UNIVERSITY OF NEW ENGLAND

THE ZOOARCHAEOLOGY OF SARUQ AL-HADID:

1200 YEARS OF HUMAN-ANIMAL INTERACTIONS AT THE DESERT FRINGES OF LATE PREHISTORIC SOUTHEASTERN ARABIA

A Thesis Submitted by

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ABSTRACT

The study of the prodigious faunal assemblage from the archaeological site of Saruq al-Hadid has yielded a vast quantity of data relating to the relationships between humans and animals on the desert fringes of late prehistoric southeastern Arabia, with implications for our understanding of the human past in the region more broadly. Within this thesis the multi-dimensional approach used to analyse these remains is detailed, the data recorded by this analysis is presented, alongside interpretations of the data. Specifically, these interpretations of the data demonstrate the importance of wild terrestrial animals to the occupation of Saruq al-Hadid, the unique nature of the relationship between humans and dromedary camels (*Camelus dromedarius*) that transpired at the site and the regional movement of coastal food resources into the desert interior. These factors highlight the significance of Saruq al-Hadid and the activities represented there in the regional and temporal context, while helping to place it firmly within a wider network of contemporary sites located in other environmental zones. In turn, these findings contribute to broader discussions regarding the role of desert spaces in human societies through time, how human behaviour can adapt to suit these environments and how these environments have been shaped by human behaviour.

Certificate of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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INTRODUCTION

This thesis details the analysis and interpretation of the faunal assemblage recently excavated from the late prehistoric site of Saruq al-Hadid, located on the fringes of the Rub al-Khali desert in the Emirate of Dubai, United Arab Emirates. The remains highlight the importance of animals to Saruq al-Hadid's role as a well-utilised node in a regional network of late prehistoric sites involved in transhumance, the exchange and production of goods and subsistence strategies. Specifically, the animal bone assemblage provides new insights into the role of Saruq al-Hadid in the exploitation of wild terrestrial animals, the movement of marine resources and domesticates from the coast to the site, and the relationships between humans and dromedary camels before, during and after their conjectured date of domestication. This research contributes to our wider understanding of the use of the desert interior of southeastern Arabia during late prehistory and how this relatively under-studied zone interacted with the zones of concentrated human habitation – the coasts, mountains and oases. In turn, this thesis adds to the growing body of literature that presents this desert area of southeastern Arabia as an area of substantial and unique cultural activity, despite its geographical location on the peripheries of more intensively inhabited zones.

The thesis itself comprises a collection of academic outputs, hereafter referred to as 'Papers', bracketed by introductory and concluding sections. These academic outputs take the form of one monograph chapter (Paper 1) and four academic papers submitted to peer-reviewed journals (Papers 2, 3, 4 & 5). At the time of writing, two of these papers have been published (Papers 2 & 5), two have been accepted for publication (Papers 1 & 4), and one is under peer review (Paper 3).

The introductory sections explain the background of the current project, the questions that were targeted by the project and the significance of addressing these questions (Sections 1, 2 & 3). The focus of the publications, as well as their relationship to one another, is described in Section 4, and the papers are then presented, detailing the major themes identified during this study (Sections 5, 6, 7, 8 & 9). Subsequently, the findings of this study are summarised in Section 10, and the work then concludes with an explicit outline of the future research potential of the faunal remains from Saruq al-Hadid (Section 11). A number of additional papers that include the candidate as a co-author are appended to the thesis; these papers provide further information regarding the excavations and dating of the excavated deposits from Saruq al-Hadid, and discuss the wider findings and significance of recent research at the site (Appendix 1). The measurements taken from the remains and used to form some of the conclusions within this thesis are also included (Appendix 2).

1. Project Background

1.1. Late Prehistoric Southeastern Arabia and Human-Animal Relationships

Archaeological studies of the Bronze and Iron Ages in southeastern Arabia have highlighted the existence of a regionally distinctive cultural trajectory extending from the Neolithic through to the Islamic period (Potts 1992; Cleuziou & Tosi 2007; Magee 2014). The Bronze Age in southeastern Arabia is broadly defined by its material culture traditions (Cleuziou & Tosi 2007: 109-110, 268; Giraud 2009; Magee 2014: 96, 101), diachronic changes which are used as the basis to demarcate the local chronological sub-phases that are referred to in this research (**Table 1**). Similarly, the Iron Age is broadly distinguished by a distinctive material culture tradition, including ceramic and architectural types alongside evidence for settlement intensification and technological innovations, which can be sub-divided into separate phases based on typo-chronological considerations (Cleuziou & Tosi 2007; Magee 1996; 2003; 2014 - **Table 1**). While this thesis focuses principally on the timespan from 2000 BCE – 800 BCE, i.e. the end of the Umm an-Nar period to the end of the Iron Age II period, earlier and later phases are discussed where relevant.

Table 1. *The chronology and periodisation of late prehistoric southeastern Arabia.*

	Stage	Period	Approx. Date BCE
Late Prehistoric SE Arabia	NEOLITHIC	Neolithic	6000 - 3200
	BRONZE AGE	Hafit	3200 - 2600
		Umm an-Nar	2600 - 2000
		Wadi Suq	2000 - 1600/1500
		Late Bronze Age	1600/1500 - 1300
	IRON AGE	Iron Age I	1300 - 1100
		Iron Age II	1100 - 600
		Iron Age III	600 - 300

Zooarchaeology has been a significant component of archaeological studies in southeastern Arabia. Faunal remains have been recovered from a number of late prehistoric sites in different environmental settings (**Fig. 1**), including the coast (e.g. Tell Abraq – Uerpmann 2001; Uerpmann & Uerpmann 2008; Kalba, K4 – Phillips & Mosseri-Marlio 2002; Eddisford & Phillips 2009; al-Sufouh 2 – von den Driesch & Obermaier, 2007; Sharm – Andrews 2003; Shimal – Vogt & Franke-Vogt 1987; Hamriyah – Magee *et al.* 2009), in the mountains (e.g. Bithnah 44 – Skorupka, Mashkour & Benoist 2013; Thuqeibah – Uerpmann & Uerpmann 2008) and from oasis sites in the mountain piedmont zone (e.g. Hili 8 – Cleuziou 1982; Uerpmann & Uerpmann 2008). Studies of these faunal remains have highlighted the importance of the marine resource to coastal societies throughout the region (Beech 2004; Uerpmann & Uerpmann 2005), as well as the increasing role of domesticates in subsistence strategies through time and the relatively infrequent exploitation of wild animals (Uerpmann & Uerpmann 2007; 2008). The consistent occupation of the coastal and mountainous zones demonstrates their long-term viability for human habitation; zooarchaeology has played a key role in demonstrating how interactions between humans and animals helped to facilitate the habitation of these areas. In contrast, however, the Bronze and Iron Age in southeastern Arabia's desert interior has remained relatively under-studied (with some recent exceptions – see **Section 1.2.**), largely due to a lack of modern development and occupation within the desert zone compared to other environmental zones in southeastern Arabia. Little is therefore known about how this environmental zone of southeastern Arabia was utilised by late prehistoric societies and how it tied into the wider landscape of late prehistoric human activity in the region.

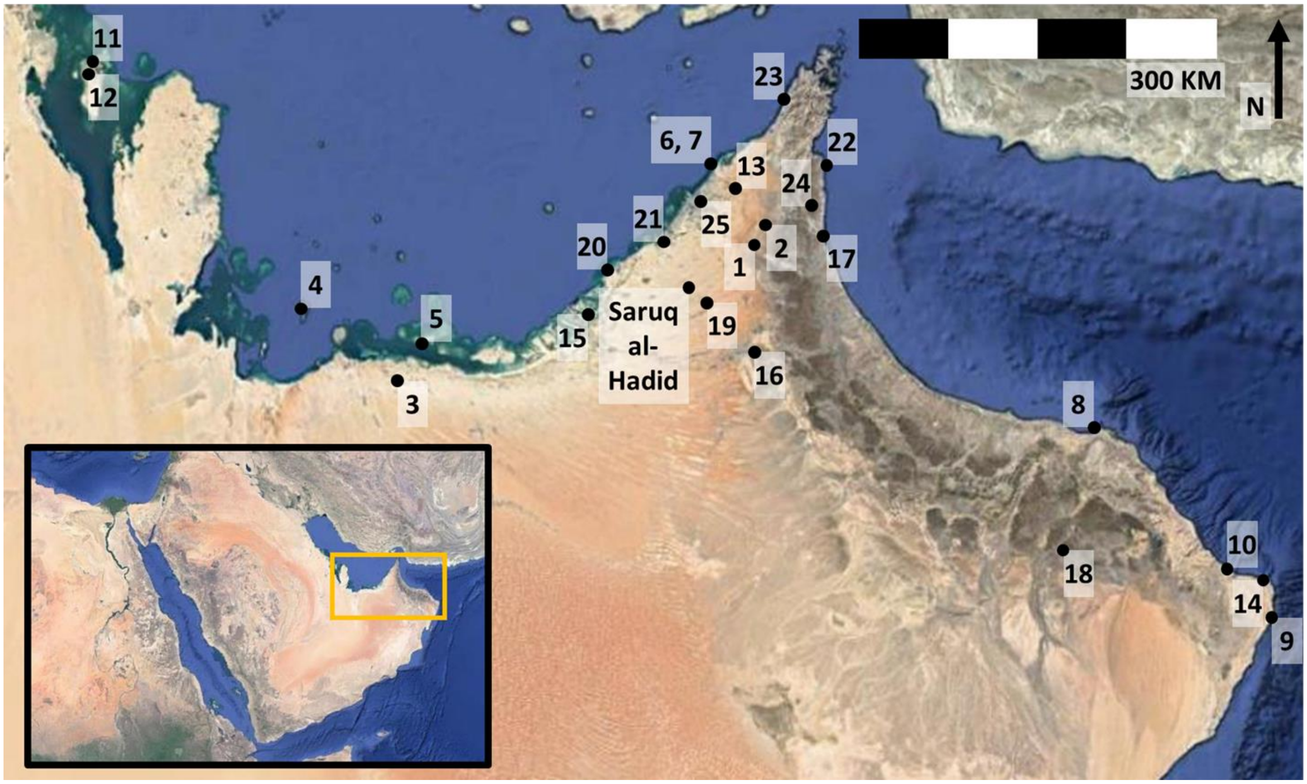

Figure 1. *Late prehistoric sites from which faunal remains have been recovered, including the recently excavated assemblages from Saruq al-Hadid and al-Ashoosh (Site 19).*

Site Key: *1. Jebel al-Buhais 18; 2. Jebel Faya (FAY-NE15); 3. Baynunah; 4. Dalma Island; 5. Mawarah Island (MH 11); 6. Umm al-Quwain 2; 7. Akab; 8. Ra's al-Hamra (RH5 & RH6); 9. Ra's al-Jinz 2; 10. Wadi Shab (Area 1); Qala'at al-Bahrain; 12. Saar; 13. Tell Abraq; 14. Ra's al-Hadd (HD-6); 15. Umm an-Nar; 16. Hili 8; 17. Kalba; 18. Maysar; 19. al-Ashoosh; 20. Ra's al-Ghanada; 21. Al-Sufouh 2; 22. Sharm; 23. Shimal (SX/SY); 24. Bithnah 44; 25. Muweilah. Map Data: © SIO, NOAA, US Navy, NGA, GEBCO, Landsat, Copernicus (Google Earth).*

1.2. The Discovery of Saruq al-Hadid, the Dubai Desert Survey (DDS) and Other Recent Archaeological Discoveries at the Fringes of the Rub' al-Khali

In 2003 the discovery of a site was reported, located 40 km south of Dubai City in the fringes of the Rub al-Khali desert (Qandil 2005 - **Fig. 1** & **Fig. 2**). Dubbed 'Saruq al-Hadid (SAR-7)', the site was originally identified as an area used primarily for metallurgy, with a large amount of slag, crucible fragments and metallic finds recovered from the site (Qandil 2005). While later excavations at Saruq al-Hadid undertaken by a team of researchers from the Jordanian Department of Antiquities recovered a vast array of materials from the site from a variety of different material classes (al-Khraysheh & an-Nashef 2007; Nashef 2010), its interpretation as a metallurgical site prevailed. Based upon the typology of artefacts recovered from the site and a limited number of absolute dates, the site was dated to the Early Iron Age (Nashef 2010). Qandil also identified a number of other archaeological deposits in the wider area around SAR 7, including a substantial third millennium BCE site at al-Ashoosh (Qandil 2005: 124; Contreras *et al.* 2016), 28 artefact scatters dating to the Neolithic period (Qandil 2005) and a concentration of archaeological features and materials 100 metres to the east of the principle area of the site; this area, Area 2A, is discussed in further detail in Paper 1.

It was not until more detailed surveys were undertaken at SAR 7, by a team from the University of Arkansas (the Dubai Desert Survey – DDS), that material predating the Iron Age was recovered from the site (Herrmann 2013; Herrmann *et al.* 2012). Geophysical survey coupled with test excavations by the DDS identified a large number of archaeological horizons within the stratigraphy of the site (Herrmann 2013; Herrmann *et al.* 2012). Typological analyses of artefacts and a limited programme of absolute dating suggested that a number of hearths at Saruq al-Hadid were utilised in the third and even late fourth millennium BCE (Herrmann *et al.* 2012). DDS excavations also produced a substantial amount of animal bone, although taxonomic identifications were preliminary (Herrmann *et al.* 2012). In addition to surveying Saruq al-Hadid, the University of Arkansas surveyed a substantial portion of desert around the site (Casana *et al.* 2009). This survey expanded the known limits of SAR-7, to include a substantial concentration of archaeological deposits 500 metres to the east of their test excavations, in an active military base (referred to in this thesis as the 'Military Base excavations'). This area is discussed in further detail in **Paper 1**. While none of these adjacent sites were identified to be of the same scale as Saruq al-Hadid, the survey added to the evidence collected by the Jordanian mission and the Dubai Department of Tourism and Antiquities to conclusively demonstrate that humans had been undertaking activities in the vicinity of the site from the Neolithic to the present day (Casana *et al.* 2009), including in periods of aridification and desertification / dune formation.

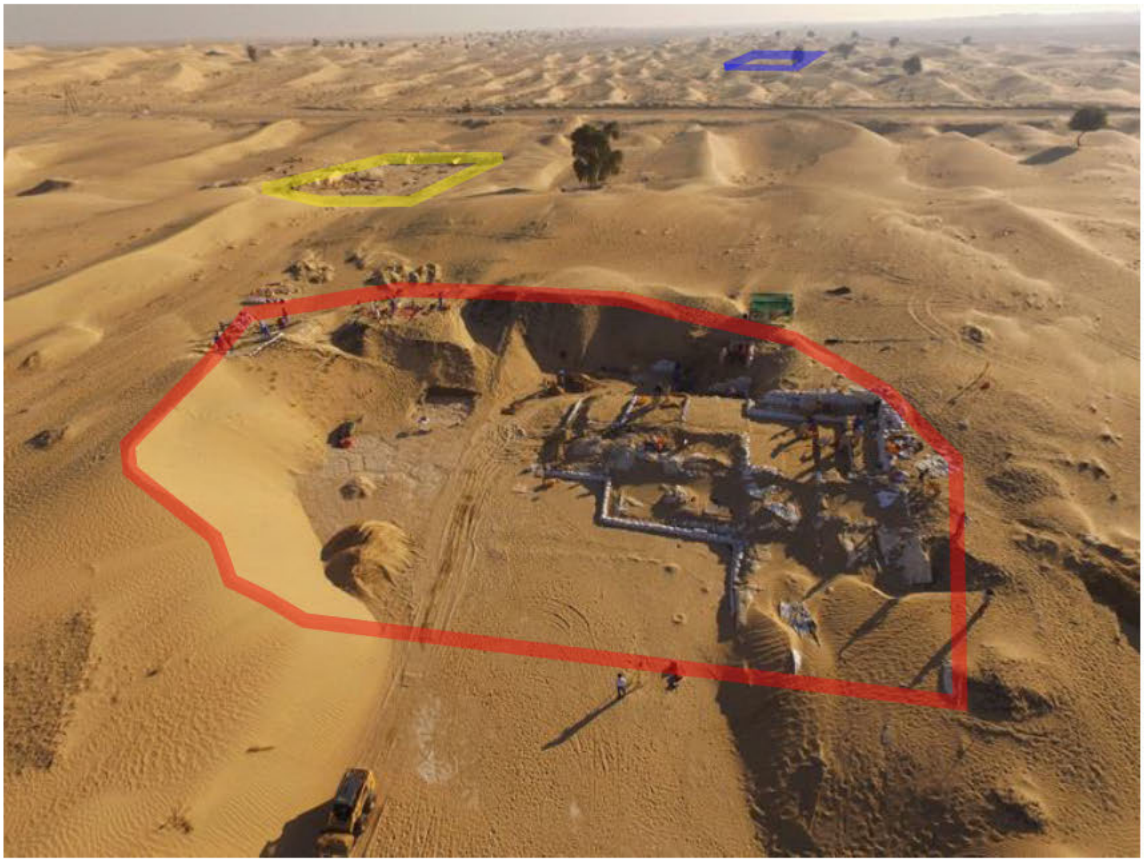

Figure 2. *The three main areas of excavation at Saruq al-Hadid and the surrounding environment. Red – Central Area; Yellow – Area 2A; Blue – Military Base Excavations.*

This conclusion has been strengthened by successive discoveries of late prehistoric sites in the desert zone of the U.A.E. and the Sultanate of Oman. This includes the late Neolithic site of Baynunah in the desert zone of the Emirate of Abu Dhabi (Beech *et al.* 2009) and the Iron Age sites of Uqdat al-Bakrah (Yule & Gernez 2018) and Jebel Mudhmar (Gernez *et al.* 2017) in Oman, both of which are located on the fringes of the Rub' al-Khali desert. While the role of the desert interior during the Neolithic period has long been known (e.g. Cleuziou & Tosi 2007: 10), the use of this space at this time is associated with early and mid-Holocene humid phases that ended by the 4th millennium BCE (Parker *et al.* 2006; Drechsler 2010). These recent discoveries have demonstrated that occupation of this zone continued into the Bronze Age, after this climate aridification. The desert zone is therefore becoming an increasing focus of study in the broader archaeological framework of Bronze and Iron Age southeastern Arabia; the research undertaken at Saruq al-Hadid is a major facet of this new research orientation.

1.3. The Saruq al-Hadid Archaeological Research Project (SHARP) and the Origins of this Current Zooarchaeological Study

In November 2014 the Saruq al-Hadid Archaeological Research Project (SHARP) commenced excavations at Saruq al-Hadid (SAR-7), hereafter referred to as Saruq al-

Hadid. These excavations were focused broadly on the area of the test excavations undertaken by the DDS, dubbed ‘the Central Area’ of the site. The SHARP excavations were undertaken alongside several different teams, including a team from the Dubai Municipality, who are engaged in large-scale, ongoing excavations in both the Central Area of the site and adjacent areas of archaeological activity (**Table 2**).

Table 2. *The archaeological horizons identified during the SHARP excavations, with calibrated absolute date ranges.*

Horizon	Date Range	Cultural Assignment
V	*c.*2000 – *c.*1750 BCE	Wadi Suq
IV	*c.*1750 – *c.*1300 BCE	Wadi Sug – Late Bronze Age
III	*c.*1300 – *c.*1000 BCE	Iron Age I – II
II	*c.*1000 – *c.*800 BCE	Iron Age II
I	*c.*900 BCE and later	Iron Age II and later

1.3.1. The SHARP Excavations – a Brief Outline

The excavations undertaken by the SHARP team, covering a total of 195 m^2, reconstructed five archaeological horizons in the Central Area, spanning 1200 years of human occupation (**Table 3**). At the time of writing, this is the only area of the site were remains dating to the Bronze Age have been recovered. The extensive nature of the excavations combined with the comprehensive analysis of materials recovered from the site allow for an expansion of the interpretations of Saruq al-Hadid. This includes a greater elucidation of the Bronze Age activity at Saruq al-Hadid than had previously been possible, a better understanding of how the different phases of occupation at Saruq al-Hadid relate to one another, and how the activities undertaken at the site changed through time. These findings are briefly outlined here, in terms of the five archaeological Horizons reconstructed by the SHARP excavations and discussed in detail in Weeks *et al*. (2019).

The earliest identified horizon in the SHARP excavations in the central sector at Saruq al-Hadid, Horizon V, is characterised by a series of features, often cut into the underlying gypsum surface of the site. The features include postholes in alignment, indicative of temporary or semi-permanent structures, and hearths. Animal bone was often found in association with these hearths, suggesting they are the remains of cooking events. Ceramics, lithics and shell were also identified in this horizon. Horizon IV represents an intensification of activity at Saruq al Hadid. The horizon is defined by a dense midden of animal bone, stretching up to 30 metres north-south, at least 25 metres east-west and up to 1 metre in thickness. Hearths were identified throughout the midden and a microlithic assemblage was recovered, alongside a substantial ceramic assemblage, relatively infrequent copper-based artefacts and some groundstone tools. In addition, the remains of a stone and mortar structure was recovered from atop the bone midden, dated to this phase of occupation. As described in further detail below (**Paper 1** & **Paper 3**), a number of animal bone fragments had been built into this structure. As yet, this is the only built structure identified at the site. It is unclear how many depositional events are represented by this midden, however the numerous hearths identified throughout the midden and absolute dating of remains from within the midden suggest that it was formed by repeat deposition over multiple centuries (cf. Weeks *et al.* 2019).

Table 3. *The programmes of excavations that occurred alongside the SHARP excavations, 2014-2017.*

Institution	Excavated Area	Dates of Excavation
Dubai Municipality Government	Central Area and Military Base	2014 – ongoing
Sanisera Archaeological Institute	Area 2A	2014 – ongoing
Urban Archaeologists, Commercial Archaeologists from Berlin	Central Area	2015 – 2017
Polish Centre of Mediterranean Archaeology, University of Warsaw	Central Area	2016 – 2019

The remains from Horizon III are evidence of a particularly enigmatic phase of occupation at the site. This horizon comprises of a thin layer of activity atop the bone midden of Horizon IV, made up of deposits of animal bone, ceramic objects (including a large number of pedestalled bowls), copper-based objects, stone artefacts and sandstone slabs. This horizon appears to have been subject to a variety of taphonomic processes, including bioturbation from burrowing rodents and reptiles, discussed further in **Paper 1**. This horizon also contains evidence for dune deposition and deflation.

Horizon II represents yet another use of the Central Area of Saruq al-Hadid. It is during this period where dune accumulation is hypothesised to have increased at the site, with evidence for large sand dunes (up to 3 metres thick) being deposited atop the earlier archaeological horizons. Distinct clusters of artefacts were recovered from these dune deposits representing an incredibly rich and diverse material culture. This included copper production debris from all stages of the metallurgical process, finished copper-based objects, iron artefacts, a range of ceramics, beads of a variety of materials, wood objects, worked and unworked shell, precious metals, softstone vessels and animal bone. Clusters of sandstone were also identified throughout this horizon which are interpreted as the inorganic components of temporary or semi-permanent structures largely made of perishable organic materials. As discussed in further detail in **Paper 1**, it is important to note here that these remains are contemporary with the aforementioned archaeological area located 500 metres east of the Central Area and the smaller assemblage recovered from the Sanisera excavations in Area 2A (cf. Contreras Rodrigo *et al.* 2017).

Horizon I, encompassing activity at the site from c. 800 BCE through to the present day, is a deflated layer of slag, metallic objects, ceramics and animal bone that extends 120 metres north-south and ranges from 10-40 cm thick. This layer overlies the previous occupation horizons and disrupts the passage of dunes over the site, thereby largely protecting them from the full extent of dune movement and preserving the underlying stratigraphy of the site (i.e. Horizons V-II). The remains within this layer have been interpreted as the remains of industrial activity, including copper smelting in the Late Pre-Islamic and Early Islamic periods and the scavenging and recycling of iron (Stepanov *et al.* 2019; Weeks *et al.* 2019).

The archaeology of Saruq al-Hadid portrays a persistent, temporary site, with repeated occupation by members of mobile communities over 1200 years, from c. 2000-800 BCE, set against a background of more intermittent use of the site and its environs from the Neolithic period to the present day (Weeks *et al.* 2019). The differences between the five horizons highlight diachronic changes in the occupation of Saruq al-Hadid, hypothesised by Weeks *et al.* (2019: 19) to be a site occupied by members of a 'multi-sited community' in the Bronze Age, before becoming a site at which multiple communities gathered in the Iron Age.

Some levels of climatic change are also indicated in the sequence of archaeological horizons at Saruq al-Hadid in the form of increased magnitudes of dune accumulation from Horizon II onwards. However, the archaeobotanical evidence highlights consistency in the types of vegetation present at the site (Weeks *et al.* 2019: 11-12); while the site may have experienced dune accumulation in the Iron Age, it can be considered to be an arid landscape throughout the sequence of occupation identified by the SHARP excavations. While a number of significant insights were provided by the SHARP excavations, a number of fundamental questions remain regarding the occupation of Saruq al-Hadid – what drew people to the site in the early 2nd millennium BCE?; how did this site function within the network of late prehistoric sites in southeastern Arabia?; what drew people to return to the site repeatedly over 1200 years?

A comprehensive programme of material analysis, outlined by Weeks *et al.* (2017), accompanied the SHARP excavations in order to properly interpret the variety and abundance of material culture recovered from the site and address some of the questions raised by the SHARP excavations. Zooarchaeological analyses were a crucial component of this larger study.

1.3.2. Zooarchaeological Study

Over the course of SHARP's three excavation seasons, 1.5 metric tonnes of animal bone were recovered, with material from all occupation horizons at the site. Approximately two-thirds of this material was analysed in the field, over a period of 11 months. Remains were also analysed from the Sanisera excavations in Area 2A and the Dubai Municipality excavations that occurred simultaneously with the SHARP excavations in an adjacent portion of the Central Area, and in the aforementioned archaeological concentration located 500m east of the Central Area. Substantial assemblages of faunal material were only recovered from the SHARP and Dubai Municipality Government's excavations, however some remains were also recovered from the Sanisera excavations in Area 2A. The remains from all of these excavations were analysed by the candidate. It is important to note that faunal remains were also recovered from the excavations in the Central Area undertaken by the German team led by Dr Thomas Urban and Dr Christian Ihde, however these were not analysed by the candidate. The differences between these excavations and the relationship between the different excavation areas are explained in further detail in **Paper 1** below.

An integral part of the zooarchaeological work undertaken at Saruq al-Hadid by the candidate was the demonstration of the research potential of the faunal remains to our collaborators in the Dubai Municipality Government, highlighting the vast amounts of information that can be gleaned from seemingly indistinguishable, ubiquitous and visually dull fragments of bone. This endeavour culminated in the accession of zooarchaeological remains into the displays at the Saruq al-Hadid museum.

2. Theoretical Frameworks for Interpretation & Central Questions

2.1. Theoretical Background and Perspectives

At its foundational level, zooarchaeology provides insight into the interactions between humans and animals with a focus on the subsistence economy of past societies, informing on diet and resource capture and management. This line of enquiry is at the heart of zooarchaeological practice and is therefore a well-established use of the discipline. However, over recent decades zooarchaeologists have begun to use zooarchaeological remains to explore aspects of societies beyond the practicalities of diet and subsistence economies. Under the theoretical umbrella of 'Social Zooarchaeology' (cf. Russell 2011), faunal assemblages from archaeological sites have been used to investigate a wide array of societal questions involving animals, from the deification and ritualistic significance of animals (e.g. Conneller 2004; Russell *et al.* 2009; Hill 2013) to hunting practices and the social performances surrounding such activity (e.g. Hamilakis 2003; Sykes 2005; Arbuckle 2012; Blasco 2014).

Interrogation of zooarchaeological material in this manner often draws upon other lines of evidence outside of zooarchaeology (e.g. wider archaeology, ethnography, history, art history etc.), in order to appropriately tackle the complexities and address the nuances of human-animal relationships (e.g. Lupo & Schmitt 2005; Pluskowski 2007; Prendergast & Mutundu 2009; Martin & Meskell 2012; Sykes 2015). The interplay between the 'practical' and the 'social' is an important factor in this line of inquiry; subsistence needs and other practical uses of animals may influence the social perception of animals and, in turn, the social perception of a species may affect its practical use by humans. This interplay can be explored using zooarchaeological remains and other sources of evidence (e.g. Russell *et al.* 2009; Sapir-Hen *et al.* 2013). Additionally, subsistence strategies utilising multiple resource zones or rely upon exchange of resources between groups may result in a social dynamic of transhumance or inter-group relationships, which can also be explored using zooarchaeology (e.g. Crabtree 1990; de France 2009).

Therefore, it follows that zooarchaeological study, combined with other sources of evidence where appropriate, has great potential to address a number of the aforementioned gaps in our understanding of Saruq al-Hadid, and late prehistoric societies of southeastern Arabia more generally. Thus, this thesis follows an integrated theoretical approach that engages with practical aspects of the human-animal relationship, i.e. subsistence and economy, but which also engages, where appropriate, with the wider societal implications behind this relationship. Ethnographic and historical evidence is utilised throughout the thesis in order to explore hypotheses regarding human-animal relationships at Saruq al-Hadid. From this theoretical perspective, the zooarchaeological remains from Saruq al-Hadid provide an opportunity to explore fundamental questions about the site itself and late prehistoric Arabia more broadly. A social zooarchaeology perspective allows this thesis and its constituent papers a greater utility and significance for researchers studying the archaeology of southeastern Arabia, beyond the scope of traditional subsistence-focused zooarchaeological approaches.

2.2. Central Questions

This study aims to explore the implications of the faunal remains recovered from Saruq al-Hadid for our understanding of the site and the wider region. To address this aim, several smaller questions guided the research. In relation to the site itself:

1. What activities are represented by the animal bones?

2. Why were humans occupying an inland, desert area, so far away from the well-defined resource areas of the coast and the mountains?

3. What prompted humans to repeatedly occupy this site over 1200 years, and how did this occupation change through time?

The assemblage is also well placed to address human-animal interactions beyond Saruq al-Hadid. The animal bones derive from a stratified, comprehensively dated site (Weeks *et al.* 2019), located in a region of southeastern Arabia (the Rub’ al-Khali desert) in which the human past is poorly understood. They represent *c.* 1200 years of human-animal interactions, providing an as yet unique insight into how humans utilised animals to inhabit this under-studied region. Thus, exploring the ways in which the Saruq al-Hadid faunal assemblage compares to assemblages from contemporary sites became a major research focus of this project. This comparison was necessary to facilitate an assessment of how the human-animal relationships at Saruq al-Hadid could expand our understanding of human-animal relationships and wider human society in southeastern Arabia more broadly.

The importance of the temporality of the faunal remains also became increasingly clear through the course of the project and provoked a number of questions regarding the remains. The period to which the assemblage dates (*c.*2000 - *c.*800 BCE) spans a series of dramatic social changes in southeastern Arabia. The earliest occupation horizons in the SHARP excavations at Saruq al-Hadid date from 2000 – 1300 BCE, comprising two phases of local chronology; the Wadi Suq period and Late Bronze Age (**Table 1**). The Wadi Suq period has been dubbed the 'southeast Arabian Dark Age' (Cleuziou & Tosi 2007: 257), due to widespread abandonment of Umm an-Nar period sites and the ephemeral archaeological record typically associated with this period (Magee 2014: 187-189). The Wadi Suq period remains from Saruq al-Hadid, particularly the extensive assemblage of faunal material, are therefore an incredibly valuable resource when filling lacunae in our knowledge of Wadi Suq society. Determining what information the Wadi Suq period animal remains could provide regarding the nature of human behaviour in southeastern Arabia during this period presented itself as an important question to answer, and was therefore addressed in all papers of this thesis.

The dynamics of the transition from the Late Bronze Age (cf. Velde 2003) to the Iron Age are also poorly understood, due to a relative lack of archaeological remains from this time period (Magee 2014: 190). Once again, the faunal remains from Saruq al-Hadid are well positioned to help fill this gap in our understanding. The onset of the Iron Age in southeastern Arabia, from *c.* 1300 BCE onwards, is also of great interest to archaeologists studying the region. This period sees the introduction of a number of new technologies (Uerpmann & Uerpmann 2002; Magee 2014: 215), settlement patterns (Potts 2001: 49; Magee 2007; Magee 2014: 214) and social practices (Benoist 2007; 2010; Benoist *et al.* 2014) that dramatically changed the trajectory of human occupation in southeastern Arabia. This includes the widespread introduction of the domesticated dromedary camel, a particularly significant topic in the zooarchaeology, and indeed the wider archaeology, of southeastern Arabia and beyond (Uerpmann & Uerpmann 2002; Magee 2015). Thus, establishing how the animal bone assemblage from Saruq al-Hadid related to and reflected these Iron Age innovations, particularly the introduction of the domestic dromedary, also became a central research focus of this thesis.

3. The Archaeological Significance of the Study and Human-Animal Relationships in Southeastern Arabia More Broadly

3.1. Understanding Saruq al-Hadid

The most obvious significance of this study lies in understanding human activity at Saruq al-Hadid. Animal remains are one of the few material classes that were recovered in substantial amounts from every occupation phase at the site and are therefore integral to our understanding of the long-term occupation of Saruq al-Hadid and how this changed over time. The abundance of animal remains recovered from the site suggests that animals were a major part of life at Saruq al-Hadid; the study of those remains elucidates numerous aspects of human activity at the site that are not necessarily addressed by other material classes.

The animal remains also provide answers to some broader questions regarding the occupation of Saruq al-Hadid, including the original impetus for inhabiting the site and the motivations behind the repeat occupation over 1200 years. Identifying the animals utilised at Saruq al-Hadid, particularly wild species, demonstrates which animals were present at the site and its environs in the past. In turn, this provides insight into how humans would have been able to survive at this inland site away from the well-established habitation zones of the coast and the mountains.

3.2. Implications for the Archaeological Understanding of the Wider Region

Saruq al-Hadid represents a hugely significant addition to the archaeological framework of southeastern Arabia (Weeks *et al.* 2018). The nature of occupation represented through time at the site is so far unique in the archaeology of the region (Weeks *et al.* 2017; 2019), and developing our understanding of what activities and behaviours are represented by this occupation is an important objective.

Understanding Saruq al-Hadid therefore has major implications for the wider comprehension of human occupation in southeastern Arabia during late prehistory. Exploring the nature of human activity at the onset of the second millennium BCE is of great significance, due to the aforementioned social reorganisation that occurred from 2000 BCE, marking the end of the Umm an-Nar period and the transition in the Wadi Suq Period. Understanding how the intensification of activity at Saruq al-Hadid, observed during Horizons V (*c*. 2000-1750 BCE) and IV (*c.* 1750 – 1300 BCE), relates to these wider social changes provides a new insight into human behaviour during this poorly understood period.

In a similar vein, characterising changes in the nature of occupation observed at Saruq al-Hadid will also prove fruitful in terms of examining the onset of the Iron Age in southeastern Arabia, and how Saruq al-Hadid was utilised during this period of change. In particular, the appearance of domesticated dromedary camels in southeastern Arabia after the onset of the Iron Age is a major focus of research, to which the faunal remains from Saruq al-Hadid are well positioned to contribute. Furthermore, the onset of the Iron Age in southeastern Arabia is associated with wider climatic changes (Parker *et al.* 2006), as reflected by the aforementioned dune accumulation identified at Saruq al-Hadid. As discussed above, the faunal assemblage is an invaluable resource in exploring diachronic trends at the site and therefore can contribute towards the wider discussion of climatic change in the desert zone through time, and how this affected the human-animal relationship at Saruq al-Hadid.

Moving beyond period-specific issues, a number of aspects of the faunal assemblage from Saruq al-Hadid have implications for our understanding other facets of southeastern Arabian archaeology. Of particular importance is the contribution that the dromedary camel bones from Saruq al-Hadid make towards the wider discussion surrounding the domestication of this animal. This topic is central to late prehistoric southeastern Arabian archaeology (Uerpmann & Uerpmann 2002; Magee 2015; Uerpmann & Uerpmann 2017), as it has major ramifications for all aspects of human activity during this period. Additionally, the domestication of the dromedary camel also impacted upon regions adjacent to Arabia, facilitating the spread of peoples, trade goods and warfare out of the Arabian Peninsula (Bulliet 1975; Artzy 1994; Magee 2015). Elucidating the dynamics behind this animal's domestication is therefore of great importance to our understanding of late prehistory throughout the wider Near East.

3.3. The Human Past in Desert Environments

In addition to its significance for furthering the understanding of late prehistoric southeastern Arabia, this study ties into a number of ongoing projects that are focused on understanding the nature of human occupation in the desert spaces of Arabia and adjacent regions. These multi-period, multi-regional studies examine how human societies navigated and utilised desert spaces, often focusing on adaptations made to their behaviour in order to integrate these spaces into wider areas of habitation (e.g. Herrmann *et al.* 2012; Akkermans *et al.* 2014; Crassard *et al.* 2015; Carvajal-López *et al.* 2017). Animals are often presented as an important part of these behaviour adaptations, with frequent representations of animals in rock-art (Maraqten 2015; Bruusgard 2019), architectural features related to the hunting and trapping of animals (Akkermans *et al.* 2014; Crassard *et al.* 2015) and remains of animals themselves left at archaeological sites (Chahoud *et al.* 2015; Beech *et al.* 2017; Marom *et al.* 2019). Zooarchaeological research at Saruq al-Hadid, and indeed the study of other components of material culture from the site, therefore stands to contribute to this wider framework by demonstrating how the desert zone of southeastern Arabia was utilised and integrated with other environmental zones in its surroundings.

4. An Outline of The Collection of Papers

The collection of papers that comprise the main body of this thesis are listed here. Their relationship to one another – in terms of their contributions to the overall research goals of the zooarchaeological study – is displayed in **Figure 3**.

1. *Zooarchaeological studies* (Chapter 6 of Saruq al-Hadid Archaeological Research Project Monograph).

2. *The role of wild terrestrial animals in late prehistoric societies of southeastern Arabia: new insights from Saruq al-Hadid.*

3. *The changing relations between humans and the dromedary camel (*Camelus dromedarius*) in Late Prehistoric Arabia: new zooarchaeological evidence from Saruq al-Hadid.*

4. *The exploitation of marine resources at Saruq al-Hadid: insights into the movement of people and resources in Bronze and Iron Age southeastern Arabia.*

5. *Preliminary insights into late prehistoric fish procurement strategies in the desert interior of southeastern Arabia: the results of LA-ICP-MS analysis of a fish otolith assemblage from Saruq al-Hadid, UAE.*

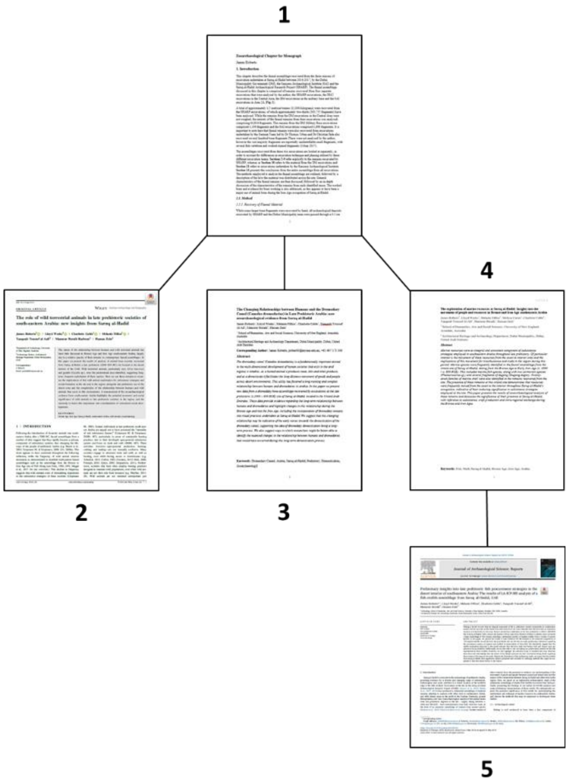

Figure 3. *A flow chart depicting the conceptual links between the papers that comprise this thesis.*

The first paper will be published as a chapter in the upcoming monograph on the 2014-2017 SHARP excavations at Saruq al-Hadid. Within it the substantial zooarchaeological dataset from Saruq al-Hadid is presented and, where appropriate, compared with other zooarchaeological datasets from the region. This chapter contains some interpretation of the faunal material, however its main purpose is to descriptively present raw zooarchaeological data and highlight the key features of the faunal assemblage.

The second, third and fourth papers explore different aspects of the faunal remains that both provide insights into the nature of occupation at Saruq al-Hadid and help to place Saruq al-Hadid within the archaeological framework of late prehistoric southeastern Arabia, Arabia more widely, and desert spaces in general.

Paper 2 presents the wild terrestrial animal remains recovered from the site, exploring potential reasons why the faunal assemblage from Saruq al-Hadid contains a higher frequency of wild terrestrial animals than other sites in the region. Paper 3 focuses on another aspect of the faunal remains that sets them apart from other regional assemblages – the nature of the camel bones – and the way in which they contribute to our wider understanding of human-dromedary relationships in late prehistory. Paper 4 then presents the remains of marine animals recovered from Saruq al-Hadid, demonstrating the networks in place between Saruq al-Hadid and coastal sites. Some questions regarding these links, raised in the fourth paper are further explored in the fifth paper, which presents the results of preliminary studies undertaken on the fish otolith assemblage from Saruq al-Hadid.

A number of papers featuring the candidate as co-author have also been included in the appendices (**Appendix 1a-1c**). These papers serve to further contextualise the faunal assemblage discussed in this thesis and provide additional information regarding the other material classes from the site. The appendices also contain all the anatomical measurements recorded from the remains (**Appendix 2**). The remaining raw data from the zooarchaeological analyses are available here: https://rune.une.edu.au/web/index.jsp.

5. Paper 1

The first paper in this thesis is entitled '*Zooarchaeological Studies*'. It is a chapter in the upcoming monograph from the SHARP excavations, intended to be published alongside a number of other chapters detailing the other studies undertaken at Saruq al-Hadid (**Table 4**).

The publication and dissemination of the primary zooarchaeological data from Saruq al-Hadid is the major motivation for the production of this paper. As such, it is data heavy and descriptive. Within the context of this thesis, it serves as an introduction to the prodigious zooarchaeological assemblage on which the rest of the papers are based. It also serves to highlight the most significant aspects of the assemblage, however it relies upon the successive papers to explore these aspects in further detail.

Given the potential implications of the findings presented in the other papers included in this PhD, the publication of this data is of fundamental significance and Paper 1 therefore forms the keystone of this thesis.

Table 4. *List of chapters to be included in the SHARP monograph alongside* ***Paper 1.***

Chapter List
1. Introduction
2. SHARP Excavations
3. Absolute Dating
4. Archaeobotanical Studies
5. Phytolith Studies
6. Zooarchaeological Studies
7. Stone Artefacts
8. Soft Stone Vessels
9. Ceramics
10. Copper Metallurgy
11. Ferrous Metallurgy
12. Gold, Silver, Lead & Antimony
13. Other Materials: Beads, Seals, Textiles
14. Saruq al-Hadid and Late Prehistoric Arabia
15. Ongoing and Future Research

Higher Degree Research Thesis by Publication
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Candidate

06/09/2019
Date

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Principal Supervisor

06/09/2019
Date

Zooarchaeological Studies (Chapter for Monograph)

James Roberts

1. Introduction

This chapter describes the faunal assemblage recovered from the three seasons of excavation undertaken at Saruq al-Hadid between 2014-2017. The faunal assemblage discussed in this chapter is comprised of remains recovered from four separate excavations that were analysed by the author, including: those by the Saruq al-Hadid Archaeological Research Project (SHARP) in the Central Area; by the Dubai Municipality Government (DM) in the Central Area and the Military Base area; and by the Sanisera Archaeological Institute (SAI) in Area 2A (**Fig. 1**).

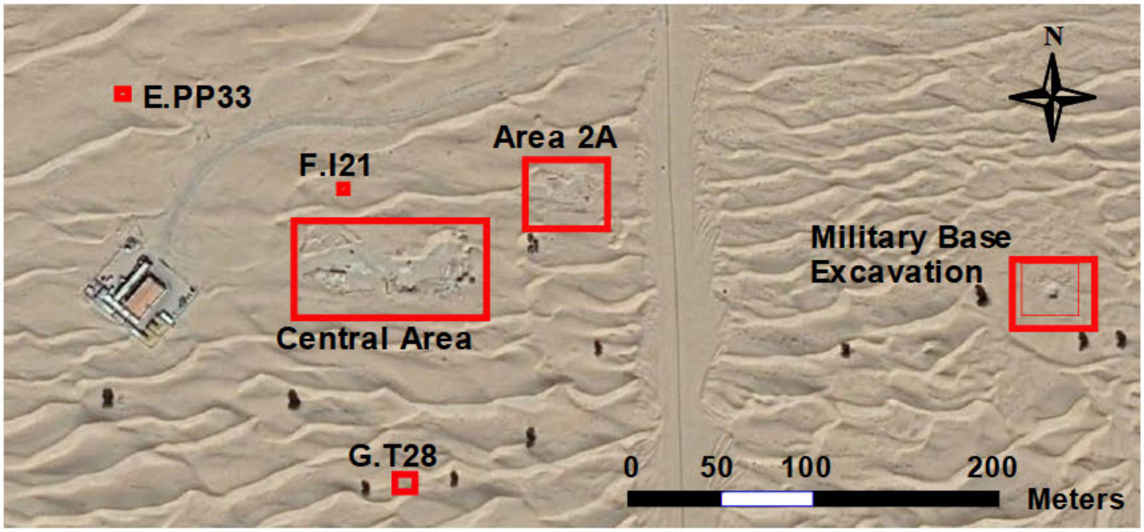


Figure 1. *A map displaying the different excavation areas referred to in this text. Map data: © Maxar Technologies (Google Earth).*

A total of 1.5 metric tonnes (1,420.5 kilograms) of bone were recovered from the SHARP excavations, of which approximately two-thirds (363,755 fragments) have been analysed. While the remains from the DM excavations in the Central Area were not weighed, the entirety of the faunal remains from their excavations was analysed, comprising 64,814 fragments. The remains from the DM Military Base excavations comprised 1,106 fragments and the SAI excavations comprised 1,868 fragments. The several hundred bone fragments recovered in excavations undertaken by the German Team (directed by Dr Thomas Urban and Dr Christian Ihde) have not been analysed by the author, however the vast majority of that sub-assemblage reportedly comprises unidentifiable small fragments, with several fish vertebrae and worked/stained fragments (Ihde 2017).

The assemblages recovered from these excavations are looked at separately to account for differences in excavation technique and phasing utilised by each team. **Sections 2-9** refer specifically to the remains excavated by SHARP, whereas as **Section 10** presents the material from the DM excavations and **Section 11** relates to excavations undertaken by the Sanisera Archaeological Institute. **Section 12** presents the conclusions from the entire assemblage from all excavations. The methods employed to analyse the faunal assemblage are outlined, followed by a description of the how the material was distributed across the site. General characteristics of the faunal remains are then discussed, followed by an in-depth discussion of the characteristics of the remains from each identified taxon. The worked bone and evidence for bone working is also addressed, as this appears to have been a major use of animal bone during the Iron Age occupation of Saruq al-Hadid.

1.1. Method

1.1.1. Recovery of Faunal Material

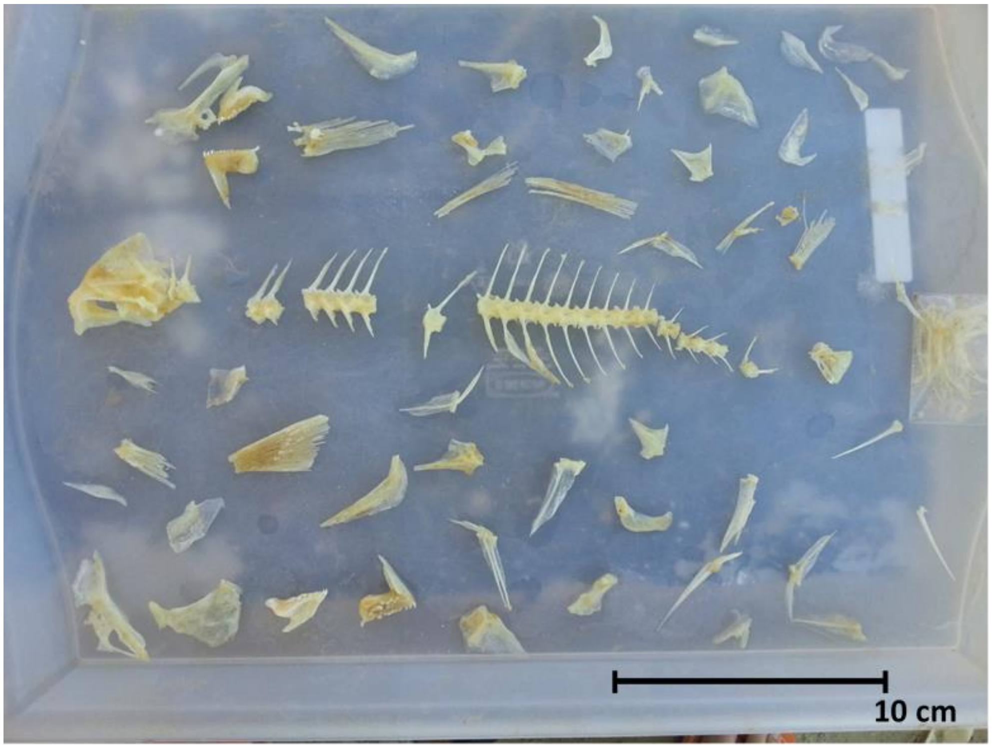
Figure 2. *Remains recovered by the sieving process from a typical Horizon IV context.*

While some larger bone fragments were recovered by hand, all archaeological deposits excavated by SHARP and the Dubai Municipality team were passed through a 0.3 cm sieve whilst still dry to ensure recovery of smaller bone fragments. This led to the recovery of a large number of fragments (**Fig. 2**). Due to the comprehensive sieving undertaken on site, the remains recovered by hand and those recovered from the 0.3 cm sieve were amalgamated for each context and analysed together. SHARP excavations employed a single context recording methodology based on the delineation of individual features and deposits, with all excavated material being separated by context. In some instances, artificial ‘spits’ of 5 cm or 10 cm depth were employed where differences in deposits could not be identified during the course of excavation. Excavated bone from all contexts was stored separately after analysis, while the data generated from the analysis of individual contexts were aggregated into broader stratigraphic units (‘Horizons’) in order to facilitate phasing and interpretation. Further details are provided below. This methodology contrasts with that employed by the DM excavation team, who also sieved their deposits but amalgamated all remains from each of the occupation 'loci' they excavated during their excavations, as opposed to keeping individual contexts separate.

1.1.2. Building a Reference Collection

To facilitate the identification of the archaeological faunal remains, the skeletal remains of modern species local to the site were collected over the three seasons of excavation. The species that were recovered and incorporated into the on-site reference collection are listed in **Table 1**. A number of remains, particularly those of gazelle and camel, had been thoroughly dried by exposure to the sun (**Fig. 3**) and therefore did not require preparation before use as reference material. Remains of smaller species that were still fleshed, such as a spiny tailed lizard, were macerated over the course of several weeks (**Fig. 4**). The remains of oryx were macerated with a biological washing powder to increase the speed of the cleaning process (**Fig. 5**). Three fish skeletons from different species were also prepared for use as reference material (**Fig. 6**). These fish, along with the oryx's skull, have since been put on display in the Saruq al-Hadid museum to highlight the importance of zooarchaeological studies at the site (**Fig. 7**).

Figure 3. *Remains of a non-archaeological juvenile camel, bleached by the sun.*



Top Left: **Figure 4.** *Bones of a spiny-tailed lizard, (*Uromastyx aegyptia microlepis*), post-maceration.* ***Top Right:*** **Figure 5.** *The skull of the oryx specimen, (*Oryx leucoryx*), during the maceration process.* ***Bottom Left:*** **Figure 6.** *The skeleton of a Haffara Seabream (*Rhabdosargus haffara*), post maceration. Once clean, this skeleton was reassembled, using epoxy-resin, and mounted for display in the Saruq al-Hadid Museum (see* ***Fig. 7****).*

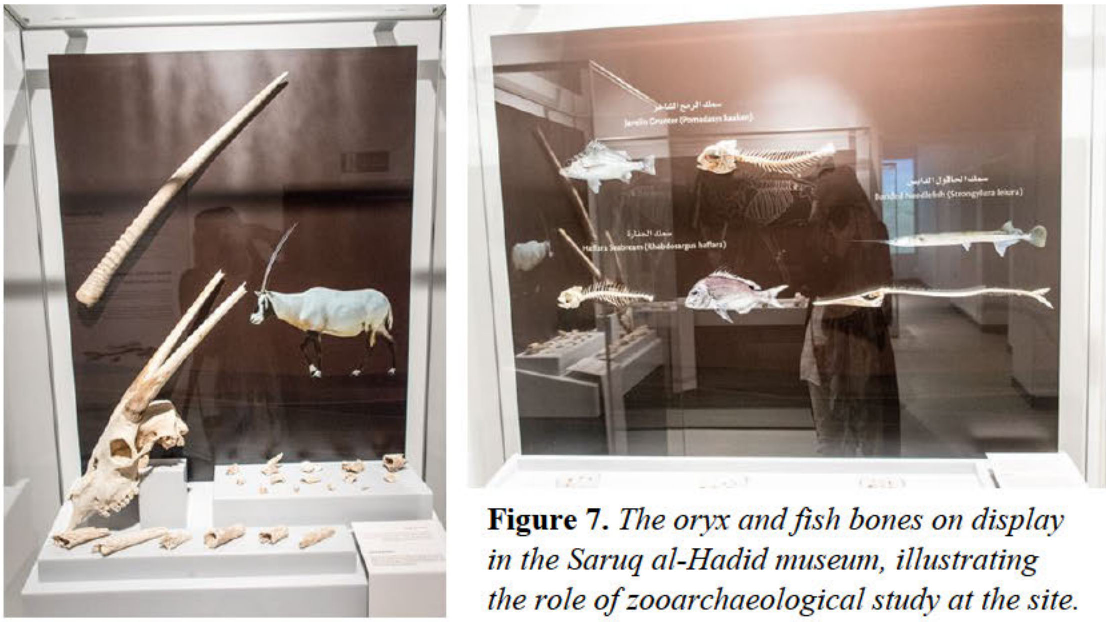


Figure 7. *The oryx and fish bones on display in the Saruq al-Hadid museum, illustrating the role of zooarchaeological study at the site.*

Table 1. *The specimens collected for the reference material utilised in this study.*

Species	Common Name	Elements Present	Treatment
Camelus dromedarius	Dromedary Camel	Full carcass	Maceration
Oryx leucoryx	Arabian Oryx	Full carcass	Maceration
Camelus dromedarius	Dromedary Camel	Skull	Exposure to the sun (Prior to collection)
Camelus dromedarius	Dromedary Camel	Tibia (unfused); Femur (unfused); Astraglus; 1st phalanxes (unfused)	Exposure to the sun (Prior to collection)
Camelus dromedarius	Dromedary Camel	Full carcass (foetal)	Exposure to the sun (Prior to collection)
Gazella saudiya	Gazelle	Skull	Exposure to the sun (Prior to collection)
Gazella saudiya	Gazelle	Skull; scapula; humerus; radius	Maceration
Columba sp.	Pigeon	Full carcass	Maceration
Uromastyx aegyptia microlepis	Spiny tailed lizard	Full carcass	Maceration
Phrynocephalus arabicus	Arabian Toad-Headed Agama Lizard	Full carcass	Maceration

1.1.3. Specimen Identification

All fragments of bone recovered from the site underwent visual examination, during which each fragment was taxonomically identified to varying degrees of detail (e.g. Order, Class, Family, Genus, Species etc. - **Table 2**) utilising both the reference collection described above and identification guides (e.g. Cohen & Serjeantson 1996; Hillson 1992; Olsen 1968; Schmidt 1972). Birds and fish were separated from the wider assemblages for further taxonomic identification. Bird remains were identified using the skeletal reference collection housed at the Natural History Museum at Tring, U.K. and the fish remains were identified using the skeletal reference collection kept by Dr Mark Beech, Abu Dhabi Department of Culture and Tourism, housed privately in Abu Dhabi.

Where possible, each fragment was identified to skeletal element and anatomical side. The proportion of each element represented by the fragment was recorded, according to Serjeantson's (1996) 'Eight Zones per Bone' system for mammalian remains and Cohen & Serjeantson's (1996) system for bird remains. A zoning system was also devised for mandibles (**Fig. 8**), allowing for their incorppration into the 'Eight Zones per Bone' recording system. This approach allowed for the calculation of the Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and therefore the calculation of the Minimum Number of Individuals (MNI - **Table 3**). All anthropogenic alterations (i.e. butchery marks [following Lauwerier 1988; Sykes 2005], burning marks [following Lyman 1994], worked fragments) and other alterations (i.e. staining and gnawing) observed on each fragment were also recorded and described.

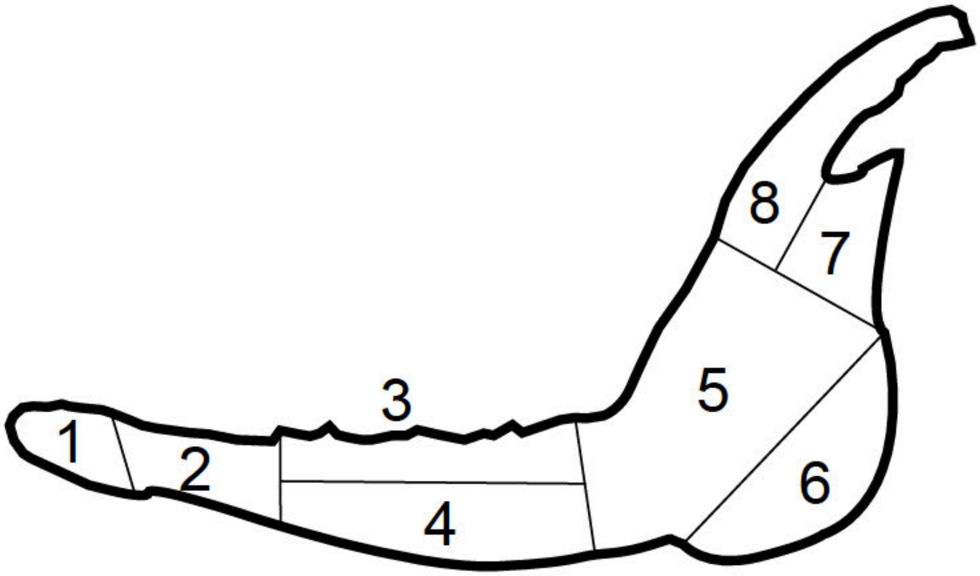


Figure 8. *The zoning system devised to record mandibular fragments.*

Table 2. *Number of identified specimens (NISP) of taxa identified across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Cattle	-	-	-	10	-	3	13
Goat	2	53	60	46	-	70	231
Ovicaprid	33	139	89	665	23	161	1110
Domestic Animals	**35**	**192**	**149**	**721**	**23**	**234**	**1354**
Camel	65	480	548	1821	28	1143	4085
Canid, indet.	1	2	1	15	-	9	28
Wild or Domestic Animals	**66**	**482**	**549**	**1836**	**28**	**1152**	**4113**
Oryx	163	1810	875	3809	48	1709	8414
Gazelle	57	493	229	720	1	417	1917
Hare	9	15	-	42	-	16	82
Lagomorph, indet.	1	14	85	74	2	33	209
Rodent	156	129	3532	190	2	702	4711
Reptile	20	333	3218	197	1	595	4364
Bird (excl. cormorant)	-	9	43	12	3	23	90
Wild Terrestrial Animals	**406**	**2806**	**7986**	**5067**	**59**	**3497**	**19787**
Cormorant	-	3	4	23	2	2	34
Dugong	-	-	-	6	-	2	8
Fish	59	557	1671	5975	150	1346	9758
Marine Animals	**59**	**557**	**1671**	**5964**	**150**	**1348**	**9783**
Total Identified	**566**	**4037**	**10355**	**13588**	**260**	**6231**	**35037**
Large Mammal	587	3662	3156	8850	11	8716	24982
Medium Mammal	782	5377	4436	18650	23	13530	42798
Small Mammal	33	139	552	644	9	488	1865
Unidentified	7100	25996	18328	155258	2916	49458	259056
Grand Total	**9068**	**39211**	**36827**	**196990**	**3219**	**78440**	**363755**

Table 3. *Minimum Number of Individuals (MNI) of taxa identified across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Cattle				3		**3**
Goat	1	9	12	14		**36**
Ovicaprid	1	7	14	49	6	**77**
Camel	1	33	32	84	8	**158**
Canid, indet.	1	1	1	3		**6**
Oryx	3	112	55	225	13	**408**
Gazelle	2	28	19	62	1	**112**
Hare	2	4	15	24	1	**46**
Rodent	2	30	63	28	1	**124**

1.1.4. Data Recording

All data were recorded directly into an Excel spreadsheet. Information was recorded from each individual fragment for 542 contexts. Due to time constraints during the field season, only total values of each taxa (i.e. NISP per skeletal element, MNE per skeletal element, MNI) from 124 contexts were recorded. The raw data from these analyses are available here: https://rune.une.edu.au/web/index.jsp

2. Distribution of Material and Taphonomic Considerations

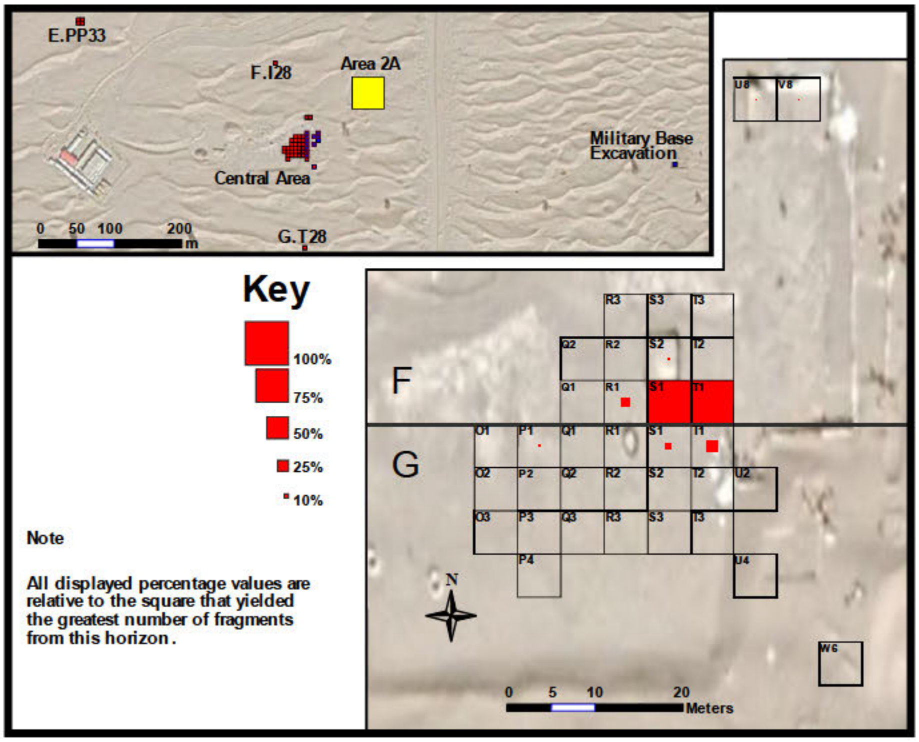
The SHARP excavations recovered animal bone from across the site. Before examining the taxonomic content of this assemblage, the distribution of bone across the site in each horizon is summarised.

2.1. Horizon V (2000 – 1750 BCE)

Relatively few remains were recovered from Horizon V, but those that were concentrated around squares F.R1, F.S1, F.T1, G.S1 & GT.1 (**Table 4**, **Fig. 9, Fig. 10**). These remains were often in direct association with hearths and other archaeological features excavated just above or cut into the gypsum surface that underlies the Central Area of the site. Furthermore, a relatively large portion of these remains was burnt (**Table 5**, **Fig. 11**). A diffused layer of bone was also identified on an ancient dune surface overlying the gypsum surface.

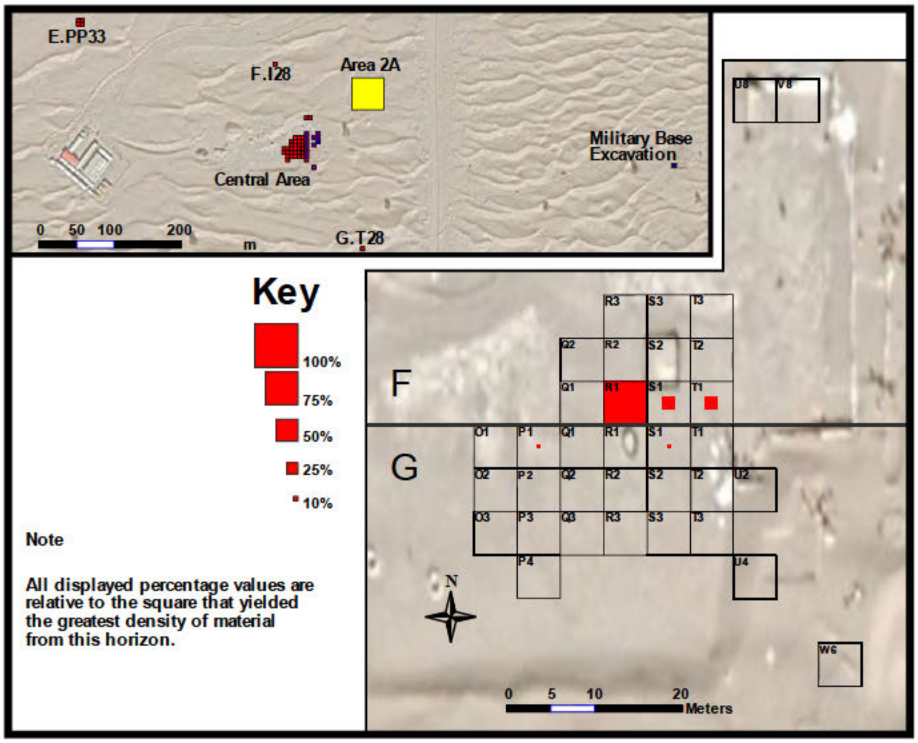
Table 4. *The number of fragments analysed from each square excavated by SHARP across all horizons.*

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
E	PP33	10						**10**
F	Q1	435	339		2752		46	**3572**
	Q2				2089			**2089**
	R1		1153	13360		221	8821	**23555**
	R1/R2						2097	**2097**
	R2		1212		38998		14104	**54314**
	R3						4826	**4826**
	S1	111	7270	16122	19336	1238	6867	**50944**
	S2	499	4954		35476	31	2853	**43813**
	S3		2		3006		3293	**6301**
	S3/T3						7272	**7272**
	T1	490	3542	7	19232	1232	5995	**30498**
	T2	93	913	1550	9944		3229	**15729**
	T3						1497	**1497**
	U8	7						**7**
	V8	2						**2**
G	O3						149	**149**
	P1		272		20240	43	2170	**22725**
	P2		365				490	**855**
	P3	148	651				317	**1116**
	P4	76	1364				173	**1613**
	Q1	1446	127	991			906	**3470**
	Q2	104	303	12			114	**533**
	Q3	1150	3225				1591	**5966**
	R1	497	1005	1229	1255		1976	**5962**
	R2		461				2080	**2541**
	R3	533	2009				814	**3356**
	S1	395	2535	1674	25186	154	4612	**34556**
	S2	2729	2668	1591	2968		482	**10438**
	S3	105	1457				266	**1828**
	T1		884	291	16508	300	835	**18818**
	T2		1479				469	**1948**
	T3		987				96	**1083**
	T28	217						**217**
	U2	1						**1**
	U4	20						**20**
	W6		34					**34**
Total		**9068**	**39211**	**36827**	**196990**	**3219**	**78440**	**363755**



All displayed percentage values are relative to the square that yielded the greatest number of fragments from this horizon.

Figure 9. *The distribution of fragments from Horizon V, across the squares excavated by SHARP. Map data: © Maxar Technologies (Google Earth).*



All displayed percentage values are relative to the square that yielded the greatest density of material from this horizon.

