BIOARCHAEOLOGICAL ANALYSIS OF A LATE BRONZE AGE SKELETAL

ASSEMBLAGE FROM KATARET ES-SAMRA, JORDAN

by

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Two tombs from approximately the Late Bronze Age IB and IC (ca. 1400–1300 B.C.E.) were discovered at Tell Kataret es-Samra, Jordan and excavated in 1978 and 1985. Until this thesis, the skeletal remains had not been fully studied, with only an unsystematic osteological description of Tomb 2 published in 2017. The Late Bronze Age signals a period of transition within the Near East during which many Mediterranean and Levantine civilizations underwent notable political, economic, and settlement shifts theoretically related to growing global trade and the impact of the Egyptian empire. The LBA IB and IC in particular represent the height of Egyptian power and influence in the Cisjordan. Despite many Late Bronze/Early Iron Age cemetery excavations in the southern Levant, little skeletal material has been studied, and those assemblages that have been studied produced only nominal descriptions rather than an interpretive and analytical perspective. Bioarchaeological data can provide a novel perspective on both the health and diet effects of social change, and the information derived could provide a new understanding of this period of Jordanian history. This thesis establishes an updated MNI for both tombs, as well as a systematic study of skeletal lesions that can illuminate physiological stress and malnutrition in addition to morbidity and mortality patterns more successfully than a descriptive report.

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ASSEMBLAGE FROM KATARET ES-SAMRA, JORDAN


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By

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**CHAPTER ONE:**

**INTRODUCTION**

The Late Bronze Age IB to IC (1400 BCE - 1300 BCE) Tombs 1 and 2 from Kataret es-Samra, Jordan were excavated in 1978 and 1985 (respectively); however, had not received full bioarchaeological analysis. A study of Tomb 2's remains was published as a preliminary descriptive report (Ward Briggs and Leonard 2017:1-18), but it did not include analysis of Tomb 1. Proper bioarchaeological analysis of these two assemblages can add to the sparse skeletal data we have from rural populations dated to the Late Bronze Age southern Levant, which was a time of dynamic political and economic change.

The Late Bronze Age (LBA) in Transjordan largely continues regional cultural themes, such as a reliance on pastoralism, consumption of cereal grain, and continuity of ceramic typologies from the Middle Bronze Age (MBA) (Fisher 2013), albeit with the added presence of the Egyptian empire in the Cisjordan, whose expansion into this area can be used to date the beginning of the LB (Strange 2008:281). The LB is a period in which international trade and cultural exchange flourished between Egypt, Canaan, Anatolia, and the Mycenaean World (Pantiz-Cohen 2013:543), although the continuation of local material culture in Transjordan may suggest this expanded commerce had little impact in the region. Based on survey data from 1985 and material culture found in the tombs and soundings excavated on the tell, Kataret es-Samra apparently existed at the periphery of this expanding world and its inhabitants interacted with the herding of domesticated cattle, goat, and sheep (Leonard 2017). While the Transjordan seems to have been minimally impacted by the growing Egyptian empire, bioarchaeological data can help test how and if these changes impacted bodily stress, diet, and mortality of rural individuals. This project documented skeletal pathologies and information on age and sex that provide evidence of

physiological stress, malnutrition, and morbidity and mortality patterns of those buried in Kataret es-Samra Tombs 1 and 2. Despite many LB/Early Iron Age excavations in the southern Levant, little skeletal material has been studied, and those that have been studied provide only nominal descriptions rather than an interpretive and analytical perspective. Ultimately, these data will be made available for scholars who aim to similarly analyze remains from excavations in the Near East and shed further light on this critical but bioarchaeologically understudied region.

## CHAPTER TWO:

## BACKGROUND

**Introduction**

  The LBA IB to IC (1400 BCE – 1300 BCE) Kataret es-Samra skeletal collection was excavated in 1978 and 1985 from two tombs found on a  hillside adjacent to Tell Kataret es-Samra in northwest Jordan (Leonard 1979, 1983, 1989, 2017). Tell Kataret es-Samra lies within the *katarrah* region of Transjordan, a landscape marked by sandy Pleistocene cliffs approximately 40 km north of the confluence of the Jordan River and Wadi Zarqa (Figure 2.1) (Leonard 2017:xi). In 1975 the site was visited by the Jordan Valley Survey Team from the Department of Antiquities, Jordan University, and the American Center for Oriental Research, who discovered both surface evidence for occupation as early as the Early Bronze Age (3300 – 2100 BCE) through the LBA, and signs of ongoing tomb looting (Leonard 2017:xi). The subsequent East Jordan Valley Survey conducted in 1975-1976 noted several archaeologically significant points in the Kataret es-Samra region, identifying the tell (Site I) and the tombs (Site IV) (Ibrahim et al. 1976). Initial excavations in 1978 by the Jordan Valley Survey Team retrieved skeletal material from a looted rock-cut shaft tomb, named Tomb 1 (Leonard and Greene 2017:1). A subsequent season in 1985 discovered additional skeletal material, ceramics, and artifacts from a second nearby tomb, Tomb 2. Although a preliminary analysis was completed on the skeletons from Tomb 2 (Ward-Briggs and Leonard 2017), it was primarily descriptive and did not include a detailed bioarchaeological analysis, nor did it include the remains excavated from Tomb 1. The excavation director Dr. Albert Leonard contacted East Carolina University so that a full analysis might be completed before the remains are returned to the Department of Antiquities. This project aimed to reanalyze the skeletal material from Tomb 2

as well as analyze the contents of Tomb 1 in order to provide a contextualized perspective on these individuals in the LBA. In addition, the data analysis aims to facilitate comparative analyses in the future by standardizing collection skeletal stress markers following current osteological standards.
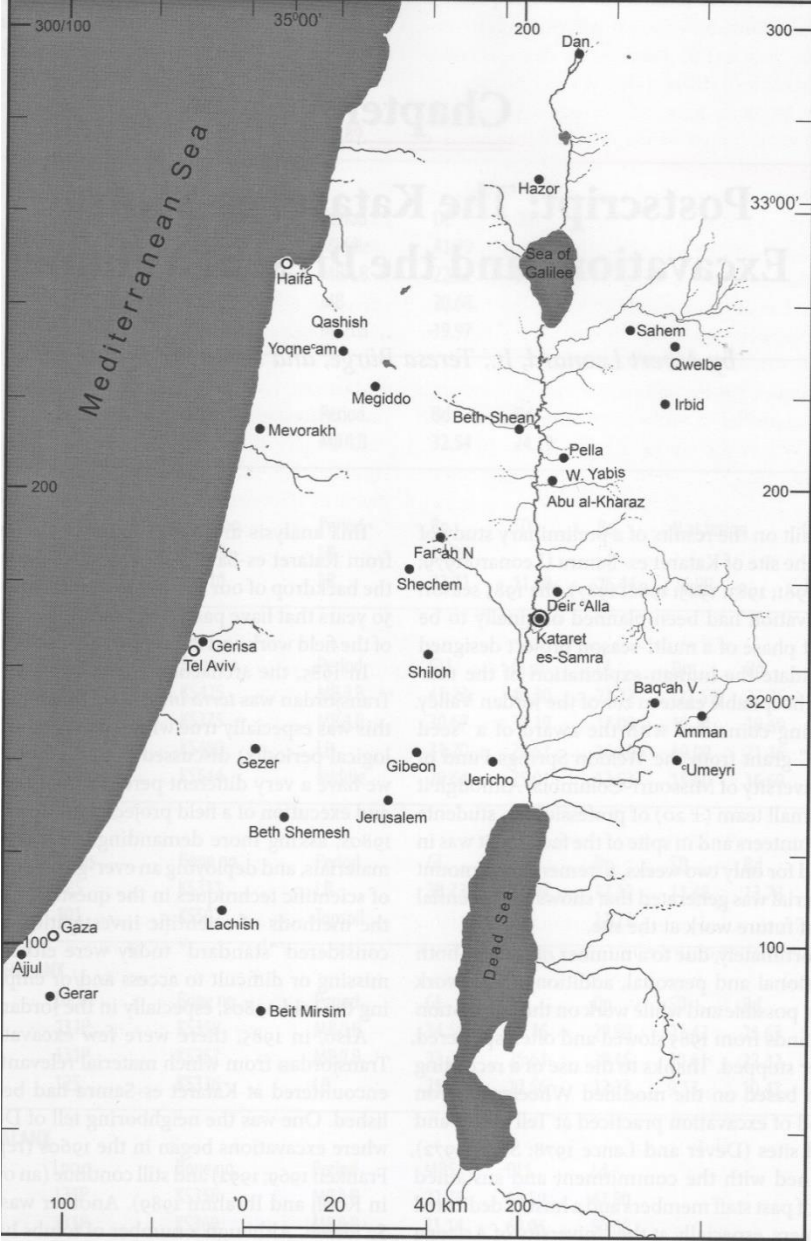


*Fig. 2.1: Kataret es-Samra in LB context (Leonard 1979)*

**Historical Background**

They key to studying the Late Bronze Age in Jordan is to understand the drastic increases in international trade and impacts of an imposing Egyptian imperial force in the southern Levant and recognize the impact, if any, on the settlements in Cisjordan. For almost a century, northern Egypt was ruled by the Hyksos, a Semitic group of uncertain origin. The Egyptian Pharaoh Ahmose finally expelled the Hyksos from Egypt in 1550 BCE and expanded Egyptian influence into the southern Levant. Early LB Egyptian control of the southern Levant appears to have been concentrated in newly established imperial governmental centers in Gaza, Jaffa, and Beth Shean. Regional administration either relied on loyalty oaths from local polities (Pantiz-Cohen 2013), or, based on the widespread Egyptian material culture in Cisjordan, by direct pharaonic control (Bunimovitz 2018). Either way, subsequent local generations experienced an increasingly present imperial force after the Battle of Meggido in the late 15th century BCE through control of trade and taxing the populous. This control eventually waned in the tertiary LB and ended with the LB collapse event around 1150 BCE (Pantiz-Cohen 2013). Throughout the earlier LBA, populations in the southern Levant aggregated in cultural centers such as Gezer, Beth Shean, and Jerusalem, while those in peripheral smaller settlements continued their rural lifestyle (Pantiz-Cohen 2013).
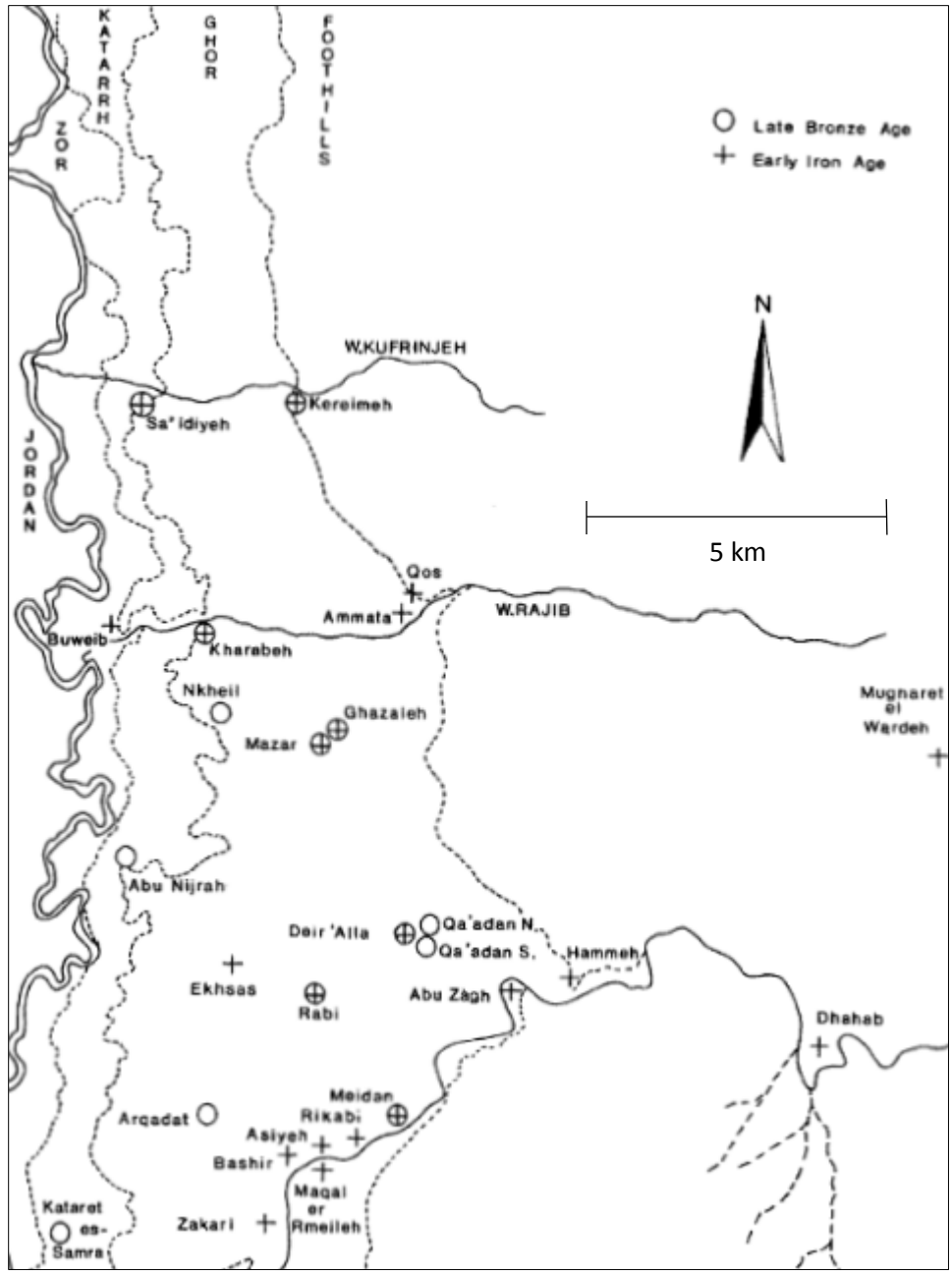
*Fig. 2.2: Kataret es-Samra (bottom left) in comparison with Tell Deir 'Alla (center) and Tell es-Sa'idiyeh (top) (van der Steen 1996). The added scale is approximate.*

