters 1966, p. 22), but emergence of new sites generated a network with several trade hubs (Cohen 2002, p. 24, Stager 2001). The dental nonmetric analysis suggests these populations were not only involved in active trading but migrating from one port to another and travelling along the land routes as well.

Tell el-Dab'a, founded to gain better access to the emerging Eastern Mediterranean trade routes, was inundated not only by imported goods but people as well (Bietak 1996, p. 20, Mourad 2018). According to the dental nonmetric evidence, Tell el-Dab'a had strong phenetic similarity to Levantine sites, particularly Ugarit, Sidon and Pella. Only Pella was morphologically close enough to be considered the same population. No sweeping statements of the whole "Hyksos population" can be given, as the sample was mostly restricted to Area A/II (with some individuals from F/I) and strata G-D/2. Nevertheless, the biodistance data does support the archaeological

interpretations and presence of Asiatics in Egypt before and during the Second Intermediate Period. The Tell el-Dab'a sample was highly homogenous, reflecting the general similarity of coastal Levantine populations.

The curious connection between Tell el-Dab'a and Pella was considered in light of Stager's (2001) Port Power and dendritic system model. Pella's archaeological material shows strong connections to the coastal town of Tell el-'Ajjul Ajjul (Bourke et al. 2006, Eriksson 2001, Richards 1992, pp. 43-4). The site was likely founded to protect Ashkelon from the south (Burke 2008, p. 132), but its location at the wadi system and along the Road of Horus, the ancient highway, gave it particular advantage for trade with Egypt. The Tell el-Dab'a individuals may have originally either moved along the sea and land routes from Pella, or the people along the Pella-Tell el-'Ajjul axis may have been phenetically similar due to constant migration and interaction taking place locally.

The increasing number of dental nonmetric studies from an array of time periods and sites may not only provide opportunities for migration studies in the Near East but could also be used to explore local social organisation and microevolution. The increasing interest in climate change in the ancient Near East could vastly benefit from further biodistance analyses. The role of climate has been acknowledged as a factor in the events taking place during the Bronze Age Near East but the complex interplay of all compounding factors (i.e. human versus nature) is only beginning to unravel.

8. Conclusions

The aim of this PhD was to assess Hyksos provenance and potential migration pathways. By incorporating the full archaeological record into the investigation, it was possible to reconstruct a series of events that led to the occupation of Tell el-Dab'a. Egypt's interest in the commodities and raw materials provided by the Levant have been well attested from the Old Kingdom onwards. Already during this time it was possible some non-locals were present in the Nile Delta, such as in Tell Ibrahim Awad, in substantial enough roles that they left a distinguishable mark in the archaeological record. The evidence from the Middle Kingdom is much more direct, visible from the onomastic evidence and material culture. These people have been called Aamu, Western Asiatics, used also when referring to the Hyksos. When the Old and Middle Kingdom evidence is taken into account, the emergence of Avaris does not appear sudden, contrary to the accounts by the ancient historians.

Tell el-Dab'a was founded by Middle Kingdom rulers to acquire better access to the Eastern Mediterranean trade network. The Bronze Age was the first period to define trade networks on the basis of ores and metallurgical skills. Ugarit, a mediator between the inland and the maritime trader routes, was also a manufacturer and distributor of raw material and bronze items. Together with Cyprus, which was beginning to trade copper, these polities extended their reach across the Levantine coast.

Whether spurred on by bronze or other products from the surrounding kingdoms, the active trade network circulated not only commodities but people alike. Ugarit's close connection to contemporary Sidon could have been due to ancestral similarity or exchange of people, highlighting the role of both sites as active harbour towns, but Pella is slightly more mysterious, given its peripheral location. The best explanation at the moment is that Pella, on the basis of its archaeological record, was part of the Tell el-'Ajjul network, which did have better access to commodities due to its location at the wadi mouth and land routes along the Levantine coast.

Reasons for migration can be many. Literature offers a variety of phenomena causing destabilisation of local systems (such as environmental

or political turmoil), creating a substantial enough “push” factor to an area with enough “pull”. Proxy records have produced evidence of fluctuating climate conditions circa 2300-1800 BCE in the Eastern Mediterranean (and beyond), causing aridity and likely decreased available resources. The events may have intensified competition between local communities, changed subsistence strategies and potentially pushed some to relocate. The full impact of climate change during the end of the Early Bronze Age and the beginning of the Middle Bronze Age is currently investigated.

By the time the Middle Kingdom decentralised, Tell el-Dab’a had already been established as the Egyptian connection point for the Eastern Mediterranean trade network. The weakening central government had already assured local independence of the site to maintain connections, making the final loss of all oversight one of only minor impact. The statistical analysis of the Tell el-Dab’a dental nonmetric traits found the local population to be distinct from the contemporary Egyptian samples, deriving from Thebes and el-Lisht, which together with the biomolecular analyses, confirms the non-local provenance of the population. Further intra-cemetery analysis of Tell el-Dab’a showed no changes taking place between the pre-Hyksos 13th and 14th Dynasties and 15th Hyksos Dynasty, again matching the biomolecular results. This biological data supports the archaeological finds and interpretations of a non-local population which had taken root in Egypt before the collapse of the Middle Kingdom.

Without more material from earlier strata (G/4 and earlier), it is impossible to say whether people came directly from Ugarit. Based on the archaeological evidence in both Tell el-Dab’a and Ugarit (specifically, Ras Shamra), it would be likely. What can be proposed is that people did move between Ugarit and the south (or from Ugarit to the south), from where they continued further on to Egypt, at least from stratum G onwards.

The evidence presented in this work supports the Southern Levantine provenance of the Tell el-Dab’a individuals studied in this analysis. As stressed throughout this study, the results are wholly dependent on the available samples. The majority of samples derived from Area A/II, but there is a possibility that different tells could represent different population structures. The absence of some key sites from the analysis such as Byblos and

Ashkelon, could skew the reality. The increasing research in Near Eastern bioarchaeology and the utilisation of dental nonmetrics is paving way for further assessments in the future. Nevertheless, the available material from Area A/II and F/I combined, were near identical to the material from Pella, consisting mostly of individuals interred in Tomb 62.

The dating uncertainty of Pella Tomb 62 (due to the tomb's potential role as a secondary deposit) hinders a full estimation of timelines, i.e. where the Hyksos went. While it is possible (and likely) some returned to their source communities or left for other sites along the trade route, it is equally possible some stayed, voluntarily or involuntarily. Ahmose's strategic attack on Sharuhén (be it Tell el-'Ajjul or another site) makes the most sense under a fear of renewed interest in the Delta. The attack also presented an opportunity to weaken nearby competition and assume trading posts. The lack of destruction in Tell el-Dab'a, continued temple activity, establishment of a military base, and later reuse and rebuilding, show that foreign trade (and Tell el-Dab'a place in it) was as much of interest to the 17th and 18th Dynasties as it was to the 12th Dynasty.

The continued small-scale production of MBA pottery types suggests at least some of Tell el-Dab'a occupants remained at the site, perhaps to facilitate new trade deals or service the army. Slaves were taken from the city further south, as mentioned in the biography of Ahmose, son of Ibana. How large these numbers were is difficult to estimate, but the emergence of a wide range of Semitic words in the Egyptian literary corpus at the beginning of the New Kingdom suggests the population was substantial (or ethnically distinct) enough to resist total assimilation.

Even without extensive historical documentation by the New Kingdom officials, the Hyksos lived in social memory and folk tales. To discuss the impact of the Hyksos is to discuss the impact of Eastern Mediterranean and Levantine connections to Egypt. This study has shown the deep roots of interaction between the regions, extending even beyond the historical records and become embodied by the Hyksos during the Middle Bronze Age network.

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Glossary (following appendices)

Appendices

A1. Egyptian chronology from Shaw (2000, pp. 481-7). The chronology shows only dynasties 1-26.

Period	Dynasty	Dates BCE
Early Dynastic Period of Egypt	1st	c. 3000–2686
	2nd	
Old Kingdom	3rd	2686–2613
	4th	2613–2494
	5th	2494–2345
	6th	2345–2181
First Intermediate Period	7th	2181–2160
	8th	
	9th	2160–2025
	10th	
Middle Kingdom of Egypt	11th	2125–1985
	12th	1985–1773
Second Intermediate Period	13th?	1773–1550
	14th?	
	15th	
	16th	
	17th	
New Kingdom of Egypt	18th	1550–1295
	19th	1295–1186
	20th	1186–1069
Third Intermediate Period	21st	1069–945
	22nd	945–715
	23rd	818–715
	24th	727–715
	25th	747–656
Late Period of ancient Egypt	26th	664–525

A2. Transliteration guide used in the text.

	Gardiner 1957	Buurman, Grimal, <i>et</i> <i>al.</i> 1988
	□/3	A
	i	i
	y	y
	□/ʿ	a
	w	w
	b	b
	p	p
	f	f
	m	m
	n	n
	r	r
	h	h
	ḥ	H
	ḥ	x
	ḥ	X
	s	s
	s	s
	š	S
	k	q
	k	k
	g	g
	t	t
	t	T
	d	d
	d	D

A3. Construction of rulers during the Second Intermediate Period (after Ryholt 1997: 336-405, 408-410)

13th Dynasty

- Sobkhotep I Sekhemrekhutawy
- Sonbef Sekhemkare
- Nerikare
- Amenemhet V Sekhemkare
- Qemaw
- Siharnedjheritef Hotepibre
- Iufni
- Amenemhat VI Seankhibre
- Sehotepibre (Horus name: Sewesekhtawy)
- Nebnun Semenkare
- Sewadjkare
- Nedjemibre
- Sobkhotep II Khaankhre
- Ranisonb
- Hor Awibre
- Sekhemrekhutawy (Horus name: Khabaw)
- ... kare (?) (Horus name: Djedkheperew)
- Seb
- Kay
- Amenemhat VII Sedjefakare
- Wegaf Khutawyre
- Khendjer Woserkare
- Imyremeshaw Semenkare
- Intef V Sehotepkare
- Seth Merybre
- Sobkhotep III Sekhemresewadjtawy
- Neferhotep I Khasekhemre
- Sihathor Menwadjre
- Sobkhotep IV Khaneferre
- Sobkhotep V Merhotepre

- Sobkhotep VI Khahotepre
- Ibiaw Wahibre
- Aya Merneferre
- Ini Merhotepre
- Sewadjtew Sankhemre
- Ined Mersekhemre
- Hori II Sewadjkare
- Sobkhotep VII Merkawre
- (several kings lost in Turin kinglist)
- Mer...re
- Merkheperre
- Merkare
- Monthhotep V Sewedjare
- ... mosre
- Ibi ...maatre
- Hor (...?) ...webenre
- Se...kare
- Sankhptahi Seheqenre
- ...re
- Se...enre

13th Dynasty (uncertain)

- Ini Mershepesre
- Neferhotep II Mersekhemre
- Sonbmijew Sewahenre
- Sekhaenre ...s

14th Dynasty

- Yakbim Sekhaenre
- Ya'ammu Nubwoserre
- Qareh Khawoserre
- Ammu Ahotepre
- Sheshi Maaibre
- Nehsy Asehre

- Khakherewre
- Nebefawre
- Sehebre
- Merdjefare
- Sewadjkare (III)
- Nebdjefare
- Webenre
- (lost in Turin kinglist)
- ...djefare
- ...webenre
- Awibre (II)
- Heribre
- Nebsenre
- (lacuna in Turin kinglist)
- (lost in Turin kinglist)
- Sekhepenre
- Djedkherewre
- Sankhibre (II)
- Nefertum...re
- Sekhem...re
- Kakemure
- Neferibre
- I...re
- Khakare
- Akare
- Hapu... Semenenre
- 'Anati Djedkare
- Babnum ...kare
- (eight lines lost Turin kinglist)
- Senefer...re
- Men...re
- Djed...re
- (three lines lost Turin kinglist)

- Ink ...
 - 'A...
 - Apophis I (?)
- (five lines lost Turin kinglist)

14th Dynasty (uncertain)

- Nuya
- Sheneh
- Shenshek
- Wazad
- Khamure
- Yaqub-Har Merwoserre
- Yakareb

15th Dynasty

- Samuqenu
- 'Aper-'Anati
- Sakir-Har
- Khayan Sewoserenre
- Apophis (Aawoserre, Aaqenenre, Nebkhepeshe)
- Khamudi Hotepibre

16th Dynasty

- Djehuty Sekhemresemertawy
- Sobkhotep VIII Sekhemresemertawy
- Neferhotep III Sekhemresemertawy
- Monthhotepi Sankhenre
- Nebirraw I Sewadjenre
- Nebirraw II
- Semenre
- Bebiankh Sewoserenre
- Sekhemreshedwaset
- (five lines lost in the Turin King list)

16th Dynasty (uncertain)

- Dedumose I Djedhotepre
- Dedumose II Djedneferre
- Monthemsaf Djedankhre
- Monthhotep VI Merankhre
- Senusret IV Seneferibre

“The Abydos Dynasty”

- Woser...re
- Woser...re
- (eight lines are lost in the Turin king list)
- ...hebre
- (three lines are lost in the Turin king list)
- ...hebre (?)
- webenre

Abydos Dynasty (uncertain)

- Wepwawemsaf Sekhemreneferkhaw
- Pantjeny Sekhemrekhutawy
- Snaaib Menkhawre

17th Dynasty

- Rahotep Sekhenrewahkhaw
- Sobkemsaf I Sekhemreshedtawy
- Intef VI Sekhemrewepmaat
- Intef VII Nubkheperre
- Intef VIII Sekhemreherhermaat
- Sobkemsaf II Sekhemrewadjkhaw
- Siamun (?) Senakhtenre
- Tao Seqenenre
- Kamose Wadjkheperre

17th Dynasty (uncertain)

- Nebmaatre

Unattributed

- Pepy
- Sobk

A4. Dental anthropology

Tooth structures used for morphological studies:

- Crown: exposed part of tooth anatomy occlusion, covered by enamel
- Root: attaching the tooth into the alveolar socket, covering the pulp (hosting blood vessels and nerves) and covered by cementum
- Cementoenamel junction (CEJ) or neck: the border between crown and root

Modern human teeth differentiate into four different types (figure A4.1):

- incisors (I): chisel-shaped with one biting edge
- canines (C): one sharp biting edge
- premolars (P): have one buccal cusp and anywhere between zero to three lingual cusps, with more variation in the mandibular premolars.
- molars (M): maxillary molars usually have 3-4 cusps and three roots while mandibular molars have 4-5 cusps and two roots. (Hillson 1996, pp. 6-9) Due to the number of cusps in molars, they are referred to with specific terms (figure A4.2). Originally, these terms were correlated with the order of evolutionary sequence in appearance. Later research has changed this order but retained the old terminology (Osborn 1907; Butler 1978).

Deciduous teeth follow the formula 2-1-2 (two incisors, one canine, two molars), permanent teeth follow the formula 2-1-2-3 (two incisors, one canine, two premolars and up to three molars) per quadrant. There are four quadrants, right and left for both mandibular (lower) and maxillary (upper) teeth.

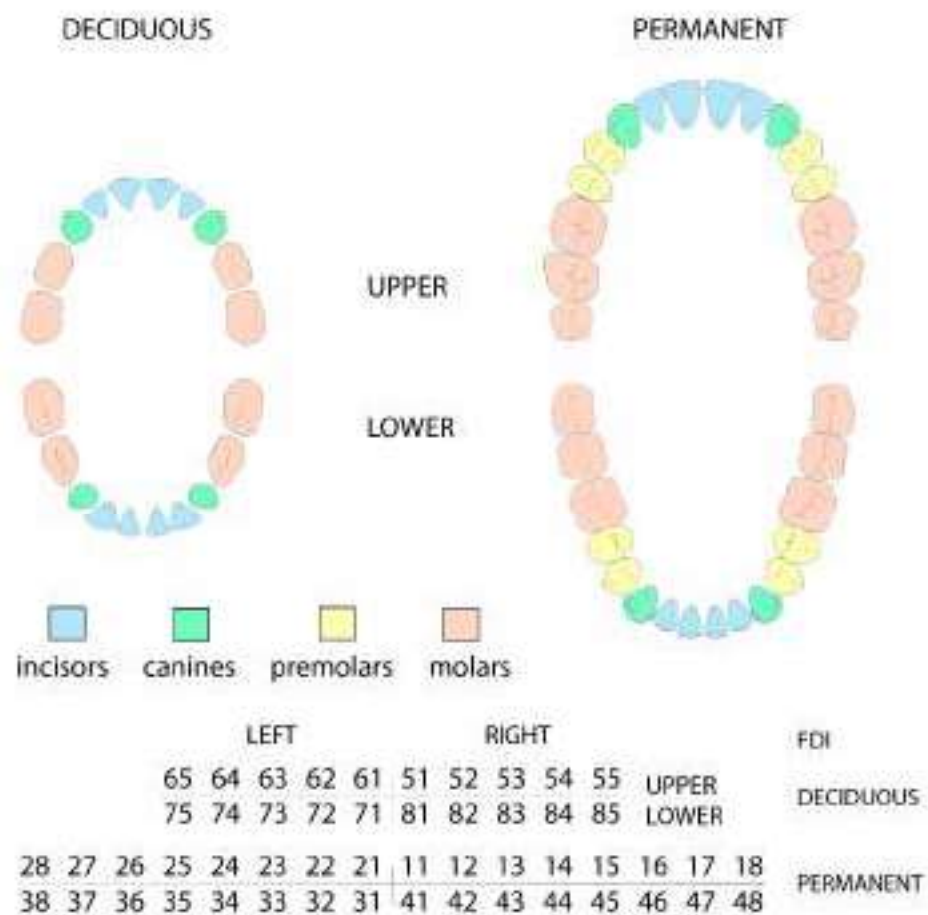


Figure A4.1. Permanent and deciduous teeth placement and the FDI system used to record dentition in this study.

Tooth orientation

When discussing correlating teeth in different quadrants, the terms antimere (corresponding tooth in the other side) and isomere (corresponding teeth between upper and lower sets) are used. Tooth orientation (figure A4.3) is described by a number of terms (Hillson 1996, p. 12):

- Mesial: surface towards the midline
- Distal: surface away from the midline
- Lingual: surface facing the tongue
- Labial: incisor surfaces facing lips
- Buccal: incisor, canine and premolar surfaces facing cheeks
- Occlusal: surface in which upper and lower teeth connect when chewing
- Incisal: cutting edge of incisors and canines
- Apical: surface facing towards the apex of the roots

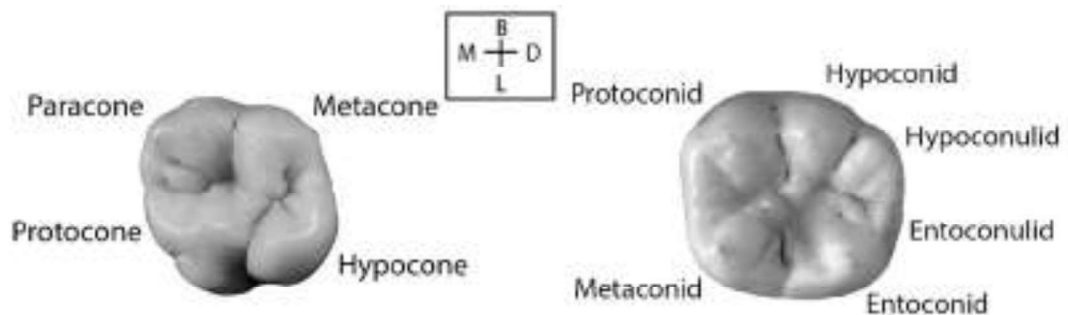


Figure A4.2. Cusp terminology for the upper molars. ASUDAS often refers to cusp names.

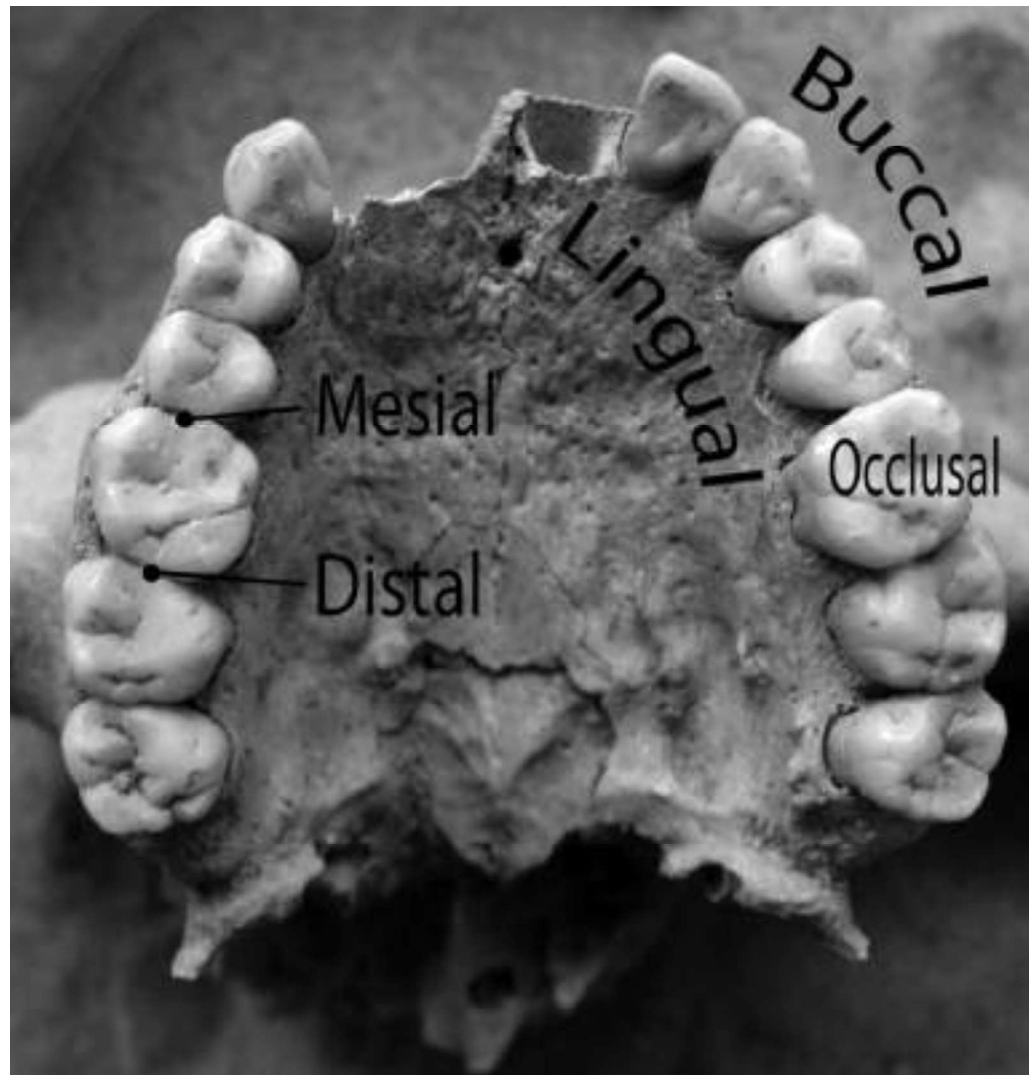


Figure A4.3. Tooth orientation shown on upper dental arcade.

A5. Description of dental nonmetric traits and scoring used in the study. Tooth indicates the main tooth used in the study, BP= breakpoint for present.

Trait (abbreviation in text)	Description	References	Tooth	Grades	BP
Winging (W)	Rotation mesio- or distolingually	Dahlberg 1963, Enoki and Dahlberg 1958	UI1	1=bilateral winging, 2=unilateral winging, 3=no expression, 4=counter winging	(+=ASU 1)
Labial convexity (LC)	Convex curvature on the labial surface	Nichol et al. 1984	UI1	0=no expression, 1=trace curvature, 2=weak curvature, 3=moderate curvature, 4=strong curvature	(+=ASU 2-4)
Palatine torus (PT)	Bony exostosis along the palatine suture	Thoma 1937, Turner et al. 1991, Woo 1950		0=no expression, 1=trace (1-2 mm elevation), 2=medium (2-5 mm), 3=marked (over 5mm), 4=very marked (ca 10 mm)	(+=ASU 2-3)
Shoveling (S)	Presence of mesial and distal vertical ridges on lingual surface	Dahlberg 1956, Hrdlička 1920, Scott 1973	UI1	0=no expression, 1=faint ridges, 2=trace ridges, 3=semi-shovel shaped, 4=shovel shaped, 5=marked shovelling	(+=ASU 2-6)
Double-shoveling (DS)	Presence of mesial and distal marginal ridges on labial surface	Dahlberg 1956, Snyder 1960, Turner et al. 1991	UI1	0=no expression, 1=trace ridge on one margin, 2=trace ridges on both margins, 3=one moderate and one trace ridge, 4=two moderate ridges, 5=one large and one moderate ridge, 6=two large ridges	(+=ASU 2-6)

Peg-shaped incisor (I2V)	Reduced in size and displaying little morphology	Turner 1967, Turner et al. 1991	UI2	0= normal, 1= diminutive in size (less than ½ mesiodistal diameter of UI1), Grade 2: congenital absence, 3=peg-shaped, 4= talon cusp, 5= triform with a large lingual structure that runs from basal cingulum to incisal edge, 6= unusual form that does not fit to 1-5	(+=ASU+)
Interruption grooves (IG)	Groove on lingual border of teeth	Turner 1967	UI2	0 = no expression, M = groove on mesiolingual marginal ridge, D = groove on distolingual marginal ridge, MD = grooves on both mesiolingual and distolingual marginal ridges, med = groove on medial aspect of basal cingulum that sometimes extends onto root	(+=ASU +)
Tuberculum dentale (TD)	ridging or cusp formation on the mesiolingual surface	Hrdlička 1921, Scott 1973, Turner 1967	UI2	0= no ridges, 1= slight ridge, 2= moderate ridge, 3= small tubercle, 4= moderate tubercle, 5= large or double tubercle, 6= welt on basal cingulum (distinct from talon cusp)	(+=ASU 2-6)
Mesial accessory ridge (MAR), Bushman canine	Large mesiolingual ridge that makes the UC resemble LP1	Galloway 1937, Morris 1975, Oranje 1934, Scott and Irish 2017	UC	0=no expression, 1=ML>DL and weakly attached to td, 2=ML>DL and moderately attached to td, 3=ML much larger than DL and fully incorporated into the td	(+=ASU 1-3)
Distal accessory ridge (DAR)	Distolingual ridge anterior to the distal marginal ridge	Scott 1973, 1977	UC	0=no expression, 1=ridge is very faint, 2=ridge is weakly developed, 3=ridge is moderately developed, 4=ridge is strongly developed, 5=ridge is very large	(+=ASU 2-5)

Mesial and distal accessory ridges (PAR)	Ridge on the mesial or distal sulcus of the buccal cusp of any of the premolars	Burnett et al. 2010, Gilmore 1968	UP2	0= no expression, T= truncated/discontinuous, 1=slight continuous, 2=small continuous, 3= moderate, 4=pronounced	(+=ASU 2-4)
Mesial and distal accessory cusp (AC)	A small accessory cusp or tubercle on the sulcus dividing the lingual and buccal cusps of upper premolars.	Turner 1967	UP1	0= no expression, 1= well-defined mesial accessory cusp, 2= well-defined distal accessory cusp, 3= well-defined mesial and distal accessory cusps	(+=ASU+)
Metacone (M)	Size of the distobuccal cusp that forms the trigon of the upper molars with the paracone and protocone	Butler 1941, Turner et al. 1991	UM3	0= metacone no expression, 1= a ridge but no free apex, 2= faint cuspule with free apex, 3= weak cusp, 3.5= intermediate-sized cusp, 4= large, 5= equal in size to a large hypocone	(+=4-5)
Hypocone (H)	Size of distolingual cusp	Gregory 1922, Turner et al. 1991	UM2	0=no expression, 1=faint ridge present, 2=faint cuspule present, 3=small to moderate sized cusp present, 4=large cusp present, 5=very large cusp present	(+=ASU 3-5)
Bifurcated hypocone (BH)	well-defined groove dividing the hypocone	Scott and Irish 2017	UM2	0=no expression, 1=division	(+=ASU+)

Cusp 5 (C5UM)	Presence of extra cusp between third and fourth	Harris 1977, Harris and Bailit 1980	UM1	0=no expression, 1=tiny round cusp, 2=tiny wedge-shaped cusp, 3=small cusp, 4=medium-sized cusp, 5=large cusp	(+=ASU 2-5)
Marginal ridge tubercles (MRT)	Marginal tubercles on the mesial border of upper molars. Disappear quickly after signs of wear.	Kanazawa et al. 1990	UM1	0=protoconule no expression, 1= protoconule present; 0= mesial, accessory tubercle no expression; 1= mesial accessory tubercle present; 0= mesial paracone tubercle no expression, 1= mesial paracone tubercle present	(+=ASU 1)
Carabelli cusp (CC)	Expression on the lingual surface of the mesiolingual cusp	Carabelli 1842, Dahlberg 1956	UM1	0=no expression, 1=furrow, 2=pit, 3=double furrow, 4=small attached cusp, 5=large attached cusp, 6=small free cusp, 7=large free cusp	(+=ASU 2-7)
Parastyle (PUM3)	Expression on the buccal surface of the mesiobuccal cusp	Bolk 1916, Turner et al. 1991	UM3	0=no expression, 1=pit, 2=small attached cusp, 3=small free cusp, 4=medium-sized free cusp, 5=large free cusp	(+=ASU 1-5)
Enamel extensions (EE)	Enamel border extending toward the root apex	Pedersen 1949, Turner et al. 1991	UM11	0=no expression, 1=short extension (1 mm), 2=medium extension (2 mm), 3=lengthly extension (4 mm)	(+=ASU 1-3)

Root number (RUP1)	Number of free roots	Wheeler 1965, Turner 1981	UP1	Number of roots	(+=ASU 2+)
Root number (RUM2)	Number of free roots	Wheeler 1965, Turner et al. 1991	UM2	Number of roots	(+=ASU 3+)
Pegged/reduced/missing third molar (M3V)	Third molars are least stable and can be pegged in shape, reduced in size or missing completely	Garn et al. 1963, Nanda 1954, Scott and Irish 2017, Turner et al. 1991	UM3	0= present and normal, 1=ca. ½ normal size, 2= peg-shaped (single cusp), 3=congenitally no expression	1+ (defined in study)
Odontome (O)	Any pin- or spike-shaped projection on occlusal surface	Merrill 1964, Turner et al. 1991	P1- P2	0=no expression, 1=present	(+=ASU +)
Midline diastema (MID)	Space between upper teeth	Lavelle 1970, Shaw 1931	I1	0=no expression (<0.5 mm), 1=diastema (>0.5 mm)	(+≥0.5 mm)

Lingual cusp number (LC)	Number of lingual cusps	Kraus and Furr 1953, Scott 1973	LP2	Number of cusps	(+=ASU 2-9)
Anterior fovea (AF)	Depression anterior to cusps one and two	Hrdlička 1924, Turner et al. 1991	LM1	0=no expression, 1=faint depression, 2=small depression, 3=medium depression, 4=large depression	(+=ASU 2-4)
Mandibular torus (MT)	Bony exostosis on the lingual surface below the canine and premolars	Hrdlička 1940, Turner et al. 1991		0=no expression, 1=trace elevation, 2=elevation 2-5 mm, 3=elevation >5 mm	(+=ASU 2-3)
Groove pattern (GP)	Pattern on the occlusal surface	Gregory and Hellman 1926, Jørgensen 1956	LM2	1=Y cusps 2 and 3 touch, 2=X cusps 1 and 4 touch, 3+= cusps 1 to 4 touch	(+=ASU Y)
Rocker jaw (RJ)	Vertical curvature of the inferior surface of the horizontal ramus, age-dependent	Martin and Saller 1959, Scott and Irish 2017		0=no expression, 1=slight curvature, 2=extreme curvature	(+=ASU 1-2)

Cusp 5 (C5LM2), hypoconulid	Size of distobuccal cusp 5	Cope 1874, Gregory and Hellman 1926, Turner et al. 1991	LM2	0=no expression, 1=tiny round cusp, 2=tiny wedge-shaped cusp, 3=small cusp, 4=medium- sized cusp, 5=large cusp	(+=ASU 5+)
Cusp 6, entoconulid, tuberculum sextum (C6)	Presence and size of an extra cusp lingual to fifth, graded only in the presence of cusp 5	Dahlberg 1961, Turner et al. 1991	LM1	0=no expression, 1=much smaller than 5, 2=smaller than 5, 3=equal to 5, 4= slightly larger than 5, 5= much larger than 5	(+=ASU 1+)
Cusp 7, metaconulid, tuberculum intermedium (C7)	Presence of extra cusp between second and fourth	Turner et al. 1970	LM1	0=no expression, 1=faint cusp, 2=faint bulge on the lingual surface of cusp 2, 2=small cusp, 3=medium-sized cusp, 4=large cusp	(+=ASU 2-4)
Protostylid (PLM1)	Paramolar cusp on the mesiobuccal surface of cusp one	Dahlberg 1950, 1956	LM1	0=no expression, 1=buccal pit, 2=distal deviation of the buccal groove, 3=secondary mesial groove, 4=secondary groove larger than 3, 5=secondary groove larger than 4, 6=small cusp, 7=large cusp	(+=ASU 1-6)
Deflecting wrinkle (DW)	Deflection of the metaconid ridge	Turner et al. 1991, Weidenreich 1937	LM1	0=no expression, 1=ridge extends half-way across the cusp, 2=ridge extends completely across, 3=ridge extends to central groove	(+=ASU 2-3)

Mesial and distal trigonig crest (MDTC)	A ridge connecting cusps one and two	Hanihara 1961, Hrdlička 1924	LM1	0=no expression, 1=present	(+=ASU +)
Tome's root (TR)	Mesial and distal root surface are deeply grooved	Tomes 1923, Turner et al. 1991	LP1	0=no expression, 1=shallow groove, 2=moderate groove, 3=deep groove, 4=very deep groove, 5=two free roots	(+=ASU 3-5)
Root number (RLC)	Number of free roots	Harborow 1934, Scott and Irish 2017	LC	Number of roots	(+=ASU 2+)
Root number (RNLM)	Number of free roots	Turner 1967; Turner 1971	LM1	Number of roots	(+=ASU 3+)
			LM2	Number of roots	(+=ASU 2+)

Torsomolar angle (TA)	Rotation relative to first and second molars, only scored if there is no crowding or other shifting to teeth	Goodwin 1964, Neiberger 1978	LM3	0= torsomolar angle <10°, 1= torsomolar angle ≥10° in either buccal or lingual direction	(+=ASU +)

A6. Additional information on Jericho burials.