Figure 10. *The density distribution of faunal remains from Horizon V. Map data: © Maxar Technologies (Google Earth).*

Table 5. *The number and percentage of burnt fragments in each horizon. Colour classifications after Lyman (1994).*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring	136 (20.5%)	88 (8.6%)	1065 (48.2%)	11651 (28.3%)	401 (49.4%)
Charred, burnt black	74 (11.1%)	381 (37.4%)	396 (17.9%)	11734 (28.5%)	94 (11.6%)
Grey	254 (38.4%)	259 (25.4%)	338 (15.3%)	7452 (18.1%)	66 (8.1%)
Burnt white	173 (26.2%)	263 (25.8%)	367 (16.6%)	9017 (21.9 %)	201 (24.8%)
Calcined	25 (3.8%)	29 (2.8%)	44 (2%)	1317 (3.2%)	50 (6.1%)
Burnt Fragments	**662**	**1020**	**2210**	**41171**	**812**
Percentage of Horizon Fragments Total	***7.3***	***2.6***	***6***	***20.9***	***25.2***

Figure 11. *Burnt fragments of faunal bone recovered from Context 2451, Square F.T1, found in association with a hearth feature.*

2.2. Horizon IV (1750 – 1300 BCE)

The vast majority of the fragments recovered during the SHARP excavation were associated with Horizon IV (**Table 4**). Indeed, Horizon IV is largely defined by a high concentration of animal bone that appears to form a midden (also referred to as the 'Bone Layer' – cf. Herrmann *et al.* 2012), a relatively large amount of which has been burnt (**Table 5**). This midden is centred on squares F.R2 and F.S2, however also extends into a number of adjacent squares (**Fig. 12**). The density of faunal remains in F.S2 was particularly high (**Fig. 13**, **Fig. 14**), with the remains becoming more diffuse away from these central squares. The remains from this horizon were generally highly fragmented, yet some intact specimens were recovered (**Fig. 15**). While some of this material was likely fragmented by anthropogenic processes (i.e. marrow extraction), it is probable that the majority of this fragmentation was caused by natural taphonomic processes (**Section 2.7**).

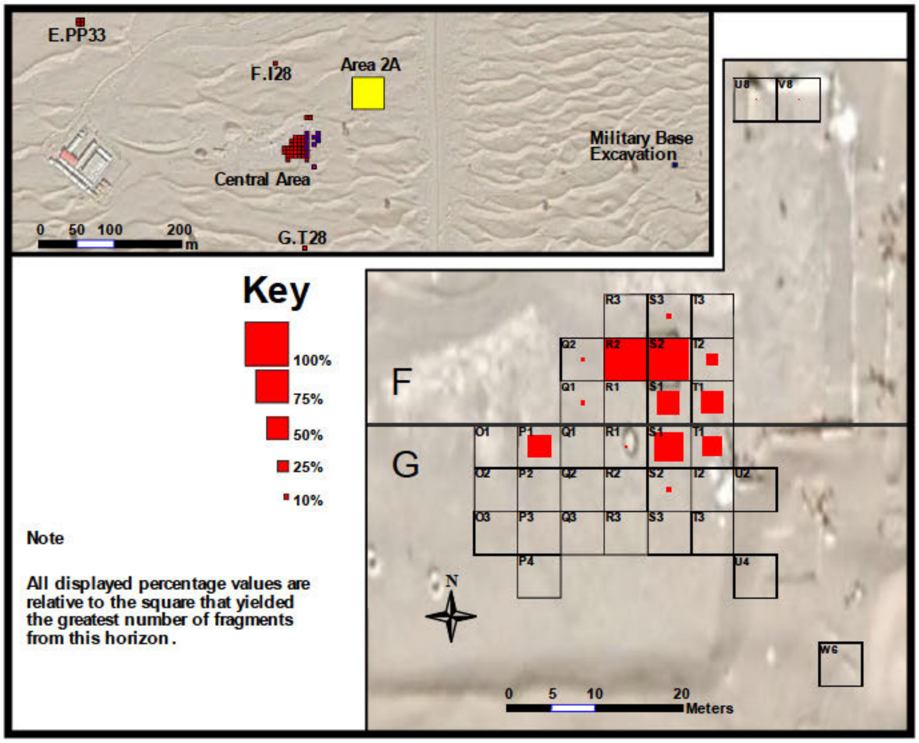


Figure 12. *The distribution of fragments from Horizon IV, across the squares excavated by SHARP. Map data: © Maxar Technologies (Google Earth).*

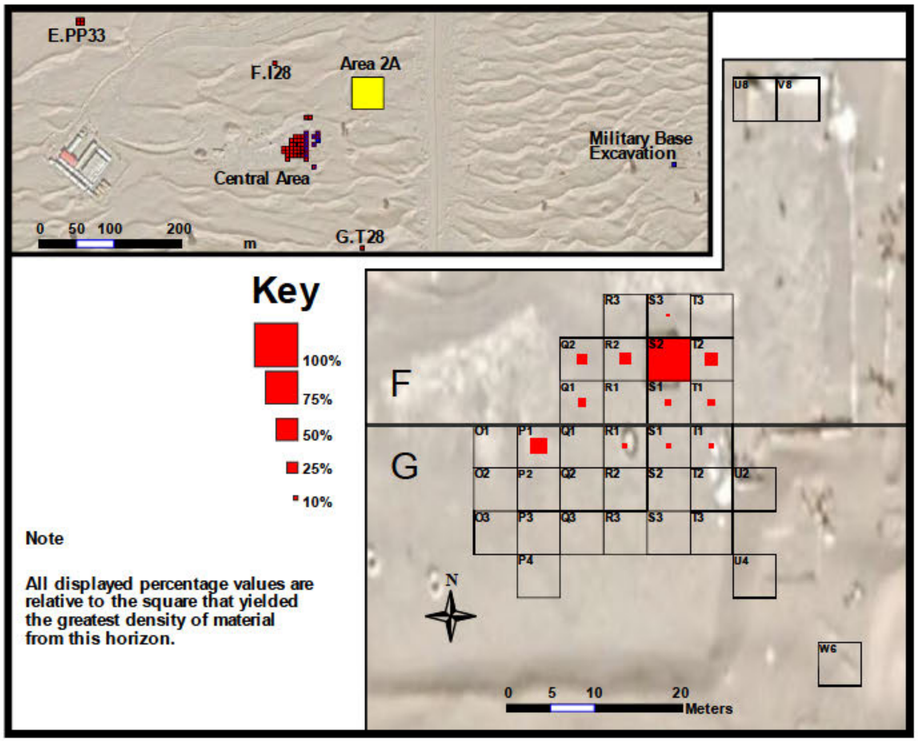


Figure 13. *The density distribution of faunal remains from Horizon IV. Map data: © Maxar Technologies (Google Earth).*

Figure 14. *An image demonstrating the density of animal bone, H. IV, Square F.S2.*

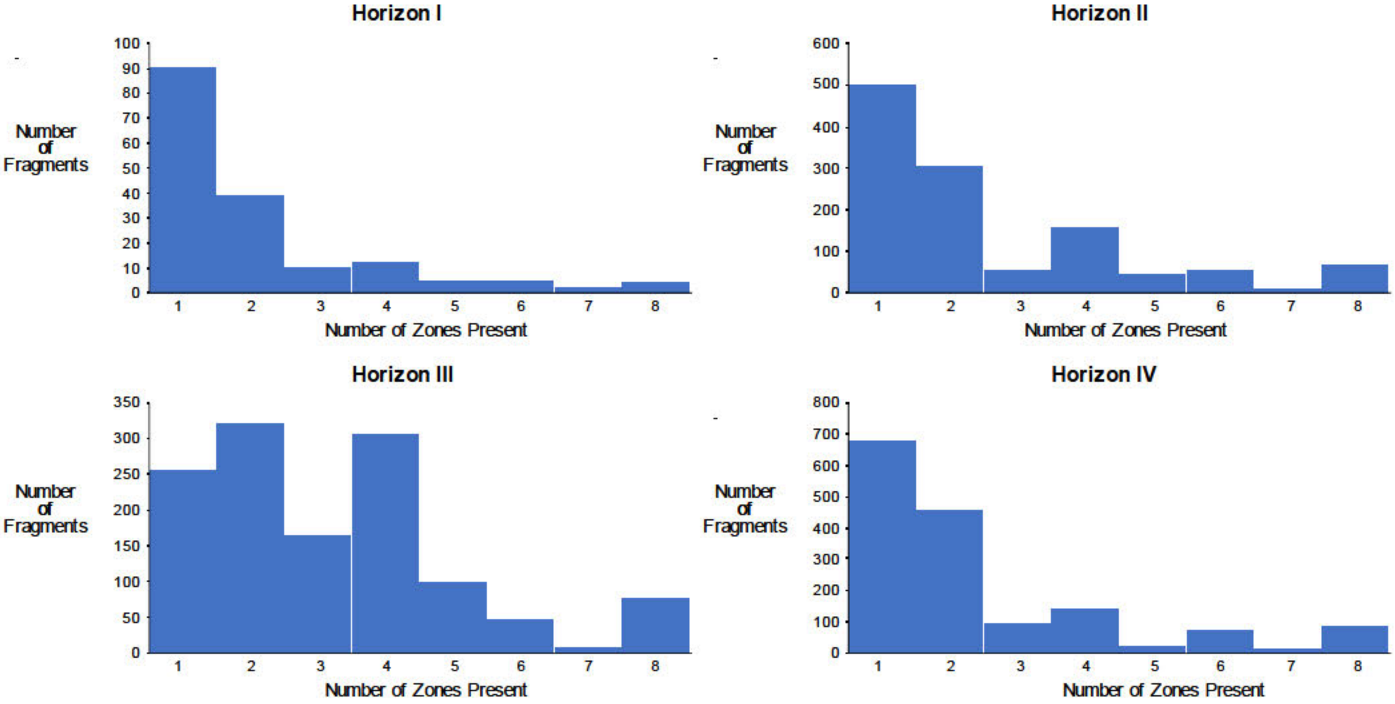


Figure 15. *The number of faunal bone fragments recorded with each zone present, following Serjeantson's '8 Zone per Bone' system.*

It was unclear as to how many individual 'events' are represented by this bone midden, however a number of hearths were identified within different layers of the midden itself, indicating repeated interactions. Additionally, absolute dating of samples taken from Horizon IV demonstrates that it was deposited over several centuries (Weeks *et al.* 2019). The burning rates observed on this material, combined with the presence of hearths throughout the horizon, and the representation of complete carcasses strongly suggests these remains are the waste from consumption.

2.3. Horizon III (1300 – 1000 BCE)

The vast amount of bone from this horizon were recovered from squares F.R1 and F.S1, however faunal material in this horizon was spread over a relatively large area of the excavations (**Table 4**, **Fig. 16**, **Fig. 17**). The faunal remains from this context were recovered from distinct deposits (e.g. **Section 4.1**) that were in some instances in direct association with other objects, as discussed in further detail below (**Section 5.1**). This horizon also contained a high number of rodent and reptile bones. While some of these fragments are undoubtedly the result of human activities (**Sections 5.4** & **5.5**), a large number of them likely became deposited at the site via natural processes. A number of rodents and reptiles were witnessed at the site today and their burrows were occasionally identified in excavations (**Fig. 18**).

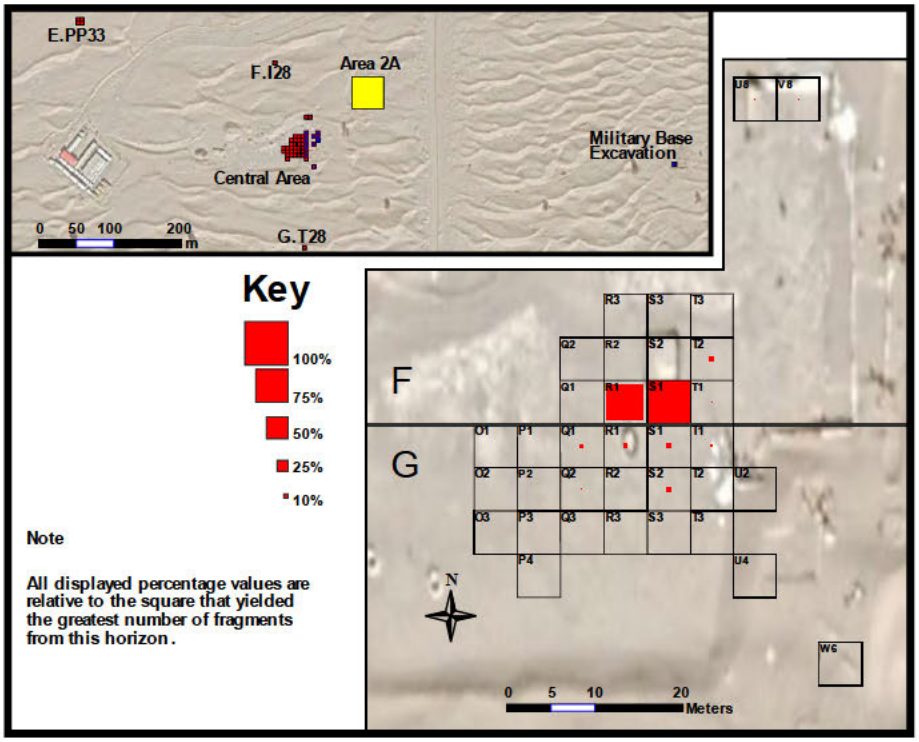


Figure 16. *The distribution of fragments from Horizon III, across the squares excavated by SHARP. Map data: © Maxar Technologies (Google Earth).*

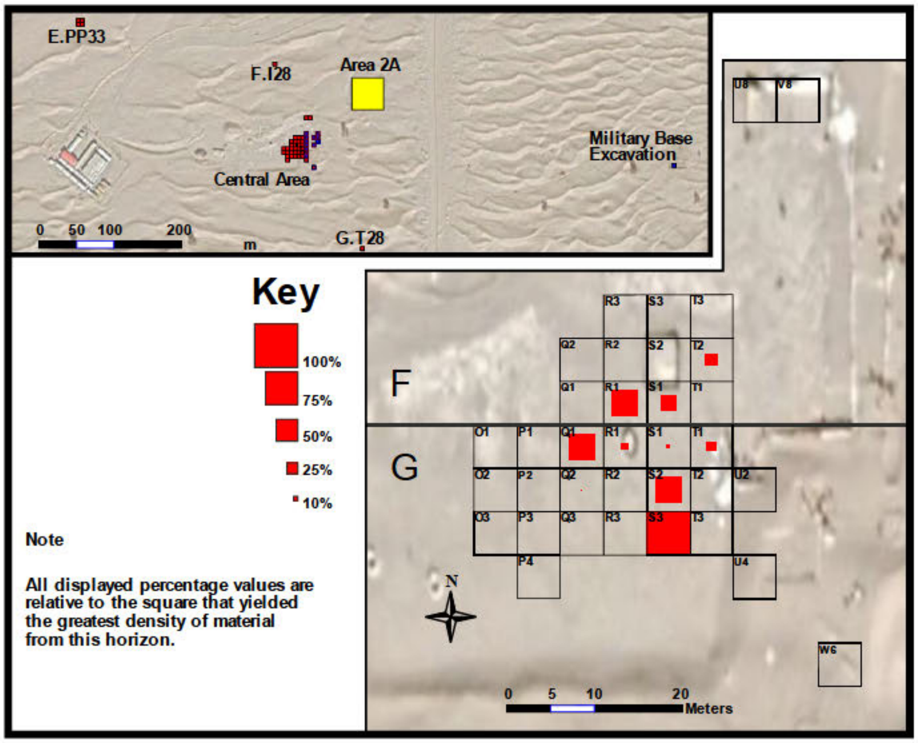


Figure 17. *The density distribution of faunal remains from Horizon III. Map data: © Maxar Technologies (Google Earth).*

Figure 18. *Animal burrows identified during excavations, circled in red (top), demonstrating the presence of burrowing animals (i.e. rodents, reptiles, lagomorphs) at the site.*

2.4. Horizon II (1000 – 800 BCE)

Remains associated with Horizon II were recovered from the widest area of the site (**Table 4**), with fragments concentrated in F.S1, F.S2, F.T1, G.Q3, G.S1 and G.S2 (**Fig. 19**, **Fig. 20**). The faunal remains from this horizon were excavated from discrete deposits, consisting of animal bone occasionally associated with beads of various materials (Weeks *et al.* 2017: Fig. 23). These remains were highly fragmented (**Fig. 15**), with large numbers of small fragments (<5mm^2) recovered. The high fragmentation rates observed in this horizon were amplified by the preponderance of elements prone to fragmentation (i.e. horncores and long bones; Madgwick & Mulville 2012: 511).

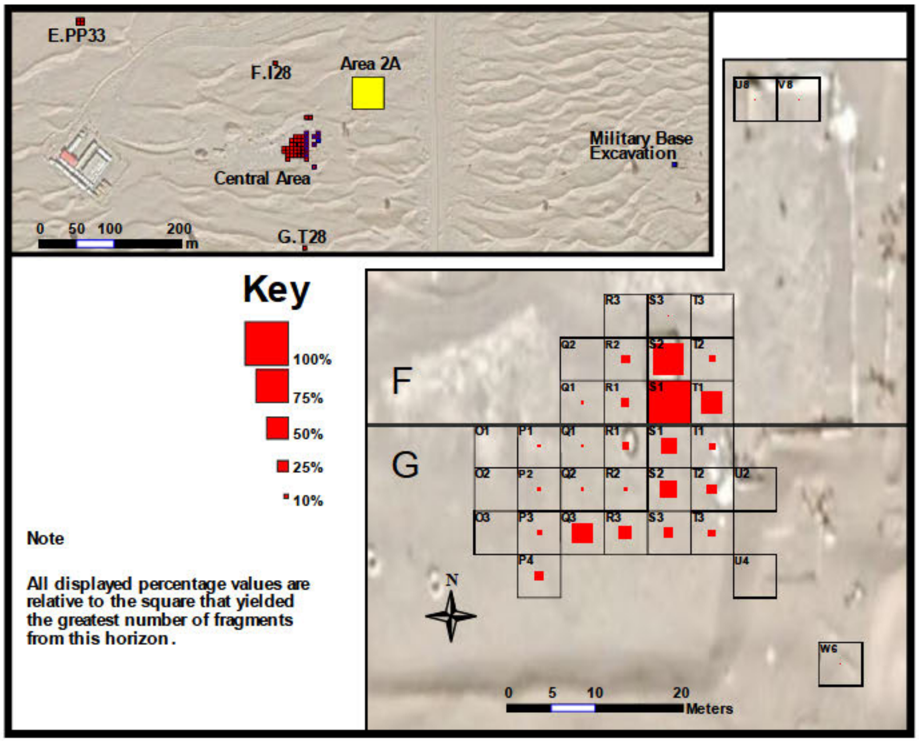


Figure 19. *The distribution of fragments from Horizon II, across the squares excavated by SHARP. Map data: © Maxar Technologies (Google Earth).*

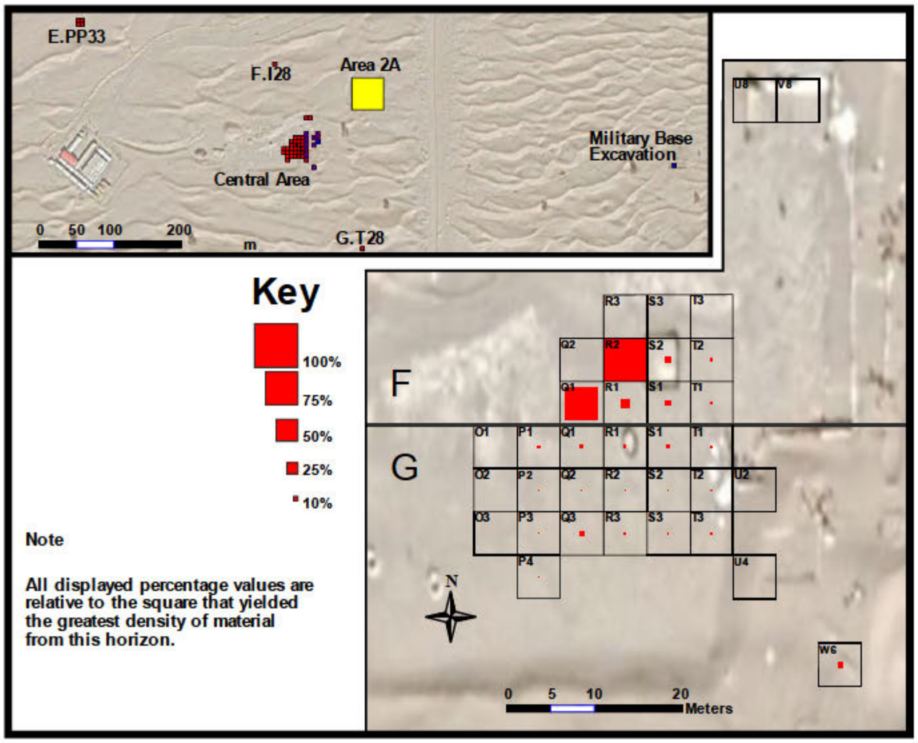


Figure 20. *The density distribution of faunal remains from Horizon II. Map data: © Maxar Technologies (Google Earth).*

In some instances, these small fragments were considered to have been the direct waste from bone working due to the ‘green’ fracture (e.g. Fernández-Jalvo & Andrews 2016: 283) and shaving marks observed on them (**Section 8.1**), however the majority of the fragmentation seen in this horizon likely results from movements in the burial environment and the sub-aerial weathering of the faunal remains (cf. Behrensmeyer 1978). It should be noted that the mobility of the burial environment (i.e. mobile sand dunes) likely resulted in variability of the rates of exposure of material, as demonstrated by the observation of well-preserved bone surfaces on some fragments. The implications of this are discussed further in **Section 2.7**. Large numbers of worked bone and bone objects were also recovered from contexts associated with this horizon (**Section 8**). Additionally, it is important to note that a number of animal burrows, as discussed above for Horizon III, were also identified in this horizon (**Fig. 18**).

2.5. Horizon I (800 BCE and later)

The remains from this horizon were well distributed across the area studied during the SHARP excavations (**Fig. 21**, **Fig. 22**). These remains were often highly fragmented (**Fig. 15**) and demonstrated clear evidence of sub-aerial weathering, e.g. abrasion and sun-bleaching (Behrensmeyer 1978; Ubelaker 1997: 79), with large numbers of small fragments (<5mm^2) present. While the effects of sub-aerial weathering were more apparent in the remains from this horizon than observed in the remains from Horizon II, some bone surfaces were well preserved. This horizon also contained a large number of worked fragments and bone objects (**Section 8**), including a number of bone handle inlay fragments that were still attached to weaponry (**Fig. 23**).

2.6. Other Faunal Deposits Excavated by SHARP

Faunal remains were recovered from a number of excavations undertaken by SHARP away from the Central Area of the site. The first of these was an exploratory trench opened to explore a geophysical anomaly, labelled in **figures 7, 9, 11, 13** & **14** as ‘G.T28’. The remains from this trench comprised smaller fragments of reptile, rodent and lagomorph, along with a single fragment of fish and small fragments of ovicaprid and gazelle (**Table 6**). These fragments were associated with Horizon I. The second was another exploratory trench opened to explore another geophysical anomaly, labelled E.PP33 in **figures 7, 9, 11, 13** & **14**. Only two fragments of bone were recovered from this area, both of which could only be identified as ‘medium-sized mammal’. The remains from E.PP33 are also tentatively associated with Horizon I.

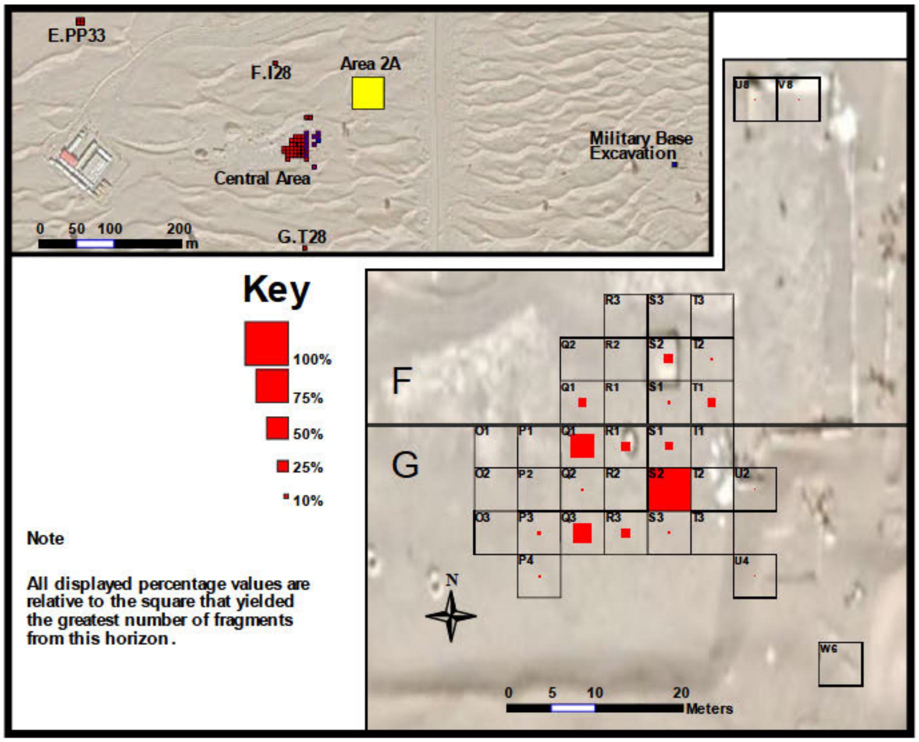


Figure 21. *The distribution of fragments from Horizon I, across the squares excavated by SHARP. Map data: © Maxar Technologies (Google Earth).*

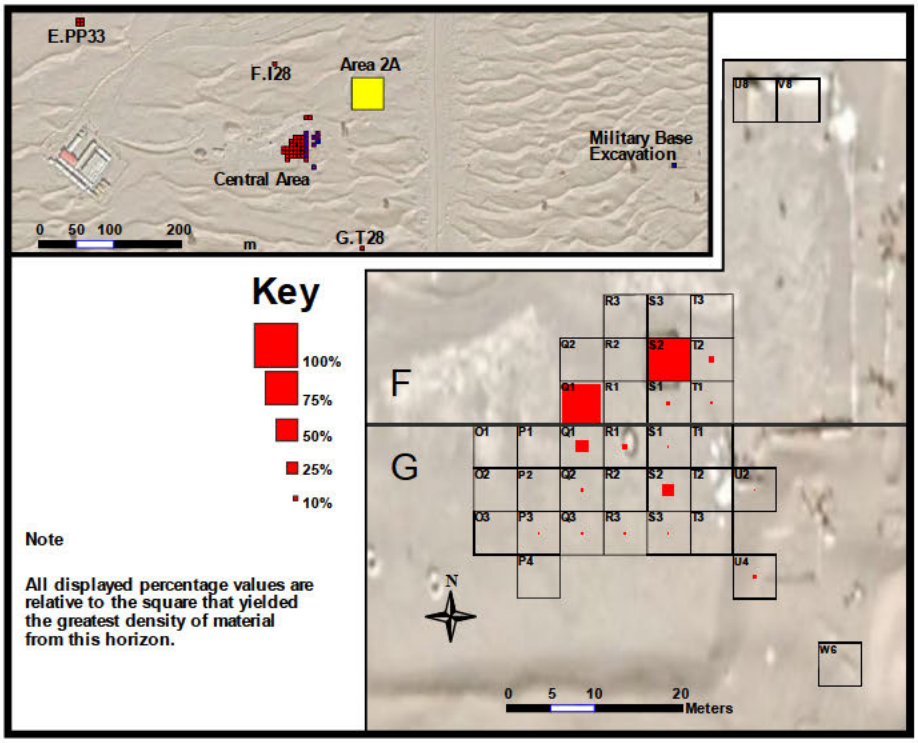
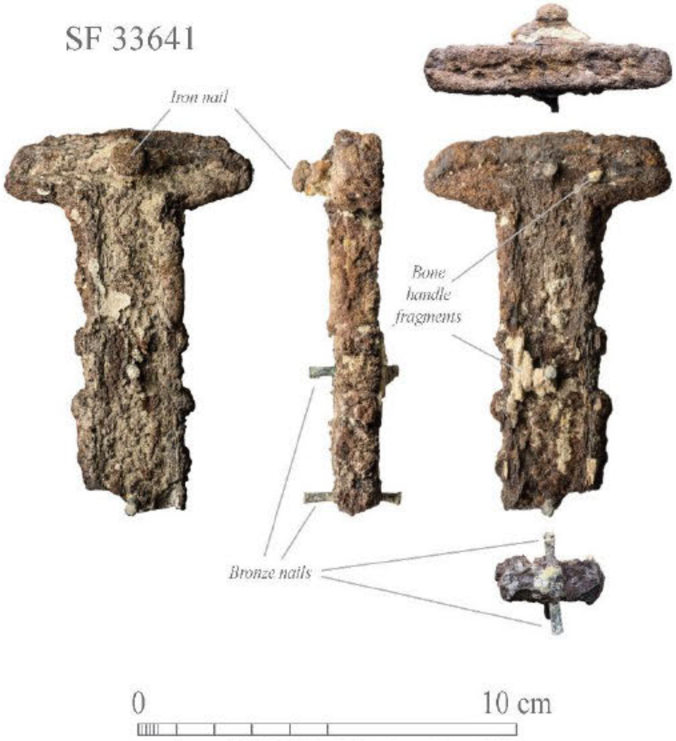


Figure 22. *The density distribution of faunal remains from Horizon I. Map data: © Maxar Technologies (Google Earth).*



Graphics © SHARP-UNE / Hélène DAVID-CUNY - 2016

Figure 23. *Iron sword handle with fragments of bone handle inlays* in-situ *(SF 33641).*

Table 6. The taxonomic *identifications made in the material recovered from square G.T28.*

	NISP
Ovicaprid	1
Domestic Animals	**1**
Gazelle	2
Hare	7
Rodent	148
Reptile	17
Wild Terrestrial Animals	**174**
Fish	1
Marine Animals	**1**
Total Identified	**176**
Unidentified	41
Grand Total	**217**

2.7. Taphonomy

Fragmentation

In general, the bone recovered from the SHARP excavations is highly fragmented (**Fig. 12**). This is likely due to post-depositional mechanical breakage resulting from the mobile burial environment; slight movements of the sand surrounding these fragments are common, causing an interface between the 'flowing' phase and the 'frozen' phase (e.g. Gennes 1998; GDR MiDi 2004) that exerts pressure upon bone fragments situated across both phases and leads to fragmentation. Human activity at the site, occurring atop previously deposited animal bone, would have added to the mechanical stress placed upon bone fragments, also increasing fragmentation through trampling (Saccà 2012; Madgwick 2014). While linear striations, often associated with trampling (e.g. White 1992), were not observed in the assemblage from Saruq al-Hadid, such marks are not always present in all cases of trampling (Haynes 1988; 1991). In addition to this mechanical breakage, the large daily and seasonal fluctuations in temperature and humidity that occur at Saruq al-Hadid (cf. Herrmann 2012: Fig. 29) would have undoubtedly encouraged the fragmentation of material (e.g. Grupe & Dreses-Werringloer 1993; Grupe 1995: 197). Bone samples taken throughout the stratigraphic sequence of the site from different areas of the SHARP excavation were found to contain negligible amounts of collagen (**Table 7**), which also reflects these fluctuations in the temperature and moisture content of the burial environment (**Fig. 24 –** Grupe 1995).

Figure 24. *On-site fog on a December morning at Saruq al-Hadid, during excavation. This periodically moist environment likely increased bone diagenesis.*

Table 7. *The C/N ratios in bone samples from Saruq al-Hadid. C/N ratios are reliable proxies for determining the presence of collagen within bone, with C/N values of ~3.2 present in bone from recently deceased animals (Nelson et al. 1986).*

Sample Number	Context	%C	%N	C/N Ratio	Collagen Preservation?
0001	1123	1.6	0	-	No
0002	1123	1.6	0	-	No
0003	1123	1.9	0	-	No
0004	1123	2.0	0	-	No
0005	1123	2.0	0	-	No
0006	1172	2.8	0	-	No
0007	1172	3.0	0	-	No
0008	1172	2.9	0	-	No
0009	1172	2.3	0	-	No
0010	1087	2.5	0	-	No
0011	1087	2.4	0.003	774.3	No
0012	1087	2.5	0	-	No
0013	1161	2.4	0	-	No
0014	1161	3.5	0	-	No
0015	1161	3.4	0	-	No
0016	1161	3.8	0	-	No
0017	1083	2.2	0	-	No
0018	1083	2.3	0	-	No
0019	1016	3.8	0	-	No
0020	1016	3.2	0	-	No
0021	1085	2.3	0	-	No
0022	1085	1.8	0	-	No
0023	1085	2.0	0	-	No
0024	1085	2.4	0	-	No
0025	1085	1.9	0	-	No
0026	1086	2.5	0	-	No
0027	1086	1.9	0	-	No
0028	1086	2.5	0	-	No
0029	1086	2.0	0	-	No
0030	MODERN	19.3	4.1	4.6	Yes
0031	MODERN	18.4	4.4	4.1	Yes
0032	MODERN	19.7	4.2	4.7	Yes
0033	MODERN	16.5	4.5	3.6	Yes
0034	MODERN	20.6	4.2	4.9	Yes
0035	1161	4.5	0	-	No
0036	1161	5.5	0	-	No
0037	1163	3.8	0	-	No
0038	1223	6.0	0	-	No
0039	1123	2.1	0	-	No
0040	1123	1.8	0	-	No

While natural taphonomic processes have most likely affected the fragmentation of faunal remains at Saruq al-Hadid, it is also important to consider potential anthropogenic causes of this fragmentation. Anthropogenic processes (i.e. bone working) are considered to have been a major factor in the fragmentation identified in Horizons II and I (**Section 8**), however activities like marrow extraction, while less visible, may have also been a factor in the fragmentation of the assemblage in all horizons. Marrow extraction often results in 'green' or spiral fractures (cf. Haynes 1983; Fisher 1995; Outram 2001; Munro & Bar-Oz 2005), however the relatively high levels of burning observed in Horizons V & IV may lead to an under-representation of these 'green' fractures, as burnt fresh bone can fracture as if it were dry bone (Villa & Mahieu 1991). The sub-aerial weathering observed in Horizon II & I may also obscure these fractures by 'rounding' the acute fracture angles (e.g. Fernández-Jalvo & Andrews 2016: Chapter 6), leading to their under-identification. No pattern in the fragmentation of remains was observed in the faunal assemblage from Saruq al-Hadid, both in terms of the locations, direction and angle of fractures. This prohibited firm conclusions being drawn from bone fragmentation alone (as undertaken by e.g. Pickering *et al.* 2005; Fillios *et al.* 2010; Fernández-Jalvo & Andrews 2016). Despite this, some inferences regarding the burial history of the faunal assemblage from Saruq al-Hadid can still be made with reference to other characteristics of the assemblages.

Without knowing the precise directions and magnitude of dune movements across the site during the Iron Age occupation, we cannot reliably determine the degree of exposure of these bone deposits. Furthermore, the long duration and potential irregularity of the deposition of Horizon V and IV obscures the taphonomic processes that have affected the material deposited during this time. It is most likely the case that the assemblage is not uniformly impacted by these taphonomic processes, even across the same archaeological horizons. This irregularity is evidenced by the mixture of abraded and well-preserved bone surfaces observed in the remains; the weathering identified on bone surfaces from Horizons V & IV was generally classified as Stage 0-1, however some fragments displayed weathering up to stage 5 (Behrenmeyer 1978). Bone surfaces displaying limited evidence of abrasion (i.e. sub-aerial weathering) imply a relatively rapid deposition (e.g. Denys 2002: 477; Madgwick & Mulville 2012: 519), that is well explained by the site formation processes at Saruq al-Hadid, i.e. the movement of dunes across the site and the repeat anthropogenic deposits sealing previous deposits in the stratigraphy. The alkaline-neutral sediment of Saruq al-Hadid also encouraged bone surface preservation (cf. Roberts *et al.* 2019: Tab. 2). Well preserved bone surfaces allowed for the identification of some butchery marks, and other bone surface modifications, as discussed by taxa below. Some general remarks about the butchery observed on the faunal material are discussed here, as they are relevant to our wider understanding of taphonomy at the site.

Bone Surface Modifications

Butchery. A relatively small number of bones had evidence of cut marks (**Table 8)**. The majority of butchery marks (86.9%) were fine cut marks, suggesting the use of small knives (e.g. Merritt 2019). Such knives may not always cut through the periosteum, which can serve a 'protective' function on the bone surface (e.g. Fisher 1995) and may not necessarily have been removed during carcass processing (e.g. O'Connell *et al.* 1988: 121) resulting in an under-representation of the butchery marks in an assemblage (e.g. Pineda *et al.* 2019). Additionally, sub-aerial weathering would cause abrasion of the bone surface, obliterating fine butchery marks, as can thermally altering bone through boiling or cooking (e.g. Fisher 1995: 31). The potential that the butchery marks observed on material from Saruq al-Hadid do not accurately reflect the amount of butchery activity at the site should therefore be considered. The heavier chop marks, often associated with material from Horizons II & I are unlikely to have been obliterated in such a manner, due to their anatomical location and depth. They may have been obscured by the high rates of fragmentation observed in the remains from Horizons II & I, leading to their underrepresentation during analysis.

Table 8. *The total number of specimens displaying each type of butchery mark observed across all five horizons.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Total**
Cut	1	9	5	21	**36**
Chop		5		2	**7**
Total	**1**	**14**	**5**	**23**	**43**
Percentage of Horizon Fragments Total	**0.01**	**0.04**	**0.01**	**0.01**	**0.01**

Burning. Sixteen percent of the assemblage displays evidence of burning, the potential causes of which are discussed here. While burning on archaeological animal bones can be difficult to interpret (e.g. Stiner *et al.* 1995; Hanson & Cain 2007), the wider archaeological context that the burnt fragments were recovered from at Saruq al-Hadid is key to understanding the burnt remains. While cooking meat 'on the-bone' often does not leave macroscopically visible marks (e.g. Koon *et al.* 2010), the high rates of burning and frequently patchy, localised charring observed on material from Horizons V & IV, combined with the frequent identification of hearths and the slight preponderance of meat bearing elements in these horizons, is strongly indicative that at least some of this burning is evidence of cooking (Asmussen 2009; Bosch *et al.* 2012: Table 4). The subsequent deposition of these bones in a fire, and their direct exposure to fire, is then likely to have caused the more intense burning (i.e. grey-calcined) observed on the fragments from these horizons (Stiner *et al.* 1995; Bosch *et al.* 2012: 114). Calcined bone may also reflect repeat use of hearths (Collins & Willoughby 2010) and later use of hearths dug into the bone midden, which would have then burnt the surrounding bone. Such a phenomenon was observed in a Late Natufian assemblage from Hayonim Cave that was burnt by a glass furnace built through the bone deposits during the Byzantine period, several millennia after the initial deposition of the bone (Bar-Oz & Munro 2004: 209). Given that cooking does not always leave macroscopic marks, it is likely that some of the unburnt fragments from these two horizons also represent remains from cooking. The burning observed in Horizons III, II & I is harder to explain. The recovery of burnt fragments from the Military Base excavations (**Section 10.2**) that are contemporary with Horizons III, II and I suggests that bone may have originated from another area of the site (i.e. the Military Base), before being deposited in the Central Area. The association between bone working and bone burning, observed in archaeological bone assemblages and ethnographic studies (e.g. Henshilwood *et al.* 2011; Moore 2011: 182), is also important to note, given the other evidence for bone working observed in Horizons II & I, and suggests the higher percentage of calcined fragments in Horizons II & I may reflect an aspect of the bone working process.

3. Mammalian Remains Classified by Size

The majority of fragments that could be taxonomically identified were mammalian but could not be identified further (66.5%). These remains were therefore divided into size classes (**Table 2**). While few insights into human activity at the site were provided by these remains, they affect our interpretations of the rest of the assemblage and it is therefore important to briefly outline them here. ‘Large Mammal’ refers to camel, oryx or cattle-sized animals; ‘Medium Mammal’ refers to ovicaprid or gazelle-sized animals; ‘Small Mammal’ refers to dog, cat or rabbit-sized animals. These fragments were present across all excavated areas and horizons (**Table 9**) and represented a wide array of skeletal elements (**Table 10**). Where appropriate these tables are referred to below, in order to account for the effect these remains have on our interpretations of the assemblage.

When compared across the five horizons, several patterns can be observed in these remains. Few remains from Horizon V were assigned to one of these size classifications, however the remains identified as ‘Large Mammal’ and ‘Medium Mammal’ from Horizons IV and III represented entire carcasses, with elements from the entire axial and appendicular skeleton present (**Table 10**). The remains from Horizon III contained a notable preponderance of horncore, skull fragments and caudal vertebrae for both ‘Large’ and ‘Medium’ sized mammals. This preponderance of caudal vertebrae, skulls and horncore was far more prevalent in the ‘Large’ and ‘Medium’ sized mammals from Horizons II and I. This broad skeletal element pattern is reflected in the remains of ovicaprid (**Section 4.1**), camel (**Section 5.1**), oryx (**Section 6.1**) and gazelle (**Section 6.2**) remains as discussed below. Another notable observation is the predominance of indeterminate long bone fragments in both Horizons II and I (**Table 10**), likely associated with the bone working hypothesised to have occurred during this occupation phase at the site. Little can be said about the fragments identified as ‘Small Mammal’, aside from a preponderance of axial elements (**Table 10**).

Table 9. The number of fragments identified as large/medium/small mammal.

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Large Mammal							
F	Q1	68	76				**144**
	R1			1335			**1335**
	R2				1533		**1533**
	S1	17	786	691			**1494**
	S2		8		5700		**5708**
	T1	82	479				**561**
	T2	16	111				**127**
G	P1		70		1318	11	**1399**
	P2		21				**21**
	P3		9				**9**
	P4	15	65				**80**
	Q1	176	21	302			**499**
	Q2	12	44	6			**62**
	Q3	1	409				**410**
	R1	59	253	344	96		**752**
	R2		83				**83**
	R3	48	219				**267**
	S1	60	381	478	203		**1122**
	S2		157				**157**
	S3	27	156				**183**
	T1		173				**173**
	T2		63				**63**
	T3		76				**76**
	U2	1					**1**
	U4	5					**5**
	W6		2				**2**
Total		**587**	**3662**	**3156**	**8850**	**11**	**16266**
Medium Mammal							
F	Q1	64	122		28		**214**
	Q2				166		**166**
	R1		170	2482			**2652**
	R2		23		4436		**4459**
	S1	6	1142	726			**1874**
	S2	75	624		11311		**12010**
	S3				31		**31**
	T1	91	490				**581**
	T2	23	127				**150**
G	P1		56		2313	23	**2392**
	P2		63				**63**

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Medium Mammal (Cont.)							
G	P3	9	95				**104**
	P4	21	237				**258**
	Q1	185	32	357			**574**
	Q2	12	67				**79**
	Q3	10	345				**355**
	R1	102	183	346	130		**761**
	R2		87				**87**
	R3	89	230				**319**
	S1	60	401	525	235		**1221**
	S2	11	196				**207**
	S3	16	215				**231**
	T1		127				**127**
	T2		127				**127**
	T3		206				**206**
	U4	8					**8**
	W6		12				**12**
Total		**782**	**5377**	**4436**	**18650**	**23**	**29268**
Small Mammal							
E	PP33	10					**10**
F	Q2				68		**68**
	R1		1	273			**274**
	R2				534		**534**
	S1		38	205			**243**
	S2	8	34		27		**69**
	T1		11				**11**
	T2	1	2				**3**
G	P1		2		14	9	**25**
	P2		3				**3**
	Q1	2		51			**53**
	Q3	2	1				**3**
	R1		2	12	2		**16**
	R3	3					**3**
	S1	7	7	11			**25**
	S2		5				**5**
	S3		10				**10**
	T1		1				**1**
	T2		12				**12**
	T3		10				**10**
Total		**33**	**139**	552	644	**9**	**1377**
Grand Total		**1402**	**9178**	**8144**	**28144**	**43**	**46911**

Table 10. *The skeletal element representation (NISP) from the mammalian remains categorised by size across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Large Mammals						
Horncore	79	722	111	66		**978**
Skull	47	922	266	249	1	**1484**
Maxilla		2		10		**9**
Mandible	2	1	10	29		**42**
Teeth	21	63	222	528		**834**
Hyoid	1					**1**
Atlas	2		1	6		**9**
Axis	1	1		3		**5**
Cerv. Vert.			14	43		**57**
Thor. Vert.	3	2	14	72		**91**
Rib	21	43	253	453	3	**773**
Sternum		3				**3**
Scapula	1	4		16		**21**
Humerus	1	2	6	27		**36**
Radius	1	2	3	24		**30**
Ulna	2	1	1	10		**14**
Carpals	2	1	18	9		**30**
Metacarpal	1		1	6		**8**
Phal. 1				3		**3**
Phal. 2	1					**1**
Lumb. Vert.	1	2	10	55		**68**
Caudal Vert.	35	664	375	81		**1155**
Vert. Indet.	12	9	96	273	1	**391**
Pelvis	1	7	7	35		**50**
Sacrum			4	12		**16**
Femur	1			19		**20**
Patella			15	1		**17**
Tibia	1	1	3	10		**15**
Fibula			1	3		**4**
Nav. Cub.				1		**1**
Tarsal			11	4		**16**
Metatarsal		2	4	12		**18**
Metapodial	8	18	11	62		**99**
Sesamoid	1	12	15	6		**34**
Ln. Bn.	265	886	986	3422	4	**5563**
Fl. Bn.	34	193	304	1188	2	**1720**
Canc. Bn.	11	62	136	237		**447**
Indet.	31	38	256	1877		**2201**
Total	**587**	**3662**	**3156**	**8850**	**11**	**16266**

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Medium Mammals						
Horncore	91	990	324	117	1	**1522**
Skull	65	598	184	241	1	**1089**
Maxilla		1	3	7		**11**
Mandible	1	19	15	59		**94**
Teeth	23	101	405	437		**966**
Hyoid		1	5	1		**7**
Atlas	1		2	14		**17**
Axis			8	1		**9**
Cerv. Vert.	1	2	11	79		**93**
Thor. Vert.	1	2	14	63		**80**
Rib	29	164	278	894	2	**1367**
Sternum		4	5	30		**38**
Scapula		3	9	45		**57**
Humerus		4	6	20		**30**
Radius	1	4		28	1	**34**
Ulna		1	15	32		**49**
Carpals	1	3	2	8		**14**
Metacarpal	1	2	8	7		**18**
Phal. 1	1	3	5	3		**11**
Phal. 2		1	2			**3**
Lumb. Vert.			2	28		**30**
Caudal Vert.	13	492	292	42		**839**
Vert. Indet.	8	43	47	431	1	**530**
Pelvis		4	12	21		**37**
Sacrum		2	6	7		**15**
Femur	1	1	2	8		**12**
Patella			2			**2**
Tibia		1		13		**14**
Fibula				3		**3**
Calcaneum			2	1		**3**
Nav. Cub.				4		**4**
Tarsal		1	9	30		**40**
Metatarsal		3	2	20		**24**
Metapodial	16	52	15	65		**148**
Sesamoid		2	8	14		**24**
Ln. Bn.	427	2198	1547	6811	12	**10995**
Fl. Bn.	70	436	238	2289	4	**3037**
Canc. Bn.	18	48	78	117	1	**262**
Indet.	13	190	881	6658		**7742**
Total	**782**	**5377**	**4436**	**18650**	**23**	**29268**

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Small Mammals (Cont.)						
Skull			11	3		**15**
Maxilla			3			**3**
Mandible		8	13	7		**28**
Teeth		2	20			**22**
Hyoid			1			**1**
Atlas		2				**2**
Axis			2			**2**
Cerv. Vert.			2	29		**31**
Thor. Vert.		1	3	2		**6**
Rib	11	46	175	175		**407**
Scapula		1	4	5		**11**
Humerus		2	3			**5**
Radius			2	2		**4**
Ulna			1	3		**5**
Carpals		2	3	3		**9**
Phal. 1		5	6	2		**12**
Phal. 3		1				**1**
Lumb. Vert.			2			**2**
Caudal Vert.		3	8	5		**16**
Vert. Indet.		9	76	97		**182**
Pelvis		4	11	2		**17**
Sacrum		1				**1**
Femur		8	18	2		**28**
Tibia		1	8			**9**
Calcaneum		3	2			**5**
Astragalus			2			**2**
Tarsal				3		**3**
Metapodial	1	1	6	2		**9**
Sesamoid			2			**2**
Ln. Bn.	18	32	31	289		**370**
Canc. Bn.					1	**1**
Indet.	3	7	132	14	8	**163**
Total	**33**	**139**	**552**	**644**	**9**	**1377**
Grand Total	**1402**	**9178**	**8144**	**28144**	**43**	**46911**

4. Domestic Species

4.1. Sheep and Goat, **Ovis** ***sp./*** **Capra** ***sp.***

Sheep or goat?

While 231 fragments of bone, predominantly horncore, could be definitively identified as goat (**Table 11** & **Table 12**), a large number of fragments could only be identified as ovicaprid during preliminary analysis (**Table 11** & **Table 12**). The similarities between the skeletal remains of sheep and goat are well described in zooarchaeological literature, as are the difficulties of distinguishing between the post-cranial skeletons of the two taxa (Salvagno & Albarella 2017: 1-2). A method recently published by Salvagno & Albarella (2017) allows for such distinction based upon metrical analysis. This method could not be fully applied to the remains from Saruq al-Hadid as it was published after the bones were analysed and, as such, not all required measurements were taken. However, such analysis was applicable on two different elements, the astragalus and the scapula (**Fig. 25**). Two of the three scapulae measured clearly fell within the size range for goats, as displayed by Salvagno & Albarella (2017). It was harder to distinguish between sheep and goats using the measurements from astragalii, however the majority of datapoints did trend towards the range for goats (**Fig. 18**). This cursory analysis suggests that these fragments are predominantly from goats, however some small amounts of sheep are also present in the remains. Both sheep and goats are known from contemporary sites in the region (e.g. Uerpmann 2008; Skorupka & Mashkour 2016), so it is possible for both of these animals to be present at Saruq al-Hadid. Further metrical analysis of the remains in the future will allow for greater distinction between the sheep and goats at Saruq al-Hadid. For the purposes of the current monograph the remains are treated as a whole.

Skeletal Element Representation

Entire carcasses of ovicaprid were well represented in the remains from Horizon V & IV, with a predominance of lower limb bones (**Table 12**, **Fig. 25**). In Horizons III, II, & I horncore was the dominant skeletal element, while lower limb and foot bones were well represented (**Table 12**, **Fig. 26**). Other skeletal elements were present in these three horizons, however in relatively small amounts. It is important to note that while horncores are often the most well represented element from ovicaprid in these three horizons mandibles are not very common, suggesting that these horncores had generally been removed from the rest of the skull prior to their deposition. Of note is a context consisting of two goat horncores and a single fragment of oryx horncore, associated with Horizon III (**Context 2330 - Fig. 27**). This skeletal element pattern corroborates with the skeletal elements identified as 'Medium Mammal' therefore suggesting that the data presented in **Figure 26** is an accurate representation of the ovicaprid remains that were deposited in the Central Area through time.

Table 11. *The number of ovicaprid fragments across each area and horizon.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
F	Q1				23		**23**
	Q2				7		**7**
	R1		15	28			**43**
	R2		16		141		**157**
	S1		21	79	127	20	**247**
	S2		46		5	1	**52**
	S3				22		**22**
	T1		6	4	125	2	**137**
	T2		3	8	27		**38**
G	P3	5	3				**8**
	Q3	13	19				**32**
	R1	2	5	4	9		**20**
	S1		3	17	111		**131**
	S2	14	15	9	15		**53**
	S3		11				**11**
	T1		1		99		**100**
	T2		16				**16**
	T3		12				**12**
	T28	1					**1**
Total		**35**	**192**	**149**	**711**	**23**	**1110**

Bone Surface Modifications

Ten fragments identified as ovicaprid displayed butchery marks, six of which could confidently be associated with one of the five horizons (**Table 13**). This included two individual hyoid (a bone from the throat) fragments with cut marks on their medial surfaces (**Fig. 28**), both of which were from Horizon IV. Butchery marks on this bone are often indicative of tongue removal for consumption (e.g. White 1953, 162; Terry *et al.* 1990: 4201). Chop marks were identified at the base of a horncore recovered from Horizon II, a mark seen elsewhere in the assemblage as discussed below (**Sections 6.1** & **6.2**). and two forelimb elements from Horizons IV & III displayed cut marks towards their joint surfaces, indicative of carcass disarticulation (**Fig. 28**). A number of fragments identified as ovicaprid were also burnt to varying degrees of intensity (**Table 14**).

Table 12. *The skeletal element representation (NISP) from the ovicaprid remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Horncore	8 (*4*)	47 (*27*)	58 (*52*)	24 (*22*)	2 (*1*)	**139**
Skull	2 (*1*)	4 (*2*)		15 (*13*)		**21**
Mandible	4 (*3*)	5 (*3*)		27 (*23*)		**36**
Teeth	1	8	2	9		**20**
Hyoid		2 (*2*)		5 (*5*)		**7**
Axis				15 (*15*)		**15**
Cerv. Vert.	1 (*1*)			16 (*11*)	1 (*1*)	**18**
Thor. Vert.	1 (*1*)			31 (*28*)		**32**
Rib	7 (*1*)	10 (*6*)		34 (*14*)		**51**
Scapula			7 (*5*)	23 (*20*)	3 (*1*)	**33**
Humerus				39 (*37*)		**39**
Radius		8 (*6*)	10 (*8*)	57 (*54*)	8 (*8*)	**83**
Ulna		7 (*5*)		91 (*85*)		**98**
Carpals		4 (*4*)	13 (*13*)	12 (*12*)		**29**
Metacarpal		7 (*4*)		25 (*24*)		**32**
Ant. Phal. 1	2 (*2*)	8 (*6*)	4 (*4*)	13 (*10*)		**27**
Ant. Phal. 2		4 (*4*)		11 (*10*)		**15**
Ant. Phal. 3		5 (*5*)	4 (*4*)	1 (*1*)		**10**
Lumb. Vert.	1 (*1*)			28 (*24*)		**29**
Caudal Vert.		1 (*1*)				**1**
Vert. Indet.	1	6		2		**9**
Pelvis		8 (*5*)	9 (*6*)	56 (*47*)	2 (*1*)	**75**
Femur		10 (*8*)	9 (*7*)	24 (*21*)		**43**
Tibia		8 (*7*)	7 (*7*)	60 (*55*)	3 (*3*)	**78**
Fibula				4 (*4*)		**4**
Astragalus		7 (*6*)	7 (*7*)	24 (*24*)	4 (*4*)	**42**
Calcaneum		4 (*3*)				**4**
Nav. Cub.		2 (*2*)	6 (*5*)			**8**
Tarsal		4 (*4*)	1 (*1*)	17 (*17*)		**22**
Metatarsal	6 (*4*)	3 (*2*)	10 (*7*)	30 (*23*)		**49**
Post. Phal. 1	1 (*1*)	5 (*4*)	1 (*1*)	4 (*4*)		**11**
Post. Phal. 2		7 (*4*)		12 (*12*)		**19**
Post. Phal. 3		2 (*1*)	1 (*1*)	2 (*1*)		**5**
Metapodial		6				**6**
Total	**35**	**192**	**149**	**711**	**23**	**1110**

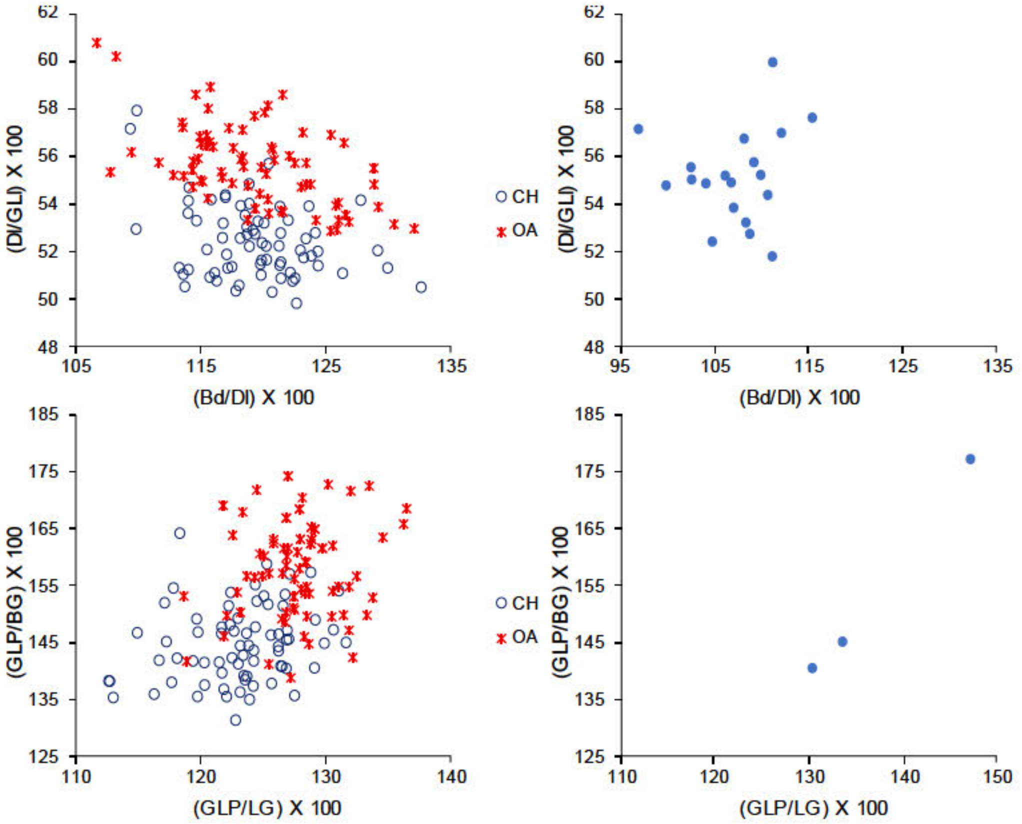


Figure 25. *The results of metrical analysis undertaken on the faunal remains from Saruq al-Hadid to distinguish between sheep and goat, compared to the results from Salvagno & Albarella's study (2017).*

Table 13. *The number of specimens displaying butchery marks in the ovicaprid assemblage.*

	Horizon II	**Horizon III**	**Horizon IV**	**Total**
Horncore				
Chop marks in base of horncore	1			1
Mandible				
Cut on buccal surface			1	1
Hyoid				
Cut on lingual surface			1	1
Humerus				
Cut marks on distal articulation			1	1
Radius				
Cut marks on proximal end across dorsal surface		1		1
Total	**1**	**1**	**3**	**5**

Figure 26. *The skeletal element representation in the ovicaprid remains, shown as a percentage of MNI, across each horizon. Skeletal image: © 1996 ArcheoZoo.org*

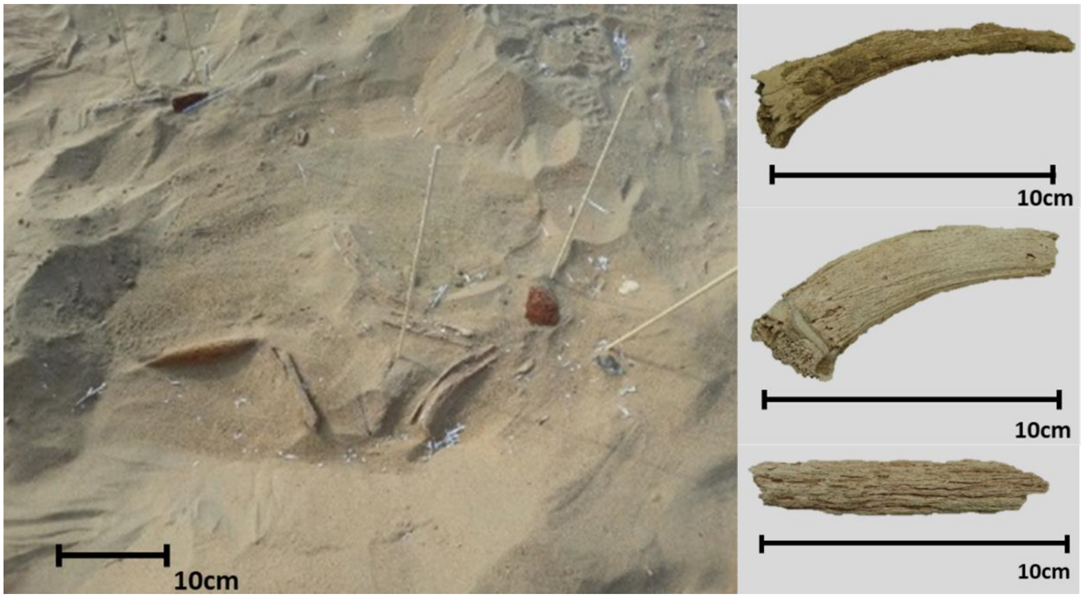


Figure 27. *A cache of horncore from Horizon III, Context 2330, Square F.T1. Goats and an oryx are represented.*

Table 14. *The number and percentage of burnt ovicaprid fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring		1 (10%)		2 (4.8%)	1 (100%)
Charred, burnt black	1 (50%)	6 (60%)		19 (45.2%)	
Grey	1 (50%)	1 (10%)		15 (35.7%)	
Burnt white		2 (20%)		6 (14.3%)	
Burnt Fragments	**2**	**10**	**-**	**42**	**1**
Percentage of Horizon Fragments Total	***5.7***	***5.2***	**-**	***5.9***	***4.4***

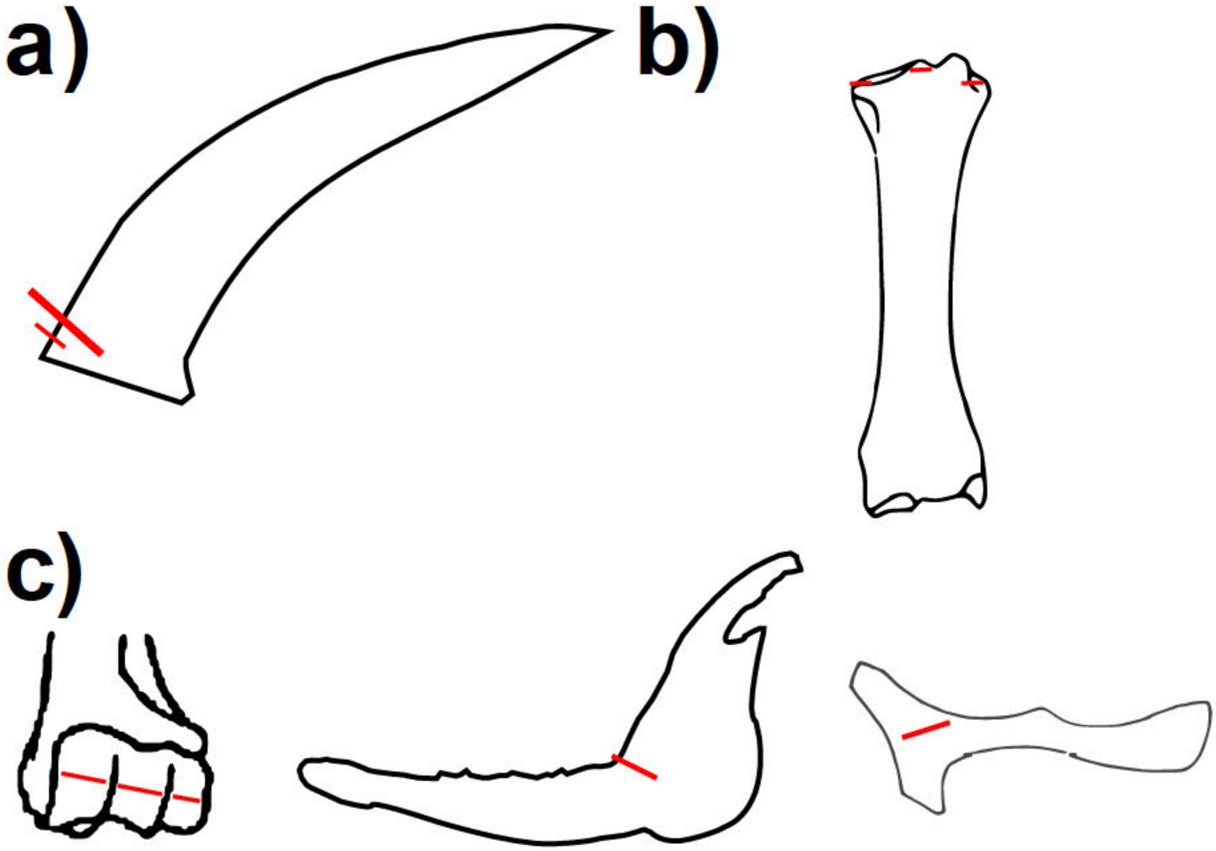


Figure 28. *Schematic depictions of skeletal elements displaying the location and type of butchery marks (red lines) identified on the ovicaprid remains across each horizon. Thicker line, in a), represents chop mark. a) Horizon II; b) Horizon III; c) Horizon IV. Skeletal outline after Lauwerier 1988.*

Population Demographics

Two fragments of ovicaprid from individuals younger than 10 months were present in the remains excavated by SHARP, both of which were from Horizon IV (**Table 15**). The majority of ovicaprid remains from Horizon IV were generally from older animals, however some younger animals were present in the assemblage (**Table 15**). This predominance of older animals throughout all horizons suggests that the primary use for these animals was their secondary products, with herd management strategies involving the culling of males likely to account for the presence of some younger individuals in the remains. The presence of some juvenile is also important to note, as it suggests that an entire herd was likely brought to the site.

Size

In order to compare the sizes of ovicaprid across each horizon and between different sites a logarithmic size index was employed, a methodology commonly utilised in zooarchaeological studies (e.g. Meadow 1991; Grigson 2012; Thomas *et al.* 2013). Due to the general inability to distinguish between sheep and goat in this assemblage, measurements from ovicaprid remains were tested against standard measurements from both goat and sheep, as presented by Uerpmann & Uerpmann (1994: Tab. 12 & 14). This analysis demonstrated a wider range of sizes present in Horizon IV than Horizons III & II (**Fig. 29**). Aside from this there is little evidence for a change in size of ovicaprid remains over time at Saruq al-Hadid (**Fig. 29**). The range of sizes represented in Horizon IV corroborate with ovicaprid remains recovered from other late prehistoric sites around Arabia and adjacent regions (**Fig. 30**).