Little evidence suggests that Transjordan (where Kataret es-Samra is located), ever came under direct Egyptian control (Fischer 2013). Instead, city-states close to the Jordan river (Figure 2.2) such as Tell Deir 'Alla (ca. 8 km to the north of Kataret es-Samra) and Tell es-Sa'idiyah largely governed themselves, albeit while paying required tributes to Egyptian forces in the form

of livestock, produce, and timber (Fischer 2013). Egyptian interest in the Transjordan was

mainly in establishing and maintaining trade routes, often through periodic Egyptian raids

(Fischer 2013). One proposed trade route ran through the Deir 'Alla/Sa'idiyeh region (van der

Steen 1996).
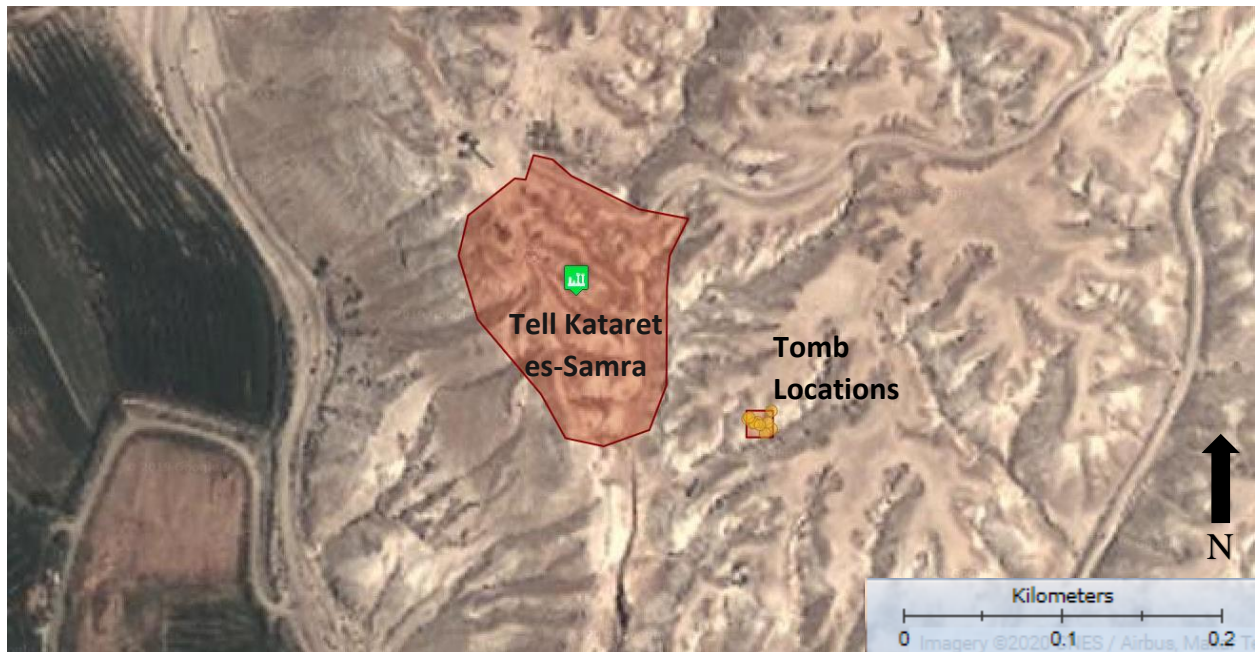


*Fig. 2.3: Satellite image of the immediate Kataret es-Samra area, including the tell and location of the tombs. Yellow dots indicate surface finds. (Courtesy of MEGAJordan © the Getty Conservation Institute, World Monuments Fund, and the Department of Antiquities of Jordan)*

Unlike Deir 'Alla, the immediate Kataret es-Samra region (Figure 2.3) seems to have

been sparsely inhabited by nomads and semi-sedentary pastoralists during the MB to LB (2100 –

1150 BCE). Questions remain as to how much Kataret es-Samra was politically independent

versus incorporated into the political spheres of nearby city-states. Textual sources in the region

that may shed light on this question are few and all come from tablets at Tell Deir 'Alla. As of

now, these texts are written in an undeciphered local script (van der Steen 2004). Other textual

sources relating to the LB in Transjordan come from Egyptian sources, which include detailed

letters from local governors and families controlling small regions in the Cisjordan (van der

Steen 2004). These sources describe a patchwork of "tribes," or small, familial communities which were complexly interlinked in trade, travel, and conflict (van der Steen 2004). Textual sources from Egypt include inscriptions on statues and stelae of Sethos I and Ramesses II mentioning the land of "Moab" east of the Dead Sea (Fischer 2013). Some texts from the Egyptian garrison at Beth Shean mention conflict in the Transjordan but nothing more (Fischer 2013). Therefore, very little can be said about Kataret es-Samra from written sources in this time period.

The only excavations of Tell Kataret es-Samra are shallow soundings on the tell's summit from the 1985 field season (Bürge, Leonard, and Fischer 2017b). These revealed permanent mudbrick structures, and scatters of animal bone, flints, and ceramics dating from the MB to LB (Bürge, Leonard, and Fischer 2017b). Occupation seems to have stopped in the mid-LB, though a handful of Iron Age ceramics were found during survey of the tell's summit (Bürge, Leonard, and Fischer 2017b). The abundance of sheep, goat, and cattle bones both in the tombs and recovered from soundings confirms sedentary and/or nomadic pastoralism was economically important to Kataret es-Samra (Lange 2017).
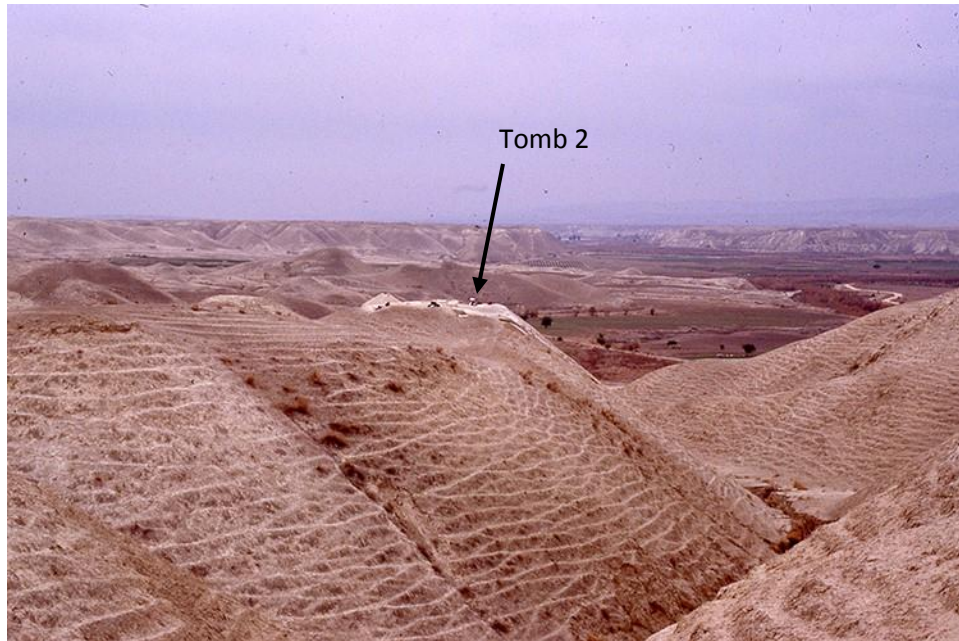
*Fig. 2.4: The excavation of Tomb 2 (center) (Image courtesy of Albert Leonard Jr)*

The two tombs associated with Tell Kataret es-Samra were located just east on an opposite hillside. The temporally diagnostic artifacts in the small material culture assemblage indicate the tombs were contemporaneous with final permanent occupation at the tell. Tomb 2 contained mostly local ceramics with few imports, dating to the LB IB and IC periods, or from 1400 – 1300 BCE (Bürge, Leonard, and Fischer 2017a). This period is noted as being the height of Egyptian power, resulting from the decisive Battle of Meggido (Fischer 2013). Two confirmed Cypriot imports were found in Tomb 2, one Base Ring Ware I *bilbil* and one Base Ring Ware I or II juglet (Bürge, Leonard, and Fischer 2017a). These both date to the Late Cypriot $1A_2$ through Late Cypriot IIC (1550 - 1200 BCE) (Bürge, Leonard, and Fischer 2017a). Their presence at Kataret es-Samra may link the site to the proposed nearby trade route to the north (van der Steen 1996) or may indicate migration into the region by Cypriot peoples. Cypriot influence in the LB of the southern Levant is not unique to Kataret es-Samra. Base Ring Ware I and II type containers (such as the one found in Tomb 2) have been found throughout the

southern Levant (Bunimovitz and Lederman 2016). Many of these are actual imports into the region, e.g., at Tell Bruna (Shai et al. 2019) and Tell es-Sa'idiyah (Green 2013). Evidence at the site of Tell Esur in northern Israel indicates regional adoption of Cypriot ceramic-production techniques alongside use of imported Cypriot ceramics (Shalvi et al. 2020). The presence of imported Cypriot ceramics at Kataret es-Samra suggests its inhabitants were tapped into the local import market.

Also notable among the small finds of the tomb was a scarab with a motif dating to the 18th Dynasty (1550-1292 BCE) (Bürge, Leonard, and Fischer 2017a). This kind of object is not uncommon in the region. Bürge, Leonard, and Fischer (2017a) suggest that many might have been copies of Egyptian originals, originating in craft centers in Tell al-'Ajjul near modern-day Gaza. Tomb 1 was highly disturbed from looting but assumed to be roughly contemporaneous with Tomb 2. Both tombs were described by Bürge, Leonard, and Fischer (2017a) as being very "average" in their contents, reflecting rural peoples with less wealth than at larger sites such as Deir 'Alla.

*Fig. 2.5: Burials at Kataret es-Samra Tomb 2, demonstrating the context and disposition of the remains. It is not clear which "burial" this image depicts (Image courtesy of Albert Leonard Jr)*

**Mortuary Patterns of the Tombs and Nearby Sites**

Tomb 2 was a vertical rock-cut shaft tomb with a depth about 1.3 meters below the

modern surface (Ward Briggs and Leonard 2017). Burials were in the E-NE corner of the burial

chamber (Ward Briggs and Leonard 2017) (Figure 2.5). A large circular stone was found at the

bottom of the shaft which may have been a chamber door, though it was not used after the last

burial (Ward Briggs and Leonard 2017). The lack of detailed drawings and photographs of the

skeletal remains *in situ* makes it difficult to discern the original position, which must rely on

stick-figure drawings in the final publication. It is not clear if these are actual representations of

what was seen during excavation, including the presence of specific skeletal elements, or just a

hypothetical reconstruction of how the original burial might have looked. According to these, the

tomb contained 11 separate primary burials, and all were laid on their back in extended position,

except for the final individual, who was interred on their left side in a flexed position (Ward

Briggs and Leonard 2017). Seven of these individuals were placed with their heads to the south

and four with heads to the north, and there seemed to be no specific age or sex pattern to their orientation. The individuals seem to have been interred in four superimposed layers, grouped by Ward Briggs and Leonard (2017) from bottom to top as: (1) three adults (one male and two females) and two children, (2) three adults (one male and two females), (3) and adult male and a child, and (4) an adolescent female. Small objects were found associated with a young female, who was buried near stone and bone beads, a bronze tweezer, a scarab, several toggle pin fragments, and a young child interred near a bronze anklet and beads similar to those from the other burial (Ward Briggs and Leonard 2017). No description of burials is given for Tomb 1 in Leonard (2017).

The burial practices and mortuary architecture seen at Kataret es-Samra differs from other LB cemeteries excavated in the Jordan Valley. For instance, the LB cemetery at Tell es-Sa'idiyah contains 74 graves which date to the LB IIB to Iron IA (Green 2006:97). The site displays notable variation in burial patterns, even within the LB/Iron I burials, yet most individuals were interred singly rather than in communal tombs. Most (78%) of the individuals were interred in simple pit graves aligned W-E (heads at W) of which only six contained two individuals (Green 2006:97). On the other hand, 11% were double-pithoi burials and the remainder were subadult jar burials and cist tombs, which could contain single burials or several individuals in various states of articulation (Green 2006:48). Cist tombs were seemingly reserved for high-status individuals (Green 2006:98). This pattern is also observed at the early Iron Age cemetery of Tell Mazar, located between Tell es Sa'idiyah and Kataret es-Samra. Green (2006) notes that Mound A at Tell Mazar bears similarities to the LB to Iron Age cemetery at Tell es-Sa'idiyah.

The transition from mostly single burials in the LB to multiple internments in the Iron Age at Tell es-Sa'idiyah seems to support Bunimovitz's (1995:331) suggestion that the societal strain of the Egyptian empire ended the continued use of family tombs and ushered in an era of simpler single internments throughout the southern Levant (Green 2006:273). These single internments also revealed a strict social structure at Tell es-Sa'idiyah, with classes defined by access to prestige goods (Green 2006:282). These goods could include the more common toggle pins, wrappings, beads, and anklets, or more rare items such as bronze bowls, weapons, and imports. The cemetery at Sa'idiyah seemed to have allowed middle classes, "sub-elites," and elites be buried there, excluding an assumed lower class (Green 2006:282). Finally, burials featured a strong Egyptian influence with scarabs, Egyptian ceramics, seals, and potential attempted mummification with bitumen (Green 2006:279). However, Green (2013) interprets the toggle pins and beads discussed earlier as belonging to a non-Egyptian tradition, and their presence in Tell es-Sa'idiyah graves indicating a "de-Egyptianized" identity: An identity which is strictly not Egyptian and seems to resist the dominant Egyptian cultural force (Green 2013). Determining what the mixture of Egyptian and non-Egyptian artifacts means for the cultural identity of those buried at Tell es-Sa'idiyah is difficult. Complicated historical and Biblical sources point to a broad "Canaanite" identity (which could include Kataret es-Samra), though this is a "catch-all" term for the various tribes and identities which must have existed. Genetically, skeletons of the Bronze Age southern Levant are relatively homogenous, with this homogeneity continuing past the LB collapse event (Agranat-Tamir et al. 2020). Questions remain as to if Tell es-Sa'idiyah's cemetery includes Egyptian-Caananites, or Caananite-Egyptians (Green 2006:275), though it is likely they are locals experiencing elite emulation and

injection of Egyptian material culture into trade. These questions extend to Kataret es-Samra, whose tombs contain a similar mixture of foreign and domestic product.