Burial	Burial type	Dating	Age	Sex	Assessment by	Curated
B35	commingled	MB				Nicholson Museum
B51	individual	MB	subadult	indeterminate	author	Duckworth Laboratory
H9	individual	EBIV-MBI	adult	indeterminate	author	Duckworth Laboratory
P1 skull N	individual	MB	subadult	indeterminate	author	Duckworth Laboratory
P1 skull C	individual	MB	adult	female?	author	Duckworth Laboratory
A136 skull A	individual	MB	adult	indeterminate	author	Duckworth Laboratory
A136 skull B	individual	MB	adult	indeterminate	author	Duckworth Laboratory
A136 skull N	individual	MB	adult	indeterminate	author	Duckworth Laboratory
J3A warrior	individual	MB	adult	male?	author	Duckworth Laboratory
P17 D 2	individual	MB	adult	male?	author	Duckworth Laboratory
P17 B	individual	MB	subadult	indeterminate	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 G	individual	MB	subadult	indeterminate	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P12	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 O	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 P	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
H(TELL)3	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P5 ind 2	individual	MB	adult	indeterminate	author	Duckworth Laboratory
P5	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 D	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 N	individual	MB	adult	male?	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 F	individual	MB	subadult	indeterminate	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 J	individual	MB	subadult	indeterminate	Don Brothwell (Duckworth notes)	Duckworth Laboratory
B54 A	individual	EBIV-MBI	adult	male?	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P9	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
G85	individual	EBIV	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P26	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory

P27	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P10	individual	EB-MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 Q	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 H	individual	MB	subadult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P21 A	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
H.III.405A	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
G83 A	individual	EBIV-MBI	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P21 B	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P21 C	individual	MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 M	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 R	individual	MB	subadult	indeterminate	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P21 A	individual	MB	adult	indeterminate	author	Duckworth Laboratory
P24	individual	EB-MB	adult	male	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P30	individual	MB	adult	female	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 E	individual	MB	adult	female?	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 K	individual	MB	subadult	female?	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P17 L	individual	MB	subadult	female?	Don Brothwell (Duckworth notes)	Duckworth Laboratory
P19 B	individual	MB	subadult	indeterminate	author	British Museum
P19 C	individual	MB	subadult	indeterminate	author	British Museum
P19 D	individual	MB	subadult	indeterminate	author	British Museum

A7. Additional information on Sidon burials.

Burial	Burial type	Age	Sex	Assessment by	Curated
1	individual	subadult	indeterminate	author	Bournemouth University
2	commingled			author	Bournemouth University
3	individual	adult	female?	author	Bournemouth University
4,1	individual	adult	female?	author	Bournemouth University
4,2	individual	subadult	indeterminate	author	Bournemouth University
5	individual	adult	male?	author	Bournemouth University
6,1	partially commingled			author	Bournemouth University
7	commingled			author	Bournemouth University
8,1	individual	subadult	indeterminate	author	Bournemouth University
8,2	individual	subadult	indeterminate	author	Bournemouth University
9	individual	subadult	indeterminate	author	Bournemouth University
10	individual	subadult	indeterminate	author	Bournemouth University
11	individual	subadult	indeterminate	author	Bournemouth University
12	individual	adult	male?	author	Bournemouth University
13	individual	subadult	indeterminate	author	Bournemouth University
14	individual	subadult	indeterminate	author	Bournemouth University
15	individual	subadult	indeterminate	author	Bournemouth University
16	individual	subadult	indeterminate	author	Bournemouth University
17	individual	subadult	indeterminate	author	Bournemouth University
18	individual	subadult	indeterminate	author	Bournemouth University
20	individual	subadult	indeterminate	author	Bournemouth University
21	individual	subadult	indeterminate	author	Bournemouth University
22	individual	subadult	indeterminate	author	Bournemouth University
23	individual	adult	male?	author	Bournemouth University

24	individual	subadult	indeterminate	author	Bournemouth University
25	individual	adult	male	author	Bournemouth University
27	individual	adult	indeterminate	author	Bournemouth University
28	individual	subadult	indeterminate	author	Bournemouth University
29	commingled			author	Bournemouth University
30	individual	subadult	indeterminate	author	Bournemouth University
31	individual	subadult	indeterminate	author	Bournemouth University
32	individual	subadult	female	author	Bournemouth University
32B	individual	subadult	indeterminate	author	Bournemouth University
33	individual	subadult	indeterminate	author	Bournemouth University
34	individual	subadult	indeterminate	author	Bournemouth University
36	individual	adult	female?	author	Bournemouth University
37	individual	adult	indeterminate	author	Bournemouth University
38	individual	subadult	female?	author	Bournemouth University
39	individual	subadult	indeterminate	author	Bournemouth University
40	individual	adult	possible male	author	Bournemouth University
41	individual	subadult	indeterminate	author	Bournemouth University
42	commingled			author	Bournemouth University
43	individual	subadult	indeterminate	author	Bournemouth University
44	individual	adult	indeterminate	author	Bournemouth University
44	only mandible	subadult	indeterminate	author	Bournemouth University
44A	individual	subadult	indeterminate	author	Bournemouth University
45	individual	subadult	indeterminate	author	Bournemouth University
46	individual	subadult	female	Haber et al. 2017	Bournemouth University
48	individual	subadult	indeterminate	author	Bournemouth University
49	commingled			author	Bournemouth University

51	individual	subadult	indeterminate	author	Bournemouth University
52	individual	subadult	indeterminate	author	Bournemouth University
54	commingled			author	Bournemouth University
55	individual	subadult	indeterminate	author	Bournemouth University
56	individual	subadult	indeterminate	author	Bournemouth University
57A	individual	adult	male	author	Bournemouth University
58	individual	subadult	indeterminate	author	Bournemouth University
59	individual	subadult	indeterminate	author	Bournemouth University
60	individual	subadult	indeterminate	author	Bournemouth University
62	only mandible	subadult	indeterminate	author	Bournemouth University
63A	individual	subadult	male	author	Bournemouth University
63B	individual	adult	female	author	Bournemouth University
64	individual: truncated	adult	female?	author	Bournemouth University
65	individual	subadult	female	Haber et al. 2017	Bournemouth University
66	commingled			author	Bournemouth University
67	commingled			author	Bournemouth University
67A	individual	adult	male?	author	Bournemouth University
68	individual	subadult	indeterminate	author	Bournemouth University
69	individual	subadult	indeterminate	author	Bournemouth University
70B	commingled			author	Bournemouth University
71	individual	subadult	indeterminate	author	Bournemouth University
72	individual	adult	male?	author	Bournemouth University
73	individual	subadult	indeterminate	author	Bournemouth University
74	individual	adult	male	author	Bournemouth University
75A	commingled	adult	male?	author	Bournemouth University
75B	commingled	adult	female	Haber et al. 2017	Bournemouth University

76	individual	subadult	indeterminate	author	Bournemouth University
77	individual	subadult	indeterminate	author	Bournemouth University
78	individual	subadult	indeterminate	author	Bournemouth University
79A	individual	subadult	indeterminate	author	Bournemouth University
79B	individual	subadult	indeterminate	author	Bournemouth University
80	individual	subadult	indeterminate	author	Bournemouth University
81	individual	subadult	indeterminate	author	Bournemouth University
82	individual	subadult	indeterminate	author	Bournemouth University
83	individual	subadult	indeterminate	author	Bournemouth University
84A	individual	adult	male	author	Bournemouth University
84B	individual	adult	female?	author	Bournemouth University
85	individual	subadult	indeterminate	author	Bournemouth University
86	individual	subadult	indeterminate	author	Bournemouth University
87	individual	subadult	indeterminate	author	Bournemouth University
88	individual	subadult	indeterminate	author	Bournemouth University
89	individual	subadult	indeterminate	author	Bournemouth University
90	individual	subadult	indeterminate	author	Bournemouth University
91	individual	subadult	indeterminate	author	Bournemouth University
93	individual	subadult	indeterminate	author	Bournemouth University
95	individual	adult	male	author	Bournemouth University
97	individual	subadult	indeterminate	author	Bournemouth University
98,1	individual	subadult	indeterminate	author	Bournemouth University
98,2	individual	adult	female?	author	Bournemouth University
99	individual	adult	male	author	Bournemouth University
100	individual	adult	female	author	Bournemouth University
101	commingled			author	Bournemouth University

102	individual	subadult	indeterminate	author	Bournemouth University
103	individual	adult	male	author	Bournemouth University
104	individual	adult	female	author	Bournemouth University
105	individual	adult	female	author	Bournemouth University
106	individual	adult	male?	author	Bournemouth University
107	commingled			author	Bournemouth University
108	individual	adult	male	author	Bournemouth University
109	individual	adult	female?	author	Bournemouth University
111	individual	adult	male	author	Bournemouth University
112	individual	adult	indeterminate	author	Bournemouth University
113	individual	adult	female	author	Bournemouth University
114	individual	subadult	indeterminate	author	Bournemouth University
115	commingled			author	Sidon project
116	individual	subadult	indeterminate	author	Sidon project
117	individual	subadult	indeterminate	author	Sidon project
118	individual	subadult	indeterminate	author	Sidon project
119	individual	subadult	indeterminate	author	Sidon project
120	individual	subadult	indeterminate	author	Sidon project
121,1	individual	subadult	indeterminate	author	Sidon project
121,2	individual	adult	male	author	Sidon project
123	commingled			author	Sidon project
124	individual	subadult	female	author	Sidon project
125	individual	subadult	indeterminate	author	Sidon project
126	commingled			author	Sidon project
127	individual	adult	female	author	Sidon project
128,1	individual	subadult	indeterminate	author	Sidon project

128,2	individual	subadult	indeterminate	author	Sidon project
131,1	individual	adult	female	author	Sidon project
131,2	individual	adult	female	author	Sidon project
132	individual	subadult	indeterminate	author	Sidon project
133	individual	subadult	indeterminate	author	Sidon project
134	individual	subadult	indeterminate	author	Sidon project
135	individual	adult	male?	author	Sidon project
136	individual	subadult	indeterminate	author	Sidon project
138	individual	subadult	indeterminate	author	Sidon project
139,1	individual	subadult	indeterminate	author	Sidon project
139,2	individual	adult	male	author	Sidon project
140	individual	subadult	indeterminate	author	Sidon project
141	individual	subadult	indeterminate	author	Sidon project
142	individual	adult	female	author	Sidon project
143	individual	subadult	indeterminate	author	Sidon project
144,1	individual	subadult	indeterminate	author	Sidon project
144,2	individual	subadult	indeterminate	author	Sidon project
146	individual	adult	female	author	Sidon project
145	individual	subadult	male	author	Sidon project
147	individual	subadult	indeterminate	author	Sidon project
148	individual	subadult	indeterminate	author	Sidon project
149	individual	subadult	indeterminate	author	Sidon project
150,1	individual	adult	female	author	Sidon project
150,2	individual	subadult	indeterminate	author	Sidon project
151	individual	adult	indeterminate	author	Sidon project
152	individual	subadult	indeterminate	author	Sidon project

153	individual	subadult	indeterminate	author	Sidon project
154	individual	subadult	indeterminate	author	Sidon project
155	individual	subadult	indeterminate	author	Sidon project
156	individual	adult	female	author	Sidon project
157	individual	adult	female?	author	Sidon project
158	individual	adult	indeterminate	author	Sidon project
159	individual	subadult	indeterminate	author	Sidon project
160	individual	subadult	indeterminate	author	Sidon project
161	individual	subadult	indeterminate	author	Sidon project
162	individual	adult	male	author	Sidon project
163	individual	adult	indeterminate	author	Sidon project
164	individual	subadult	indeterminate	author	Sidon project
165	individual	adult	male	author	Sidon project
47	individual			author	Bournemouth University
85,2	individual	adult	indeterminate	author	Bournemouth University
167,1	individual	subadult	indeterminate	author	Sidon project
167,2	individual	subadult	indeterminate	author	Sidon project
168	individual	subadult	indeterminate	author	Sidon project
169	individual	subadult	indeterminate	author	Sidon project
170	individual	subadult	indeterminate	author	Sidon project
57	individual	subadult	indeterminate	author	Bournemouth University

A8. Additional information on Duckworth Laboratory samples Tell el-‘Ajjul and Tell el-Far’ah S. Unpublished information omitted as per agreement with the original investigator.

Curation id	Site	Age	Sex	Assessed by	Burial	Dating
66.4.14	Tell el-'Ajjul	adult	male?	author		MBA
66.4.17	Tell el-'Ajjul	adult	male?	author	omitted	LBIIB/IA
66.4.18	Tell el-'Ajjul	adult	male?	author	omitted	LBIIB/IA
66.4.19	Tell el-'Ajjul	adult	male?	author		
66.4.20	Tell el-'Ajjul	adult	male?	author	omitted	MBA
66.4.21	Tell el-'Ajjul	adult	male?	author		
66.4.22	Tell el-'Ajjul	adult	female?	author	omitted	MBIII-LBI
66.4.23	Tell el-'Ajjul	adult	male?	author	omitted	MBIIC-LBI?
66.4.24	Tell el-'Ajjul	adult	female?	author		
66.4.25	Tell el-'Ajjul	adult	female?	author		
66.4.26	Tell el-'Ajjul	adult	female?	author	omitted	
66.4.27	Tell el-'Ajjul	adult	female?	author	omitted	LBA
66.4.29	Tell el-'Ajjul	subadult	indeterminate	author	omitted	MBA
66.4.30	Tell el-'Ajjul	adult	male?	author	omitted	MBI-II
66.4.31	Tell el-'Ajjul	adult	male?	author	omitted	LBIB-II
66.4.32	Tell el-'Ajjul	adult	indeterminate	author	omitted	LBIIB
66.4.33	Tell el-'Ajjul	adult	male?	author	omitted	MBA
66.4.34	Tell el-'Ajjul	adult	male?	author	omitted	LBIIB
66.4.38	Tell el-'Ajjul	adult	female?	author	omitted	LBI
66.4.39	Tell el-'Ajjul	adult	female?	author	omitted	MBA
66.4.42	Tell el-'Ajjul	adult	female?	author	omitted	MBA
66.4.43	Tell el-'Ajjul	adult	male?	author	omitted	
66.4.44	Tell el-'Ajjul	adult	female?	author	omitted	MBIIC-LBI?

66.4.45	Tell el-'Ajjul	adult	male?	author	omitted	
66.0.65	Tell el-Far'ah S	adult	female?	author	omitted	LBIIB/IA
66.4.1	Tell el-Far'ah S	adult	male?	author	omitted	LBIIB
66.4.2	Tell el-Far'ah S	adult	indeterminate	author	omitted	LBIIB
66.4.3	Tell el-Far'ah S	adult	male?	author	omitted	LBIIB
66.4.4	Tell el-Far'ah S	adult	indeterminate	author	omitted	LBIIB/IA
66.4.5	Tell el-Far'ah S	adult	female?	author	omitted	LBIIB/IA
66.4.6	Tell el-Far'ah S	adult	female?	author	omitted	LBIIB/IA
66.4.7	Tell el-Far'ah S	adult	female?	author	omitted	IA
66.4.8	Tell el-Far'ah S	subadult	indeterminate	author	omitted	LBIIB
66.4.9	Tell el-Far'ah S	subadult	indeterminate	author	omitted	LBIIB/IA
66.4.10	Tell el-Far'ah S	adult	female?	author	omitted	LBIIB/IA
66.4.11	Tell el-Far'ah S	adult	male?	author	omitted	LBIIB/IA
66.4.12	Tell el-Far'ah S	adult	indeterminate	author	omitted	LBIIB
66.4.13	Tell el-Far'ah S	subadult	indeterminate	author	omitted	LBIIB/IA
66.4.15	Tell el-Far'ah S	subadult	indeterminate	author	omitted	IA
66.4.16	Tell el-Far'ah S	subadult	indeterminate	author	omitted	IA
66.4.28	Tell el-Far'ah S	adult	female?	author	omitted	IA
66.4.35	Tell el-Far'ah S	adult	male?	author	omitted	IA
66.4.36	Tell el-Far'ah S	adult	female?	author	omitted	Persian
66.4.37	Tell el-Far'ah S	adult	female?	author	omitted	IA
66.4.40	Tell el-Far'ah S	adult	female?	author	omitted	Persian
66.4.41	Tell el-Far'ah S	subadult	indeterminate	author	omitted	LBIIB

A9. Additional information on the Egyptian and Syrian samples curated by Musée de l'Homme.

Museum id	site	Age	Sex	Assessed by	Dating
33960	Dra' Abu el-Naga'	adult	female?	author	XI
7319	Dra' Abu el-Naga'	adult	male?	author	XI
7330	Dra' Abu el-Naga'	adult	female?	author	XI
7332	Dra' Abu el-Naga'	adult	female?	author	XI
7323	Dra' Abu el-Naga'	adult	male?	author	XI
7321	Dra' Abu el-Naga'	adult	male?	author	XI
7325	Dra' Abu el-Naga'	adult	indeterminate	author	XI
7333	Dra' Abu el-Naga'	adult	male?	author	XI
7310	Dra' Abu el-Naga'	adult	female?	author	XI
7311	Dra' Abu el-Naga'	adult	male?	author	XI
7316	Dra' Abu el-Naga'	adult	female?	author	XI
33962	Dra' Abu el-Naga'	adult	female?	author	XI
33963	Egypt	adult	female?	author	XI
33964	Egypt	adult	male?	author	XI
33965	Egypt	adult	female?	author	XI
33966	Egypt	adult	female?	author	XI
33968	Egypt	adult	female?	author	XI
33969	Egypt	adult	male?	author	XI
24530	Ras Shamra	adult	indeterminate	author	16-15th century
33970	Egypt	adult	male?	author	XI
7301	Dra' Abu el-Naga'	adult	female?	author	XI
7303	Dra' Abu el-Naga'	adult	male?	author	XI
7305	Dra' Abu el-Naga'	adult	male?	author	XI
7307	Dra' Abu el-Naga'	adult	male?	author	XI

7315	Dra' Abu el-Naga'	adult	indeterminate	author	XI
7320	Dra' Abu el-Naga'	adult	female?	author	XI
7322	Dra' Abu el-Naga'	adult	male?	author	XI
7327	Dra' Abu el-Naga'	adult	female?	author	XI
33959	Egypt	adult	female?	author	XI
33961	Dra' Abu el-Naga'	adult	female?	author	XI
33967		adult	male?	author	XI
7302	Dra' Abu el-Naga'	adult	female?	author	XI
7304	Dra' Abu el-Naga'	adult	female?	author	XI
7306	Dra' Abu el-Naga'	adult	female?	author	XI
7308	Dra' Abu el-Naga'	adult	female?	author	XI
7309	Dra' Abu el-Naga'	adult	male?	author	XI
7313	Dra' Abu el-Naga'	adult	female?	author	XI
7317	Dra' Abu el-Naga'	adult	indeterminate	author	XI
7318	Dra' Abu el-Naga'	adult	female?	author	XI
7324	Dra' Abu el-Naga'	adult	female?	author	XI
7328	Dra' Abu el-Naga'	adult	male?	author	XI
7329	Dra' Abu el-Naga'	adult	female?	author	XI
7331	Dra' Abu el-Naga'	adult	male?	author	XI
24516	Minet el-Beida	adult	male?	author	15th century
24517	Minet el-Beida	adult	female?	author	15th century
24519	Minet el-Beida	adult	female?	author	15th century
24521	Minet el-Beida	subadult	indeterminate	author	14-13th century
24522	Minet el-Beida	adult	male?	author	14-13th century
24523	Minet el-Beida	adult	male?	author	14-13th century
24541	Ras Shamra	adult	female?	author	15-13th century

24544	Ras Shamra	adult	indeterminate	author	15-13th century
24550	Ras Shamra	adult	indeterminate	author	15-13th century
24553	Ras Shamra	adult	male?	author	15-13th
26020	Ras Shamra	adult	male?	author	15th century
26016	Ras Shamra	adult	male?	author	15th century
260231	Ras Shamra	adult	male?	author	4th century Roman
26023	Ras Shamra	adult	male?	author	4th century Roman
24518	Minet el-Beida	adult	indeterminate	author	15th century
26025	Ras Shamra	adult	female?	author	4th century Roman
24520	Minet el-Beida	adult	indeterminate	author	14-13th century
24524	Minet el-Beida	adult	male?	author	14-13th century
24528	Ras Shamra	adult	female?	author	18-17th century
24539	Ras Shamra	adult	female?	author	15-13th century
24552	Ras Shamra	adult	male?	author	18-17th century
24548	Ras Shamra	subadult	indeterminate	author	15-13th century
26430	Ras Shamra	adult	female?	author	
26024	Ras Shamra	adult	indeterminate	author	4th century Roman
24551	Ras Shamra	adult	female?	author	15-13th century
24531	Ras Shamra	adult	male?	author	15-13th century
24533	Ras Shamra	adult	indeterminate	author	15-13th century
24540	Ras Shamra	adult	indeterminate	author	15-13th century
24554	Ras Shamra	subadult	indeterminate	author	15-13th century
26017	Ras Shamra	adult	male?	author	15th century
26018	Ras Shamra	adult	female?	author	15th century
26019	Ras Shamra	adult	indeterminate	author	15th century
26428	Ras Shamra	adult	indeterminate	author	

26433	Minet el-Beida	subadult	indeterminate	author	
245541	Ras Shamra	adult	indeterminate	author	15-13th century
24532	Ras Shamra	subadult	indeterminate	author	15-13th century
24534	Ras Shamra	adult	male?	author	15-13th century
24535	Ras Shamra	adult	male?	author	15-13th century
24537	Ras Shamra	adult	indeterminate	author	15-13th century
24542	Ras Shamra	adult	indeterminate	author	15-13th century
24545	Ras Shamra	adult	indeterminate	author	15-13th century
24546	Ras Shamra	subadult	indeterminate	author	15-13th century
24547	Ras Shamra	subadult	indeterminate	author	15-13th century
24549	Ras Shamra	adult	male?	author	15-13th century
24526	Ras Shamra	adult	indeterminate	author	18-17th century
26429	Ras Shamra	adult	male?	author	
24538	Ras Shamra	adult	female?	author	15-13th century
24538	Ras Shamra	subadult	indeterminate	author	
24543	Ras Shamra	adult	female?	author	15-13th century
26431	Ras Shamra	adult	indeterminate	author	
26432	Ras Shamra?	adult	indeterminate	author	
24525	Ras Shamra	adult	male?	author	18-17th century
24536	Ras Shamra	adult	indeterminate	author	15-13th century
7312	Dra' Abu el-Naga'	adult	female?	author	
7314	Dra' Abu el-Naga'	adult	male?	author	
7326	Dra' Abu el-Naga'	adult	male?	author	
7335	Qurna	adult	female?	author	
24527	Ras Shamra	adult	female?	author	18-17th century
24529	Ras Shamra	adult	male?	author	18-17th century

26021	Ras Shamra	adult	male?	author	14-13th

A10. Contextual information available from individuals buried in Area A/II. Coordinate information is arbitrary, used to explore spatial relations.

Spatial information									
individual ID	orientation	position	skull	facing	body	side	stratum	type	intact
All-k/9-34	NNW-SSE	SSE-NNW	SSE	NE	flexed	R	D/2	jar burial	yes
All-k/9-35-1	WSW-ENE						D/2	chamber burial	no
All-k/9-35-2	WSW-ENE						D/2	chamber burial	no
All-k/9-35-3	WSW-ENE						D/2	chamber burial	no
All-k/9-35-4	WSW-ENE						D/2	chamber burial	no
All-k/9-35-5	WSW-ENE						D/2	chamber burial	no
All-k/9-35-6	WSW-ENE						D/2	chamber burial	no
All-k/9-36	WSW-ENE						D/2	chamber burial	no
All-k/11-1	NW-SE	SE-NW	SE	SW	flexed	L	D/3	chamber burial	no
All-k/12-1	NNE-SSW	NNE-SSW	NNE	E	flexed	L	F-G	pit burial	no
All-k/12-2	NNE-SSW	NE-SW	NE		supine		F-G	pit burial	no
All-k/12-3	NE-SW	WNW-ESE	WNW	W	flexed	R	G	chamber burial	no
All-k/14-1-1	WSW-ENE						E/1-D/3	chamber burial	no
All-k/14-1-2	WSW-ENE						E/1-D/3	chamber burial	no
All-k/14-3	NNW-SSE	SSW-NNE	SSW				E/1	chamber burial	
All-k/14-4	WNW-ESE	ESE-WNW	ESE	NNE	flexed	R	F	chamber burial	no
All-k/14-5	NNE-SSW							chamber burial	no
All-k/14-8	NW-SE	SE-NW	SE	W	flexed	L	E/2	chamber burial	no
All-k/15-8	WSW-ENE	WSW-ENE	W	N	flexed	L	D/3	jar burial	no
All-k/16-20			NNW	E	supine		E/1-2	jar burial	yes
All-k/16-23							D/2	chamber burial	no
All-k/16-24	ENE-WSW	ENE-WSW	ENE		supine		E/2	chamber burial	no

All-k/17-11	ENE-WSW						D/3	jar burial	yes
All-k/17=I/17-13	ENE-WSW				flexed	r	D/2-3	chamber burial	no
All-k/17-19	NW-SE						D/2	chamber burial	no
All-k/17-22	NNW-SSE	NNW-SSE	N		supine		E/1	jar burial	yes
All-k/17-29	ENE-WSW	ENE-WSW	ENE	W	flexed	R	E/3-E/2	jar burial	yes
All-k/17-30-1	WNW-ESE	ESE-WNW	ESE	WSW	supine		D/3-E/1	chamber burial	no
All-k/17-30-2	WNW-ESE	WNW-ESE	WNW		supine		E/3-F	chamber burial	no
All-I/10-1							E	jar burial	
All-I/10-2							E/2	chamber burial	
All-I/11-1-1	NE-SW	NE-SW	NE	NW	supine		F/G	pit burial	yes
All-I/11-1-2	NE-SW	NE-SW	NE	NW	flexed	R	F/G	pit burial	yes
All-I/11-2	NE-SW	SE-NW	SE	SW	flexed	L	F	chamber burial	no
All-I/11-3-1	NW-SE	SE-NW	SE		supine	L	F	chamber burial	yes
All-I/11-3-2	NW-SE	SSE-NNW	SSE	NNE	supine		F	chamber burial	yes
All-I/11-3-3	NW-SE	SSE-NNW	SSE	NNE	supine		F	chamber burial	yes
All-I/11-3-4	NW-SE						F	chamber burial	yes
All-I/11-4	NW-SE						F	chamber burial	
All-I/12-1-3	WSW-ENE	NE-SW			supine		E/1-D/3	chamber burial	no
All-I/12-1-4	WSW-ENE	ENE-WSW	ENE	NW	flexed	R	E/1-D/3	chamber burial	no
All-I/12-1-5	WSW-ENE	ENE-WSW	ENE	S	flexed	L	E/1-D/3	chamber burial	no
All-I/12-1-6	WSW-ENE	ENE-WSW	ENE		flexed	R	E/1-D/3	chamber burial	no
All-I/12-1-7	WSW-ENE						E/1-D/3	chamber burial	no
All-I/12-1-8	WSW-ENE						E/1-D/3	chamber burial	no
All-I/12-2-1	NNW-SSE	SSE-NNW	SSE	ENE	supine		E/1	chamber burial	yes
All-I/12-2-2	NNW-SSE	SSE-NNW	SSE		supine		E/1	chamber burial	yes
All-I/12-2-3	NNW-SSE	SSE-NNW	SSE	ENE	supine		E/1	chamber burial	yes

All-I/12-3	NNW-SSE						E/3	chamber burial	no
All-I/12-4	WNW-ESE	WNW-ESE	WNW	SW	supine		F/G	pit burial	yes
All-I/12-5-1	NNW-SSE	SSE-NNW	SSE	ENE	flexed	R	F	chamber burial	yes
All-I/12-5-2	NNW-SSE						F	pit burial	no
All-I/12-5-3	NNW-SSE						F	pit burial	no
All-I/12-5-4	NNW-SSE						F	pit burial	no
All-I/13-1							E/1-D/3	jar burial	
All-I/13-2	NNW-SSE						E/1-D3	jar burial	no
All-I/13-3	NNW-SSE	SSE-NNW	SSE		supine		E/3	chamber burial	
All-I/13-4	NE-SW						D/2	chamber burial	no
All-I/14-1	ENE-WSW	ENE-WSW	ENE	SSE	flexed	R	E/1	chamber burial	yes
All-I/14-2	ENE-WSW	ENE-WSW	ENE		supine		E/1	chamber burial	no
All-I/14-3	NW-SE						D/2	chamber burial	no
All-I/14-4-1	NNW-SSE						D/2	chamber burial	no
All-I/14-4-2	NNW-SSE						D/2	chamber burial	no
All-I/14-5	ENE-WSW	WSW-ENE	WSW				E/1	chamber burial	no
All-I/14-6	N-S						D/3	jar burial	no
All-I/14-7-1	SSE-NNW	SSE-NNW	SSE		supine		E/3	chamber burial	no
All-I/14-7-3	SSE-NNW						E/3	chamber burial	no
All-I/14-7-3	SSE-NNW						E/3	chamber burial	no
All-I/14-7-4	SSE-NNW						E/3	chamber burial	no
All-I/14-8	NW-SE						F	chamber burial	no
All-I/14-12-1	NNW-SSE	SSE-NNW	SSE		supine		D/3	chamber burial	no
All-I/14-12-2	NNW-SSE						D/3	chamber burial	no
All-I/14-12-3	NNW-SSE						D/3	chamber burial	no
All-I/15-1	ENE-WSW	ENE-WSW	ENE	NNW	supine		D/2-3	chamber burial	no