Table 15. *The epiphyseal fusion state of fragments identified as ovicaprid (NISP) (after Silver 1969).*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	**%F**	**F**	**UF**	**%F**	**F**	**UF**	**%F**	**F**	**UF**	**%F**	**FS**
Scapula							1	-	*100*	1	1	*50*	
P. Metapodia	2	-	*100*	5	-	*100*				20	-	*100*	
Pelvis													
D.Humerus										2	1	*66.7*	
P.Radius	2	-								5	-	*100*	
<10 mths.	**2**	**-**	***100***	**5**	**-**	***100***	**1**	**-**	***100***	**28**	**1**	***97***	**-**
D.Tibia				2	1	*33.3*							
D.Metapodia				2	3	*40*				4	2	*66.7*	
Phalanx 1	1	-	*100*	7	1	*87.5*	1	1	*50*	4	-	*100*	
Phalanx 2	1	-	*100*	1	5	*20*				2	1	*66.7*	
1-2 years	**2**	**-**	***100***	**12**	**10**	***55***	**1**	**1**	***50***	**10**	**3**	***77***	**-**
Ulna										1	2	*33.3*	
P.Femur				3	-	*100*				-	1	-	
Calcaneum													
D.Radius										3	1	*75*	
2.5-3 years	**-**	**-**	**-**	**3**	**-**	***100***	**-**	**-**	**-**	**4**	**4**	***50***	**-**
P.Humerus													
D.Femur													
P.Tibia				1						4	2	*66.7*	*1*
3-3.5 years	**-**	**-**	**-**	**1**	**-**	***100***	**-**	**-**	**-**	**4**	**2**	***67***	***1***

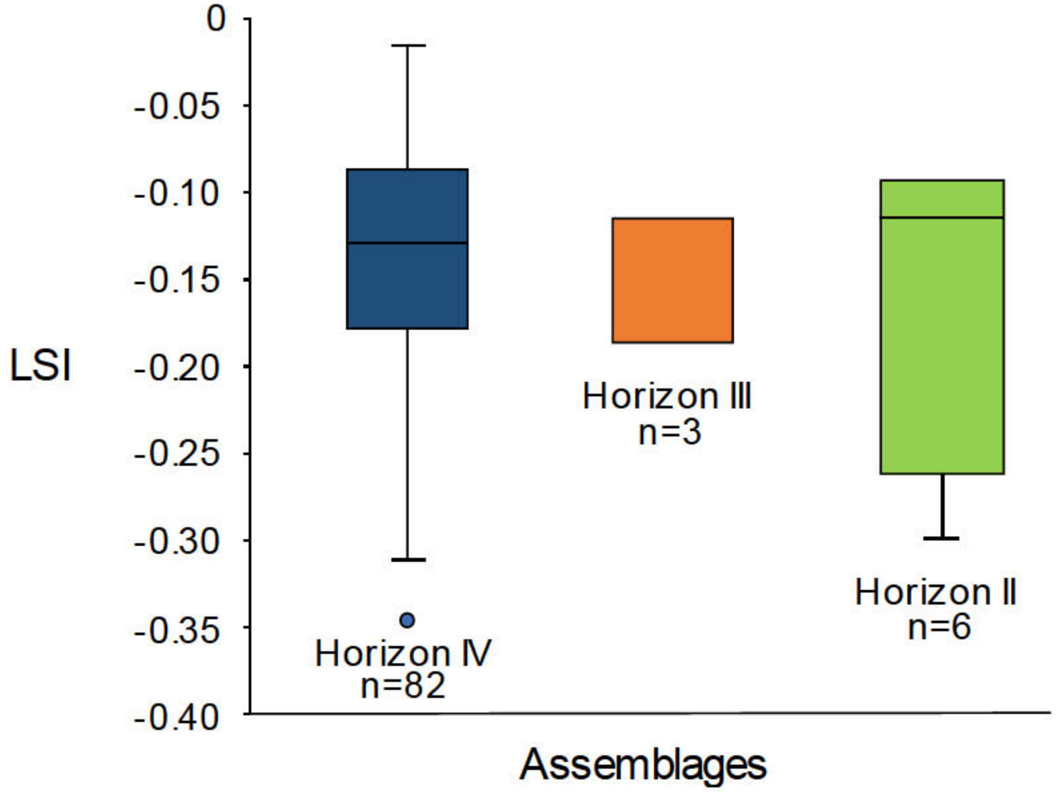


Figure 29. *The log-scaled size anatomical measurements taken from the ovicaprid remains across each horizon.*

4.2. Cattle, **Bos** *sp.*

Only 13 fragments of cattle were identified in the remains, the majority of which could be confidently associated with Horizon IV (**Table 2** & **Table 16**). These fragments were all from the distal hind limb (i.e. tibia, astragalus, calcaneum, navicular cuboid - **Fig. 31**). It is unclear whether these fragments were deposited in the same event or were from the same animal, as they were not found in articulation. All of these fragments had fused epiphyseal surfaces, suggesting that no juvenile cattle were present in the assemblage from the Central Area. One of the fragments, an astragalus, was found to have cut marks on its medial surface (**Fig. 31**). Measurements were taken from this fragment and compared to published data from other prehistoric sites in southeastern Arabia (Uerpmann & Uerpmann 1994: Tab. 8; van Neer et al. 2017). This comparison suggests that this astragalus is relatively large.

Table 16. *The number of cattle fragments across each area and horizon.*

Area		**Horizon IV**	**Indeterminate Horizon**
G	S1	10	
	S2		3

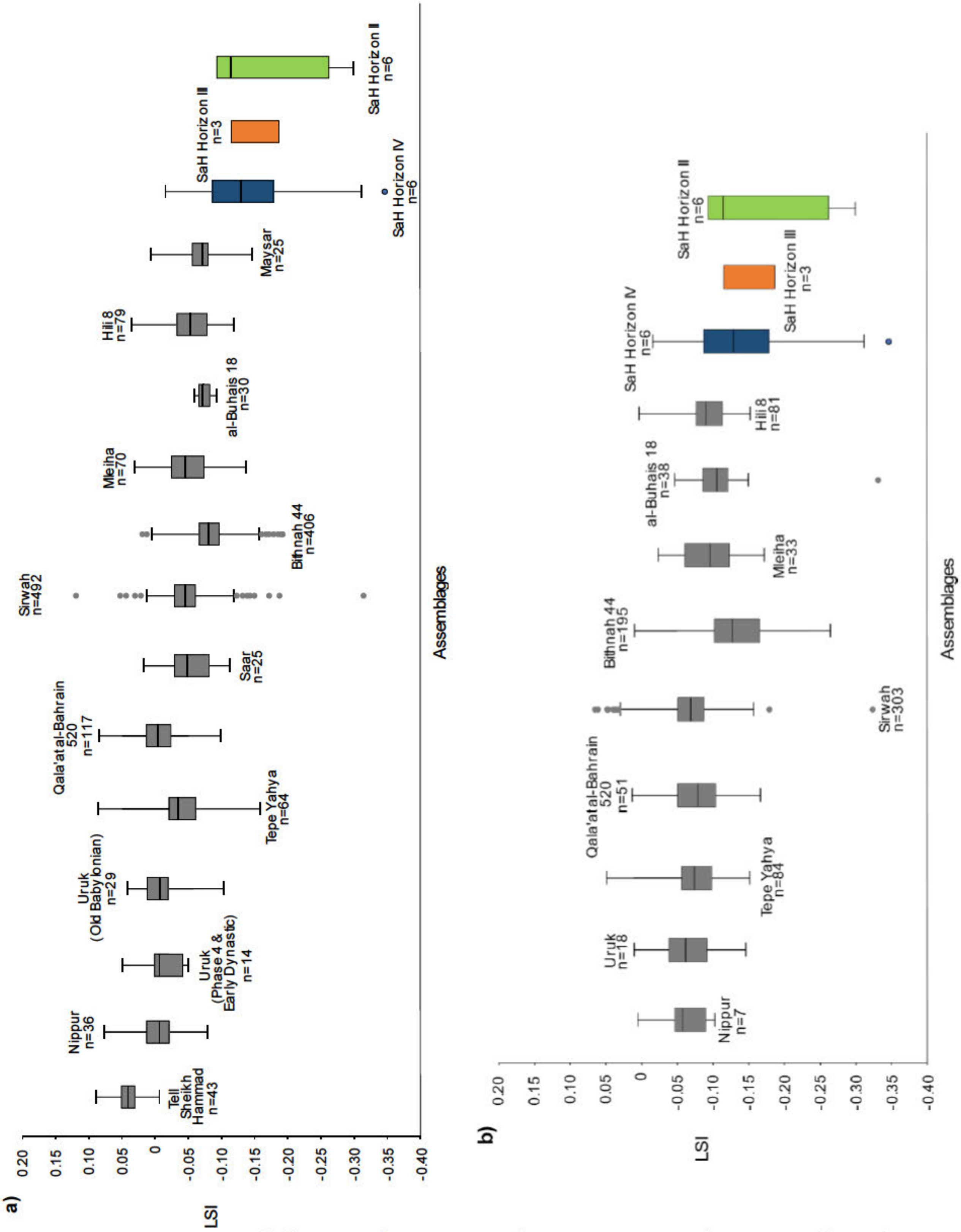


Figure 30. *Log-scaled metrics from ovicaprid remains compared to metrics from a) sheep, b) goat assemblages in the region (Skorupka & Mashkour 2013: Fig. 168, 169).*

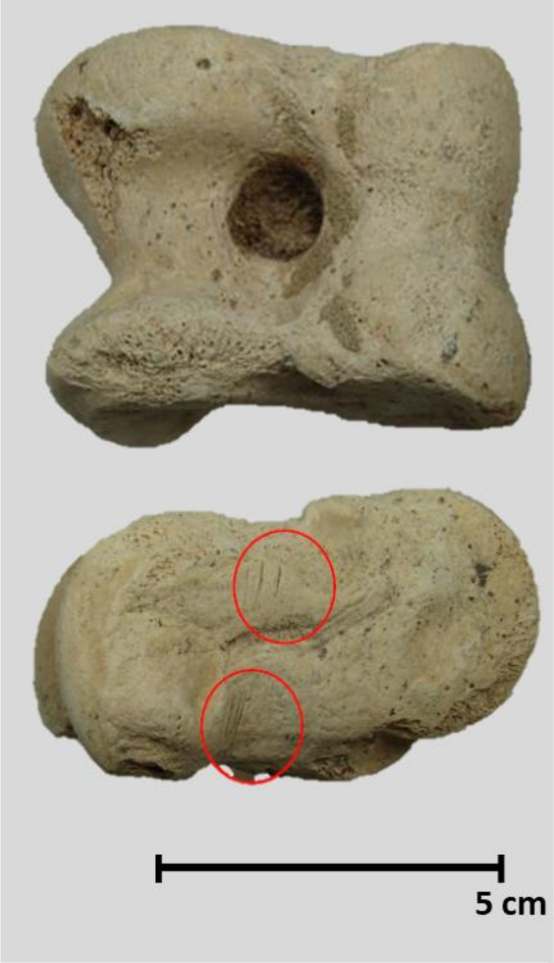


Figure 31. *The cattle astragalus recovered from Context 2818, Horizon IV, Square G.S1. Note the cut marks on the medial surface, circled in red.*

4.3. Domestic Species Discussion

The presence of complete carcasses of ovicaprid at the site, particularly during Horizons V & IV, is demonstrative of these animals being brought to the site 'on-the-hoof'. Furthermore, the presence of animals younger than 10 months of age in the assemblage, whilst infrequent, suggests that an entire population of sheep or goat could have been moved through the site or pastured in the site environs. The skeletal element representation from Horizons III, II & I is largely indicative of the processing of the animals' skins. The abundance of horncore and foot bones reflects the difficulty in extracting these bones from the skins of animals; it appears skins could have been brought to this area during the occupations of Horizons III – I with these bones attached, a common practice in the past (Jones 1980: 154). These bones were then removed from the skins on site with the bones being waste products from this removal process, an association also identified on other archaeological sites (e.g. Binford 1981: 106; Lyman 1994: 309). The abundance of metapodia that would have resulted from this process may have in turn be used in bone working (**Section 8.1**). Alternatively, these bone clusters may reflect depositions of skins, or indeed objects (e.g. beads) wrapped in skins that still have these bones attached. The butchery marks observed on the remains from this horizon reflect the removal of horncore from the rest of the skull, which was likely also part of the skin extraction process. It is important to reiterate here that the area excavated by SHARP is but one area of a much larger site during the Iron Age occupation phases (see **Section 10.2**). This area can therefore only be interpreted as a particular use area of this larger Iron Age site.

When compared against either a standard sized goat or sheep, the stature of the ovicaprids at Saruq al-Hadid is comparatively small across all occupation horizons at the site, however a range of sizes were present in the remains from Horizon IV. The size of ovicaprid remains from Horizon IV therefore corroborate with a number of late prehistoric sites in Arabia and adjacent regions. It is likely that this range of sizes has been caused by the amalgamation of ovicaprid measurements, however it may also reflect the transhumance of the site's occupants during this time and the resulting mixture of ovicaprids arriving at Saruq al-Hadid from different regional populations. Without a greater distinction between sheep and goat, it is inappropriate to integrate these measurements with the wider discussion about the presence of various sheep breads in late prehistoric Arabia (e.g. Uerpmann & Uerpmann 2008: 481). The measurements taken from the Wadi Suq cattle astragalus suggests that the cattle remains that were brought to Saruq al-Hadid during this period were from a relatively large animal.

The relative lack of cattle at Saruq al-Hadid is highly significant, as this species has been frequently identified in faunal assemblages from contemporary sites in southeastern Arabia e.g. Uerpmann & Uerpmann 2008). No cattle were identified at the nearby Umm an-Nar period site of al-Ashoosh (Contreras *et al.* 2016). This suggests that cattle may not have been utilised at sites in the desert interior, contrasting with their ubiquity at sites in the coastal and piedmont zones. Additionally, no full carcasses of cattle were present in the remains from the Central Area (or from the excavation in the Military Base – **Section 10.2**), suggesting that these animals were not brought to the site 'on-the-hoof', whereas ovicaprids were.

5. Domestic or Wild Species

5.1. Dromedary Camel, Camelus dromedarius

A large number of camel remains were recovered from the excavations at Saruq al-Hadid from all occupation phases at the site (**Table 2** & **Table 17**). These fragments were analysed using the methodologies set out by Wapnish (1984) for distinguishing between dromedary and Bactrian camels, with no Bactrians being identified in the assemblage. Furthermore, the anatomical measurements taken from the fragments identified as camel are similar to others taken from known dromedary camels (**Fig. 32**). These factors, combined with the fact that the earliest known appearance of the Bactrian camel in southeastern Arabia is far later than the main occupation at Saruq al-Hadid (Potts 2004), lead to the conclusion that all of these camel fragments are from dromedary camels. Hereafter, 'camel' shall refer exclusively to dromedary camels, unless stated otherwise.

Camels were relatively well represented through time at Saruq al-Hadid, with their NISP consistently representing *c.* 10% (**Table 2**) of the total identified assemblage. They have been included as a wild species as the remains from Saruq al-Hadid pre and post-date the currently conjectured dates of camel domestication. A question therefore remains as to whether these bones are from wild or domestic populations, as discussed further below.

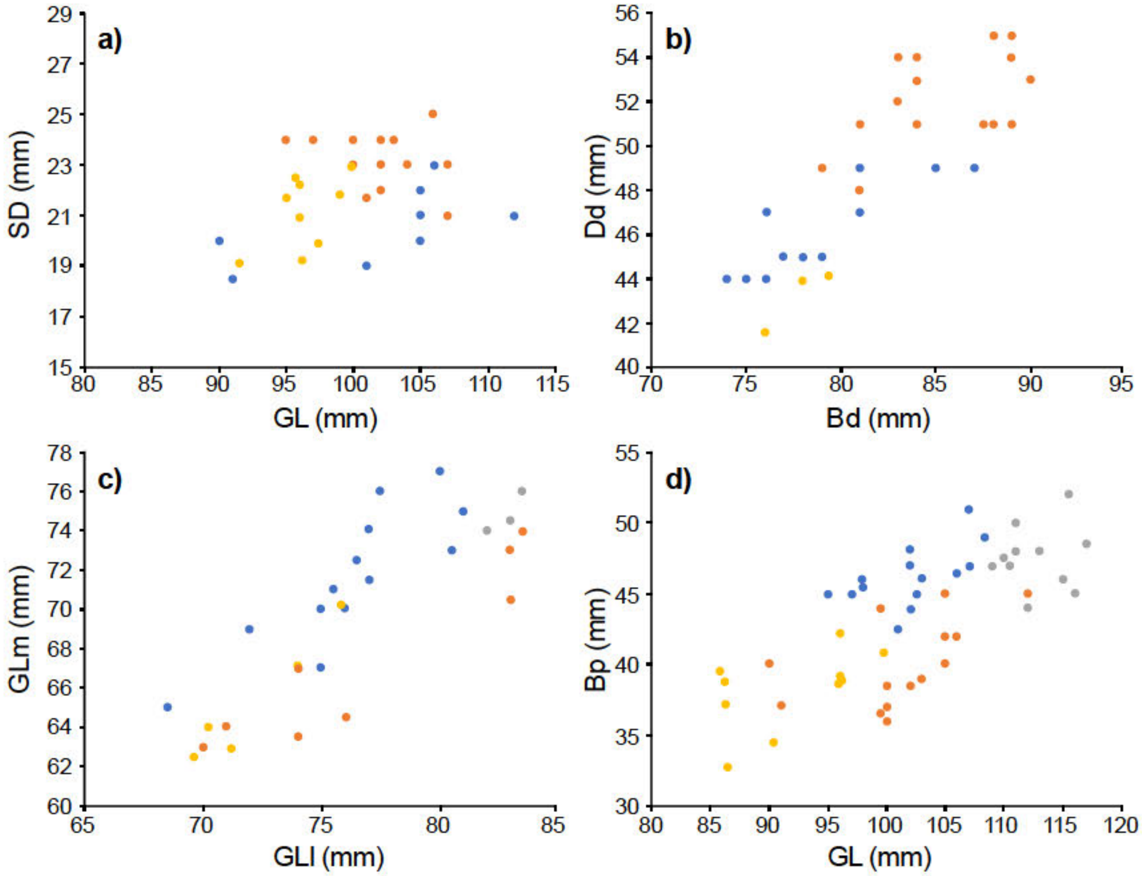


Figure 32. *The measurements taken from camel remains from Saruq al-Hadid (yellow), compared to measurements taken from known specimens of Bactrian (orange), Dromedary (blue) and hybrid (grey) camels. Shown here are measurements (following von den Driesch's guidelines (1976) from a) Anterior first phalanx (after Bartosiewicz & Dirjec 2001), b) Tibia (after Bartosiewicz & Dirjec 2001), c) Astragalus (after Uerpmann 1999), d) Anterior first phalanx (after Uerpmann 1999).*

Skeletal Element Representation

The skeletal element representation of the camel remains in the assemblage varied through time. The remains from Horizons V & IV were from complete carcasses, with a preponderance of forelimbs and distal hindlimbs (**Table 18**, **Fig. 33**). The remains from Horizon III, II and I consisted mainly of bones from the feet, with fewer limb bones and bones from the vertebral column (**Table 18**, **Fig. 33**).

Table 17. *The number of camel fragments across each area and horizon.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
F	Q1	3			101		**104**
	Q2				41		**41**
	R1		13	165			**178**
	R2		39		520		**559**
	S1		113	176	211	16	**516**
	S2	7	62		98		**167**
	S3		2		40		**42**
	T1		61		216	11	**288**
	T2		15	10	149		**174**
G	P1		2		50		**52**
	P3		1				**1**
	P4		1				**1**
	Q1	5	3	40			**48**
	Q2		1				**1**
	Q3	7	6				**13**
	R1	6	29	68	24		**127**
	R2		2				**2**
	R3	1					**1**
	S1		64	79	217	1	**361**
	S2	35	28	9	19		**91**
	S3	1	5				**6**
	T1		29	1	135		**165**
	T2		1				**1**
	T3		2				**2**
	W6		1				**1**
Total		**65**	**480**	**548**	**1821**	**28**	**2942**

Bone Surface Modifications

Only eight fragments of camel bone definitively associated with each of the occupation horizons displayed butchery marks (**Table 19**). The location and nature of each of these butchery marks is shown in **Figure 34**. The butchery marks identified on camel bones from Horizon IV occur on meat bearing elements and are situated near the joint surfaces of those elements. These butchery marks therefore likely reflect the disarticulation of carcasses for meat extraction. The two butchered elements from Horizons III & II are from the lower limb and are heavily chop marked (**Fig. 34**), potentially reflecting a different process. A number of camel bones were also burnt to varying degrees (**Table 20**).

Table 18. *The skeletal element representation (NISP) from the camel remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Skull	1 (*1*)	2 (*2*)	4 (*1*)	21 (*4*)		**28**
Maxilla			2 (*1*)	4 (*2*)		**6**
Mandible			6 (*4*)	47 (*45*)		**53**
Teeth	13 (*13*)	28 (*28*)	15 (*15*)	178 (*176*)		**234**
Atlas				4 (*4*)	2 (*1*)	**6**
Axis				8 (*8*)		**8**
Cerv. Vert.		5 (*3*)	18 (*8*)	15 (*1*)		**38**
Thor. Vert.			7 (*3*)	14 (*3*)		**21**
Rib	1 (*1*)	14 (*2*)	21 (*5*)	55 (*12*)		**91**
Sternum				6 (*6*)		**6**
Scapula		4 (*2*)	8 (*5*)	36 (*24*)		**48**
Humerus		15 (*12*)	16 (*14*)	83 (*76*)		**114**
Radius	1 (*1*)	6 (*2*)	8 (*7*)	75 (*71*)	10 (*10*)	**100**
Ulna				123 (*108*)	8 (*8*)	**131**
Carpals		4(*4*)	11 (*11*)	29 (*29*)		**44**
Metacarpal		6 (*4*)	8 (*4*)	72 (*51*)	4 (*4*)	**90**
Ant. Phal. 1	6 (*2*)	31 (*31*)	35 (*28*)	20 (*16*)		**92**
Ant. Phal. 2		16 (*15*)	14 (*14*)	18 (*7*)		**48**
Ant. Phal. 3			3 (*3*)	9 (*9*)		**12**
Lumb. Vert.				12 (*12*)		**12**
Caudal Vert.	4 (*4*)	7 (*7*)	26 (*26*)	4 (*4*)		**41**
Vert. Indet.		3	24	112		**139**
Pelvis		4 (*2*)	5 (*5*)	31 (*27*)	2 (*1*)	**42**
Femur			38 (*34*)	30 (*28*)		**68**
Patella			1 (*1*)	2 (*2*)		**3**
Tibia		3 (*2*)	5 (*4*)	69 (*64*)		**77**
Astragalus			9 (*9*)	54 (*49*)		**63**
Calcaneum		4 (*3*)	1 (*1*)	32 (*30*)		**37**
Tarsal		6 (*6*)	8 (*8*)	21 (*21*)		**35**
Os Mall.			2 (*2*)	2 (*2*)		**4**
Metatarsal		59 (*33*)		34 (*30*)	2 (*2*)	**95**
Post. Phal. 1	5 (*2*)	40 (*38*)	22 (*21*)	25 (*13*)		**92**
Post. Phal. 2		15 (*15*)	19 (*18*)	9 (*3*)		**43**
Post. Phal. 3		5 (*5*)	1 (*1*)	5 (*5*)		**11**
Metapodial	23	41	20	129		**213**
Sesamoid		2		4		**6**
Fl. Bn. Indet.	1	47	42	52		**142**
Lg. Bn. Indet.	10	113	149	377		**649**
Total	**65**	**480**	**548**	**1821**	**28**	**2942**

Figure 33. *The skeletal element representation in the camel remains, shown as a percentage of MNI, across each horizon. Skeletal Image: © 2006 Archeozoo.org*

Table 19. *The number of specimens displaying butchery marks in the camel assemblage.*

	Horizon II	Horizon III	Horizon IV	Total
Ulna				
Cut marks across proximal end			1	**1**
Cut mark across midshaft, near articulation with radius		1		**1**
Femur				
Cut marks across the trochanter minor			1	**1**
Tibia				
Cut marks on proximal tip			1	**1**
Cut marks below proximal tip			1	**1**
Metapodial, indet.				
Heavy chop mark in proximal tip			1	**1**
1st Phalanx				
Chopped laterally down midshaft, cut mark in distal end	1			**1**
Heavy chop mark in distal end	1			**1**
Total	**2**	**1**	**5**	**8**

Table 20. *The number and percentage of burnt camel fragments across each horizon.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V
Patchy Charring	-	2 (18.2%)	14 (77.8%)	65 (18.6%)	-
Charred, burnt black	2 (28.6%)	5 (45.5%)	-	48 (13.7%)	4 (100%)
Grey	-	2 (18.2%)	3 (16.7%)	150 (42.9%)	-
Burnt white	5 (71.4%)	2 (18.1%)	1 (5.5%)	85 (24.3%)	-
Calcined	-	-	-	2 (0.6%)	-
Burnt Fragments	**7**	**11**	**18**	**350**	**4**
Percentage of Horizon Fragments Total	***10.8***	***2.3***	***3.3***	***19.2***	***14.3***

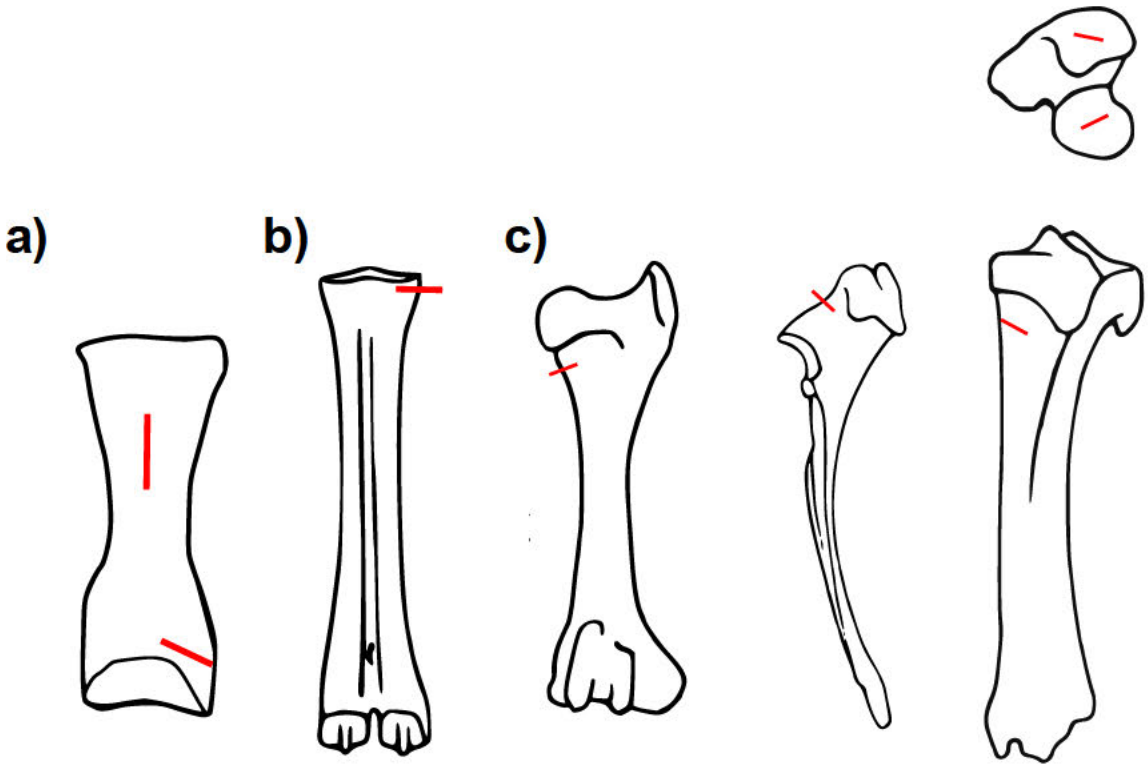


Figure 34. *Schematic depictions of skeletal elements displaying the location and type of butchery marks (red lines) identified on the camel remains across each horizon. Thicker lines represent chop marks. a) Horizon II; b) Horizon III; c) Horizon IV. Skeletal outline after Lauwerier 1988.*

Population Demographics

Male and female camels can be distinguished based upon the size and shape of the maxillary canines (von den Driesch *et al.* 2008: 492). No intact canines were recovered from the SHARP excavations at Saruq al-Hadid, preventing this methodology from being employed. Anatomical measurements taken from the camel bone assemblage were assessed in order to model the sexual composition of the population represented by the remains (cf. von den Driesch *et al.* 2008). The raw measurements taken from the bones were logarithmically scaled to a camel specimen of known standard (cf. Uerpmann & Uerpmann 2002: Tab. 1). The resulting plots were multi-modal, which was not conducive to a clean distinction between male and female camels within the population (**Fig. 35**).

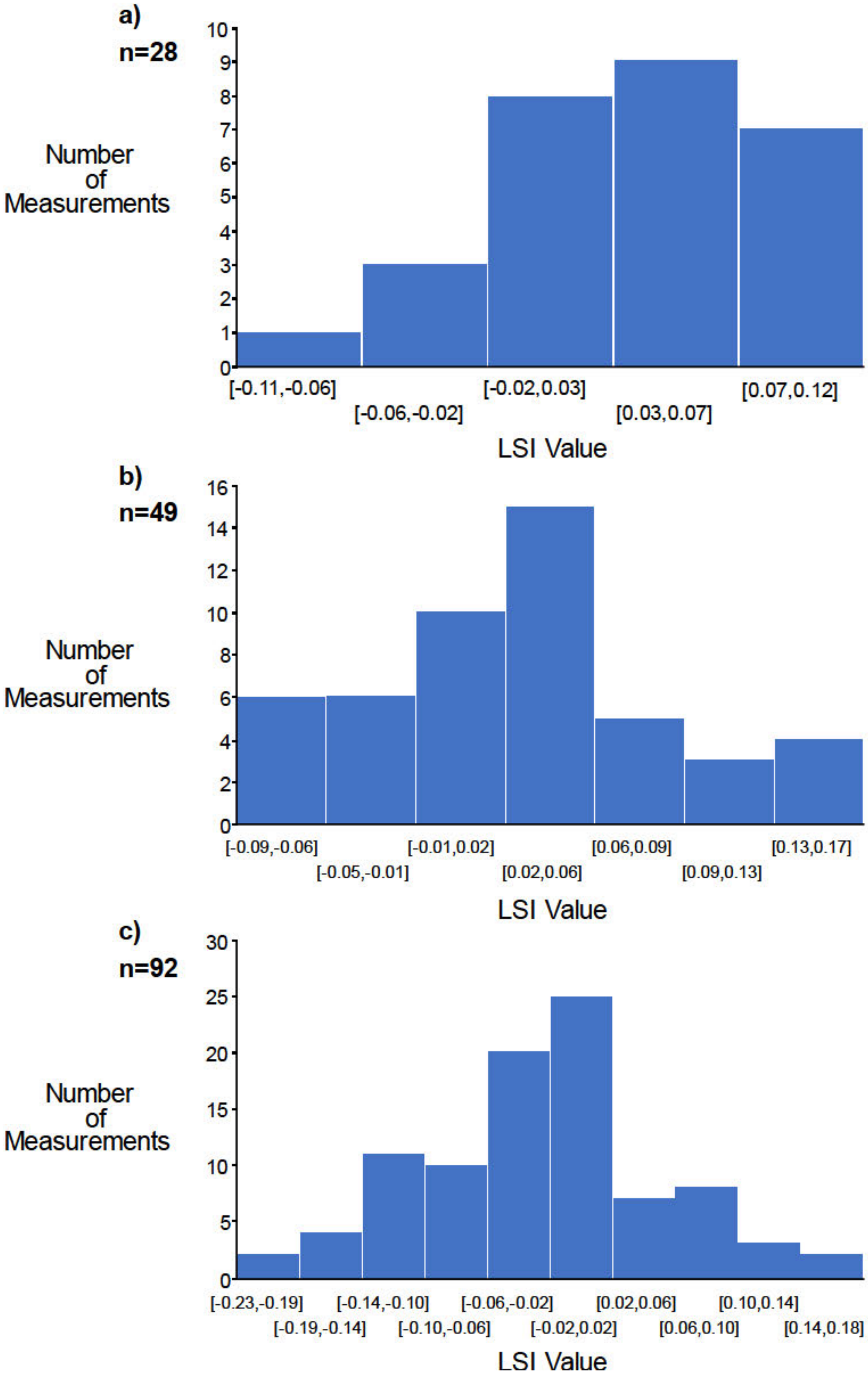


Figure 35. *Histograms representing the measurements taken from the camel remains across all horizons; a) Horizon II, b) Horizon III, c) Horizon IV.*

As of the writing of this chapter, in mid-2019, no method exists for interpreting the epiphyseal fusion state of dromedary long bones to determine the age of death of the animal. Previous researchers have utilised epiphyseal fusion schemes from a small sample of dromedary camels and by combining fusion schemes from other ungulates (e.g. Monchot 2014: 196; Uerpmann & Uerpmann 2017: Fig. 21.5), however researchers studying the rates of epiphyseal fusion in south American camelids have demonstrated differences between the fusion rates of alpaca (*Vicugna pacos*) and other artiodactyls (de Medina *et al.* 2016: Tab. 6). To analyse the assemblage from Saruq al-Hadid both fusion schemes were used (**Table 21** & **Table 22**), however it is likely that the fusion scheme presented by de Medina *et al.* is more applicable to the remains from Saruq al-Hadid, due to the similarities in skeletal anatomy between dromedary camels and alpaca (both members of the Camelid family). The epiphyseal fusion state of the camel remains from Saruq al-Hadid are similar to those recorded from the camel assemblage excavated at al-Sufouh 2, a Bronze Age site hypothesised to have been a butchery site for camel carcasses (von den Driesch *et al.* 2008).

Table 21. *The epiphyseal fusion state of fragments identified as camel (NISP), following a fusion scheme derived from other artiodactyls.*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**FS**
Scapula				1	-	*100*							
Pelvis													
7-10 months	**-**	**-**	**-**	**1**	**-**	***100***	**-**	**-**	**-**	**-**	**-**	**-**	**-**
D. Humerus				4	-	*100*				5	-	*100*	
Phalanx I	3	-	*100*	52	9	*85*	25	7	*78*	7	4	*64*	
Phalanx II							10	3	*77*				
13-18 months	**3**	**-**	***100***	**56**	**9**	***86***	**35**	**10**	***78***	**12**	**4**	***75***	**-**
D. Tibia										2	2	*50*	
D. Metapodia	-	1	-				1	2	*33.3*	8	13	*38*	
2-3 years	**-**	**1**	***0***	**-**	**-**	**-**	**1**	**2**	***33.3***	**10**	**15**	***40***	**-**
D. Radius/Ulna	1	-	*100*	1	-	*100*				8	2	*80*	
P. Humerus				-	1	-	-	1	-	1	2	*33*	1
Calcaneum				1	-	*100*	1	-	*100*				
P. Femur							-	8	-	2	2	*50*	
D. Femur							2	-	*100*	4	-	*100*	
P. Tibia										1	-	*100*	
3-4 years	**1**	**-**	***100***	**2**	**1**	***66***	**3**	**9**	***33***	**16**	**6**	***73***	***1***

Table 22. *The epiphyseal fusion state of fragments identified as camel (NISP) (after de Medina* et al. *2016).*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**FS**
Scapula				1	-	*100*							
D. Humerus				4	-	*100*				5	-	*100*	
Pelvis													
<12-18 months	**-**	**-**	**-**	**5**	**-**	***100***	**-**	**-**	**-**	**5**	**-**	***100***	**-**
Phalanx I	3	-	*100*	52	9	*85.3*	25	7	*78.1*	7	4	*63.6*	
Phalanx II							10	3	*76.9*				
Calcaneum				1	-	100	1	-	*100*				
D. Tibia										2	2	*50*	
D. Metapodia	-	1	-				1	2	*33.3*	8	13	*38.1*	
<18-36 months	**3**	**1**	***75***	**53**	**9**	***86***	**37**	**12**	***76***	**17**	**19**	***47***	**-**
D. Radius/Ulna	1	-	*100*	1	-	*100*				8	2	*80*	
P. Humerus				-	1	-	-	1	-	1	2	*33.3*	1
P. Femur							-	8	-	2	2	*50*	
D. Femur							2	-	*100*	4	-	*100*	
P. Tibia										1	-	*100*	
<36-48 months	**1**	**-**	***100***	**1**	**1**	***50***	**2**	**9**	***18***	**16**	**6**	***73***	***1***

Size

A total of 203 measurements were taken from fragments of dromedary bones that could be associated with one of the five horizons. Using an LSI, as described above (**Section 4.1**), these measurements show that camels of a wide range of sizes were utilised at the site, particularly in Horizon IV (**Fig. 36**). This range of sizes could reflect a number of different aspects to the relationship between humans and dromedaries that took place at Saruq al-Hadid, an issue discussed in further detail elsewhere (Roberts *et al.* Forthcoming a).

Furthermore, the sizes of the camels in the assemblage from Saruq al-Hadid do not corroborate with the size of camels from contemporary sites (**Fig. 37**), which has major implications for our understanding of camel domestication and our ability to distinguish between wild and domestic camels in the archaeological record. A seminal study undertaken by Uerpmann & Uerpmann (2002) demonstrated that, at a number of southeastern Arabian sites, camels decrease in size between the Bronze and Iron age, a change that occurs alongside diachronic changes in the representation of dromedary camels at these sites; in effect, the amount of camels in assemblages decreases throughout the Bronze Age, attributed to overhunting, before increasing from the start of the Iron Age (Uerpmann & Uerpmann 2002). These changes are suggested to have resulted from the introduction of domesticated camels into the southeastern Arabia from the Iron Age onwards (Uerpmann & Uerpmann 2002).

The Iron Age camel remains from Saruq al-Hadid represent larger individuals than those from other Iron Age sites in the region, with the Bronze Age camels from the site being some of the smallest dromedary remains in the region (**Fig. 37**). Furthermore, the change in the amount of camel in assemblages observed by Uerpmann & Uerpmann is not a feature of the camel bone assemblage from Saruq al-Hadid, with camels consistently represented throughout the site's occupation.

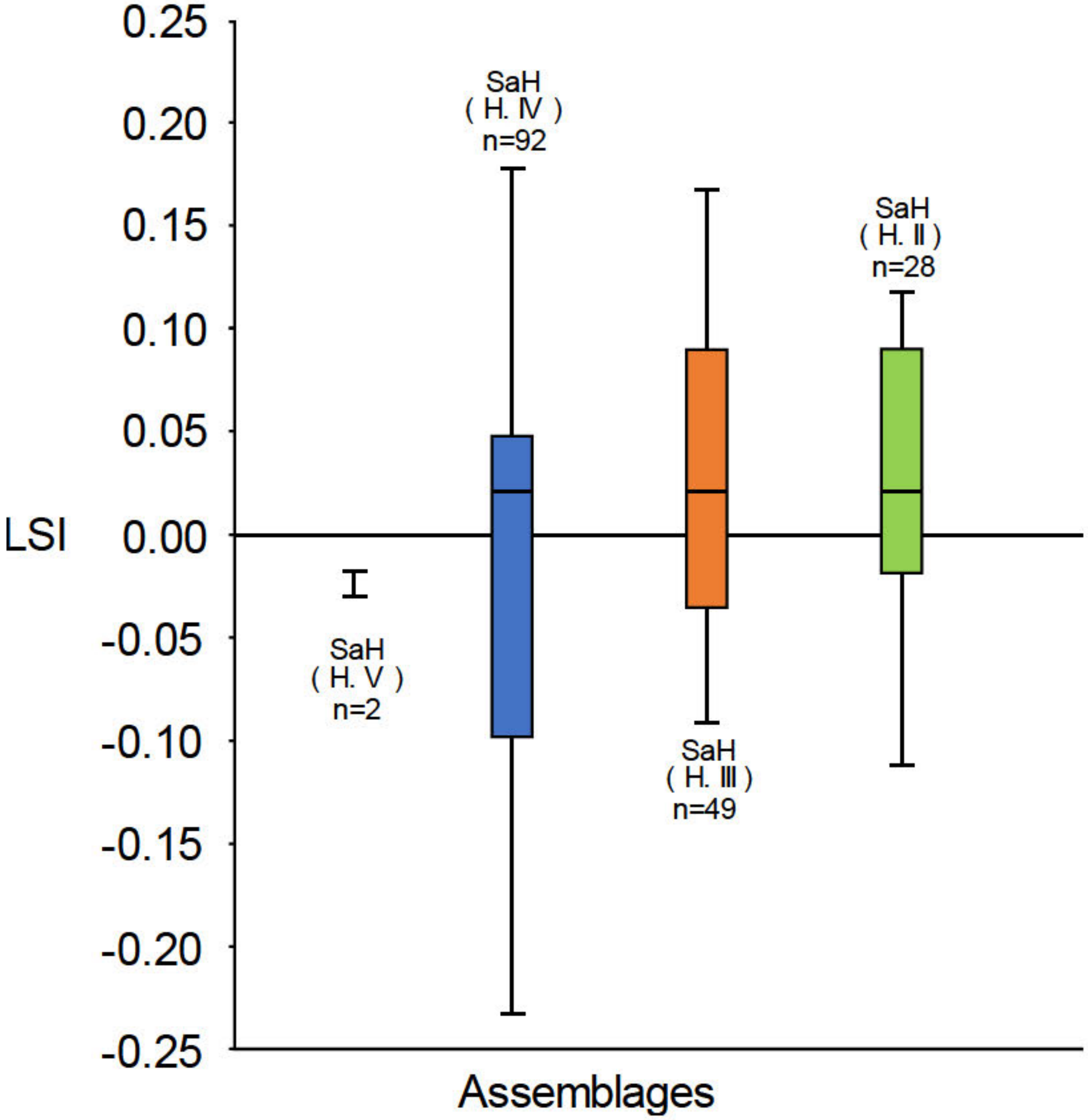


Figure 36. *The log-scaled indices of measurements taken from the camel remains across each horizon.*

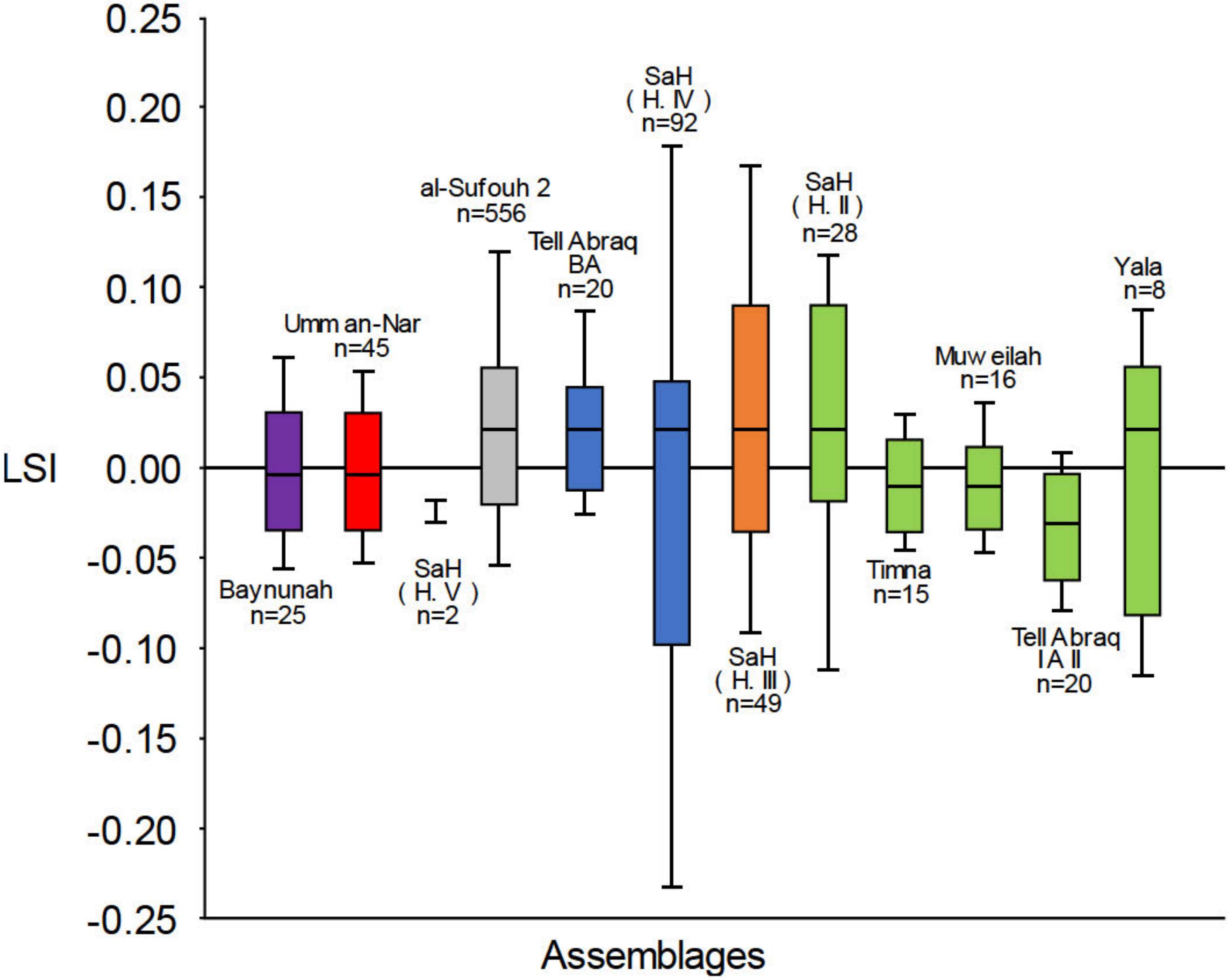


Figure 37. *The log-scaled indices of measurements taken from camel remains compared to other published datasets from contemporary sites in the region (Beech et al. 2009; Uerpmann & Uerpmann 2002; von den Dreisch et al. 2008; Grigson 2012; Fedele 2017).*

Other Notable Characteristics

A number of other aspects of the camel bone assemblage should be discussed here. This includes three separate 2nd phalanxes displaying the same extensive pathology (**Fig. 38**). Additionally, a discrete cluster of four camel bones directly associated with two ceramic pedestalled burners were recovered from Horizon III (**Fig. 39**). These fragments consisted of two unfused 1st phalanxes and a sesamoid (**Fig. 39**). These burners, while their precise function is unknown, appear to have ritual significance at Saruq al-Hadid and the wider region during the Late Bronze – Early Iron Age, as discussed in (Karacic *et al.* 2018). Lastly, several camel mandible fragments were present within the single stone and mortar structure identified at the site (**Fig. 40**).

Figure 38. *A non-pathological camel 2nd phalanx (left) compared to a pathological camel 2nd phalanx (right), recovered from Context 2714, Horizon IV, Square F.S1.*

5.2. Canid

Canid remains were identified in four of the five horizons (**Table 23**). In each horizon, all of the fragments identified as canid were from the lower limb (**Table 24**). The remains identified in Horizons III, II & I were all metapodial fragments, however other skeletal elements from the lower forelimb were present in Horizon IV (**Table 24**). One of these, a fragment of distal radius, was unfused indicating the fragment is from an individual that died before the age of 12 months (Amorosi 1989). Two fragments of canid recovered from Horizon IV had been charred, but none of the canid remains had been butchered.

In addition, a singular fragment from Horizon I was identified as an atlas from a fox.

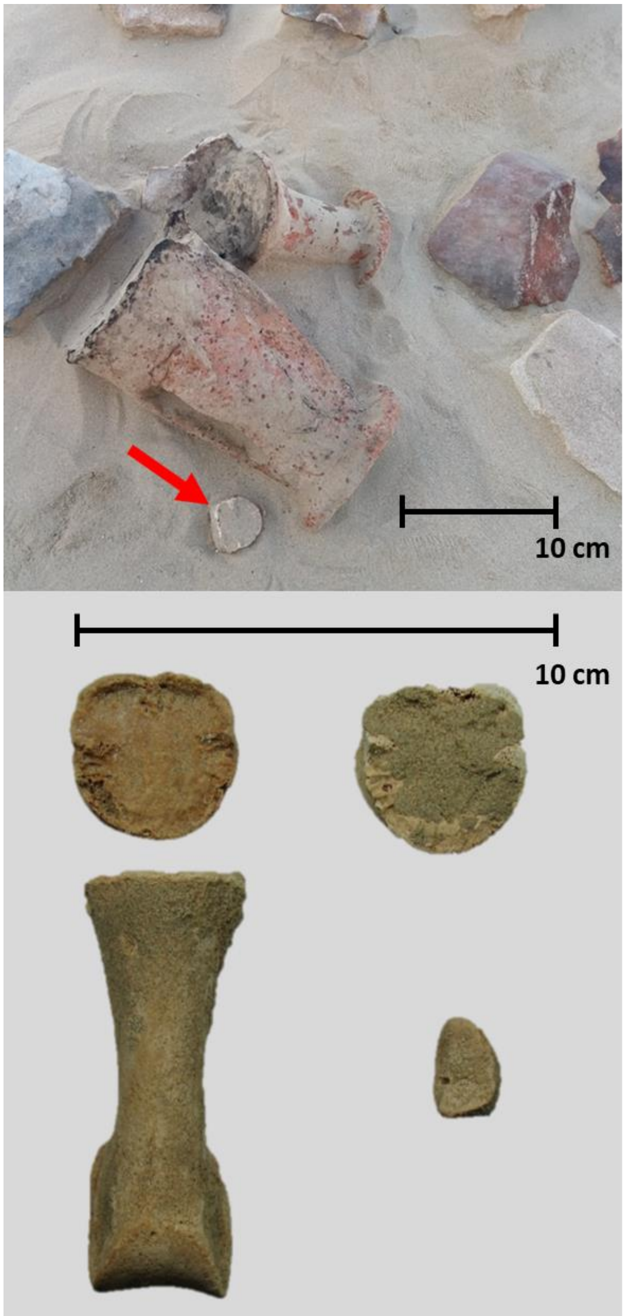


Figure 39. ***Above****: Camel bone, marked by the red arrow, with pedestalled burners in-situ – Context 2030;* ***Below****: the camel remains recovered from Context 2030.*

5.3. Domestic or Wild Species Discussion

As stated above, the camel remains from Saruq al-Hadid could be from a domestic population, a wild population, or both; the domesticity of the camels being utilised at Saruq al-Hadid could have changed through time. There is very little in this assemblage that allows us to conclusively determine this, however the fragments discussed in **Section 4.5.5.** do prompt questions as to the nature of the relationship between humans and dromedaries prior to their domestication, hypothesised to have occurred during the onset of the Iron Age in Arabia (*c.* 1200 BCE – e.g. Uerpmann & Uerpmann 2002; Magee 2015; Almathen *et al.* 2016; Uerpmann & Uerpmann 2017). The characteristics of the camel bone assemblage from Saruq al-Hadid prompt questions regarding how these camel remains fit into our current framework of understanding the nature of camel domestication and wider questions about how zooarchaeological material may be used to address questions regarding the domestication of dromedary camels, also asked by Uerpmann & Uerpmann during their recent discussion of the camel remains from the Iron Age site of Muweilah (2017: 315). These remains are therefore critically important to our understanding of human-dromedary relationships during late prehistory in southeastern Arabia and implications of these remains has been discussed at length elsewhere (Roberts *et al.* Forthcoming).

Figure 40. *The stone and mortar structure with an inset image of the camel mandible built into the structure, one of which has been charred.*

Table 23. *The number of canid fragments across each area and horizon.*

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
***Canis* sp.**							
F	R1			1			**1**
	R2				2		**2**
	S2		2		1		**3**
	S3				5		**5**
G	P1				6		**6**
Total		**-**	**2**	**1**	**14**	**-**	**17**
***Vulpes* sp.**							
G	S2	**1**					**1**
	T1				**1**		**1**
Total		**1**	**-**	**-**	**1**	**-**	**2**
Grand Total		**1**	**2**	**1**	**15**	**-**	**19**

Table 24. *The skeletal element representation (NISP) from the canid remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
***Canis* sp.**						
Radius				1 (*1*)		**1**
Ulna				2 (*2*)		**2**
Metacarpal II				1 (*1*)		**1**
Metacarpal III				3 (*3*)		**3**
Metacarpal IV				1 (*1*)		**1**
Metacarpal V				1 (*1*)		**1**
Metapodia Indet.		2 (*2*)	1 (*1*)	3 (*3*)		**6**
Phal. 1 Indet.				1 (*1*)		**1**
Phal. 2 Indet.				1 (*1*)		**1**
Total	-	2	1	14	-	**17**
***Vulpes* sp.**						
Metacarpal Indet.				1 (*1*)		**1**
Metatarsal, indet.	1 (*1*)					**1**
Total	1	-	-	1	-	**2**
Grand Total	**1**	**2**	**1**	**15**	**-**	**19**

Without the further identification of canid remains to a genus or species level, it is difficult to determine whether they are from domestic or wild dogs. Dogs are known to have been kept as domesticates by humans throughout late prehistory, with several intentional dog burials (including some human-dog co-burials) known from the Umm an-Nar and Ed-Dur period sites in southeastern Arabia (Blau & Beech 1999; van Neer *et al.* 2017) and depictions of humans hunting with dogs in rock art from the wider Arabian region (Maraqten 2015). On the other hand, wild dog species have been identified in other faunal assemblages contemporary to Saruq al-Hadid (Uerpmann 2001: 229; von den Driesch & Obermaier 2007; Uerpmann & Uerpmann 2008: 473; Uerpmann & Uerpmann 2017) suggesting wild species were present and exploited by humans in the region during late prehistory. Furthermore, a number of finds interpreted as evidence of the consumption of dogs have been recovered (Blau & Beech 1999: 40), suggesting that dogs, either wild or domestic, may have been utilised for consumption in the past. The single fragment of fox from Horizon I is likely from a modern-day intrusive animal, as identified in the faunal remains from Ed Dur (van Neer *et al.* 2017: 15).

6. Wild Terrestrial Species

6.1. Oryx, Oryx leucoryx

Oryx were the most frequently identified taxa in the remains across the entire assemblage and in four of the five horizons, both in terms of NISP and MNI (**Tables 2, 3 & 25**).

Table 25. *The number of oryx fragments across each area and horizon.*

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
F	Q1	9	17		109		**135**
	Q2				17		**17**
	R1		15	151		5	**171**
	R2		15		290		**305**
	S1	1	297	389	678	25	**1390**
	S2	6	97		264		**367**
	S3				1		**1**
	T1	6	256	3	472	17	**754**
	T2	4	36	49	319		**408**
G	P1		2		80		**81**
	P2		1				**1**
	P3		1				**1**
	P4	2	33				**35**
	Q1	24	5	8			**37**
	Q2	3	6	1			**10**
	Q3	5	291				**296**
	R1	26	118	66	56		**266**
	R2		50				**50**
	R3	19	107				**126**
	S1	8	145	169	848	1	**1171**
	S2	23	65	27	156		**271**
	S3	27	134				**161**
	T1		54	12	519		**585**
	T2		36				**36**
	T3		29				**29**
Total		**163**	**1810**	**875**	**3809**	**48**	**6705**

Skeletal Element Representation

The representation of skeletal elements identified as oryx varied across time in the assemblage. The remains from Horizons V & IV represent full carcasses, with a general preponderance of meat bearing elements (e.g. pelvis, scapula, humerus - **Fig. 41** & **Table 26**). This contrasts greatly with the remains from Horizons III, II & I in which horncores and lower limb bones are predominant (**Fig. 41** & **Table 26**). Horizon II in particular contained a clear predominance of horncore and lower limb bones. Furthermore, as outlined in **Section 3**, a large number of caudal vertebrae from large mammals were recovered from this horizon; given the relative proportion of species identified in this horizon it is likely that a large proportion of these derive from oryx. While fewer remains were identifiable from Horizon I, those that were identified to skeletal elements were also found to be largely horncore however other parts of the body were still present.

The occurrence of oryx horncore in the Horizon III horncore deposit described above (**Section 4.1**) should be noted here (**Fig. 27**). In a similar vein, a notable feature of the oryx remains from Horizon II was a cache of five horncores deposited in alignment (**Fig. 42**). A number of beads were found in association with this cache.

Bone Surface Modifications

The butchery marks identified on the remains from Horizon IV were centred around joint surfaces, indicative of carcass disarticulation (**Table 27** & **Fig. 43**). This corroborates the butchery marks observed on the domesticates from Horizon IV, described above (**Section 3.2.1**).

This contrasts greatly with the butchery marks identified on oryx remains from Horizon II, which were largely focused around the base of horncores with multiple examples of cutting and chopping marks made around the protrusion of the horncore from the skull (**Fig. 44** & **Table 27**). These marks are strongly indicative of the removal of horns from the skull, as discussed in further detail below (**Section 5.7.**). A similar cut mark was also identified on a fragment of horncore from Horizon III, alongside several butchered metatarsals (**Table 27**).

A number of fragments identified as oryx also displayed evidence of having been burnt to varying degrees, the characteristics of which varied across each horizon (**Table 28**). Oryx remains from both Horizons V & IV included a relatively large number of burnt fragments, the majority of which have been burnt by relatively low heat suggestive of cooking (**Table 28**). A significantly lower number of oryx remains from Horizons III-I were burnt (**Table 28**). The presence of fragments that have been burnt to a high intensity require an explanation outside of cooking.

Figure 41. *The skeletal element representation in the oryx remains, shown as a percentage of MNI, across each horizon. © 2016 ArcheoZoo.org*

Table 26. *The skeletal element representation (NISP) from the oryx remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Horncore	124 (*3*)	1706 (*224*)	528 (*69*)	252 (*211*)	1 (*1*)	**2611**
Skull	4 (*1*)	9 (*2*)	10 (*6*)	38 (*21*)		**61**
Maxilla		1 (*1*)		5 (*3*)		**6**
Mandible	3 (*2*)		11 (*11*)	118 (*104*)		**132**
Teeth	3 (*3*)	11 (*3*)	36 (*24*)	159 (*148*)		**209**
Atlas	2 (*2*)	2 (*2*)	3 (*3*)	20 (*20*)		**27**
Axis				102 (*102*)		**102**
Cerv. Vert.		1 (*1*)	2 (*2*)	29 (*22*)		**32**
Thor. Vert.			2 (*2*)	31 (*27*)		**33**
Rib		1 (*1*)		57 (*49*)		**58**
Scapula	1 (*1*)	9 (*7*)	20 (*13*)	168 (*143*)		**198**
Humerus	1 (*1*)	3 (*1*)	6 (*3*)	252 (*235*)		**262**
Radius	2 (*2*)	3 (*3*)	18 (*9*)	291 (*279*)		**314**
Ulna	2 (*2*)	2 (*1*)	12 (*6*)	358 (*343*)	9 (*9*)	**383**
Carpals	1 (*1*)	5 (*5*)	14 (*14*)	165 (*161*)	3 (*3*)	**188**
Metacarpal			13 (*9*)	118 (*111*)		**131**
Ant. Phal. 1	3 (*1*)	4 (*2*)	17 (*10*)	133 (*121*)	3 (*3*)	**160**
Ant. Phal. 2	1 (*1*)	3 (*3*)	12 (*9*)	25 (*20*)	1 (*1*)	**42**
Ant. Phal. 3		3 (*3*)	1 (*1*)	4 (*4*)		**8**
Lumb. Vert.			1 (*1*)	17 (*14*)		**18**
Sacrum				23 (*20*)		**23**
Vert. Indet.		2	2	9		**13**
Pelvis	1 (*1*)	5 (*3*)	28 (*15*)	303 (*288*)	1 (*1*)	**338**
Femur	2 (*1*)	1 (*1*)	8 (*7*)	39 (*35*)	1 (*1*)	**51**
Tibia	1 (*1*)	3 (*3*)	27 (*24*)	302 (*288*)	15 (*15*)	**348**
Fibula		1 (*1*)		5 (*5*)		**6**
Astragalus		2 (*1*)		348 (*347*)	5 (*5*)	**355**
Calcaneum			9 (*5*)	212 (*201*)	7 (*7*)	**228**
Nav. Cub.	2 (*1*)	2 (*1*)	7 (*5*)	42 (*38*)		**53**
Tarsal		2 (*2*)	32 (*32*)	26 (*23*)		**60**
Os Mall.			2 (*2*)	33 (*33*)		**35**
Metatarsal	4 (*2*)	2 (*2*)	24 (*18*)	30 (*23*)		**60**
Post. Phal. 1	1 (*1*)	1 (*1*)	9 (*9*)	65 (*62*)	1 (*1*)	**77**
Post. Phal. 2		3 (*2*)	3 (*3*)	19 (*16*)	1 (*1*)	**26**
Post. Phal. 3			1 (*1*)	1 (*1*)		**6**
Metapodial	4	20	15	7		**46**
Sesamoid	1 (*1*)		1 (*1*)	3 (*3*)		**5**
Lg. Bn. Indet.		3	1			**4**
Total	**163**	**1810**	**875**	**3809**	**48**	**6705**

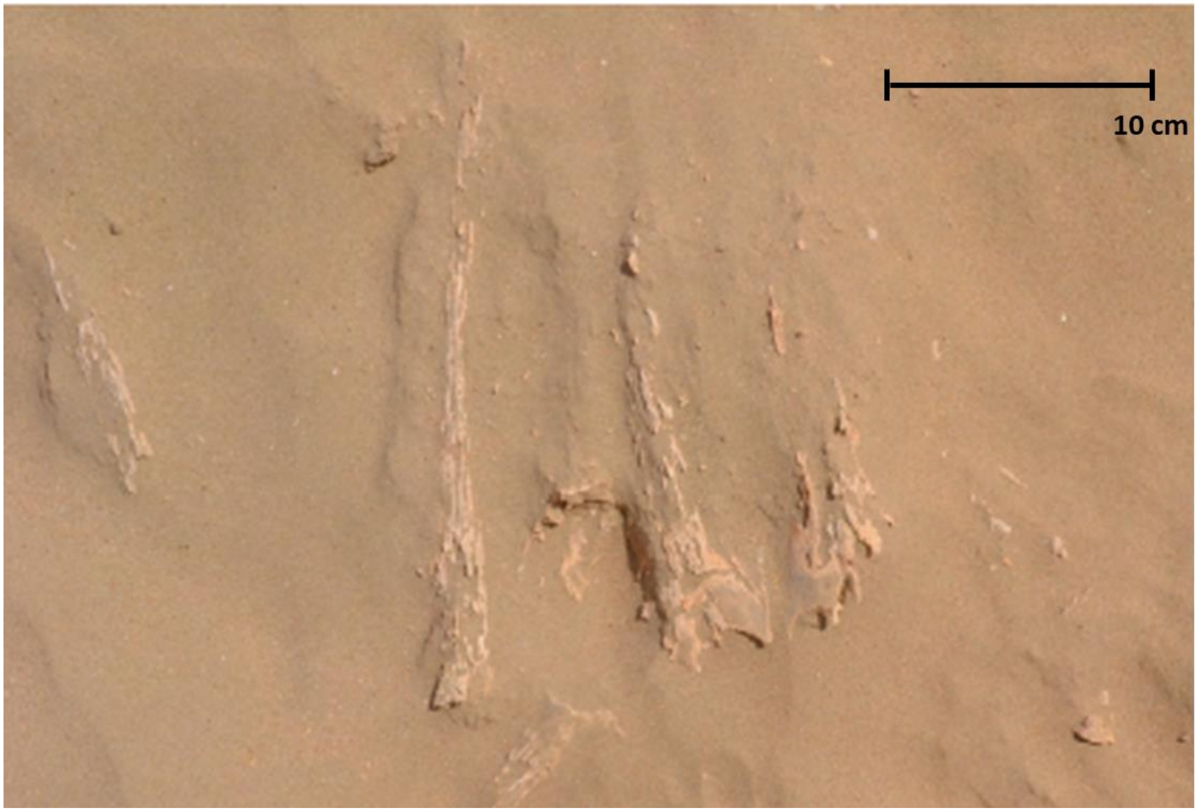


Figure 42. *A cache of five horncores, representing three individual animals in Context 1182, Horizon II, Square G.Q3.*

Population Demographics

The timing and sequence of epiphyseal fusion in oryx is poorly known, therefore any interpretation of population demographics based upon their skeletal remains recovered from Saruq al-Hadid must be made with caution. However, assuming that the progression of epiphyseal fusion in oryx skeletal anatomy follows that of other artiodactyls with similar skeletal anatomies, some inferences can be made regarding the age demographic of the oryx population recovered at Saruq al-Hadid.

The fusion data recorded from the oryx remains suggests the presence of a range of ages in the assemblages from all the 4 horizons (**Table 29**). This is particularly true for the oryx remains from Horizon IV; three fragments of remains were found to be from juvenile animals, however the majority of fragments were from adult animals (**Table 29**). Juvenile oryx were also present in the remains from Horizon III and II, however in less relative quantities than suggests by the remains from Horizons V and IV (**Table 29**). No juveniles were explicitly represented by the oryx remains from Horizon I, however three fragments were present from animals not older than the ‘young-adult’ age stage (**Table 29**).

Table 27. *The number of specimens displaying butchery marks in the oryx assemblage.*

	Horizon II	Horizon III	Horizon IV	Total
Horncore				
Chop marks in base of horncore	3			**3**
Cut marks at base of horncore	4	1		**5**
Scapula				
Cut marks on distal end across the medial surface	1			**1**
Humerus				
Cut marks across distal articulation			1	**1**
Radius				
Cut marks on proximal end			1	**1**
Ulna				
Cut marks across proximal end			1	**1**
Metacarpal				
Cut mark across distal shaft			1	**1**
Pelvis				
Cut along acetabulum			1	**1**
Femur				
Cut marks across shaft below femoral head			1	**1**
Cut across shaft towards distal end			1	**1**
Calcaneum				
Cut marks on ventral side of coronoid process			1	**1**
Cut marks across proximal tuberosity			1	**1**
Cut marks across mid-shaft			1	**1**
Navicular Cuboid				
Cut marks across posterior surface			1	**1**
Metatarsal				
Cut marks across proximal end		3		**1**
Total	**8**	**4**	**11**	**23**

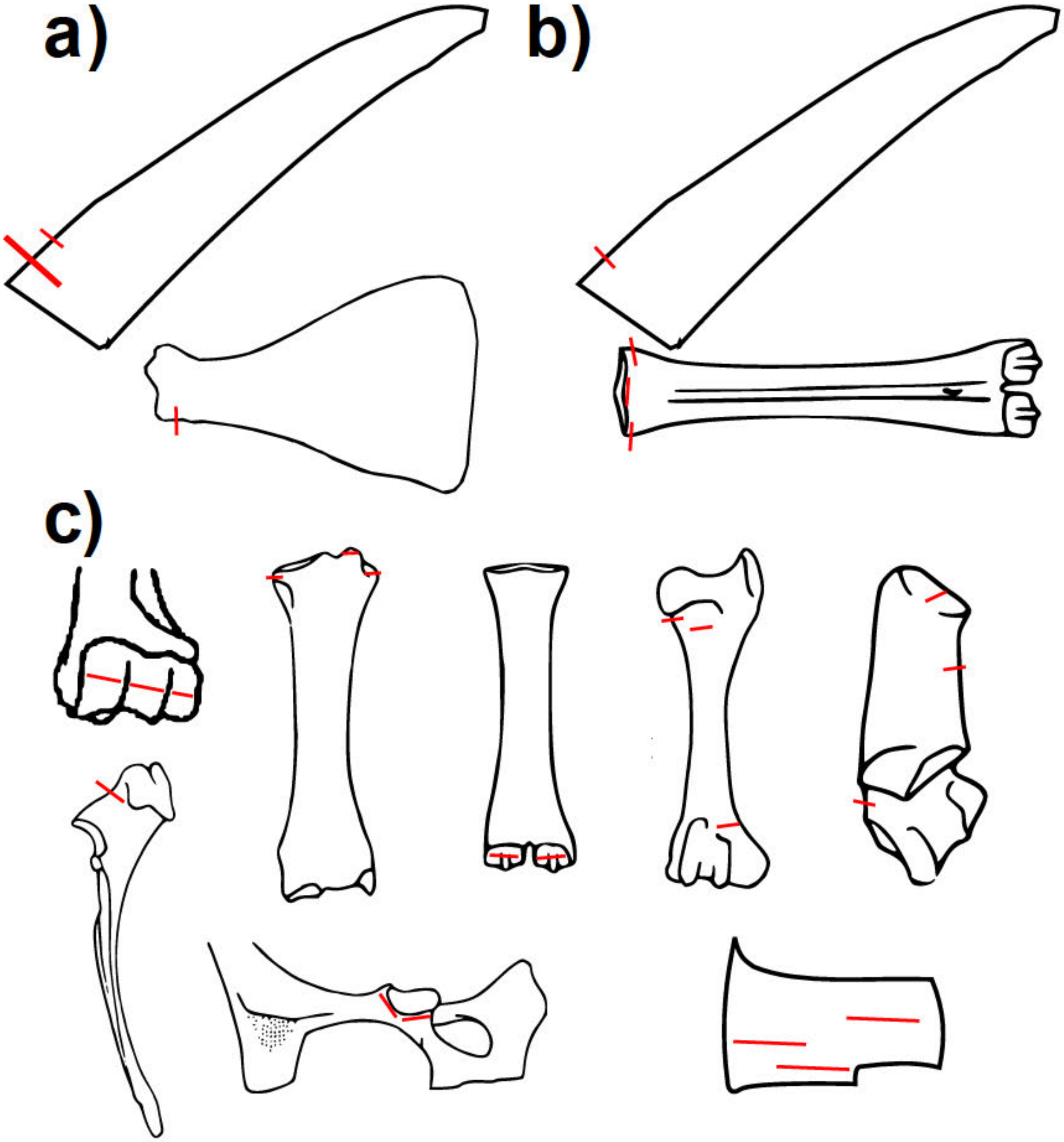


Figure 43. *Schematic depictions of skeletal elements displaying the location and type of butchery marks (red lines) identified on the oryx remains across each horizon. Thicker lines represent chop marks. a) Horizon II; b) Horizon III; c) Horizon IV. Skeletal outline after Lauwerier 1988.*

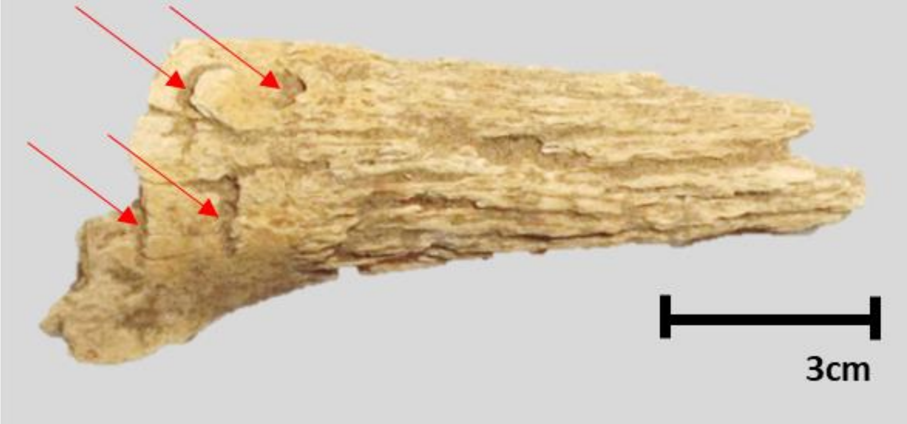


Figure 44. *An oryx horncore recovered from Context 1507, Horizon II, Square G.R3, displaying heavy chop marks at the base of the horn.*

Table 28. *The number and percentage of burnt oryx fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring	2 (18.2%)	1 (4.6%)	6 (54.6%)	269 (40.8%)	2 (15.4%)
Charred, burnt black		15 (68.2%)		112 (17%)	7 (53.8%)
Grey	2 (18.2%)	3 (13.6%)	4 (36.3%)	139 (21.1%)	3 (23.1%)
Burnt white	7 (63.6%)	3 (13.6%)		139 (21.1%)	1 (7.7%)
Calcined			1 (9.1%)		
Burnt Fragments	**11**	**22**	**11**	**659**	**13**
Percentage of Horizon Fragments Total	***6.8***	***1.2***	***1.3***	***17.3***	***27.1***

Table 29. *The epiphyseal fusion state of fragments identified as oryx (NISP), following a fusion scheme derived from other artiodactyls.*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**FS**
Scapula	1	-	*100*	3	-	*100*	1	-	*100*	6	-	*100*	
D. Humerus							3	-	*100*	10	1	*90.9*	
P. Radius										4	-	*100*	1
Phalanx I	2	-	*100*	2	1	*66.7*	18	-	*100*	43	2	*95.6*	
Phalanx II	1	-	*100*	2	-	*100*	4	1	*80*	5	-	*100*	
Juvenile	**4**	**-**	***100***	**7**	**1**	***88***	**26**	**1**	***96***	**68**	**3**	***96***	***1***
D. Tibia							4	1	*80*	6	1	*85.7*	
D. Metapodia	-	3	-	4	1	*80*	8	1	*88.9*	27	19	*58.7*	
Young-Adult	**-**	**3**	***0***	**4**	**1**	***80***	**12**	**2**	***86***	**33**	**20**	***60***	**-**
Ulna										2	2	*50*	
D. Radius										5	2	*71.4*	
P. Humerus										3	-	*100*	
Calcaneum										4	-	*100*	
P. Femur										3	1	*75*	
D. Femur										4	-	*100*	
P. Tibia							1	-	*100*	6	2	*75*	
Adult	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	***100***	**27**	**7**	***79***	**-**

As with epiphyseal fusion, the manifestation of sexual dimorphism in oryx skeletal anatomy is poorly understood so few conclusions could be drawn into the sexual demographic of the oryx remains. Using the assumption that adult male oryxes are larger than adult females, the composition of male and female animals in the remains should be able to be determined using metrical analysis (**Fig. 45**). The collapse of oryx populations in southeastern Arabia means that relatively little is known about the behaviour of wild oryx, including ecological aspects such as herd demographics and geographic range. Some studies have been made into the behaviour of reintroduced herds (e.g. Spalton *et al.* 1999), which suggest that the demographic represented in the remains demonstrates a relative lack of juveniles, when taking into account the abundance of females represented. In turn, this allows us to conclude that juvenile animals may not have been hunted at Saruq al-Hadid, the implications of which are discussed further by Roberts *et al.* (2019).