**Published Osteological Findings from Tomb 2**

Chapter 1 of Leonard's *Kataret es-Samra, Jordan: The 1985 Excavation and Survey* details the loci and burials found in Tomb 2. A brief osteological description is provided.

Ward Briggs and Leonard (2017) describe 11 burials in Tomb 2 interred in four layers. These include: three young children (ages 2.5, 3, and 4), three adult males (ages 26, 29, and 32) and five adult females (ages 15-20, 20, 20, at least 20, and 33). Already this osteological report is problematic: Modern osteological techniques do not provide an exact age in years even with full, well preserved burials. How these exact ages were determined is not included in the report, and. ages should have included the range of error inherent in any age estimation technique (see *Bioarchaeological Methods*).

Pathological findings are brief and unsystematic. Ward Briggs and Leonard (2017) record four of the 11 individuals as demonstrating vertebral body degeneration in the form of vertebral lipping and porosity of the endplates. A description of which vertebrae are affected is absent for two of these individuals. One individual is recorded as having arthritic degeneration on the distal humerus. Three individuals are recorded as demonstrating dental caries, though the location and teeth affected are absent. One individual is recorded as having an abscess related to an advanced carious lesion. Two individuals are recorded as having shoveled incisors. Pathological data is entirely absent for three of the individuals. No photographs of pathologies are included.

Stick-figure sketches are included for all individuals, and more detailed top-view sketches included for 10 individuals. Four photographs of the excavation process are included.

As discussed above, the accuracy of the stick figure sketches is called into question as they represent 11 individuals, while 18 individuals were recorded at the time of excavation when the sketches should have been made. In sum, the osteological findings of Ward Briggs and Leonard (2017) constitute just five pages of the volume and are not systematically described.

**Bioarchaeology of the Late Bronze Age Southern Levant**

Bioarchaeological studies are limited for the LB southern Levant. This stems not only from a lack of excavation and publication of burial features, but also a lack of analysis and publication of the human skeletal remains recovered (Sheridan 2017). MEGAJordan, a publicly accessible database of archaeological sites in Jordan (http://www.megajordan.org/), identifies 84 sites from the LB with mortuary features that have been recorded. Of those 84, 30 have been excavated and of those 30, only three sites (Tell es-Sa'idiyah, Ya'amun, and Kataret es-Samra) include published bioanthropological analyses that are publicly accessible (al Rousan 2011; al-Shorman 2004; Leach and Rega 1996; Sandia and Müldner 2015; Wilson 2014). None of the published reports include data on the level of the 2019 Kataret es-Samra analysis that can be used for comparison. Unlike the more extensive work done on EB contexts, such as the systematic studies of the human remains from Bâb edh- Dhrâ (Gregoricka et al. 2020; Ortner and Frohlich 2007; Sheridan 2018), most of the studies of skeletal remains from LB contexts have specialized rather than general approaches. These analyses include stable carbon isotope analysis (al-Shorman 2004; Sandias and Müldner 2015) and investigation of dental microwear (al Rousan 2011) and enamel defects in canines (Wilson 2014) at LB Ya'amun, and analysis of dental crown morphology (Ullinger et al. 2005) and strontium, oxygen, and carbon isotope analysis (Gregoricka and Sheridan 2016) at LB and Iron Age Dothan. The studies at Ya'amun

have demonstrated that diet was more variable in the LB than the MB but still largely consisted

of terrestrial $C_3$ plants, particularly legumes, which may indicate a diet more resistant to climatic

fluctuations and with a greater array of nutritional sources (al Shorman 2004; al Rousan 2011;

Sandias and Müldner 2015). Additionally, those living at LB Ya'amun may have survived less

childhood stress episodes than those from Roman and Byzantine contexts in the region (Wilson

2014). The investigations of dental morphology and isotopes utilizing the LB remains from

Dothan focused on identifying population shifts between the LB and Iron Age in the southern

Levant. Ullinger and colleagues (2005) compared dental non-metric traits from this sample to

those from Iron Age IA Lachish and found little evidence for drastic genetic change over the

LB/Iron Age transition. This was confirmed by isotopic data that showed no isotopic differences

between LB and Early Iron age Dothan and thus no evidence for large-scale immigration during

this period (Gregoricka and Sheridan 2016). Leach and Rega (1996) published a brief

osteological report done in the field at areas BB and DD of Tell es-Sa'idiyah under the

impression that they were LB to Iron Age graves, though later reassessment indicates they are

likely Islamic/Ottoman era (Green 2006). Beyond these few dental and isotopic studies however,

little is known about the general physiological stress of those living in the LB in the southern

Levant, especially in relation to the Egyptian empire. The present study of Kataret es-Samra is

among the first of its kind to offer a full analysis of LB commingled mortuary features in the

region.


**Bioarchaeological Methods**

One of the difficulties in analyzing the assemblages from the LB southern Levant, not to

mention other periods from the region, is the fact that mortuary practices and other disturbance

resulted in commingling. The lack of distinct bodies hinders an integrated analysis about a single individual, and instead many variables need to be treated at the sample, rather than individual level. Methods for estimating the number of individuals in the sample generally involve estimating the minimum number of individuals, or MNI, that could be contained in the assemblage based on the highest element count. These calculations can be refined to take into consideration age, sex, or other characteristics of the bones. Additionally, the excavation and storage of the Kataret es-Samra remains presented a unique challenge. As noted above, Ward Briggs and Leonard (2017) report 11 individuals found within Tomb 2. This diverges from an original field designation of 18 burials in Tomb 2, as is evidence from original excavation records. Unfortunately, it is not clear what criteria were used by Ward Briggs to regroup the 18 "burials" into 11 individuals. The remains in 2019 were rediscovered in storage labeled and separated according to their field designations of 18 burials, not 11. Additional bags of mixed human remains were found unlabeled. These discrepancies meant the new analysis would treat the sample was if it was commingled, keeping the original burial designations in the inventory code for each element. Photographs of the excavation (Figure 2.5) reinforce this decision and suggest perhaps the remains should have been treated as commingled from the beginning.

Estimates of MNI using maximum likelihood (ML), such as the most likely number of individuals (MLNI) or Lincoln Index (LI), can ameliorate the inevitable undercounting that occurs in a raw MNI calculation (Adams and Konigsberg 2004). The MLNI method calculates the likely sample size based on the probability of element recovery and the number of pair-matches and un-matched paired bones that were recovered from a communal grave and applies this to the MNI to account for "ghost" individuals who may not be represented in the sample but likely were amongst the dead (Adams and Konigsberg 2004). However, this method requires

more complete elements than are present at Tombs 1 and 2, as the calculations are based on

numbers of left, right, and paired bones. In a fragmentary assemblage, it less clear if two

fragments of a left femur, for example, come from the same bone or two bones, and if those two

bones have matching pairs. Additionally, MLNI calculations require knowing the proportions of

left, right, and paired bones found in previous excavations of that type. Counts of this kind are

not available for fragmented commingled LB assemblages of the southern Levant. The LI

similarly bases a population estimation on maximum likelihood though incorporating the

probability that a proportion of the original population will not be recovered, though this has

been shown to inflate the MNI when recovery of remains is at or below 50% (Adams and

Konigsberg 2004). The taphonomic disturbance and fragmentary nature of the remains at Kataret

es-Samra means recovery is likely low. Other standard inventory methods, such as the *Standards*

*for Analysis of Human Skeletal Remains* (Buikstra and Ubelaker 1994) and the *Updated*

*Guidelines of the Standards for Recording Human Remains* (Mitchell and Brickley 2017),

include some means for recording commingled assemblages. However, these publications are

meant for analysis of single burials, and contain little information on methods of population

determination of commingled assemblages (Sussman 2017). They often rely on the counting of

whole elements, and separate pathological/age and sex information from element counting

(Sussman 2017).

  To address the lack of consistent, accurate methods in determining MNI, osteologists

have adopted methods drawn from zooarchaeology. "Zonation" divides fragmentary remains into

recognizable zones based on muscle attachments (Knüsel and Outram 2004). These zones are

then counted and nonrepeatable elements used to establish an MNI. This method has since been

refined utilizing muscle attachments and other recognizable features on bone fragments in a large

study on commingled and fragmented remains from Tell Abraq in the UAE and Sacred Ridge in Colorado (Osterholtz et al. 2013). In this system, the researcher is tasked with identifying recognizable features on the fragments, such as the upper orbital borders of the frontal bone or the medial malleolus of the tibia with the use of a visual recording method. These features are then counted like whole bones in a normal MNI calculation to arrive at a somewhat similar figure. Of course, this method does not prevent underestimation in poorly preserved assemblages that may be missing critical features. Even so, a comparative study of a traditional MNI calculation (White 1953), a zone-based system (Knüsel and Outram 2004), and a feature-based system (Lambacher et al. 2016) found the feature-based system to be the most accurate due to double-counting in the traditional and zonal methods (Lambacher et al 2016). A study on a commingled and fragmented skeletal assemblage from Petra, Jordan found similar results (Sussman 2017). However, knowing the accuracy of any technique requires a controlled study of a commingled, fragmentary assemblage from a known population.

Based on the above studies, the feature-based system was utilized to estimate the MNI of the Kataret es-Samra assemblage. This study utilized a modified form of Osterholtz's recording system using FileMaker 14.0 (see Osterholtz 2019) that records fragmentary bone as well as the age and sex estimations of appropriate fragments, relevant metric information, data on skeletal lesions, taphonomic observations, burial number/context, and photographs.

As noted above, refining an MNI estimation requires assessing the sex and age of individuals in the assemblage. In addition, this can provide important information on the paleodemography of a mortuary context. Sex estimation in adults relies on identifying the sexually dimorphic morphologies and measurements in humans. The *Standards* volume by Buikstra and Ubelaker (1994) provides a visual scoring system based on five points on the skull:

The supraorbital ridges, the mastoid processes, the nuchal crest, the mental eminence, and the supraorbital margins. Since many sexually dimorphic features can overlap in presentation, the morphology of these locations is scored on a five-point scale from more female (1) to more male (5) expressions. The morphology of the human pelvis is more sexually dimorphic than the skull, and *Standards* provides scoring criteria of the ventral arc, subpubic concavity, and ischiopubic ramus ridge along with the greater sciatic notch and preauricular sulcus of the ilium (Buikstra and Ubelaker 1994). Non-metric traits exhibiting sexual dimorphism are highly genetically related and thus can be population specific (Buikstra and Ubelaker 1994). Like non-metric traits, sexually dimorphic metric variables also have been affected by genetic and environmental factors that have resulted in variable degrees of dimorphism in different populations (Charisi et al. 2011; Safont et al. 2000). Therefore, the use of sexually dimorphic metric traits in ancient populations should rely on a population-specific reference study that most closely matches the geographic and genetic descendants of the ancient population. The results found using those population-specific studies are then only applicable within the target population. Population-specific studies which are wide in scope or involve nearby populations, rather than the population in question, are less accurate. It is obviously impossible to study the metric traits of bones versus living individuals in ancient populations, so a closest approximation must be made. While the fragmentary nature of the Kataret es-Samra assemblage meant many critical measurements for this method could not be taken, a few measurements such as maximum diameter of the femoral head and distal epicondylar breadth in humerii were successful and critical to the MNI. These measurements were then compared to studies which best match the genetic and geographic origin of the individuals at Kataret es-Samra, such as Charisi et al.'s (2011) study on sexual dimorphism in the humeral epicondylar breadth and Papaloucas et al.'s

(2008) study on sexual dimorphism of the femur head and acetabular breadth in modern Greek samples.

Age estimation from skeletal remains is normally completed via macroscopic observation of either the dental development of subadults, growth and fusion of bones through childhood, or the degeneration of key joints in adulthood. Dental development is largely regarded as the most accurate method of aging children and young adults (Ubelaker 1989a). The development of deciduous teeth in the alveolar bone of infants and the rate at which adult teeth grow and replace those deciduous teeth is a highly canalized trait in human evolution and can be used to age a child to within two months in some cases (Ubelaker 1989a). Age estimation of children and adolescents can also rely on formation and fusion of primary and secondary ossification centers during growth and development (Brothwell 1981; Krogman and Iscan 1986; McKern and Stewart 1957; Redfield 1970; Steele and Bramblett 1988; Suchey et al. 1984; Ubelaker 1989a, 1989b). The order in which bones fuse at certain ages is generally similar in the growth of all humans, though females tend to undergo these processes before males, and it can be affected by nutritional deficiencies, disease, or other environmental factors and is therefore less accurate than dentition. Charts detailing the order and length of time of ossification center fusion have been documented (Krogman and Iscan 1986; McKern and Stewart 1957; Redfield 1970; Suchey et al. 1984; Ubelaker 1989a, 1989b; Scheuer and Black 2004). The measurement of long bones in young subadults has shown to be accurate in age estimation, though this method becomes less accurate with age as environmental and population-specific factors begin to affect bone growth (Fazekas and Kosa 1978).

Age estimation of adults is significantly less accurate than for non-adults because it relies on the degeneration of bone over time, a process that varies due to an individual's sex, behavior,

disease, nutrition, genetics, or other factors. One of the standard locations for measurable degeneration occurs at the pubic symphysis of the pelvis. Todd (1921a, 1921b) established early protocols for aging the pubic symphysis based on a ten-phase system later modified by McKern and Stewart (1957). Suchey-Brooks (1990) recalibrated the original ten stages into six and included confidence intervals of age with each phase. The auricular surface of the pelvis, which tends to preserve better than the public symphysis, also predictably degenerates with age, which Lovejoy and colleagues (1985) broke down into eight phases.