All-I/15-2							D/3	chamber burial	
All-I/15-3	WSW-ENE	ENE-WSW	ENE		supine		D/2-3	chamber burial	no
All-I/15-4/6	NNW-SSE	NNW-SSE	NNW	ENE	flexed	L	E/1-2	jar burial	yes
All-I/15-5	E-W	E-W	E	S	flexed	L	F	pit burial	yes
All-I/16-1	NNW-SSE						D/3-E/1	chamber burial	no
All-I/16-2	NNW-SSE						D/3-E/1	chamber burial	no
All-I/16-3	E-W	W-E	W		flexed		F	jar burial	yes
All-I/16-4-1	NNW-SSE	SSE-NNW	SSE	E	flexed	R	F	chamber burial	yes
All-I/16-4-2	NNW-SSE						F	chamber burial	yes
All-I/16-5	NNW-SSE	SSE-NNW	SSE				F	chamber burial	
All-I/16-6	ENE-WSW	ENE-WSW	E	S	flexed	R	E/2	jar burial	yes
All-I/17-1	NW-SE	NW-SE	NW	NE	flexed	R	D/2	jar burial	yes
All-I/17-3-1	NW-SE						D/2	chamber burial	no
All-I/17-3-2	NW-SE						D/2	chamber burial	no
All-I/17-3-3	NW-SE						D/2	chamber burial	no
All-I/17-5-1	WNW-ESE	ESE-WNW	ESE	N	flexed	R	D/3	chamber burial	yes
All-I/17-5-2	WNW-ESE	ESE-WNW	ESE		supine		D/3	chamber burial	yes
All-I/17-5-3	WNW-ESE						D/3	chamber burial	yes
All-I/17-6	NW-SE	SE-NW	SE		supine		D/2	jar burial	yes
All-I/17-8	ENE-WSW	ENE-WSW	ENE		supine		D/2-3	jar burial	yes
All-I/17-10	ESE-WNW						E/1-2	jar burial	no
All-I/17-14	NW-SE	NW-SE	NW	E	flexed	L	E/2	jar burial	yes
All-I/17-15	E-W	W-E	W		supine		E/2	jar burial	yes
All-I/17-16	ENE-WSW	WSW-ENE	ESE	S	flexed	L	E/2	chamber burial	yes
All-I/17-17	E-W	W-E	E		supine		E/3-2	jar burial	yes
All-m/10-2	N-S	N-S	N				D/3	jar burial	yes

All-m/10-4	SSW-NNE	SSW-NNE	SSW				E/1	jar burial	
All-m/10-5	NNW-SSE						E/2	jar burial	
All-m/10-6	ENE-WSW	ENE-WSW	ENE	N	supine		E/1	jar burial	yes
All-m/10-7-1	OVAL	NW-SE	NW	SW	flexed	R	E/1	pit burial	
All-m/10-7-2	OVAL	NW-SE	NW	SW	supine	R	E/1	pit burial	
All-m/10-8-1	NW-SE	SE-NW	SE	NE	flexed	R	F	chamber burial	yes
All-m/10-8-2	NW-SE	SE-NW	SE	NE	flexed	L	F	chamber burial	yes
All-m/10-9	NW-SE	SSE-NNW	SE	NW	flexed	R	F	chamber burial	yes
All-m/10-10	WSW-ENE	ENE-WSW	ENE		supine		D/2	chamber burial	no
All-m/11-1	ENE-WSW	WSW-ENE	WSW		flexed	R	D/2	jar burial	no
All-m/11-2	WSW-ENE						D/2	chamber burial	no
All-m/11-3	NNE-SSW	NNW-SSE	NNE	NNW	flexed	R	E/1	chamber burial	no
All-m/11-4	N-S						D/3	jar burial	no
All-m/11-5	NNW-SSE	SSE-NNW	SSE	NE	supine		E/1	chamber burial	no
All-m/11-6-1	ENE-WSW	ENE-WSW	ENE	NNW	flexed	R	E/2	chamber burial	no
All-m/11-6-2	ENE-WSW						E/2	chamber burial	no
All-m/11-6-3	ENE-WSW						E/2	chamber burial	no
All-m/11-7	N-S	S-N	S	NW	flexed	R	E/1	pit burial	yes
All-m/11-8	NNW-SSE						D/3	chamber burial	no
All-m/11-9	NNW-SSE	SSE-NNW	SSE	E	flexed	R	E/2	pit burial	no
All-m/11-10	NNE-SSW	SSW-NNE	SSW	NNW	flexed	L	E/1	jar burial	yes
All-m/11-11	ENE-WSW	ENE-WSW	ENE	N	supine		E/1	jar burial	no
All-m/11-12	E-W	E-W						jar burial	
All-m/11-13	NNW-SSE						E/1	chamber burial	no
All-m/11-14							D/3	jar burial	no
All-m/12-1	ENE-WSW	ENE-WSW					D/2	jar burial	

All-m/12-2	NW-SE	NW-SE	NW	SW	flexed	R	D/3	jar burial	yes
All-m/12-3	NW-SE	NW-SE					D/3	jar burial	
All-m/12-4	WSW-ENE						D/3	jar burial	no
All-m/12-5	ESE-WNW						D/3	jar burial	
All-m/12-6	NW-SE						D/3-E/1	jar burial	no
All-m/12-7	NNW-SSE	NNW-SSE	NNW	E	supine		E/1	jar burial	
All-m/12-8	NE-SW	NE-SW	NE	NW	flexed	R	E/3	pit burial	yes
All-m/12-9-1	NE-SW	S-N	S	W	supine		E/2	chamber burial	
All-m/12-9-2	NE-SW						E/2	chamber burial	
All-m/12-9-3	NE-SW						E/2	chamber burial	
All-m/12-10	WSW-ENE						E/1-2	chamber burial	no
All-m/12-11	ENE-WSW	ENE-WSW	ENE	NW	flexed	R	E/2-3	pit burial	yes
All-m/12- 12 / 13-1	ENE-WSW	ENE-WSW	ENE	NW	flexed	R	E/2	chamber burial	yes
All-m/12- 12 / 13-2	ENE-WSW	ENE-WSW	ENE	NE	flexed	L	E/2	chamber burial	yes
All-m/12- 12 / 13-3	ENE-WSW						E/2	chamber burial	
All-m/12-14	NNE-SSW	NNW-SSE	ENE	NNW	flexed	R	E/1-2	pit burial	yes
All-m/13-1							D/2	jar burial	yes
All-m/13-2	ENE-WSW	ENE-WSW	ENE		supine		D/2	chamber burial	no
All-m/13-3	ENE-WSW						D/2	jar burial	no
All-m/13-4	ENE-WSW	ENE-WSW	ESE	S	flexed	R	E/1	chamber burial	yes
All-m/13-5	NNW-SSE						E/1	jar burial	no
All-m/13-6	NNW-SSE	SSE-NNW	SSE	NW	flexed		E/1	chamber burial	yes
All-m/13-7	NNW-SSE	SSE-NNW	SSE	N	flexed	L	E/2	chamber burial	yes
All-m/13-8	E-W	E-W	E	NNW	flexed	L	E/2	jar burial	yes
All-m/13-9	ENE-WSW	WSW-ENE	WSW		flexed		E/2	jar burial	yes
All-m/13-10	WSW-ENE	ENE-WSW	ENE	S	flexed	L	E/1	chamber burial	yes

All-m/13-11	ENE-WSW						D/3	jar burial	no
All-m/13-12	WSW-ENE						D/3	jar burial	no
All-m/13-13-1	WNW-ESE	ESE-WNW	ESE	WSW	flexed	L	E/3	chamber burial	yes
All-m/13-13-2	WNW-ESE	ESE-WNW	ESE	ENE	flexed	R	E/3	chamber burial	yes
All-m/13-13-3							E/3	chamber burial	yes
All-m/13-13-4			ESE	ENE	flexed	R	E/3	chamber burial	yes
All-m/13-13-5							E/3	chamber burial	yes
All-m/13-14	NNW-SSE	SSE-NNW	SSE	ENE	flexed	R	E/1	pit burial	no
All-m/13-15	NNW-SSE	SSE-NNW	SSE		flexed		D/3	jar burial	yes
All-m/13-16							E/1	jar burial	no
All-m/13-17	N-S						D/2	jar burial	no
All-m/14-1							D/2-3	jar burial	
All-m/15-1	N-S	S-N	S		supine		D/2-3	chamber burial	no
All-m/15-2	N-S	N-S	N	E	flexed	L	D/2-3	chamber burial	no
All-m/15-3-1	NNW-SSE	SSE-NNW	SSE	NW	supine		E/1	chamber burial	yes
All-m/15-3-2	NNW-SSE						E/1	chamber burial	yes
All-m/15-4	ENE-WSW	ENE-WSW	ENE	S	flexed	L	E/1	chamber burial	yes
All-m/15-5	NE-SW						D/3	chamber burial	no
All-m/15-6	NNW-SSE	SSE-NNW	SSE		flexed	R	D/3	jar burial	yes
All-m/15-7	N-S	N-S	N		supine		D/2-3	chamber burial	no
All-m/15-8	N-S	S-N	S	NNW	supine		F	chamber burial	yes
All-m/15-9-1	NNW-SSE	SSE-NNW	SSE	W	supine		G	chamber burial	no
All-m/15-9-2	NNW-SSE	SSE-NNW	SSE		supine		G	chamber burial	no
All-m/15-9-3	NNW-SSE						G	chamber burial	no
All-m/15-10	NNW-SSE						G	chamber burial	no
All-m/15-11	NNW-SSE	SSE-NNW	SSE	E	supine		G	pit burial	yes

All-m/15-12-1	NNW-SSE	SSE-NNW	SSE	NNE	flexed	R	E/3	chamber burial	yes
All-m/15-12-2	NNW-SSE	SSE-NNW	SSE	E	flexed	R	E/3	chamber burial	yes
All-m/16-1	N-S	N-S	N		flexed	L	E/1-2	pit burial	no
All-m/16-2-1	NNW-SSE	W-E	W	N	supine		F	chamber burial	no
All-m/16-2-2	NNW-SSE						F	pit burial	no
All-m/16-3-1	NNW-SSE						F	chamber burial	no
All-m/16-3-2	NNW-SSE	SSE-NNW	SSE		supine		F	chamber burial	no
All-m/16-3-3	NNW-SSE	SSE-NNW	SSE		supine		F	chamber burial	no
All-m/16-3-4	NNW-SSE						F	chamber burial	no
All-m/16-3-5	NNW-SSE						F	chamber burial	no
All-m/16-4	NNW-SSE						F	chamber burial	no
All-m/17-1	WSW-ENE						D/2	chamber burial	no
All-m/17-3-1	WSW-ENE						D/2	chamber burial	no
All-m/17-3-2	WSW-ENE						D/2	chamber burial	no
All-m/17-3-3	WSW-ENE	WNW-ESE	WNW	ENE	supine		D/2	chamber burial	no
All-m/17-3-4	WSW-ENE	ENE-WSW	ENE		supine		D/2	chamber burial	no
All-m/17-3-5	WSW-ENE						D/2	chamber burial	no
All-m/17-3-6	WSW-ENE	NE-SW	NE	SSE	supine		D/2	chamber burial	no
All-m/17-3-7	WSW-ENE						D/2	chamber burial	no
All-m/17-3-8	WSW-ENE	ENE-WSW	ENE		supine		D/2	chamber burial	no
All-m/17-3-9	WSW-ENE		NNE		supine		D/2	chamber burial	no
All-m/17-3-10	WSW-ENE	ENE-WSW	ENE		supine		D/2	chamber burial	no
All-m/17-3-11	WSW-ENE	ENE-WSW	ENE		flexed		D/2	chamber burial	no
All-m/17-3-12	WSW-ENE	ENE-WSW	ENE				D/2	chamber burial	no
All-m/17-3-13	WSW-ENE	ENE-WSW	ENE				D/2	chamber burial	no
All-m/17-3-14	WSW-ENE	ENE-WSW	ENE				D/2	chamber burial	no

All-m/17-4	ENE-WSW	ENE-WSW	ENE	SSE	flexed	R	D/2-3	jar burial	
All-m/17-5	NNW-SSE	SSE-NNW	SSE	W	flexed	L	E/1	pit burial	yes
All-m/17-6	ENE-WSW	WSW-ENE	WSW	N	flexed	R	E/1	chamber burial	yes
All-m/17-7	NNW-SSE	NNW-SSE					E/3-2	pit burial	no
All-m/17-8	WSW-ENE	ENE-WSW	ENE		flexed	L	E/2	chamber burial	no
All-m/18-1	ENE-WSW						D/2-3	chamber burial	no
All-n/10-1	NNW-SSE						D/2	chamber burial	no
All-n/10-2	NW-SE	SE-NW	SE		flexed		D/3	chamber burial	yes
All-n/10-3	ENE-WSW	WSW-ENE	WSW	WSW	flexed	L	E/1	chamber burial	
All-n/10-4	WNW-ESE	ESE-WNW	ESE	NNE	flexed	R	E/2-3	chamber burial	yes
All-n/10-5	NNE-SSW						E/1	chamber burial	no
All-n/10-6	ESE-WNW	ESE-WNW	ESE		supine		E/1-2	jar burial	yes
All-n/10-7	NE-SW	NE-SW	NE	WSW	flexed	R	E/2	jar burial	yes
All-n/11-1	WSW-ENE						D/2	jar burial	no
All-n/11-2	NW-SE	SE-NW	SE	NE	flexed	R	D/3-E/1	jar burial	yes
All-n/11-3	NW-SE						E/1	chamber burial	no
All-n/11-4	NW-SE						D/3	chamber burial	no
All-n/11-5	NNW-SSE						E/1	chamber burial	no
All-n/11-6							D/3	jar burial	
All-n/11-7	NNW-SSE	NNW-SSE	NNW		supine		F	pit burial	no
All-n/11-8							E/1	jar burial	yes
All-n/11-9							D/3	jar burial	
All-n/11-10							D/3	jar burial	
All-n/11-11	NNW-SSE						D/2	jar burial	yes
All-n/11-12	NW-SE						D/2	jar burial	no
All-n/12-1	WSW-ENE						D/3	chamber burial	no

All-n/12-2	WSW-ENE	WSW-ENE	WSW	S	flexed	R	D/3	jar burial	yes
All-n/12-3	SSE-NNW	SSE-NNW	SSE		flexed	R	D/3-E/1	jar burial	yes
All-n/12-4	WSW-ENE	ENE-WSW	E		supine		G	sarkophag	yes
All-n/12-5	E-W	W-E	W	S	flexed	R	G	pit burial	
All-n/12-6	NE-SW	NE-SW	NE	NW	flexed	R	F	pit burial	no
All-n/12-7	NE-SW	NE-SW	NE	S	supine		E/1	chamber burial	yes
All-n/12-8	NNW-SSE						D/3	jar burial	no
All-n/12-9							D/2	jar burial	
All-n/12-10							D/3	chamber burial	no
All-n/12-11	NW-SE						D/3	jar burial	no
All-n/13-1-1	NE-SW						D/2	chamber burial	no
All-n/13-1-2	NE-SW						D/2	chamber burial	no
All-n/13-1-3	NE-SW						D/2	chamber burial	no
All-n/13-1-4	NE-SW						D/2	chamber burial	no
All-n/13-1-5	NE-SW	SSE-NNW	SSE	ENE	flexed	R	D/2	chamber burial	no
All-n/13-1-6	NE-SW						D/2	chamber burial	no
All-n/13-2	NE-SW						D/2	chamber burial	no
All-n/13-3	NW-SE	NW-SE	NW	ENE	flexed	L	E/1	jar burial	yes
All-n/13-4	N-S						D/3	chamber burial	no
All-n/13-5	OVAL	SSE-NNW	SSE		flexed		E/1	chamber burial	
All-n/13-6	ENE-WSW						E/1	jar burial	yes
All-n/13-7							D/3-E/1	jar burial	
All-n/13-8-1	WNW-SE	ESE-WNW	ESE	WNW	supine		D/3	chamber burial	yes
All-n/13-8-2	WNW-SE	ESE-WNW	ESE	ENE	flexed	R	D/3	chamber burial	yes
All-n/13-9	NW-SE	SE-NW	SE	SW	flexed	L	E/3	chamber burial	yes
All-n/13-10	NW-SE	S-N	S	W	flexed	L	E/3	chamber burial	no

All-n/13-11								D/2	jar burial	
All-n/13-12	NNE-SSW							D/2	jar burial	no
All-n/14-1	NW-SE	NW-SE						E/1	jar burial	
All-n/14-2								E/1	jar burial	
All-n/15-1-1	NNW-SSE	NNW-SSE	NNW	E	supine			D/3	chamber burial	no
All-n/15-1-2	NNW-SSE	SSE-NNW	SSE	W	supine			D/3	chamber burial	no
All-n/15-1-3	NNW-SSE	NNW-SSE	NNW	S	supine			D/3	chamber burial	no
All-n/15-2-1	N-S							F	pit burial	no
All-n/15-2-2	N-S							F	pit burial	
All-n/15-2-3	N-S							F	pit burial	
All-n/16-1	NNW-SSE							E/1-2	pit burial	no
All-n/16-2	NNE-SSE	S-N	S	W	flexed	L		G	chamber burial	yes
All-n/18-2	WNW-ESE	ESE-WNW	ESE	W	flexed	L		E/1-2	jar burial	
All-n/18-3								E/1-2	jar burial	
All-n/19-1								D/2	chamber burial	
All-n/19-2								D/2	chamber burial	
All-n/19-4-1								E/3-F	chamber burial	
All-n/19-4-2								E/3-F	chamber burial	
All-n/19-4-3								E/3-F	chamber burial	
All-n/19-5								E/2	chamber burial	
All-n/19-6								E/3-F	chamber burial	
All-o/12-1A								D/3	jar burial	
All-o/12-1B								D/3	jar burial	
All-o/12-2	ESE-WNW	ESE-WNW	ESE	SSW	flexed	L		D/3	jar burial	yes
All-o/12-3	NNE-SSW							D/3	chamber burial	no
All-o/12-4	NNE-SSW							D/3	chamber burial	no

All-o/12-5							D/3	chamber burial	
All-o/12-6	NNE-SSW						E/2	chamber burial	no
All-o/12-7	N-S	S-N	S				E/1	jar burial	yes
All-o/12-8	NNW-SSE						E/2	chamber burial	no
All-o/12-9	NW-SE						E/3	chamber burial	no
All-o/12-10							E/3	jar burial	
All-o/13-1-1	NE-SW	NE-SW	NE	S	supine	L	E/3-F	chamber burial	yes
All-o/13-1-2	NE-SW	NE-SW	NE		flexed		E/3-F	chamber burial	yes
All-o/14-3-4	NE-SW						D/3	chamber burial	no
All-o/14-3-5	NE-SW	SW-NE	SW	SE	supine		D/3	chamber burial	no
All-o/14-5	N-S						D/2	jar burial	yes
All-o/14-7	NW-SE						D/3	jar burial	no
All-o/14-11	NW-SE	SE-NW	SE	W			D/3	jar burial	yes
All-o/14-12	NW-SE						D/3	jar burial	no
All-o/14-17	NW-SE						D/3	jar burial	no
All-o/14-20	N-S						D/3	jar burial	no
All-o/14-39	N-S						E/1	jar burial	no
All-o/14-43	ENE-WSW	ENE-WSW	ENE		supine		E/1	chamber burial	yes
All-o/14-46	ENE-WSW	WSW-ENE	WSW	NNE	supine		E/2-1	chamber burial	yes
All-o/14-57	NE-SW			SE			E/2	jar burial	no
All-o/20-4							E/1	chamber burial	
All-o/20-5							E/1-3	chamber burial	
All-o/20-6							E/3	chamber burial	
All-o/21-1							D/3	jar burial	
All-o/21-3							F-E/3	chamber burial	
All-o/21-4							D/3	chamber burial	

All-o/21-5							E/2-3	jar burial	
All-o/21-7							D/3	chamber burial	
All-o/21-8							E/1-D/3	chamber burial	
All-p/13-1							D/2	jar burial	yes
All-p/13-3	N-S	N-S	N	W	flexed	R	D/2	jar burial	yes
All-p/13-4	NE-SW				supine		D/2	chamber burial	no
All-p/13-14	NW-SE	NW-SE	NW		flexed	R	E/1	jar burial	yes
All-p/13-15	WNW-ESE	WNW-ESE	WNW		supine		E/2	chamber burial	yes
All-p/13-16	WSW-ENE						E/2	jar burial	no
All-p/13-18	NW-SE	NW-SE	NW	NE	flexed	L	E/2	jar burial	yes
All-p/13-25	NW-SE	SE-NW	SE	SSW	flexed	L	E/3	jar burial	yes
All-p/14-2	N-S	S-N	S		flexed	L	E/2	jar burial	yes
All-p/14-3	WNW-ESE						E/1	chamber burial	no
All-p/14-4-1	NE-SW	NE-SW	NE		supine		E/2	chamber burial	yes
All-p/14-4-2	NE-SW						E/2	chamber burial	no
All-p/14-6	NW-SE				supine		E/1	chamber burial	no
All-p/14-10	ESE-WNW	ESE-WNW	ESE	N	supine		E/3	chamber burial	yes
All-p/14-11	ENE-WSW	ENE-WSW	ENE	SSE	flexed		E/3	jar burial	yes
All-p/14-12-1	NNW-SSE	SSE-NNW	SSE	SW	flexed	L	E/3	chamber burial	yes
All-p/14-12-2	NNW-SSE	SSE-NNW	SSE		supine		E/3	chamber burial	yes
All-p/14-12-3	NNW-SSE		SSE				E/3	chamber burial	yes
All-p/14-13	NW-SE	SSE-NNW	SSE	ENE	flexed	R	E/3	chamber burial	yes
All-p/14-15	ESE-WNW	ESE-WNW	ESE	NE	flexed	R	F	chamber burial	yes
All-p/14-18	NW-SE	SE-NW	SE	N	flexed	R	F	chamber burial	yes
All-p/14-19	NW-SE	SE-NW	SE		flexed		F	pit burial	yes
All-p/14-20	NW-SE	SE-NW	SE		supine		F	pit burial	yes

All-p/20-1			D/3-E/1	jar burial
All-p/20-2	flexed	R	E/1-2	chamber burial
All-p/20-3-1			E/1-2	chamber burial
All-p/20-3-2			E/1-2	chamber burial
All-p/20-3-3			E/1-2	chamber burial
All-p/20-3-4			E/1-2	chamber burial
All-p/20-4				
All-p/21-1	flexed	L	D/3-E/1	jar burial
All-p/21-2			D/3-E/1	jar burial
All-p/21-3-1			D/3-E/1	chamber burial
All-p/21-3-2			D/3-E/1	chamber burial
All-p/21-4			D/3	jar burial
All-p/21-5			D/3	jar burial
All-p/21-6	supine		E/1	jar burial
All-p/21-7	supine		E/1-D/3	chamber burial
All-p/21-8			D/3	jar burial
All-p/21-9	flexed	R	D/3	jar burial
All-p/21-10			D/3	jar burial
All-p/21-11	supine		D/3-E/1	chamber burial
All-p/21-12			E/3-F	chamber burial
All-p/21-13			D/3	chamber burial
All-p/21-14			D/3	pit burial
All-p/21-15			D/3	pit burial
All-p/21-16			G-F	jar burial
All-p/22-1			D/2-3	pit burial
All-p/22-2			D/2-3	chamber burial

All-q/20-1	NNW-SSE	SSE-NNW	SSE	W	flexed	L	E/1	pit burial	yes
All-q/21-1	NNW-SSE						E/1	chamber burial	no
All-q/21-2	WSW-ENE						E/1	chamber burial	no
All-q/21-3	NNW-SSE						E/1	chamber burial	no
All-r/18-1	NNW-SSE	NNW-SSE	NNW	E	supine		F	chamber burial	no
All-r/18-2	NE-SW	SW-NE	SW	N	flexed	L	G	pit burial	no
All-s/18-1	ENE-WSW						E/1	chamber burial	no

A10 cont'd. Contextual information available from individuals buried in Area A/II. Coordinate information is arbitrary, used to explore spatial relations.

individual ID	associated equid burial	Personal burial goods											
		axe	dagger	spear	knife	pommel	sword	belt	ring	pin	jewellery (metal)	jewellery (beads)	earring
All-k/9-34	no	0	0	0	0	0	0	0	0	0	0	0	0
All-k/9-35-1	no									1		1	
All-k/9-35-2	no												
All-k/9-35-3	no												
All-k/9-35-4	no												
All-k/9-35-5	no												
All-k/9-35-6	no												
All-k/9-36	no												
All-k/11-1	no									1			
All-k/12-1	no												
All-k/12-2	no												
All-k/12-3	no												
All-k/14-1-1	no				1						1	1	
All-k/14-1-2	no												
All-k/14-3	yes												
All-k/14-4	no												
All-k/14-5	no												
All-k/14-8	no								1	1		1	
All-k/15-8	no												
All-k/16-20	no	0	0	0	0	0	0	0	0	0	0	0	0
All-k/16-23	no												

All-k/16-24	no													
All-k/17-11	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-k/17=I/17-13	no				1									
All-k/17-19	no													
All-k/17-22	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-k/17-29	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-k/17-30-1	no													
All-k/17-30-2	no	0	0	0	0	0	0	0	0	1	1	1		
All-I/10-1	no													
All-I/10-2	no													
All-I/11-1-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-1-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-2	no													
All-I/11-3-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-3-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-3-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-3-4	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/11-4	no													
All-I/12-1-3	no									1		1		
All-I/12-1-4	no									1				
All-I/12-1-5	no									1		1		
All-I/12-1-6	no													
All-I/12-1-7												1	3	
All-I/12-1-8														
All-I/12-2-1	yes	1	0	0	0	0	0	0	0	1	0	0	0	0

All-I/12-2-2	yes	0	0	0	2	0	0	0	0	1	0	0	0
All-I/12-2-3	yes	0	0	0	0	0	0	0	0	0	0	1	0
All-I/12-3	no												
All-I/12-4	no	0	0	0	0	0	0	0	0	0	0	0	0
All-I/12-5-1	yes	1	1	0	0	0	0	0	0	0	1	0	0
All-I/12-5-2	no												
All-I/12-5-3	no												
All-I/12-5-4	no												
All-I/13-1	no												
All-I/13-2	no												
All-I/13-3	no									1			
All-I/13-4	no												
All-I/14-1	no	0	0	0	0	0	0	0	0	0	0	0	0
All-I/14-2	no												
All-I/14-3	no												
All-I/14-4-1	no											1	
All-I/14-4-2	no												
All-I/14-5	no	1	1									1	
All-I/14-6	no												
All-I/14-7-1	no												
All-I/14-7-3	no												
All-I/14-7-3	no												
All-I/14-7-4	no												
All-I/14-8	no												
All-I/14-12-1	no											1	
All-I/14-12-2	no												

All-I/14-12-3	no													
All-I/15-1	no													
All-I/15-2	no											1		
All-I/15-3	no													
All-I/15-4/6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/15-5	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/16-1	no													
All-I/16-2	no				3									
All-I/16-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/16-4-1	no	0	1	0	0	0	0	1	0	0	0	0	0	0
All-I/16-4-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/16-5	no													
All-I/16-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-3-1	no									1				
All-I/17-3-2	no													
All-I/17-3-3	no													
All-I/17-5-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-5-2	no	0	0	0	0	0	0	0	0	0	1	0	0	0
All-I/17-5-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-8	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-10	no													
All-I/17-14	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-15	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-I/17-16	no	0	0	0	0	0	0	0	0	0	0	0	0	0

All-l/17-17	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/10-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/10-4	no													
All-m/10-5	no													
All-m/10-6	no	0	0	0	0	0	0	0	0	0	0	0	1	0
All-m/10-7-1	no													
All-m/10-7-2	no													
All-m/10-8-1	no	1	1	0	0	0	0	0	0	0	0	0	0	0
All-m/10-8-2	no	0	0	0	0	0	0	0	0	0	0	0	1	0
All-m/10-9	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/10-10	no													
All-m/11-1	no													
All-m/11-2	no									1				
All-m/11-3	no												1	
All-m/11-4	no													
All-m/11-5	no												1	
All-m/11-6-1	no								1	1				
All-m/11-6-2	no									1				
All-m/11-6-3	no													
All-m/11-7	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/11-8	no													
All-m/11-9	no													
All-m/11-10	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/11-11	no													
All-m/11-12	no													
All-m/11-13	no													

All-m/11-14	no														
All-m/12-1	no													1	
All-m/12-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/12-3	no														
All-m/12-4	no														
All-m/12-5	no														
All-m/12-6	no														
All-m/12-7	no														
All-m/12-8	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/12-9-1	yes														
All-m/12-9-2	yes														
All-m/12-9-3	yes														
All-m/12-10	no														
All-m/12-11	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/12- 12 / 13-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/12- 12 / 13-2	no	0	0	0	0	0	0	0	0	0	0	0	1	0	0
All-m/12- 12 / 13-3															
All-m/12-14	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-2	no												1		
All-m/13-3	no														
All-m/13-4	no	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-5	no														

All-m/13-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-7	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-8	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-9	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-10	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-11	no													
All-m/13-12	no													
All-m/13-13-1	no	0	0	0	0	0	0	0	0	0	0	0	1	0
All-m/13-13-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-13-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-13-4	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-13-5	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-14	no									1				
All-m/13-15	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/13-16	no													
All-m/13-17	no													
All-m/14-1	no													
All-m/15-1	no												1	
All-m/15-2	no												1	
All-m/15-3-1	no	0	0	0	0	0	0	0	0	1	0	1	1	
All-m/15-3-2	no	0	0	0	0	0	0	0	0	1	0	0	1	
All-m/15-4	no	0	0	0	0	0	0	0	0	1	0	0	0	
All-m/15-5	no													
All-m/15-6	no	0	0	0	0	0	0	0	0	0	0	0	0	
All-m/15-7	no													
All-m/15-8	no	0	0	0	0	0	0	0	0	1	1	0	0	

All-m/15-9-1	no	1				1			1					1	
All-m/15-9-2	no											1			
All-m/15-9-3	no														
All-m/15-10	no														
All-m/15-11	no	0	0	0	0	0	0	0	0	0	0	0		1	0
All-m/15-12-1	no	0	0	0	0	0	0	0	0	0	1	0		0	1
All-m/15-12-2	no	0	0	0	0	0	0	0	0	0	2	0		0	0
All-m/16-1	no														
All-m/16-2-1	no										1			1	
All-m/16-2-2	no														
All-m/16-3-1	no														
All-m/16-3-2	no													1	
All-m/16-3-3	no											3		1	
All-m/16-3-4	no														
All-m/16-3-5	no														
All-m/16-4	no														
All-m/17-1	no														
All-m/17-3-1	no										1				1
All-m/17-3-2	no														
All-m/17-3-3	no														
All-m/17-3-4	no														
All-m/17-3-5	no														
All-m/17-3-6	no														
All-m/17-3-7	no														
All-m/17-3-8	no														
All-m/17-3-9	no														