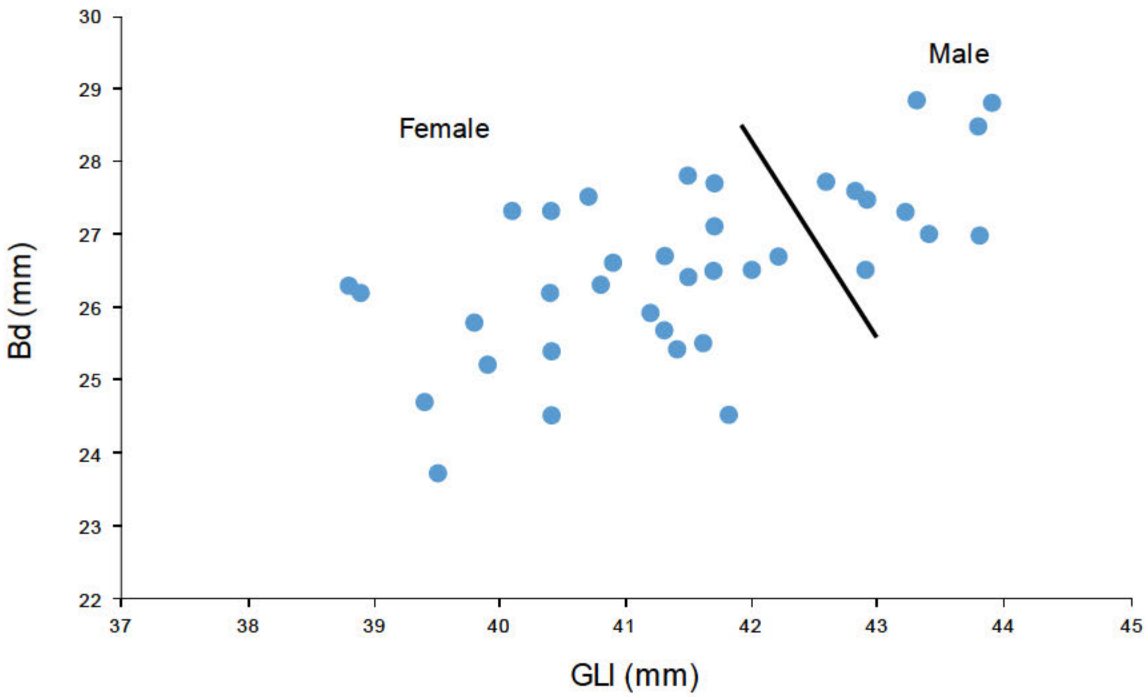


Figure 45. *The distribution of measurements taken from oryx astragalii, displaying sexual dimorphism within the oryx remains.*

6.2. Gazelle, **Gazella saudiya**

Attempts to identity the gazelle remains, utilising known methods of species discrimination (Horwitz & Goring-Morris 2000) were unsuccessful, largely due to the fragmented nature of the horncore recovered from the site. Despite this, a tentative identification of *Gazella saudiya* was made, based upon the observation that gazelles from the assemblage were smaller in stature than our reference gazelles, which were known to be Arabian Sand Gazelle (*Gazella marica*). This tentative identification is strengthened by the recent reporting of *G. saudiya* in the faunal remains from the Iron Age site of Salut in Oman (Strolin 2019). There was no evidence for more than one species of gazelle in the assemblage.

Skeletal Element Representation

Gazelle were present across all Horizons and the majority of excavated areas (**Table 2** & **Table 30**). The only gazelle remains identified in Horizon V was an astragalus fragment (**Table 31** & **Fig. 46**). Different parts of the body were well represented in the remains from Horizon IV, however there was a slight predominance of meat bearing elements (**Table 31** & **Fig. 46**). Horncore was the predominant skeletal element identified in the gazelle remains from Horizons III and II, mirroring the pattern seen for oryx and ovicaprid (**Figs. 26** & **41**). The remains from Horizon I varied from the pattern set by the aforementioned taxa, however, with a strong representation of limb elements as well as crania and horncore (**Table 31** & **Fig. 46**).

Table 30. *The number of gazelle fragments across each area and horizon.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
F	Q1	5	4		14		**23**
	Q2				5		**5**
	R1		7	96			**103**
	R2		6		169		**175**
	S1		150	68	54		**272**
	S2	11	45		121		**177**
	T1	3	55		55		**113**
	T2		24		32		**56**
G	P1				43		**43**
	P2		3				**3**
	P3		1				**1**
	P4		8				**8**
	Q1	11		12			**23**
	Q2	2	3				**5**
	Q3	3	26				**29**
	R1	2	9	13	10		**34**
	R2		12				**12**
	R3	4	29				**33**
	S1	5	37	31	110		**183**
	S2	9	20	5	7		**41**
	S3		10				**10**
	T1		8	4	100	1	**113**
	T2		8				**8**
	T3		28				**28**
	T28	2					**2**
Total		**57**	**493**	**229**	**720**	**1**	**1500**

Bone Surface Modifications

Eleven fragments of gazelle bone displayed marks from butchery (**Table 32**). The cut marks observed on gazelle remains from Horizon IV are indicative of carcass disarticulation and meat extraction, with light cut marks present on fragments from a rib and a cervical vertebra (**Fig. 47**). Similarly, the butchered radius from Horizon III was likely the result of carcass disarticulation, particularly when combined with the representation of full carcasses in the gazelle remains from this horizon. The cut marks observed on fragments of horncore from Horizon II reflect the butchery marks observed on oryx and ovicaprid remains, as outlined above (**Sections 4.1, 6.1**). The butchered metapodial fragments from Horizons II & I also have parallels in remains from other taxa recovered from Horizons III & II.

[redacted]

Figure 46. *The skeletal element representation in the gazelle remains, shown as a percentage of MNI, across each horizon. © 2005 ArcheoZoo.org*

Table 31. *The skeletal element representation (NISP) from the gazelle remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Horncore	18 (*10*)	274 (*108*)	52 (*45*)	35 (*31*)		**379**
Skull	2 (*1*)	11 (*2*)	3 (*1*)	4 (*2*)		**20**
Maxilla		1 (*1*)		4 (*2*)		**5**
Mandible	2 (*1*)	9 (*7*)	11 (*5*)	44 (*43*)		**66**
Teeth	3 (*3*)	18 (*15*)	9 (*8*)	15 (*14*)		**45**
Hyoid			1 (*1*)	1 (*1*)		**2**
Atlas		1 (*1*)		4 (*4*)		**5**
Cerv. Vert.		7 (*5*)	13 (*11*)	5 (*4*)		**25**
Thor. Vert.		5 (*5*)	16 (*16*)	12 (*12*)		**33**
Rib	3 (*2*)	5 (*2*)		12 (*10*)		**20**
Scapula		3 (*3*)	2 (*1*)	19 (*18*)		**24**
Humerus	1 (*1*)	2 (*2*)	16 (*12*)	52 (*52*)		**71**
Radius	1 (*1*)	4 (*2*)	13 (*10*)	40 (*39*)		**58**
Ulna	1 (*1*)	2 (*2*)	4 (*1*)	41 (*40*)		**48**
Carpals	3 (*3*)	6 (*6*)	17 (*17*)	23 (*23*)		**49**
Metacarpal		8 (*3*)	3 (*1*)	17 (*17*)		**28**
Ant. Phal. 1	2 (*1*)	7 (*5*)	12 (*9*)	10 (*9*)		**31**
Ant. Phal. 2	2 (*2*)	13 (*9*)	11 (*9*)	13 (*12*)		**39**
Ant. Phal. 3	1 (*1*)	7 (*7*)	3 (*3*)	9 (*9*)		**20**
Lumb. Vert.	1 (*1*)	8 (*7*)	9 (*8*)	5 (*4*)		**23**
Sacrum		2 (*2*)				**2**
Caudal Vert.	1 (*1*)	3 (*3*)				**4**
Vert. Indet.		10		2		**12**
Pelvis		6 (*4*)		61 (*59*)		**67**
Femur		1 (*2*)	1 (*1*)	45 (*44*)		**47**
Tibia	1 (*1*)	4 (*3*)	1 (*1*)	74 (*74*)		**80**
Fibula				2 (*2*)		**2**
Astragalus	2 (*2*)	5 (*5*)	6 (*6*)	88 (*87*)	1 (*1*)	**102**
Calcaneum	1 (*1*)	2 (*2*)	6 (*5*)	21 (*21*)		**30**
Nav. Cub.		2 (*2*)		6 (*6*)		**8**
Tarsal	1 (*1*)	2 (*2*)	7 (*7*)	10 (*10*)		**20**
Os Mall.				2 (*2*)		**2**
Metatarsal	2 (*1*)	14 (*11*)		31 (*31*)		**47**
Post. Phal. 1	1 (*1*)	5 (*2*)	4 (*1*)	6 (*5*)		**16**
Post. Phal. 2		10 (*6*)	6 (*6*)	2 (*2*)		**18**
Post. Phal. 3		1 (*2*)	1 (*1*)	4 (*4*)		**6**
Metapodial	8	32	1			**41**
Sesamoid			1	1		**2**
Lg. Bn. Indet.		3				**3**
Total	**57**	**493**	**229**	**720**	**1**	**1500**

Table 32. *The number of specimens displaying butchery marks in the gazelle assemblage.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Total
Horncore					
Cut marks at base of horncore		2			**2**
Cervical Vertebrae					
Diagonal cut mark across ventral body				1	**1**
Radius					
Cut marks on proximal end			1		**1**
Cut marks on ventral side of proximal end			1		**1**
Rib					
Cut marks below articular surface		1		1	**2**
Metapodial, indet.					
Cut mark across proximal tip	1			1	**2**
Astragalus					
Chopped through longitudinally				1	**1**
Metatarsal					
Lateral cut marks on dorsal shaft		1			**1**
Total	**1**	**4**	**1**	**4**	**11**

A relatively small proportion of gazelle fragments were burnt. As with the other identified taxa in the remains, Horizon IV contained the highest number of burnt gazelle remains (**Table 33**). The burning observed in Horizon IV was generally light, with a number of fragments displaying patchy charring which likely reflect cooking. The heavier burning cannot be explained by cooking, however, meaning that we must look to other activities to explain some of the burning represented on these remains.

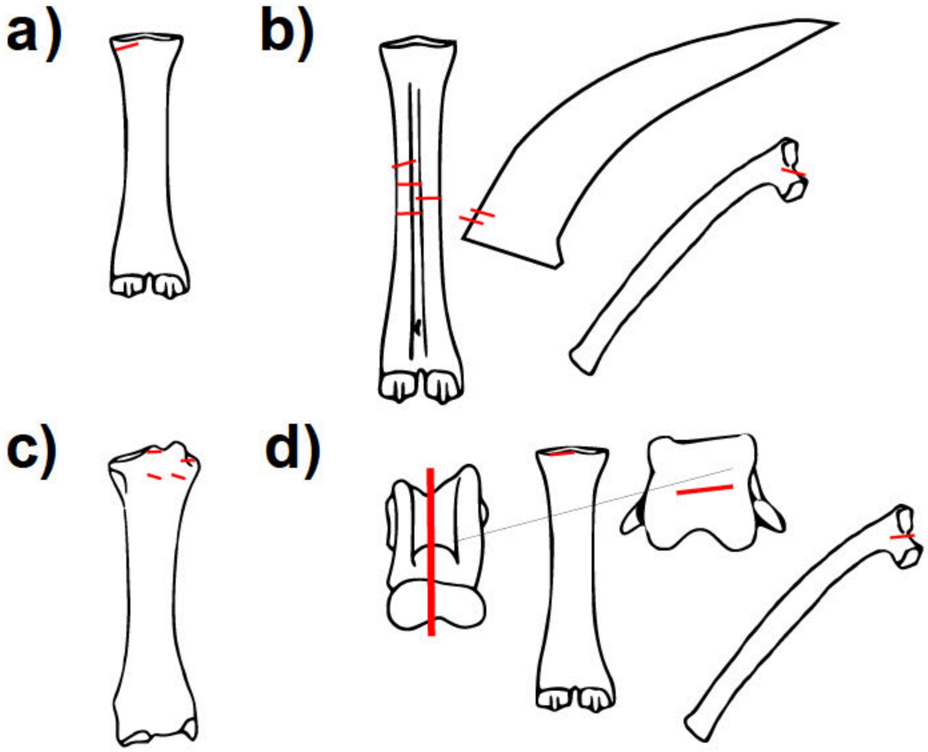


Figure 47. *Schematic depictions of skeletal elements displaying the location and type of butchery marks (red lines) identified on the gazelle remains across each horizon. Thicker lines represent chop marks. a) Horizon I; b) Horizon II; c) Horizon III; d) Horizon IV. Skeletal outline after Lauwerier 1988.*

Table 33. *The number and percentage of burnt gazelle fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**
Patchy Charring	1 (33.3%)	3 (37.5%)	2 (50%)	13 (25.5%)
Charred, burnt black	1 (33.3%)	2 (25%)	1 (25%)	16 (31.4%)
Grey			1 (25%)	18 (35.3%)
Burnt white	1 (33.3%)	3 (37.5%)		2 (3.9%)
Calcined				2 (3.9%)
Burnt Fragments	**3**	**8**	**4**	**51**
Percentage of Horizon Fragments Total	***5.3***	***1.6***	***1.8***	***7.1***

Population Demographics

Unlike the oryx, a scheme exists for timing the epiphyseal fusion of gazelle as presented by Munro *et al.* (2009). While this scheme was developed for mountain gazelle, it was considered to be appropriate to provide age estimates for the gazelle from Saruq al-Hadid (**Table 34**). No gazelle younger than 7 months were explicitly represented in the remains from Horizons IV and III, however a small proportion of the remains from Horizon II were from such animals. Remains from gazelle younger than 18 months were present across all horizons, however they were in the minority of fragments from Horizons III and II (**Table 34**). All of the tooth rows recovered were too fragmentary to reliably estimate age using tooth wear. This lack of juveniles corroborates with the observed lack of juveniles represented by the oryx remains.

Horncore morphology is known to be a reliable indicator of sex in gazelles, however the fragmentary nature of the horncore meant this could not be reliably estimated.

Table 34. *The epiphyseal fusion state of fragments identified as gazelle (NISP), following a fusion scheme presented by Munro et al. 2009: Tab. 4.*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**		
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***
P. Radius							1	-		2	-	*100*
0-3 Months	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	***100***	**2**	**-**	***100***
Pelvis												
Scapula				1	-	*100*				1	-	*100*
D. Humerus				1	-	*100*	3	-	*100*	5	-	*100*
Phalanx I				5	1	*83.3*	9	-	*100*	4	-	*100*
Phalanx II				6	3	*66.7*	3	-	*100*	3	-	*100*
3-7 Months	**-**	**-**	**-**	**13**	**4**	***76.5***	**15**	**-**	***100***	**13**	**-**	***100***
D. Tibia				3	-	*100*				6	-	*100*
7-18 Months	**-**	**-**	**-**	**3**	**-**	***100***	**-**	**-**	**-**	**6**	**-**	***100***
P. Ulna												
D. Radius				1	-	*100*	1	-	*100*	1	1	*50*
P. Humerus										-	2	-
Calcaneum				1	-	*100*	2	-	*100*	1	-	*100*
D. Metapodia	-	1	-	7	8	*46.7*	3	1	*75*	6	10	*37.5*
P. Femur										3	-	*100*
D. Femur							1	-	*100*			
P. Tibia										2	2	*50*
18 Months <	**-**	**1**	**-**	**9**	**8**	***52.9***	**7**	**1**	***87.5***	**13**	**16**	***44.8***

6.3. Lagomorpha

A total of 291 fragments were identified as lagomorph, of which 82 fragments were definitively identified as hare (*Lepus capensis* - **Table 35**). While it is likely that the remaining 209 fragments were also hare, this could not be confirmed. For the purposes of this monograph, all fragments identified as lagomorph are considered hare in the following sections.

Table 35. *The identification of hare within the remains across each horizon and area.*

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
F	Q1				1		**1**
	Q2				9		**9**
	R1			19			**19**
	R2				33		**33**
	S1		7	59	16	2	**84**
	S2	1	4		8		**13**
	T1		3		15		**18**
	T2		1		2		**3**
G	P1				3		**3**
	P2		1				**1**
	P3		1				**1**
	P4		1				**1**
	Q3		1				**1**
	R2		1				**1**
	S1	1	1	4	9		**15**
	S2	1	7		5		**13**
	T1			3	15		**18**
	T2		1				**1**
	T28	7					**7**
Total		**10**	**29**	**85**	**116**	**2**	**242**

Skeletal Element Representation

In general, entire carcasses of hare are well represented in the remains from Saruq al-Hadid throughout the five horizons (**Table 36**, **Fig. 48**). Remains from the hind limb were often predominant, which represent the parts of the body with the most meat. Mandibles were also frequently identified, suggesting that entire carcasses of hare were brought to the site for processing.

[redacted]

Figure 48. *The skeletal element representation in the hare remains, shown as a percentage of MNI, across each horizon. Skeletal Image: © 2015 ArcheoZoo.org*

Table 36. *The skeletal element representation (NISP) from the hare remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Maxilla		1 (*1*)	4 (*2*)			**5**
Mandible		3 (*3*)	10 (*9*)	12 (*12*)		**25**
Cerv. Vert	1 (*1*)			1 (*1*)		**2**
Thor. Vert	1 (*1*)			1 (*1*)		**2**
Rib	1 (*1*)	10 (*10*)	2 (*2*)	3 (*3*)		**16**
Humerus	1 (*1*)	3 (*1*)	19 (*19*)	27 (*27*)		**50**
Ulna			12 (*12*)	12 (*12*)		**24**
Ant. Phal. 1		2 (*2*)	5 (*2*)	2 (*2*)		**9**
Ant. Phal. 2			2 (*2*)			**2**
Lumb. Vert.	2 (*2*)			2 (*2*)		**4**
Pelvis	1 (*1*)	1 (*1*)		11 (*11*)	2 (*1*)	**15**
Femur	2 (*2*)	2 (*1*)	5 (*5*)	14 (*14*)		**23**
Tibia		1 (*1*)	7 (*7*)	21 (*21*)		**29**
Astragalus		1 (*1*)				**1**
Calcaneum		4 (*4*)	19 (*19*)	10 (*10*)		**33**
Metapodial		1				**1**
Indet.	1					**1**
Total	**10**	**29**	**85**	**116**	**2**	**242**

Bone Surface Modification

No butchery marks were identified on any lagomorph remains, however a number of lagomorph fragments had been burnt (**Table 37**). As observed in the remains of other taxa, remains from Horizon IV displayed the highest proportion of burning. A number of burnt hare remains had been lightly, irregularly charred, consistent with cooking, however the majority were burned by a higher degree of temperature. This likely reflects the disposal of these remains in a fire.

Table 37. *The number and percentage of burnt hare fragments across each horizon.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V
Patchy Charring			3 (100%)	8 (30.8%)	1 (100%)
Charred, burnt black				10 (38.5%)	
Grey				2 (7.7%)	
Burnt white		1 (100%)		6 (23%)	
Burnt Fragments	**-**	**1**	**3**	**28**	**1**
Percentage of Horizon Fragments Total	**-**	***3.5***	***3***	***24.1***	***50***

6.4. Rodents

Only a single species of rodent was definitively identified in the faunal assemblage, the Lesser Egyptian Jerboa (*Jaculus jaculus*). There was no observable second species in the assemblage, therefore all fragments identified as rodent are treated as *J.jaculus*. Notably, vast amounts of rodent remains were recovered from squares F.R1 and F.S1 (**Table 38**). This feature of the assemblage is explored below.

Skeletal Element Representation

Entire rodent carcasses were represented in Horizons IV-I (**Table 39**). Vertebrae were generally the most abundant elements, however mandibles and teeth were also commonly identified. This abundance of vertebrae is highlighted in the remains from Horizon III (**Table 39**). Taphonomic processes likely explain this pattern; rodent bones are particularly susceptible to mechanical breakage, which was a major factor in the taphonomy of Saruq al-Hadid. It is therefore unsurprising that fragile elements, such as the skull, did not preserve well, while smaller elements, such as vertebrae, did.

Bone Surface Modifications

No butchery marks were identified on any rodent remains, however a small number of bones were burnt (**Table 40**). This burning is almost certainly anthropogenic in nature and therefore suggests interaction between rodents and humans at the site, as discussed in further detail below (**Section 6.7**).

Table 38. *The identification of rodents within the remains across each horizon and area.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
F	Q1				1		**1**
	Q2				16		**16**
	R1		2	1264			**1266**
	R2				19		**19**
	S1		22	2145		2	**2169**
	S2	3	12		23		**38**
	S3				3		**3**
	T1		8		12		**20**
	T2		1		9		**10**
G	P2		3				**3**
	P3		2				**2**
	Q1	1		67			**68**
	Q2	2	2				**4**
	Q3	1	1				**2**
	R1		1	15			**16**
	R3		4				**4**
	S1	1	3	8	78		**90**
	S2		9	24			**33**
	S3		21				**21**
	T1		5	9	29		**43**
	T2		26				**26**
	T3		7				**7**
	T28	148					**148**
Total		**156**	**129**	**3532**	**190**	**2**	**4009**

Table 39. *The skeletal element representation (NISP) from the rodent remains identified across each horizon. Italic number in parentheses represents the MNE.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Skull		3 (*1*)				**3**
Maxilla	1 (*1*)	1 (*1*)	23 (*17*)	3 (*1*)		**28**
Mandible	10 (*10*)	25 (*23*)	103 (*98*)	6 (*6*)		**144**
Teeth	13 (*13*)	3 (*3*)	67 (*67*)	11 (*11*)		**94**
Axis			1 (*1*)			**1**
Cerv. Vert.		3 (*3*)				**3**
Rib		3 (*3*)	64 (*38*)			**67**
Humerus	1 (*1*)	4 (*4*)	13 (*12*)	6 (*6*)		**24**
Radius			1 (*1*)	6 (*6*)		**7**
Ulna	1 (*1*)					**1**
Sacrum			6 (*6*)	3 (*3*)		**9**
Caudal Vert.		3 (*3*)	20 (*20*)			**23**
Vert. Indet.	20	23	2754	93	1	**2891**
Pelvis	2 (*2*)	4 (*4*)	15 (*15*)	14 (*14*)		**35**
Femur	7 (*7*)	18 (*16*)	91 (*85*)	6 (*6*)	1 (*1*)	**123**
Tibia	1 (*1*)	7 (*7*)	32 (*28*)			**40**
Calcaneum	2 (*2*)		15 (*14*)	6 (*6*)		**23**
Metatarsal		2 (*2*)	30 (*27*)	2 (*2*)		**34**
Phal. 1		2 (*2*)	20 (*20*)			**22**
Phal. 2			1 (*1*)			**1**
Metapodial	1	1	3			**5**
Lg. Bn. Indet.	3	19	143	20		**185**
Indet.	94	8	130	14		**246**
Total	**156**	**129**	**3532**	**190**	**2**	**4009**

Table 40. *The number and percentage of burnt rodent fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring			24 (80%)	15 (78.9%)	
Charred, burnt black		1 (100%)	3 (10%)	4 (21.1%)	
Grey			3 (10%)		
Burnt Fragments	-	**1**	**30**	**19**	-
Percentage of Horizon Fragments Total	-	***0.78***	***0.85***	***10***	-

6.5. Reptiles

Four distinct taphonomic identifications were made in the reptile remains (**Table 41**). Unlike the rodent bones, it is possible that other species of smaller lizards (i.e. 'skinks') may be present in these remains based upon observed morphological variation, however they could not be identified. Fragments of reptile egg were also identified and are discussed here, as they are relevant to the interpretation. It is important to highlight that, as observed in the rodent remains, large amounts of reptile remains were recovered from squares F.R1 & F.S1 (**Table 41**).

Skeletal Element Representation

Cranial and axial elements were present from the spiny tailed lizard, however no long-bone elements were definitively identified (**Table 42**). The same body parts were represented for the toad-headed lizard. Both of these species were only present in Horizon IV-II, as snake remains (**Table 42**). It is likely that the long bones identified to 'Reptilia' are from either the spiny-tailed or toad-headed lizard. Bearing this in mind, complete carcasses are well represented across the three horizons in which these species were identified, although, as with the rodent remains discussed above, there was an abundance of vertebrae (**Table 42**). This can likely be attributed to the taphonomic factors that are hypothesised to have affected that rodent bone assemblage. Fragments of reptile eggshell was also recovered from Horizon II (**Table 42**).

Bone Surface Modifications

No butchery marks were identified on any of the reptile remains however, as with the rodent remains, some reptile fragments were burnt (**Table 43**). A relatively large proportion of reptile remains from Horizon IV had been burnt by lower degrees of heat (**Fig. 49**), however there was some evidence of higher temperatures affecting the assemblage. Burning evidenced on the reptile remains from Horizons III & II was also caused by low heat (**Table 43**).

Table 41. The identification of reptiles within the remains across each horizon and area.

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Uromastyx aegyptia microlepis							
F	R1			11			**11**
	S1		1	18	22		**41**
G	Q3		1				**1**
	S1				26		**26**
	S2		3				**3**
	T1				6		**6**
	T3		7				**7**
Total		-	**12**	**29**	**54**	-	**95**
Phrynocephalus arabicus							
F	S1			46	45		**91**
G	S2		4				**4**
	S3		3				**3**
	T1		3	1			**4**
	T2		4				**4**
	T3		5				**5**
Total		-	**19**	**47**	**45**	-	**111**
Snake, indet.							
F	R1			59			**59**
	S1		1	5	3		**9**
G	Q1			1			**1**
	R3		1				**1**
	S1				1		**1**
	S2		5				**5**
	T3		1				**1**
Total		-	**8**	**65**	**4**	-	**77**
Reptilia, indet.							
F	Q1	1			4		**5**
	Q2				5		**5**
	R1		1	1390			**1391**
	S1		50	1581	27	1	**1659**
	S2		17		19		**36**
	T1		10		13		**23**
	T2	1	3		3		**7**
G	P1				3		**3**
	P2		19				**19**
	Q1			60			**60**
	Q3		32				**32**
	R1	1	3	20			**24**

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Reptilia, indet. (Cont.)							
G	R2		2				**2**
	R3		2				**2**
	S1		2	9	17		**28**
	S2		24				**24**
	S3		41				**41**
	T1		3	17	3		**23**
	T2		52				**52**
	T3		33				**33**
	T28	17					**17**
Total		**19**	**294**	**3077**	**94**	**1**	**3486**
Grand Total		**20**	**333**	**3218**	**197**	**1**	**3769**

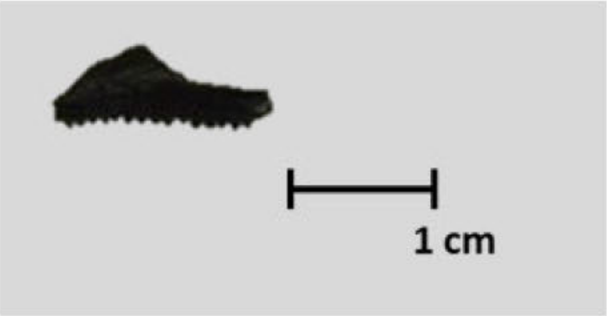


Figure 49. *A charred maxillary fragment from an Arabian Toad-headed lizard. Context 2708, Horizon III, Square F.S1.*

Table 42. *The skeletal element representation (NISP) from the reptile remains identified across each horizon. Italic number in parentheses reflect the MNE.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Uromastyx aegyptia microlepis						
Cranial		2 (*1*)				**2**
Maxilla			4 (*4*)	9 (*9*)		**13**
Mandible		4 (*4*)	7 (*7*)	12 (*12*)		**23**
Max./Mand.			2	8		**10**
Vert. Indet.		6	10	21		**37**
Lg. Bn. Indet.			1	4		**5**
Indet.			5			**5**
Total	-	**12**	**29**	**54**	-	**95**
Phrynocephalus arabicus						
Cranial				4 (*1*)		**4**
Maxilla		2 (*2*)	8 (*8*)	5 (*5*)		**15**
Max/Mand		5	19	12		**36**
Mandible		7 (*7*)	14 (*14*)	5 (*5*)		**26**
Vert., indet.		5	6	19		**30**
Total	-	**19**	**47**	**45**	-	**111**
Snake, indet.						
Mandible		1 (*1*)	3 (2)			**4**
Vert., indet.		7	62	4		**73**
Total	-	**8**	**65**	**4**	-	**77**
Reptilia, indet.						
Cranial	1 (*1*)	2 (*1*)				**3**
Maxilla		25 (*25*)	241 (*236*)	9 (*9*)		**275**
Mandible	11 (*11*)	90 (*87*)	585 (*564*)	37 (*37*)		**723**
Max./Mand.		16	59	2		**77**
Atlas		4 (*4*)				**4**
Scapula		1 (*1*)	1 (*1*)			**2**
Coracoid		2 (*2*)		1 (*1*)		**3**
Humerus	1 (*1*)	1 (*1*)	1 (*1*)			**3**
Vert. Indet.	1	65	1498	35	1	**1600**
Co-axle				1 (*1*)		**1**
Tibia		7 (*7*)	4 (*4*)	1 (*1*)		**12**
Lg. Bn. Indet.	4	22	367	8		**401**
Indet.	2	47	321			**370**
Eggshell		12				**12**
Total	**19**	**294**	**3077**	**94**	**1**	**3486**
Grand Total	**20**	**333**	**3218**	**197**	**1**	**3769**

Table 43. *The number and percentage of burnt reptile fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Uromastyx aegyptia microlepis					
Patchy Charring			1 (50%)	4 (100%)	
Calcined			1 (50%)		
Burnt Fragments	-	-	**2**	**4**	-
Percentage of Horizon Fragments Total	-	-	***6.9***	***7.4***	-
Phrynocephalus arabicus					
Charred, burnt black			1 (100%)		
Burnt Fragments	-		**1**		
Percentage of Horizon Fragments Total	-	-	***2.1***	-	-
Snake, indet.					
Charred, burnt black			2 (100%)		
Burnt Fragments	-		**2**		
Percentage of Horizon Fragments Total	-	-	***3.1***	-	-
Reptilia, indet.					
Patchy Charring			30 (73.2%)	13 (48.2%)	
Charred, burnt black		1 (100%)	11 (26.2%)	11 (40.7%)	
Burnt white				3 (11.1%)	
Burnt Fragments	-	**1**	**41**	**27**	-
Percentage of Horizon Fragments Total	-	***0.3***	***1.3***	***28.7***	-

6.6. Terrestrial Bird Species

A number of bird species were identified in the assemblage (**Table 44**). The majority of these bird fragments were recovered from Horizon III, however a fragment from an unidentified passeriforme was recovered from Horizon IV (**Table 44**). All of the identified taxa prefer to inhabit environments with greater levels of vegetation than are currently present in the locale of Saruq al-Hadid today (**Table 45**). Cormorant was also identified in the remains, and is included with the other animals from the marine environment below (**Section 6**).

Skeletal Element Representation

Of the taxa identified beyond the class level (i.e. Aves) only long bones were identified, however a number of vertebrae were identified as indeterminate bird species (**Table 46**). The lack of skull fragments could well reflect identification bias, propensity for fragile elements, such as skulls, to be destroyed by mechanical breakage should also be considered when interpreting these remains. It is therefore likely that entire carcasses of birds were deposited at the site, despite the seeming abundance of long bones.

Bone Surface Modifications

No butchery marks were identified on any of the bird remains, however three vertebral fragments from a ‘Medium-Sized’ bird (likely cormorant), displayed patchy charring.

6.7. Wild Species Discussion

The most important observation to be made regarding the wild animal remains from Saruq al-Hadid is their frequency. Both in terms of NISP and MNI, wild terrestrial animals are the most well represented taxa in the assemblage, which contrasts with all other contemporary zooarchaeological assemblages from southeastern Arabia, in which they generally form less than 10% of identified remains (Roberts *et al.* 2018). This is a highly significant feature of this faunal assemblage, both in terms of understanding the nature of occupation at Saruq al-Hadid and how Saruq al-Hadid ties into the wider landscape of southeastern Arabia during late prehistory.

The representation of skeletal elements for oryx and gazelle match those identified in the assemblages of ovicaprid and camel, suggesting that both wild animals and domesticates were being utilised for the same purposes in these areas of Saruq al-Hadid throughout its occupation. As discussed in relation to the ovicaprid remains above (**Section 4.1**), the remains from Horizon II, with an abundance of horncore fragments and lower limb bones, are interpreted as waste from the skinning process. This interpretation is reinforced by the butchery marks observed on the remains from Horizon II, particularly the example displayed in **Figure 38**, that show the intentional removal of horncores from the rest of the skull. Similar butchery marks have also been reported on an assemblage of gazelle bones recovered from early Iron Age deposits at the site of Salut in Oman (Strolin 2019). Some tentative inferences can also be made regarding the demographics represented by the oryx and gazelle remains, and therefore the hunting practices of the inhabitants of Saruq al-Hadid; a relative lack of juveniles from both species suggests a selective hunting strategy that avoided juvenile animals, the implications of which are discussed further elsewhere (Roberts *et al.* 2018).

Table 44. *The identification of birds, excluding cormorant, within the remains across each horizon and area.*

Area		Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
***Corturnix* sp.**							
F	R1					3	3
	Total	**-**	**-**	**-**	**-**	**3**	**3**
***Lanius* sp.**							
F	R1		1			2	3
G	T2	1					1
	Total	**1**	**1**	**-**	**-**	**2**	**4**
Falconidae, indet.							
G	S1		1				1
	Total	**-**	**1**	**-**	**-**	**-**	**1**
Picidae							
F	S1		2				2
	Total	**-**	**2**	**-**	**-**	**-**	**2**
Turdidae							
F	R1		3				3
	R2					1	1
	Total	**-**	**3**	**-**	**-**	**1**	**4**
Passerine							
F	R1		4	1		1	6
	R1/F.R2					1	1
	S1	1	6				7
	S2	1					1
	Total	**2**	**10**	**1**	**-**	**2**	**15**
Indeterminate Bird							
F	R1		15	1		3	19
	R1/F.R2					2	2
	R3					1	1
	S1	2	10	6		6	24
	T1	3		2		1	6
G	S1	1					1
	T1			4	3		7
	Total	**6**	**25**	**13**	**3**	**13**	**60**
Grand Total		**9**	**42**	**14**	**3**	**21**	**89**

Table 45. *The preferred habitats of the birds, excluding cormorant, identified in the assemblage from Saruq al-Hadid.*

Identified Bird	Common Habitat (after Porter and Aspinall 2012)
Cortunix sp.; Quail	Two known species in the region today; tend to prefer grassland, scrubland areas with vegetative cover.
Lanius sp.; Shrike	Multiple known species in the region today; some species tend towards semi-desert or sparsely wooded areas and scrubland, some prefer greater degrees of vegetation.
Picadae; Woodpecker/Wrynet	Very few species known in the region today, however some in the wider Middle East; those that do occur prefer areas of woodland.
Turdidae; Thrush	Dozens of known species in the region today; all occur in areas with frequent vegetation in the form of trees or bushes.

The presence of snake in the remains should also be discussed here, due to the iconographic representations of snakes that becomes a frequent component of the archaeological assemblage from Saruq al-Hadid from the Early Iron Age. The snake remains could not be identified to species, however the burn marks observed on two vertebral fragments from Horizon III does suggests a level of interaction between snakes and humans at the site in the past during this period, which is notable due to the deposition of snake *appliqué* vessels during this period (Karacic *et al.* 2017).

The vast amount of rodent and reptile remains in Horizon III are a significant feature of the faunal assemblage at Saruq and merit future study. These accumulations of remains could be anthropogenic given the rodent and reptile bones both include some burnt fragments. This would correlate with ethnographic observations of dietary components of southeastern Arabia. Reptiles of all sizes are known to be consumed by traditional societies, from the larger spiny tailed lizard (el-Mahi 2002; Monchot *et al.* 2014) to the smaller reptilian species (Thesiger 2007:162). However, while some of the remains might be the result of anthropogenic activity on the site, it is likely that the majority of these remains are the result of natural intrusions of burrowing animals. In turn, this highlights the potential from small fragments of bone and other material classes to be stratigraphically relocated by this burrowing process.

The variety of species represented in the faunal assemblage that demonstrate signs of human interaction suggest that humans occupying Saruq al-Hadid were exploiting as many animals in the surrounding landscape as possible. This dietary breadth, not observed on other contemporary sites, may be a strategy to mitigate hypothetical food shortages in the marginal environment of the desert fringe, in turn explaining why the faunal assemblage from Saruq al-Hadid varies to those from sites in other environmental zones. When interpreting the remains from some species (i.e. canid, lagomorph, rodent and reptile) it is important to consider the potential for natural intrusions of material into the zooarchaeological assemblage; it is certain that the remains of larger wild animals were deposited at the site anthropogenically. The importance of wild animals at Saruq al-Hadid, as highlighted by these faunal remains, prompt a number of questions regarding the differences between the faunal assemblage from Saruq al-Hadid and those from other contemporary sites, and in turn how Saruq al-Hadid functioned in the regional network of late prehistoric sites in southeastern Arabia.

Table 46. *The skeletal element representation (NISP) from the bird remains, excluding cormorant, identified across each horizon.*
Italic number in parentheses represents the MNE.

	Horizon II	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
***Corturnix* sp.**						
Ulna					2 (*2*)	**2**
Femur					1 (*1*)	**1**
Total	**-**	**-**	**-**	**-**	**3**	**3**
***Lanius* sp.**						
Humerus					2 (*2*)	**2**
Ulna	1 (*1*)	1 (*1*)				**2**
Total	**1**	**1**	-	**-**	**2**	**4**
Falconidae, indet.						
Carpometacarpal		1 (*1*)				**1**
Total	**-**	**1**	-	-	-	**1**
Picidae, indet.						
Coracoid		1 (*1*)				**1**
Radius		1 (*1*)				**1**
Total	-	**2**	-	-	-	**2**
Turdidae, indet.						
Carpometacarpal		1 (*1*)				**1**
Ulna		1 (*1*)				**1**
Tibiotarsus		1 (*1*)				**1**
Total	-	**3**	-	-	-	**3**
Passerine, indet.						
Carpometacarpal		1 (*1*)				**1**
Humerus		1 (*1*)				**1**
Ulna		2 (*2*)	1 (*1*)		1 (*1*)	**4**
Radius	1 (*1*)	3 (*3*)			2 (*2*)	**6**
Tibiotarsus		3 (*3*)			1 (*1*)	**4**
Total	**1**	**10**	**1**	-	**4**	**16**
Bird, indet.						
Coracoid			1 (*1*)			**1**
Humerus	1 (*1*)				2 (*2*)	**3**
Radius		1 (*1*)				**1**
Fibula					1 (*1*)	**1**
Vert., indent.	3	22	7	3	8	**33**
Rib		1 (*1*)				**1**

	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Bird, indet. (*Cont.*)						
Phal. 1	1 (*1*)					**1**
Phal. 3					1 (*1*)	**1**
Long Bone, indet.	1	1		5	1	**8**
Total	**6**	**25**	**8**	**8**	**13**	**60**
Grand Total	**8**	**42**	**9**	**8**	**22**	89

7. Marine Species

7.1. Fish

A total of 9753 fragments of a variety of species of fish were recovered from all horizons and areas across the site (**Table 47**). All of the identified fish species were from marine environments and occur in a range of habitats that exist both in the Persian Gulf and the Indian Ocean (**Table 48**).

Skeletal Element Representation

Skeletal element representation from different species is the same throughout all horizons, with a mix of elements from the head and body of fish (**Table 49**). However, there were differences in skeletal representation between different genera and species, notably an absence of skeletal elements from the heads of tuna and emperors (**Table 49**). Only teeth were definitively identified as shark, however some of the larger vertebrae identified as cartilaginous fish could have been from smaller sharks (**Fig. 45**). The distal tail spines from rays were also present (**Fig. 46**).

Bone Surface Modifications

No butchery marks were identified on any fish remains, consistent with the general lack of butchery marks identified on fish from other archaeological sites (likely a result of poor identification, as opposed to a genuine lack of butchery marks - Willis *et al.* 2008). As with the rest of the remains from Saruq al-Hadid, a relatively large proportion of the bone displayed signs of burning (**Table 50**, **Fig. 47**). A large amount of this burning likely resulted from the disposal of these fish bones in a fire, however some of the instances where bones had been unevenly burnt appear to be evidence of cooking (**Fig. 48**); the irregular charring may suggest an irregular exposure to heat, which could in turn be explained the exposure of these bones to a fire with flesh still attached. Alternatively, the burning identified on these could result from the disposal of the remains in a fire. Regardless, it is undoubtable that these were fish were brought to the site for the purposes of consumption. Such consumption would not necessarily require the cooking of the fish, as discussed elsewhere (Roberts *et al.* In Press).

Table 47. *The identification of fish within the remains across each horizon and area.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Belonidae, indet.								
F	Q1		1					**1**
	Q2				2			**2**
	R1			6			5	**11**
	R2				15		4	**19**
	S1		1	7	5	1		**14**
	S2				5			**5**
G	Q1	3					1	**4**
	R1						2	**2**
	S1		1					**1**
	T1				1			**1**
Total		**3**	**3**	**13**	**28**	**1**	**12**	**60**
Serranidae, *Epinephelus* sp.								
F	R1						1	**1**
	R2				1		1	**2**
	S2				3			**3**
G	T1				4			**4**
Total		-	-	-	**8**	-	**2**	**10**
Serranidae, indet.								
F	Q1				4			**4**
	R1			6			3	**9**
	R2				5			**5**
	S1		1	2				**3**
	S2						2	**2**
	S3						5	**5**
G	Q1			4				**4**
Total		-	**1**	**12**	**9**	-	**10**	**32**
Carangidae, *Carangoides* sp.								
F	Q2				3			**3**
	R1		1	1				**2**
	R2				5		2	**7**
	S3/T3						11	**11**
	T1						3	**3**
G	Q1			3				**3**
Total		-	**1**	**4**	**8**	-	**16**	**29**
Carangidae, ident.								
F	Q1				2			**2**
	R1			1				**1**
	S1			4				**4**
	S2						4	**4**
Total		-	-	**5**	**2**	-	**4**	**11**

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Haemulidae, indet.								
F	R1						1	**1**
	R2				1			**1**
	S2		-		1			**1**
G	S1			2				**2**
	Total	-	-	**2**	**2**	-	**1**	**5**
Lethrinidae, *Lethrinus* sp.								
F	R2				3			**3**
	S2				6			**6**
	T1						2	**2**
G	Q3	1						**1**
	Total	**1**	-	-	**9**	-	**2**	**12**
Lethrinidae, indet.								
F	Q1				3			**3**
	R1			3			1	**4**
	S1		2					**2**
	S2						3	**3**
	S3						4	**4**
G	Q1	1						**1**
	S1				1			**1**
	Total	**1**	**2**	**3**	**4**	-	**8**	**18**
Sparidae, *Rhabdosargus* sp.								
F	Q1				1			**1**
	Q2				1			**1**
	R1		1					**1**
	R2		1		8		3	**12**
	R3						2	**2**
	S1		3	4	4	4	2	**17**
	S2		9		8			**17**
	S3				5		5	**10**
	S3/T3						15	**15**
	T1		5		2		3	**10**
	T2	1			3			**4**
G	P1				5			**5**
	P2		3					**3**
	P3		1					**1**
	P4		1					**1**
	Q2						1	**1**
	Q3	3	3					**6**
	R3		4				2	**6**
	S1				9			**9**
	S2	2	1					**3**
	S3		1					**1**
	T1			1	16			**17**
	T2		1					**1**

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Sparidae, *Rhabdosargus* sp. (*cont.*)								
G	T3		1					**1**
	Total	**6**	**35**	**5**	**62**	**4**	**33**	**145**
Sparidae, indet.								
F	R1			8			5	**13**
	R2				25			**25**
	S1			1				**1**
	S2				5			**5**
	S3						1	**1**
	S3/T3						19	**19**
	T1						1	**1**
G	Q1			1				**1**
	R1						1	**1**
	S1				2			**2**
	Total	-	-	**10**	**32**	-	**27**	**69**
Scombridae, ident.								
F	R1			2				**2**
	R2				1			**1**
	Total	-	-	**2**	**1**	-	-	**3**
Osteichthyes, indet.								
F	Q1	2	2		77		1	**82**
	Q2				76			**76**
	R1		18	728			245	**991**
	R1/R2						10	**10**
	R2		10		866		303	**1179**
	R3						83	**83**
	S1	1	67	697	474	91	56	**1386**
	S2		41		697		84	**822**
	S3				79		73	**152**
	S3/T3						176	**176**
	T1	2	18		504	22	23	**569**
	T2		14	17	109			**140**
G	P1				94		4	**98**
	P2		11				1	**12**
	P3	4	4				1	**9**
	P4	3	5				2	**10**
	Q1	10		47			12	**69**
	Q2		2	2			3	**7**
	Q3	9	22				5	**36**
	R1		1	16	10		39	**66**
	R2		1				5	**6**
	R3		14				5	**19**
	S1	2	6	41	836			**885**
	S2	2	41	28	134			**205**
	S3		28					**28**

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Osteichthyes, indet. (*cont.*)								
G	T1		10	12	1688	8		**1718**
	T2		107					**107**
	T3		28					**28**
	W6		1					**1**
	T28	1						**1**
Total		**36**	**451**	**1588**	**5644**	**121**	**1131**	**8971**
Carcharhinidae, *Negaprion* sp.								
F	R2				1			**1**
	T2		1					**1**
G	R1	1						**1**
Total		**1**	**1**	-	**1**	-	-	**3**
Batoidea, indet.								
F	R1			2				**2**
	S1			1				**1**
	T2				1			**1**
G	S1				1			**1**
Total		-	-	**3**	**2**	-	-	**5**
Elasmobranchii, indet.								
F	Q1		1		5			**6**
	Q2				1			**1**
	R1			12			4	**16**
	R1/R2						1	**1**
	R2		1		16		34	**51**
	R3						11	**11**
	S1		6	9	5	24		**44**
	S2		2		2			**4**
	S3				10		3	**13**
	S3/T3						23	**23**
	T1	4	1		10		1	**16**
	T2				25			**25**
G	P1				18		3	**21**
	P3	2	2					**4**
	P4		13				9	**22**
	Q1			2				**2**
	Q2						1	**1**
	Q3	1	3				4	**8**
	R1			1			2	**3**
	R2						2	**2**
	R3		6					**6**
	S1		5		23		1	**29**
	S2	4	6				1	**11**
	S3		1					**1**
	T1		3		48			**51**
	T2		11					**11**

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Elasmobranchii, indet.								
G	T3		2					**2**
Total		**11**	**63**	**24**	**163**	**24**	**100**	**385**
Grand Total		**59**	**557**	**1671**	**5975**	**150**	**1346**	**9758**

Table 48. *The preferred habitats of the fish identified in the assemblage from Saruq al-Hadid.*

Identification	**Common Habitat**
Belonidae, *i*ndet.	Marine; epipelagic (Collette 1986: 385).
Serranidae, *Epinephelus* sp.	Marine; largely demersal (Heemstra & Randall 1986: 515).
Serranidae, indet.	Largely marine; wide geographic range, all tropical and subtropical waters (Heemstra & Randall 1986: 509).
Carangidae, *Carangoides* sp.	Largely marine; wide geographic range and marine zones (Smith-Vaniz 1986: 638). Tend towards reefs (Berg 1958).
Carangidae, indet.	Largely marine; wide geographic range and marine zones (Smith-Vaniz 1986: 638). Tend towards reefs (Berg 1958).
Haemulidae, indet.	Largely marine; generally inhabit depths up to 80 metres, however spawn in deep seas (Smith & McKay 1986: 564).
Lethrinidae, *Lethrinus* sp.	Marine: Marine; tropical bottom feeders; coastal (Smith 1986: 595).
Lethrinidae, indet.	Marine; tropical bottom feeders; coastal (Smith 1986: 595).
Sparidae, *Rhabdosargus* sp.	Marine; tends towards reefs and shallower waters (Frimodt 1995).
Sparidae, indet.	Largely Marine; inhabit a range of depths, from coastal to 60 metres but generally coastal (Smith & Smith 1986: 580).
Scombridae, indet.	Marine; epipelagic, some species occur in coastal waters, others far offshore (Collette 1986: 831).
Negaprion sp.	Marine; tends to inhabit shallow waters (Bass *et al.* 1986: 67).
Batoidea, indet.	Largely marine; inhabit all areas and depths (Smith *et al.* 1986: 108).

Table 49. *The skeletal element representation (NISP) from the fish remains identified across each horizon.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Belonidae, indet.							
Dentary		1		2		1	4
Dentary/Premaxilla			2	6	1		9
Premaxilla				1			1
Vertebra	3	2	11	19		11	46
Total	**3**	**3**	**13**	**28**	**1**	**12**	**60**
Serranidae, *Epinephelus* sp.							
Premaxilla				1			1
Vertebra				7		2	9
Total	–	–	–	**8**	–	**2**	**10**
Serranidae, indet.							
Vertebra		1	12	9		10	32
Total	–	**1**	**12**	**9**	–	**10**	**32**
Carangidae, *Carangoides* sp.							
Dentary		1					1
Vertebra			4	8		16	28
Total	–	**1**	**4**	**8**	–	**16**	**29**
Carangidae, indet.							
Vertebra			5	2		4	11
Total	–	–	**5**	**2**	–	**4**	**11**
Haemulidae, indet.							
Maxilla			1				1
Premaxilla			1				1
Vertebra				2		1	3
Total	–	–	**2**	**2**	–	**1**	**5**
Lethrinidae, *Lethrinus* sp.							
Vertebra	1			9		2	12
Total	**1**	–	–	**9**	–	**2**	**12**
Lethrinidae, indet.							
Vertebra	1	2	3	4		8	18
Total	**1**	**2**	**3**	**4**	–	**8**	**18**
Sparidae, *Rhabdosargus* sp.							
Angular				1			1
Dentary		8	1	16		3	28
Dentary/Premaxilla	2	10	1	11		12	36
Hyomandibular		1		1			2
Maxilla						1	1
Opercular		1		1		1	3
Premaxilla		5	2	17	2	4	30
Tooth	3	10	1	15	2	8	39
Vert	1					4	5
Total	**6**	**35**	**5**	**62**	**4**	**33**	**145**

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Sparidae, indet.							
Tooth						1	1
Vert			10	32		26	68
Total	-	-	**10**	**32**	-	**27**	**69**
Scombridae, indet.							
Vert			2	1			3
Total	-	-	**2**	**1**	-	-	**3**
Osteichthyes, indet.							
Angular		4	8	1			13
Articular		2				2	4
Branchiostegal Ray		21	62	49	1	57	190
Cleithrum		1					1
Dentary		10	39	5		19	73
Dentary/Premaxilla		3	39	2			44
Hyomandibular		1					1
Maxilla			2	1		2	5
Opercula			1			1	2
Post-Temporal		1	2				3
Premaxilla	2	7	20	2		9	40
Quadrate		2	4			3	9
Scale		1					1
Tooth		10	35	1		8	54
Volar			1			1	2
First Vertebra			5	12			17
Vertebra	29	314	1032	5492	117	904	7888
Penultimate Vertebra			1				1
Final Vertebra			1	1			2
Unidentifiable Cranial Element		4	3	26	3		36
Unidentifiable Fragment	5	70	333	52		125	585
Total	**36**	**451**	**1588**	**5644**	**121**	**1131**	**8971**
Carcharhinidae, *Negaprion* sp.							
Tooth	1	1		1			3
Total	**1**	**1**		**1**			**3**
Batoidea, indet.							
Tail Spine			3	2			5
Total	-	-	**3**	**2**	-	-	**5**
Elasmobranchii, indet.							
Vert	11	63	24	163	24	100	385
Total	**11**	**63**	**24**	**163**	**24**	**100**	**385**
Grand Total	**59**	**557**	**1671**	**5975**	**150**	**1346**	**9758**

Table 50. *The number and percentage of burnt fish fragments across each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring			9 (50%)	47 (9%)	1 (20%)
Charred, burnt black	1 (100%)	14 (100%)	7 (38.8%)	466 (89.6%)	3 (60%)
Grey			1 (5.6%)	4 (0.77%)	1 (20%)
Burnt white			1 (5.6%)	3 (0.58%)	
Burnt Fragments	**1**	**14**	**18**	**520**	**5**
Percentage of Horizon Fragments Total	***1.7***	***2.5***	***1.1***	***8.7***	***3.3***

Top Left: **Figure 50.** *Large cartilaginous fish vertebrae that are likely from a small shark but could not be definitively identified. Context 2319, Horizon IV, Square F.T1.* ***Top Right:*** **Figure 51.** *A tail spine from a ray, recovered from Context 1494, Horizon III, F.S1.* ***Bottom Right:*** **Figure 52.** *Burnt fish vertebrae fragments, recovered from Context 2822, Horizon IV, Square G.S1.* ***Bottom Left:*** **Figure 53.** *Cartilaginous fish vertebrae with patchy charring marks, recovered from Context 2458, Horizon IV, Square G.T1.*

Otoliths

The presence of fish sagittal otoliths in the faunal remains was quickly noted, and they became a target for excavators due to their research potential. As a result, otoliths were more likely to be extracted from the 'sieve debris' than other bone fragments, hence their separate discussion here. Identifications made in the otoliths generally matched those made in the wider fish assemblage, however there were some notable differences between the two (**Table 51**). Firstly, the most abundantly identified otolith was *Pomadasys kaakan* (**Fig. 49**), a species in the Haemulidae family. While some bone fragments were identified as Haemulidae, they were by no means the most abundant taxa in the bone assemblage. Some otoliths were also present from taxa not represented in the bone remains at all, namely *Lutjanus* sp. and *Pennahia anea*. This likely reflects the differential preservation of fish remains resulting from the substantial taphonomic processes that have had an effect over the formation of this assemblage (Lubinski 1996). Otoliths are known to preserve incredibly well, especially in alkaline burial environments (Disspain *et al.* 2016: 629), and they therefore would survive in an assemblage while the rest of the fish bone did not.

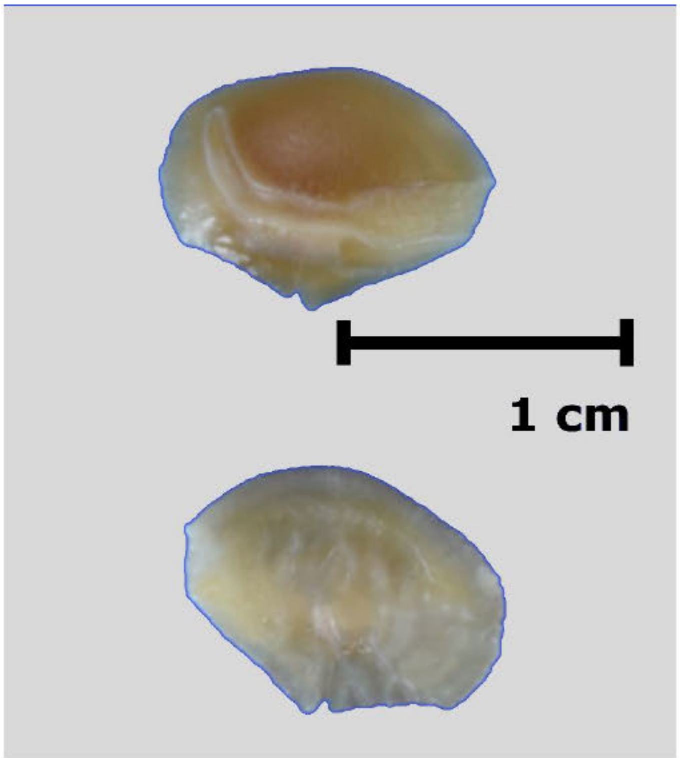


Figure 54. *An otolith identified as Pomadasys kaakan from Context 1085, Horizon IV, Square F.R2.*

Table 51. *The taxonomic identifications made in the otolith assemblage.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Belonidae indet.		1	1		1	1	**4**
Carangoides sp.		5	4	7		1	**17**
Epinephelus sp.		8	2	1	1	1	**13**
Lutjanus sp.		11	9	8	2	3	**33**
Pennahia anea		1	1	2			**4**
Pomadaysys kaakan	3	2	17	30	1	13	**66**
Pomadaysys sp.		1					**1**
Rhabdosargus sp.			2	2	1		**5**
Total	**3**	**29**	**36**	**50**	**6**	**19**	**143**

7.2. Cormorant

A total of 34 fragments were identified as cormorant in the remains, including two distinct species of the *Phalacrocorax* genus (**Table 52** & **Table 53**). The elements of cormorant represented in the remains from Saruq al-Hadid varied from horizon to horizon (**Table 54** & **Fig. 55**). It is noteworthy that only limb bones were identified across all horizons, with no full cormorant carcasses recovered. The abundance of wing elements in Horizon IV might be indicative of a focus on the exploitation of cormorant wing feathers as opposed to their meat, as represented by limb elements (**Fig. 55**).

Three fragments of cormorant were burnt to varying degrees of intensity, comprising three fragments of coracoid that had been patchily charred. No identifiable butchery marks were present on any of the remains identified as cormorant. A single fragment of cormorant bone from Horizon II has the porous texture of a juvenile animal.

Table 52. *The identification of cormorants within the remains across each horizon and area.*

Area		**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Phalacrocorax carbo **(Great Cormorant)**							
F	S1		1				**1**
G	T2	1					**1**
Total		**1**	**1**	**-**	**-**	**-**	**2**
Phalacrocorax nigrogularis **(Socotra Cormorant)**							
F	R1		1				**1**
	S2			1			**1**
	T1				2		**2**
G	Q1					1	**1**
	S1			1			**1**
	T1			1			**1**
Total		**-**	**1**	**3**	**2**	**1**	**7**
Phalacrocorax **sp.**							
F	R1		1	1			**2**
	R2					1	**1**
	S1		1	4			**5**
	T1	1					**1**
G	P1	1					**1**
	S1			5			**5**
	T1			10			**10**
Total		**2**	**2**	**20**	**-**	**1**	**25**
Grand Total		**3**	**4**	**23**	**2**	**2**	**34**

Table 53. *The preferred habitats of the cormorant identified in the assemblage from Saruq al-Hadid.*

Identified Bird	Common Habitat (after Porter and Aspinall 2012)
Phalacrocorax carbo; Great Cormorant	Inhabits coasts and inland lakes; nests on offshore islands.
Phalacrocorax nigrogularis; Socotra Cormorant	Maritime and coastal habitats; predominantly occur on off-shore islands.

Table 54. *The skeletal element representation (NISP) from the cormorant remains identified across each horizon.*

Area	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
***Phalacrocorax carbo* (Great Cormorant)**						
Tibiotarsus	1					1
Vert		1				1
Total	**1**	**1**	**-**	**-**	**-**	**2**
***Phalacrocorax nigrogularis* (Socotra Cormorant)**						
Coracoid			1			1
Scapula			1			1
Humerus			1			1
Femur		1				1
Tibiotarsus				2	1	3
Total	**-**	**1**	**3**	**2**	**1**	**7**
***Phalacrocorax* sp.**						
Coracoid		1	6			7
Scapula			1			1
Humerus			5			5
Pelvis			2			2
Femur	1					1
Tibiotarsus	1	1	4			6
Vert			2		1	2
Total	2	2	20		1	25
Grand Total	**3**	**2**	**23**	**2**	**2**	**34**

[redacted]

Figure 55. *The skeletal element representation in the cormorant remains, shown as a percentage of MNI, across each horizon. Skeletal Image: © 2015 ArcheoZoo.org*

7.3. Dugong

A total of eight fragments of dugong were identified in the remains from Saruq al-Hadid (**Table 55**). Five of the six fragments that could be securely associated with an archaeological horizon were ribs (**Fig. 56**). A single fragment of dugong ivory was also identified. No butchery or burning marks were identified on any of the fragments.

Table 55. *The number of dugong fragments across each area and horizon.*

Area		**Horizon IV**	**Indeterminate Horizon**
G	R1	4	
	S1		2
	T1	2	

Figure 56. *A fragmented dugong rib. Context 4807, Horizon IV, Square G.T1.*

7.4. Marine Species Discussion

The presence of animals from the marine environment at Saruq al-Hadid, a site 40km away from the nearest coastline, is a crucial factor in assessing the links between Saruq al-Hadid and other sites in the region. Remains of these animals are present in all phases of occupation, demonstrating the long-term significance of these animals to the subsistence strategies. Furthermore, remains from the marine species represented at Saruq al-Hadid are well represented on coastal sites, indicative of their importance in coastal subsistence strategies (e.g. Beech 2004; Uerpmann & Uerpmann 2005; 2008).

In addition to the significance for understanding the human occupation of Saruq al-Hadid, marine remains have implications for our understanding of the movement of people in the wider region of southeastern Arabia. The movement of resources from coastal sites to the interior of the region is hypothesised to have been a major driver of the movement of goods and people around the region in late prehistory (Cleuziou 1996; Cleuziou & Méry 2002; Magee 2014), of which some evidence has been identified in the Bronze and Iron Age (Beech *et al.* 2008; Uerpmann *et al.* 2012: 398). The evidence from Saruq al-Hadid demonstrates that marine resources were being transported around the landscape of prehistorical southeastern Arabia from as early as 2000 BCE.

A preliminary study has been undertaken on the chemistry of the fish otoliths recovered from Saruq al-Hadid to determine the location and season of capture (Roberts *et al.* 2019). This study highlights differences in the chemistry of the otoliths from the site that are hypothesised to reflect fish being brought from different locations (i.e. the Persian Gulf and Omani coast), however the multiple factors affecting otolith chemistry prevented a definitive conclusion from being drawn in this regard (Roberts *et al.* 2019). In addition to their role in the subsistence strategy at Saruq al-Hadid, the dense bones of dugong and other products from these animals (feathers from cormorant, skins from sharks etc.) may have been brought to the site for use in craft production at the site. Ultimately, the remains of marine animals are highly significant to our understanding of the movement of goods and people around the landscape of late prehistoric Arabia, and the way these coastal resources may have been utilised to enhance the subsistence strategies employed in the interior zone, a concept discussed in further detail elsewhere (Roberts *et al.* In press).

8. Worked Bone

Given the frequent identification of these fragments during the zooarchaeological analysis, it was considered appropriate to include them in this chapter. It is strongly recommended that a future, separate study is devoted to the material included in this section.

8.1. Direct Evidence of Bone Working

As mentioned above (*Section 2.4*), a number of smaller fragments recovered from Horizon II were identified as the direct waste from bone working. This identification was made based upon the clustering of these fragments in certain areas of the site in direct association with other archaeological features (**Fig. 57**), indicative of distinct activity areas, and the fresh fracture marks and evidence for bone shaving identified on the fragments (**Fig. 58**). Notably, several fragments that were stained green (**Section 8.3**) also were found to exhibit green fracture marks (**Fig. 59**).

More tenuous evidence of bone working at Saruq al-Hadid can also be found in the frequencies of certain proportions of particular skeletal elements, from which handle inlays can be made (i.e. metapodial and radius). These shafts may have also been fractured for the extraction of marrow and it is important to note that long bone fragments are a common feature of the mammalian assemblages that could only be classified by size (**Section 3)**, however this does not prohibit these shaft fragments being utilised in craft production.

8.2. Form

The vast majority of worked bone fragments recovered from the SHARP excavations were in the form of handle inlays (**Table 56**). The occurrence of some bone handle inlay fragments *in-situ* on weaponry (**Fig. 23**) demonstrates that these items were utilised in weaponry. During this basic analysis it was unclear as to whether there are different forms within the fragments identified as ‘handle inlays’, however further research on the worked bone fragments might provide additional insight.