Bioarchaeological analysis also can identify skeletal responses to stress to reveal impacts on an individual's environment or growth history. While some bioarchaeologists utilize investigations of stress as a means for understanding population health, "health" should be conceived of as a larger and more subjective status than can be revealed through stress indicators in the skeleton (Klaus 2014; Wood et al 1992). The concept of "stress" should be limited to periods when the body is undergoing insufficiencies in diet, disease, violence, or any conditions that prevent normal physiological functioning (Klaus 2014). The gap between "health" and "stress" exists largely because of the subjective nature of one's health. Disease, degeneration, poor diet, or any variety of stress markers endemic in a society may seem unhealthy to researchers, yet an individual of the society may not perceive themselves as such (Klaus 2014). Additionally, "unhealthy" individuals may die without skeletal lesions, marking them as skeletally "healthy" (Wood et al. 1992). Compounding this is that a population likely includes individuals at risk for death (hidden heterogeneity) but identifying subsets of these individuals in a skeletal sample is difficult. Analysis of skeletal remains to understand population health is also confounded by the assumption that populations are stationary and not experiencing any growth or decline – both factors that can impact the mortality profile (Wood et al. 1992). Additional

factors mentioned in Wood et al.'s article on this "osteological paradox" include the fact that mortality of a population is a dynamic value, while a single burial gives only a static image of that mortality (Wood et al. 1992). Perhaps the biggest issue Wood et al. highlight is the most obvious factor of all – the individuals included in cemetery studies are dead. The living individuals who might have survived stress factors may not be included in the study or may be included as older individuals who were not susceptible to those stress factors, when in fact they were (Wood et al. 1992).

The exploration of stress within the Kataret es-Samra samples focused on skeletal pathologies evident by the abnormal addition or loss of bone, some of which represent periods when the body is undergoing stress. Bony indicators of stress take four main forms: non-specific indicators of stress, evidence for specific diseases, indicators of oral health, and observations of trauma and joint degeneration.

Non-specific indicators of stress cannot be linked to a specific affliction and include linear enamel hypoplasias (LEH), porotic hyperostosis, cribra orbitalia, and periostitis. LEH are horizontal defects in the enamel typically seen in polar or anterior teeth that can result from nutritional deficiency, infection, trauma, or even psychological stress in childhood during enamel formation (Rose et al. 1985). The canalized formation of dental enamel means that the age at which the deficiency occurred can be found with some accuracy based on the line's distance from the cemento-enamel junction (CEJ) (Goodman and Armelagos 1985).

Two other often interlinked non-specific indicators of stress include porotic hyperostosis, which appears in the parietals and occipitals of the cranium, and cribra orbitalia, which occurs in the upper portion of the internal eye orbits. Porotic hyperostosis presents as increasing expansion of the internal diploe of the cranial table and resulting resorption of the outer table of the skull in

the posterior cranium, i.e., the parietal and occipital bones. Cribra orbitalia is indicated by porosity within the upper internal portion of the eye orbits that also results from diploic expansion and cortical resorption. Porotic hyperostosis and cribra orbitalia have traditionally been linked to iron-deficiency anemia, and the expansion of hemopoietic trabecular tissue in response to the body's need to produce more red-blood cells (Stuart Macadam 1985). This anemia was thought to have a synergistic effect with nutrition and infection, and thus evidence for porotic hyperostosis and cribra orbitalia were secondary indicators of these conditions (Kent 1987; Palkovich 1987; Walker 1986). The fact that these areas are the primary producers of red blood cell production in childhood meant these conditions generally are not seen in adults except in a healing or healed form (Brickley 2018). However, further research has indicated that anemia caused by conditions other than iron deficiency, such as hemolytic or megaloblastic anemias, are more strongly linked to the manner of diploic expansion seen in the parietals and occipitals consistent with porotic hyperostosis (Walker et al. 2009). In addition, cribra orbitalia seems to be caused by a different suite of conditions, such as anemia from chronic disease, renal failure, protein deficiency, and endocrine disorders (Rivera and Lahr 2017; see also Miller 2018). Thus, porotic hyperostosis and cribra orbitalia observed in the Kataret es-Samra assemblage will serve as indicators of non-specific anemic conditions that may be interlinked with disease and nutrition in the Kataret es-Samra community.

Periostitis (or periostosis) results from general inflammation of or damage to the periosteum (a tough outer membrane of bone) that results in formation of additional bone with a woven appearance on top of the outer bone cortex (Weston 2008).  Its appearance has traditionally been linked to either localized or systemic bacterial infection, likely due to *Staphylococcus* or *Streptococcus* bacteria (Goodman and Martin 2002). Since these chronic

infections have a synergistic relationship with nutrition and diet (Goodman and Martin 2002), they often are classified as "non-specific." Infection of the bone itself through transportation of pathogens into bone via the bloodstream or nearby infected tissue results in osteitis. As the body responds, inflammation triggers rapid bone growth on the periosteal surface, appearing as inorganized porous bone (Roberts 2019). In advanced cases, cloacae (sinus tracks) may appear. These smooth-walled channels indicate advanced infection deep in the bone and may drain pus outside the body from necrotic interior tissue. Similarly, osteomyelitis begins as an infection of the bone marrow, and moves to the cortical bone, which can result in necrosis of the original bone (sequestrum) and development of an involucrum around the sequestrum that can initiate bone repair.

Specific diseases may be identified by the pattern, distribution, and nature of bone lesions. For instance, advanced treponemal infections manifest in the skull with abnormal bone loss on the outer table of frontal and parietal bones and osteosis of the tibiae (Roberts and Buikstra 2019). Leprosy may destroy bone structures of the distal limbs and nasal cavity (Roberts 2011). Other specific indicators include the vertebral body degeneration associated with advanced tuberculosis and related lower respiratory infections (Roberts 2011) and the fine, cortical porosity of the cranium argued to be linked with scurvy and other conditions (Snoddy et al 2018). However, many of the indicators of these diseases are still non-specific in nature, so additional factors must be considered before diagnosis. Ancient geographic limits of the diseases, demographic consideration of affected sexes and ages, and behavioral patterns which could protect individuals from contracting the disease must all be considered, if possible.

Oral pathologies such as dental caries, dental calculus, abscesses, and antemortem tooth loss (AMTL) are among the most common pathologies noted in archaeological assemblages. The

most prevalent of these is dental caries (Hillson 2008). Dental carious lesions are pockets of enamel degeneration caused by the buildup of organic acid-producing bacteria in plaque (Hillson 2008). Fermentation of carbohydrates into acidic fluid lowers the pH of the local saliva, demineralizing enamel (Hillson 2008). Therefore, diets high in carbohydrates have been shown to cause a higher occurrence of dental carious lesions (Larson 2015). Dental caries plays a large role in tracking the transition from hunting/gathering to agriculture in many parts of the world, appearing more frequently as diets become richer in carbohydrates (Temple 2016). However, a diet high in carbohydrates is not the only risk factor. The nature of the tooth surface, either being smooth, grooved, or worn, influences the ability of plaque, and the bacteria below it, to adhere to the tooth (Hillson 2008). A diet of abrasive foods can inhibit plaque growth on the tooth itself. The specific bacterial colonies present in an individual's mouth can also influence dental carious lesions. Low pH producing bacteria are found most often in the mouths of patients with high levels of dental caries (Hillson 2008). Sex differences in lesion formation resulting in higher instances in females has been noted (Lukacs and Largaespada 2006). Studies suggest fluctuations in hormones during puberty, menstruation, and pregnancy affect saliva levels in the mouth, and lead to higher instances of dental carious lesions in women (Lukacs and Largaespada 2006). Exposure of the tooth pulp chamber through dental attrition, fracture, or carious lesion development can lead to infection and development of an abscess in the alveolar bone. These infections, if left long enough, can cause blood poisoning and potentially death. Antemortem tooth loss (ATML) often results from these infections, either by accidental loss of the tooth or purposeful removal of the infected tooth, though ATML has shown to be caused by trauma and should not be taken alone as a sign of poor dental health (Lukacs 2007).

Dental calculus is the crystallization of dental plaque biofilms on teeth (Little et al. 1963). Etiologies for calculus have traditionally surrounded dietary factors, particularly protein consumption (Lieverse 1999). However, like many of the pathologies listed above, the causes of calculus are likely more complex. The formation of mineralized calculus beneath unmineralized plaque is strongly linked to bacterial mineralization (Lieverse 1999), thus variable microbial fauna in each individual result in varying development of calculus. Tooth position, with posterior teeth generally more affected, is also a factor, along with the abrasiveness of the diet. Calculus is also useful for reconstructing ancient diets with both macro and microscopic food particles found in the calculus matrix (Lieverse 1999). Taphonomy of the teeth is a major factor in the preservation of calculus. Poor preservation of the Kataret es-Samra assemblage likely led to a loss of dental calculus along with loss of enamel on many posterior teeth. Therefore, the 2019 analysis only records frequency of calculus and relative intensity on a four-point scale of "absent" to "large amount" as is recommended in *Standards* (Buikstra and Ubelaker 1994), instead of a more robust locational recording and collection methodology.

Finally, trauma and joint degeneration were observed in the Kataret es-Samra assemblage. Arthritis is the breakdown of the cartilaginous surface in diarthrodial joints and subsequent growth of bony spurs into the joint due to biomechanical strain, injury, genetics, age, and other factors (Weiss 2017). While researchers often suggest that osteoarthritis can reflect repetitive activities, primarily in semi-professional or professional athletes (Weiss and Jurmain 2007), evidence from skeletal analysis of individuals of known occupations found issues with a strict behavioral interpretation of arthritis (Adams and Reeve 1987). For instance, analysis of individuals who were buried in the Christ Church crypt in Spitalfields found no relationship to arthritis in the hand and wrist with work in the textile industry (Adams and Reeve 1987).

Osteoarthritis at Kataret es-Samra was recorded, but only to identify unexpected patterns rather than to make broad interpretations regarding activity and workload.

Vertebral body degeneration (VBD), which appears as lipping or spicule-like bone formation along the edges of the vertebral body, results from the breakdown of the interosseus discs between vertebrae. Progression of this degeneration can eventually result in fusion of the vertebral bodies. While some clinical studies have linked VBD to repetitive physical behavior and heavy-load strains on the back (see Kurowski and Kubo 1986), it also is a function of simply walking bipedally (Knüsel et al. 1997) and has as complex an origin as osteoarthritis. Schmorl's nodes, resorptions of bone on the upper or lower surface of the vertebral body due to rupture of intervertebral disc fibrocartilage and extrusion of the nucleous pulposis, are another indicator of vertebral biomechanical strain. Even these have a complex etiology, however, and their frequency has been linked to vertebral body shape (Plomp et al 2015). This would suggest that, while extremely heavy loads may cause traumatic injury to the back, VBD is an affliction with complex etiologies in heredity and nutrition. Like osteoarthritis, observing these variables at Kataret es-Samra seeks to identify unexpected patterns or predisposition to the degeneration based on heredity and nutrition.

Trauma's long history in bioarchaeology has provided researchers with the ability to reconstruct past behaviors, both incidental and antagonistic in nature (Walker 2001). Trauma, at its basic level, is a person's interaction with their environment which leaves their body harmed. The interpretation of trauma as either incidental, interpersonal, or a combination of both is highly culturally specific and difficult to ascertain (Walker 2001). Definitions of violence in the ancient world have been heavily biased by Western perspectives but should remain culturally specific (Martin and Harrod 2015). Incidental trauma may also be difficult to distinguish from intentional

violence, especially concerning ritual violence (Martin and Harrod 2015). Basic recording of traumatic lesions classifies them into three categories: antemortem, perimortem, and postmortem. Antemortem trauma refers to non-fatal trauma incurred while living. It is often observed due to the process of healing, which can include calluses of new bone as well as remodeling around the injury (Walker 2001). Perimortem trauma describes injury occurring at or near death. These injuries are significant in that they may have led to a person's death or reflect treatment of the body soon after. Postmortem trauma often appears as taphonomic changes well after death, though can result from postmortem treatment of the body or later manipulation of the burial. It is critical that the osteologist recognize differences between perimortem trauma and postmortem, and even more importantly recognize the impact of excavation on bones themselves. Incidental scratches and breaks are common among skeletal excavations and must be recognized as completely unrelated to pathology or taphonomy. Recording of trauma following Buikstra and Ubelaker (1994) separates injuries into either fractures or dislocations, with fractures containing subcategories for location, type, characteristics, and levels of healing. Dislocations are recorded by cause, if known. The highly fragmented nature of the Kataret es-Samra remains means traumatic fractures were difficult to locate. Additionally, the commingled nature of the remains prevents linking injuries which may belong to a single person as coming from a single event, potentially overstating the impact of trauma on the Kataret es-Samra community.

Bioarchaeological analysis has provided a novel perspective on the lives of the Kataret es-Samra individuals in the face of both a rapidly changing cultural landscape, and an isolation from nearby cultural centers controlled by an imperial force. Archaeological data from the Transjordan region has been admittedly lacking (Leonard, Bürge, and Fischer 2017:125), and

bioarchaeological data nearly non-existent. The techniques used to analyze the Kataret es-Samra skeletal assemblage have revealed truths about their lives, diets, and deaths, yet much more remains to be discovered in the dental samples taken from the assemblage.

# CHAPTER THREE:

## METHODS

The human skeletal remains from Kataret es-Samra Tombs 1 and 2 were held at the American Center of Oriental Research in Amman, Jordan as of May 2020, with plans to move them to the Department of Antiquities storage facility in Zarqa. Only Tomb 2 had been previously analyzed, and a descriptive report published by Ward Briggs and Leonard (2017). During this analysis, an unknown sample of teeth were removed and shipped to the US for further study, and they were unable to be recovered for this analysis. During excavation, each suspected burial was provided a numerical designation. However, during the preliminary analysis the skeletal remains were given new burial numbers based on the field designation as well as laboratory assessment. As discovered in 2019, the remains from Tomb 2 had been re-bagged in the original field designations, making it difficult to reconstruct the laboratory-assigned burial numbers. Since Tomb 1 was largely commingled, skeletal samples from both tombs were analyzed as commingled assemblages, with the accession number for each fragment containing the original field context information, which in the case of Tomb 2 included the field-ascribed burial number. This way, if notes detailing the recombination of the 18 field designations into the 11 published burials are located, a full analysis of individual burials can take place.