All-m/17-3-10	no													
All-m/17-3-11	no													
All-m/17-3-12	no													
All-m/17-3-13	no													
All-m/17-3-14	no													
All-m/17-4	no													
All-m/17-5	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/17-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-m/17-7	no													
All-m/17-8	no													
All-m/18-1	no												1	
All-n/10-1	no									1				
All-n/10-2	no	0	0	0	0	0	0	0	0	0	0	0	1	0
All-n/10-3	no												1	
All-n/10-4	no	0	0	0	0	0	0	0	1	0	0	0	0	4
All-n/10-5	no													
All-n/10-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/10-7	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/11-1	no													
All-n/11-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/11-3	no													
All-n/11-4	no					1							1	
All-n/11-5	no									3				
All-n/11-6	no													
All-n/11-7	no													
All-n/11-8	no	0	0	0	0	0	0	0	0	0	0	0	0	0

All-n/11-9	no														
All-n/11-10	no														
All-n/11-11	no	0	0	0	0	0	0	0	0	0	0	0	1	1	
All-n/11-12	no														
All-n/12-1	no														
All-n/12-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0	
All-n/12-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0	
All-n/12-4	no	0	0	0	0	0	0	0	0	0	0	0	1	0	
All-n/12-5	no														
All-n/12-6	no														
All-n/12-7	no	0	0	0	0	0	0	0	1	0	0	0	0	1	
All-n/12-8	no														
All-n/12-9	no														
All-n/12-10	no														
All-n/12-11	no														
All-n/13-1-1	no														
All-n/13-1-2	no														
All-n/13-1-3	no														
All-n/13-1-4	no														
All-n/13-1-5	no														
All-n/13-1-6	no														
All-n/13-2	no														
All-n/13-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0	
All-n/13-4	no														
All-n/13-5	no												1		

All-n/13-6	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/13-7	no													
All-n/13-8-1	yes	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/13-8-2	yes	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/13-9	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-n/13-10	no													
All-n/13-11	no													
All-n/13-12	no													
All-n/14-1	no													
All-n/14-2	no													
All-n/15-1-1	no		1		2								1	
All-n/15-1-2	no	1			1							1		
All-n/15-1-3	no	1	1									1		
All-n/15-2-1	no													
All-n/15-2-2	no													
All-n/15-2-3	no													
All-n/16-1	no													
All-n/16-2	no	0	0	0	0	0	0	0	0	0	1	0	0	0
All-n/18-2	no													
All-n/18-3	no													
All-n/19-1	no													
All-n/19-2	no													
All-n/19-4-1	no										1?? ?			
All-n/19-4-2	no													
All-n/19-4-3	no													

All-n/19-5	no	1											
All-n/19-6	no												
All-o/12-1A	no												
All-o/12-1B	no												
All-o/12-2	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/12-3	no												
All-o/12-4	no												
All-o/12-5	no												
All-o/12-6	no												
All-o/12-7	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/12-8	no												
All-o/12-9	no												
All-o/12-10	no												
All-o/13-1-1	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/13-1-2	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/14-3-4	no											1	1
All-o/14-3-5	no												
All-o/14-5	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/14-7	no												1
All-o/14-11	no	0	0	0	0	0	0	0	0	0	0	0	0
All-o/14-12	no												
All-o/14-17	no												
All-o/14-20	no												
All-o/14-39	no												
All-o/14-43	no	0	0	0	0	0	0	0	0	3	0	1	0
All-o/14-46	no	0	0	0	0	0	0	0	0	1	0	1	0

All-o/14-57	no													
All-o/20-4	no	1	1								1			
All-o/20-5	no													
All-o/20-6	no													
All-o/21-1	no													
All-o/21-3	no													
All-o/21-4	no										1			
All-o/21-5	no													
All-o/21-7	no				1									
All-o/21-8	no													
All-p/13-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/13-3	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/13-4	no				1									
All-p/13-14	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/13-15	no	1	1	0	0	0	0	0	0	0	2	0	0	0
All-p/13-16	no													
All-p/13-18	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/13-25	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/14-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/14-3	no													
All-p/14-4-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/14-4-2	no											1		
All-p/14-6	no													
All-p/14-10	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/14-11	no	0	0	0	0	0	0	0	0	0	0	1	1	1
All-p/14-12-1	no	0	0	0	0	0	0	0	0	0	0	0	0	0

All-p/14-12-2	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/14-12-3	no	0	0	0	0	0	0	0	0	0	0	0	0	1
All-p/14-13	no	0	0	0	0	0	0	0	1	1	0	1	0	0
All-p/14-15	no	0	0	0	0	0	0	0	1	0	0	0	0	0
All-p/14-18	yes	0	1	0	0	0	1	1	0	0	0	0	0	0
All-p/14-19	no	0	0	0	0	0	0	0	0	0	0	1	0	0
All-p/14-20	no	0	0	0	0	0	0	0	0	0	0	0	0	0
All-p/20-1	no													
All-p/20-2	no				1				1	1				
All-p/20-3-1	no		1											
All-p/20-3-2	no													
All-p/20-3-3	no		1											
All-p/20-3-4	no													
All-p/20-4														
All-p/21-1	no													
All-p/21-2	no													
All-p/21-3-1	no													
All-p/21-3-2	no													
All-p/21-4	no													
All-p/21-5	no													
All-p/21-6	no													
All-p/21-7	no	1	1							1				
All-p/21-8	no													
All-p/21-9	no													
All-p/21-10	no													
All-p/21-11	no													

A10 cont'd. Contextual information available from individuals buried in Area A/II. Coordinate information is arbitrary, used to explore spatial relations.

individual ID	Tell el-Yahudiyah ware										Cypriot and imitation Cypriot ware					
	TeY_ B4	TeY_ E2	TeY_H. 1.2	TeY_ I	TeY_J. 1.7	TeY_ L	TeY_ M	TeY_ M.1	TeY_ M.2	TeY_ N	WP_P LS	WP V	WP_V AR	PW S	W S	IWP_P LS
All-k/9-34									0	0						0
All-k/9-35-1													3		1	
All-k/9-35-2																
All-k/9-35-3																
All-k/9-35-4																
All-k/9-35-5																
All-k/9-35-6																
All-k/9-36																
All-k/11-1																
All-k/12-1																
All-k/12-2																
All-k/12-3																
All-k/14-1-1								5								
All-k/14-1-2																
All-k/14-3																
All-k/14-4																
All-k/14-5																
All-k/14-8								1								
All-k/15-8																
All-k/16-20								0		0						0
All-k/16-23																

All-k/16-24					
All-k/17-11		0		0	0
All-k/17=I/17-13					1
All-k/17-19					
All-k/17-22		0		0	0
All-k/17-29		0		0	0
All-k/17-30-1		6		1	1
All-k/17-30-2	1				
All-I/10-1					
All-I/10-2					
All-I/11-1-1		0		0	0
All-I/11-1-2		0		0	0
All-I/11-2					
All-I/11-3-1		0		0	0
All-I/11-3-2		0		0	0
All-I/11-3-3		0		0	0
All-I/11-3-4		0		0	0
All-I/11-4					
All-I/12-1-3		9	1	1	
All-I/12-1-4					
All-I/12-1-5					
All-I/12-1-6					
All-I/12-1-7					
All-I/12-1-8					
All-I/12-2-1		33	0	0	0

All-I/12-2-2		0	0	0
All-I/12-2-3		0	0	0
All-I/12-3	1			
All-I/12-4		0	0	0
All-I/12-5-1		0	0	0
All-I/12-5-2				
All-I/12-5-3				
All-I/12-5-4				
All-I/13-1				
All-I/13-2	2			
All-I/13-3				
All-I/13-4				
All-I/14-1		0	0	0
All-I/14-2				
All-I/14-3				
All-I/14-4-1	1			
All-I/14-4-2				
All-I/14-5	19			
All-I/14-6				
All-I/14-7-1	3	1		
All-I/14-7-3				
All-I/14-7-3				
All-I/14-7-4				
All-I/14-8				
All-I/14-12-1				
All-I/14-12-2				

All-I/14-12-3				
All-I/15-1	1			
All-I/15-2				
All-I/15-3				
All-I/15-4/6		0	0	0
All-I/15-5		0	0	0
All-I/16-1	19			
All-I/16-2	8			
All-I/16-3		0	0	0
All-I/16-4-1		0	0	0
All-I/16-4-2		0	0	0
All-I/16-5				
All-I/16-6		0	0	0
All-I/17-1		0	0	0
All-I/17-3-1	1			1
All-I/17-3-2				
All-I/17-3-3				
All-I/17-5-1		0	0	1
All-I/17-5-2		0	0	0
All-I/17-5-3		0	0	0
All-I/17-6		0	0	0
All-I/17-8		0	0	0
All-I/17-10				
All-I/17-14		0	0	0
All-I/17-15		0	0	0
All-I/17-16		0	0	0

All-l/17-17		0		0		0
All-m/10-2		0		0		0
All-m/10-4						
All-m/10-5						
All-m/10-6		0		0		0
All-m/10-7-1						
All-m/10-7-2						
All-m/10-8-1	7	0		3		0
All-m/10-8-2		0		0		0
All-m/10-9		0		0		0
All-m/10-10						
All-m/11-1					1	
All-m/11-2						
All-m/11-3						
All-m/11-4						
All-m/11-5		1				
All-m/11-6-1		16				
All-m/11-6-2	1					
All-m/11-6-3						
All-m/11-7		4	0		0	1
All-m/11-8						
All-m/11-9						
All-m/11-10		0		0		0
All-m/11-11						
All-m/11-12						
All-m/11-13		1				

All-m/11-14									
All-m/12-1									
All-m/12-2				0		0			0
All-m/12-3									
All-m/12-4									
All-m/12-5									
All-m/12-6									
All-m/12-7									
All-m/12-8				0		0			0
All-m/12-9-1	3	2	1						
All-m/12-9-2									
All-m/12-9-3									
All-m/12-10			1	1	1				
All-m/12-11				0		0			0
All-m/12- 12 / 13-1				0		0			0
All-m/12- 12 / 13-2				0		0			0
All-m/12- 12 / 13-3									
All-m/12-14				0		0			0
All-m/13-1				0		0			0
All-m/13-2									
All-m/13-3			1						
All-m/13-4			1	0		0			0
All-m/13-5									

All-m/13-6		0	0	0
All-m/13-7		0	0	0
All-m/13-8		0	0	0
All-m/13-9		0	0	0
All-m/13-10		0	0	0
All-m/13-11				
All-m/13-12				
All-m/13-13-1	1	0	0	0
All-m/13-13-2		0	0	0
All-m/13-13-3		0	0	0
All-m/13-13-4		0	0	0
All-m/13-13-5		0	0	0
All-m/13-14	1			
All-m/13-15		0	0	0
All-m/13-16				
All-m/13-17				
All-m/14-1				
All-m/15-1				
All-m/15-2				
All-m/15-3-1	25	0	0	1
All-m/15-3-2		0	0	0
All-m/15-4		0	0	0

All-m/15-5			
All-m/15-6		0	0
All-m/15-7			
All-m/15-8	2	0	0
All-m/15-9-1			
All-m/15-9-2			
All-m/15-9-3			
All-m/15-10			
All-m/15-11		0	0
All-m/15-12-1		0	0
All-m/15-12-2		0	0
All-m/16-1			
All-m/16-2-1			
All-m/16-2-2			
All-m/16-3-1	1		
All-m/16-3-2			
All-m/16-3-3			
All-m/16-3-4			
All-m/16-3-5			
All-m/16-4			
All-m/17-1			
All-m/17-3-1		1	
All-m/17-3-2			
All-m/17-3-3			

All-m/17-3-4				
All-m/17-3-5				
All-m/17-3-6				
All-m/17-3-7				
All-m/17-3-8				
All-m/17-3-9				
All-m/17-3-10				
All-m/17-3-11				
All-m/17-3-12				
All-m/17-3-13				
All-m/17-3-14				
All-m/17-4				
All-m/17-5		0	0	0
All-m/17-6	1	0	0	0
All-m/17-7				
All-m/17-8				
All-m/18-1				
All-n/10-1	1			1
All-n/10-2		0	0	0
All-n/10-3				
All-n/10-4		0	0	0
All-n/10-5	2			

All-n/10-6		0		0		0
All-n/10-7		0		0		0
All-n/11-1						
All-n/11-2		0		0		0
All-n/11-3	5					
All-n/11-4						
All-n/11-5	4					
All-n/11-6						
All-n/11-7						
All-n/11-8		0		0		0
All-n/11-9						
All-n/11-10						
All-n/11-11	1	0		0		0
All-n/11-12						
All-n/12-1						
All-n/12-2		0		0		0
All-n/12-3		0		0		0
All-n/12-4		0		0		0
All-n/12-5						
All-n/12-6						
All-n/12-7	6	0		0		0
All-n/12-8						
All-n/12-9						
All-n/12-10						
All-n/12-11						
All-n/13-1-1						

All-n/13-1-2				
All-n/13-1-3				
All-n/13-1-4				
All-n/13-1-5				
All-n/13-1-6				
All-n/13-2				
All-n/13-3		0	0	0
All-n/13-4	1			
All-n/13-5	1			
All-n/13-6		0	0	0
All-n/13-7				
All-n/13-8-1	4	0	3	0
All-n/13-8-2		0	0	0
All-n/13-9		0	0	0
All-n/13-10				
All-n/13-11				
All-n/13-12				
All-n/14-1	1			
All-n/14-2				
All-n/15-1-1				
All-n/15-1-2				
All-n/15-1-3				
All-n/15-2-1				
All-n/15-2-2				
All-n/15-2-3				
All-n/16-1				

All-n/16-2	0	0	0
All-n/18-2			
All-n/18-3			
All-n/19-1			
All-n/19-2			
All-n/19-4-1	1	1	
All-n/19-4-2			
All-n/19-4-3			
All-n/19-5	2		
All-n/19-6			
All-o/12-1A			
All-o/12-1B			
All-o/12-2	0	0	0
All-o/12-3	2		
All-o/12-4			
All-o/12-5			
All-o/12-6			
All-o/12-7	0	0	0
All-o/12-8			
All-o/12-9			
All-o/12-10			
All-o/13-1-1	0	0	0
All-o/13-1-2	0	0	0
All-o/14-3-4	2		
All-o/14-3-5			
All-o/14-5	0	0	0

All-o/14-7				
All-o/14-11		0	0	0
All-o/14-12				
All-o/14-17				
All-o/14-20				
All-o/14-39				
All-o/14-43	13	0	0	0
All-o/14-46		0	0	0
All-o/14-57				
All-o/20-4				
All-o/20-5				
All-o/20-6				
All-o/21-1	1			
All-o/21-3				
All-o/21-4	1			
All-o/21-5				
All-o/21-7				
All-o/21-8				
All-p/13-1		0	0	0
All-p/13-3	1	0	0	0
All-p/13-4	1			
All-p/13-14		0	0	0
All-p/13-15		0	0	0
All-p/13-16				
All-p/13-18		0	0	0
All-p/13-25		0	0	0

All-p/14-2		0	2	0
All-p/14-3				
All-p/14-4-1	1	0	0	0
All-p/14-4-2				
All-p/14-6				
All-p/14-10		0	1	0
All-p/14-11		0	0	0
All-p/14-12-1		0	1	0
All-p/14-12-2		0	0	0
All-p/14-12-3		0	0	0
All-p/14-13		0	2	0
All-p/14-15		0	0	0
All-p/14-18		0	0	0
All-p/14-19		0	0	0
All-p/14-20		0	0	0
All-p/20-1				
All-p/20-2				
All-p/20-3-1	6			
All-p/20-3-2				
All-p/20-3-3				
All-p/20-3-4				
All-p/20-4	7			
All-p/21-1	1			
All-p/21-2				
All-p/21-3-1	1		2	
All-p/21-3-2				

All-p/21-4	1	1	
All-p/21-5			
All-p/21-6			
All-p/21-7			
All-p/21-8			
All-p/21-9			
All-p/21-10			
All-p/21-11			
All-p/21-12			
All-p/21-13			
All-p/21-14			
All-p/21-15	1		
All-p/21-16			
All-p/22-1			
All-p/22-2			
All-q/20-1	0	0	0
All-q/21-1	1		
All-q/21-2			
All-q/21-3			
All-r/18-1			
All-r/18-2			
All-s/18-1	7		

A10 cont'd. Contextual information available from individuals buried in Area A/II. Coordinate information is arbitrary, used to explore spatial relations.

Biological info			
individual ID	Age	Sex	Assessed by / reference in
All-k/9-34	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-35-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/9-36			
All-k/11-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/12-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/12-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/12-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/14-1-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/14-1-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/14-3			
All-k/14-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/14-5			
All-k/14-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/15-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/16-20	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/16-23			
All-k/16-24	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-k/17-11	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/17=I/17-13	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/17-19			
All-k/17-22	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/17-29	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/17-30-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-k/17-30-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/10-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/10-2			
All-I/11-1-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-1-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-3-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-3-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-3-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-3-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/11-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-1-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-1-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-1-5			
All-I/12-1-6			
All-I/12-1-7			
All-I/12-1-8			
All-I/12-2-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-2-2			
All-I/12-2-3			

All-I/12-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-4	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-5-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-5-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-5-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/12-5-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/13-1			
All-I/13-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/13-3	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/13-4		indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-3			
All-I/14-4-1	19-60	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-4-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-5		indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-7-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-7-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-7-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-7-4	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-8			
All-I/14-12-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-12-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/14-12-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/15-1	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-I/15-2	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/15-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/15-4/6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/15-5	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-1	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-2			
All-I/16-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-4-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-4-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/16-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-3-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-3-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-3-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-5-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-5-2	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-5-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-10			
All-I/17-14	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-15	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-16	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-I/17-17	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-m/10-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-7-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-7-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-8-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-8-2			
All-m/10-9	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/10-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-2			
All-m/11-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-6-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-6-2			
All-m/11-6-3			
All-m/11-7	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-8			
All-m/11-9	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-11	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-12	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/11-13			
All-m/11-14			
All-m/12-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-m/12-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-5			
All-m/12-6			
All-m/12-7	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-9-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-9-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-9-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-10	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-11			
All-m/12- 12 / 13-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12- 12 / 13-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12- 12 / 13-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/12-14	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-2			
All-m/13-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-6	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-7	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-9	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-m/13-11			
All-m/13-12	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-13-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-13-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-13-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-13-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-13-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-14	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-15	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/13-16			
All-m/13-17	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/14-1		indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-2			
All-m/15-3-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-3-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-4	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-7			
All-m/15-8	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-9-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-9-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-9-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-10			
All-m/15-11	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-m/15-12-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/15-12-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-1			
All-m/16-2-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-2-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-3-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-3-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-3-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-3-4	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-3-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/16-4			
All-m/17-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-5	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-6	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-7	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-8	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-9	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-11	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-12	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-13	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-3-14	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-m/17-4			
All-m/17-5	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/17-7			
All-m/17-8	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-m/18-1	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-1			
All-n/10-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-5	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/10-7	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-3			
All-n/11-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-5	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-6			
All-n/11-7	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-8	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/11-9			
All-n/11-10			
All-n/11-11			
All-n/11-12			
All-n/12-1			

All-n/12-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-4	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-6	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-7	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-8			
All-n/12-9			
All-n/12-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/12-11			
All-n/13-1-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-1-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-1-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-1-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-1-5	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-1-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-2			
All-n/13-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-6			
All-n/13-7			
All-n/13-8-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-8-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-9	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/13-10	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-n/13-11			
All-n/13-12			
All-n/14-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/14-2			
All-n/15-1-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/15-1-2	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/15-1-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/15-2-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/15-2-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/15-2-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/16-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/16-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/18-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/18-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-2			
All-n/19-4-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-4-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-4-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-5	adult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-n/19-6			
All-o/12-1A	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/12-1B			
All-o/12-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/12-3			
All-o/12-4			

All-o/12-5			
All-o/12-6			
All-o/12-7	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/12-8			
All-o/12-9			
All-o/12-10			
All-o/13-1-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/13-1-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/14-3-4			
All-o/14-3-5			
All-o/14-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/14-7			
All-o/14-11			
All-o/14-12			
All-o/14-17			
All-o/14-20			
All-o/14-39	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/14-43	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/14-46	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/14-57	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/20-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/20-5	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/20-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/21-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/21-3	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/21-4	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-o/21-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/21-7	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-o/21-8	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/13-1			
All-p/13-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/13-4			
All-p/13-14	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/13-15	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/13-16			
All-p/13-18	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/13-25	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-3			
All-p/14-4-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-4-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-10	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-11	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-12-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-12-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-12-3	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-13	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-15	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-18	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-19	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/14-20	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

All-p/20-1			
All-p/20-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/20-3-1	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/20-3-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/20-3-3	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/20-3-4			
All-p/20-4			
All-p/21-1	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-3-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-3-2	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-4	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-5	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-6	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-7	adult	male	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-8			
All-p/21-9	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-10			
All-p/21-11	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-12	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-13	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-14			
All-p/21-15	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/21-16	subadult	indeterminate	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/22-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-p/22-2			

All-q/20-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-q/21-1			
All-q/21-2			
All-q/21-3			
All-r/18-1	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)
All-r/18-2	adult	female	Bietak (1991), Forstner-Müller (2008), Winkler and Wilfing (1991)

A11. Frequency table of sites used in the analysis. Breakpoints used to create the dichotomised values presented in table A5.

	Site	W	LC	PT	S	DS	IG	TD	MAR	DAR	PAR	AC	M	H	BH	C5UM	CC	PUM3	EE	RUP1	RUM2	I2V	M3V
Absolute total (n)	Lachish (all)				22	25	34	34	41	28				57		42	41	36	64	33	20	67	
	Lachish BA		7		7	7	7	10	14	4				21		25	19	9	8	11	5	10	
	Ajjul and Fara (all)		4		2	5	5	2	4	1	4	4		7			4	3	1	3	5	3	
	Ajjul, Fara and Lachish BA		11		9	12	12	12	18	5	4	4		28		25	23	12	9	14	10	13	
	Ajjul and Fara LB-IA		2			2	3		1		2	2		6		1	6	4	1	7	3	2	
	Ajjul, Fara and Lachish LB-IA		2		22	27	37	34	42	28	2	2		63		43	47	40	65	40	23	69	
	Arqa						14		13					26					24	19			
	Tell el-Fadous		5		3	5	2	1	3	2		3	1	1		1	1		2	4	2	2	4
	Umm el-Marra		5		3	4			2					1							1		1
	Qurna		21		17	22	27	23	31	23				46		38	34	33	51	34	30	62	
	Thebes		21		19	18	24	20	33	19				42		28	28	37	42	34	32	54	
	el-Lisht		11		10	12	19	19	27	23				42		26	23	32	47	42	44	22	
	el-Kubanieh	12		28			1	1	1		3	1	15	21	9	4	3	14	10	23	30	1	32
	Ermenne	3		6									6	1	1	1	2	2	2	6	5		5
	Tell el-Dab'a	4	27	4	20	25	19	19	20	16	16	22	34	42	27	23	36	22	24	12	11	26	44
	Sidon	6	51	12	54	59	40	39	49	34	35	46	29	57	47	52	71	32	46	35	25	46	50
	Pella		12		12	19	16	14	22	18	12	17	8	17	13	19	27	6	12	7	4	18	10
	Pella (Tomb 62)		12		12	18	14	13	18	17	11	17		13	12	17	23	5	8	6	1	15	
	Ugarit (Ras Shamra and Minet el-Beida)	6	6	13	5	6	12	7	10	6	12	10	17	24	9	8	16	15	20	16	15	10	37
	Tell Sukas	1	7	1	5	8	3	1	5	4	3	5	4	3	4	3	5	3	4	4	6	4	6

Jericho	4	16	18	10	9	12	6	16	6	10	15	18	29	15	15	21	13	22	18	20	14	30
Ashara, Masaikh, Jebel Mashtale EB				11		13	13	14	14		8				13	18			10	13	20	
Ashara, Masaikh, Jebel Mashtale MB				13		17	19	19			33		22		17	17			11	11	22	
Mari EB						15		8					12					15	11			
Ashara, Masaikh, Jebel Mashtale, Mari EB				11		28	13	22	14		8		12		13	18		15	21	13	20	
Mari (all)						22		13					19					27	18			
Ashara, Masaikh, Jebel Mashtale, Mari				13		39	19	32			33		41		17	17		27	29	11	22	
Tell Arbid		11		10	10	8	8	3	3	6	14		18		17	16	6	16	6	6	9	
Tell Brak		8		6	8	5	5	4	4		3		1		1	1		1	4	2	5	
Barri		12		12	9	8	8	4	4	6	14		9		10	11	11	9	9	5	11	
Tell Leilan		9		8	11	13	11		2				10		13	13	7	10	9	6		
Tell Mozan, Arbid, Brak, Barri, Leilan (all)		40		36	38	34	32	11	14	13	33		42		44	45	23	38	30	23	25	
Ugarit and Tell Sukas		13		10	14	15	8	15	10	15	15		27	13	11	21	18	24	20	21	14	

A11 cont'd. Frequency table of sites used in the analysis. Breakpoints used to create the dichotomised values presented in table A5.

	Site	O	CLP	AF	MID	MT	RJ	GP	C5LM2	DW	MDTC	PLM1	C6	C7	TR	RLC	RLM1	RLM2	TA
Absolute total (n)	Lachish (all)		49	20				70	54		32	58	54	67	59	65	33	44	56
	Lachish BA		3	1				5	8	2	2	5	2	2	2	9	2	1	6
	Ajjul and Fara (all)		4					5	4	2	2	1	1	3	1	3	2	3	6
	Ajjul, Fara and Lachish BA		7	1				10	12	4	4	6	3	5	3	12	4	4	12
	Ajjul and Fara LB-IA		1					4	2							1	1	2	2
	Ajjul, Fara and Lachish LB-IA		50	20				74	56		32	58	54	67	59	66	34	46	58
	Arqa		12	28				18	17					33		13	17		
	Tell el-Fadous	5	2	2		1	1			2	2	2	2	2	3	4	1	1	2
	Umm el-Marra	6	1	3		8		8	3	3	3	5	1	3	9	10	6	10	
	Qurna		35	17				50	40	24	24	32	32	36	31	29	29	28	37
	Thebes		37	14				48	38	30	26	41	41	44	36	39	39	36	40
	el-Lisht		12	8				24	24	9	9	15	15	23	35	29	29	29	26
	el-Kubanieh	3			3	3	3	2							1	2	2	2	2
	Ermenne	2	1		2	8	8	3	1			2			3	7	4	6	6
	Tell el-Dab'a	36	29	24				47	21	19	26	24	20	29	5	8	15	15	18
	Sidon	59	43	52	7	29	26	49	36	37	50	48	42	59	29	34	30	26	25
	Pella	47	18	16		1		23	16	10	15	8	13	16	10	11	6	3	1
	Pella (Tomb 62)		14	14				20	14	9	13	8	11	12	8	9	3	1	

Ugarit (Ras Shamra and Minet el-Beida)	30	18	12	12	42	41	34		12	7	12	19	7	26	13	18	19	15	26
Tell Sukas	6	5	3	1	5	4	8		5	4	7	5	1	8	1	1	5	5	1
Jericho	36	16	17	5	24	18	27		14	12	16	17	13	20	6	10	20	23	14
Ashara, Masaikh, Jebel Mashtale EB							12					12	11	11		9	13		
Ashara, Masaikh, Jebel Mashtale MB							18					13	12	12		9	13		
Mari EB		9	17				14		10					20		8	14		
Ashara, Masaikh, Jebel Mashtale, Mari EB		9	17				26		10			12	11	31		17	27		
Mari (all)		15	26				24		17					30		14	25		
Ashara, Masaikh, Jebel Mashtale, Mari		15	26				42		17			13	12	42		23	38		
Tell Arbid		7	11							13	15	10	17	17	3	4	9		
Tell Brak		7	11							9	13	15	18	18	3	9	15		
Barri		6	6							7	8	8	12	12	10	8	16		
Tell Leilan		5	4				10		11	4		15	17	17	8	10	4	6	

Tell Mozan, Arbid, Brak, Barri, Leilan (all)	25	35	15	12	36	41	52	66	70	25	32	45	14	
Ugarit and Tell Sukas	24	15	42	17	11	19	24	8	34	14	19	24	20	27

A11 cont'd. Frequency table of sites used in the analysis. Breakpoints used to create the dichotomised values presented in table A5.

	W	LC	PT	S	DS	IG	TD	MAR	DAR	PAR	AC	M	H	BH	C5UM	CC	PUM3	EE	RUP1	RUM2	I2V	M3V
Lachish (all)				0.00	0.00	0.06	0.26	0.07	0.07				0.04		0.21	0.73	0.06	0.08	0.00	0.80	0.01	
Lachish BA		0.14		0.00	0.00	0.00	0.30	0.00	0.00				0.86		0.24	0.89	0.00	0.00	0.55	1.00	0.00	
Ajjul and Fara (all)		0.75		0.00	0.00	0.00	0.50	0.00	1.00	1.00	0.75		1.00			1.00	0.33	0.00	0.67	0.80	0.00	
Ajjul. Fara and Lachish BA		0.36		0.00	0.00	0.00	0.33	0.00	0.20	1.00	0.75		0.89		0.24	0.91	0.08	0.00	0.57	0.90	0.00	
Ajjul and Fara LB-IA		0.50			0.00	0.00		0.00		1.00	0.50		1.00		1.00	1.00	0.25	1.00	0.71	0.67	1.00	
Ajjul. Fara and Lachish LB-IA		0.00		0.00	0.00	0.05	0.26	0.07	0.07	0.00	0.00		0.03		0.21	0.64	0.05	0.08	0.00	0.70	0.01	
Arqa						0.14		0.54					0.58					0.29	0.47			
Tell el-Fadous		0.40		0.00	0.00	0.00	0.00	0.00	0.50		0.33	1.00	0.00		0.00	0.00		0.00	0.75	1.00	0.00	0.00
Umm el-Marra		0.60		1.00	0.00			0.00					1.00							0.00		0.00
Qurna		0.29		0.00	0.00	0.04	0.52	0.00	0.09				0.87		0.05	0.71	0.03	0.10	0.71	0.70	0.02	
Thebes		0.48		0.16	0.00	0.21	0.30	0.03	0.11				0.86		0.14	1.00	0.00	0.05	0.85	0.81	0.00	
el-Lisht		0.45		0.00	0.00	0.32	0.37	0.00	0.00				0.88		0.15	0.61	0.00	0.15	0.62	0.77	0.00	
el-Kubanieh	0.17		0.00			0.00	0.00	0.00		1.00	0.00	1.00	1.00	0.00	0.50	0.33	0.14	0.20	0.91	0.83	1.00	0.13
Ermenne	0.00		0.00									1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.33	0.40		0.00
Tell el-Dab'a	0.00	0.26	0.00	0.50	0.00	0.37	0.37	0.20	0.69	0.69	0.27	0.85	0.83	0.11	0.48	0.92	0.05	0.29	0.67	0.91	0.04	0.09
Sidon	0.00	0.25	0.00	0.17	0.03	0.45	0.31	0.00	0.32	0.54	0.26	1.10	0.79	0.04	0.25	0.68	0.00	0.07	0.66	0.88	0.02	0.06
Pella		0.50		0.50	0.05	0.38	0.57	0.00	0.72	0.42	0.24	0.75	0.71	0.08	0.26	0.78	0.00	0.17	0.43	0.75	0.00	0.00
Pella (Tomb 62)		0.50		0.50	0.06	0.36	0.62	0.00	0.76	0.36	0.24		0.85	0.08	0.29	0.74	0.00	0.13	0.50	1.00	0.00	
Ugarit (Ras Shamra and Minet	0.17	0.33	0.00	0.20	0.00	0.08	0.00	0.00	0.67	0.83	0.10	0.88	0.88	0.22	0.50	0.81	0.07	0.05	0.81	0.93	0.00	0.05

el-Beida)

Tell Sukas	0.00	0.57	0.00	0.20	0.00	0.67	1.00	0.00	0.75	0.33	0.80	0.75	0.67	0.00	0.00	0.40	0.00	0.25	0.50	0.50	0.00	0.33
Jericho	0.25	0.06	0.00	0.00	0.00	0.42	0.67	0.00	0.33	0.40	0.00	0.72	0.72	0.13	0.33	0.86	0.08	0.09	0.83	0.90	0.00	0.10
Ashara. Masaikh. Jebel Mashtale EB				0.36		0.15	0.23	0.00	0.21		0.38				0.08	0.44			0.60	0.62	0.05	
Ashara. Masaikh. Jebel Mashtale MB				0.31		0.18	0.26	0.00			0.15		0.36		0.06	0.35			0.27	0.09	0.05	
Mari EB						0.00		0.13					0.67					0.20	0.27			
Ashara. Masaikh. Jebel Mashtale. Mari EB				0.36		0.07	0.23	0.05	0.21		0.38		0.67		0.08	0.44		0.20	0.43	0.62	0.05	
Mari (all)						0.23		0.08					0.74					0.26	0.28			
Ashara. Masaikh. Jebel Mashtale. Mari				0.31		0.21	0.26	0.03			0.15		0.54		0.06	0.35		0.26	0.28	0.09	0.05	
Tell Arbid		0.55		0.20	0.30	0.63	0.13	0.00	0.67	0.17	0.07		1.00		0.29	0.69	0.00	0.38	0.17	0.50	0.00	
Tell Brak		0.75		0.33	0.13	0.60	0.00	0.50	0.25		0.00		1.00		0.00	1.00		0.00	0.25	0.50	0.00	
Barri		0.42		0.33	0.44	0.38	0.00	0.25	0.75	0.17	0.00		0.89		0.10	0.73	0.73	0.11	0.44	0.40	0.00	
Tell Leilan		0.89		0.25	0.00	0.31	0.18		0.00				0.60		0.15	0.23	0.00	0.00	0.56	0.83		
Tell Mozan. Arbid. Brak. Barri. Leilan (all)		0.63		0.28	0.21	0.44	0.09	0.27	0.50	0.23	0.09		0.86		0.20	0.58	0.04	0.18	0.43	0.61	0.00	
Ugarit and Tell Sukas		0.46		0.20	0.00	0.20	0.13	0.00	0.70	0.73	0.33		0.85	0.15	0.36	0.71	0.06	0.08	0.75	0.81	0.00	

A11 cont'd. Frequency table of sites used in the analysis. Breakpoints used to create the dichotomised values presented in table A5.