A number of fragments in other forms appeared also to have a different purpose. This included a number of bone-handled awls, recovered in various states of preservation (**Fig. 60**). These awls have a notable parallel in a similar artefact recovered from the Early Dilmun occupation at Saar, Bahrain (Moon 2005: Fig. 5.2c). Two bone fragments display circumpunct decoration (**Table 56** & **Fig. 61**). A bone arrowhead was recovered from a context associated with Horizon III (**Table 56** & **Fig. 62**). Lastly, a number of fragments displayed large numbers of deep cut marks across their surface (**Table 56** & **Fig. 63**). They are similar in nature to those reported by Garfinkel & Horwitz (1988: Fig. 4**)**, from the PPNB site of Yiftahel in Israel. The function of these fragments is not known, however they were often also stained by copper or iron. A large number of fragments had a worked edge but no discernible form (**Table 56**).

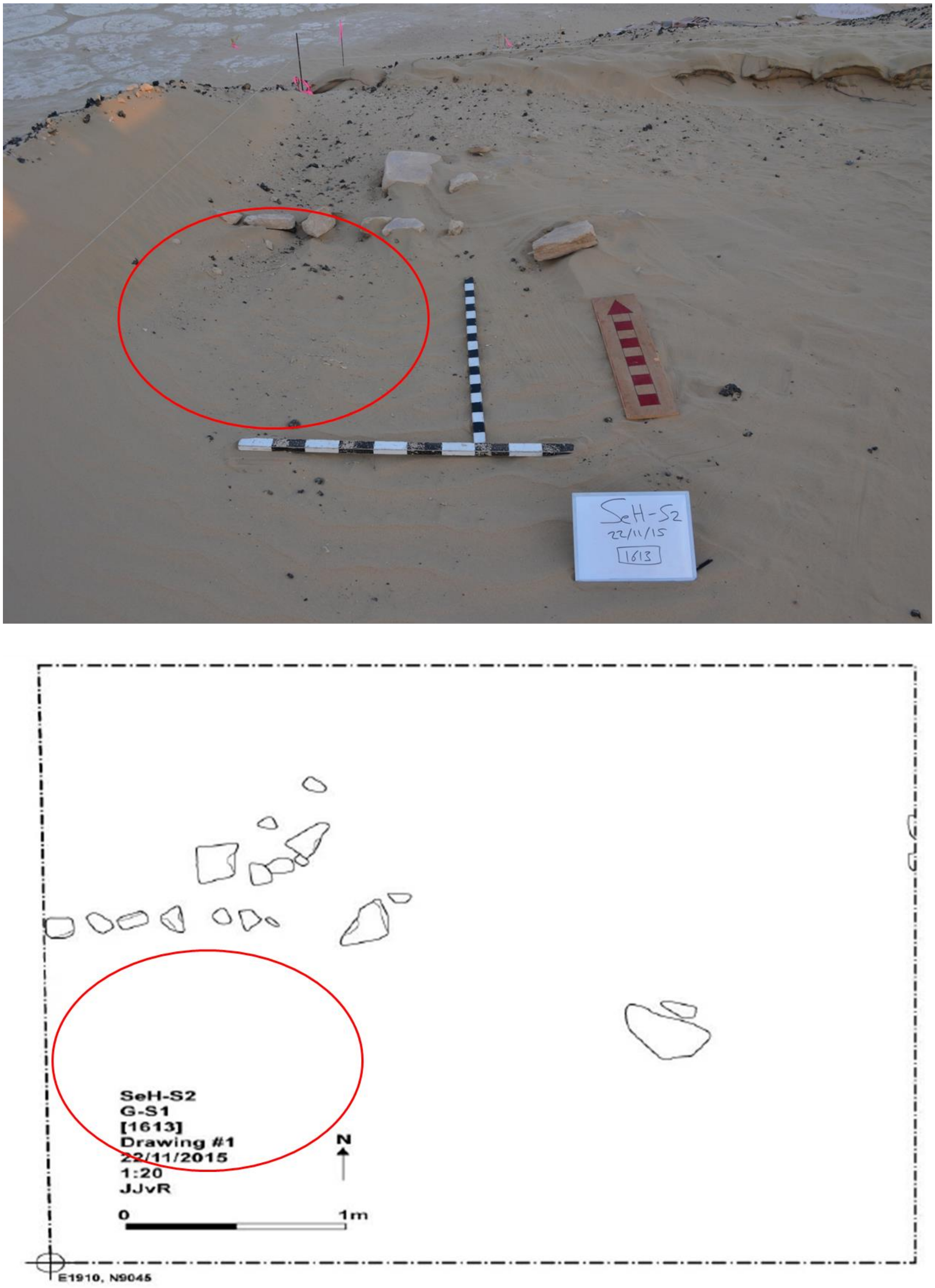


Figure 57. *Clustering of small worked bone fragments, circled in red, in association with stone feature from Horizon II, Square G.S2.*

Figure 58. *Bone fragments from Context 4004, Horizon I, Square G.S3, displaying worked edges.*

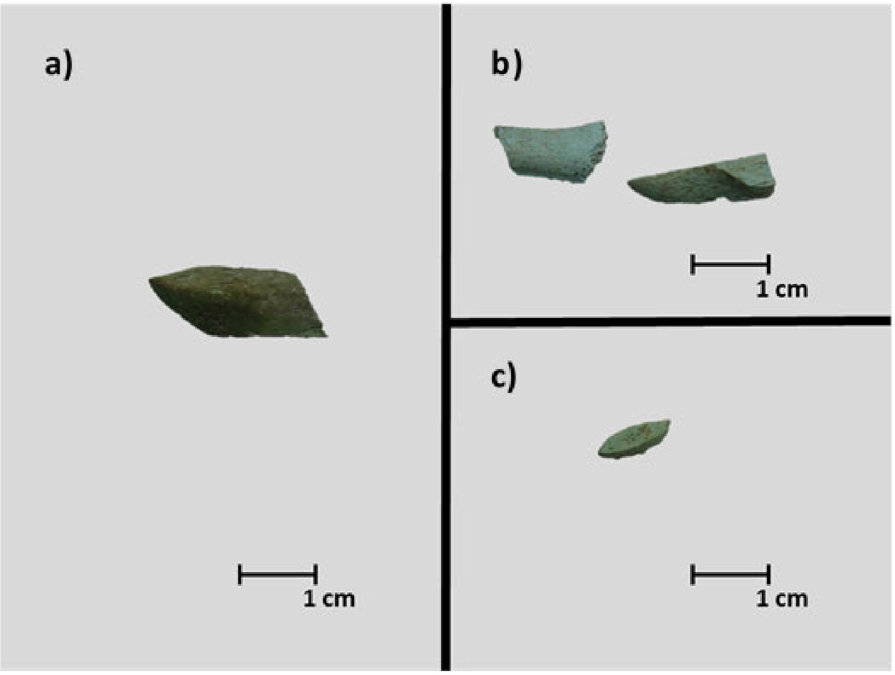


Figure 59. *Green-stained fragments with edges consistent with bone working from a) Context 1086, Horizon II, Square F.R2; b) Context 2500, Horizon I/II, Square G.T2; c) Context 2404, Horizon I/II, Square G.T1.*

Table 56. The number of each form of worked bone identified in the remains from the site, across each area and horizon.

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Handle Inlays							
F	Q1		2				**2**
	R1		8				**8**
	R2		7		3		**10**
	S1	5	51	7			**63**
	S2	13	100		2		**115**
	T1	22	45				**67**
	T2	4	15				**19**
G	P1		1				**1**
	P3	2	19				**21**
	P4		2				**2**
	Q1	3					**3**
	Q2		3				**3**
	Q3	10	7				**17**
	R1	4	6	3			**13**
	R2		5				**5**
	R3	14	6				**20**
	S1	23	32				**55**
	S2	25	20	2			**47**
	S3	2	9				**11**
	T1		4				**4**
	T3		2				**2**
	W6		1				**1**
Total		**129**	**345**	**12**	**5**	**-**	**491**
Multiple lateral cut marks							
F	Q2				1		**1**
	R1		1				**1**
	R2		1		1		**2**
	S1		4				**4**
	S2		6				**6**
	S3				1		**1**
	T1		1				**1**
	T2	1					**1**
G	P3		2				**2**
	Q2		1				**1**
	Q3	1					**1**
	R3	2	2				**4**
	S1		2				**2**
	S2		1				**1**

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Multiple lateral cut marks (*Cont.*)							
G	T2		1				**1**
Total		**4**	**22**	**-**	**3**	**-**	**29**
Arrow							
G	S1			1			**1**
Total		**-**	**-**	**1**	**-**	**-**	**1**
Circumpunct Decoration							
F	S2		1				**1**
G	S2	1					**1**
Total		**1**	**1**			**-**	**2**
Bead							
G	P3		1				**1**
Total		**-**	**1**	**-**	**-**	**-**	**1**
Worked Edge, Indeterminate							
F	Q1	1					**1**
	R1		3	5			**8**
	R2		1				**1**
	S1	2	57	2			**61**
	S2	10	52				**62**
	T1	14	61				**75**
	T2	1	16				**17**
G	P1		3		3		**6**
	P3	1	22				**23**
	P4	3	16				**19**
	Q1	1		2			**3**
	Q2		3				**3**
	Q3	6	2				**8**
	R1	8	9		1		**18**
	R2		12				**12**
	R3	14	10				**24**
	S1	21	33	11	3		**68**
	S2	5	10				**15**
	S3	3	60				**63**
	T1		6				**6**
	T2		6				**6**
	T3		11				**11**
	W6		1				**1**
Total		**90**	**394**	**20**	**7**	**-**	**511**
Grand Total		**220**	**751**	**33**	**12**	**0**	**1016**

Figure 60. *A bone handled copper awl (left), recovered from Context 1704, Horizon I, Square G.Q2, alongside comparanda recovered from Saar (right - Moon 2005: Fig. 5.2c).*

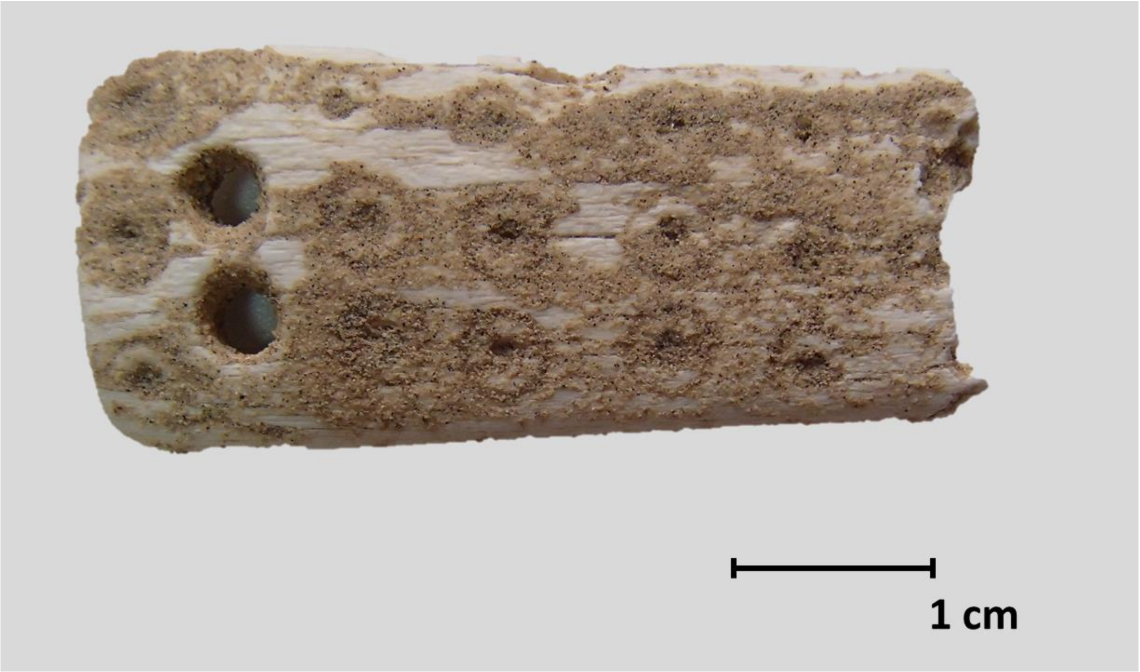


Figure 61. *A fragment of bone object with circumpunct decoration, recovered from Context 1116, Horizon II, Square F.S2.*

Figure 62. *A bone arrowhead, stained slightly green. Context 2408, Horizon II, Square G.T1.*

Figure 63. *A fragment of Medium Mammal metapodia, stained green, with multiple, deep. lateral cut marks across the shaft. Context 1087, Horizon II, Square F.S1*

8.3. Staining

Some fragments of bone were also observed to have been stained (**Table 57**). This staining was provisionally divided into two categories. The first of these was a localised ‘brown’ staining, determined to be contact-staining with iron (**Fig. 64**). This staining was often localised to the area where iron had apparently been in contact with the bone (**Fig. 64**). There appears to be little variation in the nature of this iron contact staining, either in appearance or location.

Figure 64. *A fragmented bone handle inlay display localised staining from prolonged contact with iron. Staining is only present in direct association with the iron nail and on the contact surface were the inlay was affixed to the iron weapon. Context 1435, Horizon II, Square F.S1.*

Table 57. *The number of stained fragments identified in the assemblage, across each area.*

Area		Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Total
Copper Staining							
F	Q1	1			3		**4**
	R1		12	1			**13**
	R2		13		5		**18**
	S1		33	6			**39**
	S2	5	57				**62**
	T1	8	42				**50**
	T2		5				**5**
G	P2		1				**1**
	P3	2	24				**26**
	P4	1	2				**3**
	Q1	3					**3**
	Q2		2				**2**
	Q3	31	2				**33**
	R1	4	3	2			**9**
	R2		5				**5**
	R3	1	5				**6**
	S1	11	19	1	2		**33**
	S2	22	10				**32**
	S3	2	18				**20**
	T1		3				**3**
	T2		1				**1**
	T3		2				**2**
	W6		1				**1**
Total		**91**	**260**	**10**	**10**	**-**	**371**
Percentage of Horizon Total		**1**	**0.7**	**0.03**	**0.006**	**-**	**0.1%**
Iron Staining							
F	Q1	1	2				**3**
	R1		4	2			**6**
	R2		6		3		**9**
	S1	7	71	7			**85**
	S2	16	94				**110**
	T1	22	60				**82**
	T2	2	24				**26**
G	P1		4		7		**11**
	P3	2	26				**28**
	P4	5	7				**12**

Area		**Horizon I**	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Iron Staining (Cont.)							
G	Q1	3					**3**
	Q2		4				**4**
	Q3	15	4				**19**
	R1	7	9	1	1		**18**
	R2		13				**13**
	R3	20	11				**31**
	S1	23	49	8	2		**82**
	S2	22	19				**41**
	S3	2	31				**33**
	T1		10				**10**
	T2		3				**3**
	T3		8				**8**
Total		**147**	**459**	**18**	**13**	**-**	**637**
Percentage of Horizon Total		**1.6**	**1.2**	**0.05**	**0.007**	**-**	**0.02**
Copper and Iron							
F	R1		5	1			**6**
	S1		14	3			**17**
	S2	3	27				**30**
	T1	4	9				**13**
	T2		2				**2**
G	P1		2				**2**
	P3	3	8				**11**
	Q2		1				**1**
	Q3	3					**3**
	S1	3	2				**5**
	S2	6	2				**8**
	S3		3				**3**
Totals		**22**	**75**	**4**	**-**	**-**	**101**
Percentage of Horizon Total		**0.2**	**0.2**	**0.09**	**0.01**	**-**	**0.03**
Grand Total		**260**	**794**	**32**	**23**	**-**	**1109**
Total Percentage		**2.9**	**2**	**0.09**	**0.01**	**-**	**0.3**

The second category of staining displayed far more variation in appearance, extent and location. This staining was generally described as a 'green' staining and was preliminarily attributed to contact with copper objects (many of which were present in the deposits at Saruq al-Hadid) during object use and subsequent taphonomic processes. The large amount of variation in the colouration and extent (**Fig. 65**, **Table 58**) of this staining led to the questioning of this hypothesis. In order to establish that the causation of all green staining was copper present in the fragments as opposed to another chemical process (i.e. the presence of cyano-bacteria – Turner-Walker 2012) twenty green-stained bone fragments were compositionally tested using a pXRF, under the guidance of Dr Ivan Stepanov. These fragments were taken from a number of contexts and were a variety of different types of bone (**Table 58**). The results of this experiment determined conclusively that these green stained fragments, regardless of appearance, contained high levels of copper (**Fig. 66**, **Table 58**), suggesting that copper was the cause of this discolouration.

Figure 65. *Bone fragments displaying different intensities of green staining.*

Table 58. *pXRF results* from green-stained bone fragments from the site.*

Sample Number	Context # (SF #)	Brief Description	Visual Colour (Munsel Number)	Copper	Manganese
001	1442 (26305)	Medium Mammal Long Bone	Light Turquoise (7.5BG 9/6)	Abundant	Trace
002	1614 (26308)	Gazelle Metapodial	Green (7.5GY 9/10)	Abundant	Trace
003	1618 (26346)	Unidentified Flat Bone	Very Light Green (2.5G 9/4)	Abundant	Trace
004	1618 (26347)	Medium Mammal Long Bone	Medium Green (10GY 9/10)	Abundant	Trace
005	1451 (26481)	Medium Mammal Long Bone	Intense Turquoise (5G 9/8)	Abundant	Trace
006	1750 (26482)	Medium Mammal Metapodial	Light Turquoise (5G 9/1)	Abundant	Trace
007	1443 (26409)	Medium Mammal Long Bone	Turquoise (5G 9/3)	Abundant	Trace
008	1443 (26410)	Large Mammal Long Bone	Green GY 9/10)	Abundant	Trace
009	1750 (26586)	Large Mammal Long Bone	Light Green (10GY 9/6)	Abundant	Trace
010	1751 (26592)	Medium Mammal Cancellous Bone	Light Turquoise (5G 9/4)	Abundant	Trace
011	1750 (26589)	Unidentified Flat Bone	Light Turquoise (5G 9/4)	Abundant	Trace
012	1420 (26587)	Medium Mammal Flat Bone	Medium Green (2.5G 9/8)	Abundant	Trace
013	1751 (26594)	Unidentified Flat Bone	Light Turquoise (7.5G 9/4)	Abundant	Trace
014	1750 (26590)	Medium Mammal Long Bone	Medium Turquoise (7.5G 9/4)	Abundant	Trace
015	1755 (26853)	Unidentified Handle Inlay Fragment (Large)	Intense Green (2.5G 9/8)	Abundant	Trace
016	1628 (26756)	Unidentified Handle Inlay Fragment	Medium Turquoise (5G 9/4)	Abundant	Trace
017	1570 (26660)	Medium Mammal Metapodial (Worked)	Dark Green (2.5G 7/8)	Abundant	Trace
018	1153 (21337)	Medium Mammal Long Bone (Worked)	Dark Green (2.5G 8/10)	Abundant	Trace
019	1602 (25355)	Large Mammal Long Bone (Worked)	Light Turquoise (7.5G 9/3)	Abundant	Trace
020	1506 (25378)	Large Mammal Long Bone (Handle Inlay)	Light Green (2.5G 9/6)	Abundant	Trace

*All fragments were analysed for 120 seconds using a yellow filter with 40kV at 3.4 μA.

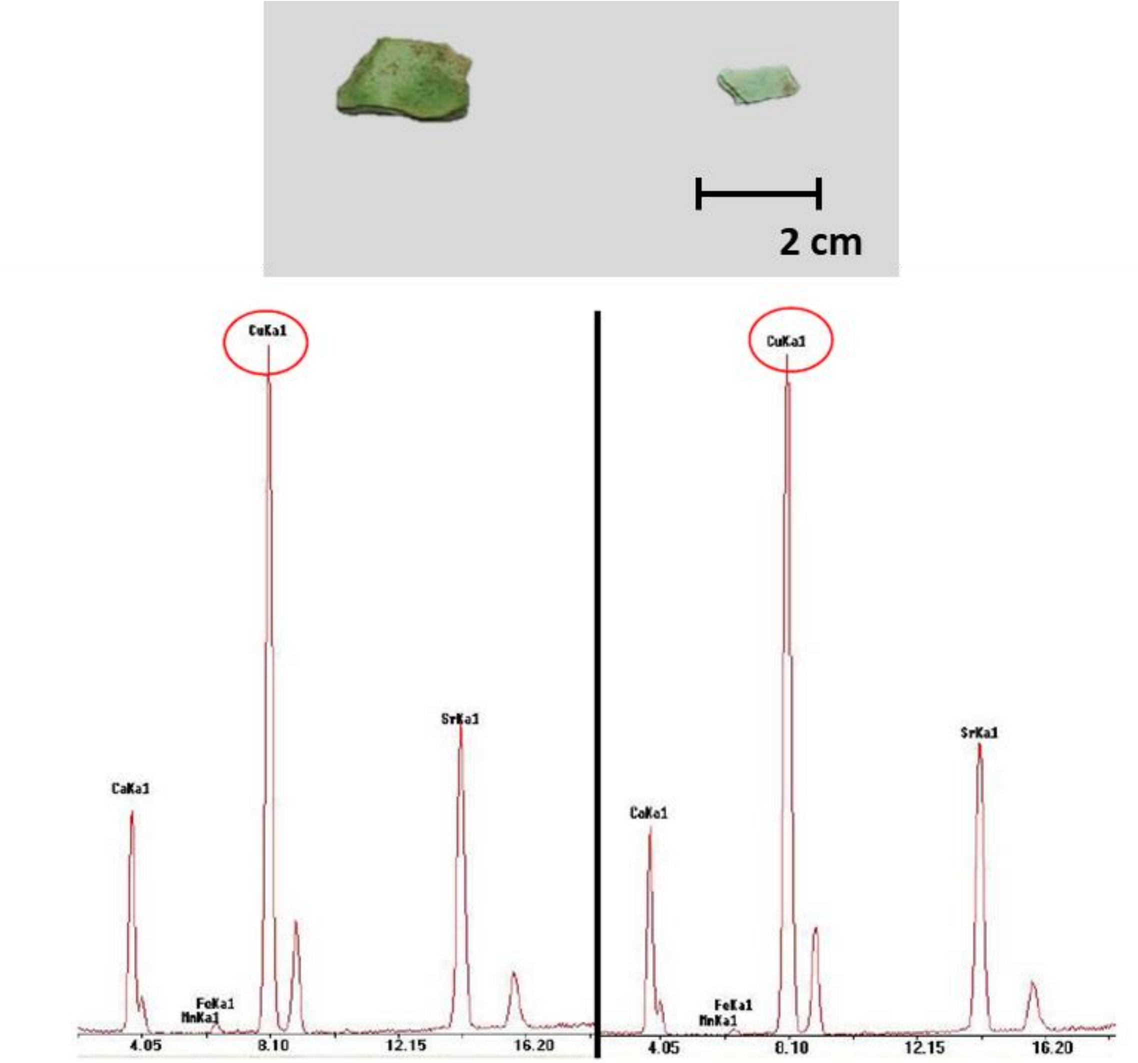


Figure 66. *Bone fragments displaying different intensities of green staining and their corresponding chemical spectra from pXRF analysis.*
The copper peaks are circled in red.

A number of factors reinforce an intentional, anthropogenic origin to the copper staining on bone. One such factor is the nature of the staining across large fragments and objects; the staining exhibited is often uniform in colour and coverage across the entire fragment and throughout the cross-section (**Fig. 67**). This contrasts with the nature of contact staining, which typically is focused around a centre of contact, with the staining effect diffusing from around this centre (cf. the localised iron staining displayed in **Fig. 67**). Furthermore, a number of fragments were recovered in direct contact with copper yet showed no signs of having been stained, suggesting that the copper staining cannot be attributed to taphonomic processes (cf. **Fig. 60**). Evidence for the use of copper as a colouration was also recovered from Saruq al-Hadid, in the form of numerous shells with green copper-based pigment (Weeks *et al.* 2019: 52). Whether these pigmented shells are technologically associated with the green stained bone is uncertain, however these shells do demonstrate the use of copper as a pigment during the occupation of Saruq al-Hadid and tentatively suggest a colourant with which these green fragments could have been stained. Further examination will be required to test these hypotheses.

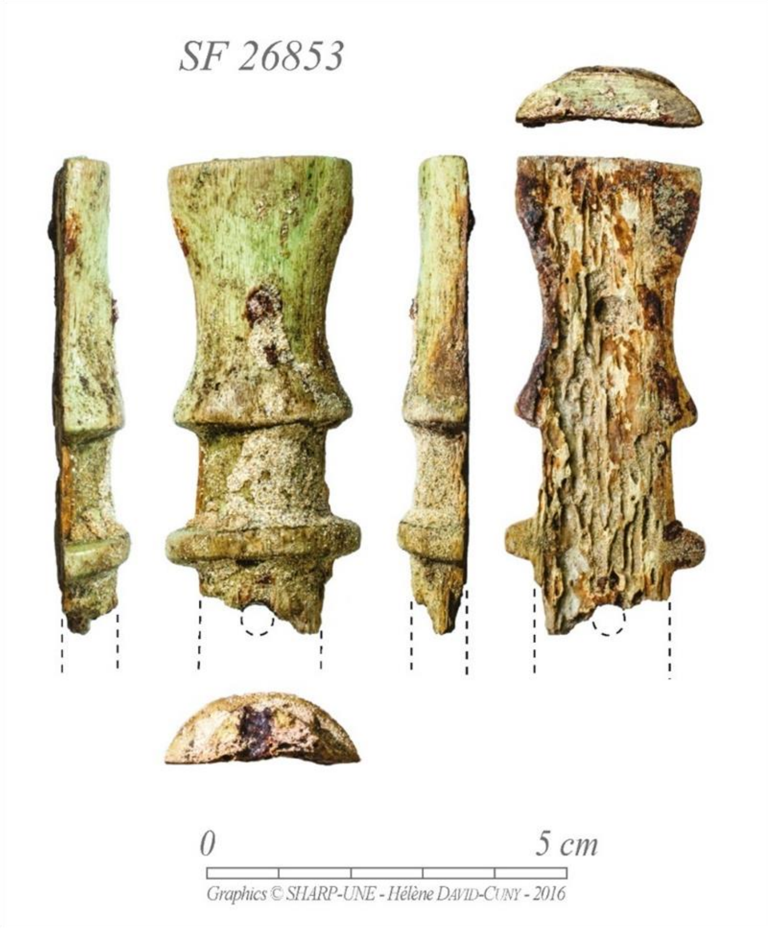


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Figure 67. *A handle inlay fragment, stained uniformly green, displaying iron staining where the fragment had been in contact with iron.*
Context 1755, Horizon I, Square G.R1.

8.4. Discussion

While this section only reports the very basic characteristics of the worked bone assemblage from Saruq al-Hadid, it is possible to draw some preliminary conclusions regarding the use of bone objects and bone working at Saruq al-Hadid. Firstly, it is clear that bone working was taking place at Saruq al-Hadid, as demonstrated by the clusters of small fragments with green-breaks and shaving marks (**Figs. 57**, **58** & **59**) and the deposition of lone bone epiphyses without shafts, suggesting that the shafts had been used utilised elsewhere. This does not mean that all of the bone objects recovered from

Saruq al-Hadid were manufactured on-site, however it does demonstrate another way in which animals were being utilised, particularly during Horizons III & II.

The green-stained bone is particularly intriguing. Little is known about the practice of bone staining in the past, however it has been hypothesised in select faunal assemblages (e.g. Zidarov 2008). Establishing the role of this staining in the production that took place during the Iron Age at Saruq al-Hadid would therefore be particularly significant for understanding other stained bone assemblages found in the archaeological record. Further research should undoubtedly be conducted on this aspect of the assemblage, as outlined below.

9. Faunal Remains Recovered from Fine-Sieving Undertaken by SHARP

In addition to the remains recovered from the general excavations, faunal remains were identified in samples extracted from the site during archaeobotanical analysis (Weeks *et al.* 2017). These samples were dry sieved through increasingly fine mesh (4mm, 2mm, 1mm, 0.5mm), and the content of the bone assemblage recovered from the fine sieving process matches the content of the remains form the general assemblage (**Table 59**). This similarity in species and element frequencies between the remains recovered during the fine-sieving process and those recovered from the general excavation suggests that the recovery methods employed during the general excavations resulted in a thorough representation of the faunal remains present at Saruq al-Hadid.

10. Dubai Municipality Excavation Results

Faunal remains were analysed from Dubai Municipality excavations in both the Central Area of the site and the military base.

10.1. Faunal Remains from the Central Area

Animal bone was recovered by the Dubai Municipality's excavation, and was analysed concurrently with the SHARP excavations. Bone originated from squares in the central area in close proximity to the SHARP excavations (**Table 60**), and was therefore examined. The material was recovered and analysed according to the methodology set out in **Section 1.2**. The full results of this analysis were presented to the Dubai Municipality team in three separate reports, which is synthesised below.

Overall, the assemblage from the Dubai Municipality excavations in the Central Area of the site was markedly similar to the remains excavated by SHARP. The 'Bone Layer' or midden, represented by loci 4, 5 & 6, was found to continue into the Dubai Municipality trenches and was identified in a number of squares (**Table 61**). The northern and north-eastern limits of the Bone Layer were identified in eastern squares of Area F and Area G. Distinct clusters of bone were excavated below the bone layer that represented a mix of taxa and skeletal elements (**Fig. 68**).

Table 59. *The taxonomic content of the faunal remains recovered during the fine sieving process undertaken by SHARP.*

	Horizon II	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Ovicaprid	3		3			**6**
Domestic Animals	**3**	-	**3**	-	-	**6**
Camel			1		1	**2**
Wild or Domestic Animals	-	-	**1**	-	**1**	**2**
Oryx			1	1	4	**6**
Gazelle					1	**1**
Hare	1		5	32	3	**12**
Jerboa	84	20	82	60	141	**387**
Spiny Tailed Lizard				1	4	**5**
Toad-Headed Lizard	121	8	20	13	39	**201**
Snake, indet.					3	**3**
Reptile, indet.	67	6	45	8	63	**189**
Bird			2			**2**
Wild Terrestrial Animals	**273**	**34**	**155**	**86**	**258**	**806**
Belonidae indet.			4	2		**6**
Carangidae, *Carangoides* sp.			2			**2**
Sparidae, *Rhabdosargus* sp.	23	2	13	2	9	**49**
Osteichthyes indet.	28	5	281	71	254	**639**
Elasmobranchii indet.			5	2	4	**11**
Marine Animals	**51**	**3**	**211**	**108**	**334**	**707**
Large Mammal	-	-	5	4	8	17
Medium Mammal	4	1	16	18	75	114
Total Identified	**331**	**38**	**391**	**216**	**676**	**1652**
Unidentified	116	1	26	22	27	192
Grand Total	**447**	**39**	**417**	**238**	**703**	**1844**

Table 60. *The number of fragments recovered from each square excavated by the Dubai Municipality Government excavations, as of mid-2017.*

Area	Square	Fragments
F	U1	33,941
	U2	10,145
	U3	422
	U4	293
	W1	58
	W3	76
	X2	7
	X3	390
	X4	58
G	U1	23,544
	U2	2,684
	U3	1,485
	V1	133
	Unknown	652
H	U1	2,658
	U2	19
	V2	263
Unknown	Unknown	68
Total		**76,896**

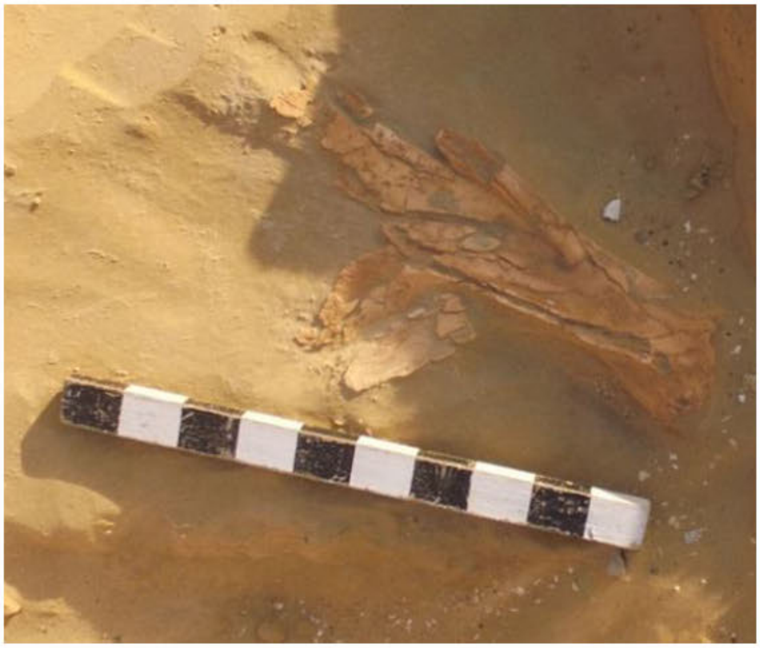

Figure 68. *A cluster of animal bone, including a camel scapula and two oryx phalanxes, excavated in square F.U1, from layers contemporary with Horizon IV/V.*

In the squares immediately joining the SHARP excavations (Squares F.U1, F.U2, F.U3, G.U1, GU.3) deposits of horncore, lower limb and tail bone were recovered from above the Bone Layer, represented by loci 1, 2 &3, in accordance with the remains from Horizon II identified by SHARP (**Table 61**). There were some excavated squares where no such deposits were present, particularly on the eastern edge of the excavations (F.X1, F.X2, F.X3, F.X4, G. V1). Instead, the faunal remains from the upper layers in these squares were highly fragmented and frequently had worked edges (**Fig. 70**). These small fragments are likely to be the discard from bone working, suggesting that bone was worked at this area of the site during its Iron Age occupation. The Dubai Municipality excavations undertaken in squares away from the Bone Layer recovered several clusters of animal bone. These remains were often unburnt and displayed no signs of butchery.

The taxonomic content of the Dubai Municipality assemblage from the Central Area was found to be very similar to the SHARP assemblage (**Table 61**) with an almost identical list of species represented. The amount of burning and butchery was also similar, particularly in those squares bordering the SHARP area of excavations, suggesting that the activities indicated by the remains are the same and that the areas likely belonged to the same stratigraphic context.

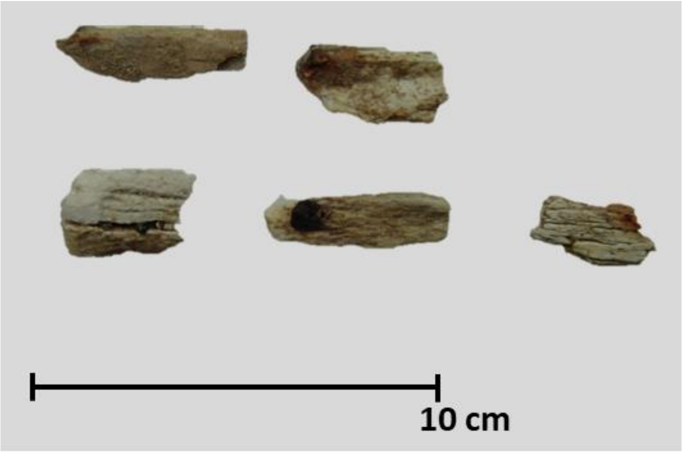

Figure 69. *Worked bone fragments recovered from Square F.X3, from layers contemporary with Horizon II in the SHARP excavations.*

Table 61. *The NISP of each taxa identified in each context excavated by the Dubai Municipality excavations undertaken in the Central Area.*

	Context							**Totals**
	1	**2**	**3**	**4**	**5**	**6**	**20**	
Goat	2	3	2	4	3	2		**16**
Ovicaprid	1	3	9	12	24	57		**106**
Domestic Animals	**3**	**6**	**11**	**16**	**27**	**59**	-	**122**
Camel	23	17	103	119	267	196		**725**
Canid				1	2	-		**3**
Wild or Domestic	**23**	**17**	**103**	**120**	**269**	**196**	-	**728**
Oryx	23	28	63	135	353	486		**1088**
Gazelle	4		2	20	61	48		**135**
Hare						8		**8**
Lagomorph, indet.		2		2	15	16		**35**
Rodent				15	65	158		**238**
Snake					3	3		**6**
Reptile			2	30	54	119		**205**
Bird					21	13		**34**
Wild Animals	**27**	**30**	**67**	**202**	**572**	**851**	-	**1749**
Dugong				3				**3**
Fish		14	36	454	2698	3052		**6254**
Marine Animals	-	**14**	**36**	**457**	**2698**	**3052**	-	**6257**
Large Mammals	221	106	483	1726	5019	5031	12	**12598**
Medium Mammals	194	73	531	1825	5389	6224	2	**14238**
Small Mammals	2	2	1	48	122	47		**222**
Total Identified	**470**	**248**	**1232**	**4391**	**14099**	**15460**	**14**	**35900**
Unidentifiable Fragments	311	271	1108	7135	10368	9712	10	**28915**
Total	**781**	**519**	**2340**	**11514**	**24464**	**25172**	**24**	**64814**

10.2. Faunal Remains from the Military Base area

These remains were excavated by the Dubai Municipality in the summer of 2016, and analysis took place during the third season. The material was analysed according to the methods set out in **Section 1.2.** of this chapter, and the results of this analysis were presented to Dr Mansour and Dr Qandil in November 2016. Due to the differences between this material and the assemblages from the 'Central' area, they are considered in some detail below.

10.2.1. Individual Find Groups

These fragments were recovered either individually or in small Associated Bone Groups. Each were designated a unique identifying number by the Dubai Municipality team and are listed by these numbers below.

SA 6454 (Locus 6)

This specimen represents the most intact camel mandible unearthed at Saruq al-Hadid to date. A complete tooth row on both the left and right sides of the mandible is present (in two pieces), however the ramus is absent (**Fig. 70**). It is hard to conclude whether or not the bone has been burnt; whilst the exterior surface is discoloured, an examination of the bone interior showed no signs of heat exposure (**Fig. 70**).

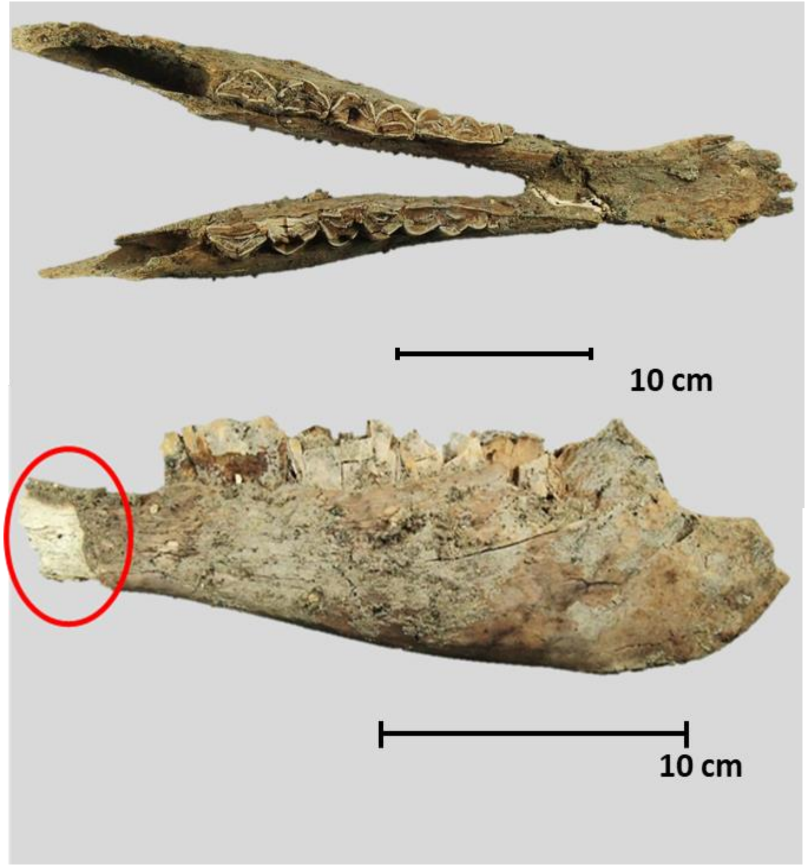

Figure 70. *Camel mandible SA 6454, recovered from locus 6 in the Military base excavations. Note the uncharred bone interior of the right-sided mandible. below, circled in red.*

SA 6459 (Locus 7)

This fragment is the left side of a cattle mandible, the buccal (cheek) side of which has been charred (**Fig. 71).** This mandible originates from a younger individual, as evidenced by the eruption stages of the teeth (**Fig. 71**). According to the ages at which teeth erupt, this animal is likely to have been between one and eight months of age at death. Measurements were not taken from this specimen as juvenile bones can produce variable metrical information due to differentiation in growth rates between individuals. No signs of butchery were present on the bone surface.

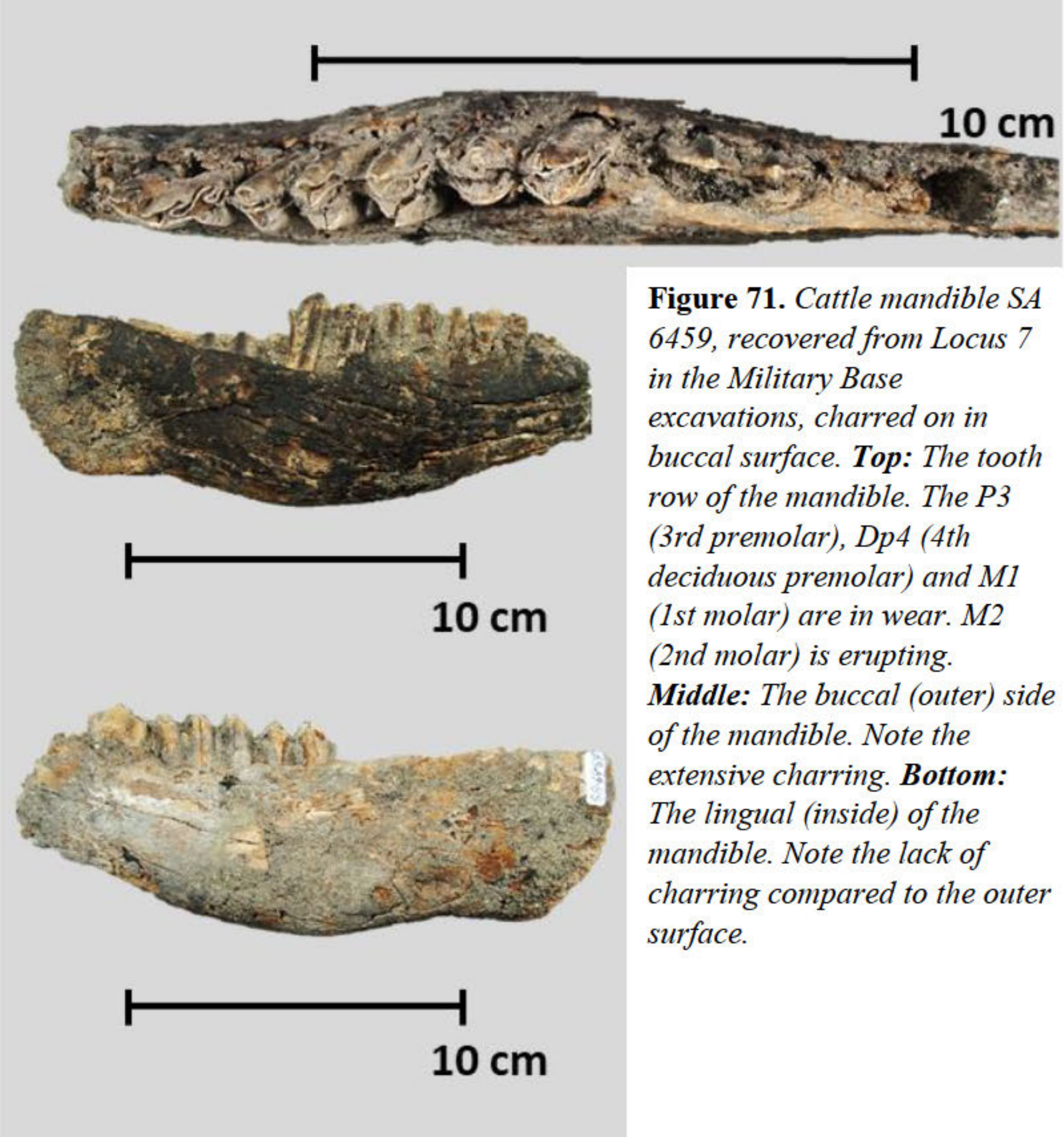

Figure 71. *Cattle mandible SA 6459, recovered from Locus 7 in the Military Base excavations, charred on in buccal surface.* ***Top:*** *The tooth row of the mandible. The P3 (3rd premolar), Dp4 (4th deciduous premolar) and M1 (1st molar) are in wear. M2 (2nd molar) is erupting.* ***Middle:*** *The buccal (outer) side of the mandible. Note the extensive charring.* ***Bottom:*** *The lingual (inside) of the mandible. Note the lack of charring compared to the outer surface.*

SA 6460 (Locus 7)

This fragment was the right side of a cattle mandible (**Fig. 72**). Using the wear on the teeth as a guide, this mandible came from an individual aged between 30-36 months old at death. No signs of butchery or burning are obvious on the bone surface.

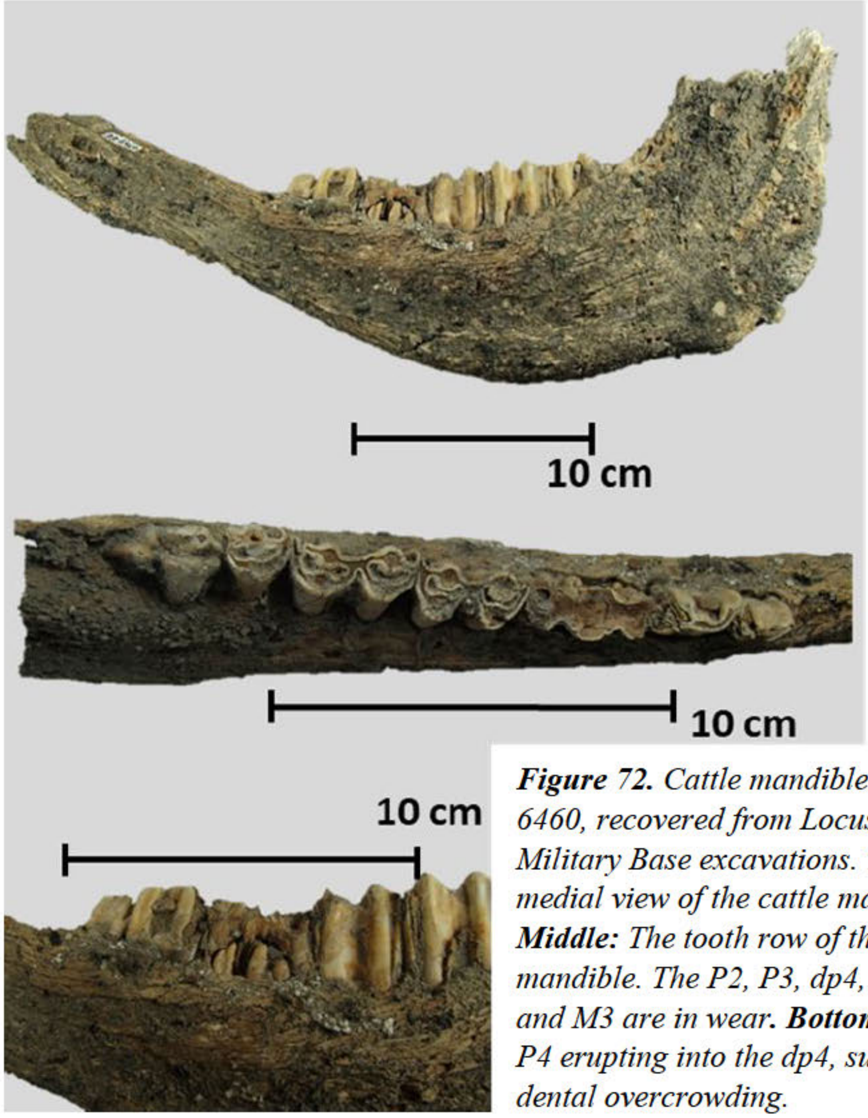

Figure** 72. Cattle mandible SA 6460, recovered from Locus 7 in the Military Base excavations.* ***Top: *A medial view of the cattle mandible.* ***Middle:*** *The tooth row of the mandible. The P2, P3, dp4, M1, M2 and M3 are in wear.* ***Bottom:*** *The P4 erupting into the dp4, suggesting dental overcrowding.*

SA 6461 (Locus 7)

This find was identified as a mostly intact right mandible from a sheep or a goat (**Fig. 73**) – with the early stage of development rendering distinguishing between sheep and goat not possible. Based upon the state of wear and eruption of the teeth the animal was between 9 and 12 months old at the time of death (**Fig. 73**). No signs of butchery or burning are present on the bone surface.

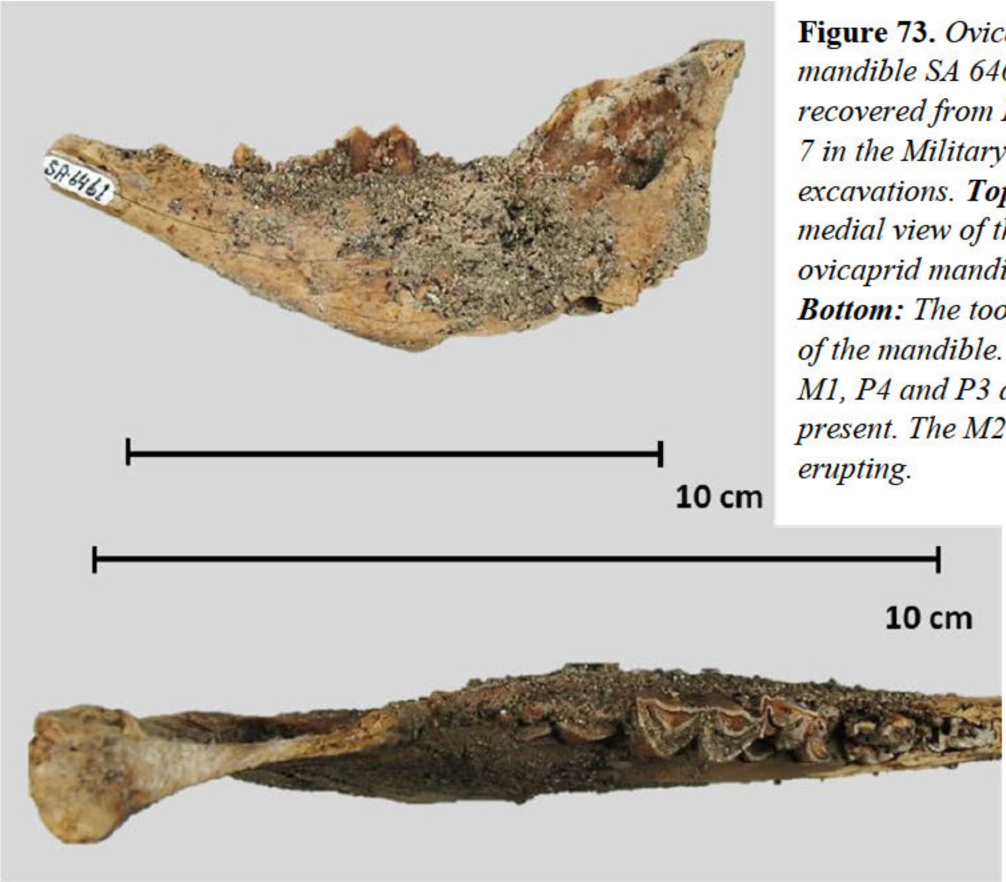

Figure 73. *Ovicaprid mandible SA 6461, recovered from Locus 7 in the Military Base excavations.* ***Top:*** *A medial view of the ovicaprid mandible.* ***Bottom:*** *The tooth row of the mandible. The M1, P4 and P3 are present. The M2 is erupting.*

SA 6569 (Locus 8)

This find is a fragment of a camel left radius and ulna (**Fig. 74**).While the bone surface is coloured, there is little sign of burning, as depicted in **Fig. 70**. No butchery marks were present.

Figure 74. *Camel radius/ulna SA 6569 recovered from Locus 8 in the Military Base excavations.*

SA 6570 (Locus 8)

This fragment is from the skull of a camel, specifically the left maxilla. It shows little sign of heat exposure or butchery. It joins together with the camel mandible (designated SA 6454), suggesting that they were from the same individual animal, whose head may have been deposited intact.

JM 80 (Unknown Locus)

JM 80 contained six fragments of animal bone. These were three fragments of tooth, a metatarsal fragment and a humerus, all of which were from ovicaprid and a fragment of vertebra from an unknown large mammal. The humerus was fused suggesting it came from an individual who was older than 13-18 months of age. None of these fragments showed signs of burning or butchery.

JM 85 (Unknown Locus)

This group of finds contained 43 fragments of animal bone. Five of these fragments could be identified to species; a fragment of mandible, humerus and phalanges from an ovicaprid were identified, along with a fragment of a cattle maxilla Additionally, 27 long bone shaft fragments from various sizes of animal were present. Six of these fragments had been charred, while one fragment showed signs of heavier burning and was calcined. This group also contained a number of rib fragments from different sized animals. Four fragments of teeth were identified and a burnt fragment of metapodial shaft was also present. None of these remains displayed any signs of butchery.

JN 118 (Locus 1)

While eight fragments of bone were present in this material, they were all from the same oryx radius from the right side of the body. There was no sign of butchery or burning on any of the fragments.

JN 121 (Locus 4)

This bone was a fragment from a right camel's mandible. It displayed no signs of butchery or burning, and the teeth were too fragmented to draw conclusions about the relative age of the individual.

JN 124 (Locus 7)

These fragments are from a camel metapodia (i.e. metacarpal or metatarsal). These bones are particularly thick and straight, making them material often used in bone working.

JN 125 (Locus 8)

This assemblage contained nine fragments of bone. Three of these could be reassembled to form part of a juvenile cow's skull (**Fig. 75**). An ovicaprid metacarpal was also present. A highly burnt fragment of rib from a larger mammal was also identified and fragments of long bone shafts from various sizes of mammal were also recovered, one of which was charred.

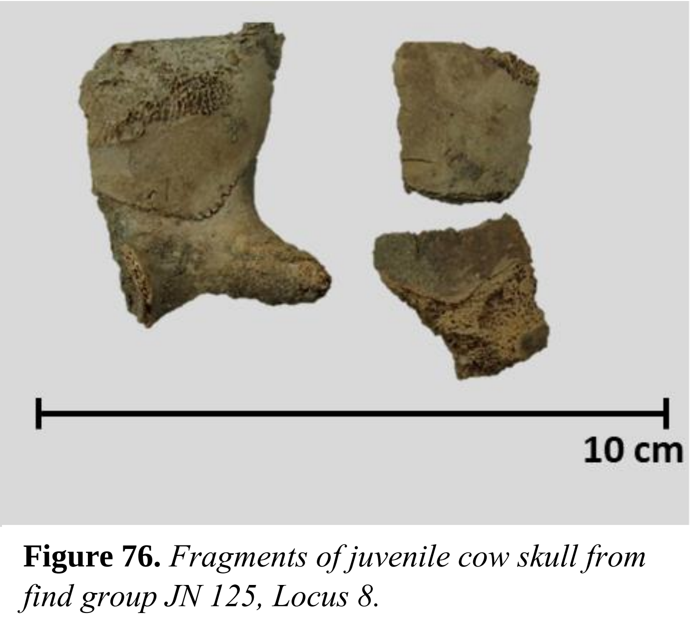

Figure 76. *Fragments of juvenile cow skull from find group JN 125, Locus 8.*

JN 126 (Locus 9)

This find was a large fragment of a right camel ulna with evidence of heavy burning. It is probable that this ulna is from the same individual that SA 6569 originated from. The fragment showed no clear signs of butchery marks.

JN 199 (Locus 2)

This fragment is the shaft of a left oryx tibia. There are no obvious signs of burning or butchery on the bone surface although it is heavily weathered.

10.2.2. Locii

These remains were recovered from across entire stratigraphic layers in the excavations. The excavated material was separated over nine different levels, all of which were dated to the Iron Age period (**Table 62**, **Table 63**).

Table 62. *The NISP of each taxa identified in each context excavated by the Dubai Municipality excavations undertaken in the Military Base area.*

	Locus									**Total**
	1	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**?**	
Cattle					4	4			1	**9**
Goat			3		5		4			**12**
Ovicaprid			12		44	23			6	**85**
Domestic Animals	**-**	**-**	**18**	**1**	**53**	**25**	**7**	**1**	**6**	**106**
Camel			2	1	4	2		1		**13**
Wild or Domestic	**-**	**-**	**2**	**1**	**4**	**2**	**-**	**1**	**-**	**13**
Oryx	8	1	1		8					**18**
Gazelle			1		6	1				**8**
Wild Animals	**8**	**1**	**2**	**-**	**14**	**1**	**-**	**-**	**-**	**26**
Large Mammal			37		107	22	3		16	**185**
Medium Mammal			32		251	46	2		14	**345**
Small Mammal			8		12	2				**22**
Total Identified	**8**	**1**	**99**	**2**	**441**	**98**	**12**	**1**	**37**	**691**
Unidentifiable Fragments			85		273	39			12	**409**
Total	**8**	**1**	**181**	**1**	**714**	**139**	**12**	**1**	**49**	**1106**

Table 63. *The skeletal element representation (NISP) from the domesticate remains recovered from the Military Base excavations.*

	Ovicaprid	**Goat**	**Cattle**	**Camel**	**Oryx**	**Gazelle**	**Large Mammal**	**Medium Mammal**	**Small Mammal**	**Indeterminate Taxa**	**Total**
Horncore		1 (*1*)			2 (*1*)	1 (*1*)		1		18	23
Skull		3 (*1*)					8	5			16
Maxilla	3 (*1*)	3 (*3*)	1 (*1*)	1 (*1*)							8
Mandible	14 (*12*)		2 (*2*)	4 (*4*)							20
Teeth	7 (*7*)		4 (*4*)	3 (*3*)	4 (*4*)		37	56		29	140
Atlas					1 (*1*)						1
Rib				1 (*1*)			12	10	22		45
Humerus	14 (*14*)										14
Radius	7 (*3*)			1 (*1*)	8 (*8*)	1 (*1*)					17
Ulna	3 (*2*)			1 (*1*)	1 (*1*)	2 (*2*)					8
Metacarpal	13 (*9*)	2 (*2*)	2 (*1*)								17
Phal. 1	13 (*13*)	1 (*1*)				2 (*2*)		4			20
Phal. 2	1 (*1*)				1 (*1*)			1			3
Phal. 3						1 (*1*)					1
Vert. Indet.							2	2			4
Tibia	1 (*1*)				1 (*1*)						2
Metatarsal	7 (*5*)	2 (*2*)				1 (*1*)		1			11
Metapodial	2 (*2*)			2 (*1*)			2	14			20
Ln. Bn.							116	247		38	401
Fl. Bn.							6	4		1	11
Canc. Bn.							1			1	2
Indet.							1			322	323
Total	**85**	**12**	**9**	**13**	**18**	**8**	**185**	**345**	**22**	**409**	**1106**

Wild Animals

Two wild taxa were present in the remains from the Military Base, oryx and gazelle. As seen in the assemblage from the 'Central' area, oryx were the most well represented of the two species. A range of skeletal elements were present from both of these species, suggesting that the butchery of entire carcasses occurred in this area (**Table 63**). A number of these remains were burnt to various degrees of intensity (**Table 64**), suggesting that these animals were also cooked at the site. Only a singular fragment was identified to be from a younger individual, suggesting that the majority of animals present in the remains from the Military Base would have been adult at death, as seen in the assemblage from the central area (**Table 65**).

Table 64. *The number and percentage of burnt wild animal remains from the Military Base excavations.*

	Taxa	
	Oryx	Gazelle
Patchy Charring	1 (33%)	
Charred, burnt black		1 (16.7%)
Grey	1 (33%)	4 (66.7%)
Burnt white	1 (33%)	1 (16.7%)
Burnt Fragments	**3**	**6**
Percentage of Horizon Fragments Total	***16.7***	***75***

Table 65. *The state of epiphyseal fusion from the Military Base identified as ovicaprid.*

	F	UF	%F
Scapula			
P. Metapodia			
Pelvis			
D.Humerus	3	6	
P.Radius	2	1	
<10 mths.	**5**	**7**	***41.7***
D.Tibia	2		
D.Metapodia	3	9	
Phalanx 1	5	2	
Phalanx 2	1		
1-2 years	**11**	**11**	***50***
Ulna	1	-	
P.Femur			
Calcaneum			
D.Radius			
2.5-3 years	**1**	**-**	***100***
P.Humerus			
D.Femur			
P.Tibia			
3-3.5 years	**-**	**-**	**-**

Domestic Animals

In contrast to the assemblage from the Central Area, domestic animals were far more numerous than wild animals (**Table 62**). There was also a much higher relative representation of cattle. Ovicaprids were the most frequently represented domestic taxa however, as seen in the 'Central' area.

The skeletal element representation in this assemblage differs from the Iron Age levels in the 'Central' area (**Table 63** & **Fig. 77**). A higher proportion of meat bearing elements were present along with a number of cranial, mandibular and tooth fragments (**Fig. 77**). Furthermore, a relatively high proportion of juvenile animals, including both cattle and ovicaprid, were identified within the remains (**Tables 65**, **66** & **67**). This included a large amount of neonatal remains. High concentrations of neonatal and juvenile animals are often associated with the use of domesticates for milk; a surplus of younger animals often results from keeping animals in milk, which are often consumed and deposited in the archaeological record. When combined with the evidence of burning within this assemblage (**Tables 68**), the evidence for the consumption of juvenile animals in the area becomes compelling, as does the hypothesis that herds of domesticates were being kept at Saruq al-Hadid in this period.

Measurements taken from ovicaprids in the Military Base assemblage were compared to those from the 'Central' area of Saruq al-Hadid and found to be substantially larger, therefore making them similar in size to other Iron Age ovicaprid remains in the region (**Fig. 78**).

This high concentration of domestic animals is similar to the faunal assemblages from domestic sites such as Tell Abraq (Uerpmann 2001) and Maysar (Uerpmann and Uerpmann 2008). The domestic sites also contained large amounts of domesticates with a high proportion of juvenile animals. These similarities suggest that the occupation in the military base was primarily domestic in nature, however further excavation will be needed to confirm this.

Camels

Camel remains were represented in the majority of loci. Entire carcasses were represented in the remains, suggesting that these were remains from primary butchery. While no butchery marks were identified on these remains, a number of these fragments were burnt adding to the conclusion that they were waste from consumption (**Table 69**).

Other Observations

None of the marine animals identified in the assemblage from the 'Central' area (i.e. fish, dugong and cormorant) were present in the assemblage from the Military Base excavations. No lagomorphs, reptiles, rodents or any other species of bird were present in the assemblage from this area either. While it is important to reiterate that these remains are from a limited area of excavation, they do suggest some strong differences between the activities occurring in both of the areas, further strengthening the concept that the Military Base and Central Area were different use areas of the site during the Iron Age.

Table 66. *The tooth wear of mandibular fragments from the Military Base identified as ovicaprid and goat, following Payne 1973 and Grant 1982.*

Observed Tooth Wear/Eruption	Designated Age
P4 Erupting; M3 Erupting	1.5 years
P4 = a	1-2 years

Table 67. *The tooth wear of mandibular fragments from the Military Base identified as cattle, following Grant 1982 and Halstead 1985.*

Observed Tooth Wear/Eruption	Designated Age
dp4 unworn; M2 Unerupted	0-1 month
dp4 = n; P4 erupting; M3 unworn	12-24 months
M3 = b	30-36 months

Table 68. *The number and percentage of burnt domesticate remains from the Military Base excavations.*

	Taxa	
	Ovicaprid	**Cattle**
Patchy Charring	4 (17.3%)	2 (100%)
Charred, burnt black	8 (34.8%)	
Grey	11 (47.8%)	
Burnt Fragments	**23**	**2**
Percentage of Horizon Fragments Total	***27.1***	***22.2***

[redacted]

Figure 77. *The skeletal elements representation in the ovicaprid remains, shown as a percentage of MNI, in the Military Base assemblage. © 1996 ArcheoZoo.org*

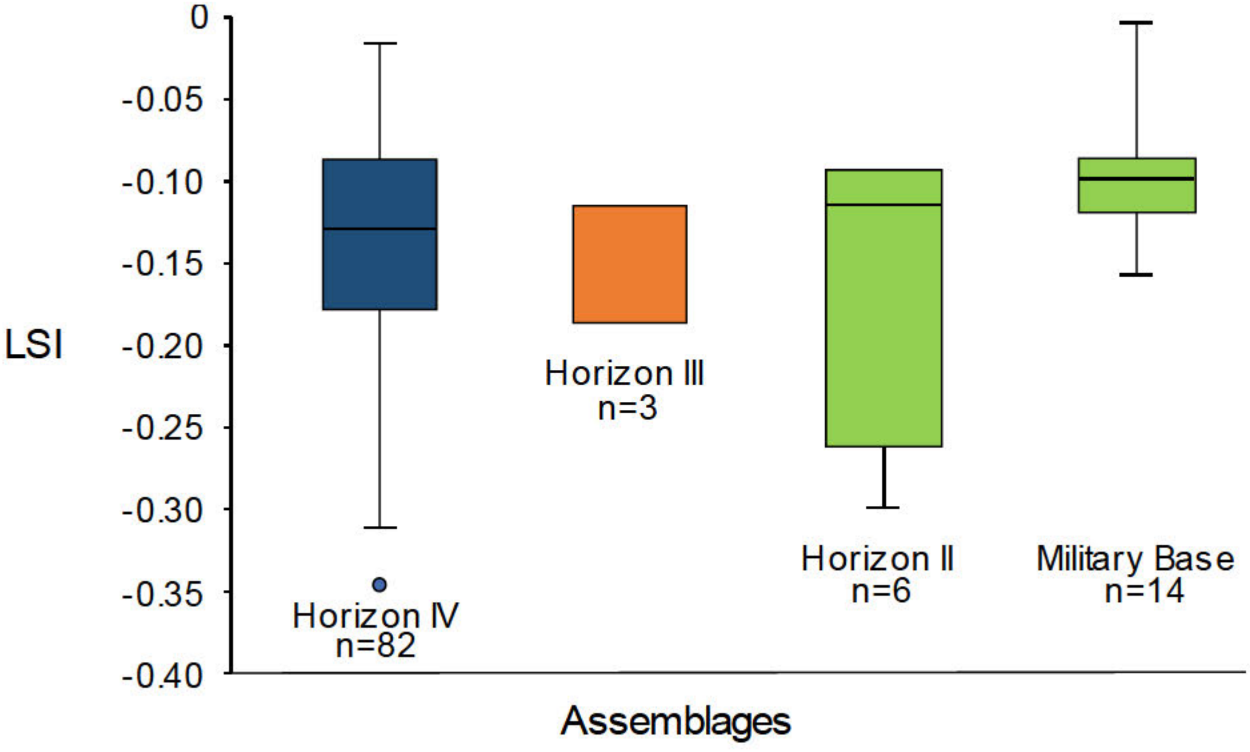

Figure 78. *The size of ovicaprid remains from the Military Base excavations compared to those from the Central Area.*

Table 69. *The number and percentage of burnt camel remains from the Military Base excavations.*

	Camel
Patchy Charring	4 (66.7%)
Charred, burnt black	1 (16.7%)
Grey	1 (16.7%)
Burnt Fragments	**6**
Percentage of Horizon Fragments Total	***46.2***

11. Sanisera Archaeological Institute Excavation Results (Area 2A)

The remains recovered from this excavation are dated to Horizons II-I in the Central Area (900-700 BCE, Contreras Rodrigo *et al.* 2017). A relatively small assemblage of animal bone, comprising 1868 fragments were recovered from these excavations, of which only 51 were taxonomically identifiable (**Table 70**). The vast majority of remains were small fragments that had worked edges similar to those in Horizons II & I in the Central Area.

Little can be said about those fragments that were taxonomically identified, due to the small size of the assemblage. Fourteen fragments of worked bone were also present, comprising eleven handle inlay fragments, one bead and two larger fragments with worked edges. The presence of worked is therefore the only real comparison between the remains from this area and those from the Central Area.