The skeletal remains were inventoried and data stored using a feature-based method based on one developed by Osterholtz (2019) in FileMaker 14.0. Each commingled fragment was given a unique accession number containing the site designation (KS), year of excavation, field number, tomb number, locus, pottery bucket number, material culture number, field burial designation (if present) and letter of fragment.

**Bioarchaeological Methods**

Age and sex were estimated for fragments with diagnostic metric or morphological features. Age estimations of adults in the sample relied on observations of pubic symphyses following Suchey and Brooks (1990) that scores the pubic symphysis based on breakdown of the subchondral surface with age. Auricular surface morphology in the pelvis was also used for adult age estimation following Lovejoy et al. (1985) and Meindl and Lovejoy (1989). Age estimation of subadults relied on measurement of long bone length in children based on Scheuer and Black (2004), dental eruption and formation where possible following Moorrees et al. (1963a, 1963b), and the union of primary centers of ossification and secondary epiphyseal growth plates following Scheuer and Black (2004), McKern and Stewart (1957), Redfield (1970), Suchey et al. (1984), and Ubelaker (1989a; 1989b). Sex estimations of adults was based on observations of cranial indicators included in *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994) which follows Acsadi and Nemeskeri (1970), and pelvic morphology (Buikstra and Mielke 1985; Phenice 1969) also included in *Standards* (Buikstra and Ubelaker 1994). If possible, stature was estimated through long bone measurements following Buikstra and Ubelaker (1994) and the formulae provided by Trotter (1970). Sex estimations of the distal humerus and femoral head were critical to establishing MNI and were based on sexually dimorphic measurements of the distal humerus of modern Greek populations following Charisi et al. (2010) and the femoral head diameter of modern Greek populations following Papaloucas et al. (2008).

The skeletal remains were observed for evidence of porotic hyperostosis and cribra orbitalia via macroscopic methods including use of a 10X magnifying loupe on the outer tables

of the occipital, parietal and frontal bones, as well as the all orbital roofs in the sample.

Recording was based on the skeletal pathology coding system located in Table 6 of *Standards*

(Buikstra and Ubelaker 1994), which includes codes for presence/absence, healed versus active

lesions, and severity on a four-point scale. Signs of infection including periostitis, cloacae, and

stellate lesions were observed via macroscopic observation, and noted both in location and

severity based on the coding system found in *Standards*. Osteoarthritis and degenerative disease,

including vertebral degeneration, were observed macroscopically and scored on scales of both

severity and percentage of joint surface covered, again from the skeletal pathology coding

system in *Standards*. Dental caries was recorded via macroscopic inspection using an eight-point

scale of both severity and location following Moore and Corbett (1971). Dental calculus was

observed macroscopically and recorded on a three-point severity scale after Brothwell (1981).

Linear enamel hypoplasias (LEH) and other enamel defects were observed macroscopically and

recorded with an eight-point code of both location and type of defect from Buikstra and Ubelaker

(1994). Estimation of the age that dental enamel defects occurred was based on the decile system

developed by Reid and Dean (2006). Trauma again followed the skeletal pathology coding

system in *Standards*, which includes several scales and codes for various traumas and their

severity. Any other unexpected or unknown pathologies were noted and recorded. Diagnosis and

recording followed Buikstra (2019), Larson (2015), and *Standards.* Pathologies were

photographed for later analysis and documentation.

      Minimum Number of Individuals (MNI) of each tomb was calculated based on the

highest count of specific skeletal features in the assemblage, taking into consideration age, sex,

and context. A SAS program was utilized to sort the exported FileMaker data by maximum

number of identical bone landmarks, considering factors of age, side, and sex. Tomb 1 and Tomb 2 were analyzed separately.

Calculations of skeletal lesion frequencies were based on the number of bone fragments displaying the lesions out of all bone fragments in a relevant category, and all were calculated separately for each tomb. For example, as porotic hyperostosis and cribra orbitalia only impact certain locations of specific cranial bones, frequencies were calculated out of the total number of occipital, parietal, and frontal fragments in the case of porotic hyperostosis, and total number of orbital roofs present for cribra orbitalia. Osteoarthritis frequencies were broken down by joint, with frequencies being calculated based on the number of articular surfaces related to a joint with arthritis versus all articular surfaces related to a joint in the sample (see Table 3.1). Vertebral osteophytosis frequencies were calculated by vertebra type (cervical, thoracic, lumbar, or sacral). Dental pathologies were calculated based on the number of teeth present in each tomb.

*Table 3.1: Articular surfaces in each joint group*

| Joint | Articular Surfaces Observed |
|-------|------------------------------|
| Hand | Proximal metacarpals |
| | Distal metacarpals |
| | Proximal and distal ends of phalanges |
| Wrist | Carpals |
| | Distal radius |
| | Distal ulna |
| Elbow | Proximal radius |
| | Proximal ulna |
| | Distal humerus |

| Shoulder | Proximal humerus |
|---|---|
| | Acromion process |
| | Lateral portion of clavicle |
| | Glenoid fossa |
| | Coronoid process |
| Hip | Femur head |
| | Acetabulum |
| Knee | Patella |
| | Distal anterior  femur |
| | Proximal surface of tibia |
| Ankle | Distal  fibula |
| | Distal  tibia |
| | Medial malleolus |
| | Trochlea of talus |
| Foot | Tarsals |
| | Proximal metatarsals |
| | Distal metatarsals |
| | Foot phalanges |

After analysis was completed, the remains were prepared for long term storage with the Department of Antiquities in Amman, except for 45 1st and 2nd molars of adults and subadults as well as 4 subadult canines that were exported East Carolina University's Bioarchaeology Laboratory for future isotopic analysis. In preparation for curation in Amman, the older paper

and twine tags were replaced with new cardstock and wire tags. Additionally, the tagging system was standardized to include all relevant information in the same location on each tag. The remains themselves were wrapped individually in acid-free unbuffered tissue paper for protection and secured in plastic bags with the tags attached. These bags were then transferred to rigid plastic storage bins, which were marked from the interior with computer-typed tags indicating the site, tomb number, year of excavation and burials from the original burial designations included inside.

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**CHAPTER FOUR:**

**RESULTS**

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**Minimum Number of Individuals**

The entire Kataret es-Samra sample included 379 bone fragments from Tomb 1 and 4,105 fragments from Tomb 2, as well as 25 teeth from Tomb 1 and 94 teeth from Tomb 2. Inventory of the Tomb 1 remains identified an MNI of 8 individuals: 3 females (one of which is 50+ years), 2 males, 1 adult of indeterminate sex, 1 adolescent, and 1 young child of indeterminate age (Table 4.1). The MNI for Tomb 2 was slightly less than proposed by Ward-Briggs and Leonard (2017), with the assemblage only representing at least 8 individuals including 2 young children (one 2-2.5 years, one 3-4 years), 1 adolescent (14-18 years), 3 young females, 1 adult male (35-44 years), and 1 adult of indeterminate sex (35-39 years). The adult MNI of five was indicated by counts of several features of the cranium, the humerus, femur, tibia, patella, pelvis, and clavicle (Table 4.2).

*Table 4.1: Skeletal features with key demographic information for MNI estimation from Tomb 1*

| Diagnostic Feature | Males | Females | Adults of indeterminate sex | Subadults |
|---|---|---|---|---|
| Mastoid process | | 4 | 1 | |
| Glabella | 1 | | | |
| Pelvis | | 1 (50+ years) | | |
| Humerus epicondyle (biepicondylar breadth) | 3 | 1 | 1 | |
| Clavicle medial end | | | 1 young adult < 30 years (partially fused epiphysis) | |
| Distal radius | | | | 1 (16-22) years, partially fused epiphysis) |
| Tibia | | | | 1 (Young child, unable to measure) |

*Table 4.2: Skeletal features with key demographic information for MNI estimation from Tomb 2*

| Diagnostic Feature | Males | Females | Adults of indeterminate sex | Subadults |
|---|---|---|---|---|
| Dental development | | | | 2 (2-2.5 years, 3-4 years) |
| Femoral head - partially fused | | | | 1 (15-20 years) |
| Vertebral body epiphyses - partially fused | | | | 18 thoracic fragments (8 to 28 years) |
| R adult clavicle medial epicondyle - unfused | | | 4 (16-30 years) | |
| L pubic symphysis | 1 (35-44 years) | | 1 (adult of indeterminate age) | 1 (15-24 years) |
| R pubic symphysis | | | 2 (35-39 years, adult of indeterminate age) | 1 (15-24 years) |
| R auricular surface of ilium | | | 2 (25-29 years, adult of indeterminate age) | |
| L temporal mastoid | 1 | 3 | | |
| R temporal mastoid | | 4 | 1 | |

**Porotic Hyperostosis/Cribra Orbitalia**

One left parietal fragment out of 10 total parietal fragments (10%) and none out of seven

occipital fragments (0%) showed healing porotic hyperostosis in the Tomb 1 sample. Porotic

hyperostosis in Tomb 2 was only seen in one parietal bone fragment (Figure 4.1) out of 731

parietal fragments (0.2%) and, zero of 10 occipital fragments (0%). The one parietal fragment

exhibiting porotic hyperostosis was from an adult and healed. Porosity was observed on one

subadult frontal fragment and is potentially healed porotic hyperostosis (Figure 4.2). A closer

examination of the bone's cross-section could confirm this. In Tomb 1, no orbital roof fragments

demonstrated cribra orbitalia out of a total of four fragments (0%) in the sample (Table 4.3). In

Tomb 2, four out of 15 total orbital roofs in the sample displayed lesions consistent with cribra orbitalia (Figure 4.3), two subadult displaying healed lesions and two adults displaying healed lesions (27%) (Table 4.3).

*Table 4.3: Porotic Hyperostosis and Cribra Orbitalia at Kataret es-Samra*

| Bone | Tomb 1 | | | | Tomb 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Porotic Hyperostosis | | Cribra Orbitalia | | Porotic Hyperostosis | | Cribra Orbitalia | |
| | N | % | N | % | N | % | N | % |
| Parietal | 10 | 10% | 0 | -- | 731 | 0.2% | 0 | -- |
| Occipital | 7 | 0% | 0 | -- | 10 | 0% | 0 | -- |
| Orbital roof | 0 | -- | 4 | 0% | 0 | -- | 15 | 27% |



*Fig. 4.1: Healed porotic hyperostosis on an adult parietal fragment from Tomb 2. Accession No. KS85.III.2.113.39.50.9.e*

*Fig. 4.2: Porosity on a subadult parietal fragment from Tomb 2. Accession No.
KS85.III.2.113.37.43.12.g*

*Fig. 4.3: Healed cribra orbitalia on a left subadult orbit from Tomb 2. Accession No. KS85.III.2.113.37.43.12.e*

**Periostitis or Osteomyelitis**

Only two examples of a bony response to inflammation or infection were seen in Tomb 1 out of 379 fragments bone (0.5%). This involved an L5 and an S1 that, based on their articulation, came from the same individual. The inferior endplate of L5 and the superior of the S1 displayed circular lytic lesions surrounded by sclerotic bone (Figures 4.4 and 4.5). The infection or inflammation seen in the endplates is not associated with a bony response in the other preserved portions of the L5 and sacrum, although only part of the S1 and one sacral ala remained of the sacrum and part of the right body and neural arch were missing from the L5. Thus, this reaction is not associated with development of an epidural or paravertebral abscess or a reaction at the main nutrient foramina on the sides of the vertebral body. While these endplate lesions could be classified as an atypical Schmorl's node (Samartzis et al. 2016) or another manifestation of intervertebral disc inflammation or degeneration (e.g., those identified as Modic changes), it might be a case of pyogenic vertebral infection (Hadjipavlou et al. 2000), sometimes referred to as vertebral osteomyelitis (Lehovsky 1999; Mylona et al. 2009), or spontaneous or infectious spondylitis or spondylodiscitis (Cottle and Riordan 2008; Honan et al. 1996; Landi et al. 2017; Skaf et al. 2010; Varma et al. 2001). Radiographic imaging of these elements is necessary for a true differential diagnosis.

*Fig. 4.4: L5 with lytic lesions and some sclerotic bone formation due to inflammation or infection, articulates with sacrum in fig. 4.5, Tomb 1. Accession No. KS78.II.1.1022.a*
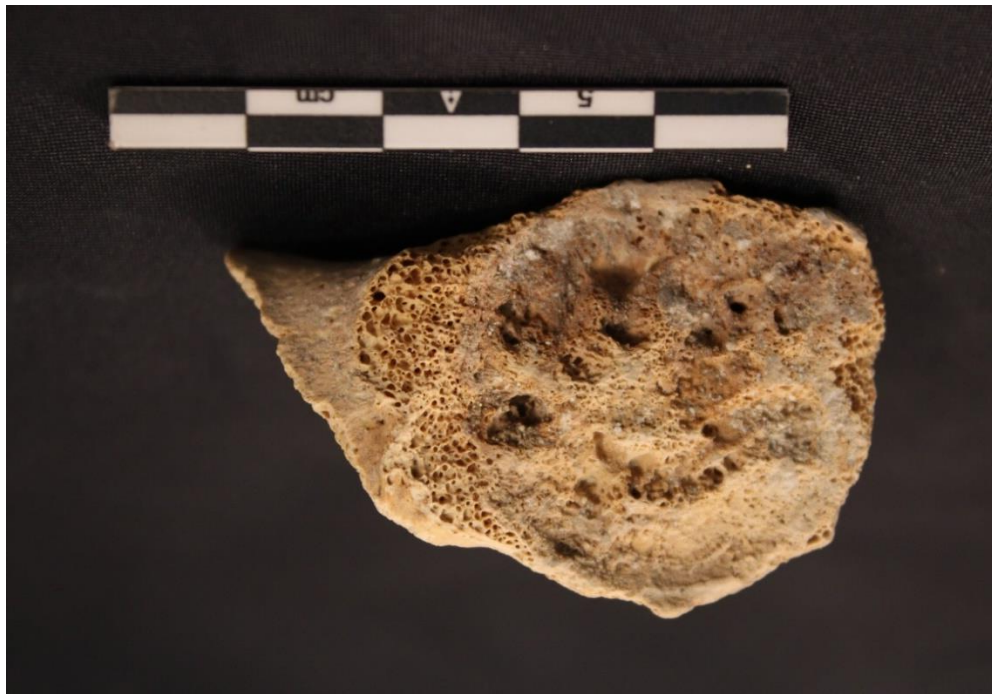


*Fig. 4.5: Sacral promontory from Tomb 1 (anterior facing toward the top) displaying lytic lesions and some sclerotic bone formation due to inflammation or infection. Articulates with L5 from fig 4.4. Accession No. KS78.II.1.1022.b*

Only one fragment of an adult tibia showed an active periosteal reaction in Tomb 2 out of a total of 4,105 fragments bone in the tomb (0.02%) (Table 4.4)

*Table 4.4: Periostitis or Osteomyelitis at Kataret es-Samra*

| Bone | Tomb 1 | | Tomb 2 | |
|------|--------|---|--------|---|
|      | N      | % | N      | % |
| All bone | 379 | 0.5% | 4,105 | 0.02% |

**Osteoarthritis**

As seen in Table 4.5, arthritic lesions only appeared in one bone from the right wrist group in Tomb 1, although many of the joints in the lower limb are not well represented in this sample. No arthritis was observed in the synovial joints of the vertebral column. In Tomb 2, very few bones from the foot, wrist, knee, elbow (Figure 4.6) and hip joint groups displayed arthritic lesions of varying degree. Again, no arthritis was observed in the synovial joints of the vertebral column.