	O	CLP	AF	MID	MT	RJ	GP	C5LM2	DW	MDTC	PLM1	C6	C7	TR	RLC	RLM1	RLM2	TA
Lachish (all)		0,80	0,40				0,34	0,37		0,03	0,03	0,04	0,00	0,07	0,03	0,03	0,00	0,14
Lachish BA		1,00	1,00				0,40	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00
Ajjul and Fara (all)		1,00					0,20	0,50	0,00	0,00	1,00	0,00	0,33	0,00	0,00	0,00	1,00	0,33
Ajjul, Fara and Lachish BA		1,00	1,00				0,30	0,42	0,00	0,00	0,17	0,00	0,20	0,00	0,00	0,00	1,00	0,17
Ajjul and Fara LB-IA		1,00					0,25	0,50							0,00	0,00	1,00	0,50
Ajjul, Fara and Lachish LB-IA		0,78	0,40				0,32	0,36		0,03	0,03	0,04	0,00	0,07	0,03	0,03	0,00	0,14
Arqa		0,17	0,43				0,28	0,18					0,12		0,08	0,12		
Tell el-Fadous	0,00	1,00	1,00		0,00	0,00			1,00	0,00	0,50	0,00	0,00	0,33	0,00	0,00	1,00	0,50
Umm el-Marra	0,17	1,00	1,00		0,13		0,13	0,33	0,67	0,00	0,20	0,00	0,00	0,11	0,00	0,00	0,90	
Qurna		0,54	0,35				0,20	0,23	0,29	0,04	0,06	0,06	0,06	0,13	0,00	0,00	0,86	0,03
Thebes		0,70	0,43				0,25	0,26	0,13	0,00	0,12	0,12	0,07	0,11	0,00	0,00	0,92	0,23
el-Lisht		0,67	0,38				0,38	0,21	0,22	0,11	0,53	0,53	0,00	0,09	0,00	0,00	0,86	0,31
el-Kubanieh	0,00			0,67	0,00	0,00	0,50							0,00	0,00	0,00	1,00	0,50
Ermenne	0,00	1,00		0,50	0,00	0,00	0,33	0,00			0,50			0,00	0,00	0,00	0,83	0,00
Tell el-Dab'a	0,00	0,93	0,79				0,32	0,33	0,68	0,08	0,63	0,10	0,10	0,20	0,00	0,00	0,93	0,28
Sidon	0,02	0,77	0,48	0,14	0,03	0,00	0,10	0,25	0,08	0,04	0,23	0,19	0,07	0,21	0,03	0,00	1,00	0,44
Pella	0,00	0,83	0,63		0,00		0,43	0,44	0,80	0,00	0,13	0,00	0,13	0,10	0,00	0,00	1,00	0,00
Pella (Tomb 62)		0,79	0,57				0,40	0,36	0,78	0,00	0,13	0,00	0,08	0,13	0,00	0,00	1,00	
Ugarit (Ras Shamra and Minet el-	0,17	0,89	0,58	0,08	0,00	0,02	0,29	0,67	0,43	0,25	0,32	0,43	0,04	0,15	0,00	0,00	0,93	0,27

Beida)

Tell Sukas	0,00	1,20	0,33	0,00	0,00	0,00	0,50	0,20	0,00	0,00	0,40	0,00	0,00	0,00	0,00	0,00	1,00	0,00
Jericho	0,00	0,81	0,47	0,00	0,00	0,00	0,19	0,21	0,33	0,06	0,59	0,08	0,05	0,33	0,00	0,00	0,96	0,50
Ashara, Masaikh, Jebel Mashtale EB							0,08				0,50	0,00	0,00		0,00	0,08		
Ashara, Masaikh, Jebel Mashtale MB							0,06				0,54	0,17	0,08		0,00	0,00		
Mari EB		0,11	0,06				0,43	0,00					0,05		0,00	0,00		
Ashara, Masaikh, Jebel Mashtale, Mari EB		0,11	0,06				0,27	0,00			0,50	0,00	0,03		0,00	0,04		
Mari (all)		0,07	0,15				0,42	0,06					0,07		0,00	0,00		
Ashara, Masaikh, Jebel Mashtale, Mari		0,07	0,15				0,26	0,06			0,54	0,17	0,07		0,00	0,00		
Tell Arbid		0,86	0,73						0,54	0,00	0,10	0,12	0,00	0,00	0,25	0,00		
Tell Brak		0,57	0,73						0,33	0,00	0,20	0,17	0,00	0,33	0,00	0,00		
Barri		0,83	0,50						0,29	0,25	0,25	0,00	0,00	0,00	0,00	0,00		
Tell Leilan		0,40	0,75				0,20	0,18	0,50		0,53	0,00	0,06	0,38	0,00	0,00	0,83	
Tell Mozan, Arbid, Brak, Barri, Leilan (all)		0,68	0,63				0,20	0,17	0,42	0,07	0,31	0,08	0,01	0,20	0,03	0,00	0,86	

Ugarit and Tell Sukas	0,88	0,53		0,33	0,53	0,27	0,16	0,33	0,38	0,03	0,14	0,00	0,00	0,95	0,26

A12. Full results from Correspondence analysis.

Trait	Mass	Score in Dimension			Inertia	Contribution Of Point to Inertia of Dimension			Of Dimension to Inertia of Point			Total
		1	2	3		1	2	3	1	2	3	
LC	0,035	-0,478	0,630	0,520	0,009	0,034	0,061	0,053	0,206	0,343	0,185	0,734
S	0,013	-2,255	-0,018	0,767	0,021	0,279	0,000	0,043	0,761	0,000	0,067	0,828
DS	0,001	-2,640	-0,160	0,441	0,004	0,032	0,000	0,001	0,514	0,002	0,011	0,526
IG	0,031	-0,060	0,237	-0,475	0,005	0,000	0,008	0,039	0,005	0,072	0,230	0,307
TD	0,044	0,038	-0,138	0,197	0,008	0,000	0,004	0,010	0,002	0,024	0,039	0,065
MAR	0,004	0,772	-2,531	-1,476	0,012	0,010	0,108	0,046	0,045	0,465	0,125	0,636
DAR	0,038	-0,908	-0,399	-0,778	0,017	0,134	0,027	0,130	0,449	0,083	0,250	0,782
H	0,083	-0,033	0,552	0,119	0,007	0,000	0,112	0,007	0,003	0,771	0,028	0,802
C5UM	0,029	0,119	-0,547	-0,522	0,004	0,002	0,038	0,043	0,023	0,452	0,326	0,800
CC	0,088	0,164	-0,251	0,332	0,005	0,010	0,024	0,054	0,117	0,261	0,362	0,740
PUM3	0,003	1,013	-1,303	-0,443	0,004	0,014	0,025	0,004	0,219	0,348	0,032	0,599
EE	0,014	-0,062	-0,392	-0,524	0,003	0,000	0,009	0,021	0,004	0,158	0,223	0,385
RUP1	0,162	0,193	0,135	0,177	0,004	0,025	0,013	0,028	0,318	0,149	0,203	0,670
I2V	0,001	0,610	-1,325	-0,564	0,002	0,002	0,009	0,002	0,056	0,255	0,037	0,348
CLP	0,088	0,200	-0,423	0,221	0,005	0,015	0,069	0,024	0,152	0,649	0,140	0,940
AF	0,057	-0,013	-0,396	-0,014	0,002	0,000	0,039	0,000	0,001	0,899	0,001	0,901
GP	0,032	0,033	-0,503	0,432	0,006	0,000	0,036	0,033	0,001	0,299	0,174	0,474
C5LM2	0,036	-0,056	-0,602	0,413	0,006	0,000	0,057	0,034	0,005	0,500	0,186	0,691
DW	0,036	-0,990	-0,141	-0,665	0,015	0,148	0,003	0,088	0,561	0,011	0,192	0,764
MDTC	0,007	0,745	0,323	-0,416	0,004	0,016	0,003	0,006	0,225	0,040	0,053	0,318
PLM1	0,034	0,572	0,378	-1,145	0,013	0,047	0,021	0,246	0,204	0,085	0,618	0,907
C6	0,019	0,874	1,157	0,160	0,018	0,061	0,112	0,003	0,192	0,322	0,005	0,519
C7	0,006	-0,978	-0,093	-0,177	0,002	0,026	0,000	0,001	0,622	0,005	0,015	0,643

TR	0,017	0,345	0,004	-0,402	0,003	0,009	0,000	0,016	0,156	0,000	0,161	0,317
RLC	0,001	1,902	-3,011	1,992	0,004	0,012	0,030	0,017	0,148	0,356	0,123	0,627
RLM1	0,000	3,380	-6,947	3,637	0,006	0,018	0,079	0,028	0,160	0,649	0,141	0,950
RLM2	0,095	-0,177	0,501	0,007	0,007	0,013	0,105	0,000	0,099	0,764	0,000	0,863
TA	0,028	0,893	0,233	-0,403	0,010	0,093	0,007	0,025	0,509	0,033	0,079	0,621
Active Total	1,000				0,207	1,000	1,000	1,000				

a. Symmetrical normalization

A13. Data used to create the MMD frequency tables. Further details available from author.

ID	Site	Skeleton id	Dating	FDI
1	Barri	1515	EBIII	
13	Barri	573	MBI-II	
14	Barri	1142	EBIV	
15	Barri	1115	EBIV-MBI	
16	Barri	1527	EBII-III	
17	Barri	1554	EBII-III	
18	Barri	1097	EBIV-MBI	
19	Barri	640	MBI-II	
20	Barri	640	MBI-II	
21	Barri	1302	EBIII	
22	Barri	1298	EBIV-MBI	
23	Barri	580	MBII	
24	Barri	1307	EBIII	
25	Barri	1065	EBIV-MBI	
26	Barri	891	MBI-II	
27	Barri	1267	EBIV	
28	Barri	122	EBIII	
29	Barri	1218	EBIV-MBI	
30	Barri	60	MBAI-II	
31	Barri	593	MBII	
32	Barri	1515	EBIII	
33	Barri	1526	EBII-III	
34	Barri	999 #1	MBI	
35	Barri	813	EBIV-MBI	
36	Barri	1440	EBIV-MBI	
37	Barri	637	MBI-II	
38	Arbid	SD 35/64 G-1	MBII	
39	Arbid	SD 36/64 G13	EBIV	
40	Arbid	SD 36/64 G8	MBI	
41	Arbid	C16 SR 36/62 L-17 Human Teeth	MBII	
42	Arbid	SD 36/64+65 Loc. 2=G4? =D08	MBII	
43	Arbid	SR 37/60 Loc. 4 E17	MBII	
44	Arbid	D 30/42 L24=F02	MBII	
45	Arbid	SD 35/64 G-2	EB	
46	Arbid	08 W 52/56 67	MBII	
47	Arbid	SR 36/62 Loc. 23=C03	MBII	
48	Arbid	SR 36/62 Loc. 17=C16	MBII	
49	Arbid	SD 36/64 G-11	EBIV	
50	Arbid	SD 36/64 L-9	MBII	
51	Arbid	D 31/42 G-2 05 BMU #2	MBII	
52	Arbid	SD 36/64 G-5	MBI-II	
53	Arbid	SD 36/64 G-10	EBIV	

54	Arbid	SL 38/54 G-1	MBI
55	Arbid	07 D 31/41 L9/G3	EBIV
56	Arbid	07 D 31/41 L15/G4	EBIV
57	Arbid	07 D 31/41 L16/G6 #1	EBIV
58	Arbid	SD 36/60 G-9	EBIV
59	Arbid	SD 35/64 G-3	EBIV
60	Arbid	SL 37/55 G-9 #2	MBI
61	Arbid	SD 37/65 Loc. 10	EBIV
62	Arbid	S-37/55-G8 Fr 5211 GU1	MBII
63	Arbid	SD 36/64 G12	EBIV
64	Arbid	30/42-D-G1	MBII
65	Arbid	37/55 5 G9 Szczeka '01-S-37/55-48	MBII
66	Arbid	SL 38/55 G-1	MBI
67	Arbid	D 31/42 G-2 O5 UBNIU #1	MBII
68	Arbid	D 31/42 G-2 Osurnin #1	MBII
69	Brak	TCJ1693 Mixed	EBIV
70	Brak	TCJ1633	EBIV
71	Brak	TCJ1693 #3	EBIV
72	Brak	TCJ1693	EBIV
73	Brak	TCJ2251 D	EBIV
74	Brak	TCJ1643 #2	EBIV
75	Brak	TCJ2251 #3	EBIV
76	Brak	TCJ2251A	EBIV
77	Brak	TCJ 1679	EBIV
78	Brak	TCJ 2251 C	EBIV
79	Brak	TCJ2214 Mixed	EBIV
80	Brak	TCJ 2251 #4	EBIV
81	Brak	TCJ 2207	EBIV
82	Brak	TCJ 2251 #6	EBIV
83	Brak	TCH 1338	EBIV
84	Brak	TCJ 2251 #5	EBIV
85	Brak	TCJ 2251 #6	EBIV
86	Brak	TCJ 2207 #6	EBIV
87	Brak	TCJ 2251 #1	EBIV
88	Brak	TCJ 2214 #3	EBIV
89	Brak	TCJ 2207 #8	EBIV
90	Brak	TCJ 2214 #1	EBIV
91	Brak	TCJ 2207 #4	EBIV
92	Brak	TCJ 2214 #2	EBIV
93	Brak	TCJ 2195	EBIV
94	Brak	TCJ 2207 Mixed	EBIV
95	Brak	TCJ 2207 Mixed	EBIV
96	Brak	TCJ 2207 Mixed	EBIV
97	Brak	TCJ 2207 #5	EBIV
98	Brak	TCJ 2251 B	EBIV

99	Brak	TCJ 2207 #3	EBIV
100	Brak	TCJ 2207 #9	EBIV
101	Brak	TCJ 2194	EBIV
102	Brak	TCJ 2207 #7	EBIV
103	Barri	813	EBIV-MBI
104	Barri	593	MBII
105	Tell Ashara	TQ 21F008	EBA
106	Tell Ashara	TQ 21F010	EBA
107	Tell Ashara	TQ 21F025	EBA
108	Tell Ashara	TQ 22F168	EBA
109	Tell Ashara	TQ 23FA038	EBA
110	Tell Ashara	TQ 23FA065	EBA
111	Tell Ashara	TQ 23FA088 -I	EBA
112	Tell Ashara	TQ 23FA088 -II	EBA
113	Tell Ashara	TQ 23FA093	EBA
114	Tell Ashara	TQ 23FA146	EBA
115	Tell Ashara	TQ 23FA158	EBA
116	Tell Ashara	TQ 23FA161	EBA
117	Tell Ashara	TQ 23FA166	EBA
118	Tell Ashara	TQ 23FA168	EBA
119	Tell Ashara	TQ 23FA187 -I	EBA
120	Tell Ashara	TQ 23FA187 -II	EBA
121	Tell Ashara	TQ 23FA194	EBA
122	Tell Ashara	TQ 24F230	EBA
123	Tell Ashara	TQ 24F259	EBA
124	Tell Ashara	TQ 24F279	EBA
125	Tell Ashara	TQ25F021	EBA
126	Tell Ashara	TQ 25F036	EBA
127	Tell Ashara	TQ 25F043+047	EBA
128	Tell Ashara	TQ 25F052	EBA
129	Tell Ashara	TQ 25F101	EBA
130	Tell Ashara	TQ 25F105	EBA
131	Tell Ashara	TQ 25F116	EBA
132	Tell Ashara	TQ 26F103	EBA
133	Tell Ashara	TQ 26F146	EBA
134	Tell Ashara	TQ 26F211	EBA
135	Tell Ashara	TQ 26F222	EBA
136	Tell Ashara	TQ 26F223	EBA
137	Tell Ashara	TQ 27F025	EBA
138	Tell Ashara	TQ 27F167	EBA
139	Tell Ashara	TQ 27F228	EBA
140	Tell Ashara	TQ 28F112	EBA
141	Tell Ashara	TQ 28F249	EBA
142	Tell Ashara	TQ 28F250	EBA
143	Tell Ashara	TQ 28F256	EBA
144	Tell Ashara	TQ 20F123	MBA

145	Tell Ashara	TQ 21A006	MBA
146	Tell Ashara	TQ 21A012	MBA
147	Tell Ashara	TQ 21A016 - I	MBA
148	Tell Ashara	TQ 21A016 - II	MBA
149	Tell Ashara	TQ 21F112	MBA
150	Tell Ashara	TQ 21A126	MBA
151	Tell Ashara	TQ 21A130 - I	MBA
152	Tell Ashara	TQ 21A130 - II	MBA
153	Tell Ashara	TQ 21F172	MBA
154	Tell Ashara	TQ 21F181 h1	MBA
155	Tell Ashara	TQ 21F181 h2	MBA
156	Tell Ashara	TQ 21A187	MBA
157	Tell Ashara	TQ 21F195	MBA
158	Tell Ashara	TQ 21A198	MBA
159	Tell Ashara	TQ 21A212	MBA
160	Tell Ashara	TQ 21F218 -I	MBA
161	Tell Ashara	TQ 21F218 -II	MBA
162	Tell Ashara	TQ 21F223	MBA
163	Tell Ashara	TQ 21A227	MBA
164	Tell Ashara	TQ 22F012	MBA
165	Tell Ashara	TQ 22/1 066	MBA
166	Tell Ashara	TQ 23FA051	MBA
167	Tell Ashara	TQ 23FB142	MBA
168	Tell Ashara	TQ 23FA172	MBA
169	Tell Ashara	TQ 23FA186	MBA
170	Tell Ashara	TQ 24F117	MBA
171	Tell Ashara	TQ 24F163	MBA
172	Tell Ashara	TQ 24F232	MBA
173	Tell Ashara	TQ 24F308	MBA
174	Tell Ashara	TQ 24F353	MBA
175	Tell Ashara	TQ 24F364	MBA
176	Tell Ashara	TQ 24F373	MBA
177	Tell Ashara	TQ 25F015	MBA
178	Tell Ashara	TQ 29F150	MBA
179	Tell Ashara	MK 03D064	MBA
180	Tell Ashara	MK 07D050	MBA
181	Tell Ashara	MK 07D101	MBA
182	Tell Ashara	MK 07D124	MBA
183	Tell Ashara	MK 09D100	MBA
184	Tell Ashara	MK 10D039	MBA
185	Tell Ashara	MK 10D043	MBA
186	Tell Ashara	MK 10D072	MBA
187	Tell Ashara	MK 10D093	MBA
188	Tell Ashara	MK 11D031	MBA
189	Tell Ashara	MK 11D052 - I	MBA
190	Tell Ashara	MK 11D052 - II	MBA

191	Tell Ashara	MK 14E030	MBA	
192	Sidon (Burak)	commingled teeth	MBA	12
193	Sidon (Burak)	commingled teeth	MBA	12
194	Sidon (Burak)	commingled teeth	MBA	15
195	Sidon (Burak)	commingled teeth	MBA	15
196	Sidon (Burak)	commingled teeth	MBA	15
197	Sidon (Burak)	commingled teeth	MBA	16
198	Sidon (Burak)	commingled teeth	MBA	16
199	Sidon (Burak)	commingled teeth	MBA	17
200	Sidon (Burak)	commingled teeth	MBA	17
201	Sidon (Burak)	commingled teeth	MBA	21
202	Sidon (Burak)	commingled teeth	MBA	21
203	Sidon (Burak)	commingled teeth	MBA	23
204	Sidon (Burak)	commingled teeth	MBA	23
205	Sidon (Burak)	commingled teeth	MBA	24
206	Sidon (Burak)	commingled teeth	MBA	24
207	Sidon (Burak)	commingled teeth	MBA	24
208	Sidon (Burak)	commingled teeth	MBA	28
209	Sidon (Burak)	commingled teeth	MBA	28
210	Sidon (Burak)	commingled teeth	MBA	33
211	Sidon (Burak)	commingled teeth	MBA	33
212	Sidon (Burak)	commingled teeth	MBA	33
213	Sidon (Burak)	commingled teeth	MBA	44
214	Sidon (Burak)	commingled teeth	MBA	44
215	Sidon (Burak)	commingled teeth	MBA	44
216	Sidon (Burak)	commingled teeth	MBA	44
217	Sidon (Burak)	commingled teeth	MBA	45
218	Sidon (Burak)	commingled teeth	MBA	45
219	Sidon (Burak)	commingled teeth	MBA	45
220	Sidon (Burak)	commingled teeth	MBA	45
221	Sidon (Burak)	commingled teeth	MBA	46
222	Sidon (Burak)	commingled teeth	MBA	46
223	Sidon (Burak)	commingled teeth	MBA	46
224	Sidon (Burak)	commingled teeth	MBA	47
225	Sidon (Burak)	commingled teeth	MBA	47
226	Sidon (Burak)	commingled teeth	MBA	47
227	Sidon (Burak)	commingled teeth	MBA	47
228	Sidon (Burak)	commingled teeth	MBA	48
229	Sidon (Burak)	commingled teeth	MBA	48
230	Sidon	116	MBA	
231	Sidon	117	MBA	
232	Sidon	118	MBA	
233	Sidon	119	MBA	
234	Sidon	120	MBA	
235	Sidon	121	MBA	
236	Sidon	121	MBA	

237	Sidon	124	MBA
238	Sidon	125	MBA
239	Sidon	131	MBA
240	Sidon	135	MBA
241	Sidon	128	MBA
242	Sidon	128	MBA
243	Sidon	133	MBA
244	Sidon	137	MBA
245	Sidon	139	MBA
246	Sidon	142	MBA
247	Sidon	144	MBA
248	Sidon	144	MBA
249	Sidon	143	MBA
250	Sidon	132	MBA
251	Sidon	141	MBA
252	Sidon	127	MBA
253	Sidon	146	MBA
254	Sidon	159	MBA
255	Sidon	162	MBA
256	Sidon	164	MBA
257	Sidon	147	MBA
258	Sidon	1	MBA
259	Sidon	2	MBA
260	Sidon	3	MBA
261	Sidon	4	MBA
262	Sidon	5	MBA
263	Sidon	6.1	MBA
264	Sidon	8.1	MBA
265	Sidon	8.2	MBA
266	Sidon	12	MBA
267	Sidon	13	MBA
268	Sidon	14	MBA
269	Sidon	16	MBA
270	Sidon	17	MBA
271	Sidon	18	MBA
272	Sidon	23	MBA
273	Sidon	24	MBA
274	Sidon	25	MBA
275	Sidon	27	MBA
276	Sidon	28	MBA
277	Sidon	32A	MBA
278	Sidon	33	MBA
279	Sidon	36	MBA
280	Sidon	38	MBA
281	Sidon	39	MBA
282	Sidon	40	MBA

283	Sidon	41	MBA
284	Sidon	43	MBA
285	Sidon	45	MBA
286	Sidon	46	MBA
287	Sidon	49A	MBA
288	Sidon	49B	MBA
289	Sidon	51	MBA
290	Sidon	52	MBA
291	Sidon	54B	MBA
292	Sidon	59	MBA
293	Sidon	62	MBA
294	Sidon	63A	MBA
295	Sidon	63B	MBA
296	Sidon	65	MBA
297	Sidon	68	MBA
298	Sidon	69	MBA
299	Sidon	72	MBA
300	Sidon	75A	MBA
301	Sidon	75B	MBA
302	Sidon	77	MBA
303	Sidon	78	MBA
304	Sidon	82	MBA
305	Sidon	83	MBA
306	Sidon	87	MBA
307	Sidon	91	MBA
308	Sidon	93	MBA
309	Sidon	95	MBA
310	Sidon	97	MBA
311	Sidon	98	MBA
312	Sidon	98B	MBA
313	Sidon	99	MBA
314	Sidon	100	MBA
315	Sidon	102	MBA
316	Sidon	104	MBA
317	Sidon	105	MBA
318	Sidon	108	MBA
319	Sidon	109	MBA
320	Sidon	112	MBA
321	Sidon	163/165	MBA
322	Sidon	167	MBA
323	Sidon	167	MBA
324	Sidon	139	MBA
325	Sidon	44 adult	MBA
326	Sidon	44 subadult	MBA
327	Sidon	55	MBA
328	Sidon	56	MBA

329	Sidon	57	MBA	
330	Sidon	103	MBA	
331	Sidon	106	MBA	
332	Sidon	107 subadult	MBA	
333	Sidon	111	MBA	
334	Tell Fadous	commingled teeth	MBA	13
335	Tell Fadous	commingled teeth	MBA	24
336	Tell Fadous	commingled teeth	MBA	24
337	Tell Fadous	commingled teeth	MBA	22
338	Tell Fadous	commingled teeth	MBA	13
339	Tell Fadous	commingled teeth	MBA	28
340	Tell Fadous	commingled teeth	MBA	36
341	Tell Fadous	commingled teeth	MBA	37
342	Tell Fadous	commingled teeth	MBA	43
343	Tell Fadous	commingled teeth	MBA	44
344	Tell Fadous	commingled teeth	MBA	45
345	Tell Fadous	commingled teeth	MBA	48
346	Tell Fadous	commingled teeth	MBA	43
347	Tell Fadous	commingled teeth	MBA	44
348	Tell Fadous	commingled teeth	MBA	45
349	Tell Fadous	commingled teeth	MBA	36
350	Tell Fadous	commingled teeth	MBA	37
351	Tell Fadous	commingled teeth	MBA	48
352	Tell Fadous	commingled teeth	MBA	26
353	Tell Fadous	commingled teeth	MBA	27
354	Tell Fadous	commingled teeth	MBA	43
355	Tell Fadous	commingled teeth	MBA	11
356	Tell Fadous	commingled teeth	MBA	11
357	Tell Fadous	commingled teeth	MBA	13
358	Tell Fadous	commingled teeth	MBA	24
359	Tell Fadous	commingled teeth	MBA	26
360	Tell Fadous	commingled teeth	MBA	36
361	Tell Fadous	commingled teeth	MBA	13
362	Tell Fadous	commingled teeth	MBA	43
363	Tell Fadous	commingled teeth	MBA	11
364	Tell Fadous	commingled teeth	MBA	13
365	Tell Fadous	commingled teeth	MBA	24
366	Tell Fadous	commingled teeth	MBA	27
367	Tell Fadous	commingled teeth	MBA	26
368	Tell Fadous	commingled teeth	MBA	11
369	Tell Fadous	commingled teeth	MBA	22
370	Tell Fadous	commingled teeth	MBA	24
371	Tell Fadous	commingled teeth	MBA	36
372	Tell Fadous	commingled teeth	MBA	37
373	Tell Fadous	commingled teeth	MBA	45
374	Tell Fadous	commingled teeth	MBA	48

375	Tell Fadous	commingled teeth	MBA	43
376	Tell Fadous	commingled teeth	MBA	44
377	Tell Fadous	commingled teeth	MBA	36
378	Tell Fadous	commingled teeth	MBA	11
379	Tell Fadous	commingled teeth	MBA	26
380	Tell Fadous	commingled teeth	MBA	43
381	Tell Fadous	commingled teeth	MBA	44
382	Tell Fadous	commingled teeth	MBA	45
383	Tell Fadous	commingled teeth	MBA	11
384	Tell Fadous	commingled teeth	MBA	22
385	Tell Fadous	commingled teeth	MBA	37
386	Tell Fadous	commingled teeth	MBA	48
387	Tell Fadous	commingled teeth	MBA	11
388	Tell Fadous	commingled teeth	MBA	24
389	Tell Fadous	commingled teeth	MBA	13
390	Tell Fadous	commingled teeth	MBA	37
391	Tell Fadous	commingled teeth	MBA	44
392	Tell Fadous	commingled teeth	MBA	48
393	Tell Fadous	commingled teeth	MBA	26
394	Tell Fadous	commingled teeth	MBA	28
395	Tell Fadous	commingled teeth	MBA	44
396	Tell Fadous	commingled teeth	MBA	11
397	Tell el-'Ajjul	AS 66.4.14	MBA	
398	Tell el-'Ajjul	AS 66.4.17	LBIIB/IA	
399	Tell el-'Ajjul	AS 66.4.18	LBIIB/IA	
400	Tell el-'Ajjul	AS 66.4.20	MBA	
401	Tell el-'Ajjul	AS 66.4.22	MBIII-LBI	
402	Tell el-'Ajjul	AS 66.4.23	MBIIC-LBI?	
403	Tell el-'Ajjul	AS 66.4.27	LBA	
404	Tell el-'Ajjul	AS 66.4.29	MBA	
405	Tell el-'Ajjul	AS 66.4.30	MBI-II	
406	Tell el-'Ajjul	AS 66.4.31	LBIB-II	
407	Tell el-'Ajjul	AS 66.4.32	LBIIB	
408	Tell el-'Ajjul	AS 66.4.33	MBA	
409	Tell el-'Ajjul	AS 66.4.34	LBIIB	
410	Tell el-'Ajjul	AS 66.4.38	LBI	
411	Tell el-'Ajjul	AS 66.4.39	MBA	
412	Tell el-'Ajjul	AS 66.4.42	MBA	
413	Tell el-'Ajjul	AS 66.4.44	MBIIC-LBI?	
414	Tell el-Far'ah	AS 66.0.65	LBIIB/IA	
415	Tell el-Far'ah	AS 66.4.1	LBIIB	
416	Tell el-Far'ah	AS 66.4.2	LBIIB	
417	Tell el-Far'ah	AS 66.4.3	LBIIB	
418	Tell el-Far'ah	AS 66.4.4	LBIIB/IA	