Table 70. *The NISP of each taxa identified in the Area 2A excavations undertaken by Sanisera Archaeological Institute.*

Taxa	Totals
Camel	3
Canid	1
Wild or Domestic	**4**
Lagomorph	1
Wild Animals	**1**
Fish	12
Marine Animals	**12**
Medium Mammal	18
Small Mammal	16
Total Identified	**51**
Unidentifiable Fragments	1,817
Total	**1868**

12. Conclusions and Future Work

The vast animal bone assemblage presented above contributes to a large number of different factors of our understanding regarding human behaviour at both Saruq al-Hadid and at the regional level. Specifically, this includes exploitation of wild terrestrial animals and the relationship between this and domesticate use, the elucidation of the domestication of the dromedary camel and the role of marine resources in provisioning inland sites, along with the movement of people this implies. Furthermore, animal bone is clearly demonstrated to have been a well-utilised resource in itself, with ample evidence for bone working and bone object use at Saruq al-Hadid.

More broadly, this assemblage has great potential to inform on the human past in the southern fringes of the Rub al-Khali desert; it demonstrates that humans were facilitating their occupation of this space by utilising a multitude of animal resources and that this environmental zone yielded resources that could be both consumed and moved to the coast. This is an important contribution to how we understand the role of the desert interior in the regional network of late prehistoric activity. Lastly, the remains may also be a useful proxy in the study of environmental change through time at Saruq al-Hadid, although other material classes must also be considered in this matter.

The key points of this study, along with suggested directions of future work, are as follows:

a) The zooarchaeological analyses demonstrate clear changes in use of the Central Area through time, with distinctive changes in the characteristics of the faunal assemblage recovered from the SHARP and DM excavations between the Bronze Age (Horizons V and IV), and the Iron Age (Horizons II and I). The bone from Horizons V and IV appears to be the remains of consumption, with largely whole carcasses and some pre-butchered elements being brought to the site for butchery, preparation for consumption and ultimately consumption during these periods. The vast majority of remains from Horizons II and I in the Central area are hypothesised to be the residue of industrial activity, focused around the processing of animal skins and the working of animal bone. The remains from the Military Base, currently thought to be contemporary with Horizons II and I in the Central Area, are suggested to be the remains of consumption, with characteristics of the assemblage (i.e. large amount of juvenile ovicaprid, greater amounts of domesticates than wild species) similar to faunal material from domestic sites (e.g. Tell Abraq). The remains from Area 2A, also contemporary with the remains from Horizons II & I, appear to attest small-scale bone working and little else. This prompts the suggestion that this area of the site was domestic in nature, which should be explored in future excavations in the Military Base.

b) The temporal relationship between the faunal assemblage excavated from the Military Base Area and the assemblage from the Central Area should be further explored, with reference to other material classes excavated in those areas as and when such data are made available.

c) The taxonomic content of the remains from all occupation phases from the Central Area of Saruq al-Hadid is indicative of a subsistence strategy that incorporates a wide array of animals from different ecological zones, from the sea to the desert interior. This is strongly reminiscent of subsistence strategies evidenced ethnographically in the region today, that incorporate seasonal transhumance and exchange to maximise resource capture in a relatively hostile environment (e.g. el-Mahi 2000). The faunal assemblage from the Central Area also demonstrates the relationship between humans and animals at Saruq al-Hadid beyond subsistence, with clear evidence for the use of animal bone as a crafting material. Furthermore, the infrequent association of animal bones with ritual objects and other ritual contexts provides tentative insight into the social dimensions of the human-animal interactions at Saruq al-Hadid.
d) The significance of the camel remains from Saruq al-Hadid is important to restate here and are explored in detail elsewhere (Roberts *et al.*, Forthcoming). The consistent representation of camels in the remains from the site, the stature of the animals represented by the remains, the presence of intentional Iron Age deposits of camel bone associated with ritual objects, and severely pathological specimens dating to the Bronze Age, all provide new insights into the relationship between humans and camels through time.
e) The quantity of evidence indicative of the exploitation of wild terrestrial animals, particularly oryx and gazelle, at Saruq al-Hadid is unparalleled at other late prehistoric sites in the region. This suggests that the exploitation of wild terrestrial species was a key activity undertaken at Saruq al-Hadid, particularly during the Bronze Age occupation which is largely represented by an animal bone midden. This hunting activity undoubtedly also had a social importance, with numerous representations of wild animals in the wider material culture recovered from the Iron Age occupation of the site. These ideas are explored further elsewhere (Roberts *et al.* 2018).
f) The occupants of Saruq al-Hadid also brought herds of goats and some sheep to the site throughout its occupation, potentially even keeping and breeding a herd there during the Iron Age, as demonstrated by the remains from the Military Base. Further exploration of the ovicaprid remains from Saruq al-Hadid should be a major objective for future research, in order to incorporate these remains into the wider discussion about the presence of different sheep breeds in southeastern Arabia during late prehistory.
g) Remains of marine vertebrates provide insight into the way in which Saruq al-Hadid was connected to coastal sites in the region, both in terms of a general exchange of goods from the coast to the interior and subsistence strategies employed at Saruq al-Hadid during late prehistory. The presence of marine vertebrates from deposits throughout the stratigraphy at the site demonstrates the significance of the marine resource at Saruq al-Hadid through time, as explored

in detail elsewhere (Roberts *et al.* In Press). The otoliths are a particularly significant component of this due to the research potential contained within them, as demonstrated elsewhere (Roberts *et al.* 2019).

h) A number of bird species identified in the remains prefer to inhabit vegetated areas, and their presence in the assemblage may therefore imply that such vegetation was present at Saruq al-Hadid in the past. Caution must be exercised when using these bird remains as a proxy for climate change due to the potential for these remains to be from migratory species passing through the site rather than occupying it (Hellyer *Pers. Comm.*).

i) The animal bones also contribute to our understanding of site formation processes at Saruq al-Hadid. The vast abundance of rodent and reptile remains recovered from Horizon III is likely the result of taphonomic processes rather than anthropogenic action. The remains likely represent modern burrowing animals that were interacting with the large bone midden (Horizon IV). This highlights the role of burrowing animals at the site and the potential for smaller bone fragments, and other artefact classes, to be stratigraphically displaced, as explored in the absolute dating of the site (Weeks *et al.* 2019).

j) The worked and stained bone should be the subject of further analysis. The form of the handle inlays should be assessed to determine to what objects those inlays relate. The staining present on the handle inlays should also be assessed in order to identify any links between the form of worked fragments and the staining identified on them. In particular the mechanism by which the bone has been stained should be explored, including via archaeometric and experimental techniques, to determine whether this staining is anthropogenic. The evidence presented in this report tentatively suggests that a bone working and staining industry may have been a part of the activity undertaken at Saruq al-Hadid, and its further exploration should be a focus of future work at the site.

Ultimately, the faunal remains are an integral component of the archaeological assemblage recovered from Saruq al-Hadid, and speak to the human use and significance of the site in ways that are different but complementary to studies of other material remains. However, it is important to note that excavation continues in all areas of the site, and will undoubtedly yield more bone remains; the remains excavated to-date may thus only illuminate a narrow slice of the human-animal interactions that were taking place at Saruq al-Hadid during its long, if intermittent, occupation. Nevertheless, the remains provide insights into how the human occupation throughout time at Saruq al-Hadid was sustained using animal resources from a variety of environments, but with a particular emphasis on the exploitation of multiple species that were likely present in the site's local environment.

13. References

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6. Paper 2

This paper is entitled '*The role of wild terrestrial animals in late prehistoric societies of southeastern Arabia: new insights from Saruq al-Hadid*'. It focuses on the wild terrestrial animal remains from Saruq al-Hadid and discusses them within the wider regional context. The terrestrial wild animals were the subject of this paper due to their abundance at Saruq al-Hadid compared to other sites in the region. The primary reason for this difference is suggested to be the location of Saruq al-Hadid and the presence of wild species at the site that were not as available at coastal or mountainous sites. Additionally, the exploitation of wild animals is suggested to have been a key reason for the initial occupation of Saruq al-Hadid, given the prevalence of animal bone in the early phases of occupation at the site.

The paper provides new understandings of human lifeways in late prehistoric southeastern Arabia. Little is known about how humans utilised the interior space away from the mountains and the piedmont. The evidence for this desert zone being utilised for wild animal exploitation on a level not attested elsewhere during this period has great significance in how we understand the human occupation of different areas of southeastern Arabia during prehistory. The intensification of this activity during the Wadi Suq period (2000-1500 BCE) is also important for the wider understanding of human activity in the region during this time. The potential links between hunting and social formation are also explored, along with a discussion on how this hunting may have taken place, with regards to the society of the Wadi Suq period.

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7. Paper 3

This paper, entitled '*The changing relations between humans and the dromedary camel (*Camelus dromedarius*) in Late Prehistoric Arabia: new zooarchaeological evidence from Saruq al-Hadid*', presents the remains of dromedary Camels recovered from Saruq al-Hadid and frames them within the wider context of dromedary camel bone assemblages from late prehistoric southeastern Arabia. The decision to dedicate an entire paper to the discussion of these remains was based upon the realisation of their unique nature compared to other camel bone assemblages from prehistoric Arabia. Upon comparing the stature of the camels from Saruq al-Hadid to those from contemporary sites, it became clear that the remains from Saruq al-Hadid raise major questions regarding the conception of human-dromedary relationships in southeastern Arabia during late prehistory. This has particular importance for the understanding of how this relationship ultimately moved towards the domestication of the dromedary camel.

The enigmatic characteristics of the dromedary remains from Saruq al-Hadid therefore provide a platform for a discussion of the wider state of understanding regarding dromedary camel domestication, and to offer some suggestions as to how this field of research might be advanced in the future. This discussion forms the bulk of Paper 3. It should also be noted that this paper benefited from feedback provided by the attendees of the 2018 Seminar for Arabian Studies and the 2019 Society for American Archaeology conference, at which these data and interpretations were first presented.

Determining the nature, location and timing of dromedary camel domestication has fundamental implications for the wider comprehension of human activity in Arabia and adjacent regions, and the remains from Saruq al-Hadid provide an entirely new insight into the relationship between humans and dromedaries during this crucial period. Following on from the discussion in Paper 2, the location of Saruq al-Hadid in the desert interior is suggested to be the central reason for the idiosyncratic nature of this camel bone assemblage.

While this paper does not reach a firm conclusion regarding the domestic status of dromedary camels from Saruq al-Hadid, it raises fundamental questions regarding the methods and theoretical approaches used by zooarchaeologists to identify the process of domestication in the archaeological record, building on recent work regarding dromedary camel domestication published by Uerpmann & Uerpmann (2017) and the wider debates around domestication more generally.

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The Changing Relationships between Humans and the Dromedary Camel (Camelus dromedarius) in Late Prehistoric Arabia: new zooarchaeological evidence from Saruq al-Hadid

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Abstract

*The dromedary camel (*Camelus dromedarius*) is a fundamentally important animal to the multi-dimensional development of human societies that exist in the arid regions it inhabits. As a hunted animal it produces meat, skin and other products, and as a domesticate it facilitates the long-distance movement of goods and people across desert environments. This utility has fostered a long running and complex relationship between humans and dromedaries in Arabia. In this paper we present new data from a dromedary bone assemblage recovered by excavations at the late prehistoric (*c.*2000 – 800 BCE) site of Saruq al-Hadid, located in the United Arab Emirates. These data provide evidence regarding the long-term relationship between humans and dromedaries and highlight changes in this relationship during the Bronze Age and into the Iron Age, including the incorporation of dromedary remains into ritual practices undertaken at Saruq al-Hadid. We suggest that this changing relationship may be indicative of the early moves towards the domestication of the dromedary camel, supporting the idea of dromedary domestication being a long-term process. We also suggest ways in which researchers might be better able to identify the nuanced changes in the relationship between humans and dromedaries that would have occurred during this long-term domestication process.*

Keywords: Dromedary Camel, Arabia, Saruq al-Hadid, Prehistory, Domestication, Zooarchaeology

1. Introduction

Humanity's relationship with the dromedary camel (*Camelus dromedarius*) greatly influenced the development of societies in prehistoric Arabia. The animal's physiology is particularly adapted to life in arid environments that are challenging to humans; the dromedary is able to sustain itself on remarkably little food and water, and has the ability to lower its metabolic rate and required feed intake when food is scarce (el-Amin 1984; Guerouali *et al.* 2004: 46). They can survive by consuming the halophytic plants (plants high in salt) that occur in arid regions (Gauthier-Pilters & Dagg 1981: 42), allowing the dromedary to survive where other animals cannot (e.g. Farid 1984; Wardeh 2004a; Wensvoort *et al.* 2004) and providing a source of meat and other products for humans in such environments. This includes the production of large quantities of milk that is particularly nutritious (e.g. Gauthier-Pilters & Dagg 1981: 164; Wardeh 2004b: 40), even during periods of dietary stress (e.g. Wardeh 2004b). Furthermore, dromedary camels can also travel extensive distances in the desert environment, even when burdened with passengers. They have been recorded covering 150 kilometres over 13 hours (Denis *Unpublished*) and can keep a similarly high pace over a number of days, as recorded by the French Captain Charlet's Saharan expedition in 1913, where he led 70 dromedaries and riders over 800km in 11 days without losing a single dromedary (Gauthier-Pilters & Dagg 1981: 101).

The dromedary's many abilities and attributes make them particularly useful as a domesticate, and have led to a long-term relationship between this species and the humans that share its environment. It is universally accepted that the dromedary was fundamental to the formation of trade routes (e.g. Retsö 1991; Artzy 1994; Magee 2004; 2014; 2015; Potts 2005; Boivin & Fuller 2009), the conduct of warfare (Bulliet 1975; Magee 2014: 269, 2015: 268), and the lifeways and movement of peoples (and with them ideas and customs) in Arabia and adjacent regions from prehistory through to the modern day (e.g. Bulliet 1975; Gauthier-Pilters & Dagg 1981; Arbuckle 2018;). Developing our understanding of the long-term relationship between humans and this important species will therefore facilitate a greater understanding of the mechanisms that have shaped humanity in this region.

While the existence and significance of the long-term relationship between humans and dromedaries has long been recognised in scholarship (e.g. Bulliet 1975: 36-38; Retsö 1991: 48-49; Magee 2015: 254), little is known about this relationship prior to the widespread appearance of domesticated dromedaries throughout the Near East at around 1000 BCE. This is largely due to a lack of evidence from earlier periods, as highlighted in the recent synthesis of evidence relating to dromedary domestication undertaken by Magee (2015: 272).

A substantial dromedary bone assemblage dating from c.2000 – 800 BCE has recently been excavated from the site of Saruq al-Hadid (**Fig. 1**), Dubai, UAE, which helps to address this issue. In this paper we present and interpret the new zooarchaeological data from these recently analysed remains in comparison to contemporaneous dromedary datasets, including insights from archaeology, ethnography and dromedary ecology. Our discussion demonstrates the importance of incorporating ecological and ethnological information in the interpretation of zooarchaeological data patterning and the formation of conclusions regarding the relationship between humans and dromedaries in the past. We also highlight lacunae in the current understanding of dromedary skeletal physiology and behaviour which hinder assessments of past human-dromedary relationships. We discuss ways in which we might reconsider the nature of interactions between humans and dromedaries in late prehistoric Arabia and suggest methods by which we might further our understanding of this topic in the future.

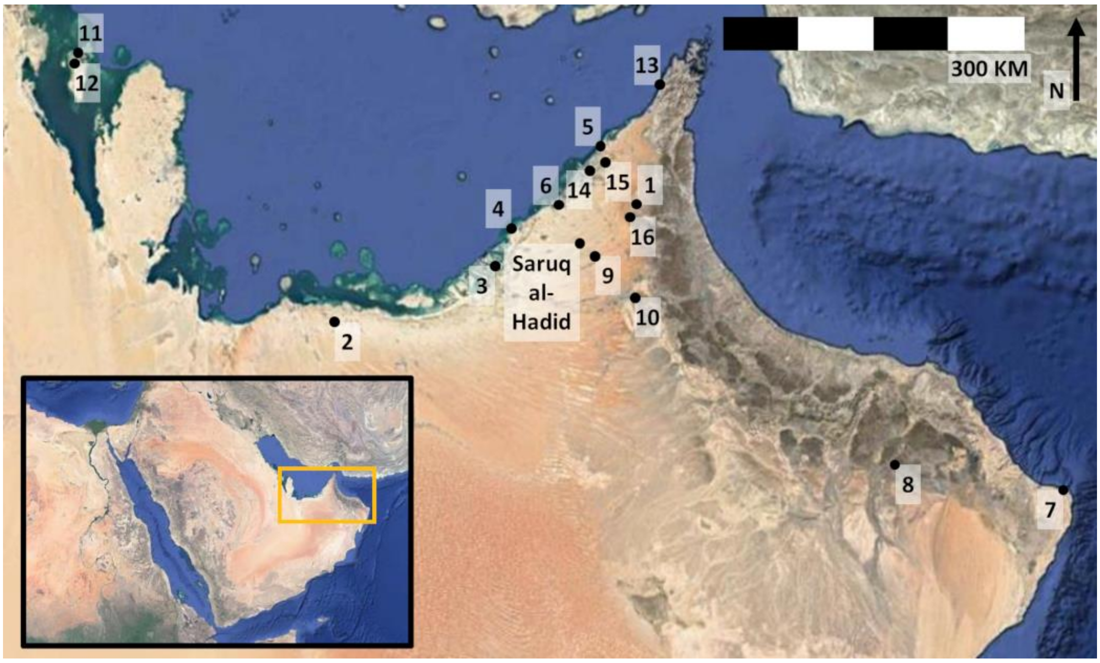

Figure 1. *A map of the sites in southeastern Arabia that have yielded camel bone assemblages dating late prehistory. See* ***Table 1*** *for key.*
Map Data: SIO, NOAA, US Navy, NGA, GEBCO, Landsat, Copernicus (Google Earth).

2. The Zooarchaeology of Late Prehistoric Human-Dromedary Relationships

In order to provide context for the relationship between humans and dromedaries it is important to outline the original ecological range of the wild dromedary camel. The evolutionary ancestry of the dromedary camel is poorly understood, largely due to the fragmentary nature of the evidence. While the dromedary had been hypothesised to have descended from the Pleistocene species *Camelus thomasi* local to north Africa (Peters 1998), a recent study comparing the morphological characteristics of *C. thomasi* and *C. dromadarius* concluded that there was not enough evidence to suggest any ancestral link between the two species (Martini & Geraads 2018). Regardless, at the onset of the Holocene, the dromedary appears to have been confined to limited habitats on the Arabian Peninsula (Peters 1998; Almathen *et al.* 2016: 6708).

2.1. Humans and Dromedaries in Southeastern Arabia

The zooarchaeological evidence for dromedary camels on archaeological sites in southeastern Arabia throughout late prehistory is synthesised in **Table 1,** and the regional archaeological periodization is summarised in **Table 2**.

The earliest dromedaries recorded in southeastern Arabia were recovered from the Neolithic site of Jebel al-Buhais 18, dating to 5100-4300 BCE (Uerpmann & Uerpmann 2000; Uerpmann & Uerpmann 2008a), where they were found alongside the remains of cooking installations in clearly anthropogenic contexts (Uerpmann & Uerpmann 2002: 236). They also appear at the fourth millennium BCE site of Baynunah in the western desert of Abu Dhabi (**Fig. 1**). While preliminary studies suggested that the deposition of these dromedaries was the result of natural causes (Beech *et al.* 2009: 26), the recent discovery of an arrowhead embedded in the skeleton of one of the dromedary bones recovered from the site, indicating that these remains are also of anthropogenic origin (Beech *et al.* 2018). These two assemblages conclusively demonstrate that dromedaries were hunted in the region during the late Neolithic period, however researchers have suggested that this may have been a sporadic act, citing the lack of dromedary bones in other Neolithic assemblages, such as those from the sites of Ra’s al-Hamra and Khawr Milh (Uerpmann & Uerpmann 2002: 236-237).

Subsequently, dromedaries appear on Early Bronze Age sites in the region, with large numbers of dromedary bones being recovered from the coastal sites of Umm an-Nar Island, where they are considered to have been a major constituent of the diet (Hoch 1979; Hoch 1995; Uerpmann & Uerpmann 2008b: 475), and Tell Abraq (Uerpmann & Uerpmann 2008b: 473). Dromedary remains were also recovered from the Bronze Age site of Ra’s Ghanada, described as fairly frequent yet poorly preserved (Uerpmann & Uerpmann 2002: 241), and four fragments were reported from Bronze Age deposits at Hili 8 (Uerpmann & Uerpmann 2008b). Recently, an anthropogenic deposit of dromedary remains representing three individual dromedaries was recovered from the Early Bronze Age site of al-Ashoosh (Contreras *et al.* 2016), located in desert interior of south-eastern Arabia (**Fig. 1**), demonstrative of their utilisation in the desert interior as well as the coast during the Early Bronze Age. In Oman, a small quantity of dromedary remains was recovered from the Early Bronze Age deposits at Ra’s al-Hadd 6 (HD-6), consisting of a fragment of mandible and third molar (Curci *et al.* 2014: 211-212). The researchers speculated as to the domestic or wild status of the dromedaries from which these fragments originated, however few definitive conclusions could be drawn, due to the small sample size. A single fragment of dromedary bone was also recovered from Bronze Age deposits at the site of Maysar 6, believed to be from a hunted animal (Uerpmann & Uerpmann 2008b: 470).

Table 1. *All late prehistoric sites that have yielded camel bone assemblages from southeastern Arabia.*

Site	Period	Number of Camel Fragments	Reference(s)
1. Jebel al-Buhais	Neolithic	Several fragments.	Uerpmann & Uerpmann 2000; Uerpmann & Uerpmann 2008a
2. Baynunah	Neolithic	Frequent remains, numbers not specified.	Beech *et al.* 2009; 2018
3. Umm an-Nar	Early Bronze Age	91 fragments.	Hoch 1979, 1995; Uerpmann & Uerpmann 2008b
4.Ra’s Ghanada	Bronze Age	Frequent remains, numbers not specified.	Uerpmann & Uerpmann 2002
5. Tell Abraq	Early Bronze-Iron Age	Umm an-Nar: 37 fragments;	Uerpmann 2001; Uerpmann & Uerpmann 2008b
6. al-Sufouh 2	Early Bronze-Iron Age	17,812 fragments.	von den Driesch *et al.* 2008
7. Ra’s al-Hadd (HD-6)	Early Bronze Age	Two fragments.	Curci *et al.* 2014
8. Maysar 6	Early Bronze Age	A single fragment.	Uerpmann & Uerpmann 2008b
9. al-Ashoosh	Early Bronze Age	Remains from three individuals.	Contreras *et al.* 2016
10. Hili 8	Early Bronze Age	Four fragments.	Uerpmann & Uerpmann *et al.* 2008b
11. Saar	Early Bronze Age-Wadi Suq	A single fragment.	Dobney & Jaques 1994; Uerpmann & Uerpmann 2005
12. Qala’at al-Bahrain	Early Bronze Age-Wadi Suq	Two fragments.	Uerpmann & Uerpmann 1994
13. Shimal	Wadi Suq – Late Bronze Age	A single fragment.	Vogt & Franke-Vogt 1987
14. Muweilah	Iron Age	891 fragments.	Uerpmann & Uerpmann 2002; Uerpmann & Uerpmann 2017
15. Hamriyah	Iron Age	Several fragments.	Magee *et al.* 2009
16. al-Madam	Iron Age	17% of total assemblage.	del Cerro 2013

Table 2. *The broad regional periodisation for southeastern Arabia during the study period.*

Period	Dates
Neolithic	7000 – 3200 BCE
Hafit	3200 – 2700 BCE
Umm an-Nar	2700 – 2000 BCE
Wadi Suq	2000 – 1600 BCE
Late Bronze Age	1600 – 1300 BCE
Iron Age I	1300 – 1000 BCE
Iron Age II	1000 – 600 BCE

Published dromedary remains dating from the Middle Bronze Age (i.e. the Wadi Suq period, **Table 2**) are generally scarce, as they are for the Late Bronze Age. The site of al-Sufouh 2, U.A.E., is an important exception to this pattern, as excavations there recovered a large dromedary bone assemblage associated with numerous hearths and other burnt deposits. Radiocarbon dates from these deposits stretch from the second half of the third millennium BCE to the Iron Age (842 – 834 cal. BCE, von den Driesch 2008: Tab. 2). The burning and butchery marks identified on these remains led to their interpretation as the remains of hunted dromedaries that were brought to the site to be butchered and prepared for consumption (von den Driesch *et al.* 2008: 495). Although these findings and interpretations have been questioned, particularly in relation to the identification of butchery marks (Curci *et al* 2014: 216), the direct association of the al-Sufouh 2 dromedary bones with hearths (von den Driesch *et al.* 2008) strongly suggests that dromedaries were indeed being utilised for their meat at the site. Elsewhere, a single fragment of dromedary camel was also reported from the Wadi Suq/Late Bronze Age site of Shimal (Area SX) however no further information has been published regarding this fragment (Vogt and Franke-Vogt 1987: 94).

Dromedary bones have been identified in material from two sites in Bahrain that are contemporary with the late Umm an-Nar and Wadi Suq periods in Southeastern Arabia. A total of five fragments of dromedary bone have been recovered from the site of Saar, dating to 2000 – 1800 BCE (Dobney & Jacques 1994; Uerpmann & Uerpmann 2005: Tab. 8.4). These fragments are hypothesised to be from a wild population of dromedaries native to the island of Bahrain and, whilst a relatively small number of fragments, they were the most significant source of protein from the wild terrestrial species identified in the assemblage, based upon bone weight (Uerpmann & Uerpmann 2005: 303). Small amounts of dromedary camel bone were also identified in deposits from the site of Qala’at al-Bahrain (Uerpmann & Uerpmann 1994). Little could be said about this assemblage, however based upon the limited number of dromedary remains at the site the researchers concluded that these dromedaries were from a wild population that was not economically important to the inhabitants of the site (Uerpmann & Uerpmann 1994: 243).

Dromedary remains reappear in southeastern Arabian archaeological assemblages from the Iron Age II period, although they have only been identified at two sites; Tell Abraq (Uerpmann 2001) and Muweilah (Uerpmann & Uerpmann 2017). Based upon the stature of the dromedaries in these Iron Age assemblages, the remains from both sites are considered to be mostly from domestic dromedaries (Uerpmann & Uerpmann 2002; 2008; 2017). Some wild dromedaries were also identified at Muweilah, designated as such because of their larger stature (Uerpmann & Uerpmann 2002: Fig. 3; Uerpmann & Uerpmann 2017). This hypothesis is explored in further detail below. A small amount of dromedary remains were also identified in the faunal assemblage excavated from Hamriyah, dating to the Iron Age I-II period (Magee *et al.* 2009: 28), although they have not yet been fully published. Dromedary remains were also reported from Iron Age II-III cenotaphs at al-Madam (del Cerro 2013: 29), however these remains have not been fully published.

2.2. Humans and Dromedaries in Adjacent Regions

To fully map our current understanding of human-dromedary relationships it is also relevant to discuss dromedary camel bone assemblages excavated from sites in areas adjacent to southeastern Arabia. The sites discussed in the text are shown in **Figure 2** and listed in **Table 3**.

A number of fragments from the site of Sihi in southwestern Arabia were identified as *Camelus* sp., one of which was dated as being older than the mid-sixth millennium BCE (Grigson *et al.* 1989: 258) yet has recently been re-dated to the first millennium BCE (Bronk-Ramsey *et al.* 2015). It is also unclear as to whether these fragments are from dromedary camel or another species, however the researchers consider an identification of *Camelus dromedarius* to be likely (Grigson *et al.* 1989: 360). No examples of dromedary bones

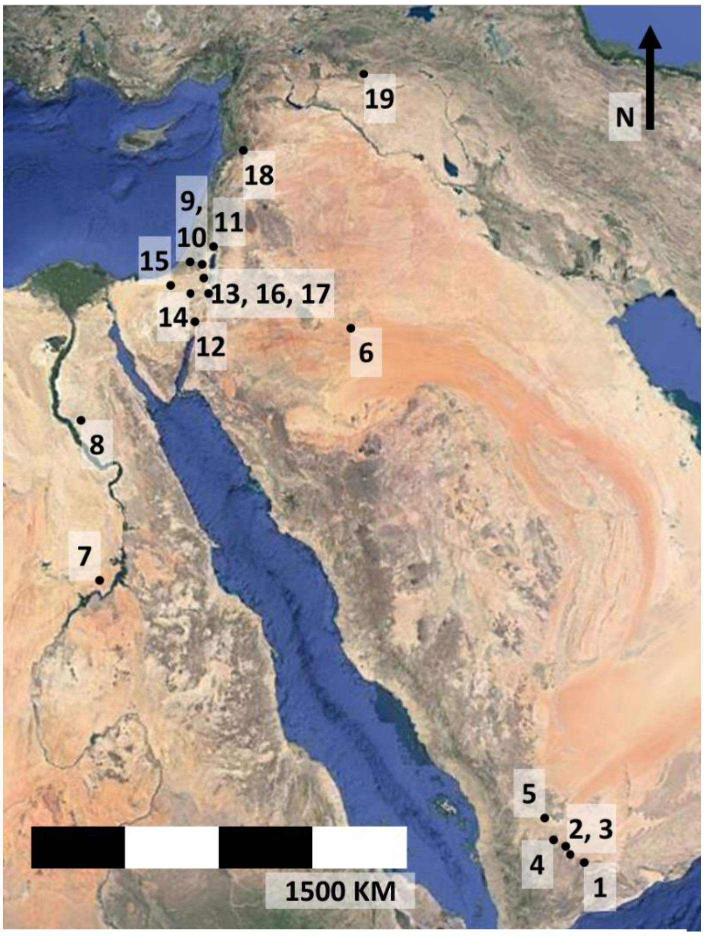

Figure 2. *A map of the sites in regions adjacent to southeastern Arabia that have yielded camel bone dating to the Bronze and Iron ages, referred to in the text. See* **Table 3** *for key. Map Data: SIO, NOAA, US Navy, NGA, GEBCO, Landsat, Copernicus (Google Earth).*

have yet been identified in any Neolithic or Bronze Age assemblages from southwestern Arabia, however Iron Age dromedary remains are found in relatively high frequency in this region, with their remains being recorded at Hajar Ibn Humayd, Hajar at Tamra, Hajar ar-Rayhani, Yala and Baraqish in Yemen (Fedele 2009; Fedele 2017: 297).

Table 3. *Bronze and Iron Age sites in regions adjacent to southeastern Arabia that have yielded camel bone assemblages*

Site	Country	Reference(s)
1. Hajar Ibn Humayd	Yemen	Fedele 2017
2. Hajar at-Tamra	Yemen	Fedele 2017
3. Hajar ar-Rayhānī	Yemen	Fedele 2017
4. Yala	Yemen	Fedele 2009; 2017
5. Baraqish	Yemen	Fedele 2017
6. Dumat al-Jandal	Saudi Arabia	Monchot 2014
7. Qasr Ibrim	Egypt	Rowley-Conwy 1988
8. Mostagedda	Egypt	Grigson 2014
9. Arad	Israel	Lernau 1978
10. Tell Jemmeh	Israel	Wapnish 1984
11. Jericho	Israel	Clutton-Brock 1979; Kenyon & Holland 1983
12. Timna (Tell Meneiye)	Israel	Knauf 1988; Grigson 2012; Sapir-Hen & Ben-Yosef 2013
13. Faynan	Jordan	Sapir-Hen & Ben-Yosef 2013
14. Har Sa'ad	Israel	Cohen 1980
15. Kadesh Barnea	Israel	Cohen 1979
16. Be'er Resism	Israel	Hakker-Orion 1984
17. Aroer	Israel	Hakker-Orion 1984
18. Tell Nebi Mend	Jordan	Grigson 2015
19. Tell Beydar	Syria	De Cupere & van Neer 2014

Further afield, small amounts of dromedary camel remains have been identified in Egypt, dating to the first half of the first millennium BCE. A single fragment of dromedary mandible was found at Qasr Ibrim, a site located in the Nile Valley just north of the modern border between Egypt and North Sudan, alongside a number of dromedary dung pellets (Rowley-Conwy 1988). Radiocarbon dating of the bone fragment provided a wide date range within the first millennium BCE and the dung was dated to the early first millennium BCE (Rowley-Conwy 1988: 73-74). A small amount of dromedary bones were also recovered from a cave site at Mostagedda, located close to the Nile River north of Sohag, and were dated to the mid-first millennium BCE (Grigson 2014).

A number of dromedary remains have also been recovered from late prehistoric Levantine sites. The oldest of these remains were recovered from Arad in Israel, dating to the third millennium BCE (Lernau 1978), and a late third millennium fragment from Tell Beydar in Syria (de Cupere & van Neer 2014). Dromedary remains were identified in an assemblage from Tell Nebi Mend in Syria, dating to the Late Bronze/Early Iron Age (Grigson 2015). The largest assemblage of dromedary remains from the Levant, excavated at Tell Jemmeh, date from the Late Bronze Age (1400-1300 BCE) through to the Hellenistic Period (332-200 BCE) (Wapnish 1984). Dromedary remains were also recovered from major and smaller sites in the southern Levant (**Table 3**) dating from the late second to the early first millennium BCE (synthesised by Sapir-Hen & Ben Yosef 2013: Tabs.1, 2).

2.3. Interpreting the Zooarchaeological Evidence

These remains demonstrate that the dromedary was regularly hunted by humans in southeastern Arabia from the Neolithic through to the Bronze Age. Whilst this also appears to have been happening sporadically in other regions, such as Bronze Age Syria, the dramatic increase in dromedary remains across the ancient Near East from the Early Iron Age suggests a step-change in human-dromedary interaction. Together with a number of concurrent changes in the characteristics of dromedary bones from archaeological sites (detailed below in Section 5), this post-Bronze Age appearance has been used to suggest that dromedaries were domesticated in the Middle East by the early first millennium BCE (e.g. Uerpmann & Uerpmann 2002; 2017; Magee 2015; Almathen *et al.* 2016).

However, researchers have consistently acknowledged the difficulties in identifying the characteristics and process of domestication and therefore assigning a timescale to it, recognising that the appearance of the domestic dromedary after 1000 BCE likely reflected longer-term human-dromedary interactions (e.g. Curci *et al.* 2014; Magee 2015: 272-273; Uerpmann & Uerpmann 2017: 315). Additionally, the likelihood of a co-existence and intermixing of early domestic and wild camel populations (Almathen *et al.* 2016; Uerpmann & Uerpmann 2002; 2017).

This current model of potentially complex but relatively rapid domestication of the camel around 1000 BCE stands in strong contrast to current understandings of the domestication of other species throughout time and space. As discussed in the case of the dog (e.g. Frantz *et al.* 2016; Lescureux 2018), the horse (e.g. Outram *et al.* 2009; Warmuth *et al.* 2012; Gerbault *et al.* 2014) and the goat (e.g. Zeder 2008;

Zeder 2012b; Daly *et al.* 2018), domestication is now considered to have incorporated long-term, erratic, and spatially-dispersed processes that eventually coalesced on a more widespread scale. Of course, it is not reasonable to insist, based solely upon the nature of the domestication of other species, that dromedary domestication must have been a long, complex process. As Zarins (1978: 45) notes: “Vague references to opinions concerning the process of domestication do not make a *prima facie* case for proof of domestication”.

In this instance, the relative lack of relevant zooarchaeological evidence from the second millennium BCE, highlighted above, has been the major factor preventing the discussion from moving beyond speculating at the nature of the long-term interactions between humans and dromedaries, prior to their widespread use as a domesticate. Nevertheless, the potential variability and complexity of these interactions is abundantly clear from ethnographic accounts, as explored later in this paper, which demonstrate the influence of many variables including environment or cultural preference. More broadly, the possibility of a longer-term process of human-animal interaction underpinning the domestication of the dromedary is supported by recent studies of the relationships between humans and other wild animal species in late prehistoric southeastern Arabia (Roberts *et al.* 2018).

Furthermore, it is arguable that discussions of camel domestication have been influenced by the presumption of a stark dichotomy between wild and domestic dromedary bone assemblages. This hypothesis implies a relatively rapid transition from one state to the other, thereby neglecting to consider the intermediate state(s) between wild and domestic. Reconsidering the nature of the difference between wild and domestic dromedaries may therefore allow for greater elucidation of the domestication process.. This is not to say that there is no difference between wild and domestic dromedary populations and their remains, however the evidence from Saruq al-Hadid presented below suggests this difference is not as stark as previously considered. The remains from Saruq al-Hadid are therefore presented below in terms of the long-term relationship between humans and dromedaries, as opposed to through the lens of the wild/domestic dichotomy. The term ‘management’ is particularly useful here as it describes a relationship between humans and dromedaries in which humans are influencing aspects of the dromedary population (e.g. behaviour, population demographic *via* selective culling, location *via* driving etc.), in turn encompassing the relationship prior to, during and after the appearance of characteristics that might be regarded as indicative of domestication. This term shall therefore be employed throughout this paper.

3. Zooarchaeological Research at Saruq al-Hadid

3.1. The Site of Saruq al-Hadid

Saruq al-Hadid is located 40 km from the gulf coast of the United Arab Emirates, in the dune fields of the Rub’ al-Khali desert. Programmes of survey and excavation undertaken at the site have identified persistent, temporary occupation from the Early Bronze Age, locally known as the Umm an-Nar period, through to the early Iron Age (*c.*2000 - 800 BCE), with evidence for periodic later activities through to the Islamic Period (Karacic 2016: 286; Casana *et al.* 2009; Nashef 2010; Hermann *et al.* 2012;

Contreras *et al.* 2017; Weeks *et al.* 2017; 2018; 2019; Karacic *et al.* 2018a). This activity is represented by a deep stratigraphy of interspersed cultural and natural layers in the 'Central Sector' (Weeks *et al.* 2018: 8, Fig. 3; 2019). The nature of the occupation of the site changed over time, from a large scale hunting and grazing site hypothesised to have been utilised by members of a multi-sited Bronze Age community, to a centre of ritual and industrial activity in the Iron Age, with evidence for interaction by groups from a wide geographic range (Karacic *et al.* 2018a; Weeks *et al.* 2018; Roberts *et al.* 2019). The dromedary bones discussed in this paper were recovered from the excavations undertaken by the Saruq al-Hadid Archaeological Research Project (SHARP; Weeks *et. al* 2017; 2018), which identified five occupational horizons (**Table 4**, cf. Weeks *et al.* 2017: Tab. 1). It is in relation to these five horizons that the remains are discussed below; only remains that can be securely associated with each of these horizons have been considered in this paper.

Table 4. *The general nature of the faunal remains from each archaeological horizon at Saruq al-Hadid.*

Horizon	Dates	Regional Period	Nature of Faunal Deposits	Fragmentation
I	c.1000-later	Early Iron Age and Later	Exposed surface deposit.	Highly fragmented.
II	c.1000-c.800BCE	Early Iron Age	Distinct deposits and concentrations of bone separated by the sand matrix of the site.	More intact than Horizon I, however a high degree of fragmentation. Some examples of more intact specimens and associated bone groups. A mix of large and small fragments.
III	c.1300-c.1000BCE	Late Bronze Age to Early Iron Age	Distinct deposits of bone overlying Horizon IV made up of groups of more intact, associated bone and small fragments that have likely filtered down from higher stratigraphy.	Highly fragmented. Some distinct Associated Bone Groups consisting of more intact specimens, but generally mixed, small fragments.
IV	c.1750-c.1300BCE	Wadi Suq to Late Bronze Age	A concentrated layer of bone, sometimes 1.5 metres thick, covering almost 20 by 20 metres, forming a mound.	Highly fragmented, with some intact specimens. A mix of large and small fragments.
V	c.2100-c.1800BCE	Umm an-Nar to Wadi Suq	Small deposits of bone underlying Horizon IV, often associated with hearths, post-holes and other features.	Relatively intact, larger fragments.

A small collection of 13 fragments of dromedary remains, provisionally dated to the Iron Age, were also recovered from a test excavation undertaken by the Dubai Municipality Government approximately 500 metres to the east of the SHARP excavations (Roberts 2017; Forthcoming). Limited excavations continue in this area of the site and have the potential to influence the interpretations presented here, but due to the uncertain chronological relationship between these remains and those from the SHARP excavations they are not further discussed in this paper.

3.2. Zooarchaeological Methods

The majority of deposits excavated by SHARP were passed through a 0.3 cm sieve whilst still dry, leading to the recovery of a large number (363,755) of fragments of animal bone. All bone was subject to visual examination, during which each fragment was assigned to a taxon and skeletal element, with any butchery, burning, pathology or other notable effects on the bone recorded. The mammalian assemblage was recorded using Serjeantson's (1996) '8 Zones per Bone' system. These data produced basic NISP (Number of Identified Specimens) and MNE (Minimum Number of Elements) counts. The MNI (Minimum Number Individuals) was calculated from the most common element according to the MNE, by taking sides into consideration. Epiphyseal fusion data were recorded for all taxa where possible and anatomical measurements were taken according to the guidelines set out by von den Driesch (1976). Randomly selected measurements were repeated to reduce the potential for measurement error.

Where possible, specimens were identified according to Wapnish's (1984) guidelines for distinguishing between dromedary and Bactrian camels (*Camelus bactrianus*). All of the fragments tested in this fashion were found to be from dromedary camels, as to be expected for this region at this time period. Although the Bactrian camel was domesticated by at least the third millennium BCE (e.g. Peters & von den Driesch 1997; Potts 2004: 148), the species is not native to Arabia (Potts 2004) and Bactrian camels have not been identified in any Arabian assemblages older than or contemporary with Saruq al-Hadid. Furthermore, metrical assessment (**Fig. 3**) of the remains did not suggest the presence of Bactrian camels or potential hybrids (crosses between dromedary and Bactrian camels) in the assemblage. The earliest examples of these large statured hybrid camels in southeastern Arabia were identified in the first century AD assemblage from Mleiha (Uerpmann 1999: 114).

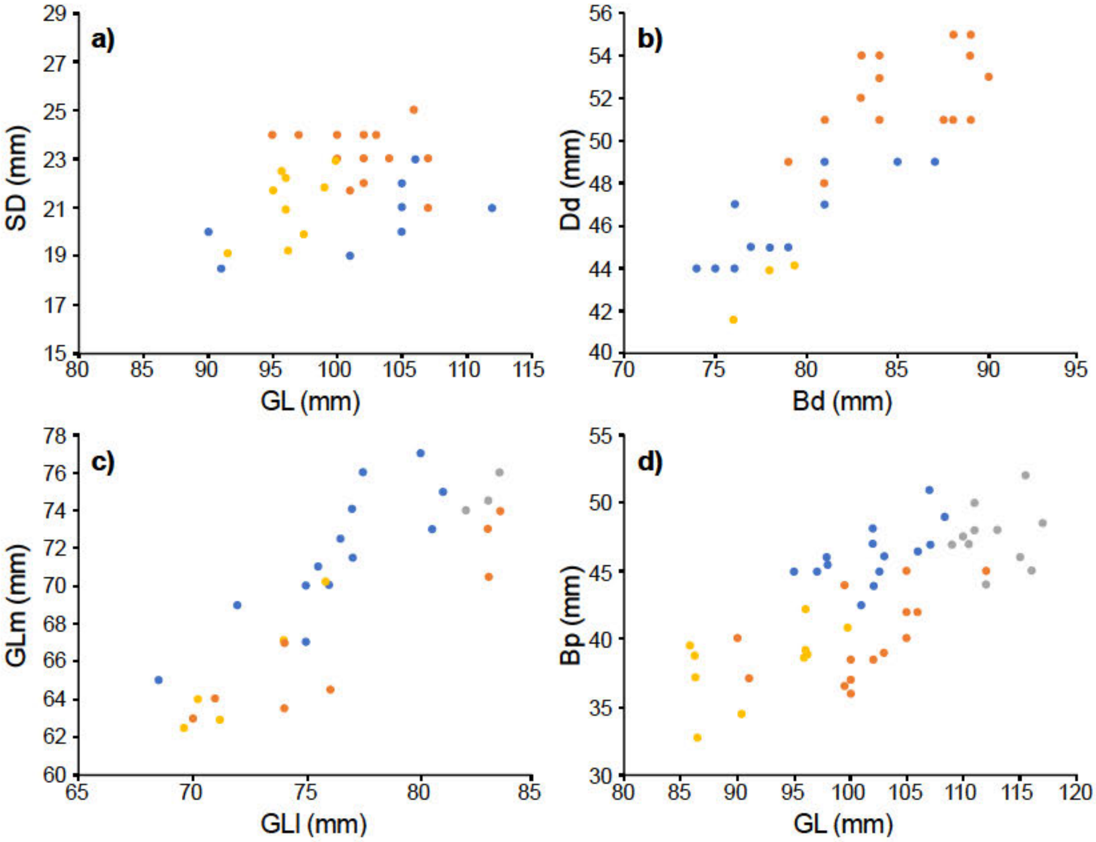

Figure 3. *Measurements of the camel remains from Saruq al-Hadid (yellow), compared to measurements from known dromedaries (blue), Bactrians (orange) and hybrids (grey). Shown here are measurements (following von den Driesch's guidelines (1976) from a) Anterior first phalanx (after Bartosiewicz & Dirjec 2001), b) Tibia (after Bartosiewicz & Dirjec 2001), c) Astragalus (after Uerpmann 1999), d) Anterior first phalanx (after Uerpmann 1999)*

4. Results and Interpretation

4.1. Frequency

The dromedary bone assemblage from Saruq al-Hadid is one of the largest yet discovered in southeastern Arabia, second only in size to the assemblage from the site of al-Sufouh 2. However, the dromedary remains at al-Sufouh 2 were deposited over a very broad date range that is broadly contemporary with the occupation at Saruq al-Hadid, but without a clear stratigraphic succession (von den Driesch 2008: Tab.2). Therefore, the ability to separate the dromedary remains from Saruq al-Hadid into the five occupation horizons observed at the site greatly increases the potential of the assemblage to provide insight into diachronic changes in the utilisation of the dromedary in the region. The dromedary camel comprises a significant proportion of the Saruq al-Hadid assemblage in each horizon, compared to other contemporary sites in southeastern Arabia (**Table 5**). Aside from al-Sufouh 2, dromedary camels never comprise more than 5% of the total NISP of an assemblage for this period (e.g. Uerpmann 2001; Uerpmann & Uerpmann 2002; Uerpmann & Uerpmann 2008b 2017: 314; Curci *et al.* 2014), as opposed to consistently comprising over 10% of the

NISP at Saruq al-Hadid. This high representation of dromedary across all horizons is demonstrative of persistent interactions between humans and dromedaries at or near Saruq al-Hadid from *c.*2000 BCE – 800 BCE, which further places these remains in a position to inform on how interactions between humans and dromedaries changed over time.

Table 5. *The NISP of identified taxa in each horizon at Saruq al-Hadid. Number in parenthesis is the relative amount of each taxonomic classification in each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Domestic Animals	**35 (*6.2*)**	**192 (*4.7*)**	**152 (*1.5*)**	**721 (*5.3*)**	**23 (*8.9*)**	**1,123** ***3.9%***
Camel	65 (*11.5*)	480 (*11.9*)	548 (*5.3*)	1,821 (*13.4*)	28 (*10.9*)	2,942
Canid, indet.	1 (*0.2*)	2 (*0.1*)	1 (*0.01*)	15 (*0.1*)	-	19
Wild or Domestic Animals	**65 (*11.5*)**	**480 (*11.9*)**	**548 (*5.3*)**	**1,821 (*13.4*)**	**28 (*10.9*)**	**2,961** ***10.2%***
Wild Terrestrial Animals	**408 (*71.9*)**	**2,818 (*69.6*)**	**8,021 (*77.2*)**	**5,103 (*37.5*)**	**57 (*22.1*)**	**16,388** ***56.8%***
Marine Animals	**59 (*10.4*)**	**557 (*13.8*)**	**1,671 (*16.1*)**	**5,964 (*43.8*)**	**150 (*58.1*)**	**8,401** ***29.1%***
Total NISP	**567**	**4047**	**10,392**	**13,609**	**258**	**28,873**

The drop in the relative amount of dromedary bones in Horizon III should be noted (**Table 5**). This is due to the high representation of rodents and reptiles in this horizon, which in turn likely reflects taphonomic effects, including bioturbation, as discussed in detail elsewhere (Roberts *et al.* 2018: 7; Weeks *et al.* 2019). While these taphonomic effects have influenced the stratigraphy at the site, a comprehensive absolute dating programme (Weeks *et al.* 2019) allows us to state with confidence that our understanding of the chrono-stratigraphy at Saruq al-Hadid is an accurate reflection of the broad history of human activities and deposition at the site.

Dromedaries are also well represented in terms of MNI, as shown in **Table 6**. The fact that NISP values are far higher than the MNI values can be attributed to the high fragmentation rates observed, as seen throughout the rest of the assemblage (**Table 4**).

The consistently high representation of dromedaries in the assemblage from Saruq al-Hadid gives little evidence of increases or declines in dromedary usage throughout this period, as have been evidenced in the remains from other sites. Specifically, Uerpmann and Uerpmann's (2002: 258) study of dromedary remains from Tell Abraq and contemporary sites demonstrated a substantial decrease in the presence of dromedary remains in assemblages throughout the Bronze Age, before an increase again in the Iron Age II period. This led them to conclude that overhunting of dromedaries on the coast throughout the Bronze Age led to their decreased availability (Uerpmann & Uerpmann 2002; Uerpmann & Uerpmann 2008b). This Bronze Age overhunting does not appear to have occurred in the desert interior, with no sign of a notable decrease in the utilisation of dromedaries at Saruq al-Hadid from Horizons V - III. Indeed, the consistently high representation of dromedary suggests that a potentially separate population existed in the desert interior that was utilised throughout its occupation and not affected by activity on the coast.

Table 6. *The MNI of identified taxa in each horizon at Saruq al-Hadid.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Cattle	-	-	-	3	-	**3**
Goat	1	9	12	14	-	**36**
Sheep/Goat	1	7	14	49	6	**77**
Camel	1	33	32	84	8	**158**
Canid, indet.	1	1	1	3	-	**6**
Oryx	3	112	55	225	13	**408**
Gazelle	2	28	19	62	1	**112**
Hare	1	1	-	1	-	**3**
Lagomorph, indet.	1	3	15	23	1	**43**
Rodent	2	30	63	28	1	**124**
Reptile	5	32	191	38	1	**267**
Bird	1	4	30	50	3	**88**

Furthermore, the presence of dromedaries at al-Ashoosh (Contreras *et al.* 2016) indicates that dromedaries were present in the desert interior prior to the Bronze Age occupation of Saruq al-Hadid. The hypothetical presence of a separate dromedary population in the desert interior reinforces the theory (Uerpmann & Uerpmann 2002: 258) that early domestic populations lived alongside wild populations, as also indicated by recent work on the Iron Age dromedary remains from Muweilah (Uerpmann & Uerpmann 2017). In turn, this has a bearing on the 'restocking from the wild' hypothesis, put forward by Almathen *et al.* during their study of ancient dromedary DNA (2016: 6709-6710). Not only is this demonstrative of long term, persistent interactions between humans and dromedaries in southeastern Arabia, it also challenges the idea of a stark dichotomy between wild and domestic dromedaries, speaking to the potential nuances in the management of dromedary populations throughout this period.

4.2. Skeletal Element Representation and Bone Surface Modification

While the relative amount of dromedary represented at Saruq al-Hadid remains stable throughout time, the skeletal elements represented vary across the different horizons, most evidently when comparing the dromedary remains from Horizons IV and II. The remains from Horizon II are predominantly lower limb bones (**Fig. 4**), alongside a number of tail bones (**Fig. 5**). A similar body part pattern was evidenced in the remains from Horizon I (**Fig. 4**), however due to the surface exposure of this material, the rate of fragmentation was particularly high and therefore fewer fragments were successfully identifiable to skeletal element. It is possible that this high fragmentation rate has skewed the skeletal representation shown in this horizon, however the similarities between Horizons I and II suggest that these skeletal element representations are resultant from cultural as opposed to taphonomic processes.

The early Iron Age and later horizons contrast greatly with Bronze Age Horizons V and IV, in which entire dromedary carcasses are represented (**Fig. 4**). The late Bronze – early Iron Age Horizon III consists of predominantly foot bones, with some limb elements present (**Fig. 4**). The dromedary remains from Horizons V and IV have a high proportion of burnt fragments compared to the remains from Horizons III, II and I (**Table 7**). Similar to the rates of burning, the characteristics of the limited number (n=8) of butchery marks identified on the dromedary remains also varies between each horizon. The five butchered fragments in Horizon IV displayed cut marks on the epiphyses of meat bearing elements (**Fig. 6)**, indicative of carcass disarticulation to process meat (cf. Monchot 2014: 204). The butchery marks from Horizons II and I are focused on lower limbs, namely the phalanxes and metapodia (**Fig. 6**). This partly reflects the differential distribution of skeletal elements in these horizons, but the absence of lower limb cut marks in Horizon IV is potentially indicative of a different cultural process.

These aspects of the assemblage suggest two major uses of dromedary at the site through time. The burnt and butchered full carcasses present in the assemblage from Horizons V and IV are indicative of dromedaries being butchered and prepared for consumption, if not consumed at the site; the hearths excavated in these horizons (e.g. Weeks et al. 2018: Figs. 4, 5, 7) suggest the cooking and consumption of at least some of this meat at the site. The second is the processing of dromedary skins in Horizons II and I, shown by the predominance of distal limb and tail bones, as these elements are often the last to be removed from the skin during the skinning process (Jones 1980: 154). Identical skeletal element representations and bone surface modifications were seen for the other larger mammals, i.e. Oryx (*Oryx leucoryx*), gazelle (*Gazella* sp.) and domestic goat (*Capra hircus*), in all phases of the assemblage (Roberts *et al.* 2018). This change in use of dromedaries over time could be related to a change in the relationships between dromedaries and humans, however given the evidence for a concurrent change in the use of other animals at the site as well, it is likely more indicative of a change in site use rather than dromedaries specifically. It is important to note that both consumption and hide production could have been undertaken using wild or domestic dromedaries. Additionally, the recovery of animal bones in the Iron Age deposits elsewhere on the site further suggests that the characteristics of the assemblage from Horizons II and I may be indicative of the Central Sector being the centre for a specific sub-set of activities at this time (Roberts Forthcoming).

[redacted]

Figure 4. *The relative amount of camel skeletal elements in Horizons I, II, III, IV & V as a percentage component of the MNI figure. Skeletal Image: © 2006 Archeozoo.org*

Figure 5. *Camel tail bones (caudal vertebrae) recovered from Horizon II.*

Table 7. *The amount (NISP) of burnt camel fragments from each horizon.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**
Patchy Charring	-	2 (18.2%)	14 (77.8%)	65 (18.6%)	-
Charred, burnt black	2 (28.6%)	5 (45.5%)	-	48 (13.7%)	4 (100%)
Grey	-	2 (18.2%)	3 (16.7%)	150 (42.9%)	-
Burnt white	5 (71.4%)	2 (18.1%)	1 (5.5%)	85 (24.3%)	-
Calcined	-	-	-	2 (0.6%)	-
Burnt Fragments	**7**	**11**	**18**	**350**	**4**
Percentage of Horizon Fragments Total	***10.8***	***2.3***	***3.3***	***19.2***	***14.3***

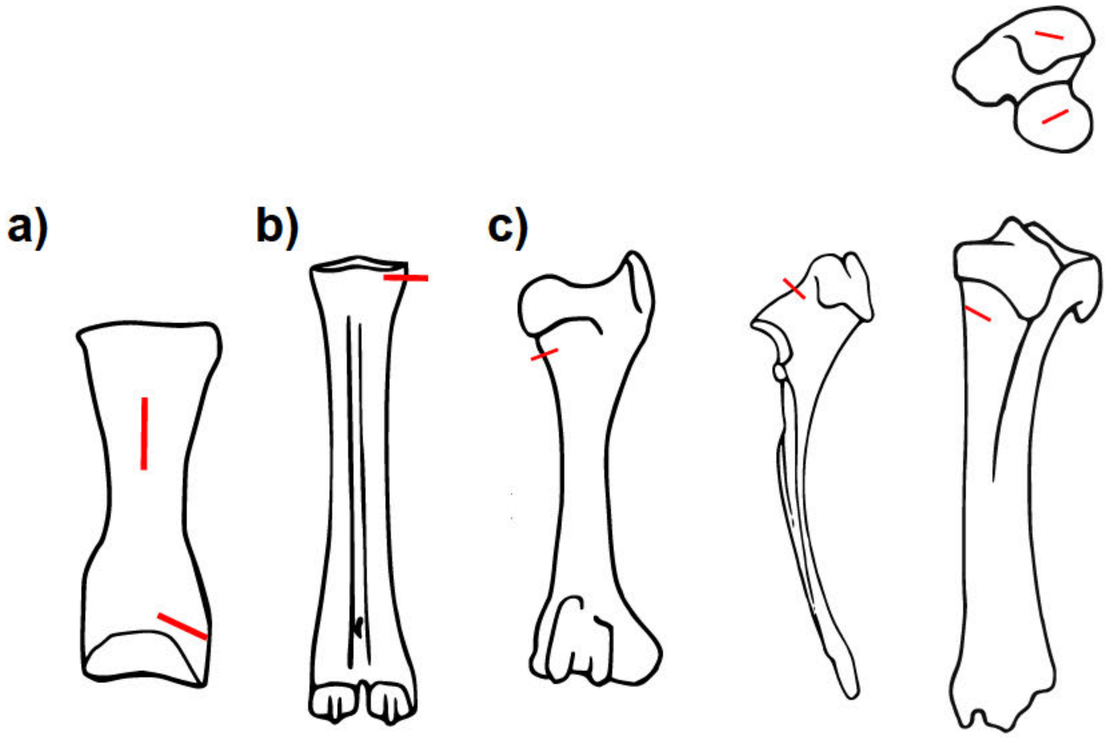

Figure 6. *The butchery marks observed on the camel remains from each Horizon, a) Horizon II, b) Horizon III, c) Horizon IV.*

4.3. Population Demographics

4.3.1. Age

The ages of animals within zooarchaeological assemblages can be determined by observing the state of epiphyseal fusion in the 'long bones'. To do so effectively requires an understanding of the skeletal development of that species and, while the precise ages of epiphyseal fusion are known for a number of domesticates (e.g. Getty 1975), they are not known for dromedaries. Previous researchers have based their age classifications for dromedary bone fusion on other ungulates, such as cattle and sheep (e.g. Monchot 2014: 196). However, epiphyseal fusion rates are known for alpaca (*Vicugna pacos* - de Medina *et al.* 2016: Tab. 6)), a member of the same taxonomic family (Camelidae) as the dromedary camel. Due to the skeletal similarities between these species, we consider the epiphyseal fusion rates of the Alpaca (de Medina *et al.* 2016: Tab. 6) to be the most appropriate proxy as a guide to interpret the rates of fusion seen in the dromedary bone assemblage from Saruq al-Hadid (**Table 8**). To increase the comparability of the assemblage from Saruq al-Hadid, we also provide the fusion data according to the methodology used by other researchers (**Table 9**).

Table 8. *The rates of fusion (NISP values) observed in the camel remains from each horizon. Ages taken from de Medina et al. 2016: Table 6*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**FS**
Scapula				1	-	*100*							
D. Humerus				4	-	*100*				5	-	*100*	
Pelvis													
<12-18 months	**-**	**-**	**-**	**5**	**-**	***100***	**-**	**-**	**-**	**5**	**-**	***100***	**-**
Phalanx I	3	-	*100*	52	9	*85.3*	25	7	*78.1*	7	4	*63.6*	
Phalanx II							10	3	*76.9*				
Calcaneum				1	-	100	1	-	*100*				
D. Tibia										2	2	*50*	
D. Metapodia	-	1	-				1	2	*33.3*	8	13	*38.1*	
<18-36 months	**3**	**1**	***75***	**53**	**9**	***86***	**37**	**12**	***76***	**17**	**19**	***47***	**-**
D. Radius/Ulna	1	-	*100*	1	-	*100*				8	2	*80*	
P. Humerus				-	1	-	-	1	-	1	2	*33.3*	1
P. Femur							-	8	-	2	2	*50*	
D. Femur							2	-	*100*	4	-	*100*	
P. Tibia										1	-	*100*	
<36-48 months	**1**	**-**	***100***	**1**	**1**	***50***	**2**	**9**	***18***	**16**	**6**	***73***	***1***

Table 9. *The observed ages of the camel remains according to amalgamating other ungulate (i.e. cattle, sheep, pig) fusion rates (NISP values).*

	Horizon I			**Horizon II**			**Horizon III**			**Horizon IV**			
	F	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**F**	**UF**	***%F***	**FS**
Scapula				1	-	*100*							
Pelvis													
7-10 months	**-**	**-**	**-**	**1**	**-**	***100***	**-**	**-**	**-**	**-**	**-**	**-**	**-**
D. Humerus				4	-	*100*				5	-	*100*	
Phalanx I	3	-	*100*	52	9	*85*	25	7	*78*	7	4	*64*	
Phalanx II							10	3	*77*				
13-18 months	**3**	**-**	***100***	**56**	**9**	***86***	**35**	**10**	***78***	**12**	**4**	***75***	**-**
D. Tibia										2	2	*50*	
D. Metapodia	-	1	-				1	2	*33.3*	8	13	*38*	
2-3 years	**-**	**1**	***0***	**-**	**-**	**-**	**1**	**2**	***33.3***	**10**	**15**	***40***	**-**
D. Radius/Ulna	1	-	*100*	1	-	*100*				8	2	*80*	
P. Humerus				-	1	-	-	1	-	1	2	*33*	1
Calcaneum				1	-	*100*	1	-	*100*				
P. Femur							-	8	-	2	2	*50*	
D. Femur							2	-	*100*	4	-	*100*	
P. Tibia										1	-	*100*	
3-4 years	**1**	**-**	***100***	**2**	**1**	***66***	**3**	**9**	***33***	**16**	**6**	***73***	***1***

The differences between the two methods are slight, but important. First, using the fusion data from other camelids decreases the precision of the age ranges assigned to the fusion of each epiphysis. Second, the fusion of the phalanxes and calcaneus occur after 18 months of age in the alpaca, yet occur prior to 18 months in other ungulates. If accepted as a valid proxy for the fusion ages of dromedary long bones, this method would therefore decrease the number of bones ascribed to individuals younger than 18 months of age on other sites. In this paper we discuss the fusion data as they are presented in **Table 9**, as this follows the methodology of previous researchers and allows us to better place the results from Saruq al-Hadid into the wider context. However, we suggest that any future analysis undertaken on dromedary assemblages follows the scheme set out in **Table 8**, until such time as fusion data are available for dromedaries.

The fusion guidelines set out in **Table 9** suggest that no remains from individuals younger than 13 months of age were present in the assemblage. This dearth of remains from the youngest of animals could be due to taphonomic bias; juvenile animal remains are more porous and therefore more susceptible to degradation over time (e.g., von Endt & Ortner 1984). However, the presence of juvenile remains from goats at Saruq al-Hadid and a local soil pH broadly favourable to bone preservation (Roberts *et al.* 2019) suggest that preservation issues cannot fully explain the dearth of juvenile dromedary bones (Roberts *et al.* 2018). Misidentification is also an issue to consider, as poorly formed juvenile bones often do not display the characteristics required to identify bones to species. However, no juvenile remains from dromedary-sized mammals were identified in the Saruq al-Hadid assemblage. Together, these factors suggest that the calculated age profile is likely to be a reliable representation of the population demographic of the dromedaries utilised at Saruq al-Hadid.

Modern dromedary camels are known reach their sexual maturity at 4-5 years for males and 3-4 years for females (Gauthier-Pilters & Dagg 1981: 93). Animals younger than 36 months of age could therefore be considered as juvenile. A large number of remains from animals younger than 36 months of age were present in the remains, decreasing through time. 46% of the ageable remains from Horizon IV were from individuals younger than three years of age (**Table 9**). This decreases to 25% in Horizon III, then decreases again to 14% in Horizon II (**Table 9**). Dromedaries reach their prime meat weight at 6 to 7 years for males and from 7 to 8 years for females (Shalash 1984: 235), however preferences for age of slaughter can change depending on taste (Shalash 1984: 236). While bone fusion is not able to provide insight into rates of survivorship of dromedaries after the animal has passed the age the age of four years, 73% of the ageable remains from Horizon IV were from animals that survived to at least 4 years of age. Notably this decreases to 33% in Horizon III, then increases again to 66% in Horizon II. This data are interpreted below.

Teeth can also be used to determine the age at death of animal remains, based upon the state of their eruption from the mandible and the rate of wear on the occlusal surfaces. A synthesis of the different systems for ageing dromedary mandibles based upon the state of tooth eruption was presented by Silver (Silver 1963, Tab. J), however no independent system currently exists for ageing dromedary mandibular tooth remains based upon the state of occlusal wear, as exist for cattle, sheep, pig (Grant 1982) and fallow deer (Bowen *et al.* 2016). The dromedary remains from the SHARP excavations did not permit either of these approaches. All recovered mandibular remains were fragmented, an issue also encountered during the analysis of the dromedary remains from Muweilah (Uerpmann & Uerpmann 2017: 317). This prevented an assessment of age at death based upon tooth eruption and the vast majority of teeth recovered were either fragmentary or degraded to the point where accurately assessing their state of wear was impossible.

4.3.2. Sex

In addition to the age at death of the dromedaries in the assemblage, it is also important to ascertain the sexual demographic of the remains. Little has been published about the sexual dimorphism in the skeletal anatomy of male and female dromedaries, although the morphologies of the pelvis and the maxillary canines are known to be markers of sex (von den Driesch *et al.* 2008: 492). The lack of reliable indicators of sex in archaeological dromedary remains is noted by Horwitz & Rosen (2005: 128-129), who highlight the limited degree of sexual dimorphism seen in the skeletal anatomy of dromedaries and the necessary reliance upon canine morphology. As no diagnostic pelvis fragments were recovered and all maxillary canines were damaged, the only insight into the sexual composition of the dromedary population at Saruq al-Hadid is metrical, under the assumption that adult male dromedaries are generally larger in size than females.

Using the log-scaled indices of metrics taken from the dromedary assemblage, which are discussed in further detail below, it is possible to produce a sex distribution (**Fig. 8** - cf. von den Driesch 2008). These graphs display a wide variance in size that opens itself to a number of interpretations. The distribution from Horizon IV shows a wide degree of variation, with the data displaying three modes. A plot that solely represents male and female individuals with a high degree of sexual dimorphism should form a bimodal distribution, therefore suggesting that other factors are influencing this distribution. Less variance is present in Horizon III with two modes observable in the data. A smaller amount of the remains are from individuals larger in stature, with the majority of values representative of medium sized individuals. This may represent a majority of female dromedaries in the assemblage from this horizon, or alternatively younger adult males that have not yet reached their maximum growth. The distribution from Horizon II is harder to interpret due to the relatively small sample size, however there is a preponderance of relatively larger animals suggesting that these remains are from predominantly male animals. These results are considered below.

It is important to note that a number of factors other than sexual composition may be influencing these distributions. One such possible factor that should be considered here is the practice of castrating males. As discussed by Cran (1984), castrating dromedaries makes males lighter and better for riding, however castrates are not as strong as other males and cannot carry as much weight. If castrated before sexual maturity then growth will be stunted (e.g. Davis 2000), which could explain the presence of the smaller individuals in these distributions. The multi-modal distributions shown in **Figure 7** may also be due to the presence of different breeds or types of dromedary, a factor explored below.