*Table 4.5: Rates of arthritis in diarthrodial joints at Kataret es-Samra by joint*

| Joint | Tomb 1 | | | | | | Tomb 2 | | | | | |
|-------|--------|---|-------|---|-------|---|--------|---|-------|---|-------|---|
|       | Left   |   | Right |   | Total |   | Left   |   | Right |   | Total |   |
|       | N      | % | N     | % | N     | % | N      | % | N     | % | N     | % |
| Wrist | 8 | 0% | 6 | 17% | 14 | 17% | 39 | 3% | 41 | 0% | 82 | 1% |
| Hand | 1 | 0% | 2 | 0% | 32 | 0% | 2 | 0% | 2 | 0% | 12 | 0% |
| Elbow | 6 | 0% | 6 | 0% | 13 | 0% | 16 | 0% | 22 | 6% | 39 | 3% |
| Shoulder | 15 | 0% | 12 | 0% | 39 | 0% | 30 | 0% | 24 | 0% | 59 | 0% |
| Hip | 3 | 0% | 1 | 0% | 11 | 0% | 13 | 0% | 13 | 15% | 18 | 11% |
| Knee | 2 | 0% | 6 | 0% | 8 | 0% | 24 | 4% | 26 | 4% | 68 | 3% |
| Ankle | 0 | 0% | 0 | 0% | 0 | 0% | 10 | 0% | 12 | 0% | 24 | 0% |
| Foot | 1 | 0% | 0 | 0% | 1 | 0% | 28 | 0% | 18 | 0% | 90 | 1% |
| Cervical vertebrae synovial joints | 7 | 0% | 7 | 0% | 14 | 0% | 11 | 0% | 9 | 0% | 20 | 0% |
| Thoracic vertebrae synovial joints | 4 | 0% | 9 | 0% | 13 | 0% | 3 | 0% | 6 | 0% | 9 | 0% |

| Lumbar vertebrae synovial joints | 0 | 0% | 1 | 0% | 1 | 0% | 5 | 0% | 5 | 0% | 10 | 0% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
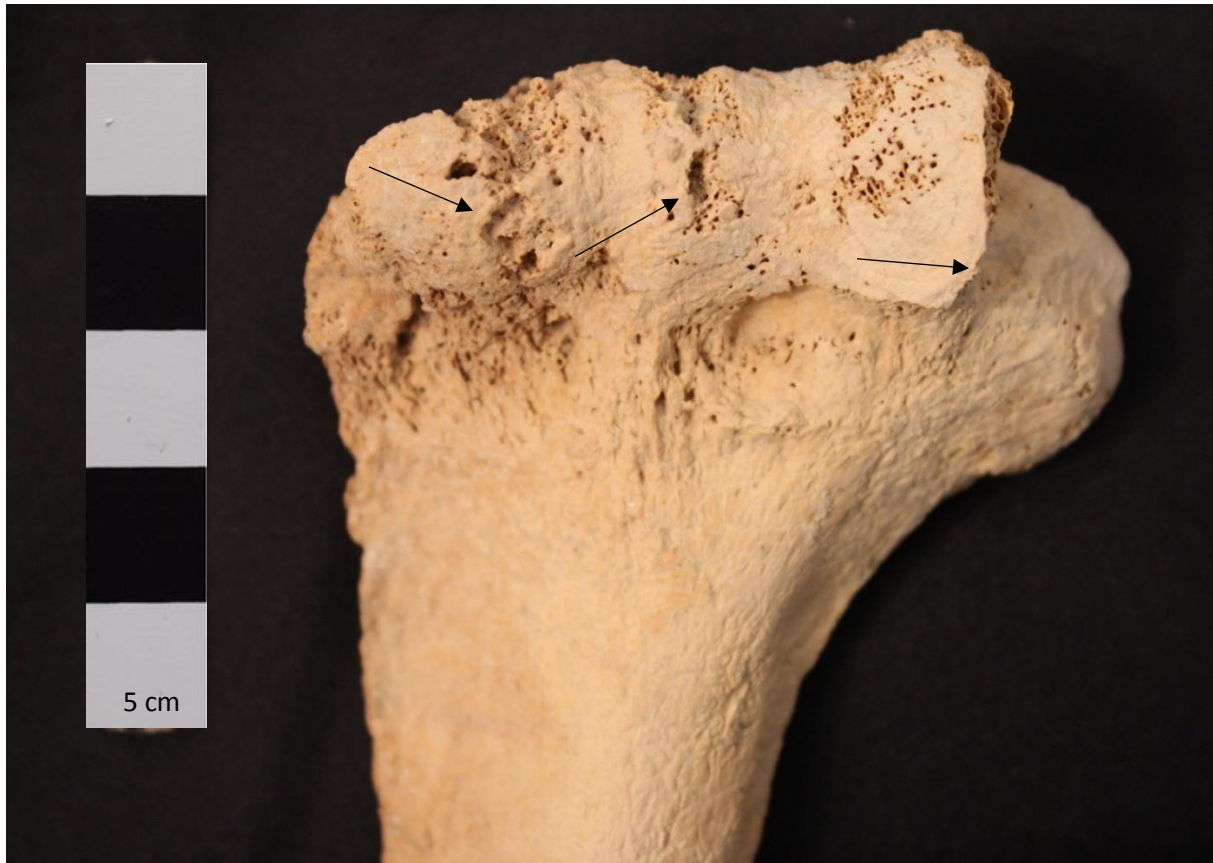


*Fig. 4.6: Osteoarthritis and destruction of the subchondral surface on a right humerus from Tomb 2. Accession No. KS85.III.2.113.37.40.5.e*

**Vertebral Body Degeneration**

Vertebral body degeneration (VBD) was calculated by comparing the number of affected vertebral bodies versus total vertebral bodies of that type. In Tomb 1, 29 out of 48 (60%) vertebral bodies displayed vertebral body degeneration in the form of vertebral osteophytosis, including two fused cervical vertebrae (a C2 and a C3) likely due to degeneration of the vertebral discs (Figure 4.7). Splitting this by vertebral type makes it clear that the lower to mid-back were most affected in Tomb 1, with seven of seven lumbar vertebral bodies affected (100%) and 10 of

10 thoracic vertebral bodies (100%), compared to zero of nine cervical vertebral bodies (0%)

(Table 4.6). Out of 40 total cervical vertebral bodies in Tomb 2, six were affected (15%), out of

46 thoracic vertebral bodies, 16 were affected (35%), and out of 37 lumbar vertebral bodies, 9

were affected (24%) (Table 4.6). The total rate of vertebral degeneration in Tomb 2 was 30%, or

41 out of 138 vertebral bodies, including those unidentified. No Schmorl's nodes were observed

in the Tomb 2 sample

*Table 4.6: Vertebral Body Degeneration at Kataret es-Samra*

| Bone | Tomb 1 | | | | Tomb 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Vertebral Osteophytes | | Schmorl's nodes | | Vertebral Osteophytes | | Schmorl's nodes | |
| | N | % | N | % | N | % | N | % |
| Cervical vertebrae | 9 | 0% | 9 | 0% | 40 | 15% | 40 | 0% |
| Thoracic vertebrae | 10 | 100% | 10 | 0% | 46 | 35% | 46 | 0% |
| Lumbar vertebrae | 7 | 100% | 7 | 0% | 37 | 24% | 37 | 0% |
| Unidentified vertebrae | 22 | 41% | 22 | 0% | 15 | 6% | 15 | 0% |
| Sacrum promontories | 2 | 0% | 2 | 0% | 52 | 6% | 52 | 0% |

*Fig. 4.7: C2 fused to C3, Tomb 1. Accession No. KS78.II.1.1003.A-H.r*

**Dental Pathology**

Three out of 24 teeth (17%) from Tomb 1 displayed dental caries, two on the smooth surfaces of the buccal/labial and one on an interproximal surface. No dental calculus, LEH, or abscesses were observed in Tomb 1 (Table 4.7). In Tomb 2, out of 94 total teeth observed 6 teeth were affected by carious lesions, two of which were deciduous teeth (6%) (Table 4.8). Five teeth out of 94 in Tomb 2 showed dental calculus (5%). No LEHs or abscesses were identified in the Tomb 2 sample, which may be impacted by the removal of teeth from during the initial analysis by Ward Briggs and Leonard (2017).

*Table 4.7: Dental pathologies in permanent dentition at Kataret es-Samra.*

| Tooth | Tomb 1 | | | | | Tomb 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Caries | Calculus | LEH | Abscesses | | Caries | Calculus | LEH | Abscesses |
| | N | % | % | % | % | N | % | % | % | % |
| RM$^3$ | 0 | 0% | 0% | 0% | 0% | 1 | 0% | 100% | 0% | 0% |
| RM$^2$ | 0 | 0% | 0% | 0% | 0% | 1 | 0% | 0% | 0% | 0% |
| RM$^1$ | 2 | 0% | 0% | 0% | 0% | 4 | 25% | 0% | 0% | 0% |
| RPM$^2$ | 1 | 0% | 0% | 0% | 0% | 1 | 0% | 0% | 0% | 0% |
| RPM$^1$ | 0 | 0% | 0% | 0% | 0% | 5 | 0% | 0% | 0% | 0% |
| RC' | 1 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| RI$^2$ | 0 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| RI$^1$ | 0 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| LI$^1$ | 0 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| LI$^2$ | 0 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| LC' | 0 | 0% | 0% | 0% | 0% | 5 | 0% | 20% | 0% | 0% |
| LPM$^1$ | 1 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| LPM$^2$ | 2 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| LM$^1$ | 1 | 0% | 0% | 0% | 0% | 4 | 25% | 0% | 0% | 0% |
| LM$^2$ | 0 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| LM$^3$ | 2 | 50% | 0% | 0% | 0% | 1 | 0% | 0% | 0% | 0% |
| LM$_3$ | 2 | 0% | 0% | 0% | 0% | 3 | 0% | 0% | 0% | 0% |
| LM$_2$ | 3 | 0% | 0% | 0% | 0% | 4 | 75% | 25% | 0% | 0% |
| LM$_1$ | 2 | 0% | 0% | 0% | 0% | 5 | 0% | 0% | 0% | 0% |
| LPM$_2$ | 1 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| LPM$_1$ | 1 | 0% | 0% | 0% | 0% | 2 | 0% | 50% | 0% | 0% |
| LC, | 0 | 0% | 0% | 0% | 0% | 2 | 0% | 100% | 0% | 0% |
| LI$_2$ | 0 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| LI$_1$ | 0 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| RI$_1$ | 0 | 0% | 0% | 0% | 0% | 3 | 0% | 0% | 0% | 0% |
| RI$_2$ | 1 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| RC, | 0 | 0% | 0% | 0% | 0% | 1 | 0% | 0% | 0% | 0% |
| RPM$_1$ | 2 | 0% | 0% | 0% | 0% | 4 | 0% | 0% | 0% | 0% |
| RPM$_2$ | 0 | 0% | 0% | 0% | 0% | 2 | 0% | 0% | 0% | 0% |
| RM$_1$ | 1 | 100% | 0% | 0% | 0% | 5 | 20% | 0% | 0% | 0% |

| RM$_2$ | 1 | 100% | 0% | 0% | 0% | 3 | 0% | 0% | 0% | 0% |
|---|---|---|---|---|---|---|---|---|---|---|
| RM$_3$ | 0 | 0% | 0% | 0% | 0% | 1 | 0% | 0% | 0% | 0% |

*Table 4.8: Dental pathologies in deciduous dentition at Kataret es-Samra (no deciduous teeth were recovered from Tomb 1).*

| Tooth | Tomb 2 | | | | |
|---|---|---|---|---|---|
| | N | Caries | Calculus | LEH | Abscesses |
| rm$^2$ | 2 | 0% | 0% | 0% | 0% |
| rm$^1$ | 2 | 0% | 0% | 0% | 0% |
| rc' | 2 | 0% | 0% | 0% | 0% |
| ri$^2$ | 1 | 0% | 0% | 0% | 0% |
| ri$^1$ | 0 | 0% | 0% | 0% | 0% |
| li$^1$ | 1 | 0% | 0% | 0% | 0% |
| li$^2$ | 0 | 0% | 0% | 0% | 0% |
| lc' | 1 | 0% | 0% | 0% | 0% |
| lm$^1$ | 1 | 0% | 0% | 0% | 0% |
| lm$^2$ | 1 | 0% | 0% | 0% | 0% |
| lm$_2$ | 1 | 0% | 0% | 0% | 0% |
| lm$_1$ | 1 | 100% | 0% | 0% | 0% |
| lc, | 0 | 0% | 0% | 0% | 0% |
| li$_2$ | 0 | 0% | 0% | 0% | 0% |
| li$_1$ | 0 | 0% | 0% | 0% | 0% |
| ri$_1$ | 0 | 0% | 0% | 0% | 0% |
| ri$_2$ | 0 | 0% | 0% | 0% | 0% |
| rc, | 0 | 0% | 0% | 0% | 0% |
| rm$_1$ | 1 | 0% | 0% | 0% | 0% |
| rm$_2$ | 1 | 100% | 0% | 0% | 0% |

**Trauma**

Trauma appeared in very low frequencies in Tomb 1 with only one bone fragment out of 379 total fragments showing a healed fracture in a rib 3-10 fragment (Table 4.9). Rates of trauma were similarly low in Tomb 2. One rib 3-10 fragment out of 4,105 total bone fragments showed signs of a healed fracture, or 0.02% of the sample. The fragmentary state of the remains in both tombs means that some instances of trauma may not have been preserved.