419	Tell el-Far'ah	AS 66.4.5	LBIIB/IA	
420	Tell el-Far'ah	AS 66.4.6	LBIIB/IA	
421	Tell el-Far'ah	AS 66.4.7	IA	
422	Tell el-Far'ah	AS 66.4.8	LBIIB	
423	Tell el-Far'ah	AS 66.4.9	LBIIB/IA	
424	Tell el-Far'ah	AS 66.4.10	LBIIB/IA	
425	Tell el-Far'ah	AS 66.4.11	LBIIB/IA	
426	Tell el-Far'ah	AS 66.4.12	LBIIB	
427	Tell el-Far'ah	AS 66.4.13	LBIIB/IA	
428	Tell el-Far'ah	AS 66.4.15	IA	
429	Tell el-Far'ah	AS 66.4.16	IA	
430	Tell el-Far'ah	AS 66.4.28	IA	
431	Tell el-Far'ah	AS 66.4.35	IA	
432	Tell el-Far'ah	AS 66.4.37	IA	
433	Tell el-Far'ah	AS 66.4.41	LBIIB	
434	Jericho	B35 commingled teeth	MBA	11
435	Jericho	B35 commingled teeth	MBA	27
436	Jericho	B35 commingled teeth	MBA	48
437	Jericho	B35 commingled teeth	MBA	44
438	Jericho	B35 commingled teeth	MBA	24
439	Jericho	B35 commingled teeth	MBA	36
440	Jericho	B35 commingled teeth	MBA	12
441	Jericho	B35 commingled teeth	MBA	24
442	Jericho	B35 commingled teeth	MBA	33
443	Jericho	B35 commingled teeth	MBA	44
444	Jericho	B35 commingled teeth	MBA	47
445	Jericho	B35 commingled teeth	MBA	48
446	Jericho	B35 commingled teeth	MBA	13
447	Jericho	B35 commingled teeth	MBA	11
448	Jericho	B35 commingled teeth	MBA	13
449	Jericho	B35 commingled teeth	MBA	12
450	Jericho	B35 commingled teeth	MBA	15
451	Jericho	B35 commingled teeth	MBA	24
452	Jericho	B35 commingled teeth	MBA	24
453	Jericho	B35 commingled teeth	MBA	47
454	Jericho	B35 commingled teeth	MBA	48
455	Jericho	B35 commingled teeth	MBA	15
456	Jericho	B35 commingled teeth	MBA	27
457	Jericho	B35 commingled teeth	MBA	36
458	Jericho	B35 commingled teeth	MBA	12
459	Jericho	B35 commingled teeth	MBA	24
460	Jericho	B35 commingled teeth	MBA	27
461	Jericho	B35 commingled teeth	MBA	13
462	Jericho	B35 commingled teeth	MBA	48
463	Jericho	B35 commingled teeth	MBA	16
464	Jericho	B35 commingled teeth	MBA	35

465	Jericho	B35 commingled teeth	MBA	36
466	Jericho	B35 commingled teeth	MBA	12
467	Jericho	B35 commingled teeth	MBA	16
468	Jericho	B35 commingled teeth	MBA	18
469	Jericho	B35 commingled teeth	MBA	24
470	Jericho	B35 commingled teeth	MBA	16
471	Jericho	B35 commingled teeth	MBA	18
472	Jericho	B35 commingled teeth	MBA	16
473	Jericho	B35 commingled teeth	MBA	27
474	Jericho	B35 commingled teeth	MBA	18
475	Jericho	B35 commingled teeth	MBA	33
476	Jericho	B35 commingled teeth	MBA	35
477	Jericho	B35 commingled teeth	MBA	47
478	Jericho	B35 commingled teeth	MBA	12
479	Jericho	B35 commingled teeth	MBA	15
480	Jericho	B35 commingled teeth	MBA	16
481	Jericho	B35 commingled teeth	MBA	27
482	Jericho	B35 commingled teeth	MBA	18
483	Jericho	B35 commingled teeth	MBA	11
484	Jericho	B35 commingled teeth	MBA	13
485	Jericho	B35 commingled teeth	MBA	16
486	Jericho	B35 commingled teeth	MBA	27
487	Jericho	B35 commingled teeth	MBA	12
488	Jericho	B35 commingled teeth	MBA	33
489	Jericho	B35 commingled teeth	MBA	44
490	Jericho	B35 commingled teeth	MBA	47
491	Jericho	B35 commingled teeth	MBA	36
492	Jericho	B35 commingled teeth	MBA	27
493	Jericho	B35 commingled teeth	MBA	24
494	Jericho	B35 commingled teeth	MBA	15
495	Jericho	B35 commingled teeth	MBA	27
496	Jericho	B35 commingled teeth	MBA	12
497	Jericho	B35 commingled teeth	MBA	13
498	Jericho	B35 commingled teeth	MBA	15
499	Jericho	B35 commingled teeth	MBA	27
500	Jericho	B35 commingled teeth	MBA	47
501	Jericho	B35 commingled teeth	MBA	13
502	Jericho	B35 commingled teeth	MBA	36
503	Jericho	B35 commingled teeth	MBA	44
504	Jericho	B35 commingled teeth	MBA	47
505	Jericho	B35 commingled teeth	MBA	16
506	Jericho	B35 commingled teeth	MBA	36
507	Jericho	B35 commingled teeth	MBA	24
508	Jericho	B35 commingled teeth	MBA	24
509	Jericho	B35 commingled teeth	MBA	16
510	Jericho	B35 commingled teeth	MBA	11

511	Jericho	B35 commingled teeth	MBA	11
512	Jericho	B35 commingled teeth	MBA	11
513	Jericho	B35 commingled teeth	MBA	13
514	Jericho	B35 commingled teeth	MBA	16
515	Jericho	B35 commingled teeth	MBA	18
516	Jericho	B35 commingled teeth	MBA	33
517	Jericho	B35 commingled teeth	MBA	44
518	Jericho	B35 commingled teeth	MBA	44
519	Jericho	B35 commingled teeth	MBA	33
520	Jericho	B35 commingled teeth	MBA	47
521	Jericho	B35 commingled teeth	MBA	47
522	Jericho	B35 commingled teeth	MBA	48
523	Jericho	B35 commingled teeth	MBA	36
524	Jericho	B35 commingled teeth	MBA	47
525	Jericho	B35 commingled teeth	MBA	36
526	Jericho	B35 commingled teeth	MBA	48
527	Jericho	B35 commingled teeth	MBA	47
528	Jericho	B35 commingled teeth	MBA	36
529	Jericho	B35 commingled teeth	MBA	48
530	Jericho	B35 commingled teeth	MBA	24
531	Jericho	B35 commingled teeth	MBA	24
532	Jericho	B35 commingled teeth	MBA	24
533	Jericho	B35 commingled teeth	MBA	16
534	Jericho	B35 commingled teeth	MBA	33
535	Jericho	B35 commingled teeth	MBA	13
536	Jericho	B35 commingled teeth	MBA	33
537	Jericho	B35 commingled teeth	MBA	33
538	Jericho	B35 commingled teeth	MBA	35
539	Jericho	B35 commingled teeth	MBA	35
540	Jericho	B35 commingled teeth	MBA	44
541	Jericho	B35 commingled teeth	MBA	47
542	Jericho	B35 commingled teeth	MBA	48
543	Jericho	B35 commingled teeth	MBA	36
544	Jericho	B35 commingled teeth	MBA	33
545	Jericho	B35 commingled teeth	MBA	36
546	Jericho	B35 commingled teeth	MBA	36
547	Jericho	B35 commingled teeth	MBA	16
548	Jericho	B35 commingled teeth	MBA	27
549	Jericho	B35 commingled teeth	MBA	18
550	Jericho	B35 commingled teeth	MBA	16
551	Jericho	B51	MBA	
552	Jericho	A94 M2	EBI	
553	Jericho	A94 T1	EBI	
554	Jericho	H9	EBIV-MBI	
555	Jericho	H9	EBIV-MBI	
556	Jericho	P1N	MBA	

557	Jericho	P1C	MBA
558	Jericho	A136A	MBA
559	Jericho	A136B	MBA
560	Jericho	A136N	MBA
561	Jericho	J3A	MBA
562	Jericho	P17D	MBA
563	Jericho	P17B	MBA
564	Jericho	P17G	MBA
565	Jericho	P12	MBA
566	Jericho	P17O	MBA
567	Jericho	P17P	MBA
568	Jericho	H(TELL)3	MBA
569	Jericho	P5	MBA
570	Jericho	P5	MBA
571	Jericho	P17D	MBA
572	Jericho	P17N	MBA
573	Jericho	P17F	MBA
574	Jericho	P17J	MBA
575	Jericho	B54A	EBIV-MBI
576	Jericho	P9	MBA
577	Jericho	G85	EBIV
578	Jericho	P26	MBA
579	Jericho	P27	MBA
580	Jericho	P10	MBA
581	Jericho	P17Q	MBA
582	Jericho	P17H	MBA
583	Jericho	P21A	MBA
584	Jericho	H.III.405A	MBA
585	Jericho	G83A	EBIV-MBI
586	Jericho	P21B	MBA
587	Jericho	P21C	MBA
588	Jericho	P17M	MBA
589	Jericho	P17R	MBA
590	Jericho	P21A	MBA
591	Jericho	P24	EBIV-MBI
592	Jericho	P30	MBA
593	Jericho	P17E	MBA
594	Jericho	P17K	MBA
595	Jericho	P17L	MBA
596	Jericho	P19B	MBA
597	Jericho	P19C	MBA
598	Jericho	P19D	MBA
599	Dra' Abu el-Naga'	7319	17-18th dyn
600	Dra' Abu el-Naga'	7330	17-18th dyn

601	Dra' Abu el-Naga'	7332	17-18th dyn
602	Dra' Abu el-Naga'	7323	17-18th dyn
603	Dra' Abu el-Naga'	7321	17-18th dyn
604	Dra' Abu el-Naga'	7325	17-18th dyn
605	Dra' Abu el-Naga'	7333	17-18th dyn
606	Dra' Abu el-Naga'	7310	17-18th dyn
607	Dra' Abu el-Naga'	7311	17-18th dyn
608	Dra' Abu el-Naga'	7316	17-18th dyn
609	Dra' Abu el-Naga'	33960	17-18th dyn
610	Dra' Abu el-Naga'	33962	17-18th dyn
611	Dra' Abu el-Naga'	33963	17-18th dyn
612	Dra' Abu el-Naga'	33964	17-18th dyn
613	Dra' Abu el-Naga'	33965	17-18th dyn
614	Dra' Abu el-Naga'	33966	17-18th dyn
615	Dra' Abu el-Naga'	33968	17-18th dyn
616	Dra' Abu el-Naga'	33969	17-18th dyn
617	Dra' Abu el-Naga'	33970	17-18th dyn
618	Dra' Abu el-Naga'	7301	17-18th dyn
619	Dra' Abu el-Naga'	7303	17-18th dyn
620	Dra' Abu el-Naga'	7305	17-18th dyn
621	Dra' Abu el-Naga'	7307	17-18th dyn
622	Dra' Abu el-Naga'	7315	17-18th dyn
623	Dra' Abu el-Naga'	7320	17-18th dyn
624	Dra' Abu el-Naga'	7322	17-18th dyn
625	Dra' Abu el-Naga'	7327	17-18th dyn
626	Dra' Abu el-	33959	17-18th

	Naga'		dyn
627	Dra' Abu el-Naga'	33961	17-18th dyn
628	Dra' Abu el-Naga'	33967	17-18th dyn
629	Dra' Abu el-Naga'	7302	17-18th dyn
630	Dra' Abu el-Naga'	7304	17-18th dyn
631	Dra' Abu el-Naga'	7306	17-18th dyn
632	Dra' Abu el-Naga'	7308	17-18th dyn
633	Dra' Abu el-Naga'	7309	17-18th dyn
634	Dra' Abu el-Naga'	7313	17-18th dyn
635	Dra' Abu el-Naga'	7317	17-18th dyn
636	Dra' Abu el-Naga'	7318	17-18th dyn
637	Dra' Abu el-Naga'	7324	17-18th dyn
638	Dra' Abu el-Naga'	7328	17-18th dyn
639	Dra' Abu el-Naga'	7329	17-18th dyn
640	Dra' Abu el-Naga'	7331	17-18th dyn
641	Dra' Abu el-Naga'	7313	17-18th dyn
642	Ugarit	24530	MBA
643	Ugarit	24516	MBA
644	Ugarit	24517	MBA
645	Ugarit	24519	MBA
646	Ugarit	24521	MBA
647	Ugarit	24522	MBA
648	Ugarit	24523	MBA
649	Ugarit	24541	MBA
650	Ugarit	24544	MBA
651	Ugarit	24550	MBA
652	Ugarit	24553	MBA
653	Ugarit	26020	MBA
654	Ugarit	26016	MBA
655	Ugarit	24518	MBA
656	Ugarit	24520	MBA
657	Ugarit	24524	MBA
658	Ugarit	24528	MBA
659	Ugarit	24539	MBA

660	Ugarit	24552	MBA
661	Ugarit	24548	MBA
662	Ugarit	24551	MBA
663	Ugarit	24531	MBA
664	Ugarit	24533	MBA
665	Ugarit	24540	MBA
666	Ugarit	24554	MBA
667	Ugarit	26017	MBA
668	Ugarit	26018	MBA
669	Ugarit	26019	MBA
670	Ugarit	245541	MBA
671	Ugarit	24532	MBA
672	Ugarit	24534	MBA
673	Ugarit	24535	MBA
674	Ugarit	24537	MBA
675	Ugarit	24542	MBA
676	Ugarit	24545	MBA
677	Ugarit	24546	MBA
678	Ugarit	24547	MBA
679	Ugarit	24549	MBA
680	Ugarit	24526	MBA
681	Ugarit	24543	MBA
682	Ugarit	24526	MBA
683	Ugarit	24543	MBA
684	Ugarit	24555 mandible	MBA
685	Ugarit	24555 mandible	MBA
686	Ugarit	24555 mandible	MBA
687	Ugarit	24555 mandible	MBA
688	Ugarit	24555 mandible	MBA
689	Ugarit	24555 mandible	MBA
690	Ugarit	24555 mandible	MBA
691	Ugarit	24555 mandible	MBA
692	Ugarit	24555 mandible	MBA
693	Ugarit	24555 mandible	MBA
694	Ugarit	24555 mandible	MBA
695	Ugarit	24555 mandible	MBA
696	Ugarit	24555 mandible	MBA
697	Ugarit	24555 mandible	MBA
698	Ugarit	24555 mandible	MBA
699	Ugarit	24555 mandible	MBA
700	Ugarit	24555 mandible	MBA
701	Ugarit	24555 mandible	MBA
702	Ugarit	24555 mandible	MBA
703	Ugarit	24555 mandible	MBA
704	Ugarit	24555 mandible	MBA
705	Ugarit	24555 mandible	MBA

706	Ugarit	24555 mandible	MBA
707	Ugarit	24556 mandible	MBA
708	Ugarit	24556 mandible	MBA
709	Ugarit	24556 mandible	MBA
710	Ugarit	24556 mandible	MBA
711	Ugarit	24556 mandible	MBA
712	Ugarit	24556 mandible	MBA
713	Ugarit	24556 mandible	MBA
714	Ugarit	24556 mandible	MBA
715	Ugarit	24556 mandible	MBA
716	Ugarit	24556 mandible	MBA
717	Ugarit	24556 mandible	MBA
718	Ugarit	24556 mandible	MBA
719	Ugarit	24556 mandible	MBA
720	Ugarit	24556 mandible	MBA
721	Ugarit	24556 mandible	MBA
722	Ugarit	24556 mandible	MBA
723	Ugarit	24556 mandible	MBA
724	Ugarit	24525	MBA
725	Ugarit	24536	MBA
726	Ugarit	24527	MBA
727	Ugarit	24529	MBA
728	Ugarit	26021	MBA
729	el-Kubaniyeh	4797	C-group
730	el-Kubaniyeh	4799	C-group
731	el-Kubaniyeh	4836	C-group
732	el-Kubaniyeh	4837	C-group
733	el-Kubaniyeh	4838	C-group
734	el-Kubaniyeh	4839	C-group
735	el-Kubaniyeh	4841	C-group
736	el-Kubaniyeh	4842	C-group
737	el-Kubaniyeh	4846	C-group
738	el-Kubaniyeh	4847	C-group
739	el-Kubaniyeh	4848	C-group
740	el-Kubaniyeh	4849	C-group
741	el-Kubaniyeh	4850	C-group
742	el-Kubaniyeh	4853	C-group
743	el-Kubaniyeh	4854	C-group
744	el-Kubaniyeh	4855	C-group
745	el-Kubaniyeh	4856	C-group
746	el-Kubaniyeh	4860	C-group
747	el-Kubaniyeh	4861	C-group
748	el-Kubaniyeh	4862	C-group
749	el-Kubaniyeh	4863	C-group
750	el-Kubaniyeh	4864	C-group
751	el-Kubaniyeh	4866	C-group

752	el-Kubaniyeh	4868	C-group	
753	el-Kubaniyeh	4869	C-group	
754	el-Kubaniyeh	4870	C-group	
755	el-Kubaniyeh	4871	C-group	
756	el-Kubaniyeh	4872	C-group	
757	el-Kubaniyeh	4873	C-group	
758	el-Kubaniyeh	4874	C-group	
759	el-Kubaniyeh	4876	C-group	
760	el-Kubaniyeh	4877	C-group	
761	el-Kubaniyeh	4878	C-group	
762	el-Kubaniyeh	4879	C-group	
763	el-Kubaniyeh	4881	C-group	
764	el-Kubaniyeh	4882	C-group	
765	el-Kubaniyeh	4883	C-group	
766	el-Kubaniyeh	4886	C-group	
767	el-Kubaniyeh	4888	C-group	
768	el-Kubaniyeh	4889	C-group	
769	el-Kubaniyeh	4893	C-group	
770	el-Kubaniyeh	4894	C-group	
771	el-Kubaniyeh	4895	C-group	
772	el-Kubaniyeh	4896	C-group	
773	el-Kubaniyeh	4897	C-group	
774	el-Kubaniyeh	4979	C-group	
775	Ermenne	5977	C-group	
776	Ermenne	5978	C-group	
777	Ermenne	5987	C-group	
778	Ermenne	5989	C-group	
779	Ermenne	5995	C-group	
780	Ermenne	5997	C-group	
781	Ermenne	5998	C-group	
782	Ermenne	5999	C-group	
783	Ermenne	6003	C-group	
784	Ermenne	6004	C-group	
785	Tell Sukas	commingled teeth	MBII	45
786	Tell Sukas	commingled teeth	MBII	36 s
787	Tell Sukas	commingled teeth	MBII	38 s
788	Tell Sukas	commingled teeth	MBII	11
789	Tell Sukas	commingled teeth	MBII	15
790	Tell Sukas	commingled teeth	MBII	16 s
791	Tell Sukas	commingled teeth	MBII	27 s
792	Tell Sukas	commingled teeth	MBII	28 s
793	Tell Sukas	commingled teeth	MBII	23

				s
794	Tell Sukas	commingled teeth	MBII	24
795	Tell Sukas	commingled teeth	MBII	16
796	Tell Sukas	commingled teeth	MBII	27
797	Tell Sukas	commingled teeth	MBII	11
798	Tell Sukas	commingled teeth	MBII	15
799	Tell Sukas	commingled teeth	MBII	22
800	Tell Sukas	commingled teeth	MBII	23
801	Tell Sukas	commingled teeth	MBII	24
802	Tell Sukas	commingled teeth	MBII	34
803	Tell Sukas	commingled teeth	MBII	36
804	Tell Sukas	commingled teeth	MBII	38
805	Tell Sukas	commingled teeth	MBII	43
806	Tell Sukas	commingled teeth	MBII	45
807	Tell Sukas	commingled teeth	MBII	47
808	Tell Sukas	commingled teeth	MBII	28
809	Tell Sukas	commingled teeth	MBII	15
				s
810	Tell Sukas	commingled teeth	MBII	16
811	Tell Sukas	commingled teeth	MBII	24
				s
812	Tell Sukas	commingled teeth	MBII	27
				s
813	Tell Sukas	commingled teeth	MBII	36
814	Tell Sukas	commingled teeth	MBII	38
815	Tell Sukas	commingled teeth	MBII	11
816	Tell Sukas	commingled teeth	MBII	23
817	Tell Sukas	commingled teeth	MBII	24
818	Tell Sukas	commingled teeth	MBII	15
819	Tell Sukas	commingled teeth	MBII	16
820	Tell Sukas	commingled teeth	MBII	27
821	Tell Sukas	commingled teeth	MBII	36
822	Tell Sukas	commingled teeth	MBII	47
823	Tell Sukas	commingled teeth	MBII	11
824	Tell Sukas	commingled teeth	MBII	23
825	Tell Sukas	commingled teeth	MBII	15
826	Tell Sukas	commingled teeth	MBII	24
827	Tell Sukas	commingled teeth	MBII	16
828	Tell Sukas	commingled teeth	MBII	27
829	Tell Sukas	commingled teeth	MBII	28
				s
830	Tell Sukas	commingled teeth	MBII	15
				s
831	Tell Sukas	commingled teeth	MBII	11
832	Tell Sukas	commingled teeth	MBII	22
833	Tell Sukas	commingled teeth	MBII	23
834	Tell Sukas	commingled teeth	MBII	24

835	Tell Sukas	commingled teeth	MBII	15
836	Tell Sukas	commingled teeth	MBII	16
837	Tell Sukas	commingled teeth	MBII	27
838	Tell Sukas	commingled teeth	MBII	28
839	Tell Sukas	commingled teeth	MBII	43
840	Tell Sukas	commingled teeth	MBII	34
841	Tell Sukas	commingled teeth	MBII	45
842	Tell Sukas	commingled teeth	MBII	36
843	Tell Sukas	commingled teeth	MBII	47
844	Tell Sukas	commingled teeth	MBII	15
845	Tell Sukas	commingled teeth	MBII	16
846	Tell Sukas	commingled teeth	MBII	43
847	Tell Sukas	commingled teeth	MBII	22
848	Tell Sukas	commingled teeth	MBII	23
849	Tell Sukas	commingled teeth	MBII	24 s
850	Tell Sukas	commingled teeth	MBII	38 s
851	Tell Sukas	commingled teeth	MBII	28
852	Tell Sukas	commingled teeth	MBII	34
853	Tell Sukas	commingled teeth	MBII	45
854	Tell Sukas	commingled teeth	MBII	47
855	Tell Sukas	commingled teeth	MBII	22
856	Tell Sukas	commingled teeth	MBII	23
857	Tell Sukas	commingled teeth	MBII	28
858	Tell Sukas	commingled teeth	MBII	43
859	Tell Sukas	commingled teeth	MBII	11
860	Tell Sukas	commingled teeth	MBII	15
861	Tell Sukas	commingled teeth	MBII	16 s
862	Tell Sukas	commingled teeth	MBII	24
863	Tell Sukas	commingled teeth	MBII	34
864	Tell Sukas	commingled teeth	MBII	36
865	Tell Sukas	commingled teeth	MBII	45 s
866	Tell Sukas	commingled teeth	MBII	47
867	Tell Sukas	commingled teeth	MBII	11
868	Tell Sukas	commingled teeth	MBII	23
869	Tell Sukas	commingled teeth	MBII	15 s
870	Tell Sukas	commingled teeth	MBII	16
871	Tell Sukas	commingled teeth	MBII	22
872	Tell Sukas	commingled teeth	MBII	27
873	Tell Sukas	commingled teeth	MBII	34
874	Tell Sukas	commingled teeth	MBII	36
875	Tell Sukas	commingled teeth	MBII	43
876	Tell Sukas	commingled teeth	MBII	45

877	Tell Sukas	commingled teeth	MBII	47
878	Tell Sukas	commingled teeth	MBII	36
879	Tell Sukas	commingled teeth	MBII	34
880	Tell Sukas	commingled teeth	MBII	36
881	Tell Sukas	commingled teeth	MBII	43
882	Tell Sukas	commingled teeth	MBII	38
883	Tell Sukas	commingled teeth	MBII	43 s
884	Tell Sukas	commingled teeth	MBII	45 s
885	Tell Sukas	commingled teeth	MBII	47
886	Tell Sukas	commingled teeth	MBII	43
887	Tell Sukas	commingled teeth	MBII	16
888	Tell Sukas	commingled teeth	MBII	36
889	Tell Sukas	commingled teeth	MBII	47
890	Tell Sukas	commingled teeth	MBII	16
891	Tell Sukas	commingled teeth	MBII	45
892	Tell Sukas	commingled teeth	MBII	34
893	Tell Sukas	commingled teeth	MBII	36
894	Tell Sukas	commingled teeth	MBII	38
895	Tell Sukas	commingled teeth	MBII	27 s
896	Tell Sukas	commingled teeth	MBII	28 s
897	Tell Sukas	commingled teeth	MBII	24
898	Tell Sukas	commingled teeth	MBII	34
899	Tell Sukas	commingled teeth	MBII	11
900	Tell Sukas	commingled teeth	MBII	43
901	Tell Sukas	commingled teeth	MBII	34
902	Tell Sukas	commingled teeth	MBII	45
903	Tell Sukas	commingled teeth	MBII	45
904	Tell Sukas	commingled teeth	MBII	23
905	Tell Sukas	commingled teeth	MBII	43
906	Tell Sukas	commingled teeth	MBII	23
907	Tell Sukas	commingled teeth	MBII	45
908	Tell Sukas	commingled teeth	MBII	11
909	Tell Sukas	commingled teeth	MBII	23
910	Tell Sukas	commingled teeth	MBII	11
911	Tell Sukas	commingled teeth	MBII	34
912	Tell Sukas	commingled teeth	MBII	23
913	Tell Sukas	commingled teeth	MBII	16
914	Tell Sukas	commingled teeth	MBII	36
915	Tell Sukas	commingled teeth	MBII	27
916	Tell Sukas	commingled teeth	MBII	47
917	Tell el-Dab'a	All-o/21 Grab 3	F-E/3	
918	Tell el-Dab'a	All-n/15 Grab 2 Bestattung 1	F	
919	Tell el-Dab'a	All-l/17 Grab 16	E/2	

920	Tell el-Dab'a	All-n/13 Grab 1 Bestattung 4	D/2
921	Tell el-Dab'a	All-n/19 Grab 4 Bestattung 2	E/1
922	Tell el-Dab'a	All-n/19 Grab 4 Bestattung 3	E/1
923	Tell el-Dab'a	All-m/16 Grab 3 Bestattung 2	F
924	Tell el-Dab'a	All-m/16 Grab 3 Bestattung 1	F
925	Tell el-Dab'a	All-m/17 Grab 3	D/2
926	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 4	D/2
927	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 5	D/2
928	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 6	D/2
929	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 7	D/2
930	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 8	D/2
931	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 10	D/2
932	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 14	D/2
933	Tell el-Dab'a	All-m/17 Grab 7 Bestattung 9	E/3-2
934	Tell el-Dab'a	All-m/12 Grab 3	D/3
935	Tell el-Dab'a	All-m/12 Grab 14	E/1,5
936	Tell el-Dab'a	All-m/15 Grab 9 Bestattung 1	G
937	Tell el-Dab'a	All-m/15 Grab 9 Bestattung 2	G
938	Tell el-Dab'a	All-m/13 Grab 1	D/2
939	Tell el-Dab'a	All-m/15 Grab 8	F
940	Tell el-Dab'a	All-m/13 Grab 7	E/2
941	Tell el-Dab'a	All-m/13 Grab 13 Bestattung 2	E/3
942	Tell el-Dab'a	All-m/13 Grab 6	E/1
943	Tell el-Dab'a	All-l/15 Grab 5	F
944	Tell el-Dab'a	All-l/17 Grab 1	D/2
945	Tell el-Dab'a	All-l/16 Grab 4 Bestattung 1	F
946	Tell el-Dab'a	All-l/17 Grab 5 Bestattung 1	D/3
947	Tell el-Dab'a	All-l/17 Grab 5 Bestattung 2	D/3
948	Tell el-Dab'a	All-l/17 Grab 5 Bestattung 3	D/3
949	Tell el-Dab'a	All-m/10 Grab 7 Bestattung 2	E/1
950	Tell el-Dab'a	All-m/10 Grab 8 Bestattung 1	F
951	Tell el-Dab'a	All-m/11 Grab 1	D/2
952	Tell el-Dab'a	All-m/11 Grab 5	E/1
953	Tell el-Dab'a	All-p/21 Grab 13	D/3
954	Tell el-Dab'a	All-p/21 Grab 12	E/3-F
955	Tell el-Dab'a	All-p/20 Grab 3 Bestattung 2	E/1,5
956	Tell el-Dab'a	All-r/18 Grab 2	G
957	Tell el-Dab'a	All-p/20 Grab 2	E/1,5
958	Tell el-Dab'a	All-l/11 Grab 3 Bestattung 1	F
959	Tell el-Dab'a	All-k/11 Grab 1	D/3
960	Tell el-Dab'a	Al-g/3 Grab 1 Bestattung 1	D/3-E/1
961	Tell el-Dab'a	All-l/14 Grab 7 Bestattung 4	E/3
962	Tell el-Dab'a	All-l/14 Grab 7 Bestattung 1	E/3
963	Tell el-Dab'a	All-m/17 Grab 5	E/1
964	Tell el-Dab'a	All-o/20 Grab 5	E/1-3
965	Tell el-Dab'a	All-o/13 Grab 1 Bestattung 2	E/3

966	Tell el-Dab'a	All-n/13 Grab 10	E/3
967	Tell el-Dab'a	All-o/13 Grab 1 Bestattung 1	E/3
968	Tell el-Dab'a	All-m/17 Grab 1	D/2
969	Tell el-Dab'a	All-n/13 Grab 8 Bestattung 2	D/3
970	Tell el-Dab'a	All-n/13 Grab 1 Bestattung 5	D/2
971	Tell el-Dab'a	All-n/13 Grab 1 Bestattung 1	D/2
972	Tell el-Dab'a	All-n/13 Grab 8 Bestattung 1	D/3
973	Tell el-Dab'a	All-m/16 Grab 3 Bestattung 4	F
974	Tell el-Dab'a	All-m/15 Grab 11	G
975	Tell el-Dab'a	All-m/16 Grab 2 Bestattung 2	F
976	Tell el-Dab'a	All-l/12 Grab 4	F/G
977	Tell el-Dab'a	All-m/17 Grab 3 Bestattung 3	D/2
978	Tell el-Dab'a	All-o/20 Grab 4	E/1
979	Tell el-Dab'a	All-p/21 Grab 15	D/3
980	Tell el-Dab'a	All-m/15 Grab 1	D/2
981	Tell el-Dab'a	All-n/15 Grab 2 Bestattung 2	F
982	Tell el-Dab'a	All-l/17 Grab 16	E/2
983	Tell el-Dab'a	All-m/15 Grab 12 Bestattung 2	E/3
984	Tell el-Dab'a	All-l/11 Grab 1 Bestattung 2	F/G
985	Tell el-Dab'a	All-l/12 Grab 5 Bestattung 1	F
986	Tell el-Dab'a	All-l/12 Grab 5 Bestattung 2	F
987	Tell el-Dab'a	All-l/12 Grab 5 Bestattung 3	F
988	Tell el-Dab'a	All-n/16 Grab 2	G
989	Tell el-Dab'a	All-r/18 Grab 1	F
990	Tell el-Dab'a	FI-i/21 Grab 11	a1
991	Tell el-Dab'a	FI-k/22 Grab 19	a1,5
992	Tell el-Dab'a	FI-j/23 Grab 13(?)	Ec
993	Tell el-Dab'a	FI-j/23(S) Grab 24	b2
994	Tell el-Dab'a	FI-j/22 Grab 31	Ec
995	Tell el-Dab'a	FI-k/23 Grab 18 Bestattung 1	a1
996	Tell el-Dab'a	FI-i/20 Grab 8	b1
997	Tell el-Dab'a	All-k/14 Grab 8 Bestattung 3	E/2
998	Tell el-Dab'a	FI-k/23 Grab 33	b2
999	Tell el-Dab'a	FI-j/23 Grab 28	Ec
1000	Tell el-Dab'a	FI-j/23(S) Grab 25	b3 Ec?
1001	Tell el-Dab'a	FI-i/21 Grab 17	a1
1002	Tell el-Dab'a	FI-k/23(S) Grab 7	a2
1003	Tell el-Dab'a	FI-i/21 Grab 24 Bestattung 1	b1
1004	Tell el-Dab'a	FI-i/20 Grab 5	a1
1005	Tell el-Dab'a	FI-i/21 Grab 30	Ec
100	Tell el-Dab'a	FI-i/21 Grab 34 Bestattung 3	c