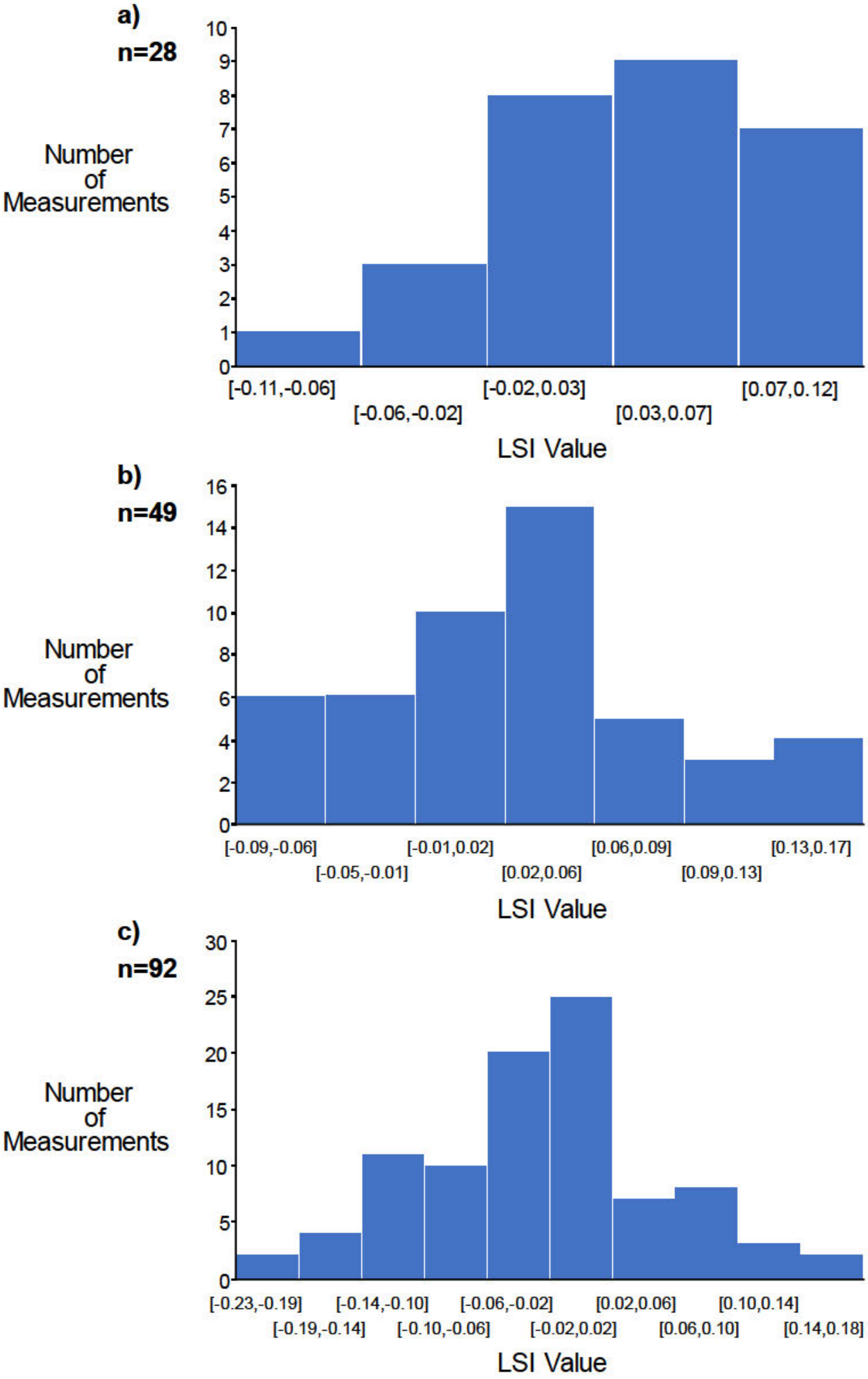

Figure 7. *Histograms showing the frequency of log-scaled measurements from a) Horizon II, b) Horizon III, c) Horizon IV.*

4.3.3. Interpretation

Given the clear evidence for large scale hunting activity at Saruq al-Hadid throughout its occupation, the demographic data are first interpreted with the assumption that the remains from all horizons are from a wild, hunted population. The epiphyseal fusion data for the dromedary assemblage from Saruq al-Hadid are very similar to those identified at al-Sufouh 2, one of the few sites where fusion data relating to dromedary populations have been published (von den Driesch *et al.* 2008: 492). These dromedaries are considered to have been hunted wild animals and, like the remains from Saruq al-Hadid, no individuals younger than 6 months were present (von den Dreisch *et al.* 2008: 492). Recent analyses of the remains of wild dromedaries from Baynunah have demonstrated a range of ages in the assemblage, however is it unclear as to whether any of these could be considered as younger than 6 months of age (Beech *et al.* 2018). The lack of individuals younger than 6 months at Saruq al-Hadid also contrasts somewhat with the material from the Iron Age site of Muweilah, where a number of remains considered to be from dromedaries younger than 6 months were recovered from an assemblage largely consisting of domestic animals (Uerpmann & Uerpmann 2017: 317). Based upon these data, one could therefore argue that contrasts between the population demographics of dromedary remains from Saruq al-Hadid and Muweilah – specifically the lack of remains from individuals younger than 6 months at Saruq al-Hadid and their presence in a domestic population at Muweilah – suggests that the Saruq al-Hadid remains are from wild dromedaries. This proposition is reinforced by the predominance of other wild taxa in the remains from this area of the site (**Table 5**).

Efforts to confirm this hypothesis are hampered by the fact that no truly wild population of dromedary camels exists today to which the archaeological demographic data can be compared, an issue also noted by Uerpmann & Uerpmann (2017). The closest analogue to a wild population of dromedaries is the feral population of 1.3 million individuals that inhabits the central Australian desert (e.g. Burrows 2018), however no data regarding the demographic composition of these herds have been published. A further issue that arises when attempting to identify wild populations in the archaeological record is their potential ‘management’ by hunting societies. Almost universally, hunting societies selectively cull individuals in herds they prey upon in order to promote the longevity of that herd (e.g. Hamilakis 2003; Beach & Stammler 2006; Zeder 2008; Bar-Oz, Zeder & Hole 2011; Russell 2011: 267-273). This directly affects the population demographic represented in zooarchaeological assemblages (e.g. Zeder 2008: 11603; Zeder 2012b). Given that hunting strategies would therefore vary throughout time and space according to the array of factors influencing the predated population, the demographic of hunted wild populations can also vary, making them hard to distinguish using zooarchaeology alone.

When we consider other categories of archaeological and environmental evidence from Saruq al-Hadid, we find indications that at least some of the dromedaries from the site were being utilised in a domestic manner, specifically as transport animals. The dramatic increase in material culture deposited at Saruq al-Hadid in Horizons III-I strongly suggests this, particularly the presence of larger ceramic vessels.

Provenancing work undertaken on the ceramic assemblage has demonstrated that ceramics were manufactured from clay sources in the Hajar mountains, away from Saruq al-Hadid; these vessels were therefore brought to Saruq al-Hadid, either in raw clay or complete form (Karacic 2018a). As these very large vessels could not have been carried by people alone, animals must have been used for transport. Evidence from excavations suggests that large sand dunes were present on the site during the Iron Age (Weeks *et al.* 2017; 2018; 2019) Deep, loose, windblown sand of this nature is poor terrain for hooved animals bearing loads (Uerpmann & Uerpmann 2008b) as they tend to sink into it and damage their legs (Sletto 1996). In turn this suggests that donkeys and cattle, identified as the transport animals of choice in the region prior to dromedary domestication (e.g. Uerpmann & Uerpmann 2008: 479), would be inappropriate for moving goods to and from Saruq al-Hadid. This factor is likely the reason why very few large hooved domesticates (e.g. cattle or donkey) were present in the remains from Saruq al-Hadid (**Table 5**), unlike their greater numbers at other sites in the region at this time (e.g. Uerpmann & Uerpmann 2008). It can therefore be hypothesised that domestic dromedaries were most likely used at Saruq al-Hadid in the early Iron Age (from Horizon III onwards) to facilitate the movement of objects to and from the site. This does not exclude the possibility that wild dromedaries were also hunted and processed at the site while domestic animals were being utilised for transport. These factors also have a bearing on the nature of the metrical data collected from the dromedary bone assemblage from Saruq al-Hadid, as discussed below.

The demographic data do not provide definitive evidence that domesticated dromedaries were present in the remains from Horizons III–I. The introduction of domesticated dromedaries may be a reason for the diminishing amount of remains from individuals younger than 36 months in the assemblage between Horizons IV–II. As discussed by Horwitz and Rosen (2005: Tab. 3), a preponderance of younger adult dromedaries is indicative of the utilisation of dromedaries as a food source. In Horizon III, where relatively few of the ageable fragments were from individuals older than 4 years of age, this appears to have been the primary use for dromedaries. The sexual distribution from Horizon III potentially reinforces this hypothesis, if the largest mode in the distributions is considered to be younger adult males that have not yet reached their maximum growth. This contrasts with Horizon II, were many more of the ageable fragments were from individuals older than 4 years of age. According to the herd structures set out by Horwitz and Rosen (2005: Tab. 3) this would imply the utilization of dromedaries as transport and labour, corroborating with the sexual composition of the remains from this horizon. While these scenarios are undoubtedly plausible, it is important to note that no individuals younger than 6 months are seen in the remains from Horizons III and II, as also observed in the remains from Muweilah. It is therefore hard to draw any definitive conclusions from these data.

Given these difficulties, it is worth exploring the ethnographic literature regarding the management of herds kept by dromedary pastoralists in greater depth, to find potential explanations for these fusion and sex distribution data. Wapnish (1981: 107, 1984) developed models for camel pastoralism based upon ethnographic observations of camel herders from a wide array of areas. According to these models, the lack of juveniles in the Saruq al-Hadid assemblage suggests that the dromedaries at the site were not being used to provision any urban meat markets, nor were they being bred for use as transport or in warfare (Wapnish 1981: 107; Grigson 2012: 88). The mixed ages of dromedaries at Saruq al-Hadid could instead be representative of dromedary herding and the use of dromedaries for physical products (i.e. meat, milk, hair and skin) rather than transport or warfare. However, the application of these models to the remains from Saruq al-Hadid assumes that dromedaries were being bred at the site (Wapnish 1981), as opposed to just being brought there for use from natural or cultural breeding centres located elsewhere. Clearly, this is by no means certain. Indeed, Saruq al-Hadid is hypothesised to have been a major centre in the early Iron Age where many different groups were moving to and from the site (Weeks *et al.* 2018). This strengthens the idea that any domesticated dromedaries deposited at the site would have been in transit through the site, as opposed to being bred there. Horwitz & Rosen (2005: 129) combined Wapnish's later observations (1984) with those of Köhler-Rollefson (1989) to produce a more detailed description of different camel management strategies at different site types. They categorise a number of different uses for camel, from a focus on meat and milk production to use as transport (Horwitz & Rosen 2005: 129), and the herd demographics associated with each of these uses. Based upon these models the demographics of the remains at Saruq al-Hadid rule out the use of dromedaries as a primarily milk producing herd and would suggest that the remains from Saruq al-Hadid are not those left behind by a group focused upon camel pastoralism (Horwitz & Rosen 2005: Tab.3).

The ethnographic literature describes a wide range of variance in the animal management strategies of dromedary pastoralists, which further confuses efforts to identify the nature of the dromedary remains from Saruq al-Hadid. In herds where the focus is on food production (i.e. meat and milk), female dromedaries often greatly outnumber the males. Typically, female to male ratios are *c.* 25:1 (Abdel-Rahim *et al.* 1994), although el-Amin (1984) has reported typical herd structures in dromedary pastoralist societies in the Sudan of 50:1. This desired herd structure, and the use of dromedaries for milking, would create a large amount of male dromedaries that were killed at a young age, as is common in the Amar'ar Beja society of eastern Sudan (Hjort & Dahl 1984: 54). However, Shalash (1984) notes that some dromedary owners are reluctant to sell their young dromedaries for the meat market, due to their multiple possible uses. While we might therefore expect to see a large amount of juvenile dromedaries in the archaeological remains from a dromedary population used predominantly for their milk, this might not be the case if the dromedary is used for other activities, or even sold or traded to other regions.

These differences evidenced in the way in which different dromedary pastoralists manage their herd must be considered when interpreting demographic information; it is not correct to assume that herds of dromedaries kept by pastoralists in late prehistoric southeastern Arabia would have a single, easily distinguishable population structure. Ultimately this variance means that without knowing more about the behaviour of the humans at Saruq al-Hadid, it is very difficult to make reliable inferences regarding the use of dromedaries at the site based upon the demographic data recovered from their remains.

4.4. Stature of Dromedaries

In total, 203 anatomical measurements were taken from the dromedary bone assemblage, made available in **SUPPLEMENT 1**. To assess the morphological changes of dromedaries over time at the site, the measurements were analysed by horizon (**Figure 8**). Due to the small sample size of measurements from each horizon, a log-ratio methodology was employed (Meadow 1991) which compares measurements from different anatomical areas to a known standard, in turn allowing different measurements to be grouped together thereby increasing sample size. As done in previous studies of size change in dromedary populations, measurements from all anatomical planes (i.e. length, breadth and depth) were grouped together to further increase sample size and to make our data comparable with other studies. No measurements were taken from unfused elements due to increased variation in the growth rates of individual animals during their youth. Nor were measurements taken from burnt elements, as burning is known to warp the morphology of bone. The log-scaled measurements of dromedary bone from each horizon at Saruq al-Hadid are shown in **Figure 9**.

It is important to note that grouping log-scaled measurements from different anatomical planes for analysis is potentially problematic. Davis (1996: 606) has conclusively demonstrated that there is very little correlation between the growth rates of different anatomical planes of sheep bones (i.e. length, breadth and depth) and subsequent studies utilising this methodology have demonstrated variances in the rates of size change of other species (Thomas *et al.* 2013), meaning that grouping them in the manner done here may not necessarily give an accurate representation of the nature of size change occurring in these animals through time. To test the potential errors caused by this grouping of dromedary measurements, the measurements from each anatomical plane were analysed separately (**Figure 10**). In this case, little difference was observed in the patterns shown by the grouped measurements and those from the individual planes, however such tests should also be undertaken on the data from the other sites included in the wider size change study (i.e. **Fig. 8**) to ensure the data present an accurate depiction of the differences in size between different dromedary bone assemblages.

In general, the metrical data show that dromedaries of a wide range of sizes were utilised at Saruq al-Hadid throughout time. This is particularly the case for Horizon IV, which contains some of the largest and smallest specimens in the study (**Fig. 8**). While only two measurements were taken from Horizon V material, they were both congruent with the mean value of measurements from Horizon IV. Additionally, the data testify to a statistically-significant (**Table 10**) *increase* in the size of the dromedaries deposited at the site from the Wadi Suq to the Late Bronze Age, and particularly into the Iron Age.

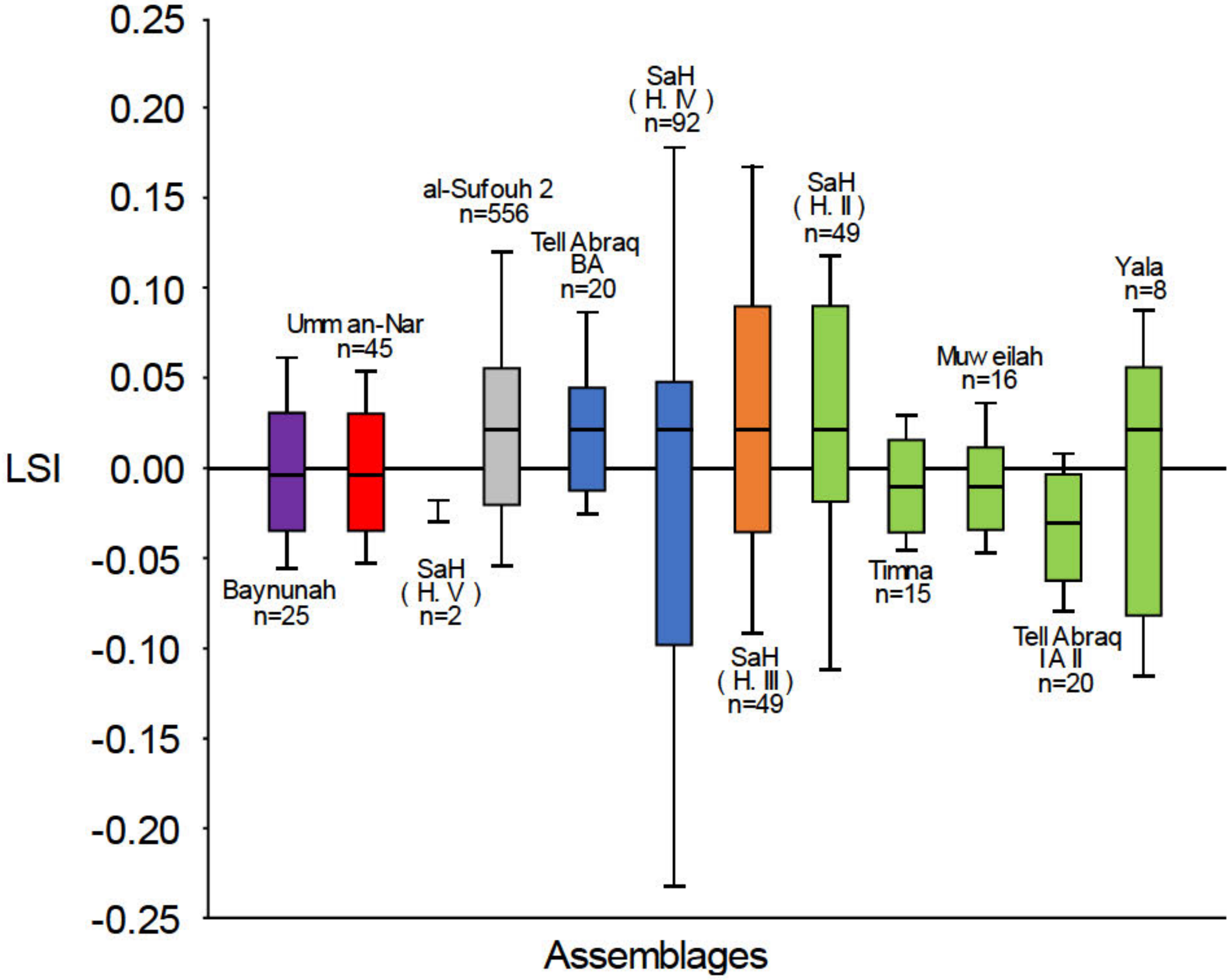

Figure 8. *The measurements from Saruq al-Hadid compared to those from other sites in the region that have been included in previous size change studies. Data from Uerpmann & Uerpmann 2002; von den Driesch* et al. *2008; Beech et al. 2009; Grigson 2012; Fedele 2017.*

Table 10. *The results of statistically testing the difference between each set of log-scaled measurements from each Horizon. Note: Analyses were undertaken using the Paleontological Statistics software (PAST; Hammer, Harper & Ryan, 2001). Differences between these two sets of groups were tested via a Mann-Whitney test of significance. These tests were bootstrapped (n = 9,999) and underwent Monte-Carlo permutations. All measurements used can be found in Supplementary Spreadsheet 1.*

	Horizon III		**Horizon IV**		**Horizon V**	
Horizon II	U=622	p=0.5034	U = 641	p=**0.0002**	U=7	P=0.0907
Horizon III			U=1306.5	p=**0.0002**	U=19	p=0.1704
Horizon IV					U=91	p=0.9883
Horizon V						

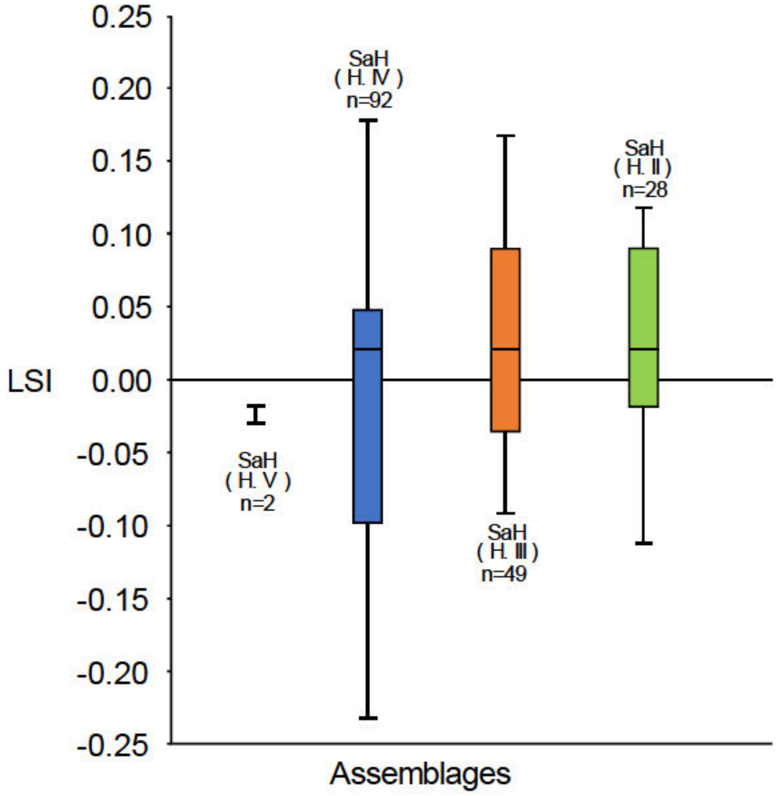

Figure 9. *The log-scaled measurements from each horizon at Saruq al-Hadid. Measurements from each anatomical plane have been grouped.*

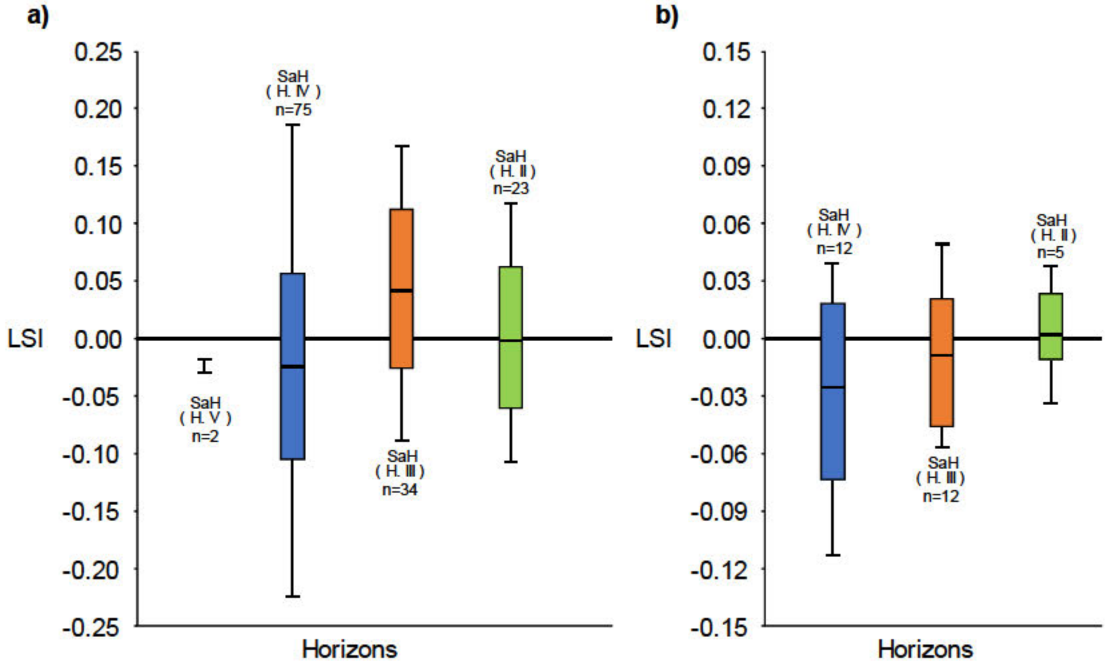

Figure 10. *The changes observed in the measurements from Saruq al-Hadid in each separate anatomical plane: a) length and b) breadth.*

This pattern contradicts previous studies of dromedary size change through time, the most recent and comprehensive of which (e.g. Grigson 2012; Uerpmann & Uerpmann 2017) reflect the previously established pattern of a diminution of dromedary size from the Bronze Age to the Iron Age (Uerpmann & Uerpmann 2002: 256). As discussed briefly above, this decrease in size is believed to have resulted directly from domestication (Uerpmann & Uerpmann 2002). If one was to apply this rationale to the remains from Saruq al-Hadid (that small dromedaries, i.e. the size of those from Muweilah and the Iron Age II assemblage from Tell Abraq, are domesticates) then the data would suggest that domestic dromedaries are present in the remains from Horizons IV and III at Saruq al-Hadid, alongside the remains from wild individuals. This would also imply that the larger remains from Horizon II would be indicative of more wild than domestic dromedaries being deposited at Saruq al-Hadid in the early Iron Age. Ultimately, these findings raise questions as to whether the stature of dromedaries in a population is directly indicative of their wild/domestic status, or whether other factors might influence the size of dromedaries in archaeological assemblages, as has been suggested by other researchers studying this topic (e.g. Curci *et al.* 2014).

The presence of the largest dromedaries in the Iron Age assemblage at Saruq al-Hadid could be due to the continued exploitation of a local wild dromedary population at the site into the Iron Age, as discussed above. However, this would not necessarily explain why the wild Iron Age dromedaries at Saruq al-Hadid were larger than some of the wild dromedaries identified at other sites. It could be due to the presence of a diverse dromedary population made up of different sizes living in the desert interior and being exploited by the occupants of Saruq al-Hadid, as opposed to coastal dromedary populations that had different statures. In turn, this may also explain the presence of smaller dromedaries in the remains from Horizons IV-III, if one wanted to consider them to be the remains from wild individuals. In this scenario, one must be mindful of the movement range of dromedary populations; how likely is it that a different population of dromedaries existed in the desert interior that never interacted with the coast? Due to the aforementioned lack of a wild dromedary camel population to provide a model for this behaviour, we must again draw on observations made on modern feral dromedaries. While little has been published on this topic, feral dromedary camels in the central Australian desert demonstrate variable ranges of movement from 10km^2 to 213km^2 (Saalfeld & Edwards 2008: 14-16), a relatively small area given the size of the study area considered in this paper. This neither confirms nor discounts the hypothetical presence of a separate dromedary population in the desert interior. The large stature of dromedaries in the Iron Age assemblage from Saruq al-Hadid could also be due to a selective use of dromedaries at Saruq al-Hadid during the Iron Age that focused upon larger animals. The processing of hides is the prime activity evidenced in the Iron Age remains; this may well be an activity for which only larger animals were utilised.

Differences in site use may also account for the unique nature of the dromedary metrics from Saruq al-Hadid. The other Bronze and Iron Age dromedary remains originate largely from domestic sites with clear evidence of permanent occupation, whereas Saruq al-Hadid appears to have been occupied on a temporary basis (Weeks *et al.* 2018). The clear distinctions between different types of dromedary used for different purposes by different sections of societies, as seen in ethnographic studies of modern day dromedary pastoralists (e.g. el-Amin 1984; Hoste 1985; Wilson 1997; Horwitz & Rosen 2005), provide appropriate examples on which to base this discussion. Pastoralists in a variety of societies that utilise the dromedary keep different types or 'breeds' of dromedary for different uses; these breeds are discussed in reference to the use of dromedaries in Sudan by el-Amin (1984). Hjort and Dahl (1984: 53) note that the Amar'ar Beja people of Sudan differentiate between three categories of dromedaries each of which have different attributes, also noting that the different environment in which the dromedary herd is raised influences the development of these attributes, more so than intentional selective breeding (Hjort & Dahl 1984). This possible environmental influence reinforces the hypothesis outlined above that dromedaries living on the coast could be different in stature to dromedaries living in the interior.

The multiple possible explanations for the measurements from Saruq al-Hadid, and the questions they raise, highlight the equifinality of size change in animal populations. This is a significant complication in drawing conclusions on domestication from size change studies, as changes in size may not be directly and solely resultant from domestication. Thus, as highlighted throughout this section, we see a number of sources of variance that greatly affect our interpretations of these data, reflecting the true complexity of the relationship between humans, dromedaries and their environment through time. This issue is inherent to the interpretation of data that reflects the lives of entire populations of animals, as opposed to data that reflects the behaviour or treatment of an individual animal. These factors are explored in further detail below. Despite this, it can be said that the evidence does suggest changes in the utilisation of dromedaries at Saruq al-Hadid over time.

4.5. Skeletal Pathologies

Skeletal pathologies are marks or effects on the remains of animals that result from disease or injury sustained during an individual's life time. These pathologies – described as entheseal changes in human osteoarchaeoloy (Villotte & Knüsel 2013) – are particularly useful insights into animal behaviour as they can result from activity over the life of a single individual, whereas other sources of evidence, including size or genetic changes might take generations to respond to alterations in behaviour (deFrance 2010). Only three pathological specimens were identified in the material, but each displayed the same pathological symptoms on the same skeletal element. These were all second phalanxes that displayed signs of severe exotosis across the entire shaft, i.e. the formation and growth of new bone on the original bone surface (**Fig. 11**). Determining the anatomical sides or whether these phalanxes were from the fore or hind limb was rendered impossible by this pathology. All of these pathological fragments were associated with Horizon IV, however attempts to date them more precisely using radiocarbon dating were unsuccessful due to a lack of organic material (i.e. collagen) preserved within the bone.

Figure 11. *Pathological 2^{nd} phalanx from Horizon IV, compared to a non-pathological specimen.*

The pathological specimens are another important source of evidence when exploring human-dromedary relationships. While only three specimens were found to have skeletal pathology, the occurrence of severe exostosis on three individual dromedaries from different contexts associated with Horizon IV, and a lack of this pathology in any other horizon, tentatively suggests a prevalence of this pathology at this time. This pathology has previously been linked to the overburdening of animals, as demonstrated in a study of llama bone assemblages from pre- and post-colonial South America (deFrance 2010). The authors of this study observed a higher degree of pathology on the spine and lower limbs of llamas and alpacas from post-colonial assemblages, suggesting that this was due to the overburdening of these animals after the Spanish conquest (deFrance 2010, 520). Horwitz & Rosen (2005:

129) also make the link between exotoses on the phalanges and the use of dromedaries as transport or labour.

It is notable that similar pathologies were identified on the dromedary remains from Timna where they were also hypothesised to be indicative of the use of dromedaries in transporting goods (Grigson 2012: 87). There were also examples of pathological dromedary second phalanxes identified in Islamic period remains from the site of Dûmat al-Jandal, suggested by the researcher to be indicative of dromedaries being used as beasts of burden (Monchot 2014: 202). The pathologies seen on the dromedary remains from Saruq al-Hadid may indicate similar dromedary activity that put stresses on the skeletal anatomy of dromedaries at the site during this time. If this were the case, then it could be said the dromedaries being utilised at Saruq al-Hadid experienced a change in their behaviour during the mid-second millennium BCE. Whether these changes reflect a change in human-dromedary relationships is by no means clear: such pathologies can occur in nature, without interaction with humans, and can be caused by abnormal gaits or old-age (deFrance 2010: 517).

4.6. Associated Bone Groups

The sandy nature of the site matrix at Saruq al-Hadid encourages the turbation of deposits and there are therefore very few articulated remains. Despite this, two clearly associated dromedary bone groups were identified during excavation. The first group comprised several fragments of dromedary mandible identified within the lone standing architectural structure uncovered at the site (see **Fig. 12**), which dates to the Wadi Suq/Late Bronze Age; the radiocarbon dating of samples taken from the structure and surrounding contexts suggested that the structure was built between 1735-1530 cal. BCE (Weeks *et al.* 2019). This structure has been preserved *in-situ* and as such these mandible fragments have not been fully zooarchaeologically analysed, and other fragments may be present in the group.

Figure 12. *Images of the structure and the charred camel identified within the composition of the structure.*

The second associated bone group was a group of two unfused first phalanxes, and a sesamoid (**Fig. 13**) recovered in association with a number of ceramic objects (**Fig. 14**). This deposit was found in Horizon III, dating to the Early Iron Age transition at the site, and radiocarbon dated to c. 1300-1000 cal. BCE. These ceramic vessels have been identified as braziers with a likely ritual function (Karacic 2016; Karacic *et al.* 2017; Weeks *et al.* 2017). It should be noted that a high number of these ceramic vessels were found in the Horizon III deposits, and not all were associated with dromedary bones. The inclusion of dromedary bones in these possible 'ritual contexts' from Horizons IV and III is not paralleled in any other occupation phase at the site, suggesting they represent a change in the significance and treatment of dromedaries that occurred in the second half of the second millennium BCE.

Figure 13. *The camel bone (an unfused 1st phalanx, two unfused 1st phalanx epiphyses and a sesamoid) recovered from Context 2030, found in direct association with the ceramic objects shown in **Figure 14**.*

Figure 14. *Ceramic objects from 2030* in-situ. *Note the unfused 1^{st} phalanx epiphysis from* ***Figure 13****, denoted by arrow.*

The dromedary bones found in special deposits and associated with ritual objects and deposits from the Late Bronze Age to early Iron Age at Saruq al-Hadid are the first that have been found in such contexts from this period. There is evidence of dromedaries being incorporated into funerary practices at later sites; for example dromedaries buried alongside humans at the site of Mleiha, U.A.E., dating to the third century BCE – third century CE (Mashkour 1997; Jasim 1999: 73) or dromedary burials at a number of other sites around the Arabian peninsula dating from the sixth century BCE through to the first millennium CE (King 2009: 83). A number of dromedary burials at the site of Ed-Dur, dating between the second and 4th centuries CE, were also recently reported by van Neer *et al.* (2017: Table 4). However, none of these are contemporary with the deposits from Saruq al-Hadid, which clearly date to the mid-late second millennium BCE. A potential human-dromedary co-burial was identified at the site of Maysar 22 alongside remains dating to the third millennium BCE (Uerpmann 1989), however this find was poorly stratified and its true date is debated (Uerpmann & Uerpmann 2002: 248). The idea of dromedary remains being incorporated into ritual activity during the Late Bronze Age at Saruq al-Hadid is alluring, but the function and use of both the ceramic objects and stone structure remains ambiguous and we must exercise caution when interpreting this evidence. Nevertheless, these finds may represent an aspect of the relationship between humans and dromedaries during the mid-late second millennium BCE that has not been identified elsewhere.

The combined evidence from the skeletal pathologies and associated bone groups suggests a change in dromedary behaviour in the mid-second millennium and change in the way they were perceived by humans in the later second millennium BCE. Regardless of their significance, these findings demonstrate that the relationship between humans and dromedaries undoubtedly changed during this time. The equifinality demonstrated above when interpreting the measurement and demographic data serves to highlight the complexities in the relationship between humans and dromedaries in the present that must be considered when attempting to understand this relationship in the past. The disparities between the evidence from Saruq al-Hadid and the existing body of archaeological data regarding dromedary utilisation prompt questions into how we view this relationship, with particular regard to our understanding of the timings and dynamic of dromedary domestication. These issues are addressed below.

5. Discussion: The Saruq al-Hadid Assemblage in Context

5.1. Defining and Identifying Domestication in Archaeology

It is clear that dromedaries are domesticated by the early first millennium BCE, given the widespread evidence for dromedary riding that emerged at that time, well summarised by Magee (2015). Our understanding of the relationship between humans and dromedaries gets less clear as we move back through time, a problem that is crucial to resolve if we are to further our understanding of the role of dromedaries in prehistoric Arabia and how they became domesticated. This issue was addressed by Uerpmann & Uerpmann (2017:315):

'*…there is a fundamental difference between identifying domestic animals and identifying the process of domestication*.'

The evidence presented above indicates changes in the utilisation of dromedaries at Saruq al-Hadid in the millennium leading up to 1000 BCE. However, the evidence is ultimately ambiguous and potentially supports contradictory conclusions regarding the nature of the relationship between humans and dromedaries, particularly with regard to when they can be considered 'domesticated'. In many ways this uncertainty reflects ambiguity around the definition of domestication itself.

Domestic animals have been a crucial component of many societies throughout time and space. Domestication thus represents a fundamental development in human subsistence and also in the ontology of individuals and societies (e.g. Boyd 2013; 2017; Overton & Hamilakis 2013). It is therefore understandable that a wealth of study has been undertaken that focuses on the process of domestication. Early discussion of animal domestication viewed domestication as a revolutionary event that was itself entirely tied into the wider Neolithic 'Revolution' (Childe 1935: 7); the domestication of animals, as with the domestication of plants, presented itself as economically more efficient to hunting as a means of food production and was therefore adopted by humans (e.g. Braidwood 1960: 134; Köhler-Rollefson 1992; Cleuziou and Tosi 2007: 56). While there was an acknowledgment that this 'revolution' was the result of long term changes, they were still described as 'climaxes' of these long-term changes (synthesised by Trigger 1980: 102). This propagated the idea that the initial domestication of animals was a conscious decision taken by those societies (Bökönyi 1969: 219; Clutton-Brock 1994), which in turn suggested that there were clearly defined social and biological distinctions between wild and domestic animals in past societies, that could therefore be easily identified in archaeological material (Grigson 1969; Davis 1987).

Later research, however, has demonstrated that the distinction between domestic animals and non-domestic animals may not be as clear cut as first thought (e.g. Jarman & Wilkinson 1972; Jarman 1977; Hecker 1982). Research into the hunting strategies of late pre-Neolithic societies located in the eastern Mediterranean and Near East has demonstrated moves toward 'domestication' (or a management of resources) taken by societies that would be traditionally considered as 'hunter-gatherers' (Zeder 2008: 11598). This ties into a wider change in our understanding regarding domestication; that rather than being a revolutionary event domestication should be seen as a process of development situated within a long-term relationship between humans and animals (e.g. Zeder *et* al. 2006: 139; Zeder 2008: 11602-11603; synthesized by Russell 2011: 144-175; Sykes 2014: 24; Zeder 2015). Discussion has also been undertaken into the agency of the animals themselves in this domestication process; that by filling an ecological niche created by the presence of humans, animals may commence their own domestication (e.g. Ericson 1997; Cucchi and Vigne 2006). This framework does not discount the economic benefits that domestic animals provide humans with, however it acknowledges animal agency would surely have affected human behaviour *before* that animal is utilised in a domesticated fashion, as well as after. In other words, domestication and its process is part of a fluid and reflexive relationship between humans and animals that existed long before 'domestication' and which continues afterwards. This has also highlighted the clear variance in this process between different species; dogs and cats for example are considered to have commenced their own domestication (e.g. Clutton-Brock 1994: 26) whereas other species may have had to have a greater level of 'coercion' from humans. The developing picture of the initial domestication of animals is generally one of complexity, far removed from a binary wild/domestic categorisation.

That domestication should be considered as a process rather than a singular event has led to some debate over the point during this process at which an animal can be considered 'domestic', as opposed to just 'tame' (or 'wild'). 'Domestication' could be considered to have occurred from the moment when humans first interacted with and 'tamed' wild animals, as some researchers argue in the case of dogs (e.g. Wang *et al*. 2013). A number of researchers studying the domestication of dogs suggest that wolves, the wild progenitor of dogs, were scavengers of the waste from human populations, which subsequently led to a closer relationship between humans and dogs (e.g. Russell 2011: 216; Zeder 2012b: 172). This initial step-change in the relationship between humans and dogs may have prompted physiological and behavioural changes in dogs (Larson *et al.* 2012: 8878; Zeder 2012b: 172), that might be traditionally associated with domestication.

This change in relationship then leads to a level of population control in terms of movement (i.e., the physical range of the animal), nutritional intake and the demographics of the population by controlling the survival of the animals born to the population. It must be noted that humans have been evidenced to exert elements of this control even over animals that are not considered domesticated, such as the North American Bison. There is evidence for a number of North American First

Nations people using fire to encourage the movement of bison populations, not only as a driving force for hunting but also in long term relocation of herds; the northern Great Plains Blackfoot used fire to rejuvenate the landscape, a practice witnessed in a number of different societies around the world (e.g. Vaarzon-Morel & Gabrys 2009; van Wilgen 2009; Kaal *et al.* 2011), in turn encouraging populations of Bison to move to certain areas (e.g. Barsh & Marlor 2003: 580). There have also been numerous archaeological and historical examples of societies moving wild animal herds around the landscape – and across seas – to introduce and maintain their populations (e.g. Vigne *et al.* 2000: 89; Masseti *et al.* 2006; Russell 2011: 279; Valenzuela 2016). These examples demonstrate the complexity of constructing a blanket definition of domestication.

The motivations for exerting this level of control must also be considered, as they can vary greatly from species to species. As highlighted by Sykes (2014: 37), 'secondary' products (i.e. products other than the meat and hide of an animal) might actually be the primary driver behind the moves towards domestication for certain species. For example, domestic fowl had multiple uses and were likely sought after by humans prior to the widespread consumption of their meat (Sykes 2014: 37). Equally, a number of researchers consider transport and traction to have been the primary motivator for the domestication of the horse (e.g. Anthony & Brown 2000; Benecke & von den Driesch 2003; Olsen 2006), however recent studies have demonstrated that horses may have been utilised for multiple purposes, such as their milk, as demonstrated by residue analysis on ceramics from societies associated with horse domestication (Outram *et al.* 2009).

The final domestication stage could be described as full control of an animal population, involving a level of selective breeding and strict nutritional control to encourage maximum occurrence of a desired outcome – for example, the breeding of specific sheep to ensure a high output of high quality wool (e.g. Purvis & Franklin 2005). These advanced levels of husbandry have been identified in a number of societies but most comprehensively in late 17th century England, after the agricultural revolution, at which time the variation observed in the breeds of animals grows dramatically as do the attempts by breeders to experiment with the characteristics of different animals (e.g. Thomas *et al.* 2013: 3320-3321). A level of this control was also present in earlier societies, however it can be difficult to identify such breed variation in archaeological animal remains without the aid of a detailed historical record. Historical sources from the Ur III period in Mesopotamia (late third millennium BCE) refer to different types of sheep, different qualities of wool and the differing husbandry strategies associated with that wool production, indicating a complex industry that relied upon different breeds or types of sheep (Wright 2013). There also appear to have been distinctions between different types of sheep in late prehistoric Arabia (Anati 1968; Uerpmann & Uerpmann 2008b: 480-481; Roberts Forthcoming). These different types may also be specifically bred to allow domesticated species to adapt to the conditions they have been placed in by humans, as observed by Epstein during his commentary on the sheep types of Arabia (1954). This divergence of domestic populations can lead to alterations in size and use of the animal, which can in turn greatly influence that animal's presence in zooarchaeological assemblages. As discussed above with regards to ethnographic observations on dromedary pastoralists, this factor has particular bearing on our considerations of ancient dromedary utilisation.

Whilst the above description of the domestication process is by no means comprehensive, it highlights the different 'stages' at which animals have been considered to be domesticated and some of the potential causes for this ambiguity. As highlighted by Bökönyi (1989) and Ducos (1989), attempting to apply blanket definitions and terminologies to processes that can vary greatly across time and space (and in the case of domestication, species) can be incredibly problematic; it is wrong to assuming that 'wild', 'domestic', 'tame' etc. are definitive categories that all animals can be classified by. It therefore seems sensible to allow for the aforementioned ambiguity when approaching the question of dromedary domestication and to aim to identify changes in the long-term relationship between humans and dromedaries through time, as opposed to focusing on the precise moment when dromedaries moved from 'wild' to 'domestic'; in effect, asking not when dromedaries were domesticated but *how*, and considering the long term dynamics of this domestication 'continuum' (cf. Harris 1996).

5.2. The Process of dromedary Domestication: Timing, Location and Motivation

The scholarship regarding the timing of the domestication of the dromedary camel has been thoroughly summarised by Retsö (1991) and there is no need to repeat this detailed summary here. However, it is worth briefly covering the two general positions outlined in that paper, in order to demonstrate the importance of moving away from the wild/domestic dichotomy and to highlight more recent contributions to the discussion. Albright (1942) concluded that the dromedary was not widely used as a domesticate prior to 1100 – 1000 BCE, due to a lack of textual references to it prior to the camel usage by the Midianites, as described biblically. This conclusion was first challenged by Free (1944) who drew upon evidence from Eygpt and Mesopotamia to argue that dromedaries were used in a domesticated manner from 3000 BCE, whilst acknowledging that they did not come into 'general' use until the Greco-Roman period (Free 1944: 193). As Retsö (1991: 29) identifies, little changed in this argument between the 1940s and the 1990s. Researchers have periodically presented evidence of the domesticated dromedary being present prior to 1000 BCE (e.g. Pohl 1950; 1952; Epstein 1955; Brentjes 1960; Zeuner 1963; Dostal 1967; Ripinsky 1975; Zarins 1989), which has been consistently refuted (e.g. de Vaux 1949; Walz 1954; Mikesell 1955; von Wissman 1960; Zarins 1978) reaffirming the idea that dromedary camels were not being utilised in a domesticated manner until the early first millennium BCE. However, as also identified by Retsö, a major outcome from this scholarship was the recognition that the dividing line between 'wild' and 'domestic' was not distinct (Retsö 1991: 40). This was first highlighted by Bulliet (1975: 36-38), who stated that while it might be true dromedaries were not used extensively in warfare and trade prior to 1100 BCE, they likely had other uses prior to this and therefore the dates of domestication should be pushed back.

As an example of this uncertainty, the Early Bronze Age dromedary remains from Umm an-Nar Island, U.A.E., were originally hypothesised to be from a domestic population, primarily due to the large numbers of dromedaries identified in the remains and representations of dromedaries on the tombs at the site (Hoch 1979). This interpretation was challenged by Uerpmann & Uerpmann (2002: 238-241), who suggested that local conditions on the island were not conducive to the keeping of domestic dromedary herds and that the depictions of dromedaries on the tombs at the site are by no means definitive evidence of their domestic status. This discussion was revisited by Curci *et al.* (2014: 216), who argue that the very presence of dromedaries on an island site, in addition to their wide age range, demonstrate that these dromedaries were a domestic population and not hunted. However, these factors can be accounted for by selective hunting and wild herd management, i.e. the range of ages could be explained by variable hunting strategies, and the presence of dromedary bones need only represent the transport to the site of carcasses, rather than the presence of live animals (e.g. Hamilakis 2003; Beach & Stammler 2006; Zeder 2008; Bar-Oz *et al.* 2011; Russell 2011: 274).

Since Bulliet's discussion, the argument for a later (c. 1000 BCE) date of domestication has been dominant. Seminal work undertaken by Uerpmann and Uerpmann (2002), focusing on the dromedary remains from Tell Abraq, reinforced this hypothesis (Uerpmann & Uerpmann 2002: 252-257). As discussed above, using logarithmic scaling they compared the size of dromedary remains from different temporal phases at Tell Abraq and some contemporary sites, highlighting what they considered to be a 'significant' diminution in the size of Iron Age II (c. 900 BCE) dromedaries compared to remains from the Bronze Age (Uerpmann & Uerpmann 2002: 256). They also identified a marked decrease throughout the Bronze Age in the amount of dromedary bones within the assemblage at the site, with dromedary becoming particularly rare in zooarchaeological assemblages towards the end of the second millennium BCE, before reappearing in the Iron Age (Uerpmann & Uerpmann 2002: 254). It was suggested that this pattern indicated overhunting of dromedaries into the late second millennium BCE, with the Iron Age increase reflecting the establishment of a domestic dromedary population in the area (Uerpmann & Uerpmann 2002: 255).

It is important to note that the authors were unable determine whether southeastern Arabia was the geographic centre of the domestication process (Uerpmann & Uerpmann 2002: 258). Indeed, a recent study into the genetic structures and lineages of modern and ancient dromedaries could also not conclusively identify southeastern Arabia as the sole centre of dromedary domestication (Almathen *et al.* 2016: 6711). However, the researchers did suggest that dromedaries from an as-yet unidentified wild dromedary population had a significant influence on the genetic makeup of modern dromedaries and acknowledged the potential for that wild population to have existed in southeastern Arabia (Almathen *et al.* 2016: 6710-6711).

A number of potential centres for dromedary domestication have been presented in the literature. Fedele's study (2017) of dromedary remains from west and southwest Arabia presented Yemen as a potential centre for early dromedary domestication, with evidence for domestic dromedaries present in the region from at least 1000 BCE, based upon the presence of smaller in stature dromedary remains recovered this area. Fedele also hypothesised that the Negev area in the southern Levant may have been an early centre of dromedary domestication, citing biblical evidence for the camel usage by the Midianites (Fedele 2017, 306). Retsö concluded that the Near East, in particular Syria, would have been the Iron Age breeding centre for the dromedary, citing the extensive contacts between the Assyrians and groups engaged in dromedary riding, breeding and trading (Retsö 1991: 49-50). That said, the recent finds of large assemblages of dromedary remains in southern Arabia dating to the second millennium BCE, as discussed in this paper, make this hypothesis less likely; they demonstrate that humans and dromedaries had been consistently interacting throughout the second millennium, far prior to their widespread appearance in the Levant, before which zooarchaeological evidence suggests interactions between humans and dromedaries was sporadic in the region

Viewing the domestication process as non-linear might suggest multiple centres of domestication, with domestic dromedaries being utilised in different places at different times for different purposes, prior to the dromedary's widespread appearance as a domesticate. Fedele presented a model for long term, non-linear, localised dromedary domestication, drawing upon evidence suggestive of domesticated dromedaries emerging in the late second/early first millennium BCE, and highlighting Yemen as one such potential area of early interactions between humans and domesticated dromedaries (Fedele 2017: 306). This multi-locational, non-linear model must be given more consideration in future studies of dromedary domestication as more dromedary remains are recovered from the wider region dating to this time period. Such models have been constructed in studies of other domesticates, with evidence for regional variation in the domestication of the goat (Daly *et al.* 2018) and multiple potential centres across a wide area for canid domestication (Larson & Fuller 2014: 124), making it a viable hypothesis regarding the nature of dromedary domestication.

To return to the issue of timing, Fedele highlighted the evidence for the utilization of dromedaries in a domesticated manner in the latter half of the second millennium BCE, focusing on the dromedary remains from the Levant and noting the emergence of states in southern Arabia and communication between the Levant and this area by 1200 BCE (Fedele 2017: 305). The potential date of domestication was also moved back before 1000 BCE by Curci *et al.* (2014), who question the use of the size change argument stating that size change can be affected by multiple factors (as demonstrated above) and that the study might be flawed due to small sample sizes (Curci *et al.* 2014: 213-215). They ultimately concluded that the wide variety of products obtained from dromedaries (e.g. milk, meat, wool etc.) suggests that their domestication began prior to their use as a transport animal in the early first millennium BCE (Curci *et al.* 2014: 221-222). Magee (2014: 213) also contended that food and milk might have been an impetus for the original domestication, however he notes that their use as a transport animal was the cause of their widespread dispersal after 1000 BCE. Uerpmann and Uerpmann contended that transport was the primary motivator for the domestication of the dromedary, citing the potentially limited returns of meat and milk from dromedaries immediately after their domestication, compared to other domesticates (Uerpmann & Uerpmann 2002: 250). While these returns might be limited when compared to existing domesticates, such as cattle or sheep and goat, the ability for dromedaries to produce meat and milk in the desert environment where other animals may not be able to should not be underestimated. Peters and von den Driesch (1997: 663) highlight this factor in the case of domestication of the Bactrian camel, noting that whilst the societies who likely domesticated the Bactrian camel had access to other domesticates, the ability of the Bactrian camel to survive in arid areas increased its desirability as a meat and milk producer.

Dromedary domestication has also been discussed in reference to prehistoric sites in the Levant, with particular focus on the Early Iron Age remains at Timna on the edge of Wadi Arabah. Based upon the characteristics of the dromedary bone assemblage, Grigson (2012) suggests that Timna was home to a domestic population of dromedaries that was used to facilitate the regional trade in ores and metals. These remains were originally assigned a date of 14th-12th century BCE, however more recent radiocarbon dating has made this assertion unlikely (Grigson 2012: 97). Sapir-Hen and Ben-Yosef concluded that the domestic dromedary was not introduced into the southern Levant until the 10th century BCE (2013: 282), demonstrating that large amounts of dromedary bone are only present in Levantine assemblages from the 10th – 9th century BCE onwards.

Questions remain regarding the date of the introduction of domestic dromedaries to the Levant, with the identification of ‘domestic’ dromedary camels at the site of Tell Nebi Mend in Syria, dating to 1400-1150 BCE (Grigson 2015). The few dromedary bones in this assemblage were identified as domestic due to their small size, which was comparable to Iron Age domestic dromedaries from Tell Abraq (Grigson 2015: 16). While some larger dromedaries were present in the assemblage, these were considered to be domestic Bactrian camels, rather than wild dromedaries (Grigson 2015: 16). Given that the Bactrian camel is known in the region at this time and the known size differences between the Bactrian and dromedary (**Fig. 3**), this seems a likely hypothesis. It is important to note a compelling argument set out by Magee (2015: 273) whereby the domestication of the dromedary could be considered to have been directly influenced by interactions with domesticated Bactrian camels, under the hypothesis that witnessing the Bactrian camel being ridden inspired the riding of the dromedary. In turn, this promotes a model whereby dromedary domestication could be considered a fairly rapid process, bypassing the initial stages of domestication above. This is a plausible scenario, with epigraphic evidence demonstrative of conceptual links between the dromedary and the Bactrian camel as early as the 11th century BCE, evident in the nomenclature used when referring to camels at this time (al-Zaidi 2017). However, even if the domestication of the dromedary was a short-term, direct process motivated by the need for traction and transport, the longer-term relationship between humans and dromedaries in southeastern Arabia would still have had a considerable bearing on the dynamic of that process.

The pictorial representation of dromedary camels in other forms of archaeological evidence should also be briefly considered here, as they have also influenced our understanding of dromedary domestication. Dromedary camels are well represented in rock art throughout Arabia and adjacent regions (e.g. Gaugin *et al.* 2016), from as early as 3000 BCE (Anati 1997: 422). These representations stretch from northern Arabia (e.g. ; Maraqten 2015; Gaugin *et al.* 2016) to Yemen, as far as the Island of Soqotra (e.g. Jung 1994; 1996), and often depict the dromedary as being hunted by humans carrying weapons or accompanied by dogs (e.g. Spassov & Stoytchev 2004; Maraqten 2015). These representations reinforce the conception of a long-term relationship between humans and dromedaries in Arabia. The dromedary is also represented by terracotta figurines, large numbers of which have been recovered from Arabia and adjacent regions and which are comprehensively catalogued by Magee (2015). Furthermore, the dromedary is also represented in small amount of metal objects as well, including a recently excavated copper-alloy seal from Saruq al-Hadid, dated to the Iron Age II Period (Karim *et al. Unpublished*). Apart from a few notable examples, such as the terracotta figurine from Muweilah or the relief from Tell Halaf (**Fig. 15**), representations are generally ambiguous as to whether wild or domestic dromedaries are represented (e.g. Macdonald 1990).

[redacted]

Figure 15. *The earliest depiction of clearly domesticated dromedary camels. Left: a terracotta figurine recovered from Muweilah, depicting a dromedary camel with burden, dating to the 10th – 8th century BCE. Right: an Assyrian relief from Tell Halaf, depicting a dromedary camel with rider, dating to the 8th Century BCE. Note the position of the saddle, located on the top of the hump in the 'northern style' as opposed to behind the hump. Images taken from Magee 2015.*

Magee's (2015) synthesis of the evidence for dromedary domestication from Arabia and adjacent regions presents compelling evidence for the domesticated dromedary being used widely by humans after 1000 BCE, highlighting the widespread appearance of depictions of dromedaries being either saddled or ridden by humans in southwest Asia in the early first millennium BCE (**Fig. 15**). The earliest of these is the aforementioned terracotta figurine, recovered from the Iron Age II occupation at the site of Muweilah (Magee 2015: 263). The dates of this occupation are securely placed between the tenth and eigth centuries BCE and the occurrence of dromedary figurines are believed to be from the entirety of this period (Magee, 2015: 263-264).

Magee does note that the innovation of dromedary riding occurring so soon after initial domestication is unlikely (Magee 2015: 273).

The training of dromedaries for use in warfare implies an advanced husbandry regime founded upon a detailed knowledge of dromedary behaviour. The fact that dromedaries were used in both warfare and transport, and presumably also as a subsistence source, further suggests the advanced level of control humans had over these animals by this time. It is also important to note, as highlighted by Curci *et al.* (2014: 220), that different dromedary saddles (namely the 'south-Arabian saddle' and 'north-Arabian saddle') were developed for different purposes. The differences between these two types of saddle are well described by Mason, who also discussed how the innovation of the northern saddle may have changed the role of the dromedary in society (Mason 1989: 24). The northern saddle was clearly in use by the early first millennium BCE, as indicated by its depiction in the tenth – eight century BCE dromedary figurine from Muweilah and the ninth – eigth century BCE Tell Halaf relief (**Fig. 15**). This saddle is suggested to have been particularly utilised in warfare due to the control it affords to the rider (Curci *et al.* 2014: 220). The southern Arabian saddle offers less control over the animal than the northern saddle, but is supposedly an older invention (Curci *et al.* 2014: 220). This technological development and divergence of the Northern Saddle is further possible evidence that that the dromedary may have been ridden, and could thus be considered domesticated, prior to the first millennium BCE.

It is arguable that this evidence should be considered as the earliest evidence of dromedaries being ridden by humans, which in itself can be regarded as another step in the domestication continuum, rather than the beginning (or the end) of the process itself. The argument could be made that the appearance of depictions of domestic dromedaries and the changes observed in the zooarchaeological record around 1000 BCE are related to the advent of their use in warfare. This would correlate with the potential evidence for violence in southeastern Arabia during the early first millennium BCE, including an increase in the number of fortified settlements and the complexity of their fortifications (e.g. Boucharlat & Lombard 1985; Benoist 2013; Magee 2014: 236; Karacic *et al.* 2018b), potential evidence of conflict in southern Arabia (Magee *et al.* 2002; Magee 2015: 243), as well as the epigraphic evidence for dromedary warfare from adjacent regions (e.g. Epstein 1954; Ripinsky 1978: 45; Sapir-Hen & Ben-Yosef 2013; Magee 2015: 268-272). However, it is unclear whether these fortified settlements reflect an increase in conflict during the early Iron Age (Potts 2001: 49; Magee 2014 236).

Regardless, the evidence for changes in dromedary behaviour and their relationship with humans from the Bronze Age remains at Saruq al-Hadid could still be viewed as precursor to the dramatic developments in the human-dromedary relationship that occurred during the Iron Age and have been highlighted in existing zooarchaeological discussion. While it is therefore indisputable that the dromedary was being utilised as a transport animal by *c.*1000 BCE, it remains uncertain as to whether traction was the primary motivation for the domestication of the dromedary (i.e., that evidence for dromedary riding can be equated to evidence for the earliest domesticated dromedaries), or whether the widespread utilisation of the dromedary for transport post-1000 BCE occurred after domestic dromedaries had been utilised by humans for other purposes, as tentatively suggested by the dromedary remains from Saruq al-Hadid.

5.3. A Word on Genetics

This paper has demonstrated many aspects of zooarchaeological material that can provide an insight into the relationship between humans and animals. As well as these methods, genetic studies have also been used to reconstruct the genetic lineages of modern domestic dromedary populations by comparing them to ancient populations, most comprehensively by Almathen *et al.* (2016) as discussed above. Paleogenomics is undoubtedly an incredibly useful tool for providing insight into the dynamics of animal domestication (Irving-Pease 2018), however recent reviews of ancient genetic studies have highlighted the fact that ancient DNA does not always provide definitive or conclusive evidence to inform upon archaeological issues and is highly dependent on the framing of the study (e.g. Larson 2011). Furthermore, the relatively small sample of ancient dromedaries utilised in Almathen *et al.*'s study may also limit the resolution of their insights into dromedary domestication. The benefits of a large sample size are demonstrated by a recent study into goat domestication in which genomes from 83 ancient goats were mapped and analysed, allowing the researchers to demonstrate a local divergence in the management and procurement strategies of early goat farmers (described as 'mosaic'), even noting the possible role of coat colour in these processes to highlight the multiple potential motivations and dynamics involved in domestication (Daly *et al.* 2018).

It is unlikely, given the apparently decentralised social structure of southeastern Arabian society during the Wadi Suq period and Late Bronze Age (Cleuziou & Tosi 2007; Magee 2014: 182), that the domestication of the dromedary would have been a sweeping event that crossed the region in a short time. It might rather be the case that changes in the relationship between humans and dromedaries during this time would have taken place on a smaller, localised scale. In turn, this may lead to such a 'mosaic' domestication dynamic, which would require comprehensive datasets of ancient genomes to identify. Additionally, Larson (2011: S491-S493) makes clear that, as with morphological changes, genetic changes do not occur over a short period of time but rather as part of the long-term domestication process. One could therefore expect that the early movements towards domestication would have left a negligible genetic trace on surviving archaeological material, if they left any trace at all. It is also important to note that even once a domestic dromedary population existed it is highly likely that it would have been restocked from wild populations accessible nearby, a dynamic discussed in detail by Machugh *et al.* (2017: 338). As discussed above, this continued interaction with wild dromedaries may be the reason for the wide range of dromedary sizes seen at Saruq al-Hadid in the Iron Age, but may also blur the genetic signature of an early domestic population. Recent advances in the capture of genetic material from ancient dromedary remains excavated from arid environments might allow genetic studies to address some of this nuance (Mohandesan *et al.* 2016) and answer some of the objectives for ancient dromedary DNA studies set out by Burger (2016).

6. Conclusions and Future Research Directions

Ultimately, the data recovered from the dromedary remains excavated at Saruq al-Hadid demonstrate changes in the relationship between humans and dromedaries during the Bronze and Early Iron Ages in southeastern Arabia; in particular the pathological phalanxes suggest a change in the behaviour of the dromedaries themselves and the finds of dromedary remains in ritual contexts demonstrate changes in the way the animal was viewed by humans. This evidence provides an insight into the relationship between humans and dromedaries in the centuries leading up to the appearance of definitively domesticated dromedaries in the archaeological record, yet whether these interactions are demonstrative of domesticated dromedaries being present at the site during this time is unclear.

Due to issues of equifinality in the demographic composition of dromedary herds, neither can we state that the evidence from Saruq al-Hadid is demonstrative of the management of a dromedary population to achieve a particular outcome. Our understanding of archaeological dromedary remains would be greatly improved by increasing our knowledge regarding the development of dromedary skeletons. This includes the development of a model for the ages of long bone epiphyseal fusion, rates of tooth wear and eruption of dromedary camels, as well as an investigation into skeletal sexual dimorphism that considers both metrical and non-metrical traits. Such a study would be a time intensive undertaking (e.g. Silver 1963; Davis 1996, 2000; Popkin *et al.* 2012), however the knowledge gained from it would be hugely rewarding in terms of the insights it would provide into archaeological dromedary populations and the authors strongly recommend such a study is undertaken in the near future.

Regardless of the limitations of our interpretations, if we view the domestication of the dromedary as a long-term process, as opposed to a rapid innovation, the changes in the relationship between humans and dromedaries evidenced at Saruq al-Hadid should be considered in future studies of dromedary domestication. As seen with innovations and significant changes in the relationships between humans and other animals, dromedary domestication was not necessarily a linear process and could have occurred several times in different areas prior to the widespread adoption of the domesticated dromedary that is evidenced in southeastern Arabia after 1000 BCE. Precisely what happened when and where is yet to be elucidated. Studying bone micro-morphology in order to determine muscle use might allow for some further elucidation. Such studies of enthesis have recently been widely applied in archaeology and other skeletal anatomical studies (e.g. O'Higgins *et al.* 2011; White 2015) and may help identify and describe early interactions between humans and dromedaries.

Two methods may prove effective in identifying early interactions between humans and domesticated dromedaries. The first of these involves an investigation into the diet of ancient dromedary populations, with the aim of identifying intervention in the diet by humans. For example, dried and salted fish are particularly well-suited as dromedary fodder, being widely evidenced to be used for this purpose since antiquity (e.g. Marsden 1818: 729; Hardy-Guilbagert 2001: 69; Beech 2004), and fish and other food sources from the marine environment are known to have a high nitrogen $^{15}N/^{14}N$ ratio and to have a strong effect on the composition of in-vivo collagen (e.g. DeNiro 1985: 808). Therefore, the identification of similarly high $^{15}N/^{14}N$ ratios in the collagen from ancient dromedary bones, particularly those found on inland sites, could well be indicative of human influence over the dromedaries' diet. In particular, a study comparing ancient dromedaries to modern dromedaries with known diets could be particularly effective (e.g. Noe-Nygaard *et al.* 2005; Makarewicz & Tuross 2006, 2012; Hu *et al.* 2009). Such a molecular study could not be undertaken on the dromedary remains from Saruq al-Hadid due to the poor preservation of collagen: a total of forty different bone samples from across the site were tested at the British Geological Survey using a GC Mass Spectrometer and all samples, regardless of their age and context, were found to contain too little collagen to be effectively analysed (Roberts Forthcoming). This lack of collagen is likely due to the burial environment at Saruq al-Hadid which, despite having a neutral-alkaline pH (Roberts *et al.* 2018: 7; 2019: Tab. 2), shows dramatic daily, seasonal and annual variation in temperature and humidity. This lack of collagen may therefore be a similar problem in other assemblages of dromedary bones due to these conditions being present elsewhere in the region, however the potential for such a dietary study to be undertaken on dromedary remains should be considered in the future.

The second method involves conducting residue analysis on Bronze Age and Early Iron Age ceramics in order to identify the consumption of dromedary milk. Such an approach recently identified the consumption of horse milk during the early phases of horse domestication (Outram *et al.* 2009) and it may serve to identify uses of domesticated dromedaries by humans prior to their widespread adoption as a transport animal.

While this paper has not provided any definitive answers to the questions surrounding dromedary domestication, it has demonstrated why these answers are not forthcoming from traditional lines of enquiry alone. The authors consider the evidence from Saruq al-Hadid to demonstrate changes in the relationship between humans and dromedaries, that in turn should be viewed outside of a 'wild'/'domestic' dichotomy. While this approach may not be conducive to immediate clarity, it is ultimately necessary to discuss domestication in a manner that better reflects its complex and long-term nature. What remains clear, however, is that developing our understanding of human and dromedary relationships will greatly enhance our knowledge of both this enigmatic period in the region's history and also our general understanding of how humans interact with the other species in their environment. The domestication of the dromedary impacted greatly upon the course of human history and continues to affect our environment into the modern day; building upon our knowledge of how this process began will be a great asset in guiding our interactions with this species in the future.

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8. Paper 4

This paper, entitled '*The exploitation of marine resources at Saruq al-Hadid: Insights into the movement of people and resources in Bronze and Iron Age southeastern Arabia*', addresses the significant amount of marine animal remains recovered from Saruq al-Hadid. Their role in the subsistence strategy employed at the site is discussed, along with the other potential uses of these animals. This analysis contributes to the situating of Saruq al-Hadid into the network of regional sites by demonstrating the movement of marine animals from the coast into the interior.

Links between the coast and the interior have been hypothesised to have existed during the Bronze Age, facilitating the movement of goods across southeastern Arabia. The remains of marine animals from Saruq al-Hadid are the first definitive evidence of marine resources being moved from the coast to the interior in substantial quantities during the Bronze Age. This paper is therefore an important contribution to the wider understanding of human activity in Bronze Age Arabia and the way in which the relationships between different parts of the landscape are considered during this time. The potential role of these animals in the trade and exchange evidenced at Saruq al-Hadid is also highlighted. This paper adds to the substantial body of archaeological, historical and ethnographic evidence that highlights the crucial role of the marine resource in the lifeways of southeastern Arabia.

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The exploitation of marine resources at Saruq al-Hadid: Insights into the movement of people and resources in Bronze and Iron Age southeastern Arabia

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Abstract

Marine resources were an integral and consistent component of subsistence strategies employed in southeastern Arabia throughout late prehistory. Of particular interest is the movement of these resources from the coast to interior sites and the implications of this movement for transhumance and trade in the region during this period. Marine species were frequently identified in the faunal assemblage from the inland site of Saruq al-Hadid, dating from the Bronze Age to Early Iron Age (c. 2000 – c. 800 BCE). This included marine fish species, along with two cormorant species (Phalacrocorax sp.) and several fragments of dugong (Dugong dugon). Twenty-seven families of marine shell were also identified in the remains recovered from the site. The presence of these remains at this inland site demonstrates that resources were frequently moved from the coast to the interior throughout Saruq al-Hadid's occupation, indicative of their enduring significance in subsistence strategies employed at the site. This paper presents the results of zooarchaeological analysis of these remains and discusses the significance of their presence at Saruq al-Hadid, with reference to subsistence, craft production and intra-regional exchange during the Bronze and Iron Ages.