*Table 4.9: Healed trauma at Kataret es-Samra*

| Bone | Tomb 1 | | Tomb 2 | |
|---|---|---|---|---|
| | N | % | N | % |
| All bone | 379 | 0.2% | 4,105 | 0.02% |

CHAPTER 5:

DISCUSSION

The skeletal remains recovered from Kataret es-Samra Tombs 1 and 2 are some of the few that have been analyzed from the Late Bronze Age southern Levant. While the sample size is small, their addition to scholarship of the LB provides a novel insight into the stress, lives, and deaths of those who lived at Kataret es-Samra. This study focused on establishing an MNI for both Kataret es-Samra tombs using a rigorous inventory system and documenting skeletal lesions indicative of stress, trauma, and joint degeneration. Bones were observed for evidence of porotic hyperostosis, cribra orbitalia, periostitis, specific infectious diseases, arthritis and vertebral body degeneration, trauma, and dental pathologies including LEH, dental caries, and dental calculus. In this chapter, these findings are related to archaeological evidence from Kataret es-Samra and the LB of the southern Levant as a whole.

**Limitations**

The sizeable gap in bioarchaeological literature in the Near East stems largely from the dominance of the British and European archaeological model of Culture History and the historical separation of archaeology from anthropology and its related methods and theory (Sheridan 2017). It has only been in the last decade that bioarchaeological and paleopathological studies have emerged in the Near East (Perry 2012a:454). In Jordan, the inception of coordinated archaeological projects was hampered even further by the country's relative lack of infrastructure prior to 1948 (Perry 2012a). Even after archaeologists began to excavate tombs and cemeteries in Jordan, those bones and data were largely lost as they were not systematically recovered, studied, or stored (Perry 2012a). The journey of the Kataret es-Samra bones echoes this pattern: After

being excavated rapidly to save them from looting, they spent nearly 35 years in storage at the American Center for Oriental Research, with only a brief descriptive analysis of the bones from Tomb 2 occurring in that gap. Research and publications of the Kataret es-Samra tombs have tended to focus on the ceramic typologies and material culture found with the remains, with only a few paragraphs and sketches included for the skeletal material (Ward Briggs and Leonard 2017). This pattern is all-too typical for the region. To quote S. G. Sheridan, "One might be tempted to think funerary structures were built for pots, not people," (Sheridan 2017:112-113). This dearth of bioarchaeological information means any detailed analysis greatly adds to the very small pool of available data. Leonard's request to have these remains analyzed in a detailed and systematic way before long-term storage is an admirable addition to this small pool of data.

**Minimum Number of Individuals**

This re-analysis of the Kataret es-Samra sample also was hindered by the relatively common problem of poor documentation in the field and of the methods used in the preliminary laboratory analysis. For instance, a possible young child in Tomb 1 is only represented by a tibia, and as these bones were recovered from a partially looted context, it is unclear if the rest of the subadult bones were simply not recognized during gathering of the elements for study, or if the bone originated from another looted tomb nearby. In addition, the skeletal remains in Tomb 2 were grouped into "burials" in the field without discussion of the criteria used for this identification (which clearly did not limit such identification to discrete, articulated skeletons) or their documentation by field drawings or photographs of each burial. This and the subsequent re-organization of the skeletal remains into individuals in the preliminary analysis (Ward Briggs and Leonard 2017) complicated later, more systematic research. There were 18 "burials"

identified in Tomb 2 in the field, but reorganization of the remains by Ward Briggs grouped them into 11 individuals based on "burials and analysis, including matching fracture bones… in the 'lab'" (Ward Briggs, Electronic Communication, 2019), by which she presumably meant refitting bones broken postmortem. There is no indication that any systematic method for estimating MNI was utilized. Therefore, is it not surprising that the 2019 analysis disagrees with Ward Briggs and Leonard (2017). This reanalysis eschewed unclear field "burial" designations and treated all of Tomb 2 as a commingled assemblage, resulting in a new MNI of eight. As the MNI establishes only the minimum number of individuals included in the assemblage based on the bones recovered, there always is the possibility of underestimation (Adams and Konigsberg 2004). Thus, this result does not discount the number of discrete individuals identified in the field or during the first analysis of Tomb 2 but provides a more systematic assessment for Tomb 2's sample representation. This analysis also produces the first MNI for Tomb 1 of eight.

Kataret es-Samra Tombs 1 and 2 were likely small family tombs based on a similar pattern observed at other sites from varied time periods in the region, from at least the EB IA (Ortner and Frohlich 2007), through the Iron Age (Bloch-Smith 2019), and the Nabataean, Roman, and Byzantine periods (1st century B.C. - 6th century A.D.) (Perry et al. 2017; Waterhouse 1998). Surveys in both 1979 and 1985 did not reveal any other tombs in the area associated with Kataret es-Samra (Leonard and Greene 2017), however the existence of a larger cemetery is likely based on the size of the tell, and would provide greater context to the tombs, including a larger sample for frequencies of pathologies and population statistics.

**Mortuary Patterns in Context**

Mortuary patterns of the region suggest that by the LB, individuals at nearby sites like Tell es-Sai'diyah and Tell el-Mazar were buried in horizontal cemeteries of mostly single internments (Green 2006). Why, then, does Kataret es-Samra differ in burial practice while remaining similar in burial goods?

One explanation for the mortuary variation between Kataret es-Samra and Tell es-Sa'idiyah could be landscape differences between the sites. Kataret es-Samra exists in steep hills and cliffs of the *ghor* and *zor* which were more conducive to rock-cut shaft tombs than horizontally-dispersed cemeteries. Another likely explanation is that Tombs 1 and 2 at Kataret es-Samra may have existed along with a cemetery of pit graves yet undiscovered. Those buried in Tombs 1 and 2 may also have been nomadic or semi-nomadic peoples buffered from the cultural changes happening at the tell. Finally, Kataret es-Samra's remoteness from population centers may have protected it from the Egyptian pressure theorized to end the use of familial tombs (Bunimovitz 1995:331) elsewhere. This isolation theory is supported by osteological findings. Individuals at Kataret es-Samra did not experience elevated levels of trauma or infectious disease possible with the violence described at Beth Shean during the maintenance of Transjordan trade routes by Egyptian forces (van der Steen 1996), for instance. Foreign goods in the tombs were few and probably originated at markets in nearby settlements. It is possible that the continued use of family tombs at Kataret es-Samra is evidence of an "isolation affect," self-imposed or not, during the Egyptian occupation. Proving this, however, would require extensive excavation of the tell itself, identification of other cemeteries at Kataret es-Samra, and a more extensive comparison with nearby sites which is beyond the scope of this thesis.

Kataret es-Samra also displays less social hierarchy in its tombs, though the sample size is admittedly small. Small artifact finds in Tomb 2 are comparable with the more modest LB IIB

graves at Tell es-Sa'idiyah (Green 2006). Toggle pins, used for burial dress (Green 2014), are found with just one individual in Tomb 2. This individual was also found near beads and a scarab. The bronze anklet and beads found with what Ward Briggs and Leonard (2017) describe as a three-year-old in Tomb 2 are often found throughout the LB Levant with children or females (Green 2016). However, due to the discontinuity between the burials as excavated and labeled and as published by Ward Briggs and Leonard (2017), the artifacts can only be associated with one of their 11 published burials, not the assessments provided here.

**Pathologies**

Interpreting the frequency of the pathological lesions in the Kataret es-Samra assemblage is difficult due to the lack of a comparable samples. Both children in Tomb 2 displayed healed cribra orbitalia, while the one child from Tomb 1 did not have observable orbital roofs. Two adult orbital roofs showed healed orbital lesions in Tomb 2, suggesting that they survived the condition leading to these lesions, although it is difficult to determine if cases of other survivors were completely remodeled and unobservable. Healed porotic hyperostosis was only observed on two adult parietal fragments, one from each tomb, though a subadult parietal fragment did show porosity potentially linked with porotic hyperostosis. Identifying the exact anemic condition causing porotic hyperostosis and cribra orbitalia in this assemblage necessitates observation of the entire skeleton (Brickley 2018). Porotic hyperostosis continues to be linked in literature to more "traditional" anemias such as iron-deficiency, hereditary, and acquired anemias (Rivera and Lahr 2017). Rivera and Lahr (2017) and Miller (2018) identify conditions leading to cribra orbitalia as anemias from chronic disease, renal failure, protein deficiency, and endocrine disorders as well as infections such as the common dengue virus and malaria (Rivera and Lahr

2017). While they come from similar anemic conditions, porotic hyperostosis and cribra orbitalia should be regarded as independent pathologies coming from different etiologies (Rivery and Lahr 2017). The adults at Kataret es-Samra displaying healed porotic hyperostosis may have had a previous episode of iron-deficiency, potentially via dietary deficiency. A hereditary or population-wide dietary deficiency is unlikely due to the low frequency of porotic hyperostosis seen in the sample. As for the healed cribra orbitalia, renal failure seems to be an unlikely cause, as it also causes severe marrow hypoplasia and it is more frequently seen in adults (Rivera and Lahr 2017). Endocrine disorders are possible but unlikely, as no other evidence for them exists in the Kataret es-Samra assemblage, and as Rivera and Lahr (2017) note, they are too infrequent to account for much of cribra orbitalia seen in ancient populations. Chronic disease and malnutrition, including protein deficiency, impacts proper immune system functioning and would lead to wider indicators of stress (Rytter et al. 2014). The skeletal response to this could appear as any of the general stress markers discussed above, including cribra orbitalia and porotic hyperostosis. Therefore, the most likely cause would be a previous episode of chronic disease, including parasitic infections or those causing diarrhea and protein deficiencies, although acknowledging the small sample size could hinder knowing the cause. It is unlikely that all afflicted individuals experienced this episode as a result of a common cause, as the pathologies occur in both tombs and etiologies differ for porotic hyperostosis and cribra orbitalia. Therefore, various anemic conditions do appear to have been present at Kataret es-Samra but were not widespread and were generally survivable.

Skeletal responses to infection or inflammation in the form of periosteal reactions or osteomyelitis also have low frequencies at Kataret es-Samra, with only one adult tibia shaft fragment out of 570 leg long bone fragments from Tomb 2 and two vertebrae out of 95 vertebral

fragments from Tomb 1 displaying an inflammatory response possibly to infection. The small

lesion observed on the tibial fragment was consistent with active periosteal reaction. The low

frequency of periostitis in the Kataret es-Samra skeletal assemblage suggests that factors leading

to the lesion were not pervasive in this community. As a periosteal reaction is a non-specific

stress marker, it has many complicated etiologies. A localized incidence of periosteal reaction

can be related to trauma, such as an impact to the bone or straining and inflammation of the

muscle. Bacterial infection, also capable of triggering an inflammatory response of the

periosteum, is more traditionally linked with the pathology (Goodman and Martin 2002).

Widespread infection should, however, leave more markers throughout the body. A localized

infection could trigger a similar response to what was observed. Ultimately, it is difficult to say

what caused this small incidence or if it even represents a major insult to the individual's

physiology. The inflammatory response recorded on the L5 inferior endplate and S1 promontory

is a more specific stress marker. As discussed, the lesions could have etiologies related to rupture

of the intervertebral disc and inflammation (Samartzis et al. 2016), but the pitted surfaces and

sclerotic bone are more consistent with localized infectious inflammation. Pyogenic spinal

infection (Hadjipavlou et al. 2000) is a term used to describe the various diagnoses of

spontaneous spondylodiscitis, discitis, and vertebral osteomyelitis, all of which fit the description

of the pathology. Pyogenic spinal infection in the modern world occurs when *S. aureus* bacteria

reach the intervertebral space through openings in the bloodstream or during accidental infection

during surgical operations (Skaf et al. 2010). In the ancient world this would have almost

certainly occurred via infection in the pelvic area. Clinical studies have reported that 90% of

patients reported pain before diagnosis, with only about 50% experiencing fever (Skaf et al.

2010). Pain is documented as being a nocturnal localized pain accompanied by spasms and

difficulty moving (Skaf et al. 2010). If the condition caused development of an epidural abscess, no evidence of which is seen here, paralysis and death can result. The prognosis for someone with pyogenic spinal infection in the ancient world would be grim. Individuals at Kataret es-Samra are already linked to the physical activities associated with pastoralism. This condition would have hindered labor and triggered a feedback loop of declining health as sleep became difficult with pain. Ultimately, the active nature of the inflammation suggests the individual died with the condition, potentially at an advanced state (though radiographic studies would be needed to prove this). This individual who was either hindered from or unable to work may have required care and support from the community or family members.

Degenerative conditions are the most pervasive pathological lesions seen at Kataret es-Samra, but even these are seen infrequently in the sample. The little arthritis seen in the sample only appears systematically at rather low frequencies in the foot, elbow, hip, wrists, and knee. The low frequencies overall at Kataret es-Samra might indicate a lack of conditions leading to arthritis, which could include workload, diet, and hereditary disposition (Weiss 2017). The inability to estimate adult ages in the tombs hinders assessment of this condition by age.

Vertebral body degeneration (VBD) appears at marginal rates, with rates peaking in the lumbar and thoracic vertebrae for both tombs. VBD results from age progression, but the inability to link vertebrae by individual and the incomplete data on age estimation makes it difficult to establish it as normal age-related degeneration. Knüsel and colleagues' (1997) findings that humans' bipedal nature is enough strain to produce VBD means these results are not indicative of abnormally strenuous behaviors. This marks another distinction between "health" and "stress" following Klaus (2014), in which an individual with lower back VBD might consider themselves relatively healthy, despite signs of stress in their skeleton. It is worth

noting that the lesions described as pyogenic spinal infections could be explained as atypical Schmorl's nodes (Samartzis et al. 2016), though this is unlikely.