6				
100	Tell el-Dab'a	Fl-j/22 Grab 30	Ec	
7				
100	Tell el-Dab'a	All-k/14 Grab 4	F	
8				
100	Tell el-Dab'a	All-n/15 Grab 2 Bestattung 3	F	
9				
101	Tell el-Dab'a	All-m/16 Grab 3 Bestattung 3	F	
0				
101	Tell el-Dab'a	All-m/12 Grab 12/13 Bestattung 1	D/2	
1				
101	Tell el-Dab'a	All-n/15 Grab 1 Bestattung 2	D/3	
2				
101	Umm el-Marra	Tomb 1 individual A	EBIII-IV	
3				
101	Umm el-Marra	Tomb 1 individual B	EBIII-IV	
4				
101	Umm el-Marra	Tomb 1 individual C	EBIII-IV	
5				
101	Umm el-Marra	Tomb 1 individual D	EBIII-IV	
6				
101	Umm el-Marra	Tomb 1 individual 1.7	EBIII-IV	
7				
101	Umm el-Marra	Tomb 4 individual B	EBIII-IV	
8				
101	Umm el-Marra	Tomb 4 individual C	EBIII-IV	
9				
102	Umm el-Marra	Tomb 4 individual D	EBIII-IV	
0				
102	Umm el-Marra	Tomb 4 individual E	EBIII-IV	
1				
102	Umm el-Marra	Tomb 4 individual F	EBIII-IV	
2				
102	Umm el-Marra	Tomb 5 individual A	EBIII-IV	
3				
102	Umm el-Marra	Tomb 6 individual A	EBIII-IV	
4				
102	Umm el-Marra	Tomb 8 individual 8.1	EBIII-IV	
5				
102	Umm el-Marra	Tomb 8 individual B	EBIII-IV	
6				
102	Pella	commingled teeth	MBA-LBA	16
7				
102	Pella	commingled teeth	MBA-LBA	24
8				
102	Pella	commingled teeth	MBA-LBA	35
9				
103	Pella	commingled teeth	MBA-LBA	48
0				
103	Pella	commingled teeth	MBA-LBA	48
1				

103 2	Pella	commingled teeth	MBA-LBA	12
103 3	Pella	commingled teeth	MBA-LBA	16
103 4	Pella	commingled teeth	MBA-LBA	43
103 5	Pella	commingled teeth	MBA-LBA	48
103 6	Pella	commingled teeth	MBA-LBA	12
103 7	Pella	commingled teeth	MBA-LBA	13
103 8	Pella	commingled teeth	MBA-LBA	45
103 9	Pella	commingled teeth	MBA-LBA	45
104 0	Pella	commingled teeth	MBA-LBA	18
104 1	Pella	commingled teeth	MBA-LBA	46
104 2	Pella	commingled teeth	MBA-LBA	16
104 3	Pella	commingled teeth	MBA-LBA	48
104 4	Pella	commingled teeth	MBA-LBA	48
104 5	Pella	commingled teeth	MBA-LBA	46
104 6	Pella	commingled teeth	MBA-LBA	12
104 7	Pella	commingled teeth	MBA-LBA	12
104 8	Pella	commingled teeth	MBA-LBA	11
104 9	Pella	commingled teeth	MBA-LBA	12
105 0	Pella	commingled teeth	MBA-LBA	12
105 1	Pella	commingled teeth	MBA-LBA	13
105 2	Pella	commingled teeth	MBA-LBA	13
105 3	Pella	commingled teeth	MBA-LBA	24
105 4	Pella	commingled teeth	MBA-LBA	24
105 5	Pella	commingled teeth	MBA-LBA	25
105 6	Pella	commingled teeth	MBA-LBA	25
105	Pella	commingled teeth	MBA-LBA	16

7				
105	Pella	commingled teeth	MBA-LBA	16
8				
105	Pella	commingled teeth	MBA-LBA	16
9				
106	Pella	commingled teeth	MBA-LBA	16
0				
106	Pella	commingled teeth	MBA-LBA	27
1				
106	Pella	commingled teeth	MBA-LBA	16
2				
106	Pella	commingled teeth	MBA-LBA	18
3				
106	Pella	commingled teeth	MBA-LBA	43
4				
106	Pella	commingled teeth	MBA-LBA	43
5				
106	Pella	commingled teeth	MBA-LBA	45
6				
106	Pella	commingled teeth	MBA-LBA	34
7				
106	Pella	commingled teeth	MBA-LBA	46
8				
106	Pella	commingled teeth	MBA-LBA	46
9				
107	Pella	commingled teeth	MBA-LBA	48
0				
107	Pella	commingled teeth	MBA-LBA	46
1				
107	Pella	commingled teeth	MBA-LBA	47
2				
107	Pella	commingled teeth	MBA-LBA	48
3				
107	Pella	commingled teeth	MBA-LBA	47
4				
107	Pella	commingled teeth	MBA-LBA	46
5				
107	Pella	commingled teeth	MBA-LBA	47
6				
107	Pella	commingled teeth	MBA-LBA	11
7				
107	Pella	commingled teeth	MBA-LBA	27
8				
107	Pella	commingled teeth	MBA-LBA	43
9				
108	Pella	commingled teeth	MBA-LBA	43
0				
108	Pella	commingled teeth	MBA-LBA	34
1				
108	Pella	commingled teeth	MBA-LBA	34
2				

108 3	Pella	commingled teeth	MBA-LBA	48
108 4	Pella	commingled teeth	MBA-LBA	48
108 5	Pella	commingled teeth	MBA-LBA	47
108 6	Pella	commingled teeth	MBA-LBA	48
108 7	Pella	commingled teeth	MBA-LBA	46
108 8	Pella	commingled teeth	MBA-LBA	48
108 9	Pella	commingled teeth	MBA-LBA	11
109 0	Pella	commingled teeth	MBA-LBA	11
109 1	Pella	commingled teeth	MBA-LBA	11
109 2	Pella	commingled teeth	MBA-LBA	12
109 3	Pella	commingled teeth	MBA-LBA	43
109 4	Pella	commingled teeth	MBA-LBA	13
109 5	Pella	commingled teeth	MBA-LBA	24
109 6	Pella	commingled teeth	MBA-LBA	24
109 7	Pella	commingled teeth	MBA-LBA	27
109 8	Pella	commingled teeth	MBA-LBA	18
109 9	Pella	commingled teeth	MBA-LBA	27
110 0	Pella	commingled teeth	MBA-LBA	18
110 1	Pella	commingled teeth	MBA-LBA	43
110 2	Pella	commingled teeth	MBA-LBA	43
110 3	Pella	commingled teeth	MBA-LBA	34
110 4	Pella	commingled teeth	MBA-LBA	34
110 5	Pella	commingled teeth	MBA-LBA	45
110 6	Pella	commingled teeth	MBA-LBA	45
110 7	Pella	commingled teeth	MBA-LBA	48
110	Pella	commingled teeth	MBA-LBA	47

8				
110	Pella	commingled teeth	MBA-LBA	47
9				
111	Pella	commingled teeth	MBA-LBA	48
0				
111	Pella	commingled teeth	MBA-LBA	48
1				
111	Pella	commingled teeth	MBA-LBA	46
2				
111	Pella	commingled teeth	MBA-LBA	48
3				
111	Pella	commingled teeth	MBA-LBA	48
4				
111	Pella	commingled teeth	MBA-LBA	48
5				
111	Pella	commingled teeth	MBA-LBA	11
6				
111	Pella	commingled teeth	MBA-LBA	11
7				
111	Pella	commingled teeth	MBA-LBA	11
8				
111	Pella	commingled teeth	MBA-LBA	11
9				
112	Pella	commingled teeth	MBA-LBA	11
0				
112	Pella	commingled teeth	MBA-LBA	43
1				
112	Pella	commingled teeth	MBA-LBA	12
2				
112	Pella	commingled teeth	MBA-LBA	11
3				
112	Pella	commingled teeth	MBA-LBA	11
4				
112	Pella	commingled teeth	MBA-LBA	11
5				
112	Pella	commingled teeth	MBA-LBA	12
6				
112	Pella	commingled teeth	MBA-LBA	13
7				
112	Pella	commingled teeth	MBA-LBA	13
8				
112	Pella	commingled teeth	MBA-LBA	24
9				
113	Pella	commingled teeth	MBA-LBA	24
0				
113	Pella	commingled teeth	MBA-LBA	25
1				
113	Pella	commingled teeth	MBA-LBA	25
2				
113	Pella	commingled teeth	MBA-LBA	24
3				

113 4	Pella	commingled teeth	MBA-LBA	24
113 5	Pella	commingled teeth	MBA-LBA	25
113 6	Pella	commingled teeth	MBA-LBA	24
113 7	Pella	commingled teeth	MBA-LBA	25
113 8	Pella	commingled teeth	MBA-LBA	25
113 9	Pella	commingled teeth	MBA-LBA	16
114 0	Pella	commingled teeth	MBA-LBA	16
114 1	Pella	commingled teeth	MBA-LBA	16
114 2	Pella	commingled teeth	MBA-LBA	18
114 3	Pella	commingled teeth	MBA-LBA	18
114 4	Pella	commingled teeth	MBA-LBA	43
114 5	Pella	commingled teeth	MBA-LBA	43
114 6	Pella	commingled teeth	MBA-LBA	43
114 7	Pella	commingled teeth	MBA-LBA	12
114 8	Pella	commingled teeth	MBA-LBA	45
114 9	Pella	commingled teeth	MBA-LBA	34
115 0	Pella	commingled teeth	MBA-LBA	34
115 1	Pella	commingled teeth	MBA-LBA	34
115 2	Pella	commingled teeth	MBA-LBA	45
115 3	Pella	commingled teeth	MBA-LBA	34
115 4	Pella	commingled teeth	MBA-LBA	34
115 5	Pella	commingled teeth	MBA-LBA	46
115 6	Pella	commingled teeth	MBA-LBA	47
115 7	Pella	commingled teeth	MBA-LBA	47
115 8	Pella	commingled teeth	MBA-LBA	47
115	Pella	commingled teeth	MBA-LBA	47

9				
116	Pella	commingled teeth	MBA-LBA	47
0				
116	Pella	commingled teeth	MBA-LBA	47
1				
116	Pella	commingled teeth	MBA-LBA	48
2				
116	Pella	commingled teeth	MBA-LBA	11
3				
116	Pella	commingled teeth	MBA-LBA	13
4				
116	Pella	commingled teeth	MBA-LBA	12
5				
116	Pella	commingled teeth	MBA-LBA	13
6				
116	Pella	commingled teeth	MBA-LBA	43
7				
116	Pella	commingled teeth	MBA-LBA	34
8				
116	Pella	commingled teeth	MBA-LBA	34
9				
117	Pella	commingled teeth	MBA-LBA	25
0				
117	Pella	commingled teeth	MBA-LBA	25
1				
117	Pella	commingled teeth	MBA-LBA	47
2				
117	Pella	commingled teeth	MBA-LBA	46
3				
117	Pella	commingled teeth	MBA-LBA	48
4				
117	Pella	commingled teeth	MBA-LBA	27
5				
117	Pella	commingled teeth	MBA-LBA	16
6				
117	Pella	commingled teeth	MBA-LBA	18
7				
117	Pella	commingled teeth	MBA-LBA	24
8				
117	Pella	commingled teeth	MBA-LBA	34
9				
118	Pella	commingled teeth	MBA-LBA	43
0				
118	Pella	commingled teeth	MBA-LBA	48
1				
118	Pella	commingled teeth	MBA-LBA	48
2				
118	Pella	commingled teeth	MBA-LBA	48
3				
118	Pella	commingled teeth	MBA-LBA	47
4				

118 5	Pella	commingled teeth	MBA-LBA	47
118 6	Pella	commingled teeth	MBA-LBA	12
118 7	Pella	commingled teeth	MBA-LBA	13
118 8	Pella	commingled teeth	MBA-LBA	13
118 9	Pella	commingled teeth	MBA-LBA	43
119 0	Pella	commingled teeth	MBA-LBA	24
119 1	Pella	commingled teeth	MBA-LBA	34
119 2	Pella	commingled teeth	MBA-LBA	45
119 3	Pella	commingled teeth	MBA-LBA	24
119 4	Pella	commingled teeth	MBA-LBA	24
119 5	Pella	commingled teeth	MBA-LBA	34
119 6	Pella	commingled teeth	MBA-LBA	12
119 7	Pella	commingled teeth	MBA-LBA	13
119 8	Pella	commingled teeth	MBA-LBA	34
119 9	Pella	commingled teeth	MBA-LBA	34
120 0	Pella	commingled teeth	MBA-LBA	43
120 1	Pella	commingled teeth	MBA-LBA	27
120 2	Pella	commingled teeth	MBA-LBA	27
120 3	Pella	commingled teeth	MBA-LBA	27
120 4	Pella	commingled teeth	MBA-LBA	16
120 5	Pella	commingled teeth	MBA-LBA	11
120 6	Pella	commingled teeth	MBA-LBA	12
120 7	Pella	commingled teeth	MBA-LBA	13
120 8	Pella	commingled teeth	MBA-LBA	24
120 9	Pella	commingled teeth	MBA-LBA	45
121	Pella	commingled teeth	MBA-LBA	16

0				
121 1	Pella	commingled teeth	MBA-LBA	16
121 2	Pella	commingled teeth	MBA-LBA	27
121 3	Pella	commingled teeth	MBA-LBA	47
121 4	Pella	commingled teeth	MBA-LBA	43
121 5	Pella	commingled teeth	MBA-LBA	13
121 6	Pella	commingled teeth	MBA-LBA	43
121 7	Pella	commingled teeth	MBA-LBA	24
121 8	Pella	commingled teeth	MBA-LBA	24
121 9	Pella	commingled teeth	MBA-LBA	43
122 0	Pella	commingled teeth	MBA-LBA	47
122 1	Pella	commingled teeth	MBA-LBA	48
122 2	Pella	commingled teeth	MBA-LBA	43
122 3	Pella	commingled teeth	MBA-LBA	25
122 4	Pella	commingled teeth	MBA-LBA	24
122 5	Pella	commingled teeth	MBA-LBA	12
122 6	Pella	commingled teeth	MBA-LBA	13
122 7	Pella	commingled teeth	MBA-LBA	43
122 8	Pella	commingled teeth	MBA-LBA	12
122 9	Pella	commingled teeth	MBA-LBA	43
123 0	Pella	commingled teeth	MBA-LBA	11
123 1	Pella	commingled teeth	MBA-LBA	27
123 2	Pella	commingled teeth	MBA-LBA	34
123 3	Pella	commingled teeth	MBA-LBA	16
123 4	Pella	commingled teeth	MBA-LBA	16
123 5	Pella	commingled teeth	MBA-LBA	47

123 6	Pella	commingled teeth	MBA-LBA	13
123 7	Pella	commingled teeth	MBA-LBA	11
123 8	Pella	commingled teeth	MBA-LBA	11
123 9	Pella	commingled teeth	MBA-LBA	12
124 0	Pella	commingled teeth	MBA-LBA	13
124 1	Pella	commingled teeth	MBA-LBA	13
124 2	Pella	commingled teeth	MBA-LBA	24
124 3	Pella	commingled teeth	MBA-LBA	25
124 4	Pella	commingled teeth	MBA-LBA	25
124 5	Pella	commingled teeth	MBA-LBA	34
124 6	Pella	commingled teeth	MBA-LBA	34
124 7	Pella	commingled teeth	MBA-LBA	45
124 8	Pella	commingled teeth	MBA-LBA	45
124 9	Pella	commingled teeth	MBA-LBA	25
125 0	Pella	commingled teeth	MBA-LBA	34
125 1	Pella	commingled teeth	MBA-LBA	27
125 2	Pella	commingled teeth	MBA-LBA	16
125 3	Pella	commingled teeth	MBA-LBA	16
125 4	Pella	commingled teeth	MBA-LBA	27
125 5	Pella	commingled teeth	MBA-LBA	16
125 6	Pella	commingled teeth	MBA-LBA	18
125 7	Pella	commingled teeth	MBA-LBA	47
125 8	Pella	commingled teeth	MBA-LBA	48
125 9	Pella	commingled teeth	MBA-LBA	46
126 0	Pella	commingled teeth	MBA-LBA	48
126	Pella	commingled teeth	MBA-LBA	27

1				
126	Pella	commingled teeth	MBA-LBA	24
2				
126	Pella	commingled teeth	MBA-LBA	34
3				
126	Pella	commingled teeth	MBA-LBA	34
4				
126	Pella	commingled teeth	MBA-LBA	16
5				
126	Pella	commingled teeth	MBA-LBA	27
6				
126	Pella	commingled teeth	MBA-LBA	16
7				
126	Pella	commingled teeth	MBA-LBA	27
8				
126	Pella	commingled teeth	MBA-LBA	46
9				
127	Pella	commingled teeth	MBA-LBA	47
0				
127	Pella	commingled teeth	MBA-LBA	48
1				
127	Pella	commingled teeth	MBA-LBA	48
2				
127	Pella	commingled teeth	MBA-LBA	47
3				
127	Pella	commingled teeth	MBA-LBA	47
4				
127	Pella	commingled teeth	MBA-LBA	43
5				
127	Pella	commingled teeth	MBA-LBA	43
6				
127	Pella	commingled teeth	MBA-LBA	13
7				
127	Pella	commingled teeth	MBA-LBA	13
8				
127	Pella	commingled teeth	MBA-LBA	45
9				
128	Pella	commingled teeth	MBA-LBA	24
0				
128	Pella	commingled teeth	MBA-LBA	47
1				
128	Pella	commingled teeth	MBA-LBA	46
2				
128	Pella	commingled teeth	MBA-LBA	16
3				
128	Pella	commingled teeth	MBA-LBA	27
4				
128	Pella	commingled teeth	MBA-LBA	43
5				
128	Pella	commingled teeth	MBA-LBA	34
6				

128 7	Pella	commingled teeth	MBA-LBA	24
128 8	Pella	commingled teeth	MBA-LBA	24
128 9	Pella	commingled teeth	MBA-LBA	45
129 0	Pella	commingled teeth	MBA-LBA	24
129 1	Pella	commingled teeth	MBA-LBA	46
129 2	Pella	commingled teeth	MBA-LBA	45
129 3	Pella	commingled teeth	MBA-LBA	46
129 4	Pella	commingled teeth	MBA-LBA	47
129 5	Pella	commingled teeth	MBA-LBA	16
129 6	Pella	P3(18) skull A	MBA	16
129 7	Pella	P3(18) skull A	MBA	45
129 8	Pella	P3(18) skull A	MBA	48
129 9	Pella	P3 skull C	MBA	27
130 0	Pella	P3(18)	MBA	47
130 1	Pella	P XXVIII	MBA	44
130 2	Pella	P XXVIII	MBA	45
130 3	Pella	P XXVIII	MBA	43
130 4	Pella	P XXVIII	MBA	16
130 5	Pella	P XXVIII	MBA	15
130 6	Pella	P XXVIII	MBA	38
130 7	Pella	P XXVIII	MBA	13
130 8	Pella	P XXVIII	MBA	14
130 9	Pella	P XXVIII	MBA	27
131 0	Pella	P XXVIII	MBA	36
131 1	Pella	P XXVIII	MBA	37
131	Pella	27, 2-2	MBA	25

2				
131	Pella	27, 2-2	MBA	23
3				
131	Pella	27, 2-2	MBA	12
4				
131	Pella	27, 2-2	MBA	46
5				
131	Pella	106 "shackled man" skull	MBA	
6				
131	Pella	106 associated skull B (1078)	MBA	
7				
131	Tell Mozan	commingled teeth	MBA	27
8				
131	Tell Mozan	commingled teeth	MBA	27
9				
132	Tell Mozan	commingled teeth	MBA	37
0				
132	Tell Mozan	commingled teeth	MBA	37
1				
132	Tell Mozan	commingled teeth	MBA	37
2				
132	Tell Mozan	commingled teeth	MBA	37
3				
132	Tell Mozan	commingled teeth	MBA	27
4				
132	Tell Mozan	commingled teeth	MBA	37
5				
132	Tell Mozan	commingled teeth	MBA	37
6				
132	Tell Mozan	commingled teeth	MBA	36
7				
132	Tell Mozan	commingled teeth	MBA	26
8				
132	Tell Mozan	commingled teeth	MBA	28
9				
133	Tell Mozan	commingled teeth	MBA	36
0				
133	Tell Mozan	commingled teeth	MBA	36
1				
133	Tell Mozan	commingled teeth	MBA	38
2				
133	Tell Mozan	commingled teeth	MBA	28
3				
133	Tell Mozan	commingled teeth	MBA	27
4				
133	Tell Mozan	commingled teeth	MBA	27
5				
133	Tell Mozan	commingled teeth	MBA	26
6				
133	Tell Mozan	commingled teeth	MBA	28
7				

133 8	Tell Mozan	commingled teeth	MBA	13
133 9	Tell Mozan	commingled teeth	MBA	28
134 0	Tell Mozan	commingled teeth	MBA	24
134 1	Tell Mozan	commingled teeth	MBA	24
134 2	Tell Mozan	commingled teeth	MBA	38
134 3	Tell Mozan	commingled teeth	MBA	36
134 4	Tell Mozan	commingled teeth	MBA	38
134 5	Tell Mozan	commingled teeth	MBA	33
134 6	Tell Mozan	commingled teeth	MBA	44
134 7	Tell Mozan	commingled teeth	MBA	36
134 8	Tell Mozan	commingled teeth	MBA	38
134 9	Tell Mozan	commingled teeth	MBA	26
135 0	Tell Mozan	commingled teeth	MBA	27
135 1	Tell Mozan	commingled teeth	MBA	36
135 2	Tell Mozan	commingled teeth	MBA	27
135 3	Tell Mozan	commingled teeth	MBA	38
135 4	Tell Mozan	commingled teeth	MBA	28
135 5	Tell Mozan	commingled teeth	MBA	13
135 6	Tell Mozan	commingled teeth	MBA	25
135 7	Tell Mozan	commingled teeth	MBA	26
135 8	Tell Mozan	commingled teeth	MBA	38
135 9	Tell Mozan	commingled teeth	MBA	37

A14. Raw data from intra-cemetery analysis (Tell el-Dab'a) using Gower distance.

ID	skeleton ID	age	sex	S_ UI2	DS_ UI2	M AR	DAR_ LC	PAR_ UP1	M_U M3	H_U M3	BH_ UM2	C5_U M2	CC_ UM1	PU M3	M 3V	CLP_ LP2	AF_ LM2	GPx_ LM1	GPy_ LM2	C5_ LM3
1	All-k/14 Grab 4	suba dult	indeterm inate	2,5	0	0	1	0					2					1		
2	All-k/14 Grab 8	suba dult	indeterm inate	0	0	0	1	0					1			2	1,5	0	1	
3	All-l/11 Grab 1 Bestattung 2	suba dult	indeterm inate	3	0						0	0	2		0					0
4	All-l/11 Grab 3 Bestattung 1	adult	female				0		4	3,5	0		4,5	0	0		1		0	
5	All-l/12 Grab 4	adult	female	2	0			2	3	0	0			0	0,5	2	2	0	1	3
6	All-l/12 Grab 5 Bestattung 3	suba dult	indeterm inate						4	3	1	1,5	6		0	2	1,5	0	0	1,5
7	All-l/16 Grab 4 Bestattung 1	adult	male			0	1	2	4	2	0	0	4	0	0	2	3	0	0	0
8	All-l/17 Grab 5 Bestattung 1	suba dult	indeterm inate	5,5	0	0		1	3	1	0	2	5	0	0,5	3	3	0	1	0
9	All-l/17 Grab 5 Bestattung 3	suba dult	indeterm inate	3,5	0				4	0			0,5	0	0	2	2	0	0	0
10	All-m/10 Grab 7 Bestattung 2	adult	female	2,5	0	0	2				0	1,5			1		2	0	0	4
11	All-m/10 Grab 8 Bestattung 1	adult	male	2	0	1	2	0	3	3	0		4	0	0	2	2	0	0	2
12	All-m/11 Grab 1	suba dult	indeterm inate			0		1			0	1	1				3	0	0	
13	All-m/12 Grab 12/13 Bestattung 1	adult	female					2	4	2	0	0	3,5	0	0	2	2		1	2,5
14	All-m/13 Grab 13 Bestattung 2	adult	female			0		0	3	2	0		5	0	0	2			1	4
15	All-m/15 Grab 11	adult	female	1	1			3	3	2	1	1,5	4,5	0	0	2,5	1		0	3
16	All-m/15 Grab 9 Bestattung 1	adult	male	1	0				3	2	0	0	4	0	0	2	2	0	1	0

17	All-m/15 Grab 9 Bestattung 2	suba dult	indeterm inate	1,5	1	1	1	0			0	0	3,5			2	2,5	0	0
18	All-m/16 Grab 2 Bestattung 2	adult	female	2,5	1						0	0			0			1	0
19	All-m/16 Grab 3 Bestattung 1	adult	female	1,5	0		0		3	1,5	0		5	0	0		2	0	1
20	All-m/16 Grab 3 Bestattung 2	adult	female				2		3	2	0		5	0	0	2		0	
21	All-m/16 Grab 3 Bestattung 3	adult	female	0	0	0					0		4		0	2	1	0	1
22	All-m/17 Grab 1	suba dult	indeterm inate	2	0	0	1	1	4	1		0		0	0	1	3,5	1	0
23	All-m/17 Grab 3 Bestattung 10	suba dult	indeterm inate				0	1			0	2				2	2	0	1
24	All-m/17 Grab 3 Bestattung 14	adult	female			0			4	4					0			0	2
25	All-m/17 Grab 3 Bestattung 6	adult	female	2	0	0	0	0	4	2	0	0	3	0	0	2	2	0	0
26	All-m/17 Grab 3 Bestattung 7	adult	male				0		3	2	0	0		1	0	2,5		0	3
27	All-m/17 Grab 5	adult	male	4	0	0	2	3	2	1	0		3	0	0	2	3	0	1
28	All-n/13 Grab 8 Bestattung 2	adult	female	1		2	2	0	3	4	0	3		0	0		1,5	1	0
29	All-n/15 Grab 1 Bestattung 2	adult	male					3	5	0				0	0	0		0	0
30	All-n/19 Grab 4 Bestattung 3	suba dult	indeterm inate	1	0	3	2				0	1,5	2		0	2	3	0	0
31	All-o/21 Grab 3	adult	female	3					3	0			6	0	0		2		1

A15. Raw data from inter-site analysis using Gower distance.