Keywords: Fish, Shell, Saruq al-Hadid, Bronze Age, Iron Age, Arabia

1. Introduction

Marine resources are recognised to have been a highly significant component of subsistence strategies in southeastern Arabia throughout late prehistory (Beech 2004; Grupe & Schkowski 1989; Uerpmann & Uerpmann 2005; 2008). Remains of both the fish and fishing paraphernalia dating from the Neolithic period onwards demonstrate that late prehistoric fishers were capable of exploiting fish from both the coastal and deep-sea zones, giving them access to a diverse array of species and large stocks of fish (e.g. Beech 2004; Lidour *et al.* 2019). In addition to fish, a number of other animals from the marine environment were exploited throughout late prehistory, including sea mammals such as dugong (*Dugong dugon*; Beech 2010) and dolphin (Delphinadae; Uerpmann & Uerpmann 2008: Tab. 4), and seabirds such as cormorant (*Phalacrocorax* sp.; Uerpmann & Uerpmann 2008: Tabs. 3-4). Shellfish from the marine environment were also commonly used by late Prehistoric communities in the region (e.g. Boivin & Fuller 2009: 126).

The high significance of this resource is demonstrated by the frequent identification of marine species in zooarchaeological and shell assemblages recovered from Bronze and Iron Age sites in the region (**Tables 1** & **2**). As one would expect, remains of marine species are commonly found on coastal sites, however marine species have also been recorded at sites in the interior of the region (**Fig. 1** & **2**). Remains of marine resources (namely pearl, shell and coral) have been found at inland sites dating to the Neolithic, whereas marine vertebrates are only represented by a single fragment of dugong tooth (Uerpmann *et al.* 2012: 398). This scarcity of marine vertebrates at inland sites continues into the Bronze Age (**Fig. 1**), while the Iron Age witnesses an apparent increase in their presence at inland sites (e.g. Beech *et al.* 2008). Shell middens are abundant on the coast of southeastern Arabia (Cleuziou & Tosi 2007; Magee 2014: 187), with multiple middens dating to the Bronze and Iron Ages (**Fig. 2**), but the much smaller numbers of marine shells found at contemporary inland sites are typically interpreted as the remains of craft production or as artefacts themselves, rather than residues of subsistence activities.

A number of researchers have hypothesised that fish may have been moved from the coast to inland areas during the Bronze Age, as part of exchange networks or seasonal subsistence strategies involving transhumance (Cleuziou 1996; Cleuziou & Méry 2002; Magee 2014). However, as researchers have highlighted, the limited direct evidence for this in the Bronze Age suggests this undertaking was infrequent during this period, if it was occurring at all (Uerpmann & Uerpmann 2008; Magee 2014: 106). The potential for meat from fish and other marine species to have been deboned before its movement inland – thus being archaeologically 'invisible' (cf. Crawford 1973; Crabtree 1990) at inland sites – has been noted (Beech 2004: 211; Uerpmann & Uerpmann 2008: 482). Such a consideration should also be made regarding the deshelling of shellfish. Several researchers have related the observed increase in marine resources at inland Iron Age sites to the domestication of the dromedary camel, which led to the expansion of inland trade routes (e.g. Beech 2004: 214; Magee 2014: 226). However, it is hypothesised that cattle and donkeys would have facilitated the exchange of goods prior to the widespread availability of the domestic camel (Uerpmann & Uerpmann 2008: 479).

Table 1. *The Bronze and Iron Age sites in southeastern Arabia from which significant assemblages of marine vertebrate species remains have been recovered.*

Sites and Map Number	Period	Reference
1. Umm an-Nar	Umm an-Nar	Uerpmann & Uerpmann 2005
2. Ra's al-Jinz 2	Umm an-Nar	Azzarà & de Rorre 2018
3. Al-Ayn 2	Umm an-Nar	Blin 2012
4. Ra's al-Hadd HD1 & HD5)	Umm an-Nar – Wadi Suq	Cartwright & Glover 2002; Cleuziou & Tosi 2007
5. Tell Abraq	Umm an-Nar- Iron Age II	Uerpmann & Uerpmann 2005
6. Shimal (SX & SY)	Wadi Suq – Late Bronze Age	Von den Driesch 1994
7. Hamriyah	Iron Age I-II	Magee *et al.* 2009: 28
8. Muweilah	Iron Age II	Uerpmann & Uerpmann 2017
9. Thuqeibah	Iron Age II-III	Uerpmann & Uerpmann 2008: 482
10. Rafaq 2	Iron Age III	Beech *et al.* 2008
11. Mleiha	Pre-Islamic	Van Neer *et al.* 2013
12. Ed-Dur	Pre-Islamic	Van Neer *et al.* 2017

Table 2. *The Bronze and Iron Age sites where major assemblages of marine shell have been recovered.*

Sites and Map Number	Period	Reference
1. Bat	Early Bronze Age	Possehl *et al.* 2009
2. Tell Abraq	Umm an-Nar- Iron Age II	Magee 2014: 187
3. Ra's al-Jinz 1	Wadi Suq	Cleuziou & Tosi 2007: 273
4. Shimal	Wadi Suq – Late Bronze Age	Vogt & Franke-Vogt 1987
5. Hamriyah	Iron Age I-II	Magee *et al.* 2009
6. Husn Awhala	Iron Age II	Potts *et al.* 1996: 228-234.
7. Muweilah	Iron Age II	Magee 2014
8. Thuqeibah	Iron Age II-III	Uerpmann & Uerpmann 2008: 482

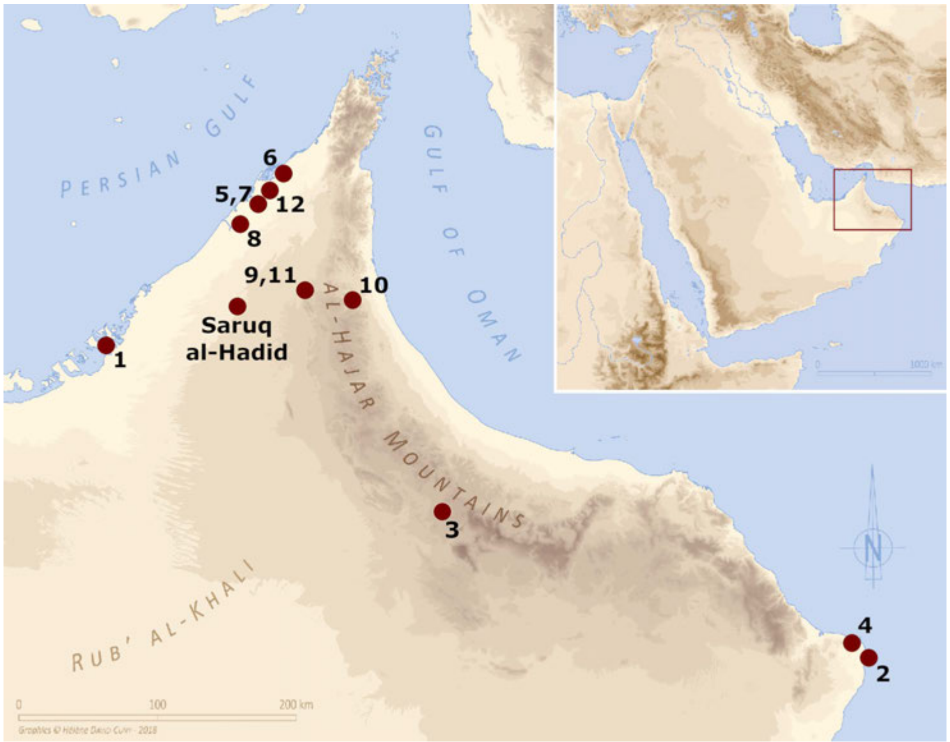

Figure 1. *A map displaying late prehistoric sites that have produced significant assemblages of marine species remains. See* ***Table 1*** *for numerical key.*

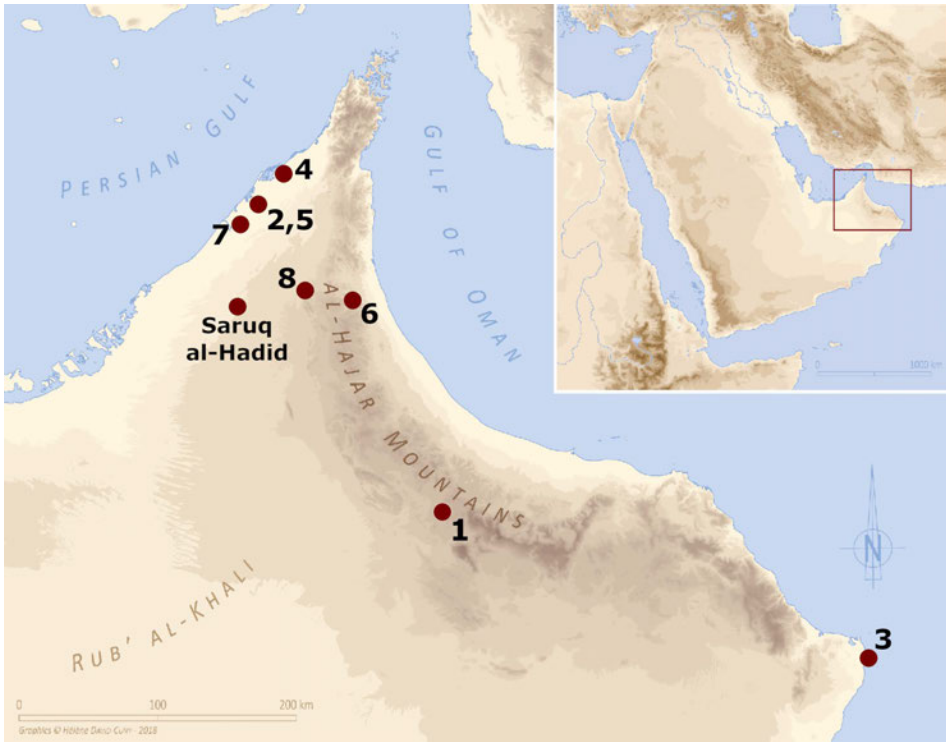

Figure 2. *A map displaying late prehistoric sites that have produced significant assemblages of marine shell remains. See* ***Table 2*** *for numerical key.*

In addition to their subsistence uses, animals from the marine environment were used for the production of objects throughout prehistory in southeastern Arabia. Marine shell species have been frequently documented as a raw material for object fabrication, from functional items such as fish hooks (Beech 2003: 291-293, Frenez & Cattani 2019) to elaborately decorated large shells dating to the Iron Age (Weeks *et al.* 2019a). The existing archaeological evidence suggests a complex network of trade, exchange and general movement of marine resources to inland sites, driven by multiple motivating factors in addition to subsistence. However, questions remain regarding the movement of this resource inland and its role in the provisioning of inland sites, particularly during the Bronze Age. Answering these questions provides information on the dynamics and motivations behind the movement of peoples and trade networks in the Bronze and Iron Ages of southeastern Arabia, as well as increasing our cognisance of subsistence strategies and manufacturing practices employed in the region during this time.

In this paper, we use recently excavated remains of marine animals from the inland site of Saruq al-Hadid to facilitate a discussion regarding the movement of resources around the landscape of prehistoric southeastern Arabia in the Bronze and Iron Ages. The presence of large amounts of fish and other marine species in Bronze Age contexts at Saruq al-Hadid is highly significant, as this is the first evidence in the region for a substantial movement of fish inland during the Bronze Age. The multiple uses of these marine species suggested by the remains from Saruq al-Hadid are discussed and placed into the framework of our understanding of the site and the wider region.

2. Zooarchaeological Remains from Saruq al-Hadid: Collection, Recording and Analysis

Saruq al-Hadid is located 40 km from the Persian Gulf coast of the United Arab Emirates, in the dune fields of the Rub' al-Khali desert (**Fig. 1**). Programmes of survey and excavation undertaken at the site have identified persistent, temporary occupation from the Early Bronze Age, locally known as the Umm an-Nar period, through to the early Iron Age (*c.*2000 - 800 BCE), with evidence for periodic later activities through to the Islamic Period (Casana *et al.* 2009; Nashef 2010; Hermann *et al.* 2012; Contreras *et al.* 2017; Karacic 2016: 286; 2017; Karacic *et al.* 2018a; Weeks *et al.* 2017; 2018; 2019b). This activity is represented by a deep stratigraphy of interspersed cultural and natural layers in the central area of the site (Weeks *et al.* 2018: 8, Fig. 3; 2019b), that can be divided into five archaeological 'horizons'. An extensive programme of absolute dating (Weeks *et al*. 2019b) has allowed broad date ranges to be assigned to these horizons, as shown in **Table 3**.

Table 3. *The dates of each the five reconstructed archaeological horizons at Saruq al-Hadid.*

Horizon	Date Range	Cultural Assignment
V	*c.*2000 – *c.*1750 BCE	Wadi Suq
IV	*c.*1750 – *c.*1300 BCE	Wadi Suq – Late Bronze Age
III	*c.* 1300 – *c.* 1000 BCE	Iron Age I – II
II	*c.* 1000 – *c.* 800 BCE	Iron Age II
I	*c.* 900 BCE and later	Iron Age II and later

Recent excavations at the site, undertaken by the Saruq al-Hadid Archaeological Research Project (SHARP), recovered a substantial assemblage of animal bone. While some larger bone fragments were recovered by hand, all archaeological deposits excavated by SHARP were passed through a 0.3 cm sieve whilst still dry to ensure recovery of smaller bone fragments. This led to the recovery of a large number (*n*=363,755) of animal bone fragments (**Table 4**). Due to the comprehensive sieving undertaken on site, the remains recovered by hand and those recovered from the 0.3 cm sieve were amalgamated and are referred to as the 'general assemblage'. The vast majority of these fragments (90.4%) were considered to be unidentifiable or were only identified to broad taxonomic classes (e.g. large mammal, medium mammal etc.). These remains are considered in further detail elsewhere (Roberts *In Prep.* a). In addition, 332 samples were taken from hearth fills and other significant contexts, with a total volume of 1348 litres. These samples were dry sieved through further fine mesh (4mm, 2mm, 1mm, 0.5mm), primarily to extract charred botanical remains, however a number of bones, including fish, were also extracted and analysed (**Table 5)**. These samples are considered separately from the general assemblage. All bone was subject to visual examination, during which each fragment was assigned to a taxon and skeletal element, with any butchery, burning, pathology or other notable effects on the bone recorded.

A number of animal species from the marine environment – fish, birds, mammals and molluscs – were identified within the assemblage, suggesting that marine resources played a role in both subsistence and other activities at the site. The fish and bird assemblages were separated from the wider faunal assemblage for detailed identification with the aid of specialised reference collections, regional species lists (e.g. Smith & Heemstra 1986; Porter & Aspinall 2012) and identification guides (e.g. Cohen & Serjeantson 1996). The fish remains were identified using Dr Mark Beech's reference collection, kept in Abu Dhabi, and the bird remains were identified using the bird skeletal reference collection kept by the Natural History Museum in Tring, UK. The fish otoliths were treated separately from the remainder of the fish bones, as outlined elsewhere (Roberts *et al.* 2019), due to their additional research potential.

Table 4. *The amount of bones from marine vertebrates (NISP) identified in the assemblage from the general excavations, excluding otoliths, compared to other groups of vertebrate species identified at Saruq al-Hadid (cf. Roberts et al. 2018: Tab. 3), alongside the number of shell remains (NISP). Values have been updated since their presentation in Roberts* et al. *2018: Tab. 3.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Domestic Animals	**35**	**192**	**149**	**721**	**23**	**234**	**1354**
Wild or Domestic Animals	**66**	**482**	**549**	**1836**	**28**	**1152**	**4113**
Wild Terrestrial Animals	**406**	**2803**	**7982**	**5044**	**57**	**3495**	**19787**
Cormorant	-	3 MNI = 2	4 MNI = 1	23 MNI = 3	2 MNI = 2	2	34
Dugong	-	-	-	6 MNI = 1	-	2	8
Fish	59	557	1671	5975	150	1346	9758
Marine Animals	**59**	**560**	**1675**	**6004**	**152**	**1350**	**9800**
Total Identified	**566**	**4037**	**10355**	**13605**	**260**	**6231**	**35054**
Large Mammal	587	3662	3156	8850	11	8716	24982
Medium Mammal	782	5377	4436	18650	23	13530	42798
Small Mammal	33	139	552	644	9	488	1865
Unidentified	7100	25996	18328	155258	2916	49458	259056
Vertebrate Grand Total	**9068**	**39211**	**36827**	**197007**	**3219**	**78423**	**363755**
Shell	1 MNI=1	55 MNI=39	80 MNI=56	578 MNI=258	40 MNI=22	1158 MNI=725	1912 MNI=1101

Table 5. *The amount of bones from marine vertebrates (NISP) identified in the fine-sieved assemblage, excluding otoliths, compared to other groups of vertebrate species identified in this assemblage. N.B. No samples were taken for fine-sieving from Horizon I and no shell remains were recovered from the fine-sieved assemblage.*

	Horizon II	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Horizon II**	**Total**
Domestic Animals	**3**	**-**	**3**	**-**	**-**	**6**	**3**
Wild or Domestic Animals	**-**	**-**	**1**	**-**	**1**	**2**	**-**
Wild Terrestrial Animals	**273**	**34**	**155**	**86**	**258**	**806**	**273**
Fish	51	3	211	108	334	707	51
Marine Animals	**51**	**3**	**211**	**108**	**334**	**707**	**51**
Total Identified	**327**	**37**	**370**	**194**	**593**	**1151**	**327**
Large Mammal	-	-	5	4	8	17	-
Medium Mammal	4	1	16	18	75	114	4
Unidentified	116	1	26	22	27	192	116
Vertebrate Grand Total	**447**	**39**	**417**	**238**	**703**	**1844**	**447**

NISP was the only quantification technique employed for the fish remains. Due to the predominance of vertebrae in the fish remains calculations of MNI (Minimum Number of Individuals) were likely to provide an inaccurate picture of the quantities of fish in the assemblage. However, MNI values (**Table 4**) were determined for the bird and dugong, utilising the ‘8-zones per bone’ system for mammals (Serjeantson 1996) and birds (Cohen & Serjeantson 1996). Furthermore, bone fragments were not weighed due to highly variable preservation of the bone observed in the assemblage, meaning that bone weights were an unreliable indicator of the quantities of bone (and therefore derived meat-weights, etc.) recovered from the site. The shell fragments recovered from Saruq al-Hadid were analysed by Dr Melissa Carter at UNE. This assemblage was quantified in three ways; weight, NISP and MNI. MNI was determined by the frequency of diagnostic morphological features or non-repetitive elements (NRE) and by determining the highest number of left or right valves per taxon for bivalves. The methodology and results of this analysis are described in further detail elsewhere (Carter Unpublished). It is important to note that excavations are still ongoing at Saruq al-Hadid and it is likely that large amounts of animal bone remain unexcavated at the site, which could have the potential to challenge the interpretations presented in this paper.

3. The Marine Animal Remains at Saruq al-Hadid

Of the remains that could be securely associated with one of the five archaeological horizons at the site, 8785 fragments of bone (29.5% of total NISP) were classified as marine species (**Tables 4** & **5**). The remains of the other species identified at Saruq al-Hadid are discussed elsewhere (Roberts *et al.* 2018; *In Prep*. a; *In Prep.* b). An observable trend in the wider assemblage should be addressed here. In Horizon III, II and I the frequency of marine animals is relatively lower than it is in Horizons V and IV. The authors attribute this relative decrease primarily to the burrowing of animals (i.e. lizards and rodents) into these later horizons and the intrusive deposition of large numbers of their remains into archaeological contexts, effectively lowering the relative proportion of marine remains. The taphonomic processes affecting site formation at Saruq al-Hadid, and the nature of the faunal assemblage, are described in further detail elsewhere (Roberts *et al.* 2018; *In Prep.* a; Weeks *et al.* 2019b).

3.1. Fish

A total of 8395 fragments could be confidently associated with the five archaeological horizons at the site (**Table 6**). The fish bones were frequently fragmented and encrusted with sand, which often obscured diagnostic features hindering finer taxonomic identification. Despite this, a number of identifications were possible, which highlighted the presence of a variety of species (**Table 6**). While specific skeletal elements were identified and recorded, here we discuss body part representation only in terms of cranial/vertebral element distinction, as this best facilitates comparison between the archaeological remains from Saruq al-Hadid and the fish preparation and fish preservation techniques discussed in this paper. The most abundant genus in the remains is *Rhabdosargus* sp., two species of which are known to occur in the region; *Rhabdosargus sarba* (Goldlined seabream – Bauchot & Smith 1984) and *Rhabdosargus haffara* (Haffara seabream – Bauchot & Smith 1984). The high incidence of this genus may be a true reflection of their predominance at the site, however it should be noted that the dentary and premaxilla of these species are both highly distinctive and robust (**Fig. 3**), which may lead to their over identification, as also observed by Uerpmann & Uerpmann (2005: 111).

Figure 3. *A dentary identified as Rhabdosargus sp, recovered from Horizon IV.*

Table 6. *The NISP of taxonomic identifications made in the fish remains from the general and fine-sieved assemblage, across archaeological horizons at Saruq al-Hadid.*

Assemblage Recovered during General Excavation Process (3mm sieved and hand collection)							
	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Belonidae indet.	3	3	13	28	1	12	**60**
Serranidae, *Epinephalus* sp.				8		2	**10**
Serranidae, indet.		1	12	9		10	**32**
Carangidae, *Carangoides* sp.		1	4	8		16	**29**
Carangidae indet.			5	2		4	**11**
Haemulidae indet.			2	2		1	**5**
Lethrinidae, *Lethrinus* sp.	1			9		2	**12**
Lethrinidae indet.	1	2	3	4		8	**18**
Sparidae, *Rhabdosargus* sp.	6	35	5	62	4	33	**145**
Sparidae, indet.			10	32		27	**69**
Scombridae, indet.			2	1			**3**
Osteichthyes indet.	36	451	1588	5644	121	1131	**8971**
Negaprion sp.	1	1		1			**3**
Batoidea indet.			3	2			**5**
Elasmobranchii indet.	11	63	24	163	24	100	**385**
Sub – Total	**59**	**557**	**1671**	**5975**	**150**	**1346**	**9758**
Assemblage Recovered from Fine-Sieved Samples							
Belonidae indet.				4	2		**6**
Carangidae, *Carangoides* sp.				2			**2**
Sparidae, *Rhabdosargus* sp.		23	2	13	2	9	**49**
Osteichthyes indet.		28	5	281	71	254	
Elasmobranchii indet.				5	2	4	
Sub - Total	**-**	**51**	**7**	**305**	**77**	**267**	**-**
Grand Total	**59**	**608**	**1678**	**6280**	**227**	**1613**	**59**

A number of other family and genii were identified in the remains (**Table 6**), all of which are known to occur commonly in the Persian Gulf and the coastal waters of Oman. Cranial and vertebral elements were present from all the taxa represented, apart from the Scombridae family, from which only vertebrae were present. There are no indications of any diachronic changes in this body part representation (**Table 8**). No butchery marks were present on the remains, however four of the *Rhabdosargus* sp. remains from Horizon IV had been burnt. Notably, taxonomic identifications made in the otolith remains did not match the identification rates of the rest of the fish assemblage (**Table 7**). Otoliths from *Pomadasys kaakan* were most abundant in the assemblage, however only four fragments of bone were identified as Haemulidae (**Table 7**). Otoliths have been presented separately in this paper due to the particular attention paid to them during the excavation process. This is described in further detail elsewhere (Roberts *et al.* 2019). The vast majority of fish remains in the assemblage could not be identified further than 'Osteichthyes'. The remains identified as osteichthyes represented cranial and vertebral elements (**Table 8)** and a notable proportion of the remains had been burnt to varying degrees (**Table 9**).

Cartilaginous fish were also frequently identified in the remains (**Table 6**). These were predominantly fragmented vertebrae and therefore were not further taxonomically identifiable, however four tail spine fragments from rays were identified (cf. Schwartz 2008), indicating their presence in the assemblage. Additionally, several shark teeth and vertebrae were recorded, including one specimen identified as *Negaprion* sp., and several vertebrae from large cartilaginous fish – likely shark - were present however could not be identified further due to concretion obscuring diagnostic aspects of the bone (**Fig. 4**). Eight fragments of cartilaginous vertebrae from Horizon IV were found to have been irregularly charred (**Fig. 5**), consistent with burning marks caused by cooking. As with the remains of osteichthyes, no butchery marks were identified on the cartilaginous fish remains.

Figure 4. *A tooth identified as belonging to shark (*Negaprion *sp.), alongside vertebrae from a large cartilaginous species – while these could not be definitely identified as shark, and therefore have been included in* ***Tables 6*** *&* ***8*** *as Elasmobranchii, they are of an appropriate size to be from shark - associated with Horizon IV. Note the sand concretion on the vertebrae which proved destructive to remove. This concretion was a common feature of the fish bone assemblage and hindered taxonomic identification.*

Figure 5. *Examples of burnt cartilaginous fish vertebrae recovered from contexts associated with Horizon IV.*

Table 7. *The taxonomic identifications made in the otolith assemblage across each archaeological horizon at Saruq al-Hadid.*

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Belonidae indet.		1	1		1	1	**4**
Carangoides sp.		5	4	7		1	**17**
Epinephelus sp.		8	2	1	1	1	**13**
Lutjanus sp.		11	9	8	2	3	**33**
Pennahia anea		1	1	2			**4**
Pomadaysys kaakan	3	2	17	30	1	13	**66**
Pomadaysys sp.		1					**1**
Rhabdosargus sp.			2	2	1		**5**
Total	**3**	**29**	**36**	**50**	**6**	**19**	**143**

Table 8. *The NISP of skeletal elements from each identified taxa from the entire fish bone assemblage excavated from Saruq al-Hadid.*

	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V	Indeterminate Horizon	Total
Belonidae, indet.							
Dentary		1		2		1	4
Dentary/Premaxilla			2	6	1		9
Premaxilla				1			1
Vertebra	3	2	11	19		11	46
Total	**3**	**3**	**13**	**28**	**1**	**12**	**60**
Serranidae, *Epinephelus* sp.							
Premaxilla				1			1
Vertebra				7		2	9
Total	-	-	-	**8**	-	**2**	**10**
Serranidae, indet.							
Vertebra		1	12	9		10	32
Total	-	**1**	**12**	**9**	-	**10**	**32**
Carangidae, *Carangoides* sp.							
Dentary		1					1
Vertebra			4	8		16	28
Total	-	**1**	**4**	**8**	-	**16**	**29**
Carangidae, indet.							
Vertebra			5	2		4	11
Total	-	-	**5**	**2**	-	**4**	**11**
Haemulidae, indet.							
Maxilla			1				1
Premaxilla			1				1
Vertebra				2		1	3
Total	-	-	**2**	**2**	-	**1**	**5**
Lethrinidae, *Lethrinus* sp.							
Vertebra	1			9		2	12
Total	**1**	-	-	**9**	-	**2**	**12**
Lethrinidae, indet.							
Vertebra	1	2	3	4		8	18
Total	**1**	**2**	**3**	**4**	-	**8**	**18**
Sparidae, *Rhabdosargus* sp.							
Angular				1			1
Dentary		8	1	16		3	28
Dentary/Premaxilla	2	10	1	11		12	36
Hyomandibular		1		1			2
Maxilla						1	1
Opercular		1		1		1	3
Premaxilla		5	2	17	2	4	30
Tooth	3	10	1	15	2	8	39
Vert	1					4	5
Total	**6**	**35**	**5**	**62**	**4**	**33**	**145**

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Indeterminate Horizon**	**Total**
Sparidae, indet.							
Tooth						1	1
Vert			10	32		26	68
Total	-	-	**10**	**32**	-	**27**	**69**
Scombridae, indet.							
Vert			2	1			3
Total	-	-	**2**	**1**	-	-	**3**
Osteichthyes, indet.							
Angular		4	8	1			13
Articular		2				2	4
Branchiostegal Ray		21	62	49	1	57	190
Cleithrum		1					1
Dentary		10	39	5		19	73
Dentary/Premaxilla		3	39	2			44
Hyomandibular		1					1
Maxilla			2	1		2	5
Opercula			1			1	2
Post-Temporal		1	2				3
Premaxilla	2	7	20	2		9	40
Quadrate		2	4			3	9
Scale		1					1
Tooth		10	35	1		8	54
Volar			1			1	2
First Vertebra			5	12			17
Vertebra	29	314	1032	5492	117	904	7888
Penultimate Vertebra			1				1
Final Vertebra			1	1			2
Unidentifiable Cranial Element		4	3	26	3		36
Unidentifiable Fragment	5	70	333	52		125	585
Total	**36**	**451**	**1588**	**5644**	**121**	**1131**	**8971**
Carcharhinidae, *Negaprion* sp.							
Tooth	1	1		1			3
Total	**1**	**1**		**1**			**3**
Batoidea, indet.							
Tail Spine			3	2			5
Total	-	-	**3**	**2**	-	-	**5**
Elasmobranchii, indet.							
Vert	11	63	24	163	24	100	385
Total	**11**	**63**	**24**	**163**	**24**	**100**	**385**
Grand Total	**59**	**557**	**1671**	**5975**	**150**	**1346**	**9758**

Table 9. *The NISP of burnt fragments identified in the main assemblage across each archaeological horizon.*

Burnt Colour	Horizon I	Horizon II	Horizon III	Horizon IV	Horizon V
Patchy Charring			9	47	1
Black	1	14	7	466	3
Grey			1	4	1
White			1	3	
Total	**1**	**14**	**18**	**520**	**5**

3.1.1. Remains from the Fine-Sieved Samples

An additional 457 fragments of fish were extracted from the fine-sieved samples. The identifications made in this material largely coincide with those from the general assemblage (**Table 6**), indicating the recovery of a robust and representative assemblage of fish remains through the excavation techniques employed during the general excavations. Notably, a single vertebra from a very small indeterminate fish species was present in the bone recovered from the fine sieving procedure that was not identified in the remains recovered by the general excavation techniques. As observed in the general assemblage, no butchery marks were present on the fragments, however a number of fragments were burnt to varying degrees of intensity (**Table 10**). No temporal change was observed in the skeletal element representation of fish, across either the general assemblage or the fine-sieved assemblage (**Table 8**). No dermal denticles ('scutes') from rays or sharks were identified in the remains from either the general assemblage or the fine-sieved assemblage.

Table 10. *The NISP of burnt fragments identified in the sieved assemblage across each archaeological horizon.*

Burnt Colour	Horizon II	Horizon III	Horizon IV	Horizon V
Patchy Charring		7	87	15
Black	1		49	11
Grey			4	
White			6	
Total	**1**	**7**	**146**	**26**

3.2. Cormorant

In total, 32 fragments identified as cormorant were present in the assemblage. Two separate species of cormorant were identified (**Table 11**), however a number of fragments could only be identified to the *Phalacrocorax* genus (**Table 11**). Bones from the legs were most abundant in Horizons II, III and V (**Fig. 6**), whereas bones from the wings were most abundant in Horizon IV (**Fig. 6**). Three fragments displayed burning marks (**Fig. 7**), but no butchery marks were identified on the cormorant remains. A single fragment from Horizon III had a porous texture indicative of a juvenile animal, while the rest of the fragments appeared to be from adult individuals.

Table 11. The NISP of all remains identified as the *Phalacrocorax* genus.

	Horizon I	**Horizon II**	**Horizon III**	**Horizon IV**	**Horizon V**	**Total**
Phalacrocorax nigrogularis			1	3	2	**6**
Phalacrocorax carbo		1	1			**2**
Phalacrocorax sp.		2	2	20		**24**
Total	**-**	**3**	**4**	**23**	**2**	**32**

3.3. Dugong

Eight fragments of the assemblage were identified as dugong (*Dugong dugon*), all of which were associated with Horizon IV. Seven of these were ribs (**Fig. 8**), however a single fragment of ivory was also identified that was likely from dugong. No burning or butchery marks were identified on the dugong remains.

3.4. Marine Shell

A total of 1912 fragments of shell were recovered from the SHARP excavations, 754 of which could be securely associated with one of the five archaeological horizons (**Table 4**). The majority of the shell assemblage was highly fragmented, however a total of 47 different taxa were identified during analysis (**Table 12)**. Overall, 27 out of the 29 represented shell families originate from marine habitats (**Table 12**), specifically the inter-tidal zone, including brackish estuarine waters, mangroves, lagoons and sandy beaches. A limited number of shell fragments appeared to have been worked, suggesting that some of this shell would have been used for object manufacture. Furthermore, the presence of unfinished examples of a variety of shell artefact types in the assemblage suggests that shell objects were being manufactured at the site (Weeks et al. 2017: Fig. 24; 2019a). In addition to the species identified in the general shell assemblage, *Lambis truncata sebae* and/or *Pleuroploca trapezium*, and possibly other large gastropods, were used for the production of decorated shell discs found in significant numbers at Saruq al-Hadid, and possibly manufactured there (Weeks et al. 2019a).

[redacted]

Figure 6. *The skeletal element representation in the cormorant remains, shown as a percentage of MNI, across each horizon. Skeletal Image: © 2015 ArcheoZoo.org*

Table 12. *Marine shell species identified from Saruq al-Hadid.*
After Carter Unpublished: 5.

Class Bivalvia		Class Gastropoda	
Arcidae		**Cerithiidae**	
	Anadara sp.		*Clypeomorus persica*
	Anadara uropigimelana		*Rhinoclavis aspera*
Cardiidae		**Columbellidae**	
	Fragum fragum	**Conidae**	
	Fragum unedo		*Conus* sp.
Chamidae		**Epitoniidae**	
	Chama reflexa	**Fasciolariidae**	
Donacidae			*Pleuroploca trapezium*†
Glycymeridid		**Littorinidae**	
Laternulidae			*Littorina* sp.
	Laternula anatina	**Muricidae**	
Lucinidae		**Nassariidae**	
	Anodontia edentula		*Nassarius jonasii*
	Pillucina angela		*Nassarius wolffi*
Mactridae			*Nassarius* sp.
Pteriidae		**Neritidae**	
	Pinctada sp.		*Nerita polita*
Psammobiidae		**Olividae**	
	Asaphis violascens		*Oliva* sp.
Spondylidae		**Potamididae**	
	Spondylus sp.		*Terebralia palustris*
Trapezidae		**Strombidae**	
	Trapezium oblongum		*Strombus luhuanus*
Veneridae			*Lambis truncata*†
	Pitar hebraeus	**Trochidae**	
			Trochus sp.
			Umbonium vestarium
			Umbonium sp.
		Turbinellidae	
			Vasum turbinllus
		Volutidae	

Key: †*Both of these species were only present in the form of shell objects.*

Figure 7. *A distal fragment of tibiotarsus recovered from Horizon IV, identified as* Phalacrocorax *sp., burnt to a medium intensity.*

Figure 8. *A dugong rib recovered from Horizon IV.*

4. Discussion

4.1. Subsistence Strategies

The marine vertebrate assemblage from Saruq al-Hadid represents the remains of subsistence activities, suggested by the identification of patchy charring on fish remains and the association of the marine vertebrate remains with other butchered animal bones. Based upon the quantification methods employed in the analysis of this assemblage, we suggest that marine vertebrates were a significant component of the subsistence strategy employed at Saruq al-Hadid, alongside wild animals local to the site (e.g. oryx and gazelle, Roberts *et al.* 2018) and domestic sheep and goat. The significance of fish derives not from their calorific contribution to the diet at Saruq al-Hadid – which may indeed have been relatively small – but from the continuous presence of marine animals in the site assemblage throughout its occupation, regardless of the contribution of their meat to the diet. It is important to note that comparing the NISP values between animals of different sizes and meat weights does not allow for effective estimations of the contributions of these taxa to the diet consumed at Saruq al-Hadid relative to each other. Given the incomplete nature of the excavations at Saruq al-Hadid, discussions regarding the relative contributions of the various taxa to the diet at Saruq al-Hadid will be better undertaken at a future time, when the zooarchaeological data from multiple field projects are fully integrated and quantified. In contrast to the fish remains, it should be reiterated that studies of the shell remains from Saruq al-Hadid suggest that they were not a significant part of the subsistence strategy at the site.

This evidence of a diet comprised of resources from multiple zones (i.e. domesticates, wild animals from the interior, wild animals from the coast) aligns with and enhances our understanding of the nature of occupation at Saruq al-Hadid. In the Bronze Age the site is hypothesised to have been temporarily occupied by members of a multi-sited community that occupied different parts of the landscape on a potentially seasonal basis (Weeks *et al.* 2018: 8). One could therefore hypothesise that the marine animal remains in the Bronze Age contexts from Saruq al-Hadid are representative of a seasonal subsistence strategy that involved transhumance, by a sector of the community, from the coast to the interior. In this scenario, the marine species may represent a stable food source carried by the mobile component of the community to supplement their diet during the occupation of Saruq al-Hadid and the inland zone. Such a seasonal subsistence strategy, that exploits different zones at different times of the year, is known to have been common in the region among traditional societies until the modern period, as observed by el-Mahi during his study of Bedouin groups in Oman (el-Mahi 2002). Dietary components of modern groups varied based upon time of year and environmental zone; while fresh fish were only observed to have been consumed on the coast during the winter months, dried fish were observed to be a dietary component for Bedouin occupying the inland zone during all times of the year (el-Mahi 2002: 35). While no reference was made to the consumption of cormorant or dugong in el-Mahi's study, both of these animals are known to have been consumed in the modern day (Uerpmann & Uerpmann 2008; Beech 2010).

Parallels to such a multi-zonal subsistence strategy can be found in the archaeological remains of societies around the globe. On the coastal fringes of the Atacama Desert in northern Chile, the hunter-fisher-gatherers of the Chinchorro culture (e.g. Reinhard *et al.* 2011; Marquet *et al.* 2012; Standen *et al.* 2018) employed a subsistence strategy that was focused on the marine resource, but also incorporated the hunting of terrestrial animals (e.g. Reinhard *et al.* 2011: 141; Santoro *et al.* 2012: 638; Standen *et al.* 2018). Their focus on the marine resource reflected the abundance of fish in coastal waters due to seasonal upwelling (e.g. Disspain *et al.* 2017: 2; Standen *et al.* 2018: 163), a mechanism that also causes an abundance of fish stocks off the coast of Oman (Cleuziou & Tosi 2007: 14; Sreeush *et al.* 2018). Similarly, Aboriginal groups in the western desert of Australia are known to utilise different environmental zones in the landscape, including river fish and wild game, on a seasonal basis (Cane 1987).

These subsistence strategies from South America and Western Australia are associated with regions that have environmental conditions that limit the amount of terrestrial resources available to societies living within them and encourage the exploitation of a number of different resource areas (Veth *et al.* 2005; Arriaza *et al.* 2008: 45-46; Reinhard 2011 *et al.*: 140). A similar pressure on terrestrial resources has been hypothesised for communities in southeastern Arabia (Uerpmann & Uerpmann 2008: 478) and, while the wild animal remains from Saruq al-Hadid are indicative of extensive hunting, this may have been an undertaking with variable returns. The diverse subsistence strategy evidenced during the Bronze Age at Saruq al-Hadid, including the use of marine resources, may therefore be seen as a buffer strategy to limit the effects of this hypothesised scarcity or unpredictability. While the examples discussed above are not directly analogous to Saruq al-Hadid in all respects, their demonstration of subsistence strategies in marginal environments that utilise multiple resource zones provide an instructive parallel for the multi-zonal subsistence strategy hypothesised for Saruq al-Hadid.

The activities undertaken at Saruq al-Hadid during the Iron Age contrast with those undertaken at the site during the Bronze Age. Archaeological evidence from Iron Age deposits suggests that materials and objects were brought to the site for the purposes of manufacture and exchange, as well as for socially-constitutive group ‘ritual’ activities that may have linked multiple communities (Weeks *et al.* 2017, 2018). Recent studies on the provenance of the Late Bronze Age and early Iron Age ceramics at Saruq al-Hadid have suggested that the assemblage was being brought to the site from a number of locations (Karacic *et al.* 2018), reinforcing the hypothesis that the site was frequented by groups from around the region. The remains of marine animals from Iron Age contexts may therefore represent movement of people from coastal sites to Saruq al-Hadid in order to undertake these activities. It is unclear whether the seasonality and/or temporality of the occupation also changes between these two periods, as discussed in further detail by Weeks *et al.* (2018).

Other instances of fish being brought inland to provision manufacturing sites with scarce local resources are known from the archaeological record. For example, at the Roman quarrying site of Mons Claudianus, situated in the Eastern Desert of Egypt 50km from the Red Sea, marine fish were found to comprise a significant part of the excavated faunal assemblage. Freshwater catfish from the Nile River, located 120km away, were also present at Mons Claudianus (van der Veen & Hamilton-Dyer 1998: 104). It is also important to consider that the marine species brought to Saruq al-Hadid may have been goods exchanged at and transported through the site. Such activities may have reflected Saruq al-Hadid’s links to wider exchange networks within the region, hypothesised by a number of researchers (Magee 2014: 234; Weeks *et al.* 2017; 2018), a prospect explored in further detail below.

In both of the above models, the frequent identification of fish and other marine resources at Saruq al-Hadid reflects the ubiquity and importance of fish to the societies engaging with the marine resource in the region. Indeed, researchers studying Bronze Age activity at the site of Ra’s al-Jinz 2 suggested that the occupants of the site were fishing to create a surplus of food that may have been exchanged inland or preserved for use as a stable food source throughout the year (Azzarà & de Rorre 2018: 20-21). The evidence from Saruq al-Hadid undoubtedly reinforces this hypothesis and goes further, demonstrating that cormorant and dugong were also involved in the movement of marine resources. It is worth noting that the abundance of cormorant in the zooarchaeological assemblages from Tell Abraq and Umm an-Nar Island (Uerpmann & Uerpmann 2008: Tabs. 3 & 4), may also be indicative of the creation of such a surplus for the provision of the inland region and activities undertaken there. Indeed, the exploitation of cormorant in late prehistory is widely evidenced throughout the Gulf, with extensive assemblages of cormorant bones being reported from the sites of Failaka and Qal ʻat al-Bahrain (Tomé 2003). It has been suggested that these animals may have been accidently caught in fishing nets rather than targeted as prey (Tomé 2003). Whether they were caught accidentally or intentionally, these animals were incorporated into the subsistence strategies at Saruq al-Hadid.

4.2. Preservation

The movement of meat from the coast to the interior would have required the preservation of the meat before transport. The methods of fish preservation employed by the late prehistoric societies of southeastern Arabia have been the topic of some discussion. The possible preservation of fish by smoking is supported by the identification of potential smoking facilities at Bronze Age Ra's al-Jinz 2 (Azzarà & de Rorre 2018: 20), whereas fish remains dating to the Late Pre-Islamic period from the site of Mleiha are thought to have been sundried before transportation, a practice widely evidenced in the region ethnographically (van Neer *et al.* 2013). Notably, a number of fish preservation techniques, including sun-drying, salting and grilling are known in the region today (el-Mahi 2000). At both Ra's al-Jinz 2 and Mleiha, skeletal element patterns in the fish assemblages were also consistent with the removal of the heads and tails of fish for preservation; an abundance of head elements and tails were recovered at Ra's al- Jinz 2 from large fish such as yellowfin tuna, without vertebrae present (Azzarà & de Rorre 2018: 21) and the fish assemblage from the Late Pre-Islamic occupation at Mleiha is composed primarily of vertebral fragments with very few cranial elements present (van Neer *et al.* 2013: 227). At Saruq al-Hadid, the presence of vertebrae but no cranial elements from tuna fits this pattern, and the differential representation of body parts across different fish species in the Saruq al-Hadid assemblage likely reflects different preservation treatments for different fish. Such variable preservation techniques were hypothesised to have been undertaken during the Early Bronze Age occupation of Ra's al-Hadd (Azzarà 2012: 255).

Employing varied preservation techniques for fish of different sizes is recorded in southeastern Arabia today (el-Mahi 2000). Small fish such as anchovies and sardines are dried intact, while larger fish are fileted and the bones are removed before being dried or salted (el-Mahi 2000: 101-103). Some fish were also grilled, however this technique was found to only keep fish edible for two to three days (el-Mahi 2000: 104). Notably, dried shark and grilled tuna were found to have particularly high protein content (el-Mahi

2000: Tabs. 1&2), and are observed to be a key constituent in the diets of traditional Omani communities throughout the region (el-Mahi 2000: 107-108). El-Mahi also highlights the importance of fish preservation in the creation of fish surpluses and the related subsistence strategies and exchange of fish (el-Mahi 2000: 107).

The chemical analysis of otoliths from Saruq al-Hadid suggests that the otoliths were not from fish that had been salted, ruling out the possibility that this method of preservation facilitated the movement of these fish (Roberts *et al.* 2019). However, the otoliths (elements from the head of the fish) can only be present from fish brought to the site intact. This study therefore does not rule out the possibility that salted fish fillets were brought to the site. It is worth noting here that the fish species present at Saruq al-Hadid are limited in comparison to the wide array of species present at coastal sites (**Table 13**). Fish preservation techniques and the resulting influence on skeletal element representation may partially explain this discrepancy; if fish of certain species or sizes were deboned prior to transport from the coast, their bones will not appear on inland sites, even if their meat has been transported. Additionally, the meat from a number of fish species may prove to be highly toxic if not preserved immediately after capture, due to raised levels of histamine (Taylor *et al.* 1989; Hungerford 2010). This toxicity is known to occur predominantly in the Scombroid family which are poorly represented at Saruq al-Hadid, but also appear in other species that are also not present at in the assemblage from the site. This propensity for toxicity may explain their absence from Saruq al-Hadid. However, the discrepancy between the fish species represented at Saruq al-Hadid and contemporary coastal sites could also be due to a number of other factors, such as seasonal availability of fish, cultural taboos, varying migration or trade routes etc. Ultimately, the equifinality regarding fish preservation makes definitive statements on fish preservation methods inappropriate, particularly given that deboned fish meat is an archaeologically invisible product.

However, other lines of evidence that discuss the preservation of fish meat can provide insight here. Ethnographic studies of the processing of Nile perch by traditional societies may provide an explanation for the presence of intact fish skeletons at Saruq al-Hadid, as they have been observed to split a whole fish into fillets, leaving the vertebral structure in the fish for support, before smoking (Peyton 1988: 32). Textual sources referring to ‘split’ and ‘dried’ fish from southern Mesopotamia, dating to 3100-2900 BCE (Potts 2012: 222), suggest that these methods of preservation were practiced in antiquity. It is also important to note frequent references in Mesopotamian texts to ‘fish oil’ (Potts 2012), a product also discussed in a southeastern Arabian context by Cleuziou & Tosi (2007: 174). Fish oil is another archaeologically invisible product, from a zooarchaeological perspective, that should be considered when discussing the role of marine resources in the region.

Table 13. *The taxonomic identification of fish at Saruq al-Hadid, compared to the identifications made in fish assemblages from other contemporary sites. Data from Beech 2003 Tab. 2-4; 2004.*

Taxon	Presence at Contemporary Sites	Presence at Saruq al-Hadid
Alopiidae indet.	•	
Triakidae indet.	•	
Carcharhinidae		
Carcharhinus sp.	•	
Negaprion sp.		•
Indet.	•	
Sphyrnidae		
Sphyrna sp.	•	
Pristidae indet.	•	
Rhinobatidae indet.	•	
Rhynchobatidae indet.	•	
Dasyatidae indet.	•	
Myliobatidae indet.	•	•
Chondrichthyes indet.	•	•
Elopidae indet.	•	
Clupeidae indet.	•	
Chanidae		
Chanos chanos	•	
Chirocentridae indet.	•	
Arriidae		
Arius sp.	•	
Belonidae indet.	•	•
Platycephalidae indet.	•	
Serranidae		
Epinephelus sp.	•	•
Indet.	•	•
Teraponidae		
Terapon sp.	•	
Rachycentridae		
Rachycentron	•	
Echeneidae		
Echeneis naucrates	•	
Carangidae		
Alectis sp.	•	
Alepes sp.	•	
Carangoides sp.	•	•
Caranx sp.	•	
Decapterus sp.	•	
Elgatis bipinnulata	•	
Gnathanodon	•	
Megalaspis cordyla	•	
Scomberoides sp.	•	

Taxon		Presence at Contemporary Sites	Presence at Saruq al-Hadid
Carangidae	**(*Cont.*)**		
	Seriola sp.	•	
	Trachinotus sp.	•	
	Trachurus indicus	•	
	Ulua mentalis	•	
	Indet.	•	
Gerreidae			
	Gerres sp.	•	
Lutjanidae indet.		•	
Haemulidae			
	Pomadasys kaakan		•
	Pomadasys sp.	•	•
	Indet.	•	•
Nemipteridae indet.		•	
Lethrinidae			
	Lethrinus lentjan	•	
	Lethrinus nebulosus	•	
	Lethrinus sp.	•	•
	Indet.	•	•
Sparidae			
	Acanthopagrus spp.	•	
	Argyrops spinifer	•	
	Rhabdosargus sp.	•	•
	Indet.	•	•
Mugilidae indet.		•	
Mullidae indet.		•	
Pomacanthidae indet.		•	
Scaridae indet.		•	
Labridae indet.		•	
Sphyraenidae			
	Sphyraena sp.	•	
Scombridae			
	Euthynnus affinis	•	
	Scomberomorus sp.	•	
	Rastrelliger	•	
	Thunnus sp.	•	
	Indet.	•	•
Istiophoridae indet.		•	
Drepanidae			
	Drepane sp.	•	
Ephippidae indet.		•	
Balistidae indet.		•	
Cyprinidae indet.		•	
Siganidae			
	Siganus sp.	•	
Balistidae indet.		•	

Taxon	Presence at Contemporary Sites	Presence at Saruq al-Hadid
Tetraodontidae		
Arothon sp.	•	
Sciaenidae		
Pennahia anea		•

The skeletal element representation observed in the dugong and cormorant remains may also provide an insight into the ways in which their meat was preserved for the journey to Saruq al-Hadid. Only dugong ribs were present at Saruq al-Hadid, consistent with Beech's (2010: 10) discussion of the processing of dugong carcasses, in which he suggested that slabs of meat would have been removed from the carcass still attached to the rib. While it is possible that the cormorants were brought to Saruq al-Hadid alive, the skeletal element representation observed in their remains suggests that these animals had been slaughtered and butchered prior to their arrival at the site. The preservation of cormorant meat is not known to occur today in the region, nor are there any archaeological parallels for such activity, however it is plausible that this meat could have been preserved while still on the bone before its transportation inland.

The use of NISP as a quantification method and its influence on our interpretation of the role of marine vertebrates in subsistence at Saruq al-Hadid must also be considered. While the high NISP values of marine vertebrates, particularly fish, might indicate their predominance in diet at the site, meat returns from the numbers of fish remains will be significantly smaller than those from an equal NISP value from larger mammals. It could therefore be argued that these NISP values might artificially inflate the role of marine vertebrates in the subsistence strategies at Saruq al-Hadid. However, contrary to this argument, the contribution of filleted fish or other deboned meat to the subsistence strategy at Saruq al-Hadid must also be considered. While we have not attempted to establish the contributions of marine animals to the diet of the inhabitants of Saruq al-Hadid relative to other species, it is clear that any discussion of how marine animals were incorporated into subsistence strategies at Saruq al-Hadid must consider these archaeologically invisible products, particularly given the ethnographic and historical evidence for their use.

4.3. Craft Production and Object Manufacture

In addition to the consumption of marine resources, there is also evidence of the remains of marine species being used in the production of objects at Saruq al-Hadid throughout the site's occupation. The most compelling evidence is the presence of semi-processed shell objects at the site in Iron Age contexts, which are described in detail elsewhere (Carter Unpublished: 13; Weeks *et al.* 2017: Figs. 23, 24; 2019a). Although fragments of large gastropod species were recovered from Saruq al-Hadid, these were present in small quantities in comparison to large-scale late prehistoric shell working sites from southeastern Arabia and the wider region (Cleuziou & Tosi 2007:175; Weeks *et al.*

2019a). Nevertheless, such remains suggest the manufacture of shell objects at Saruq al-Hadid.

The dugong ribs identified at Saruq al-Hadid are particularly dense and would therefore be suitable raw material for bone working. While a large number of bone objects and evidence for bone working has been recovered from the Iron Age occupation at the site (Roberts *et al.* in Prep. a), only a small number of bone objects were present in contexts contemporary with the dugong remains. This potential use of dugong bone is still important to highlight however, particularly given the ivory identified in the remains from Horizon IV at the site. It is highly likely that this ivory fragment was brought to the site for the purposes of craft manufacture, however the only definitive example of dugong ivory being utilised as a raw material in southeastern Arabia was recovered from the Neolithic site of Jebel Faya (FAY-NE15; Uerpmann *et al.* 2012: 398). It should also be noted that dugong carcasses can provide a number of products in addition to their bone and ivory, including blubber and hide, that would be archaeologically invisible in their extraction and use (Beech 2010: 10). These products must also be considered when interpreting the role of this species in the activities undertaken at Saruq al-Hadid.

The remains of shark and ray identified in the fish assemblage may also reflect craft production activities. While not evidenced archaeologically in Arabia, shark and ray skins have been used as components of weaponry at different times and places around the world, due to their suitability as a gripping material. An example of a shield suggested to be made of shark skin dating to the Islamic period is present in the museum of Dubai. While there is no direct evidence (i.e. the recovery of shark dermal scutes) for the working of shark skins in the remains from Saruq al-Hadid, it is possible that these dermal scutes were removed from the skins prior to their transport to the site for secondary working.

These examples, while largely speculative, may tie the remains of marine resources into the wider interpretation of Saruq a-Hadid as a centre for exchange and on-site craft production during the Iron Age (Weeks *et al.* 2017, 2018). The possible movement of these archaeologically invisible goods and raw materials around the landscape must therefore be considered when interpreting the remains of marine species at Saruq al-Hadid.

4.4. Trade and Exchange Networks

In addition to their role in subsistence strategies and craft production, marine resources possibly also played a role in regional exchange networks that moved goods from the interior to the coast. As mentioned briefly above, the existence of such an exchange network during the Bronze Age in the region was suggested by Cleuziou (1996), who speculated that fish from the coastal region may have been exchanged with copper from the ore sources that exist in the mountains of the interior. While there are no such copper sources local to Saruq al-Hadid, other resources, such as the meat from hunted wild terrestrial animals, may have been exchanged with coastal or piedmont sites (Roberts *et* *al.* 2018). A discussion of the Bronze Age animal economy of southeastern Arabia identified potential evidence for the movement of resources from the inland region to the coast, but no direct evidence for the movement of goods in the other direction (Uerpmann & Uerpmann 2008: 482). It is important to clarify that, while networks of exchange do not necessarily constitute commercial trade, exchange networks between and within community groups are likely precursors to the commercial exchange of these goods (Potts 2012: 231).

Fish are evidenced to be an important component of trade networks in the Levant during the Bronze Age, even while other items were being traded less (Routledge 2015). Specifically, the Nile Perch are thought to have been regarded as a luxury item by the Levantine societies consuming them (Routledge 2015: 225). Moreover, there is extensive evidence for the exchange of fish and fish products from coastal to interior sites around the Levant and Mesopotamia, thought to have been undertaken on a commercial basis (2012: 231). Given the evidence for traded goods, materials and objects from a wide array of places (Weeks *et al.* 2017; 2018), alongside trading paraphernalia such as weighing dishes (Contreras & Valente 2017) in the Iron Age deposits at Saruq al-Hadid, it is possible that the contemporary fish remains from the site were a component of trading activity at the site. Whether the Bronze Age fish remains should be considered as traded goods is less clear and, as discussed, it is more likely that they were part of a supply network that operated within a single, distributed community.

5. Conclusions

The remains of marine species recovered from Saruq al-Hadid contribute to the large and growing body of evidence demonstrating the importance of marine resources to late prehistoric societies in southeastern Arabia. In turn, this underlies the well-established historical and ethnographic evidence for the regional importance of fish and other marine animals, both in terms of diet and lifeways more generally. The presence of these remains at Saruq al-Hadid undisputedly demonstrates that marine resources were being moved from the coast to the interior during the Bronze and Iron Ages. The quantity and variety of the remains are indicative of the complexity and extent of this movement. Although speculative, the use of other archaeologically invisible products derived from marine resources at Saruq al-Hadid, such as dugong blubber and filleted fish, is strongly supported by ethnographic and historical data from the wider region. The importance of such archaeologically invisible products in ancient societies has been well established (e.g. Crawford 1973; Potts 2012) and the potential of zooarchaeological evidence, including 'negative' evidence, for identifying the use of such products is known (e.g. Crabtree 1990).

Although a number of fish species were brought to the site intact, the limited skeletal elements present from larger fish, such as tuna and shark, are consistent with ethnographic observations made regarding their preservation and transport after processing. Our data support the hypothesis that multiple techniques – drying, salting, smoking – were employed to preserve the fish and other marine resources, as observed ethnographically. While marine resources were clearly important to activities at Saruq al-Hadid, the fact remains that bones from marine species are more sparsely represented in the majority of other faunal assemblages recovered from inland sites. Questions therefore remain as to the extent of the inland movement of marine resources and the reasons for their presence at Saruq al-Hadid during the Bronze Age, but relative absence at other contemporary inland sites. Moreover, while some researchers have linked the increase in the exploitation of marine resources at inland Iron Age sites to the domestication of the camel (e.g. Beech 2004: 214; Magee 2014: 226), the use of marine animals throughout the occupation of Saruq al-Hadid demonstrates that patterns of resource exploitation do not necessarily depend upon transport technologies.

These findings further our understanding of the nature of the occupation at Saruq al-Hadid, broadly hypothesised to be part of a seasonal occupation by members of a 'multi-sited community' during the Bronze Age and a meeting place for different groups during the Iron Age. Not only were these resources incorporated into subsistence strategies at the site, they were utilised in craft activities and may have also been a component in exchange networks linking the coast and interior. Therefore, these remains are highly significant in terms of placing Saruq al-Hadid into the wider network of late prehistoric sites in the region and establishing how the occupants of these sites interacted with diverse resource zones. While beyond the scope of this paper, future work should also draw these findings into wider discussions regarding human responses to prehistoric climate change in the region and investigate how the exploitation of a diverse array of resources relates to those responses. Regardless of these wider implications, the marine evidence from Saruq al-Hadid ultimately indicates that the bountiful waters surrounding southeastern Arabia were an integral resource for the occupants of the site throughout the Bronze and Iron Ages.

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9. Paper 5

This paper demonstrates a potential method to pursue some of the questions raised in Paper 4 regarding marine resource exploitation at Saruq al-Hadid. Entitled '*Preliminary insights into late prehistoric fish procurement strategies in the desert interior of southeastern Arabia: the results of LA-ICP-MS analysis of a fish otolith assemblage from Saruq al-Hadid, UAE*', the paper details chemical analysis undertaken on sagittal fish otoliths recovered from Saruq al-Hadid.

The results of this analysis support some tentative hypotheses regarding the location and season of capture of the fish brought to Saruq al-Hadid; two clear groups are identified in the chemical data collected from the otoliths which could be attributed to the fish being caught in different areas or at different times of the year. The chemical data also suggest that these fish were not salted prior to their transport to Saruq al-Hadid, favouring the hypotheses that these remains were dried or smoked prior to transport. Seemingly a trivial observation, this discussion of preservation strengthens the links between Saruq al-Hadid and coastal sites at which fish processing and smoking facilities have been identified. As well as providing these preliminary answers, this paper ultimately highlights the potential for fish otoliths to elucidate the nature of regional exchange networks that were present in southeastern Arabia during late prehistory.

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10. Conclusions

The findings presented above demonstrate the nature of long-term interactions between humans and animals at Saruq al-Hadid, particularly during the Bronze Age. While the potential significance of Saruq al-Hadid to the Iron Age network of sites was identified by Magee (2014: 234), the extension of this significance into the Bronze Age is an important contribution to our understanding of the site. What may have before been seen as a marginal space, on the peripheries of the coast and the mountains, should instead be seen as a well utilised and resource rich environment that prompted its persistent exploitation for at least 1200 years. These findings also tie into wider reconsiderations of desert spaces and their role in prehistoric societies, moving away from their conceptualisation as ‘marginal’ or peripheral environments and landscapes.

More specifically, the zooarchaeological studies presented in this thesis provide numerous insights into the relationship between humans and animals at Saruq al-Hadid during the site’s late prehistoric occupation, and the activities undertaken on site that represent that relationship. The proportion of wild terrestrial animals present in the faunal assemblage is not attested in any other contemporary faunal assemblages from the region, suggesting that the exploitation of wild terrestrial animals was a central activity throughout the occupation of Saruq al-Hadid and may have even been a reason for the initial occupation of the site. The faunal assemblage from Saruq al-Hadid is also unique in terms of the characteristics of the dromedary camel bone assemblage. These factors suggest that Saruq al-Hadid, and by extension the desert interior, played host to a relationship between humans and animals that was not evidenced at sites in other environmental zones. The identification of marine animals in the assemblage demonstrates that resources from the marine environment were used to supplement subsistence strategies in the desert interior, highlighting movement of resources from the coast to the desert zone that was potentially reciprocated with the movement of wild animal resources from the desert interior to the coast.

In turn, these conclusions allow us to construct scenarios regarding human-animal relationships at Saruq al-Hadid. Wild terrestrial animal exploitation, predominantly of dromedary camels, oryx and gazelle, was central to the Wadi Suq period and Late Bronze Age occupation of the site, with domesticates and food from the marine resource further facilitating these human movements into the desert interior. Whether this occupation was seasonal or undertaken on an irregular basis, it is clear that Saruq al-Hadid was part of a wider resource network during this period that facilitated the movement of people, their livestock and food resources from the coast to the interior. This is an important contribution to our understanding of society in the latter half of the Bronze Age in southeastern Arabia and the way in which different areas were integrated during this relatively poorly understood period in the region.

The remains of this Bronze Age activity, in the form of a large bone midden, then became a focal point for subsequent activity in the early Iron Age. Despite the apparent expansion and intensification of occupation at Saruq al-Hadid that occurs in the early

Iron Age, alongside the change in use of the Central Area of the site, wild terrestrial animals are still evidenced to have been important to the site's function. Domesticates and marine resources were still brought to the site to provide subsistence for activities being undertaken during this period. The limited assemblage from the Military Base, as outlined in **Paper 1**, also suggests that domesticates may have been kept and bred at the site during this period, however this will require further excavation and analysis to be conclusively demonstrated. The predominant activity involving animals in the Central Area of the site during this period appears to be the extraction of skins and horns, as well as the manufacture of bone objects, suggesting that these products may have been involved in the wider network of trade that involved Saruq al-Hadid and that is evidenced elsewhere in the material culture of the site.

As a final statement, this thesis highlights the role of zooarchaeological studies in understanding the history of nominally 'marginal' environments, such as the southeastern fringes of the Rub' al-Khali desert, both in terms of how humans interact with and within these areas through time, and in terms of how environments themselves have changed. As the 21st Century progresses, the need to understand human-environment dynamics will become increasingly acute. Studies such as this are important, if not central, to this growing need.

11. Potential Avenues for Future Research

While this thesis presents a number of contributions to our understanding of the human past in southeastern Arabia there are a number of issues raised in this thesis that require further study. These are detailed below.

(**Paper 1**) As stated throughout this thesis, excavations at Saruq al-Hadid are ongoing and therefore further faunal materials will undoubtedly be recovered in the future. These remains should be incorporated into an overarching study of the site's zooarchaeological assemblage, using the standard methods outlined in this paper and building on the results and interpretations presented above. As excavations at the site continue, relating remains from all areas of the site to each other (e.g. remains recovered from the military base excavations) should also be a priority, as should further integration of the faunal remains with other material classes in the assemblage from Saruq al-Hadid. Such an approach will help efforts to create an integrated zooarchaeological understanding of the data collected (previously and in the future) by the multiple excavation teams working at the site.

(**Paper 2**) The evidence for the consistent and extensive exploitation of wild terrestrial animals at Saruq al-Hadid over 1200 years has significant implications for how we conceptualise late prehistoric societies in southeastern Arabia. Further exploration of the potential role of wild animal exploitation and associated social formation practices (i.e. group hunting, hunting as a kingship display, hunting as territorial expression etc.) should be undertaken, especially during the Wadi Suq period. Expanding our knowledge of Arabian Oryx behavioural ecology will allow greater insights to be made regarding the population demographics represented in assemblages like those from Saruq al-Hadid, which in turn will facilitate a nuanced analysis of hunting techniques. Greater consideration should be given to potential hunting techniques, such as non-permanent kites and traps (Maraqten 2015), with regard to on-going work examining hunting strategies in adjacent regions (e.g. Crassard *et al.* 2015). Furthermore, the potential differences in capture methods for game of different sizes should also be considered in order to account for the variety of species utilised at Saruq al-Hadid. Exploring these areas will allow for a greater elucidation of the societal practices behind wild animal exploitation at Saruq al-Hadid and in the wider region.

(**Paper 3**) The significance of the dromedary camel remains from Saruq al-Hadid, as outlined in this paper, cannot be overstated. Future finds of dromedary camel bone on archaeological sites in the desert zone should be incorporated into the wider discussion of human-dromedary relationships and domestication, as a matter of utmost importance. This paper particularly highlights the need to develop our understanding of dromedary skeletal anatomy. This will allow more detailed mapping of the changes in camel use over time in multi-period assemblages like Saruq al-Hadid and will therefore be integral to the furthering our ability to provide more detailed interpretations of archaeological assemblages of dromedary camel bone. In turn, this will increase the potential for zooarchaeological assemblages of dromedary camel bone to inform issues such as dromedary domestication.

(**Paper 4**) The Bronze Age network of sites highlighted in this paper should be further explored using different material classes and remains from other interior sites as they are discovered. While the existence of these links has been definitely proven in this paper, further elucidating the nature of them should be a major research focus in the future. The discovery of other marine animal bone and marine shell assemblages at interior sites will be invaluable in the development of the understanding of this dynamic and the research potential of any such discoveries should be properly realised. Furthermore, greater comparison between the fish assemblage from Saruq al-Hadid and those from coastal sites will help to shed further light on the dynamics behind the movement of marine resources. Establishing how the fish bone assemblage compares with those sites that have yielded evidence of fish preparation, such as Ra’s al-Jinz, RJ-2 (Azzarà & de Rorre 2017) and the recently reported remains from Ra’s al-Hadd, HD-1 (Cattani *et al.* 2019), will facilitate an exploration of how these coastal fish preparation sites were involved in the provisioning of the interior.

(**Paper 5**) This paper highlights the research potential of chemical analysis of fish sagittal otoliths in answering some broader questions about late prehistoric society in southeastern Arabia. Building a reference dataset of otolith chemistry from modern fishes will be essential to unlocking the full potential of this method, however the conclusions that can be gained from this method can still be informative without such a reference dataset. Excavation methods that allow for the recovery of otoliths should therefore be employed where possible, particularly when fish remains are known to be present on a site. As in Paper 4, Paper 5 also demonstrates the potential insights that can be gained by exploring the use of the marine resource in the late prehistoric desert interior, something that should remain a focus in studies of this period. Comparison of the otolith chemistry from the Saruq al-Hadid assemblage to the chemistry of otoliths recovered from other sites could be a particularly effective approach; for instance, establishing differences in otolith chemistry from sites on the Persian Gulf to those on the coast of Oman, then comparing these chemical signatures (if they exist as hypothesised) to those from Saruq al-Hadid will help to establish where the fish at Saruq al-Hadid may have come from. It is important to note here that, as outlined in Paper 5, a large number of variables can affect the chemistry of otoliths and all conclusions made based upon this method should acknowledge the potential influence of such variables.

As future surveys and excavations are conducted in the desert zone, new faunal assemblages will undoubtedly be recovered. These remains will be essential to exploring different aspects of the occupation of the desert interior in southeastern Arabia, as highlighted in this thesis.

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Appendices

Appendix 1 – Supplementary Papers

Appendix 1a – General Information Regarding the Excavations and Analysis undertaken by SHARP

Weeks, Lloyd; Cable, Charlotte; Franke, Kristina; Newton, Claire; Karacic, Steven; Roberts, James; Stepanov, Ivan; David-Cuny, Helene; Price, David; Bukhash, Rashad Mohammed; Radwan, Mansour Boraik; Zein, Hassan (2017). Recent archaeological research at Saruq al-Hadid, Dubai, UAE. *Arabian Archaeology and Epigraphy*, 128(1), 31-60. https://doi.org/10.1111/aae.12082

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