Dental caries and calculus appear in the Kataret es-Samra assemblage with moderate frequency. Most of the carious lesions appear on posterior dentition and do not show any expansion into the dental pulp chamber and subsequent development of abscesses in the alveolar bone. Few examples of dental calculus appear and could be underrepresented due to poor condition of the dentition. Caries and calculus may provide evidence not only of diet but also the nature of the oral microbiome and susceptibility to infectious and chronic diseases. Stable isotopic and dental microwear studies of teeth from LB period sites such as Ya'mun (al-Shorman 2004; al Rousan 2011; Sandias and Müldner 2015) suggest individual consumption was primarily centered on a wide variety of $C_3$ plants typical of many areas in the eastern Mediterranean. Carbohydrates from these sources likely contributed to the development of caries at Kataret es-Samra. The engagement with pastoralism at the site also provided a protein source, which is a factor in the development of calculus. The moderate rates of both dental pathologies may suggest other factors such as the oral microbiome, abrasives in the diet, or pH of water sources hindered their development despite the reliance on carbohydrates and protein in the diet. Further testing of the geologic nature of the region such as the groundwater's pH or testing of the few examples of calculus preserved on anterior teeth taken to ECU's Bioarchaeology Laboratory could shed light on these theories.

Observations of trauma to the skeleton did not identify many examples. Only two rib 3-10 fragments, one from each tomb, demonstrate healed fractures. Neither case appears to indicate interpersonal trauma nor even significant trauma to the body. Kataret es-Samra's isolation from Egyptian cultural centers might have protected its inhabitants from the violence and insurgencies

seen elsewhere (van der Steen 2004) in addition to intracommunity strife, although truly

understanding this would necessitate systematic investigations of trauma at other LB southern

Levantine sites. Evidence of interpersonal violence at Kataret es-Samra trauma has yet to be

uncovered. The population could also have been susceptible to accidents relating to pastoralism

and engaging with livestock such as the cattle found at the site. However, the highly fragmentary

nature of the remains and poor preservation could make identification of trauma more difficult,

likely underestimating the bodily trauma at the site.


**The Osteological Paradox**

While study of this small assemblage provides a glimpse into the inhabitants of Late

Bronze Age Kataret es-Samra, there are many limitations in broad interpretations of these data.

Largest is the lack of comparative data from the region and time period, as mentioned earlier.

However, issues exist with attempting to study a sample of the dead in order to understand the

living (Wood et al 1992). For example, children in the assemblage would theoretically represent

those who died during childhood. However, they are likely far from the entire LB subadult

population at Kataret es-Samra. Additionally, subadult individuals are often underrepresented in

mortuary contexts, and thus those recovered and analyzed may not even represent those who

died at young ages. This can result from taphonomy, which destroys the more fragile subadult

bones, or purposive buried in locations separate from adults, which is seen in many Near Eastern

contexts (Bradbury and Philip 2017). Poor preservation is especially prevalent in commingled

assemblages such as at Kataret es-Samra. Taphonomic destruction is not limited to subadult

bones. The highly fragmentary and sometimes weathered nature of all bones may have erased

pathological indicators they contained. Further taphonomic factors such as the looting of Tomb 1

and disturbance of Tomb 2 could have damaged bones displaying lesions, particularly more fragile bones with abnormal porosity or density.

Therefore, drawing conclusions of the entire subadult population based on taphonomic survivors presents a paradox: Those that are recovered not only do not represent the dead, but they also do not necessarily represent the living whose lives bioarchaeologists try to understand. The children buried in Tomb 2 represent only a portion of the subadult population who developed pathologies like cribra orbitalia. Additionally, many of the other afflicted children may have grown into adulthood with or without continued illness, and over time the lesions may have completely remodeled. Therefore, it would be incorrect to assume that because both children in Tomb 2 were affected, the rate of cribra orbitalia in all children at Kataret es-Samra was near 100%.

The paradox presents itself in adults with the data from periosteal reactions. Even with excellent preservation, a possibility for the low frequency of the lesions is that individuals perished too quickly from bacterial infection to develop bony responses to the condition. Sick individuals also need to be "healthy" enough for the body to create bony responses. Finally, those infected could have had a high chance of survival and bone remodeling, erasing the signs of past infections.

Heredity also plays a role in the varying frequencies of pathologies. Some intrinsic host factors could differentially impact those buried in Tomb 1 or Tomb 2. These tombs likely contained members of a kin group, perhaps even members of an extended household as suspected by Ward Briggs and Leonard (2017), and typical for the region, e.g., at Early Bronze Age Bâb edh-Dhrâ (Ortner and Frohlich 2007). Thus, variables with a genetic component such as propensity for the development of degenerative joint disease or dental pathologies such as

calculus could differentially affect frequencies in each tomb. However, the relatively homogeneous nature of the data across the tombs would indicate this was not a strong factor in skeletal lesion development.

Creating frequencies of bone fragments afflicted by a pathology versus those that are not assumes that individuals with affected bones were inherently unhealthy, either at their death or previously. As Temple and Goodman (2014) point out, "health" is a multi-faceted definition which intrinsically relies on self-perception. Those individuals at Kataret es-Samra with evidence for pathological indicators might not have perceived themselves as unhealthy relative to the mortality patterns of their society. Whether an iron-deficiency or a traumatic injury to a rib would cause a Kataret es-Samra individual to think of themselves as "unhealthy" is unknown, but unlikely. Bioarchaeologists tend to use the terms "health" and "stress" interchangeably and somewhat incorrectly, as "stress" is the more accurate terminology. "Stress" better refers to what is seen in the skeleton, and not what is perceived by the individual (Klaus 2014). Therefore, it is more productive to view the lesions at Kataret es-Samra as stress markers placed on the body due to physiological insults of the environment, diet, and heredity. Ultimately, these data are most useful when compared to other sites. Stress markers in the Kataret es-Samra population are infrequent, though this conclusion is biased by the lack of comparable sites in the LB of the southern Levant. The export of an undocumented list of tooth samples by Ward Briggs also skews any dental data in the sample. The lack of LEH in this study could have resulted from the removal of the most pathological teeth.

Finally, calculating frequencies of observations in commingled, fragmentary samples can vary dramatically based on the level of bone fragmentation. Researchers working with such samples must assume that fragmentation of "normal" bones occurs in the same pattern and rate

as "abnormal" or pathological bone, resulting in similar ratios of each regardless of the level of fragmentation. However, this likely is not the case. For example, take the above-mentioned rate of periostitis in Tomb 2 of one long bone leg fragment out of 570, or 0.2%. In this case the single tibia shaft fragment showing the periosteal lesion fragment obviously came from one person. Thus, we could be confident in calculating the frequency out of the MNI of the tomb, or one out of eight individuals (13%). However, what if there were five unassociated, unreconstructable tibia shaft fragments with periosteal lesions? Are these from one person with a large periosteal lesion covering a large part of the tibia shaft? Are these from five different people? Somewhere in between? Is a rate of five leg shaft fragments out of 570 meaningful? Can we assume that the bones with the periosteal lesions fragmented to the same extent as leg bones without the lesions, thereby making the 0.2% rate correct regardless of the level of fragmentation? Would we assume that if the bones were only one-half as fragmented as they were, that the 0.2% rate would still hold?

This is a difficult question to answer. Using the estimation by individual, or 13%, seems to be the most "humanist" option and considers the total skeleton as a distinct person. However, the previous discussion on health reminds us that one small patch of periosteal reaction may not have really mattered in terms of this person's "health," nor made them more susceptible to other conditions. Ultimately, the methodology used to scale pathologies in fragmentary commingled remains is less important than the methodology agreed upon by the region's academic community. If two comparable sites report their data in the same method, a comparison can be made. Perhaps Kataret es-Samra Tomb 2's periosteal reaction rate of 0.2% can be compared with a hypothetical nearby LB tomb rate of 0.4%, indicating that periosteal reaction was twice as prevalent there. Osterholtz et al. (2014) state that there is no "right way" to approach

fragmentary commingled assemblages. Perhaps there should be, at least for greater

archaeological regions. A better overlap of methods means more sites can be compared, and

more conclusions drawn. Kataret es-Samra is currently limited in its ability to tell tales about

those who lived there, yet this might not always be the case.


**Summary**

After paleopathological analysis, an image appears which does not contradict the findings

of Ward Briggs and Leonard (2017) that the individuals in Tomb 2 were part of a rural, modest

household. The tell of Kataret es-Samra was a remote village in sparsely populated Transjordan,

existing in a time of great expansions in trade and culture in the surrounding region. Individuals

in the community likely engaged in or with agro-pastoralism and animal husbandry. This

community experienced few conditions leading to non-specific indicators of stress, trauma, or

abnormal joint degeneration. The community was small, and most individuals were likely

members of an extended family or lineage and buried in family tombs not far from the town

center. Curiously, this mortuary pattern seems to differ from the nearby Tell es-Sa'diyah and Tell

el-Mazar, potentially indicating isolation from broader cultural patterns. Their position in the

landscape placed them in arm's reach of major trading routes, yet their local material culture and

lack of skeletal indicators for violence or infectious disease support the idea that they lived more

isolated lives. Diet may have been sufficiently healthy, as the LB brought with it a wider variety

of plants in the diets of nearby sites and conditions leading to anemia or vitamin deficiencies do

not seem to have been prevalent. The community certainly partook in carbohydrate rich foods, as

shown by dental caries and evidence from other sites. While in the shadow of larger sites such as

Tell es-Sa'diyah, Tell el-Mazar, and Tell Dier 'Alla, Kataret es-Samra represents the rural

(possibly semi-nomadic) society which may have been more resistant to external stressors and

may have preserved older cultural identities in the face of an imposing imperial force.

**CHAPTER SIX:**

**CONCLUSIONS**

The burials excavated from Tombs 1 and 2 at Kataret es-Samra included the remains of at least 16 individuals. In Tomb 1, an MNI of eight individuals was calculated including three adult females (one being 50+ years), two adult males, one adult of indeterminate sex, one adolescent, and one child. The Tomb 2 MNI changed from its published count of 11 (Ward Briggs and Leonard 2017) to eight individuals. These eight include one adult male, one adult of indeterminate sex, three young adult females, one adolescent, and two young children, both aged between 2.5 to four years.

Mortuary patterns seem to differ at Kataret es-Samra from the nearby LB cemeteries at Tell es-Sa'diyah and Tell el-Mazar. As discussed, this may be due to the different landscapes between the sites, or a yet undiscovered horizontal cemetery of single internments at Kataret es-Samra. It is also possible that Kataret es-Samra's small size and possible interaction with nomadic peoples protected it from the cultural changes happening at larger sites. This could provide more evidence for the resistance of smaller, transient communities during times of regional transitions.

Although data from a comparable population is lacking, porotic hyperostosis appeared in relatively low frequencies. Cribra orbitalia appeared in similarly low frequencies, though affected both children buried in Tomb 2. Two adults apparently survived the conditions leading to cribra orbitalia, suggesting this was not always linked to childhood mortality. Periostitis was only observed in one fragment from Tomb 2, though a potential case of pyogenic spinal infection was seen in Tomb 1. This infection does not dramatically alter the health of the Kataret es-Samra population, simply that of one individual. Arthritis and vertebral body degeneration appeared in

appreciable frequencies, both displaying a pattern of wrist, elbow, hip, foot, and knee arthritis and lower back vertebral body degeneration in adults. Although these cases cannot be linked to age estimates, they likely resulted from normal age-related degeneration based on the age distribution of the tombs. Dental pathologies appeared with dental calculus and dental caries in moderate amounts. LEH were not observed in the population, likely due to sampling bias. Trauma only appeared in two rib fragments, suggesting these individuals were not prone to violence or other causes of injury. This study reveals information about a rural population which seems not to have been subjected to conditions leading to the above afflictions. These assessments provide data for comparison with future analyses of other LB skeletal assemblages in the Jordan Valley.

**Further Research**

The greatest aid to the overall Kataret es-Samra project would be a proper excavation of the tell itself. The tell has only received brief surveys and soundings (Leonard 1979, 1983, 1989, 2017). A step trench along the site's slope could reveal the chronology of habitation at the site and expose the LB settlements thought to belong to the inhabitants of Tomb 2. Survey of the tell's summit recovered a few sherds from the early Iron Age (Bürge, Leonard, and Fischer 2017b), so a larger excavation there could provide critical data on the final habitations and eventual abandonment of the site.

The nearest LB site to Kataret es-Samra is Tell Dier 'Alla, approximately eight km to the northwest. This site is known for its cultic and monumental finds, while Kataret es-Samra likely presents a more common (Bürge, Leonard, and Fischer 2017a) LB settlement in the Jordan Valley. Kataret es-Samra could become a landmark site in LB studies of the Jordan Valley as it

could provide both a bioarchaeological analysis of its mortuary features along with an excavation of the tell. The ongoing analysis the LB-Iron Age Tell es-Sa'idiyeh cemetery (see Pritchard 1985; Green 2006, 2013, 2014, 2016) by researchers at the British Museum will provide an important component to this bioarchaeological perspective, particularly since opportunity for full bioarchaeological study of the remains from Tell es-Sa'idiyah is still available (Green 2006).

Additional studies can also be completed on the remains themselves. While the plan is for the return of the Kataret es-Samra skeletal assemblage to the Department of Antiquities, a sample of 49 teeth were exported to the East Carolina University Bioarchaeology Lab for future analysis. Dental microwear studies can be compared with those from al Rousan at Ya'amun (2011) in order to reveal differences in the diets between the two sites. The analysis of stable isotope ratios such as $\delta^{13}C$ and $\delta^{15}N$ to investigation diet and ratios of $^{87}Sr/^{86}Sr$ to investigate population mobility at Kataret es-Samra could provide a more accurate dietary analysis as well as add data to the assertion above that the individuals buried in Tombs 1 and 2 were largely isolated from the greater culture of the LB southern Levant.

In short, Kataret es-Samra is full of opportunity for future research. The site is in a critical position both in space and time for the understanding of Jordanian history. Further excavation and a closer analysis of the dental assemblage could provide critical data for years to come.

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