ID	skeleton ID	site	IG_U I1	M_U M2	H_U M2	BH_U M2	C5_U M2	CC_U M1	EE_U M1	M3 V	CN_L P2	AF_L M2	GPxL M1	GPyL M2	C5_L M1	PR_L M2	C7_L M1
10 0	33960	Dra' Abu el-Naga'		4.00	5.00	0.00	0.00	5.50		0.0 0	3.00	2.00	0.00	0.00	3.00	1.50	0.00
10 1	33961	Dra' Abu el-Naga'		4.00	2.00				0.00	0.0 0				0.00	4.00	1.50	
10 2	33964	Dra' Abu el-Naga'		4.00	4.00				0.00	0.0 0			0.00	1.00	4.00		
10 3	33965	Dra' Abu el-Naga'		4.00	3.50	0.00	0.00		1.00	0.0 0	2.00	3.00	0.00	1.00	3.00	0.00	0.00
10 4	33968	Dra' Abu el-Naga'		4.50	3.50			7.00		0.0 0		3.00	0.00	0.00	4.00	1.00	
20 1	H.III.405A	Jericho		4.00	3.00					0.0 0	2.00			0.00	4.00		
20 2	J3A	Jericho		4.00	1.50		0.00	4.50	0.00	0.0 0	2.00	3.00	0.00	0.00	4.00	1.00	0.00
20 3	P17B	Jericho		4.00	2.00	0.00	2.00	2.00	0.00	0.0 0		1.00		1.00		0.00	
20 4	P17D_A	Jericho	0.00	4.00	3.50				0.00	0.0 0		2.00	0.00	1.00	4.00		
20 5	P17F	Jericho		3.50	1.00		0.00	2.00				1.00	0.00		0.00		0.00
20 6	P17H	Jericho	0.00	4.00	2.00	0.00	1.00	2.00		0.0 0	2.00	1.00	1.00	0.00		1.00	0.00
20 7	P17J	Jericho		4.00	3.00	0.00	1.00						0.00		1.00		0.00
20 8	P17K	Jericho		5.00	3.00	0.00	1.00	5.00	0.00	0.0 0	1.00	2.00	0.00	0.00		0.00	0.00
20 9	P17M	Jericho		4.00	3.50				0.00			1.00	0.00	0.00	3.00	1.00	
21 0	P17N	Jericho		4.00	3.50					0.0 0	2.00			0.00	3.00		
21 1	P17O	Jericho	0.00	4.00	3.50					0.0 0	2.00		0.00	0.00	4.00	1.00	
21 2	P19C	Jericho	0.00	4.00	3.50	0.00	0.00	6.00	0.00	1.0 0	3.00	3.00	0.00	0.00	4.00	1.00	3.00

21 3	P19D	Jericho		4.00	2.00	0.00	1.50	5.00	1.00	1.0 0	2.00	1.00	0.00	0.00	4.00	0.00	0.00
21 4	P1N	Jericho		4.00	3.50	0.00	2.00	5.00	0.00	0.0 0	2.00	0.00	0.00	0.00	3.00	1.00	0.00
21 5	P5_A	Jericho	0.00	4.00	4.00	0.00		2.00	0.00	0.0 0	2.00	2.00	0.00	1.00	3.00	1.00	0.00
30 1	106__shackled_man__skull	Pella	0.00	4.00	2.00			4.00	0.00	0.0 0	2.00	1.00	0.00	1.00	3.00		0.00
30 2	106_associated_skull_B_1078_	Pella		4.00	4.00	0.00	2.00	2.00	0.00	0.0 0	2.50	3.00			5.00	0.00	0.00
30 3	XXVIII	Pella		4.00	2.00		0.00	6.50	1.00		2.00	3.00	0.00	1.00	4.00		3.00
40 1	100	Sidon	1.00	4.00	4.00	0.00		7.00		0.0 0	2.00	2.00	0.00	0.00	3.00	0.00	0.00
40 2	102	Sidon	0.00	4.00	3.00	0.00	2.00	2.00	0.00	0.5 0	3.00	0.00	0.00	0.00	4.00	0.00	0.00
40 3	105	Sidon	0.00	4.00	3.00	0.00	2.00	6.00		0.0 0	2.00	0.00		1.00		0.00	
40 4	107_subadult	Sidon	0.00	4.00	1.00		2.00	0.00	0.00		2.00	2.00	1.00	0.00	4.00	0.00	0.00
40 5	108	Sidon	0.00	4.00	3.00	0.00	1.00			0.0 0	2.00			0.00		1.00	
40 6	112	Sidon		4.00	3.00	0.00	2.00		0.00	1.0 0		1.00		0.00		0.00	
40 7	116	Sidon	0.00	3.00	2.00	0.00	0.00	7.00	0.00				0.00		3.00		0.00
40 8	12	Sidon	0.00	4.00	4.00	0.00			0.00	0.0 0	3.00	2.00	0.00	0.00	4.00	0.00	0.00
40 9	124	Sidon	0.00	4.00	2.00	0.00	2.00	3.00		0.0 0	2.00	3.00	1.00	0.00	4.00	1.00	0.00
41 0	125	Sidon	0.00	5.00	3.50	0.00	2.00	2.00	0.00	0.5 0	2.00	2.00	0.00	1.00	2.00	1.00	0.00
41 1	128_A	Sidon	0.00	3.00	0.00			1.00			1.00	3.00	0.00	0.00	3.00	0.00	0.00
41 2	131	Sidon						2.00		0.0 0		2.00	0.00	0.00	4.00		
41 3	132	Sidon	0.00	4.00	2.00	0.00	0.00	4.00	0.00				0.00	0.00	0.00		0.00

41 4	133	Sidon	0.00	4.00	2.00	0.00	0.00	1.00	0.0	1.00	2.00	0.00	0.00	3.00	0.00	0.00
41 5	135	Sidon		4.00	3.50	0.00		0.00	0.0				0.00	3.00		
41 6	137	Sidon	0.00	4.00	3.00			0.00	0.0			0.00	0.00	3.00		0.00
41 7	139	Sidon		4.00				0.00	0.0	2.00			0.00			0.00
41 8	14	Sidon	0.00	4.00	3.00	0.00	1.00	4.00	0.0	2.00	2.00	1.00	0.00	4.00	0.00	0.00
41 9	141	Sidon	0.00	4.00	3.00	0.00	0.00	2.00	0.0	2.00	0.00	0.00	0.00		0.00	0.00
42 0	142	Sidon	0.00	4.00	3.00	0.00		0.00	0.0					4.00		0.00
42 1	144_A	Sidon	0.00	4.00	3.50	0.00	0.00	1.00	0.0	2.00	2.00	0.00	1.00	3.00	0.00	0.00
42 2	16	Sidon	0.00	4.00	3.00	1.00	2.00	7.00	0.0		1.00	0.00	0.00	3.00	1.00	0.00
42 3	162	Sidon		4.00		0.00	0.00		0.0	2.00				3.00		
42 4	167_A	Sidon		4.00	3.50	0.00	0.00	5.00	1.00			0.00		0.00		3.00
42 5	2	Sidon	1.00	4.00	3.50	0.00	2.00	2.00	0.00	2.00		1.00		3.00		3.00
42 6	23	Sidon	0.00					2.00	0.0	2.00	1.00	0.00	0.00	3.00	1.00	
42 7	24	Sidon	0.00	4.00	3.50	0.00	2.00	5.00	0.00	2.00	2.00	1.00	0.00	3.00	0.00	0.00
42 8	27	Sidon	0.00	4.00	4.00	0.00	2.00	2.00	0.0		2.00	0.00	0.00	3.00	1.00	3.00
42 9	28	Sidon	0.00	4.00	3.50	1.00	0.00	1.00	0.0		2.00	0.00	0.00	2.00	0.00	0.00
43 0	33	Sidon	0.00	4.00	3.00	0.00	2.00	1.00	0.00		0.00	0.00	0.00	1.00		0.00
43 1	36	Sidon	0.00	4.00	2.00		2.00	6.00	0.0	2.00	2.00	0.00	0.00	4.00	0.00	
43 2	49B	Sidon		4.00	3.00	0.00	1.00	1.00	0.0			0.00		3.00		0.00

43 3	5	Sidon	0.00	4.00				4.00	0.00	0.5 0	2.00				3.00	0.00	3.00
43 4	51	Sidon		4.00	4.00	0.00		7.00	1.00			1.00	0.00	0.00	4.00	0.00	0.00
43 5	52	Sidon	0.00	4.00	3.00	0.00	2.00	3.00	1.50	0.0 0	2.00	1.00	0.00	0.00	3.00	0.00	0.00
43 6	55	Sidon	0.00	4.00	3.50	0.00	0.00			0.0 0	2.00	0.00	1.00	0.00	3.00	0.00	0.00
43 7	57	Sidon	0.00	4.00	3.00				0.00	0.0 0	2.00	0.00	0.00	0.00	3.00	0.00	
43 8	59	Sidon		4.00	1.00		0.00	2.00	0.00				0.00		3.00		0.00
43 9	6,1	Sidon	0.00	4.00	4.00	0.00	0.00	1.00	0.00	0.0 0	3.00	2.00	1.00	0.00	3.00	1.00	0.00
44 0	62	Sidon		4.00	3.00	0.00	0.00	1.00	0.00	0.0 0		2.00	0.00	1.00	2.00	1.00	0.00
44 1	63A	Sidon		3.00	3.00	0.00	0.00	0.00	0.00	0.0 0		1.00	0.00	0.00	3.00	0.00	0.00
44 2	63B	Sidon	1.00	4.00	3.00	0.00	0.00	1.00	0.00	0.0 0	2.00	2.00		0.00	4.00	0.00	0.00
44 3	65	Sidon	0.00	5.00	3.00			1.50	0.00	0.0 0	1.00	2.00	0.00	1.00	3.00	0.00	0.00
44 4	69	Sidon	0.00	4.00	2.00	0.00	2.00	1.00	0.00			2.00		0.00		1.00	
44 5	78	Sidon	0.00	3.00	3.50	0.00	2.00	2.00	0.00	0.0 0	2.00	2.00	0.00	0.00	3.00	1.00	0.00
44 6	8,1	Sidon	0.00	5.00	2.00	0.00	1.00	1.00	0.00		1.00		0.00		3.00		0.00
44 7	82	Sidon	0.00	4.00	4.00	0.00	1.00	4.00		1.0 0	3.00	0.00	1.00	0.00	4.00	0.00	0.00
44 8	93	Sidon	0.00	4.00	3.00	0.00	0.00	7.00	0.00				0.00		3.00		0.00
44 9	95	Sidon	1.00	4.00				2.00	0.00	0.0 0	2.00		0.00	0.00	3.00	1.00	0.00
45 0	99	Sidon	0.00	4.00	3.50	0.00			0.00	0.0 0	2.00	2.00	0.00	0.00	4.00		
50 1	66.4.14	Tell el-'Ajjul		3.00	4.00	0.00	0.00	5.50		0.0 0	3.00	2.00	0.00	1.00	4.00	3.00	0.00

50 2	66.4.20	Tell el-'Ajjul	0.00	4.00	4.00	0.00	2.00		0.0 0	2.00	1.00	0.00	0.00	4.00	0.00
50 3	66.4.23	Tell el-'Ajjul		4.00	3.00	0.00	2.00		0.0 0	2.00	2.00	0.00	0.00		
50 4	66.4.26	Tell el-'Ajjul		4.00	2.00	1.00	0.00	0.00	0.0 0		2.00	0.00	0.00	0.00	
50 5	66.4.29	Tell el-'Ajjul	0.00	4.00	3.50	0.00	0.00	4.00	0.0 0	2.00	3.00	0.00	0.00	0.00	3.00
60 1	All_k_14_Grab_8	Tell el-Dab'a	0.00				1.00			2.00	1.50	0.00	1.00	3.00	0.00
60 2	All_l_11_Grab_3_Bestattung_1	Tell el-Dab'a		5.00	4.00	0.00	4.50		0.0 0		1.00		0.00	4.00	0.00
60 3	All_l_12_Grab_4	Tell el-Dab'a	0.00	4.00	1.00	0.00		0.00	0.5 0	2.00	2.00	0.00	1.00	3.00	4.50
60 4	All_l_12_Grab_5_Bestattung_3	Tell el-Dab'a	1.00	4.00	3.50	1.00	1.50	6.00	2.00	0.0 0	2.00	1.50	0.00	0.00	4.00
60 5	All_l_16_Grab_4_Bestattung_1	Tell el-Dab'a	0.00	4.00	3.50	0.00	0.00	4.00		0.0 0	2.00	3.00	0.00	0.00	4.00
60 6	All_l_17_Grab_5_Bestattung_1	Tell el-Dab'a		4.00	4.00	0.00	2.00	5.00	0.00	0.5 0	3.00	3.00	0.00	1.00	3.00
60 7	All_l_17_Grab_5_Bestattung_3	Tell el-Dab'a	0.00				0.50			0.0 0		2.00	0.00	0.00	4.00
60 8	All_m_10_Grab_7_Bestattung_2	Tell el-Dab'a	0.00	4.00	4.00	0.00	1.50			1.0 0		2.00	0.00	0.00	4.00
60 9	All_m_10_Grab_8_Bestattung_1	Tell el-Dab'a		4.00	4.00	0.00		4.00	1.00	0.0 0	2.00	2.00	0.00	0.00	4.00
61 0	All_m_11_Grab_1	Tell el-Dab'a	0.00	4.00	2.00	0.00	1.00	1.00			3.00	0.00	0.00	4.00	2.00
61 1	All_m_12_Grab_12_Bestattung_1	Tell el-Dab'a	0.00	5.00	3.00	0.00	0.00	3.50	0.00	0.0 0	2.00	2.00		1.00	2.00
61 2	All_m_13_Grab_13_Bestattung_2	Tell el-Dab'a	0.00	3.00	3.00	0.00		5.00	1.00	0.0 0	2.00			1.00	0.00
61 3	All_m_13_Grab_6	Tell el-Dab'a		4.00	5.00	0.00		2.00	1.00		2.00		0.00	1.00	4.00
61 4	All_m_15_Grab_11	Tell el-Dab'a		3.00	2.50	1.00	1.50	4.50	0.00	0.0 0	2.50	1.00		0.00	4.00
61 5	All_m_15_Grab_9_Bestattung_1	Tell el-Dab'a		3.00	2.00	0.00	0.00	4.00	1.00	0.0 0	2.00	2.00	0.00	1.00	4.00

61 6	All_m_15_Grab_9_Besta ttung_2	Tell el-Dab'a		4.00	3.00	0.00	0.00	3.50	0.00		2.00	2.50	0.00	0.00	4.00	2.00	2.50
61 7	All_m_16_Grab_2_Besta ttung_2	Tell el-Dab'a	0.00	5.00	4.00	0.00	0.00		0.0			1.00	0.00	3.00			
61 8	All_m_16_Grab_3_Besta ttung_1	Tell el-Dab'a		3.00	3.00	0.00		5.00	0.00	0.0		2.00	0.00	1.00	4.00	2.00	
61 9	All_m_16_Grab_3_Besta ttung_2	Tell el-Dab'a		5.00	4.00	0.00		5.00	1.00	0.0	2.00		0.00		4.00		0.00
62 0	All_m_16_Grab_3_Besta ttung_3	Tell el-Dab'a	0.00	4.50	3.00	0.00		4.00		0.0	2.00	1.00	0.00	1.00	4.00	0.00	
62 1	All_m_17_Grab_1	Tell el-Dab'a		4.00	1.00		0.00		0.00	0.0	1.00	3.50	1.00	0.00	4.00	1.00	
62 2	All_m_17_Grab_3_Besta ttung_10	Tell el-Dab'a		4.00	3.50	0.00	2.00				2.00	2.00	0.00	1.00	4.00		0.00
62 3	All_m_17_Grab_3_Besta ttung_6	Tell el-Dab'a		4.00	3.00	0.00	0.00	3.00		0.0	2.00	2.00	0.00	0.00	4.00		
62 4	All_m_17_Grab_3_Besta ttung_7	Tell el-Dab'a		4.00	3.00	0.00	0.00		0.00	0.0	2.50			0.00	4.00	0.00	
62 5	All_m_17_Grab_5	Tell el-Dab'a	0.00	3.00	3.00	0.00		3.00	0.00	0.0	2.00	3.00	0.00	1.00	4.00	0.00	0.00
62 6	All_n_13_Grab_8_Bestat tung_1	Tell el-Dab'a		4.00	1.00		2.00	2.00	3.00		3.00	1.50	0.00	1.00	4.00		
62 7	All_n_13_Grab_8_Bestat tung_2	Tell el-Dab'a		4.00	4.00	0.00	3.00					1.50	1.00	0.00	4.00	0.00	0.00
62 8	All_n_15_Grab_1_Bestat tung_2	Tell el-Dab'a	0.00	5.00	3.00					0.0	0.00		0.00	0.00			
62 9	All_n_19_Grab_4_Bestat tung_2	Tell el-Dab'a		3.00	3.00		0.00			0.0	3.00	2.00		0.00			
63 0	All_n_19_Grab_4_Bestat tung_3	Tell el-Dab'a	0.00	3.00	3.50	0.00	1.50	2.00		0.0	2.00	3.00	0.00	0.00	4.00	0.00	0.00
63 1	All_o_21_Grab_3	Tell el-Dab'a		4.00				6.00		0.0		2.00		1.00		0.00	
63 2	FI_j_23_Grab_28	Tell el-Dab'a		5.00	3.50	0.00	0.00	2.00	0.00		2.00	1.00	0.00	1.00	4.00	1.00	0.00
63 3	FI_k_22_Grab_19	Tell el-Dab'a		4.00	4.00	0.00				0.5			0.00		4.00		0.00
70 1	66.4.16	Tell el-Far'ah S		4.00	3.00	1.00	0.00	3.00		0.0	2.50	2.00		1.00		0.00	

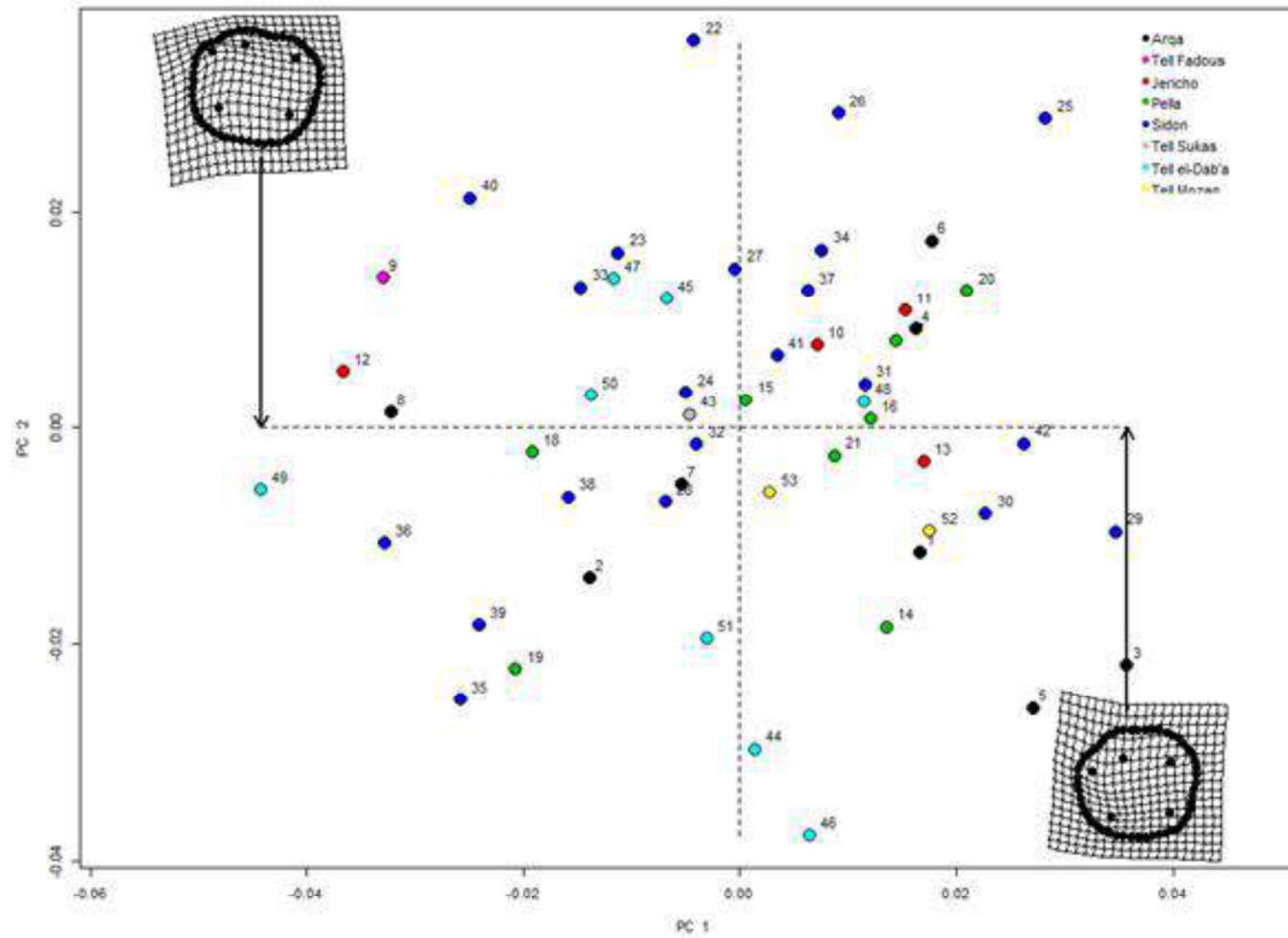
80 1	24525	Ugarit	0.00	4.00	3.50				0.00	0.5 0	1.00	2.00	0.00	0.00	4.00	2.00	0.00
80 2	24527	Ugarit	0.00	4.00	4.00	0.00		0.00	0.00	0.0 0	2.00	2.00	0.00	0.00	3.00	0.00	0.00
80 3	24529	Ugarit	0.00	4.00	4.00				0.00	0.0 0	2.00	3.00		1.00			0.00
80 4	24532	Ugarit	0.00	4.00	3.50	1.00	3.00	4.00	0.00	0.0 0		3.00	0.00	0.00	4.00	0.00	0.00
80 5	24533	Ugarit		4.00	2.00	0.00	0.00	1.00	0.00	1.0 0		3.00	0.00	1.00	4.00	1.00	0.00
80 6	24536	Ugarit		4.00	3.00					0.0 0	2.00	4.00		0.00		3.00	
80 7	24537	Ugarit		4.00	2.00			5.00		0.0 0	2.00	1.00	0.00	0.00	3.00		0.00
80 8	24538_A	Ugarit		4.00	3.00	0.00	0.00	1.00	0.00		3.00		0.00	0.00	4.00		0.00
80 9	24545	Ugarit		4.00	3.00				0.00	0.0 0	3.00	2.00	0.00	0.00			0.00
81 0	24546	Ugarit		4.00	3.00	0.00	1.00	3.00		0.0 0	2.00	2.00	0.00	0.00	4.00	1.00	0.00
81 1	24547	Ugarit		4.00	3.50	0.00	2.00	5.00	0.00	0.0 0	2.00	2.00	0.00	0.00		0.00	0.00
81 2	24549	Ugarit		4.00	3.00		2.00			0.0 0			0.00	0.00		1.00	0.00

A16. List of individuals used in the geometric morphometrics analysis.

plot_id	gm_id	full_id	Site	Tooth FDI
1	101	arqa_1257A_36	Arqa	36
2	102	arqa_1257B_36	Arqa	36
3	103	arqa_1349_36	Arqa	36
4	104	arqa_1407_46	Arqa	46
5	105	arqa_5017_36	Arqa	36
6	106	arqa_015040_46	Arqa	46
7	107	arqa_136846_46	Arqa	46
8	108	arqa_silloD_46	Arqa	46
9	209	fadous_find139_36	Tell Fadous	36
10	310	jericho_B35.2_36	Jericho	36
11	311	jericho_B35.3_36	Jericho	36
12	312	jericho_B35.4_36	Jericho	36
13	313	jericho_P17G_46	Jericho	46
14	414	pella_62.2_36	Pella	36
15	415	pella_62.3_36	Pella	36
16	416	pella_62.7_36	Pella	36
17	417	pella_62.8_36	Pella	36
18	418	pella_62.9_36	Pella	36
19	419	pella_62.10_36	Pella	36
20	420	pella_62.11_36	Pella	36
21	421	pella_62.12_36	Pella	36
22	522	sidon_1_46	Sidon	46
23	523	sidon_8_46	Sidon	46
24	524	sidon_13_46	Sidon	46
25	525	sidon_17_36	Sidon	36
26	526	sidon_33_46	Sidon	46
27	527	sidon_44_46	Sidon	46
28	528	sidon_46_36	Sidon	36
29	529	sidon_51_46	Sidon	46
30	530	sidon_52_36	Sidon	36
31	531	sidon_54_46	Sidon	46
32	532	sidon_87_46	Sidon	46
33	533	sidon_120_36	Sidon	36
34	534	sidon_122_46	Sidon	46
35	535	sidon_123.1_36	Sidon	36
36	536	sidon_123.2_36	Sidon	36
37	537	sidon_128.1_36	Sidon	36
38	538	sidon_128.2_36	Sidon	36
39	539	sidon_143_36	Sidon	36
40	540	sidon_144_36	Sidon	36
41	541	sidon_159_46	Sidon	46
42	542	sidon_160_46	Sidon	46

43	643	sukas_4_36	Tell Sukas	36
44	744	ted_a2k14g4_46	Tell el-Dab'a	46
45	745	ted_a2k14g8_36	Tell el-Dab'a	36
46	746	ted_a2l17g1_36	Tell el-Dab'a	36
47	747	ted_a2m12g3_46	Tell el-Dab'a	46
48	748	ted_a2m15g9i2_36	Tell el-Dab'a	36
49	749	ted_a2p21g12_36	Tell el-Dab'a	36
52	750	ted_f1i21g24_36	Tell el-Dab'a	36
55	751	ted_f1k23g33_36	Tell el-Dab'a	36
56	852	tem_5_46	Tell Mozan	46
57	853	tem_12_46	Tell Mozan	46

A17. PCA plot of GPA with labels on individuals.



A.18. Ethics approval.



Research Ethics Checklist

Reference Id	13367
Status	Approved
Date Approved	26/10/2016

Researcher Details

Name	Nina Moarane
Faculty	Faculty of Science & Technology
Status	Postgraduate Research (MRes, MPhil, PhD, DProf, DEng)
Course	Postgraduate Research - FST
Have you received external funding to support this research project?	Yes
RED ID	6495
Funding Body	ca half of funding from the Austrian Academy of Sciences (ERC funded)
Please list any persons or institutions that you will be conducting joint research with, both internal to BU as well as external collaborators.	Austrian Academy of Sciences, University of Southampton (supervisor Sonia Zakrzewski)

Project Details

Title	Hylsos in Egypt
Proposed Start Date of Data Collection	01/10/2016
Proposed End Date of Project	01/09/2019

Original Supervisor	Holger Schutkowski
Approver	Holger Schutkowski

Summary - no more than 500 words (including detail on background methodology, sample, outcomes, etc.)

Conventional methods have been compiled in several guidelines (e.g. by Brickley and McKinley 2004, Buksa and Ubelaker 1994 and Scheuer and Black 2000), however there is no set collection of methods due to variation. The selection of the most appropriate methods, paradoxically, requires previous understanding of the material, its age structure and prominence. The investigation would begin from assessing sex and age and evaluating their prominence in said population (e.g. the sexual dimorphism of the Hyksos). Morphometrics and nonmetric traits provide insight into ancestry, sexual dimorphism, familial relationships, habitual behaviour, pathologies and health. Metrical data can be population-specific, and caution must be taken when analysing the metric Hyksos data.

External Ethics Review

Does your research require external review through the NHS National Research Ethics Service (NRES) or through another external Ethics Committee?	No

Research Literature

Is your research solely literature based?	No

Human Participants

Will your research project involve interaction with human participants as primary sources of data (e.g. interview, observation, original survey)?	No

Final Review

Will you have access to personal data that allows you to identify individuals OR access to confidential corporate or company data (that is not covered by confidentiality terms within an agreement or by a separate confidentiality agreement)?	No
Will your research involve experimentation on any of the following: animals, animal tissue, genetically modified organisms?	No
Will your research take place outside the UK (including any and all stages of research: collection, storage, analysis, etc.)?	Yes
Does the country in which you are conducting research require that you obtain internal ethical approval (i.e. beyond that required by Bournemouth University)?	No

Could conflicts of interest arise between the source of funding and the potential outcomes of the research?

No

Please use the below text box to highlight any other ethical concerns or risks that may arise during your research that have not been covered in this form.

The project uses skeletal human remains from archaeological contexts for research purposes. The ethical issue rises from the lack of permission we have, and this is reconciled by assuring the research in question serves a purpose and produces results which could not be attained otherwise. Guidelines have been issued by several relevant institutions and parties to ensure respectful and professional treatment of the human remains, such as by BABAC (British Association for Biological Anthropology). The guidelines will be followed to ensure the highest level of professionalism and respect when treating the remains. When conducting the research abroad, the same guidelines as well as local standards will be followed.

Researcher Statement

JOURNALISM / BROADCAST RESEARCHERS: I confirm that I have consulted and understand the Research Ethics Supplementary Guide: For Reference by Researchers Undertaking Journalism and Media Production Projects (available on the Research Ethics page)

Yes

Glossary

Allele. variant form of a given gene (in paired chromosomes) which can (but often does not) result in different observable phenotypic traits. An organism is described as homozygous (same alleles) or heterozygous (different alleles).

Apoptosis. Programmed cell death.

Bending energy. Determines semilandmark placement by mapping the 'path of least resistance' between neighbouring landmarks.

Cartesian coordinates. Also called rectangular coordinates, placed in a two- or three-dimensional plane and measure the same unit of length.

Contingency table. Also known as cross-tabulation, displays the frequency distribution of the variables in a matrix.

Correspondence Analysis (CA). Also called reciprocal averaging, a multivariate technique that is similar to PCA but applies to categorical data. It meant to reduce multidimensional data into 2- or 3-dimensional for visualisation. All data must be on an equal scale. It is applied to contingency tables (chi-square). It creates orthogonal (perpendicular) components and a set of scores (also called factor scores).

Degrees of freedom. The number of parameters that can vary independently without causing change. For an example, calculating the mean of two observations has two degrees of freedom because both can vary. Calculating variance for that mean only has one degree of freedom because both observations are equally far from the mean. When cross-tabulating, the degrees of freedom is $(\text{number of columns} - 1) * (\text{number of rows} - 1)$. GM analysis decreases the df because rotation and size reduction are values that cannot vary independently.

Dendritic system. Named because of its similarity to branching organic forms. People trading have power over political systems, and local production is directed by demand and supply. The model creates decentralised system of market exchange which is the driving force behind inter-regional communication. Local distribution of power then reflects the exchange relationships, with the strongest exchange partner as the closest node in the system.

Diffusionism. Transmission of cultural characteristics from one society to other societies. 19th century diffusionism had some drastic forms where all characteristics were assumed from one specific polity (e.g. ancient Egypt).

Early Bronze Age-Middle Bronze Age. The transition EBIV-MBI has also been called Intermediate Bronze Age (IBA) and Copper Age (CA).

Eigenvalue. Measures the amount of variation the eigenvector (or principal component) explains in the data. Calculated by: (1) multiplying the lambda (eigenvalue) to an identity matrix, (2) subtracting the resulting matrix from the original matrix, (3) computing the determinant from the resulting matrix.

Eigenvector. Dimension-reduction technique by compressing the data without changing its direction. After eigenvalues are calculated, the eigenvectors are calculated by (1) multiplying an eigenvalue with an identity matrix, (2) subtracting the resulting matrix from the original matrix.

Epigenetic factors. Genetic control by factors other than an DNA, such as the environment. Epigenetic changes can switch genes on or off and determine which proteins are transcribed and are both vital and potentially harmful.

Ethnic enclave. A collective with characteristic cultural identity, and economic activity.

Euclidean distance. Straight-line distance between two points in Euclidean (i.e. geometric) space.

Eugenics. Coined by Francis Galton, the movement was aimed at improving the genetic composition of the human race (historically) through selective breeding.

Factor Analysis (FA). Dimension-reduction method used to describe variability among observed, correlated variables. It hosts a number of factor extraction methods (including PCA).

Fixation index (F_{ST}). measures population (genetic) differentiation and is defined as the correlation of gametes between subgroups, relative to gametes drawn randomly from the whole group. The values range from 0 to 1, where the increase in value indicates population divergence.

F-statistic. Often used to compare models fitted to datasets to identify the best fit for the sample. $F = (\text{between-group variability})/(\text{within-group variability})$, meaning large values indicate large between-group variability and vice versa.

Gene flow. Also known as allele flow where two populations share genes by transfer. When gene flow is high enough to equalise the frequencies of alleles, the populations are considered the same.

Genetic drift. Also known as allelic drift or Wright effect causes the frequency of a gene to change due to the random sampling of organisms. The frequency of genes is dependent on the survival and reproduction of organisms in that population.

Generalised Procrustes analysis. Also known as generalised least squares superimposition, where shapes are 'fitted' by minimising the difference between corresponding landmarks by rotating them to the origo and rescaling the configurations to a size 1.

Gower distance. measure difference between observations, beginning by computing the distance between pairs and then combining the distances into a single value per record-pair.

Inertia. Term used in correspondence analysis to assess the quality of the graphical representation of the distances created from the rows and columns. Inertia can be assessed separately for rows and columns, calculated from the total inertia rows/columns and the squared distance to the centroid (or, the total Pearson chi-square divided by total sum). For dental morphology, inertia was used to assess traits explaining the greatest amount of variation.

Kendall shape space. Shape space for multidimensional shapes that is non-linear by nature but can be approximated by Euclidean tangent space.

Microchronology. Similar to the analysis of microevolution where phenotypic change can reflect natural selection, or changes in population size or mating pathways.

Model-free and model-bound approaches. The relationship between genetic affinity and phenotypic similarity can be measured by using a specific population model (model-bound approach) or comparing the relative similarity/dissimilarity of groups (model-free approach). However, the employed methods may be cross-sectional,

such as when assuming positive correlation between biological distance and geographic distance, based on an isolation-by-distance model.

Partitioning around medoids (PAM). minimises the overall dissimilarity between observations in each cluster (medoid).

Polymorphism. Occurrence of two or more different forms in a population existing at the same time and are randomly mating.

Port Power model. Proposed by Stager (2001), the system explains network formation with organisation around natural transport systems, such as the southern Levantine wadi systems. To reach inland, sites create a market exchange network which is directed by commerce rather than politics, resembling a dendritic system.

Post-marital residence analysis. Analysis of patri-/virilocal (male kin) and matri-/uxorilocal (female kin) social organisation.

Principal Component Analysis (PCA). The eigenvalues of PCA are inflated component loadings, i.e. contaminated with error variance.

Principal Coordinate Analysis. Dimension-reduction technique which produces uncorrelated (orthogonal) axes to summarise variability in a dataset. Meant for parametric (continuous) data, the technique preserves Euclidean and chi-squared distances between objects.

Processualism. Also referred to as “new archaeology”, a research philosophy modelled after the scientific method.

Procrustes distance. Geometric morphometric technique to minimise the distance between adjacent semilandmarks (Rohlf 2010) after GPA.

R-matrix. A standardised variance-covariance matrix that indicates average kinship coefficients between populations (off the diagonal) and within populations (on the diagonal). Free software has been created to calculate the R-matrix for metric traits (<http://employees.oneonta.edu/relethjh/programs>, accessed 4.9.2019). Can be calculated from D^2 matrix. First: calculate codivergence matrix (C-matrix) that measures variance around centroid, or squared distance from population's multivariate means to the centroid. The C matrix diagonal is transformed to a column

vector that be used to calculate F_{ST} and subsequent R-matrix (see Konigsberg 2006).

Stochasticity. Random events influencing population structure, such as immigration.

Tangent space. Dimension reduction technique for Kendall shape space to visualise configuration (shape) difference between organisms and groups.

T-distributed Stochastic Neighbour Embedding. Reduces high-dimensional data by constructing a probability distribution over pairs of high-dimensional observations and then transforming them into a similar probability distribution for a 2- or 3-dimensional graph.

Tangent space. Linear vector space in geometric morphometrics approximating Kendall shape space when variation is small (i.e. within species commonly).

Thin plate spline. Visualisation of shape changes on a non-uniform transformation grid (where grid lines are allowed to change shape), showing distortion in locations where change has been detected.